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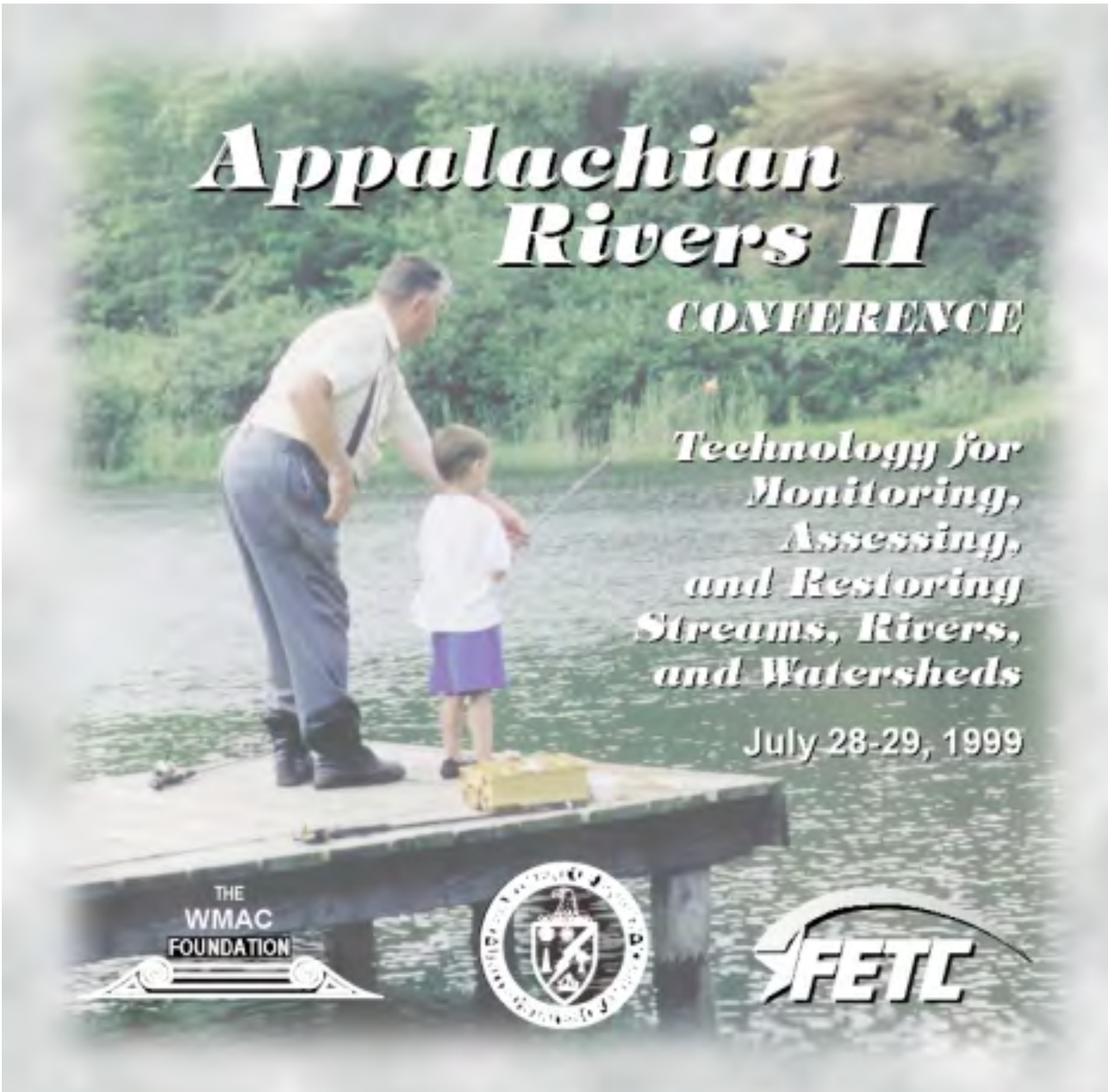

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Foreword

On July 28-29, 1999, the Federal Energy Technology Center (FETC) and the WMAC Foundation co-sponsored the Appalachian Rivers II Conference in Morgantown, West Virginia. This meeting brought together over 100 manufacturers, researchers, academicians, government agency representatives, watershed stewards, and administrators to examine technologies related to watershed assessment, monitoring, and restoration.

Sessions included presentations and panel discussions concerning watershed analysis and modeling, decision-making considerations, and emerging technologies. The final session examined remediation and mitigation technologies to expedite the preservation of watershed ecosystems.

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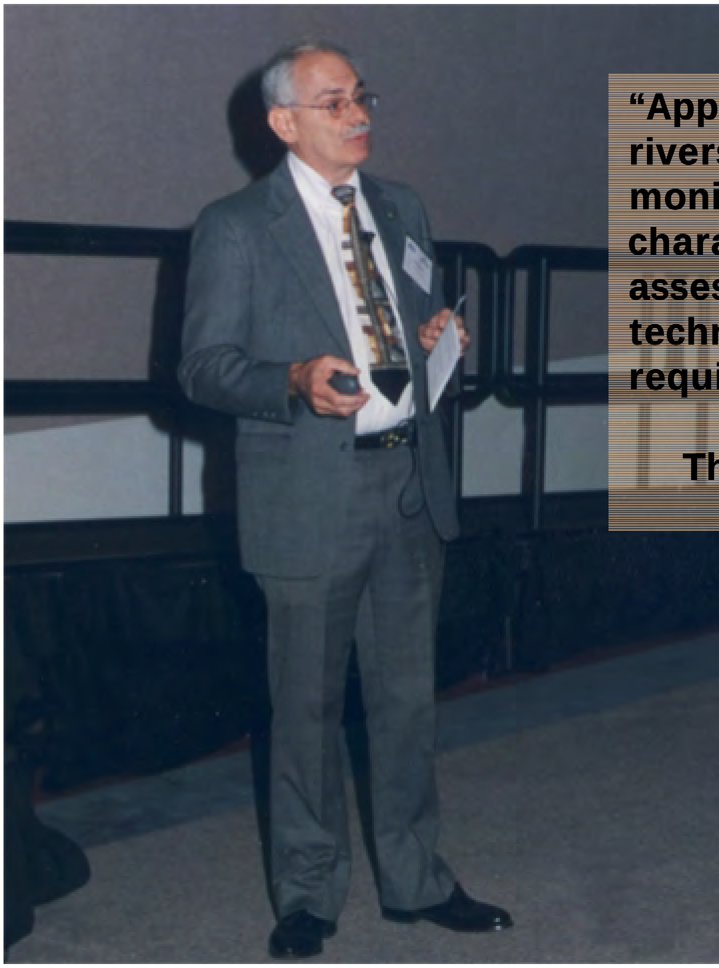
Appalachian Rivers II

Conference Scenes



"Appalachian streams & rivers have unique monitoring, characterization and assessment (MCA) technology requirements."

Zane Shuck
The WMAC Foundation

Five panelists led a discussion of *Remote Sensing Technological Development*: William Anderson, Bill Okubo, Terry Ackman, Bob Kleinmann, and moderator George Constantz.

Conference Scenes

Roger Duckworth and Lindsay Abraham served as moderators for Panel Discussion 3, *Current and Future Technology Tools for Watershed Stewards and Watershed Organizations.*

One of ten exhibitors, the Hydrolab Corporation displayed information about sensor equipment. Phyllis Crutchfield answered questions from a conference attendee.

Conference Scenes

Karl Schroeder, FETC

Bill Okubo of Research Systems, Inc. in Boulder, Colorado, took time to assist at an exhibit when he wasn't making his presentation on "Polluted Streams Near Colorado Ski Resorts" or participating in a panel discussion.

Jason Jestor
Sensys Technologies

Conference Scenes

Conferences provide excellent opportunities for networking and information gathering. Appalachian Rivers II brought together manufacturers, researchers, academicians, government representatives, and watershed stewards.

Conference Scenes

Heino Beckert of FETC and Greg Most of the Hach Corporation both served as panelists. In addition to seven major sessions, the conference featured three panel discussions related to watershed technology.

Jason Jestor of Sensys Technologies, Inc. (right) was one of over 100 conference participants.

Conference Scenes

Kyle Hartman, Division of Forestry, WVU, gave two presentations: "*Modeling as a Tool in Assessing River Biota*," and "*Influence of Turbidity on Foraging Success of Brook Trout and Smallmouth Bass*" with John Sweka.

Rick Fielder of YSI—Rick's session examined the properties of chlorophyll and how it is measured in spot sampling and continuous monitoring sessions.

APPALACHIAN RIVERS II CONFERENCE & EXHIBIT

July 28 & 29, 1999

USDOE, Federal Energy Technology Center
Conference Room and Exhibit Center
3610 Collins Ferry Road, Morgantown, WV 26507-0880

JAN WACHTER, Co-Chairman: (Welcome and opening remarks.)

L. ZANE SHUCK, Co-Chairman, and Founder
Hello, and Welcome to Appalachian Rivers II Conference and Exhibit. I would like to tell you a little bit about this conference, and then give you my own perspective on technology and methodology as applied to the study of streams and rivers and their ecosystems. But first, I would like to give special thanks to those who made this conference possible this year. First, to my good friend and co-chairman, Jan Wachter, it has been great working with you on this conference, and thank you very much for your many contributions, and the FETC for hosting the conference here this year. Second, I would like to especially thank Kim Yavorsky, Betty Robey, Lorraine Alvarez, Pam Stanley, Carolyn Moore, Martin Dombrowski, and other staff members who really did a tremendous amount of work to make this conference a success.

ABOUT APPALACHIAN RIVERS II CONFERENCE & EXHIBIT

I would like to take a couple of minutes to tell you what this conference is about. As professionals, we all go off to our own esoteric technical conferences in our fields of specialization and then go to the special break out sessions where we are further specialized and divided from communication with others. This is fine and necessary, however, in the case of streams and rivers, there are so many different federal government and state government agencies, private interest groups, universities, watershed organizations, industries and manufacturers involved in river affairs that communications alone is a serious problem. There are more disciplines involved in stream and river related science and technology than any other system on earth. These are some of the reasons why I place stream ecosystems first, ahead of humans, as the most complicated system on earth from a systems engineering point of view. The combined number of organizations and disciplines gives rise to the largest number of perspectives to be drawn relative to technology and methodology of any other system on earth. Thus, I founded Appalachian Rivers Conference & Exhibit last year to address these issues and the obvious needs, as one of the roles for The WMAC Foundation that I also founded to sponsor such activities. In order to effectively develop appropriate technologies and methodologies, all players need somehow to be at the same table, hearing the same messages, and providing input into the process. This explains why we are all here in the same room hearing all of the same messages and providing input so that all stakeholder representatives can benefit. Such an approach is essential in technology development for such a complex system.

Another issue is that while there are hundreds of conferences dealing with various aspects of streams and rivers, their ecosystems, their regulation and other affairs, and the many associated environmental problems, there are no conferences that focus exclusively upon the **TECHNOLOGY and METHODOLOGY of monitoring, characterizing, and assessing rivers.** There are conferences that pertain to the technology of problem mitigation, such as, AMD, and there are conferences for all aspects of ocean, marine and lakes, but rivers have unique characteristics and need unique technology and methodology. Methodologies are technology driven which further justifies a special technology and methodology conference. So, hopefully, this will explain to you the reasons for the structure of this conference, the program agenda, and why we have these high tech exhibits by the world's leading manufacturers represented here today, and their representatives as part of the program.

A TECHNOLOGY PERSPECTIVE

I would like to now give you my perspective as a biosystem engineer's point of view. During the past three years or so, I have discussed stream and river technology and methodology with the best experts available in most of the relevant disciplines. Considering their ideas along with a couple of my own, I have formulated for you today a unique perspective from a biosystems engineering approach. I have no bias or vested interests, except helping bring the best technology to bear on the world's most complex system to monitor, analyze, characterize, and model. Many people regard humans as the most complex system on earth to monitor, analyze, understand, characterize and model, but in my opinion, the most complex is a stream or river ecosystem.

To put things into perspective, consider how present state of the art technology is developed for humans. State of the art technology for humans allows comprehensive monitoring, characterizing, diagnostics, analysis, understanding and modeling of most all components of the human body, independently, and with dependencies upon other components, and in many ways as subsystems and as a total system. As we think of this in terms of the status of stream and river technology, we can readily visualize the stark contrast between the two technologies measured up against each other, and the shortcomings of stream and river technology. In addition to priority, technology for humans is strongly market driven with huge markets of thousands of products, each with large sales volumes in the millions. Such is not the case for any aspect of stream and river technology. Manufacturers must conduct research and develop technology for large markets. State and federal government agencies are for the most part the only customers for river assessment technology. Most technology available for streams and rivers was developed for oceans, lakes and marine applications under many government programs and represents inappropriate "hand-me-down" tools for streams. To my knowledge, there is no government program specifically for developing **technology** for the monitoring, analysis, characterization, diagnostics, and modeling of streams or rivers. The major private organization that I can think of that considers technology development for streams and rivers is the Canaan Valley Institute. Much of the technology specifically for streams and rivers is developed in universities with very small budgets.

Appalachian streams & rivers do have unique monitoring, characterization and assessment (MCA) technology requirements. However, the watershed stewards from 100's of government agencies and divisions are overburdened in labor intensive jobs of dealing with watershed problems of monitoring, mitigation, and administration with little time specifically for MCA technology development. Agencies with watershed related missions & responsibilities have budget pressures that prohibit expenditures for specific MCA technology development projects. Numerous government programs with sizeable budgets do exist for mitigation work and mitigation technology development, but we have failed to develop the technology to first understand the problems and the complex biosystems we are trying to salvage. There is also not much support for fundamental science projects for river ecosystem characterization, because it is viewed more as basic science & research, which is not that popular today. **However, much fundamental science knowledge is missing, and it must be developed simultaneously in an iterative fashion with appropriate technology.**

This begins to create a picture as to why we have such limited technology for assessing streams, even though we have imposed upon ourselves monumental tasks, such as, determining the total maximum daily loads (TMDLS) for over 20,000 streams in the United States. **This predicament with all of the attendant facets is full justification for a special government program for MCA technology development**. We desperately need technology for more efficient and more comprehensive, stream monitoring, diagnostics, modeling and simulation in order to seriously consider ourselves as doing technically competent stream assessment, and I will talk later about a program to address the problem. Some TMDLS may be too severe, while others may be inadequate. The economic and ecosystem-health impacts can both be huge. These are serious national issues.

During the two days of this conference, you will be hearing the word "model" used many times, and probably in ways that may not be immediately clear as to what is meant. Briefly, I would like to define some basic types of models and clarify what I mean when I use the term model. Some refer to data from any unknown source plotted on a set of axes and with a line drawn through it as a model. This is actually only a "curve fit". It requires absolutely no knowledge of the system, does not tell anything about the system, and really is not a "model". The next highest level is a so-called "black box" model. In this case, some known quantity is input to the black box, and an output is measured. Some correlation curve can be drawn to show the relationship between the input and output for that exact circumstance and set of conditions--which you may or may not know. This type of model also requires absolutely no knowledge about the internal structure or characteristics, and gives very limited information about the system. This is the least desirable type of model, but it may have to be used to gain some insight in the absence of a better type.

In attempting to understand the internal structure, component behavior individually and in combinations, of complex systems, a third type of model is essential. This is what I call an Internal or Intrinsically Based Model and is the type to which I shall refer. This type model is based upon knowledge of the internal components of the system, their individual characteristics, their interrelationships, and their overall behavior as a unit. For a known input, an output can be calculated apriori, and the model can be calibrated by experiment. It can be deterministic or stochastic, and further classified as static, quasi-static, dynamic, transient, etc, based upon its design features and the application system characteristics. **Most importantly, this type model can be used for diagnostics, assessment, mitigation process design, simulation, and intelligent decision making**. This is the type model needed for biosystems and for the modeling of stream and river ecosystems. Ecosystem models most common of this general type are called bioenergetic models. This type model gives direction from which to build the level of basic science knowledge, and the goals and criteria for technology development. The bioenergetic models I have attempted to use are not user friendly, do not ask for the right data, or the right questions, and do not give the needed answers. In general, they were not developed for stream or river diagnostics and assessment, but for lakes or aquaculture. **The basic science knowledge level for streams must be built specifically to meet the lowest level of technology available for each system component monitoring, characterization, and assessment, and they must grow in an iterative fashion toward measured goals.** I do not see this process happening at all, and certainly not in any systematic manner, for streams and rivers. There are several specific and explainable reasons for it not happening, some of which I have already mentioned.

Stream and river ecosystem science is highly multi-disciplinary. Not only are many disciplines involved, but most of the components and sub-component systems are coupled, or interdependent, even more so than in humans. Many approaches being used today are one-dimensional, and single disciplinary, instead of multi-dimensional and multi-disciplinary. Coupling of the component or sub-component systems is seldom included in a quantitative manner in stream characterization, analysis, diagnosis, modeling, overall assessment, and problem mitigation. This is where science and technology must meet and be focused in order to build more comprehensive understanding and assessment capabilities. Different component monitoring and analysis by different state and federal government agencies with different missions and responsibilities greatly complicates and handicaps this science and technology evolution process. Even communications as to what is being done by whom is a problem we have to address.

As a biosystems engineer I find it convenient to classify the major stream components as: water, macro-biota , micro-biota, macro-benthos, micro-benthos, micro-benthic habitat, macro-benthic habitat, macro-biota habitat, micro-biota habitat, and extra-aquatic habitat and influences, with the full realization that, except for extra-aquatic influences, all of these major components and their subsystems are fully interdependent. In this system, there are few truly independent variables, and most any relationship must be described by complex functionals instead of functions.

So what technology is needed? First, consider water quality. Measuring only 7 to 10 variables in a stream or river, as we are now doing throughout the United States, can only tell how bad the quality of the stream is**. It tells very little about the "health" of a stream or river.** Due to budget, manpower, and technology constraints, we may only go out and monitor a stream for a few minutes once a month or less frequently at a specific point in the stream. When interpreting the data, the time of day, previous rainfall history, diurnal variations, total or spectral solar radiation, and numerous other major factors are not considered, because they are generally not available. A point measurement in a stream with several small tributaries, point sources and other major variations along its length can also render interpretation a futile effort. Some variables, such as DO, may vary as much as 60% or more of their value in 24 hours due to normal diurnal processes alone. I have been especially frustrated in attempting to make any sense of historical archived data, or even data that I have been gathering on a stream about every two weeks for a year involving the same variables everyone else is measuring. **One must raise the question of cost/benefit of the methodologies we are using today and the value of the data obtained, versus the cost/benefits of methodologies we could employ, if we modify, apply and develop specific MCA technology for streams and rivers.** Biota and macro-invertebrate sampling is done more like once every one to five years on a given stream because it is so labor intensive and time consuming. Correlation of water quality, biota and benthic macro and micro components of the ecosystems is primitive at best, and seldom attempted because not enough information is available, and the data and responsibilities fall within different state or federal agencies, or divisions. Although some of these represent formidable problems, today's technologies if applied to streams and rivers, can offer huge opportunities for more comprehensive information at greatly reduced cost and manpower requirements, and focus can be on data interpretation and ecosystem understanding.

So, what technology do we need developed and what kind of a government program would be needed to address the aforementioned problems? Consider first water quality monitoring. In order to monitor a stream or river to determine its health, as opposed to how bad or whether it can sustain life**, we need to measure at least 40 to 60 variables, which is technically and economically feasible and practical.** These variables need to be monitored in real time 24 hours a day for 11 or 12 months per year. The data should be transmitted hourly, or more frequently as changes in variables occur in real time, to multiple online databases via cellular or satellite systems. River stewards could then spend more time analyzing and interpreting the data than travelling country roads collecting samples and carrying them back to laboratories for analysis. Also, two-way data transmission between stewards in the field with laptop computers and online databases could be very beneficial for interactive analysis of numerous conditions in streams and rivers if appropriate diagnostic software that could use such data were available and installed on the laptops.

It is reasonably feasible today to have online data acquisition, data screening models, data reduction and conversion, data analysis, trend routines, calculated data from routines, diagnostic models, and calculated data from diagnostic models. Such capabilities have numerous other uses beyond assessment, including monitoring for illegal dumping, accidental spills, sabotage, or early warning of hazardous trends such as algal blooms. Watershed organizations also would have access to this technology to the degree they desire, and in many cases they could greatly leverage watershed monitoring.

The level of knowledge of fundamental science aspects of stream ecology needs to be elevated by obtaining data needed for user friendly, diagnostic, and simulation bioenergetic models. This includes data on the seasonal food chain, individual component science, data and models, and relationship data and models among ecosystem components. Methods of micro and macro habitat biometrics and characterizing to levels of abstraction suitable for database and functional representation need to be developed**. Use of various emerging biotechnologies, such as DNA, biometrics, and biosensors to explore the fundamental science aspects of stream ecology could be one excellent approach for Appalachia to enter the biotechnology market for scientific, educational, and research purposes.** As the technologically advanced nations of the world now enter **the biotechnology age,** which will likely change our world, perhaps more than any other single technology including computers, **Appalachia needs to look to this area for opportunities.** Many of the basic resources and pieces of the puzzle are already in place.

Major technology development is needed in the areas of water quality, biota and benthos diagnostic and assessment software, as well as, monitoring systems. This is where application of the above described technology can be instrumental in raising the basic science knowledge level to meet the technology needs and vise versa in an iterative fashion. Only through such an approach, can the roles of all components of stream ecosystems be **accurately understood and assessed**. Only then can we hope to achieve acceptable stream and total ecosystem assessment technology, **and only then will we begin to fully understand what our mitigation and regulatory practices are really accomplishing, and whether for example, our TMDLS are too high, too low, or adequate.** This is my technology perspective.

Now, what type of program structure can most effectively accomplish the above? I think it is very important to bring all of the key players to the table with equal seating at a round table. The general mission of the program would be: a) results-oriented, b) very specific goals & tasks, c) comprehensive data acquisition systems, d) quantitative stream health parameters, e) data required for diagnostic models, f) development of diagnostic models, g) diagnostic models to include bioenergetic ecosystem simulation type, h) 2-way data onsite communications, i) satellite based technology, and j) encourage this program to generate spin-off technology (like space & other programs) for education, environment, energy, and food supply**, and become part of the infrastructure for a biotechnology enhanced economy in Appalachia.**

I would select the team members to be:

a. 6 universities-competitively selected
b. 3 manufacturers-competitively selected
c. 5 federal agencies representatives
d. 12 regional state representatives
e. other univ. + mfg -- unsolicited proposals
f. non-profit manager (such as CVI who could also appropriately involve watershed organizations)

I would start with a budget & term of $20 million/yr for 5 years, with a distribution of:

	mil $/yr	total/yr
a. each univ. (6) --------------------	1.5	9
b. each state rep. (12) ---------------	0.25	3
c. each mfg. (3)-----------------------	1.0	3
d. other univ. & mfgr. proposals---	4.0	4
e. program manager -----------------	1.0	1
Total --------- -----------		20

Universities & manufacturers would receive annual competitive review for contract renewal and contract awards would also require some cost sharing. Such a high visibility and inclusive program involving the major players in stream and river ecology, environmental affairs, and technology, should have the greatest success and impact.

Now that you have heard my perspective, and I have given you some special concepts to think about during these two days, I am very excited to hear your perspectives and learn about the technologies you have, or are developing. At this time, I would like to introduce to you Tom Keech, who is serving as Session Chairman for our first session today. Tom is an electrical/electronic instrumentation engineer who came from WVU to the U.S. Dept of Energy in 1971. He had a brilliant career here at FETC, serving in many technical and managerial capacities including Deputy Director of the Power Systems Technology Division, and Director of the Fuels Resource Management Division when he retired last year. He is the Founder and President of Process Dynamics (PRODYN), located here in Morgantown.

APPALACHIAN RIVERS II

TECHNOLOGY FOR ECOLOGY OF STREAMS & RIVERS

Thank You

Jan Wachter

Kim Yavorsky

Lorraine Alvarez

Betty Robey

Pam Stanley

Carolyn Moore

Martin Dombrowski

ABOUT
APPALACHIAN RIVERS CONFERENCE

MOST OF YOU WERE PERSONALLY INVITED BECAUSE OF THE ROLE YOU PLAY IN WATERSHED AFFAIRS

THIS CONFERENCE IS ABOUT

BRINGING TOGETHER PEOPLE OF ALL DISCIPLINES, GOV'T AGENCIES, MANUFACTURERS, UNIVERSITIES, WATERSHEDS, PRIVATE GROUPS, & OTHERS, AS TEAM MEMBERS IN SAME ROOM, AT SAME TIME, TO HEAR SAME MESSAGES, FROM ALL PERSPECTIVES

ABOUT APPALACHIAN RIVERS CONFERENCE

IN ORDER TO:

- BRING YOU STATE OF THE ART TECHNOLOGY

- HELP GET THE TECHNOLOGY YOU NEED DEVELOPED

- DEVELOP A GREATER QUANTIFIABLE UNDERSTANDING
- OF STREAM AND RIVER ECOSYSTEMS

- HELP YOU GET THE DATA YOU NEED TO DO MORE
- COMPREHENSIVE ASSESSMENTS

- INFORM EVERYONE ON ADVANCED MITIGATION METHODS

- OBTAIN INPUT & DISCUSSION FROM EACH OF YOU

Streams
Rivers
Watersheds

A Technology Perspective

By L. Zane Shuck

HOW WE DELIVER HEALTH CARE TO HUMANS
(TECHNOLOGY ISSUES)
"HUMANS--THE SECOND MOST COMPLICATED SYSTEM ON EARTH"
(TECHNOLOGY ISSUES)
A BIOSYSTEM ENGINEER'S PERSPECTIVE

WE HAVE COMPREHENSIVE DIAGNOSTIC TOOLS FOR EACH COMPONENT

- **WE KNOW THE RELATIONSHIPS/DEPENDENCIES BETWEEN COMPONENTS**
- **WE CAN MODEL INDIVIDUAL COMPONENTS**
  - **NOT ONLY BLACK BOX, BUT, FROM INTERNAL CONSTRUCTION**
- **WE CAN SIMULATE INDIVIDUAL COMPONENTS**
- **WE CAN MODEL AND SIMULATE THESE COMPONENTS AS SYSTEMS**
- **<u>DEVELOPMENT</u> OF TOOLS AND TECHNOLOGIES IS <u>MARKET DRIVEN</u>**
  $$ INCENTIVES TO MFGR'S, RESEARCHERS, PROVIDERS, HOSPITALS, DOCTORS ---THE ENTIRE CHAIN
- **EXTENSIVE GOVERNMENT R & D PROGRAMS FOR MEDICAL <u>TECHNOLOGY DEVELOPMENT</u>**
- **SPACE PROGRAM SPINOFFS - - QUICKLY APPLIED?**

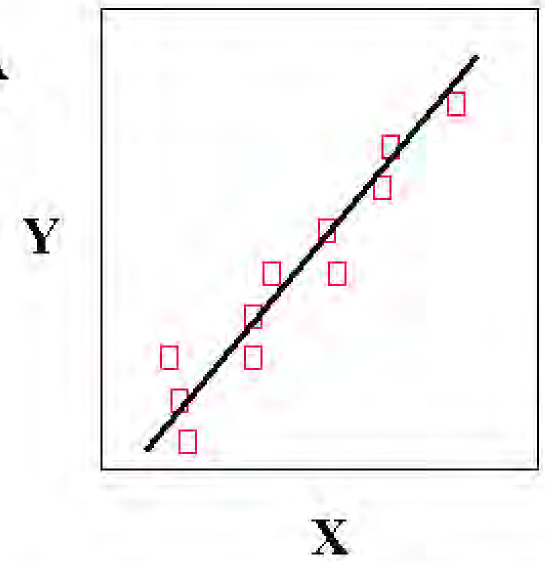
MODELS

TYPES

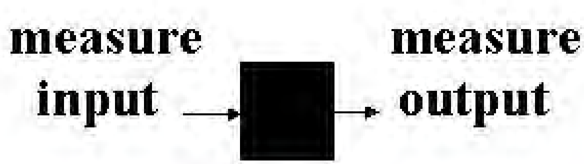
I. CURVE FIT TO DATA

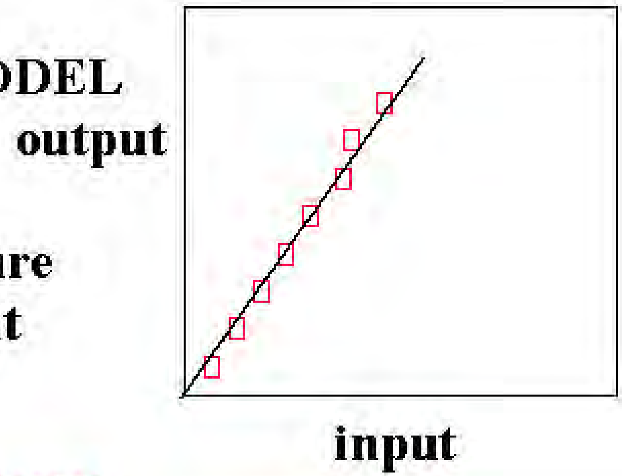
REQUIRES NO KNOWLEDGE OF SYSTEM

(not really a model)



II. BLACK BOX MODEL



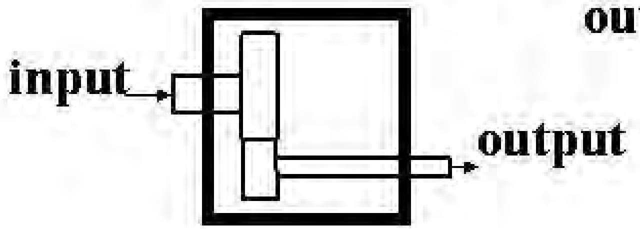


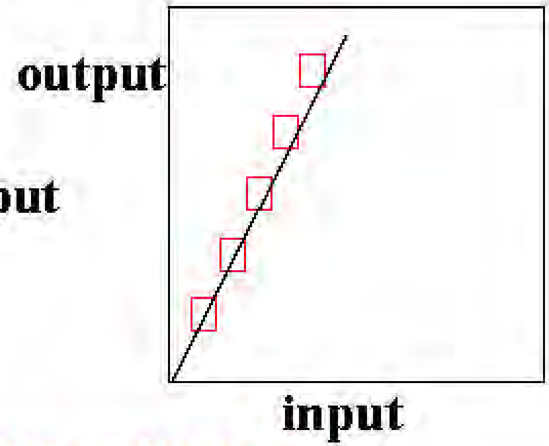
REQUIRES NO KNOWLEDGE OF INTERNAL COMPONENTS - LIMITED USE

MODELS

TYPES

III. INTERNAL - INTRINSIC BASED





FROM KNOWLEDGE OF INSIDE COMPONENTS , ONE CAN:

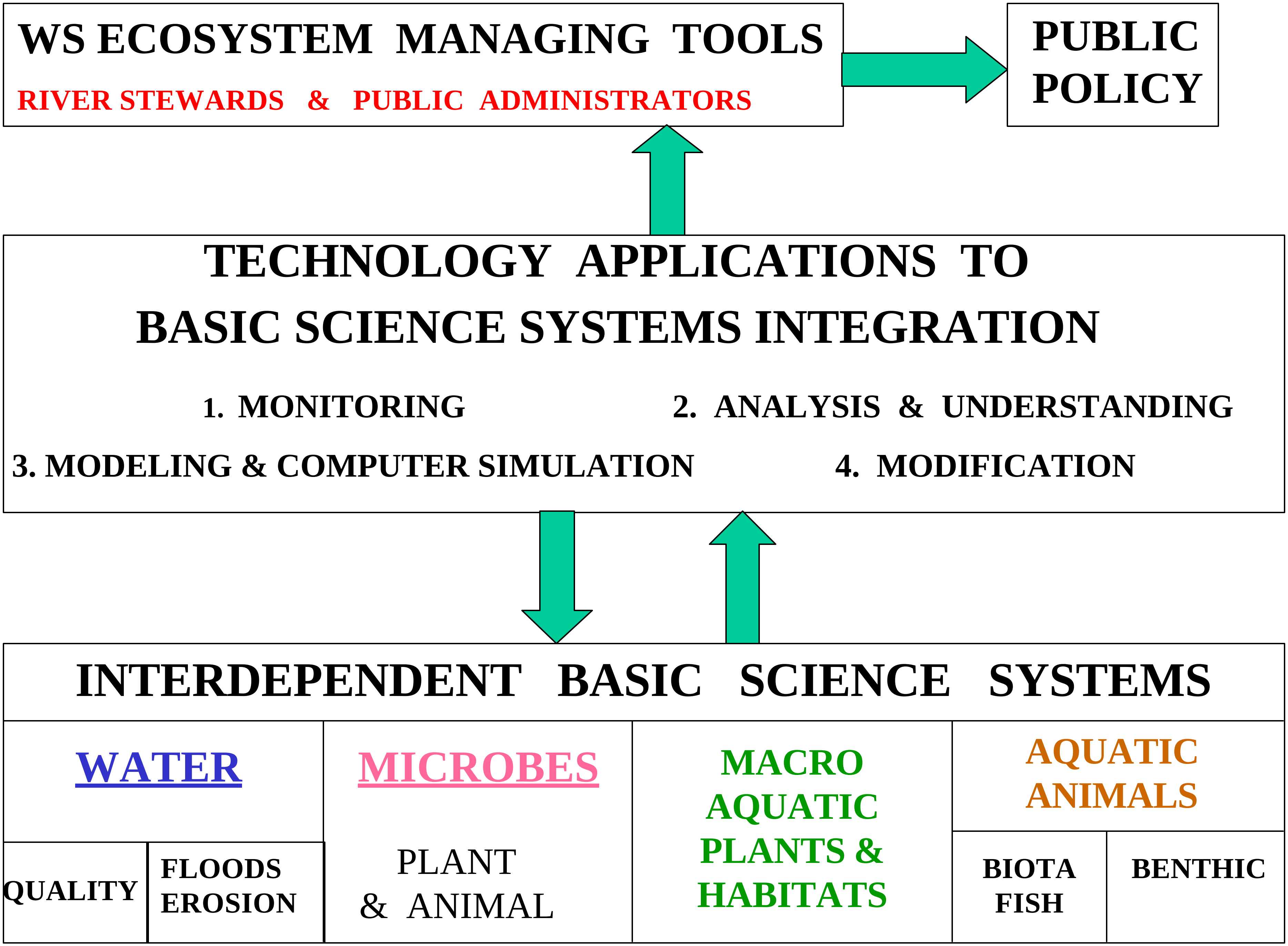
A. <u>CALCULATE APRIORI</u> FOR A GIVEN INPUT WHAT THE OUTPUT WILL BE

B. CALIBRATE BY EXPERIMENT

C. USE MODEL TO SIMULATE & DESIGN

□ MOST DESIRABLE SCIENTIFIC APPROACH

□ Models can simulate Static, Quasi-static, Dynamic, Steady-state, or Transient time varying systems


WS ECOSYSTEM MANAGING TOOLS
RIVER STEWARDS & PUBLIC ADMINISTRATORS
PUBLIC POLICY
TECHNOLOGY APPLICATIONS TO
BASIC SCIENCE SYSTEMS INTEGRATION
1. MONITORING
2. ANALYSIS & UNDERSTANDING
3. MODELING & COMPUTER SIMULATION
4. MODIFICATION
INTERDEPENDENT BASIC SCIENCE SYSTEMS
WATER
QUALITY
FLOODS EROSION
MICROBES
PLANT & ANIMAL
MACRO AQUATIC PLANTS & HABITATS
AQUATIC ANIMALS
BIOTA FISH
BENTHIC

STREAM ECOSYSTEM

MAJOR COMPONENTS

WATER

BIOTA MACRO

BIOTA MICROBES

BENTHIC

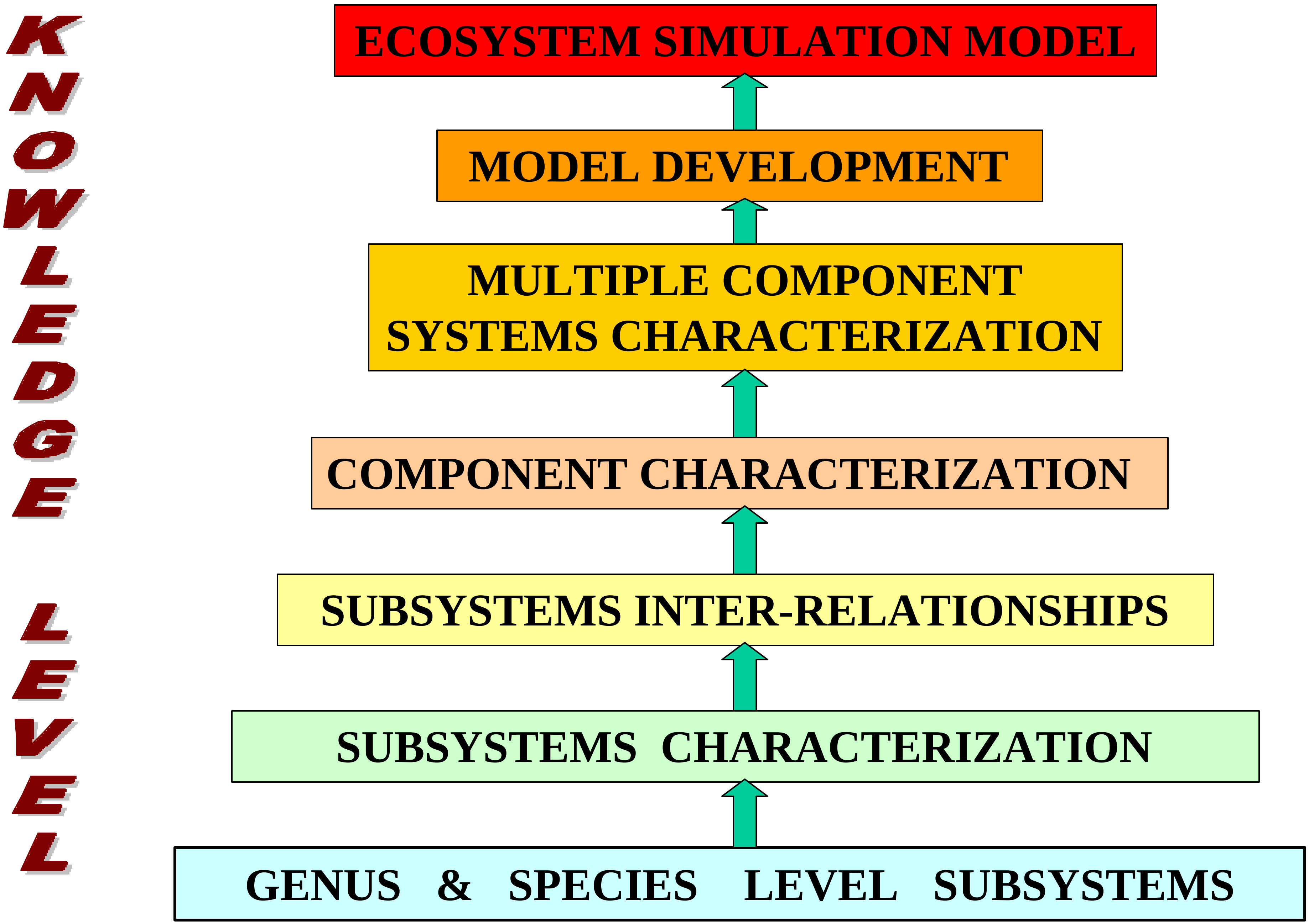
BENTHOS MACRO

BENTHOS MICROBES

WATER HABITAT

BENTHIC HABITAT

TERRESTRIAL HABIT.

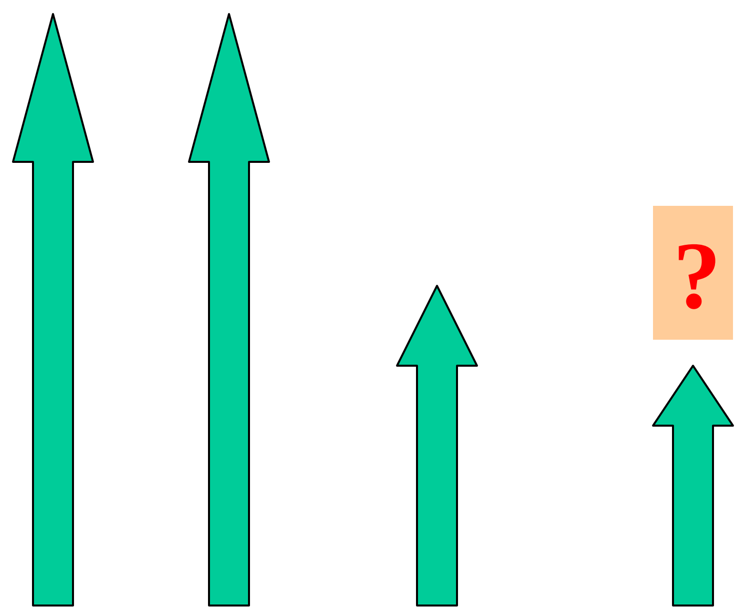

KNOWLEDGE LEVEL
ECOSYSTEM SIMULATION MODEL
MODEL DEVELOPMENT
MULTIPLE COMPONENT SYSTEMS CHARACTERIZATION
COMPONENT CHARACTERIZATION
SUBSYSTEMS INTER-RELATIONSHIPS
SUBSYSTEMS CHARACTERIZATION
GENUS & SPECIES LEVEL SUBSYSTEMS

MICROBIAL COMPONENTS

SOIL WATER MARINE STREAMS

KNOWLEDGE LEVEL

- DESIGN, MITIGATION
- SIMULATION
- COMPLEX MODELS
- SIMPLE MODELS
- INTERACTIONS
- KINETICS
- BIOCHEMISTRY, ETC.
- CHARACTERIZATION
- ISOLATION
- DESCRIPTION



MY TECHNOLOGY PERSPECTIVE

I. DEVELOPMENT OF MONITORING, CHARACTERIZATION, AND ASSESSMENT (MCA) TECHNOLOGY FOR STREAMS & RIVERS

APPALACHIAN STREAMS & RIVERS HAVE UNIQUE (MCA) TECHNOLOGY REQUIREMENTS

WATERSHED STEWARDS FROM 100'S OF GOVERNMENT AGENCIES & DIVISIONS ARE OVERBURDENED IN LABOR INTENSIVE JOBS OF DEALING WITH WATERSHED PROBLEMS OF MONITORING, MITIGATION, AND ADMINISTRATION WITH LITTLE TIME SPECIFICALLY FOR MCA TECHNOLOGY DEVELOPMENT

AGENCIES WITH WATERSHED RELATED MISSIONS & RESPONSIBILITIES HAVE BUDGET PRESSURES THAT PROHIBIT EXPENDITURES FOR SPECIFIC MCA TECHNOLOGY DEVELOPMENT PROJECTS - - - (BUDGETS DO EXIST FOR MITIGATION TECHNOLOGY DEVELOPMENT)

MY TECHNOLOGY PERSPECTIVE

NO FEDERAL OR STATE PROGRAMS OR BUDGETS EXIST SPECIFICALLY FOR STREAM & RIVER HIGH TECHNOLOGY MCA DEVELOPMENT - - - TMDLS ALONE NEED IT- - -

MOST STREAM & RIVER TECHNOLOGY IS "HAND-ME-DOWN" FROM OTHER APPLICATIONS OF OCEAN, MARINE, LAKES, SPACE, AND OTHER ENVIRONMENTAL APPS.

CUSTOMERS FOR STREAM & RIVER ONITORING, CHARACTERIZATION, & ASSESSMENT (MCA) TECHNOLOGY ARE STATE & FEDERAL GOVERNMENT AGENCIES

MY TECHNOLOGY PERSPECTIVE

MUCH OF STREAM & RIVER <u>MCA</u> IS CURRENTLY DEVELOPED IN UNIVERSITIES WITH VERY SMALL BUDGETS

THE CANAAN VALLEY INSTITUTE IS PERHAPS, THE MAJOR PRIVATE GROUP ACTIVELY PURSUING MCA TECHNOLOGY DEVELOPMENT OTHER THAN MANUFACTURERS

NOT MUCH SUPPORT FOR SCIENCE PROJECTS FOR RIVER ECOSYSTEM CHARACTERIZATION, BECAUSE IT IS VIEWED MORE AS BASIC SCIENCE & RESEARCH, WHICH IS NOT THAT POPULAR TODAY

SPECIFIC STREAM & RIVER MCA TECHNOLOGY DEVELOPMENT IS NOT MARKET DRIVEN, BECAUSE OF SMALL MARKET.

CONCLUSION

THE ABOVE REASONS ARE JUSTIFICATION FOR A SPECIFIC GOVERNMENT (MCA) TECHNOLOGY DEVELOPMENT PROGRAM

THE PROPOSED GOVERNMENT PROGRAM
I. NEEDED TECHNOLOGIES

A. WATER QUALITY MONITORING

- 7 TO 10 VARIABLES CAN TELL HOW BAD, NOT HOW GOOD. MONITOR FOR STREAM HEALTH, NOT JUST STREAM POLLUTION

- REAL TIME, 24 HR, 11 TO 12 MONTHS/YR

- DATA AUTOMATIC TRANSMIT TO MULTIPLE DATABASES VIA CELLULAR OR SAT. TELE. OR
SATELLITE DISH ANTENNA SYSTEMS

- REDUCE CARRYING SAMPLES BACK TO LAB

- MONITOR 40 TO 60 VARIABLES/PARAMETERS REAL TIME

THE PROPOSED GOVERNMENT PROGRAM
I. NEEDED TECHNOLOGIES

B. DATA TRANSMISSION, STORAGE, DISSEMINATION

TWO-WAY DATA TRANSMISSION TO MULTIPLE ON LINE DATABASES ON INTERNET, VIA

1. **CELLULAR TELEPHONE, OR**
2. **SATELLITE TELEPHONE, OR**
3. **SMALL SATELLITE DISH**

   WITH DAILY OFF-LINE ARCHIVE COPIES

LAPTOP COMPUTER & SOFTWARE TO /FROM DATABASES BY STEWARDS IN THE FIELD

GOVERNMENT, & WATERSHED ORGANIZATIONS STEWARDS OR PUBLIC MONITOR DATA IN REAL TIME VIA INTERNET FOR ANY ON-LINE STREAM

INTERNET ON LINE SUMMARY OF APPALACHIAN STREAM RESEARCH, MONITORING, CHARACTERIZATION & MITIGATION PROJECTS

THE PROPOSED GOVERNMENT PROGRAM
I. NEEDED TECHNOLOGIES

ON LINE

- DATA ACQUISITION, SCREENING MODELS
- DATA REDUCTION/CONVERSION
- DATA ANALYSIS, TREND ROUTINES
- DIAGNOSTIC MODELS (READ ONLY)
- CALCULATED DATA FROM ROUTINES
- CALCULATED DATA FROM DIAG. MODELS
- BIOENERGETIC DIAGNOSTIC MODELS

THESE CAPABILITIES ALSO HAVE OTHER MERITS

- INDUSTRIAL ACCIDENTS, SPILLS, & DUMPING
- EARLY DETECTION, WARNING & NEIGHBORHOOD WATCH (MONITORED BY WATERSHED ORGANIZATIONS JUST LIKE AMATURE RADIO)

THE PROPOSED GOVERNMENT PROGRAM
I. NEEDED TECHNOLOGIES

D. STREAM ECOLOGY

- **DATA NEEDED FOR BIOENERGETIC MODELS**
  - **DIAGNOSTIC --USER FRIENDLY**
  - **SIMULATION & QUERY**
- **DATA ON SEASONAL FOOD CHAIN**
- **RELATIONSHIP DATA AMONG ECO COMPONENTS FOR SPECIFIC STUDIES & BIOENERGETIC MODELS**
  - **WATER**
  - **BIOTA**
  - **BENTHOS**
  - **BIOTA MICROBES**
  - **BENTHIC MICROBES**
  - **BENTHIC HABITAT**
  - **BIOTA HABITAT**
  - **TERRESTIAL HABITAT**
- **STREAM LATERAL & TRANSVERSE SECTION DATA**
- **ON LINE VIDEO DATABASE OF MAJOR SPECIES AND STREAM REPRESENTATIVE REACHES VIDEO**

THE PROPOSED GOVERNMENT PROGRAM
I. NEEDED TECHNOLOGIES

E. AUTOMATED SAMPLING, MONITORING & DOCUMENTTION TECHNOLOGY FOR BENTHIC, WATER QUALITY, BIOTA & TERRESTRIAL

REMOTE SENSING
MICROBES
VIDEO USE & VIDEO DATABASE
SPECTRA (EMISSION, ABSORPTION, REFLECTION)
FLUORESCENCE
FIBER OPTIC SPECTROMETER APPLICATONS
SPECTROPHOTOMETERS

BIOTECHNOLOGY-- WE ARE NOW ENTERING THE BIOTECHNOLOGY AGE. HERE IS AN EARLY OPPORTUNITY FOR APPALACHIA

BIOSENSORS

THE PROPOSED GOVERNMENT PROGRAM
II. MANAGEMENT & ORGANIZATION

I. MISSION

A. RESULTS ORIENTED

B. VERY SPECIFIC GOALS & TASKS

C. COMPREHENSIVE DATA AQU. SYS. + DATA

D. QUANTITATIVE HEALTH PARAMETERS

E. DATA REQUIRED FOR DIAGNOSTIC MODELS

F. DEVELOPMENT OF DIAGNOSTIC MODELS

G. DIAGNOSTIC MODELS TO INCLUDE BIOENERGETIC ECOSYSTEM SIMULATION TYPE

H. 2 WAY DATA ON SITE COMMUNICATION

I. SATELLITE BASED TECHNOLOGY

J. LET THIS PROGRAM GENERATE SPINOFF TECHNOLOGY (LIKE SPACE & OTHER PROGRAMS) FOR EDUCATION & ENVIRONMENT

THE PROPOSED GOVERNMENT PROGRAM

II. MANAGEMENT & ORGANIZATION

II. TEAM MEMBERS

A. 6 UNIVERSITIES-COMPETITITIVELY SELECTED

B. 3 MANUFACTURERS-COMPETITITIVELY SELECTED

C. 5 FEDERAL AGENCIES REPRESENTATIVES

D. 12 REGIONAL STATE REPRESENTIVES

E. OTHER UNIV. + MFG -- PROPOSAL SUBMISSION

F. NON-PROFIT MANAGER (SUCH AS, CVI)
(INVOLVE WATERSHED ORG. ET.AL.)

THE PROPOSED GOVERNMENT PROGRAM
II. MANAGEMENT & ORGANIZATION

III. BUDGET & TERM: $20 MILLION/YR, FOR 5 YEARS

	MIL $/YR	TOTAL/YR
A. EACH UNIV (6) ---------------------	1.5	9
B. EACH STATE REP (12) -----------	0.25	3
C. EACH MFG (3)----------------------	1.0	3
D. UNIV, MFGRS, PROPOSALS ----	4.0	4
E. PROGRAM MANAGER -----------	1.0	1
TOTAL ---------------------		20

* UNIVERSITY & MANUFACTURER COMPETITIVE REVIEW EACH YR FOR CONTRACT RENEWAL

* CONTRACT MUST INCLUDE COST SHARING

SUMMARY

- Need a special government program for MCA development.
- All players need to be at the table.
- We need the MCA advanced technology available to all government, universities, and public in general.
- Here is a plan, free for you to implement.

United States Environmental Protection Agency
The Modernized STORET
"Ambient Water Quality and Biological Data and Information System"

Robert King, STORET Manager
US EPA 513 South 24th St., Arlington, VA 22202

Abstract

To meet the data and information needs of Place-Based/Community Focused Ecosystem Protection, the EPA's Office of Water has re-engineered its primary ambient water quality and biological monitoring data systems (STORET, BIOS, and ODES) into a client server architecture featuring local ownership and control as well as a national data warehouse accessible via the Internet.

System Design:

The new STORET is a substantial improvement over the legacy systems. In addition to the ability to store water, sediment, and tissue chemistry data, the new system provides the ability to store biological community and habitat assessment information. The new system also provides for the storage of metadata (descriptive data about data) ensuring that all future STORET data are of documented quality thus allowing the sharing of data with greater confidence.

The new STORET is designed as a client server data base with an option to function as a stand-alone system. Client workstations will execute STORET under the Windows 95/98/NT environment while connected to the ORACLE relational data base server running on any of its supported platforms. The STORET stand-alone system requires the Windows 95/98/NT operating system together with the Personal ORACLE relational data base product.

Nationally, copies of STORET data will be assembled in an EPA-maintained data warehouse and made available in read only form to the public through the Internet.

Internet access will include map based query with zoom and pan functionality. Data may be downloaded either in pre-formatted reports or delimited ASCII files. Full capability is expected by spring 2000.

Schedule:

STORET Production v1.1 was released in March 1999.

For additional information contact STORET User Support at (800) 424-9067 or STORET@epa.gov.

Appalachian Rivers II

July 28, 1999

Modernization

National Water Program

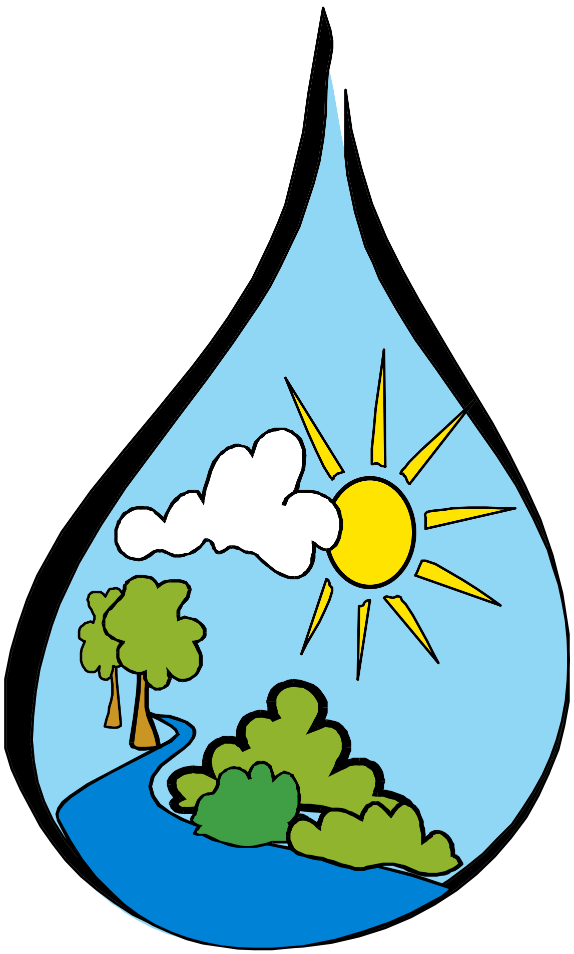
New Program Focus

- Watershed-Based
- Environmental Results Reporting
- Citizen Involvement

New Technology

- National Data Warehouse
- Public Access-Internet

STORET



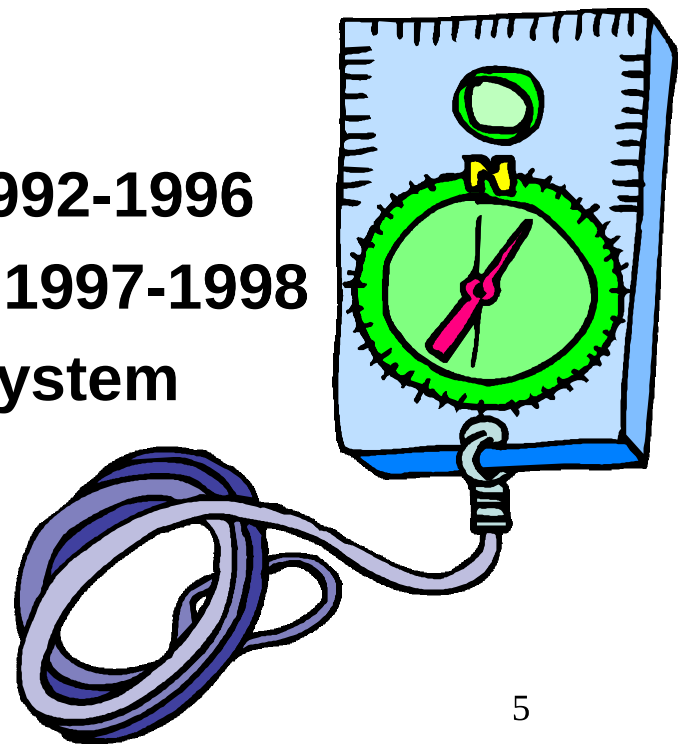
Ambient
Water Quality
and Biological
Data

Clients

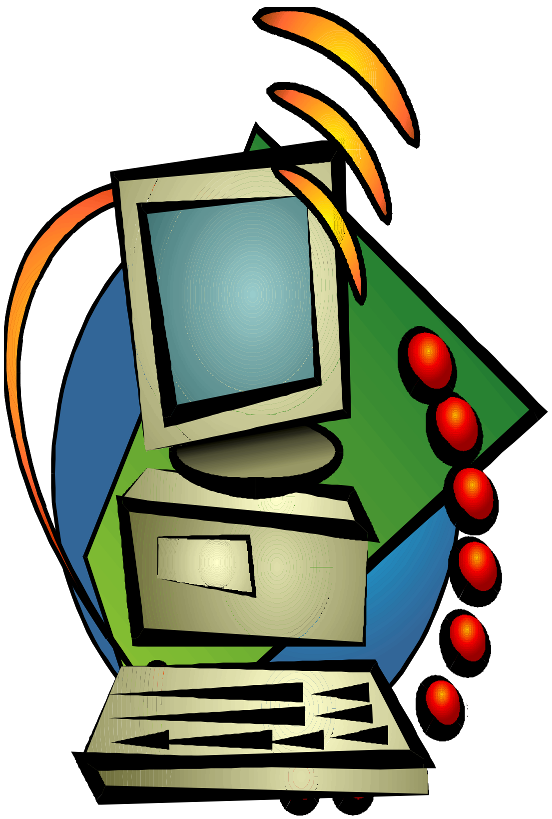
- Citizen Volunteers
- Watershed Managers
- State Environmental & Health Organizations
- Other Federal Agencies, USGS etc.

Customer Built - Customer Owned

- Requirements Gathering 1991-92
  - Links to GIS
  - Data of Documented Quality
- User Validation of Requirements
  - Four National Conferences, 1992-1996
- Prototype Testing by 200 Users, 1997-1998
  - Feedback Incorporated into System



STORET v1.1



Features

– Data of Documented Quality

– Graphical User Interface

– Data Standards for Data Sharing

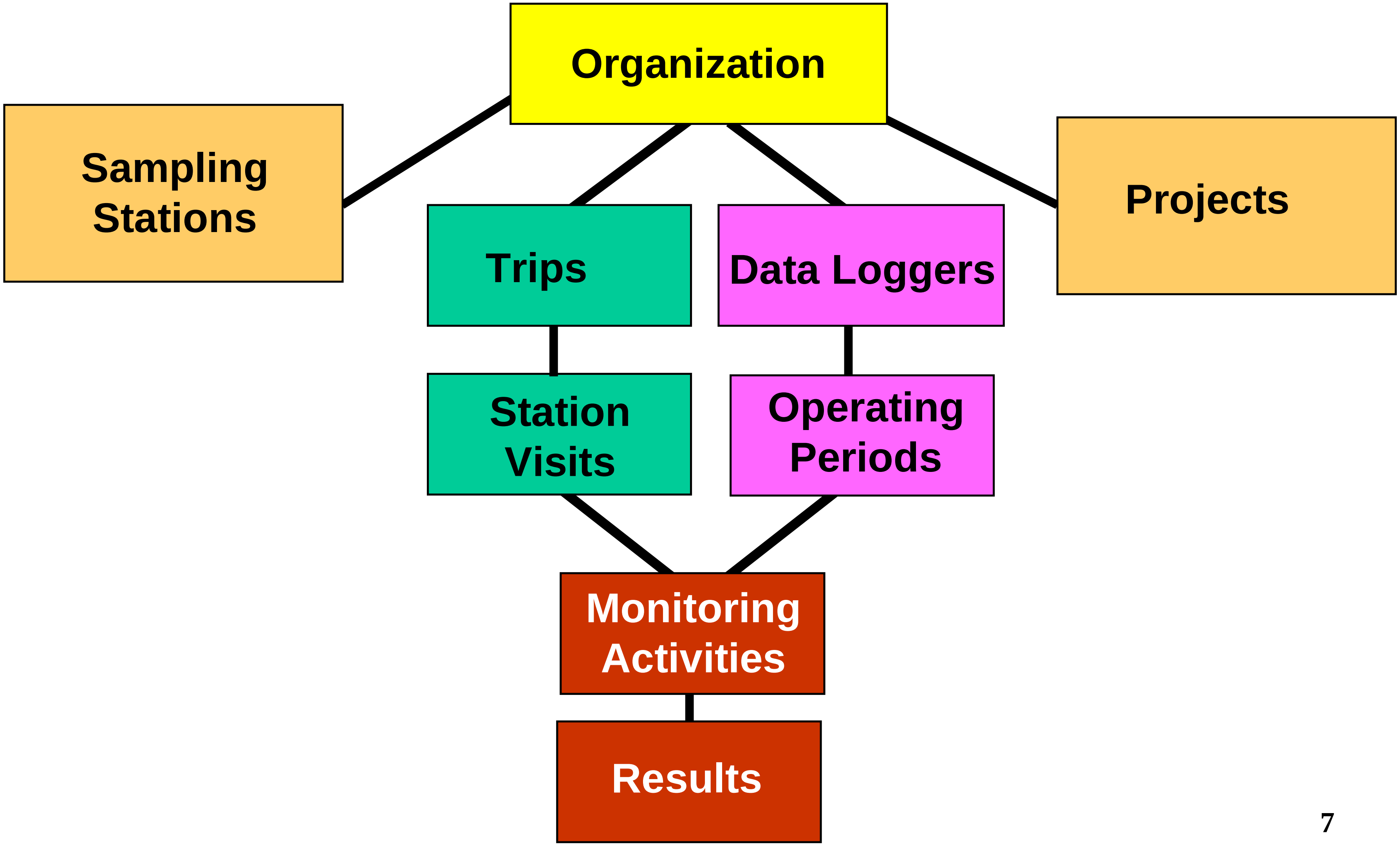
Implementation

– Scaleable - Watershed to National

  • Locally Owned and Operated

  • EPA Maintained

STORET
Mirrors the Business of Monitoring



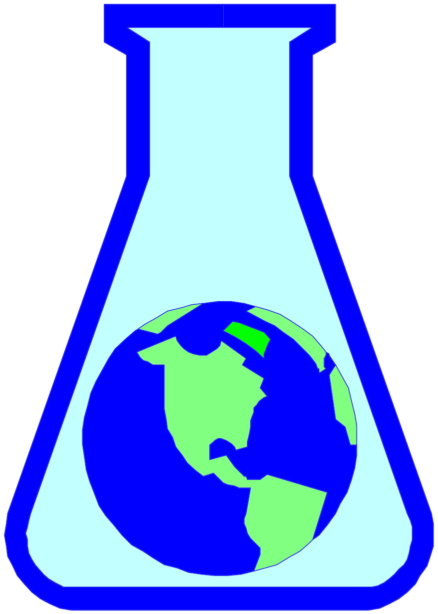
Monitoring Activities

Samples

- Routine
- Field Replicate
- Depletion Replicate
- Created from Sample
  - Composite- with Parents
  - Sample from Sample
- Composite- W/O Parents
- Integrated Time Series
- Integrated Flow Proportioned
- Integrated Horizontal Profile
- Integrated Vertical Profile

Field Measurement/Observations

- Replicate Measurement
- Habitat Evaluation
- Observation
- Measurement



Sampling Profiles

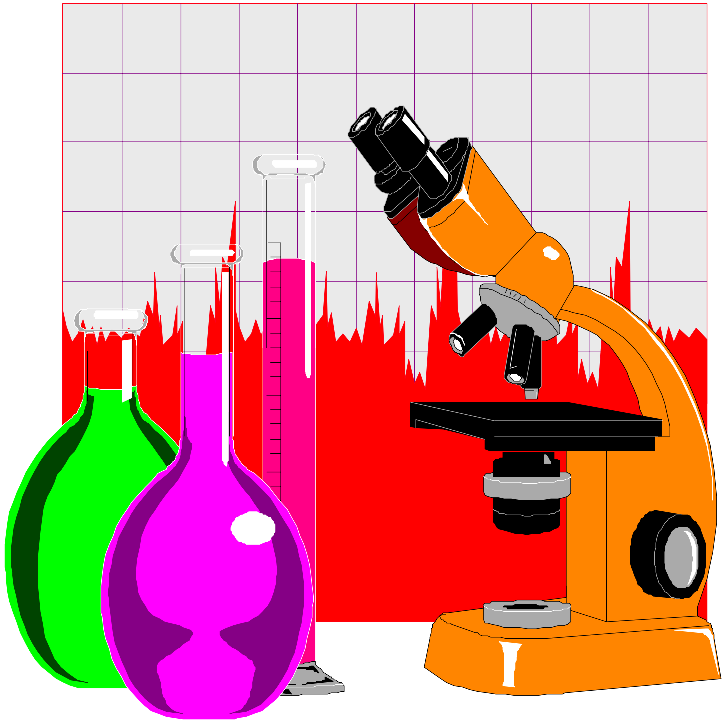
Sample Medium

- Air
- Bottom Sediment
- Soil
- Water
- Biological
  - Individual
    - Subject Taxa
  - Tissue
    - Subject Taxa
    - Bio- Part
  - Species Abundance
    - Aquatic Vegetation
    - Terrestrial Plants
    - Benthic Macroinverts
    - Birds
    - Reptiles
    - Amphibians
    - Bacteria/Viral
    - Phytoplankton/Zooplankton
    - Fish/Nekton

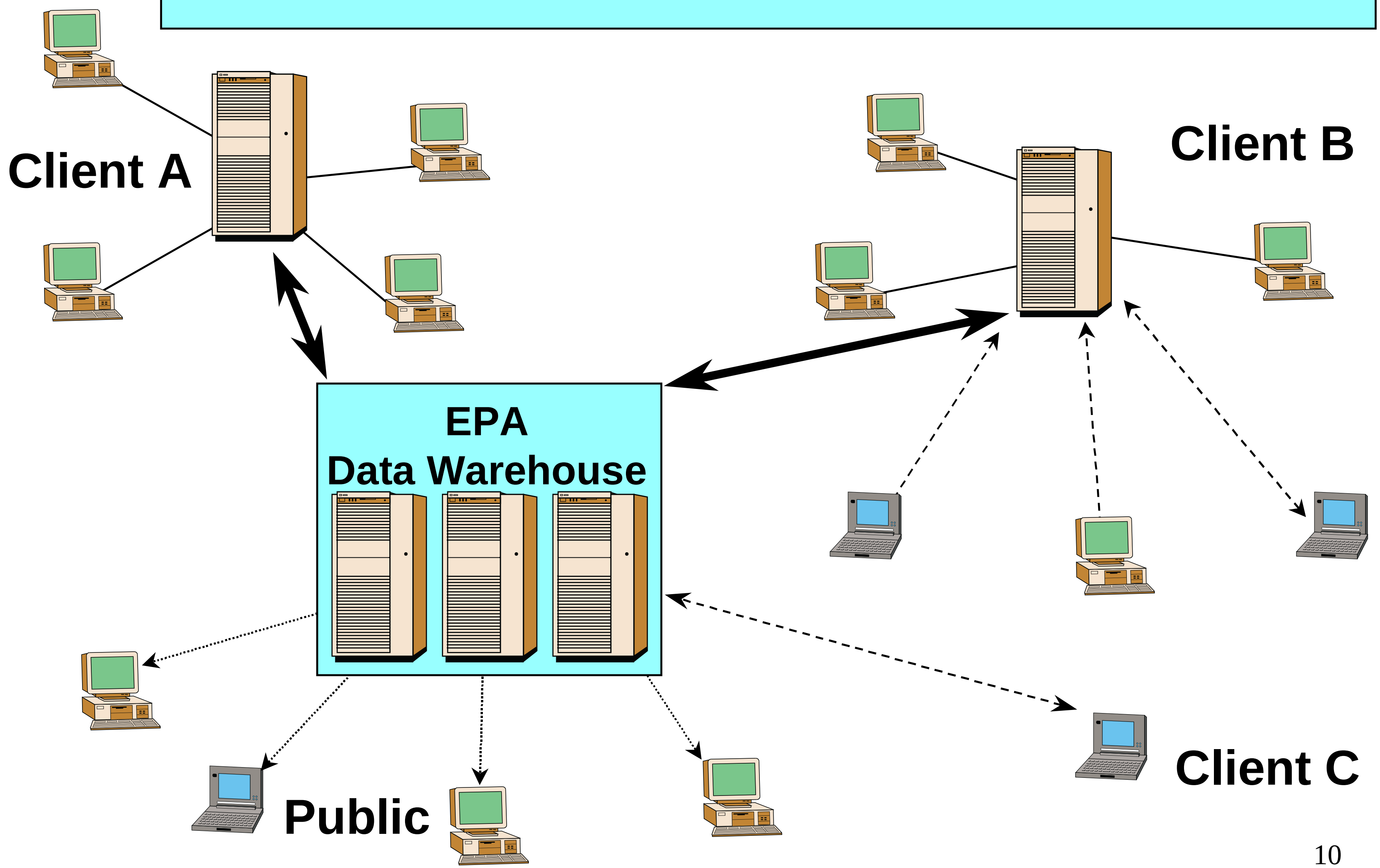
Medium

Intent

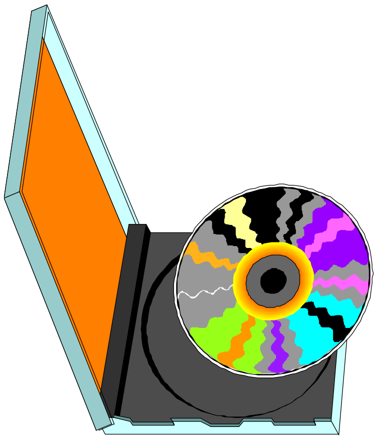
Community



National Architecture



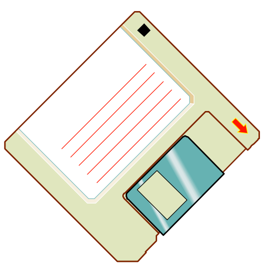
STORET v1.1 Package



STORET v1.1 CD-ROM

- Installation for complete Stand-alone
- Installation for Client
- Installation for Server
- Installation for Reports

Activation Disk



- Installation of your unique Organization code(s) into the data base.

STORET v1.1 Reguirements

- **Stand-alone Installation**
  - STORET v1.1 Package
  - Personal ORACLE 7.3.3/7.3.4
- **Client Server Installation**
  - STORET v1.1 Package
  - Server ORACLE 7.x and up

Models as Tools In Assessing River Biota

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Models represent a cost-effective means of assessing the biota in aquatic systems. A number of different types of models may be suitable as assessment tools in Appalachian rivers. Among these models are, bioenergetics models, ecosystem models, indices of biotic integrity, regression models (e.g. of EMAP data sets), habitat suitability models, and spatial models.

Bioenergetics models have been widely used in aquatic studies in the last 15 years and have accounted for well over 100 publications in peer-reviewed journals during that time. Bioenergetics models are most often used to assess the way changes in habitat such as temperature, dissolved oxygen levels, or contaminants may be expressed in terms of fish production or body burden. Usually bioenergetics models are used with single species, but recently some linking of multiple species models has been completed and community bioenergetics models for rivers should be attainable.

Ecosystem models represent the opposite end of the complexity spectrum from bioenergetics models. Ecosystem models are "data hungry" and represent a compromise between reality/complexity and simplifying assumptions that detract from the realism of the models. Ecosystem models are well developed in areas like the Great Lakes and Chesapeake Bay where such models have been used to assess "what if" questions regarding nutrient reduction impacts upon fish production and water quality, or contaminant cycling and zebra mussel effects.

Indices of biotic integrity represent assessment tools designed for small to medium streams. By combining metrics of abundance and diversity of sensitive taxa relative to tolerant taxa an index of the relative health of a stream is produced. Because certain species are more or less tolerant, the indices can be sensitive indicators of ecosystem health. Although they may not point out the source of the problem they do detect the effects at the community level and point out areas where further investigation is needed. The major obstacle to use of these indices in Appalachian rivers is the lack of research on the community taxa diversity and abundance of large rivers from which to develop and test indices for these systems.

Regression models represent analysis of data on habitat variables and taxa abundance and diversity. Effectively these types of models represent statistical analysis of the data used in indices of biotic integrity. By measuring habitat parameters such as water temperature, dissolved oxygen, conductivity, chl-a, etc. and testing whether any of these variables are significantly related to community indices. These types of models have the advantage of pointing fingers at possible causal factors in affecting low diversity, but still stop short of cause and effect.

Habitat suitability models have been widely used in assessing habitat quality for various species of fish and animals. Mostly these measurements are used in trading habitat units for mitigation purposes. HIS models do relate back to habitat quality by evaluation of relevant parameters relative to the theoretical ideal for that parameter. The resulting HSI index is the product of habitat ratings for key parameters such as breeding habitat, rearing habitat, feeding habitat, etc. The index is a value between 0 and 1 with 1 being highest quality habitat for that species. A drawback is that what is good habitat for one species may be poor for another (e.g. johnny darters vs. flathead catfish). Thus, a combined, community-based habitat suitability model may be better. To date, no efforts have been made to link these models in a community framework. However, much of the information needed to do so is available in the literature.

Spatial models are a group of models that contain a spatial component. Most of the models previously mentioned treat the river as a single homogenous unit without any spatial heterogeneity. Spatial models include everything from GIS applications of IBI or bioenergetics models to spatial ecosystem models.

There are a number of reasons we should consider using models in assessing river biota. First, fishing and tourism represent the #2 industry in the state of West Virginia. Increasing human populations and the proximity to large population centers such as Washington, D.C. will continue to put increasing demands on limited natural resources. Additional fishing demands and increasing demand for water for recreation and industrial uses will place additional pressure on aquatic biota. Models are cost-effective and can be used to assess what-if questions while pointing out areas where biota are impacted or possible problem areas. Further, models can help us to determine “what the ecosystem can stand” which may be an aspect particularly important to planning and management goals and limitations.

A variety of models could be adapted to Appalachian Rivers – we have many of the pieces, but need more info and more specific studies. These models should be pursued as possible assessment tools for a number of reasons. In addition to being cost-effective, models represent a form of technology transfer bringing together a variety of disciplines (limnologists, hydrologists, ecologists, toxicologists, and engineers). The particular type of model to be used in assessing river biota will ultimately depend upon the questions to be asked. However, many of these models have already been developed in other systems and need only to be adapted to Appalachian rivers to be a useful assessment tool.

An Overview of WCMS: (The Watershed Characterization and Modeling System developed by the Natural Resource Analysis Center at West Virginia University)

Jeff Simcoe (jsimcoe@wvu.edu; 304-296-9041 ext. 4466)
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Morgantown, WV 26507

Abstract

The WCMS was developed to bring spatial data and water quality modeling to the desktop of West Virginia Division of Environmental Protection (WVDEP) personnel. The WCMS is a customized Arc View GIS interface that combines a wide variety of spatial data layers and water quality modeling components for meeting common WVDEP tasks.

The WCMS offers many useful components in an easy to use format. These components consist of an interactive definition of study area, capabilities of querying the 1998 303-D list, non-point source pollution tools, a watershed ranking model, water quality modeling, and Acid Mine Drainage treatment cost modeling. In addition the WCMS offers over twenty five different statewide data layers.

The goal of this presentation is to provide a brief overview as to what WCMS has to offer those concerned with the quality of our watersheds. Some major points that will be discussed include the goals of the system, its major components, data layers included, and a demo. Attached you will find a brief description of the project background, the customized interface, and the modeling components.

Watershed Characterization and Modeling System

Project Background

The WCMS was developed to bring spatial data and water quality modeling to the desktop of West Virginia Division of Environmental Protection (WVDEP) personnel. The WCMS is a customized ArcView GIS interface that combines a wide variety of spatial data layers and water quality modeling components for meeting common WVDEP tasks.

Customized Interface

Interactive definition of study area – users may select a study area from a menu listing of features or a map display of features based on counties, watersheds, stream codes and names, topographic quads, or abandoned mine land problem areas; all available spatial data for the study area extent is displayed

Query 1998 303D list – search list by water quality parameter(s) violated, use affected, reporting agency, priority level; view results of query in map display

Customized tools – automatic map creation, track steepest path across landscape, delineate watersheds by a specified pour point and report drainage area, coordinate finder and utm location converter, elevation and contour query, advanced distance and area measurement, stream flow estimation and query

Modeling Components

Watershed ranking model – interactive multiple criteria watershed ranking, view results as map display with the ability to change criteria weights and rerun model to test the spatial sensitivity of preference on ranking results to prioritize AMD affected watersheds for treatment

Identify potentially affected streams – found by tracking the overland flow from possible pollution sources during a precipitation event; the results help to efficiently identify water quality sampling stations

Water quality modeling – user inputs water quality sampling points or uses event mean concentrations for land cover types, WCMS models estimated concentrations and loadings of pollutants in affected streams

Acid mine drainage treatment cost modeling – Given modeled flow and acidity level, user selects one of eight chemical treatment options and WCMS calculates AMD treatment costs and chemical requirements

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RIVER CONTINUUM CONCEPT AS AN ANALYTICAL TEMPLATE FOR ASSESSING WATERSHED HEALTH

Ben M. Stout III
Department of Biology
Wheeling Jesuit University
Wheeling, WV 26003

Understanding the theoretical framework of a river as an ecological continuum provides a fundamental base for measuring ecosystem dynamics and for providing watershed management strategies. We used the River Continuum Concept as an analytical template for conducting assessments in an urban-agricultural system. Our goals were to identify streams in need of restoration, and most importantly, to identify water quality endpoints that are representative of relatively undisturbed conditions. We used Geographic Information Systems and statistical analysis to explore physical, chemical, and biological attributes of 110 sites throughout the sixth-order Wheeling Creek watershed, WV, USA. From headwaters to mouth, many of the changes in macroinvertebrate community function were in agreement with the predictions of the River Continuum Concept. For instance, leaf shredders comprised an average of 30% of macroinvertebrate abundance in first-order streams, and declined predictably with means of 12, 5, 2, and 0.5% in second through fifth-order streams. However, shredder abundance in second-order streams ranged from 5 to 80% of the communities, with extreme measures representing agricultural versus forested landscapes. Plotting functional group compositions against continuous geomorphological variables provided models of expected community function while accounting for natural changes in the biological community due to changes in geomorphology. Physical and chemical attributes of streams that exceed functional group endpoints provided water quality targets for restoration, whereas streams that failed to meet expectations were targeted for restoration.

FIBI, BIBI and PHI: An Acronymic Assault to Assess Aquatic Assemblages

Dr. Raymond P. Morgan II
University of Maryland Center for Environmental Studies
Appalachian Laboratory
301 Braddock Road
Frostburg, MD 21532-2307

Abstract

Over the last quarter century, fish communities have been extensively employed to assess freshwater ecosystem health. Significant advances in this arena have led to development of integrative ecological indices, such as Indices of Biotic Integrity (IBI), that relate fish communities to both biotic and abiotic ecosystem components. In addition to the development of fish IBIs, recent work has also led to development of benthic and physical habitat IBIs to supplement fish IBIs. In Maryland, there has been extensive development of these indices through the Maryland Biological Stream Survey (MBSS), a state program that started in the early 90s.

The MBSS Sampling Program was designed to provide comprehensive information on the status of biological resources in Maryland streams, and how these resources are affected by acidic deposition and/or other cumulative effects of anthropogenic stressors. For many years, the Maryland Department of Natural Resources (MDNR) recognized that atmospheric deposition, resulting from electric power generation, was one of the most significant environmental problems affecting not only Maryland, but also the entire Chesapeake Bay watershed. The link between surface water acidification and acidic deposition was well established and many studies pointed to adverse biological effects of low pH and acid neutralizing capacity.

To determine the extent of Maryland stream acidification, MDNR conducted the Maryland Synoptic Stream Chemistry Survey (MSSCS) in 1987 – a survey designed to estimate the number and extent of streams affected statewide by acidification. This program was instrumental in determining that the greatest concentrations of fishery resources at risk were found in the Appalachian Plateau and Coastal Plain sampling strata. These regions of Maryland have geological formations with low buffering capacities. The MSSCS demonstrated the potential for adverse acidification effects on biota but there was little information relating biological responses of Maryland streams to overall water chemistry conditions. Although there were many studies completed on biological resources in Maryland, these data sets were not useful to compare biological differences across regions or watersheds, and could not be tied into data developed through the MSSCS. To develop a comprehensive approach for resource assessment in Maryland, MDNR initiated the MBSS in 1993.

The MBSS is a unique program. Prior to sampling, workshops were held to determine methodology as well as statistical approaches to sampling, along with one-year pilot and demonstration projects. Primary objectives of the MBSS are to: 1) assess the current status of biological resources in Maryland's non-tidal streams; 2) quantify the extent to which acidic deposition is affecting biological resources in Maryland; 3) examine which other water chemistry, physical habitat and land-use factors are important in explaining the current status of stream biological resources; 4) compile the first statewide inventory of stream biota; 5) establish a benchmark for long-term monitoring of trends in Maryland's biological resources; and 6) target future local-scale assessments and mitigation measures needed for restoration of biological resources.

In creating the MBSS, MDNR implemented a probability-based sampling design as a cost-effective method to characterize statewide stream resources – a unique design that is encouraged by EPA. Through a random-site selection process, MBSS data may be used to make quantitative inferences about characteristics of all 14,899 km of first to third order, non-tidal streams in Maryland (based on a 1:250,000 base map scale). This design allows robust estimates at the level of stream size (Strahler orders 1, 2, and 3), large watershed (18 major river basins), and statewide. Other inferences, such as counties or smaller watersheds, may be done based on the number of MBSS sampling points.

During the MBSS, three key indices were developed – a fish index of biotic integrity (FIBI), a benthic index of biotic integrity (BIBI), and a physical habitat index (PHI). The FIBI was specifically tailored to Maryland fish populations taking into account the physiographic variation found within the state. Coupled with the FIBI, a BIBI was also developed using the same general approach. Consequently, Maryland had two indices that related biotic factors to water quality and habitat.

Coupled with chemical-physical water quality, habitat quality (and quantity) is important to consider when examining fish communities, especially all derived biotic IBIs. To explain the interrelationship of biotic indices to habitat, the PHI was derived for Maryland, also using the same general approach. However, indices of habitat quality have lagged behind biotic IBI development. In part, this is because of difficulty in developing accurate, precise and complete methodologies to assess quantitatively and qualitatively habitat characteristics. Impetus for including stream habitat as an important measure came initially from the western states.

These indices are extremely useful in stream monitoring and represent a critical tool to monitor stream health in Maryland. Because of the nature of the program design, these indices have been used to provide estimates of the number of stream miles in Maryland that have been affected by various stressors. Future refinement will take place as the program increases sample size (currently at over 1000 samples stream reaches).

Overview of West Virginia Watershed Assessment Program

Presented by Mike Arcuri and Pat Campbell
WV Department of Environmental Protection
Watershed Assessment Program

The Watershed Assessment Program (WAP) of the West Virginia Division of Environmental Protection's (DEP) Office of Water Resources (OWR) determines the quality of the state's water resources by assessing major watersheds in a five-year cycle to coincide with the reissuance of National Pollutant Discharge Elimination System (NPDES) permits. This 5-year cycle has additional advantages. These include:

- facilitating the addition of stakeholders to the information gathering process,
- insuring assessment of all watersheds,
- improving the OWR's ability to plan, and
- buffering the assessment process against domination by special interests.

WAP assesses the health of a watershed by evaluating the health of as many of its streams as possible, as close to their mouths as feasible. WAP has a three-tier hierarchy of sampling, The General Sampling Strategy, The Random Sampling Strategy, and TMDL Sampling.

The General Sampling Strategy applies to most of the streams WAP samples. It can be broken into several steps:

✓ The names of streams are retrieved from the EPA's Water Body System database.

✓ A list of streams is developed that includes several sub-lists, including:
1. Severely impaired streams,
2. Slightly or Moderately impaired streams,
3. Unimpaired streams,
4. Unassessed streams, and
5. Streams of particular concern to citizens and permit writers.

✓ Assessment teams visit as many streams listed as possible and sample as close to the streams' mouths as allowed by road access and sample site suitability. Longer streams may be sampled at additional sites upstream. If inaccessible or unsuitable sites are dropped from the list, they are replaced with alternate sites.

The Random Stream Sampling Strategy follows these steps:

✓ About 30-45 stream locations are selected randomly from the EPA database.
✓ Personnel from WAP, Environmental Enforcement and other groups reconnoiter the locations to secure landowner approval for sampling and to determine if the site is suitable for sampling.
✓ Sampling teams visit the sites and sample in accordance with WAP protocols.
✓ Special statistical analyses allow comparisons between watersheds.

TMDL sampling is usually targeted towards a specific parameter. A TMDL consists of a Waste Load

Allocation, Load Allocation (a Non Point Source version of a Waste Load Allocation) and a margin of safety. WAP samples lakes, ponds and streams for TMDL purposes. In simple terms a TMDL is a plan of action used to clean up polluted waters. This plan includes:

1. Identifying and prioritizing the pollution source, and
2. Developing a strategy for contaminant source reduction and elimination

A variety of models are employed depending upon the nature of the TMDL. Dynamic models such as HSPF, WARMF, WASP, and others are used to predict impacts from non-point sources such as agriculture and acid mine drainage. Steady state models such as QUAL II are used to predict impacts from point sources such as domestic sewage treatment facilities. Many of these models are contained in the Basins Model Package developed by U. S. EPA.

WAP has chosen a specific combination of physical, chemical and biological variables to help determine stream health and what types of stressors may be operating on the benthic community.

The stream side and instream habitats, and the benthic macro- invertebrates (bottom-dwelling animals that do not have backbones) are the center of the ecological assessment. Habitat evaluations are important to the assessment because they reflect the physical conditions that support the benthic community. The benthic community is crucial because it reflects environmental conditions over an extended period of time. Other parameters, like dissolved oxygen concentration, are important, but may reflect recent fluctuations in environmental conditions. A release of a contaminant that flowed through the reach a week ago, for example, would be reflected by the impaired benthos, but probably would not be revealed in a water sample.

To determine the biological health of a stream, WAP needs a condition to compare it to. Previously, WAP used the least impaired site in a watershed as the reference condition. Some watersheds have an abundance of reference streams such as Shavers Fork of the Cheat where water quality is good and the habitat hasn't been disturbed for many years. Other watersheds, such as the Coal River or Tug Fork of Big Sandy, have few non-impaired streams. WAP now uses a collection of streams that meet a predetermined minimum impairment criterion as the reference condition.

To analyze the benthic data, DEP uses the methods outlined in the Rapid Bioassessment Protocols (RBP's) developed by U.S. EPA. DEP uses a modified version of RBP II. Five characteristics or metrics of the benthic community are used to assess stream quality. The metrics are automatically calculated from data plugged into an EXCEL spreadsheet. Once the metrics have been calculated, a bioscore is assigned based on comparability to the reference condition. The higher the bioscore, the more comparable a stream is to the reference condition.

A sample is collected to analyze for fecal coliform bacteria. Fecal coliform bacteria is an indicator of contamination from material found in sewage, livestock waste and wildlife excrement. A higher concentration of fecal coliform bacteria indicates a greater likelihood of a public health threat through direct contact with the water.

WAP largely focuses on assessing the health of the smaller streams in West Virginia. A program within WAP, called the Ambient Water Quality Monitoring Network (AWQN), assesses the health of the larger rivers. The chemical parameters used by the AWQN are basically the same as those

WAP uses.

AWQN data is used to calculate waste load allocations, determine 303(d) listings, recommend stream management direction and guide further research. For many sites this database stretches back nearly thirty years. This long-term string of data is useful in calculating water quality trends.

Over time WAP will develop a database that will provide a clear picture of the water quality based on the chemistry and the biological life existing in all of West Virginia's waters.

WAP routinely samples for the following parameters: Acidity, Alkalinity, Sulfate, Iron, Aluminum, Manganese, Fecal Coliform Bacteria, Specific Conductance, pH, Temperature, Dissolved Oxygen, Total Phosphorus, Nitrite + Nitrate Nitrogen, Ammonia-Nitrogen, Un-ionized Ammonium-Nitrogen, Suspended Solids, Stream Flow, and Chlorides.

Parameters are selected based on the type of impact suspected. For example, nutrient and bacteria data would be important in agricultural areas while metals, pH, and sulfate data would be beneficial in watersheds impacted by mining. Often times, specific parameters are collected based on TMDL needs while other parameters are collected to determine general water quality conditions.

Overview of West Virginia Watershed Assessment Program

Presented by Mike Arcuri and Pat Campbell
WV Department of Environmental Protection
Watershed Assessment Program

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State–of–the–Art Hydroacoustics as a River Fisheries Assessment Tool

R. C. Tipton and K. J. Hartman

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26506-6125

Abstract

Hydroacoustics may provide a rapid and effective method for surveying fish distributions in riverine systems. To begin the application of hydroacoustic techniques to rivers we conducted a verification study between hydroacoustics and lock rotenone samples and also surveyed the distributions of fish relative to a power plant intake. For the acoustic verification we acoustically surveyed relative fish density at the New Cumberland, Hannibal, and Belleville locks, on the Ohio River, using a SIMRAD EY-500 echo-sounder coupled with a 120 kHz split-beam transducer. The survey was performed prior to the application of rotenone by West Virginia Division of Natural Resources personnel; on 15, 16, and 17 September 1998, respectively. Our intent was to compare results of acoustic vs. rotenone density comparisons from three different sites the previous year.

The 1997 surveys on the Ohio River's Willow Island and Racine locks compared favorably with rotenone assessments. Estimates obtained from three 1998 lock surveys provided additional information on which to test the expected 1:1 relationship between acoustic and rotenone estimates. Differences in relative fish density estimates for acoustic vs. rotenone did not deviate significantly ($p<0.05$) from the expected 1:1. Additionally, we acoustically sampled fish from seven transects on the Hudson River, New York; in the vicinity of Bowline Power Generating Station. Total average relative density estimates were obtained for four size classes of fish using a 120 kHz split-beam hydroacoustic system. Size classes sampled were 12–90 mm TL, 91–160 mm TL, 161–300 mm TL, and 301–1000 mm TL, respectively. Transects were sampled in two-hour intervals over a twenty-four hour period on 16 and 17 July 1996. Three transects were sampled within 100 m of intake structures inside a secluded 49-hectare lagoon (near field), while the remaining four transects were sampled > 100 m away in the Hudson River proper (far field).

Multivariate analysis of variance was used to determine significant ($p\leq0.05$) fish total average density by size class for near field vs. far field and daylight vs. dark conditions over the diel period. Results indicated an overall near field dark preference by the smaller size classes, 12-90 mm TL and 91-160 mm TL respectively. Preference trends exhibited by small fish broke down as total length increased to the larger size classes, 161-300 mm TL and 301-1000 mm TL respectively. The results of these two studies show that hydroacoustics can be reliably applied to the study of abundance and distributions of fishes in riverine systems. We believe that hydroacoustic techniques hold promise for studies of fish and their relationship to habitat features in Appalachian Rivers.

TMDL Strategies for Wet Weather Water Quality Issues

Mark Boner
Wet Weather Environmental Technology Company

Methodologies that were used in the conduct of the Columbus, Georgia Combined Sewer Overflow (CSO) control program to demonstrate compliance with the EPA CSO Policy are applicable to other Total Maximum Daily Load (TMDL) allocation programs. These methodologies will be described in this presentation. Loadings from the various contributing watersheds and point sources in Columbus were measured and modeled. Various scenarios of river flow and hydrologic conditions were evaluated to examine the wet weather effects on water quality standards. The findings were used to formulate a TMDL allocation for the combined sewer overflow program. Strategies for compliance determination included concepts involving flush effects and cost-benefit levels, design storm and technology-based operations and standards interpretation. The analysis showed that the implemented CSO controls resulted in loadings that "do not cause" or "contribute to" violations of water quality standards including bacteria in the Chattahoochee River. Based on the measured and modeled findings, a CSO NPDES Permit was developed around the "demonstration approach" of the EPA CSO Policy, which requires a TMDL waste load allocation (WLA) and is the basis for compliance and continued program monitoring and reporting. A facility's "design storm" and demonstrated operation is the basis for its "effluent limits". Monthly wet weather event monitoring of upstream and downstream receiving waters as well as CSO and POTW's and BASINS modeling output of the nonpoint contributions is documented in the permit report. Reporting provides a direct comparison of measured and modeled loads with in-stream measured conditions that continually demonstrate the TMDL contributions.

Mark Boner's career spans over 25 years as a consulting engineer in planning, design, construction and operation. He has been primarily involved with wet weather and water quality issues. Mr. Boner is currently serving as the principal investigator for the Columbus, Georgia CSO Technology demonstration Project and the area's Regional Watershed Monitoring and Modeling Program. He has a Bachelor of Civil Engineering and a Master of Science in Environmental Engineering from the Georgia Institute of Technology. He is Vice President of Wet Weather Engineering and Technology and is registered as a Professional Engineer in Georgia, Virginia and Puerto Rico.

OVERVIEW OF TOTAL MAXIMUM DAILY LOAD (TMDL) PROBLEMS AND SUPPORTING MODEL DEVELOPMENT

Steven C. McCutcheon, Ph.D. P.E.
National Exposure Research Laboratory, Athens, GA
and
Jim Pendergast
Office of Wetlands, Oceans, and Watersheds, Washington, D.C.
U.S. Environmental Protection Agency

Approximately 18,900 impaired water bodies are on the 303(b) state lists required by the Clean Water Act. Of the 300 types of impairments on the 1996 and 1998 lists, 24% involve sediments, suspended solids, or turbidity. Nutrient problems account for 15% of the listings, and pathogens, 14%. The EPA Office of Research and Development (ORD) and the Office of Water are working closely together to develop protocols and models to address TMDL problems in order of frequency of occurrence. The ORD is developing TMDL models under its Ecological Research and Restoration Strategy, and the Office of Water under its pioneering watershed approach. The National Exposure Research Laboratory is developing methods for simpler sediment budgets and more complex sediment routing from watersheds through stratified lakes and estuaries. The EPA Office of Water is working with David Rosgen and interagency partners to develop and test the components method of sediment routing based on extensive experience in stream geomorphology. The range of simple sediment balances, the geomorphical components analysis, and the more complex multidimensional routing techniques should provide adequate science-based tools to address most sediment TMDLs. Data are being collected for the South Fork of the Broad River in Georgia and with data available from U.S. Agricultural Research Service, the Forest Service, and the U.S. Geological Survey, sufficient testing of new methods and protocols should be possible. By 2004 a case study for nutrient TMDLs is expected that will probably focus on the Neuse River in North Carolina. The ORD expects to focus on pathogens and toxic chemicals during 2005 until 2008. Each component model is being developed using a multimedia modeling context by ORD. In the short-term, the Office of Water has developed the BASINS system to manage data bases and existing water quality models in a manner that can be adapted for each state unless other methods are available.

Acknowledgments **B** The provision of overheads on the ORD Ecological Research and Restoration Strategy by Rick Linthurst and the other ORD eco associate lab directors is appreciated.

OVERVIEW OF TOTAL MAXIMUM DAILY LOAD (TMDL) PROBLEMS AND SUPPORTING MODEL DEVELOPMENT

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and

Jim Pendergast

Office of Wetlands, Oceans, and Watersheds,
Washington, DC

U.S. Environmental Protection Agency

Overview

- TMDL Definitions
- Impaired Waters in the U.S.
- Litigation
- FACA Report
- Model and Protocol Development
- Longer Range Plans of ORD

What is a TMDL?

- TMDL -- Total Maximum Daily Load
- A calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards
- The sum of the allowable loads from all point and non-point sources, plus a margin of safety and considering seasonality

TMDL Definition

$$TMDL = \Sigma WLA_i + \Sigma LA_i + MOS$$

ΣWLA_i: Sum of waste loads (point sources)

ΣLA_i: Sum of loads (nonpoint sources)

MOS: Margin of Safety

Terms must also consider seasonal variation.

Clean Water Act requires. . .

- States to identify waters not meeting water quality standards and set priorities
- States to develop a TMDL for each pollutant for each listed water
- EPA to approve or disapprove State submissions, and if disapproved, to act in lieu of State

CWA §303(d)(1)(C)

1998 State Lists of Impaired Waters

- For the 56 States and Territories:
  - EPA approved 42 lists
  - EPA partially approved 7
  - EPA still reviewing 7 lists
- Expect 21,000 waters (18,900 to date)
  - 2% with no identified impairment
  - 43% with single impairment identified
  - 55% with multiple impairments

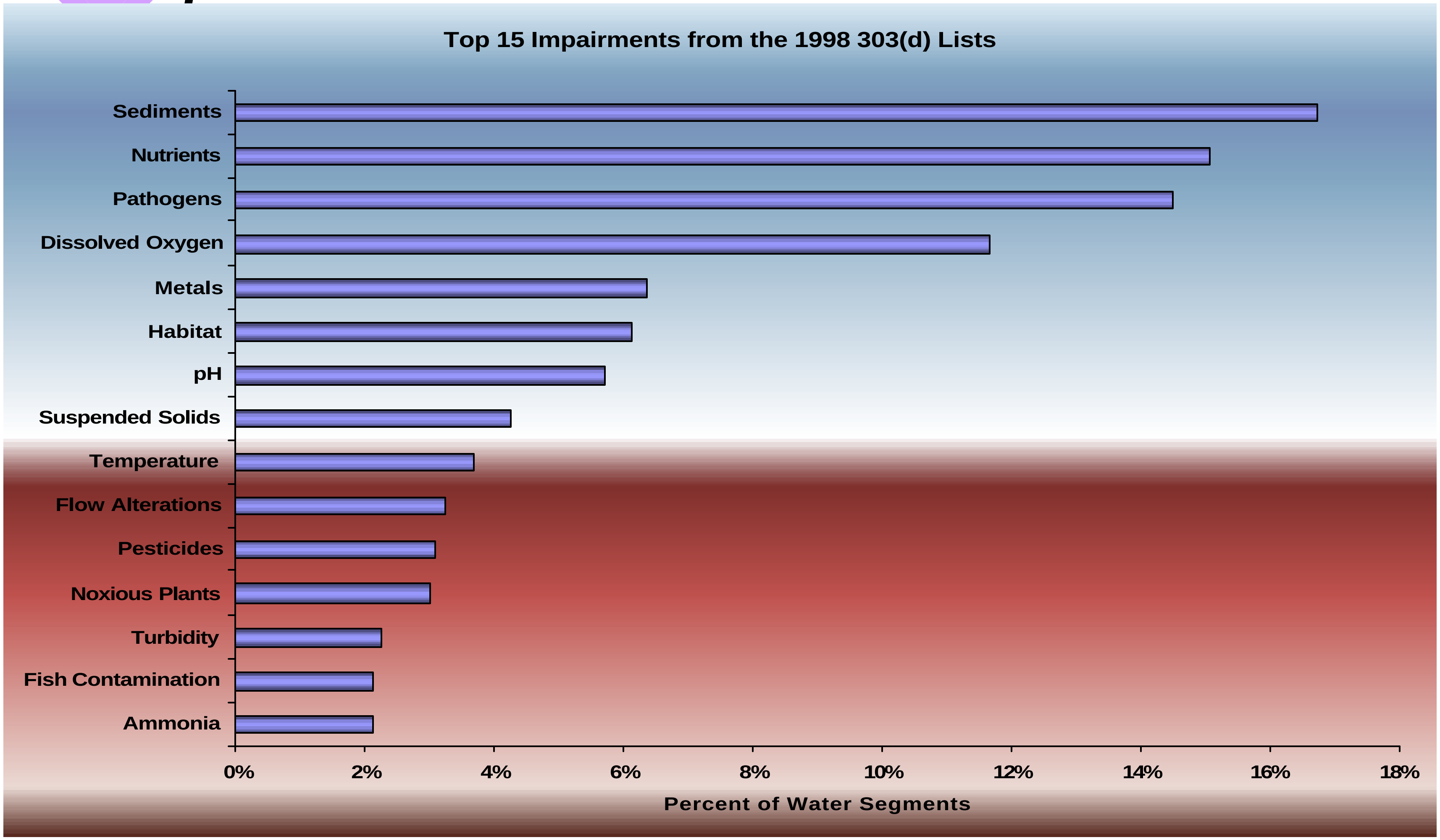
*Information as of 7/16/1999

1998 State Lists of Causes of Impaired Waters

- More than 300 types of impairments identified on the 1996 and 1998 lists
- 15 types comprise 76% of total
- Top three impairments are:
  - sediments 17% (24% including susp. solids & turbidity)
  - nutrients 15%
  - pathogens 14%

*Information as of 6/23/1999

1998 State Lists of Causes of Impaired Waters



*Information current as of 6/23/99

1998 State Lists of Sources of Impaired Waters

- Source of Impairments
  - Both point and nonpoint sources 46%
  - nonpoint sources alone 39%
  - point sources alone 3%

- 25% of point sources are on impaired waters

- 23% to 34% of silvicultural and agricultural sources are on impaired waters

*not all states provide this information

TMDL Litigation

- About 45 legal actions in more than 34 States (one action involving four States is very old)
- EPA under court order/consent decree to ensure TMDLS established in 13 States
- 3 cases dismissed since 1993

See website: http://www.epa.gov/OWOW/tmdl for litigation summary

Major Litigation Issues

- Lists -- adequacy, basis, underlying data
- Pace of TMDL development -- when will they all be done?
- Plaintiffs typically want--
  - Schedules for completing all TMDLs
  - EPA guarantee to do TMDLs when State does not
  - Settlement agreements/consent decrees to ensure continued court oversight

TMDL FACA Report

- Consensus on many issues
  - Restoring impaired waters must be high priority
  - Implementing TMDLs is key to success
  - Communication with public is critical
  - Stakeholder involvement key to successful implementation
  - Strengthen governments capacity to do TMDLs
  - Iterative approach best way to make progress in uncertain situations

For more information:
http://www.epa.gov//OWOW/tmdl

Proposed Changes to Regulations and Guidance

- FACA Committee Report sent to Administrator July 1998
- Recommendations guide proposed changes to TMDL regulations and guidance
- Proposed changes scheduled for Summer 1999 publication in *Federal Register*
- Final regulations in 2000

TMDL Information Sources

- Statute
  - Clean Water Act Sections 301-308
- Regulations
  - 40 CFR Parts 130-131
- Guidance documents
  - 1991 TMDL Guidance
  - Supplemental memoranda
  - Perciasepe memorandum "New Policies for Establishing and Implementing TMDLs." August 8, 1997.
- See web site: www.epa.gov/OWOW/tmdl/

Model and Protocol Development

- BASINS by Office of Water
- Sediment Work by Office of Water
- Ecological Research Strategy, ORD
- Sediment, Nutrient, and Pathogen Protocol Development

Ecological Research and Restoration Strategy: An Overview

Office of Research and Development

http://www.epa.gov/ORD/WebPubs/final/....

Ecological Research Program

- Core Research Capabilities
  - Monitoring
  - Modeling and Process Res.
  - Assessment
  - Risk Mgmt. & Restoration
- Environmental Hazards
  - Acid Deposition
  - Ozone
  - Mercury
  - UVB
  - Nitrogen
  - Global Change
  - Contaminated Sediments
  - Wet Weather Flows
  - Toxic Algal Blooms
  - Eco-Criteria
  - TMDL
  - Endocrine Disruptors
  - Pesticides
  - Landcover Change
- Geographic Research
  - Mid-Atlantic
  - Pacific Northwest
  - South Florida
  - Great Lakes
  - NLERAs
  - National Scale Studies

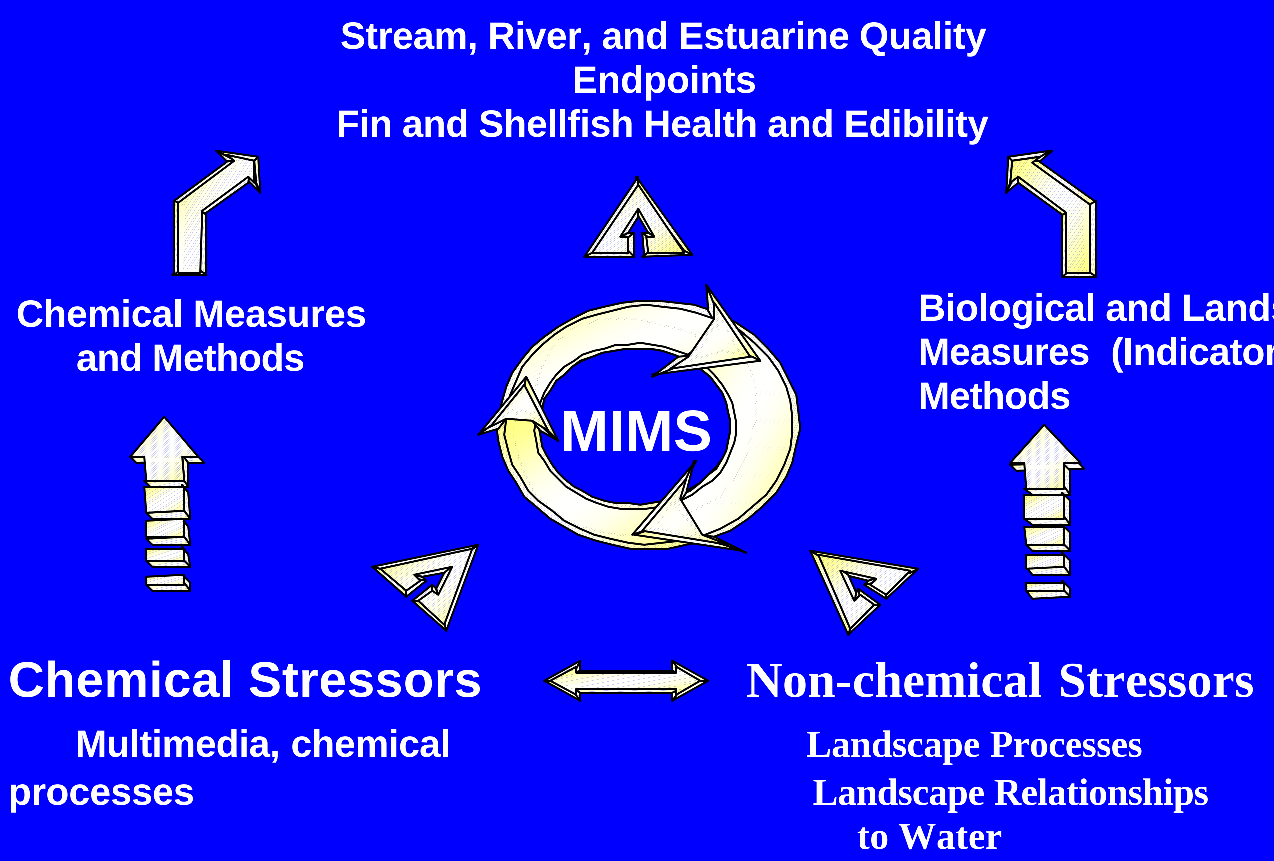
Primary Emphasis

- Chemical and Microbiological Stressors
  - Eutrophication/Acidification/Nitrogen/P
  - Mercury and other PBTs
  - Pathogens
- Habitat Stressors
  - Wet Weather Flows
  - Sedimentation
- Habitat
  - Riparian
  - Wetlands

Laboratory/Center Roles

Core Research Areas	Natl Health & Environmental Effects Research	Natl Exposure Research Laboratory	Natl Center for Environmental Assessment	Natl Risk Management Research Laboratory	Natl Center for Environmental Research & Quality Assurance
Monitoring and Monitoring Research	Primary	Primary	Supporting	Supporting	Supporting
Processes and Modeling Research	Primary	Primary	Supporting	Supporting	Supporting
Assessment Research	Secondary	Secondary	Primary	Secondary	Supporting
Risk Management & Restoration Research	Supporting	Supporting	Supporting	Primary	Supporting

Program Focus: Watershed Exposure Modeling & Exposure Assessment

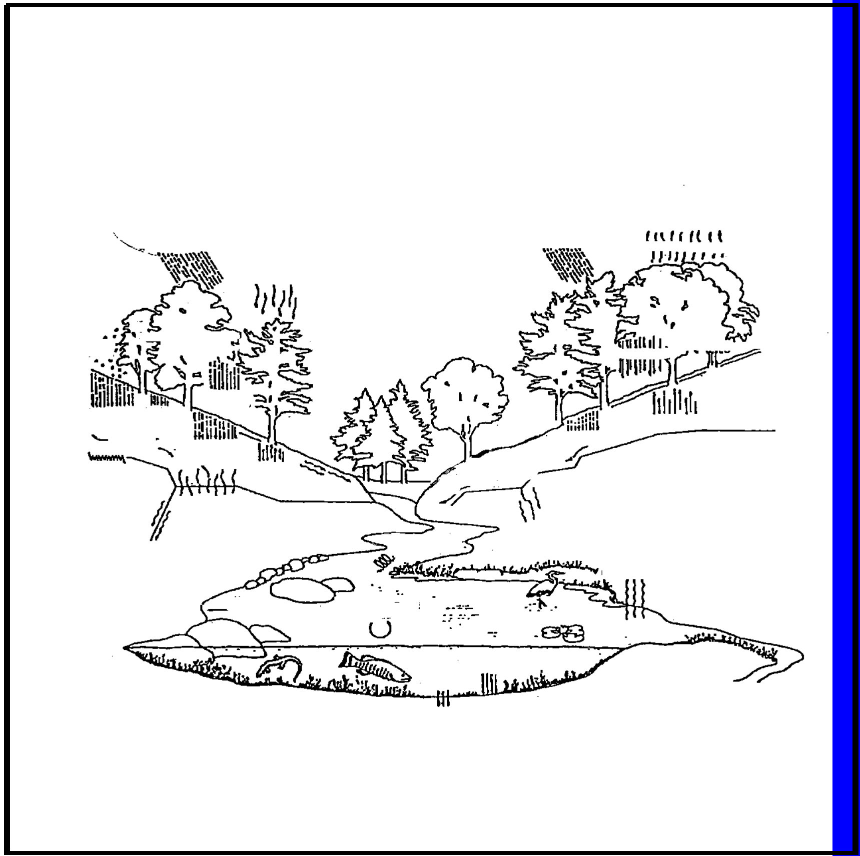


Rationale For Multimedia, Multipathway, Multiscale Modeling Approach

- Increased awareness of multiple stressor effects and a more holistic regulatory view
- Need for alternative, flexible, cost effective and certain management options
- Encouragement and need to use relative risk to assist in judging resource allocations
- Increasing recognition that spatial scale is critical in evaluating the success of management actions and the desirability of a different strategy for surface water protection is not far behind

Long-term Model Development Goal

- By 2008; Publicly release models, and the common software framework (MIMS), for computation of nutrient, toxics, sediments, and pathogen loadings into surface waters for determination of total maximum daily loadings including alternative management solutions.



Objectives

Methods to Manage Sediment Loads in Different Segments of Southeastern Piedmont Streams

Evaluate Draft TMDL Protocols for Sediment, Coliform Bacteria, and Nutrients

Intensive, High-Quality Data To Validate Methods (models and other techniques)

Information for Georgia and EPA Reg. 4 to set Total Maximum Daily Loads for Sediment

Extrapolation to Other Geomorphologic Provinces

Measurements

78 Stream Cross Sections Every 1/2 Mile (Bed Forms, Bars, & Other Features)
Bank Pins, Surveys, Trenching, and Other Methods to Measure Bank Erosion
Measure Weather Conditions (i.e., Rainfall, Temperature, Solar Radiation) at 4 to 5 Sites to Simulate Runoff, Sediment Yield, and Stream Flow

- Water Surface Elevations, Flow, Suspended Sediment, & Bed Load
  - Hourly
  - Three Stations in the Cross Section
  - Eleven Bridges, Cabled Sites, or Sites that can be Waded

    During Every Rainstorm Projected >2 cm (Spring/Fall Frontal Movement)

Measure Dissolved Oxygen, pH, Temperature, Specific Conductance, and Turbidity (Later Fecal Coliform, and Nutrients) and ISCO Grab Samples at a Point in the Cross Section
Vertically Averaged Sediment Concentration (Pressure Transducers, UGA)

- Collect Data 2-5 Years Depending on the Results, Starting Fall 1999

Model Documentation, Support, and Development for Sedimentation

- Hydrodynamic, Sediment, and Contaminant Transport Model (SED2D) Finite Difference Model on Center for Exposure Assessment Modeling Web Page (www.epa.gov/CEAM)
- SED3D Documentation Expected in Fall 1999
- Course Training Notes for HSPF on CEAM Web Page in Spring 1999
- Hotline Support for HSPF & Other Models (Waterways Experiment Station)
- Comprehensive Review of Water Quality and Sediment Transport Models to Document State of the Art (Aqua Terra using OW Report on Sediment Transport Models)
- Testing Sediment Mass Balance Simulations of Lumped Parameter (HSPF) and Distributed Watershed Models (CASC2D and MODELX) in the South Fork of the Broad River (Waterways Experiment Station)
- Develop New Generation of In-Channel Sediment Transport Algorithms -- First Step to Channel Geomorphology Model (Tetra Tech, Aqua Terra, Earl Hayter, NERL-Athens)
- Riparian Zone Model to Guide Evaluation of Best Management Practices

Next Generation In-Channel Fate and Transport Models for Sedimentation

- Phase I (Tetra Tech and Aqua Terra, Expected 2000)
  - 1D Box Model for Simplified TMDL In-Stream Sediment Balance Spread Sheet Model, and HSPF, WASP, and EXAMS
  - Advanced Cohesive and Noncohesive Erosion and Deposition, Bed Consolidation and Mobilization
  - Shear Stress for Bioengineering
  - Multiple Particle Sizes
  - Distributed Sources
  - Model Testing with Existing Data Sets
  - Documentation and Support
- Phase II (Hayter, Tetra Tech, Aqua Terra: Prelim. Version 1999)
  - 1D Model for In-Stream Processes to Upgrade HSPF and Distributed Watershed Models
  - Same Processes as Above but With Armoring and Finite Strain Consolidation of Bed

Next Generation In-Channel Fate and Transport Models -- Continued

- Phase III (Expected in 2000)
  - Model Selection Hinges on Model Evaluation by Aqua Terra in 1999
  - 3D Sediment Fate and Transport Model for Difficult TMDLs in Lakes and Estuaries
  - Expect to Build on Models Being Developed by the EPA Office of Water (EFDM by Hamrick), NERL-Athens (SED3D), WES (CH3D-SED3D), NOAA (Blumberg-Mellor), and USGS (Woods-Hole and WRD, TRIM)
- Ultimate Goals
  - Stream Geomorphology and Riparian Zone Models Nested in Distributed Watershed Models for TMDL Analysis, Stream Bioengineering, and Stream Ecosystem Restoration
  - 3D Hydrodynamics and Multi particle Size Sediment Models Combined With Distributed Watershed Models to Link Ecological and Specific Biological Effects in Stratified Lakes and Estuaries to Land Use
  - Nested in Next Generation Multimedia Risk Assessment Systems (2008)

Nutrient and Pathogen Modeling

- Look at molecular characteristics to simulate fate and transport parameters
- Carbon cycling
- Biological endpoints or links with ecosystem models
- Case study: Neuse River, NC 2004
- Next generation of pathogen and toxic chemical models for 2005-2008

Summary

- TMDL issues to the forefront due to litigation
- Extensive impairment of surface waters
- Ecosystems and multimedia modeling for long-term development
- Sediment models in the next two years
- Nutrient modeling by 2004
- Pathogen and toxics models after 2005

NASA Technology Development, Current Research and Watershed Applications

Presented by
Kevin Gashlin, Project Manager for Environmental Technology Transfer
National Technology Transfer Center
Wheeling Jesuit University
Wheeling, West Virginia

The National Technology Transfer Center (NTTC) is a not-for-profit technology commercialization organization. NTTC serves public and private sector clients by providing information about technology developed in NASA Field Centers and other government laboratories such as DOE, EPA and DOD. Conversely, NTTC serves as a technology broker and intellectual property assessment organization for technology owners. NASA is NTTC's primary public sector client.

This presentation will feature NASA's recent technology research accomplishments related to watershed issues. Selected technologies developed in other federal laboratories will supplement that body of work. The primary investment for NASA in this area is environmental monitoring via a wide array of remote sensing capabilities deployed on satellite and manned aircraft overflights. The data gathered as a result of this ongoing effort has provided critical information to government leaders and scientists around the globe about El Nino, ozone depletion, acid rain, deforestation and global warming to name just a few.

NASA environmental technology research is guided by priorities established in response to a known or suspected environmental anomaly or in response to a basic desire to understand and track the effects of a natural event or man-made phenomenon on a species, an ecosystem or earth itself.

Attendees interested in acquiring more information about specific NASA technologies are encouraged to submit their request in writing to the speaker.

Nitrate Measurement with Biosensor Technology

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Abstract

Protecting the water quality of rivers and watersheds will require improved methods for detection and analysis of compounds of environmental concern. The new methods will need to be economical and easy to use, so that the frequency of data collection and analysis can be increased. These goals need to be reached without compromising on accuracy, so that the data can be trusted and used. The new methods should also be developed with an emphasis on use of non-hazardous and nontoxic reagents, to keep both the user and the site uncontaminated and safe.

Bioanalytical methods, including immunoassays and enzyme-based assays, are beginning to bring these qualities and capabilities to quantitative analysis. Bioanalytical methods can provide data of accuracy and specificity comparable to instrumentation-driven analyses at far less cost, with the added advantage of being environmentally benign. Many of these methods can provide quality data both in the laboratory and on site in the field.

Enzymes are the protein catalysts that speed the chemical reactions that make living systems run. Enzymatic reactions are fast, efficient, very specific, and require little energy. Nitrate reductase is the enzyme that begins the process by which plants make their proteins. Ironically, it is also one of the physiological reasons that nitrate fertilizers are so effective in increasing crop productivity. These qualities make nitrate reductase a powerful tool for nitrate analysis.

Our company is dedicated to the application of enzymes to the solution of environmental problems. Our first products are a series of nitrate test kits based on the enzyme nitrate reductase, which we purify from corn seedlings. Kits based on our enzyme have been in use for biomedical research since 1995. Funding from the USDA's Small Business Innovation Research program has helped us to develop a series of nitrate test kits for analysis of nitrate in water. We are also involved in the development of a true nitrate biosensor, an electronic device capable of nitrate determination without the need for chemistry.

These kits use a chemistry similar to many other nitrate test kits, except that the heavy metal catalyst they require, cadmium or zinc, is replaced by nitrate reductase enzyme driven by the biological electron donor NADH (nicotine adenine dinucleotide, reduced form). The catalytic rate of NaR is about 200 nitrate to nitrite conversions per second per molecule of NaR. The reaction is irreversible and goes to completion:

$$\textbf{NADH + NITRATE} \; \textbf{-->} \; \textbf{NITRITE + NAD}^{+} \textbf{ + OH}^{-}$$

A series of kits for a variety of applications has been developed. Lab kits provide quantitative data, comparable to Ion Chromatography or Ion Autoanalyzers, at a fraction of the cost, and have been formulated in test tube and 96-well microtiter plate formats. Field kits for on site or classroom analysis are quantitative when the test results are read with a colorimeter, and semi-quantitative data when a color chart is used. The Consumer kit allows anyone to test for nitrate at home, on site, or on the farm, even when the sample is dirty or colored. See Figures for Standard curves generated by enzyme-based nitrate analysis in freshwater and in seawater.

The next step in enzyme technology is the biosensor. The chemistry of the enzymatic reduction of nitrate involves a flow of electrons from a biological electron donor - such as NADH - through the enzyme and to the nitrate, reducing it to nitrite. In a biosensor, the enzyme is immobilized onto a solid support material, and electrons are supplied either directly by an electrode, or via an electron-carrying molecule attached to the same support. As nitrate is reduced, there is a tiny flow of electrons, a current, through the enzyme, and this current can be amplified and detected. The amount of current (in nano- or microamps) correlates to the concentration of nitrate present in the medium in which the biosensor probe is in contact. Data generated by our nitrate biosensor is shown below.

Nitrate biosensor technology is still in the prototype stage, but one key barrier has been the need for a purified and stable enzyme preparation; this obstacle has been overcome by our enzyme purification technology. Current efforts toward development of a practical device involve examination of enzyme immobilization techniques, how to eliminate oxygen interference from the system, and optimal biosensor materials. The goal is to develop a device whereby nitrate concentration can be read on a meter as the nitrate sensing probe is immersed in the sample.

Summary:

In order for increased nutrient analysis to become mandated, methods will need to be easy and also inexpensive. The methods also need to be accurate, or the data will have little meaning. Enzyme-based assays may be part of the solution to better protection of our water resources. Enzyme-based nitrate testing has significant advantages over competing methods. Because enzymatic reactions are specific, this method can be used in a wide variety of difficult samples. Highly colored and particulate samples are not a problem because these interferences are diluted out in the assay. Nitrate reductase-based nitrate testing is versatile: samples types investigated to date include biological fluids, seawater, and maple syrup.

Contamination of the environment by excess nitrate is a growing problem world-wide. Better nitrate monitoring capabilities may help solve the problem. An accurate, sensitive and safe nitrate measurement method can be a useful tool for regulators, agribusiness, and citizens to monitor how nitrate moves in the environment.

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Acknowledgements:

This work was funded in part by the SBIR program of the USDA, Award #33610-3105. Thanks also to Troy P. Kinnunen-Skidmore, Leigh A. Winowiecki, and Victoria L. Salo for their excellent technical assistance.

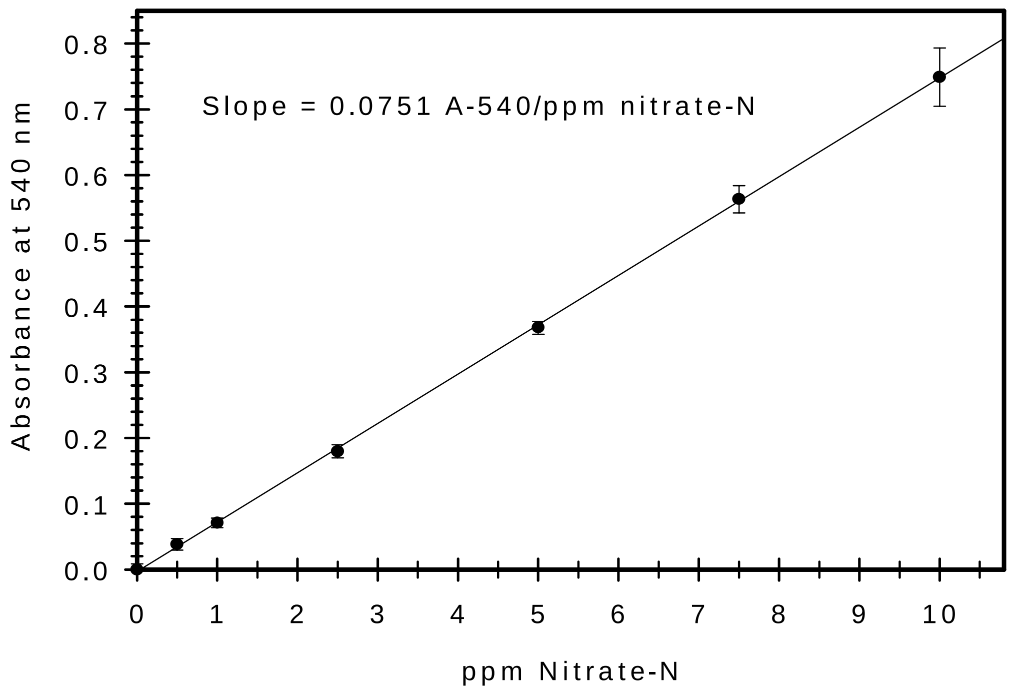
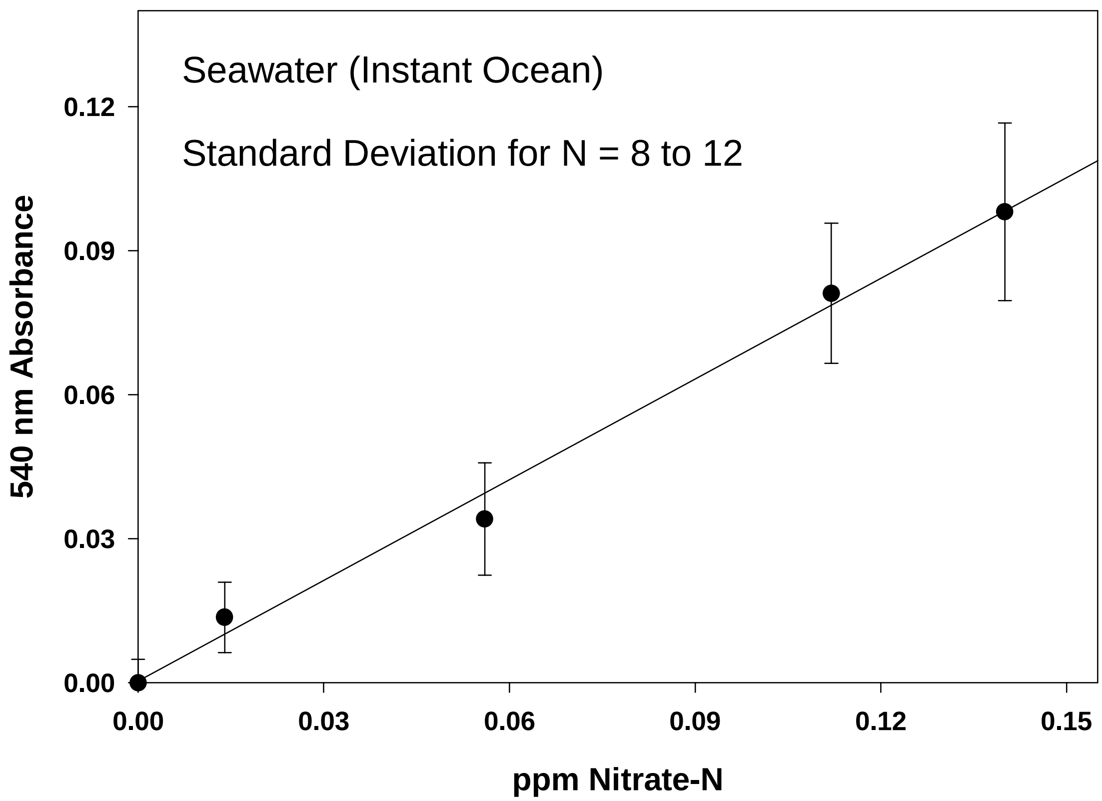


Figure 1. Typical Standard Curve generated with enzyme-based nitrate analysis. For nitrate analysis in this range, 50 µl of sample is added to one milliliter of reaction mix containing nitrate reductase (5 µl sample in 100 µl for the microwell kit), NADH, and buffer. After a reaction time of 15 minutes, at which time all (>95%) of the nitrate present in the sample will have been reduced to nitrite, 1 ml (100 µl in the microwell assay) of the Griess color reagents - acidified sulfanilamide and 0.02% N-Naphthylethylenediamine - are added. The resulting pink color is read using a spectrophotometer at 540nm (± 20nm), or by eye versus the standards and color chart provided with the Field and Consumer kits. The low sample volume in relation to total assay volume eliminates virtually all problems caused by color, pH extreme, or other contaminants in the sample.

Figure 2. Low level nitrate analysis in Seawater (Instant Ocean). Note that 0.15 ppm Nitrate-N (approx. 0.7 ppm nitrate) is equivalent to 10.7 µM Nitrate. This level of sensitivity in the presence of NaCl requires a larger sample volume of 500 µl and must be



read using a colorimeter or spectrophotometer. Low Range kits for analysis of nitrate between 0.025 - 1.0 ppm nitrate-N can be used with either the color charts or a colorimeter. The only interference found to date is permanganate or other strong oxidizers in the sample, which destroy the NADH; there are then no electrons available to the enzyme for nitrate reduction. Again, this is only an issue for the Low Range kits where the sample size is a larger portion of the total reaction volume.

Performance Characteristics of the NECi NaR-Nitrate Biosensor. When the NaR-NBS configuration shown in Fig. 1 is calibrated with anaerobic nitrate standards, a saturating current response is observed as shown in Table 1 and Fig. 3. Steady state current is obtained in 1 min after introducing a new nitrate aliquot.

Table 1. Current Response to Nitrate in the NaR-Nitrate Electrode

Normalized Current Response	Nitrate Conc (µM)	Nitrate-N Conc (ppm Nitrate-N)
0.00	0	0.00
0.01	3	0.04
0.05	10	0.14
0.11	25	0.35
0.35	100	1.40
0.60	250	3.50
0.81	500	7.00
0.97	1000	14.0
1.00	1200	16.8

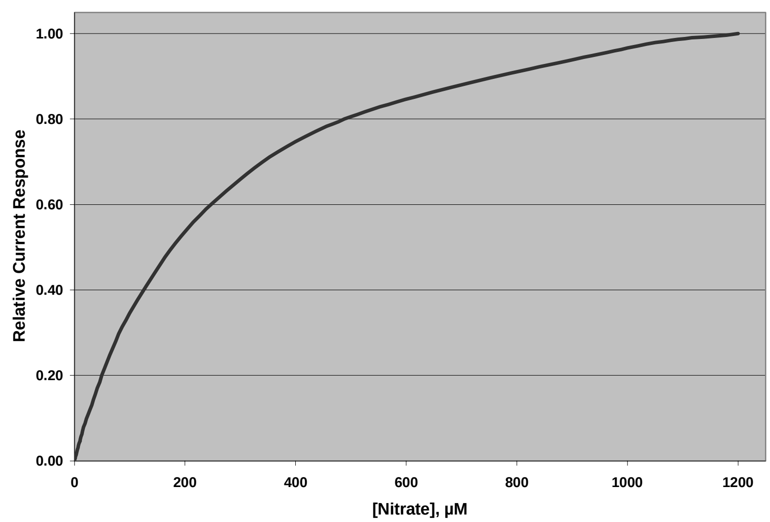


Figure 3. Current Response Curve for Calibration of the NaR-Nitrate Biosensor. Data from Glazier, Campbell & Campbell (1998).

The Use of Probiotics in Bioremediation

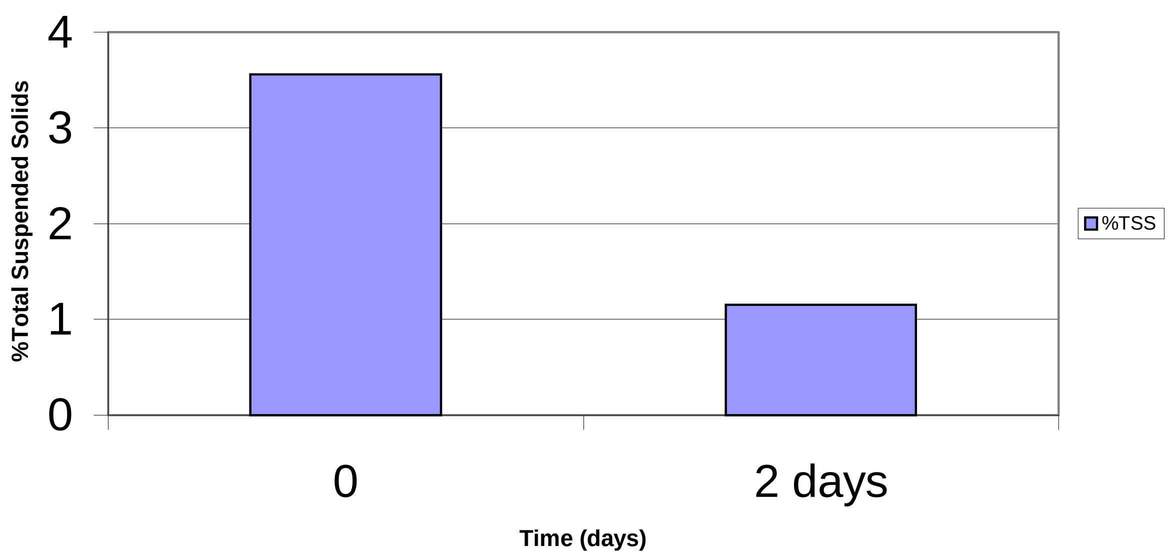
Sharon Wetzel
WV Department of Agriculture

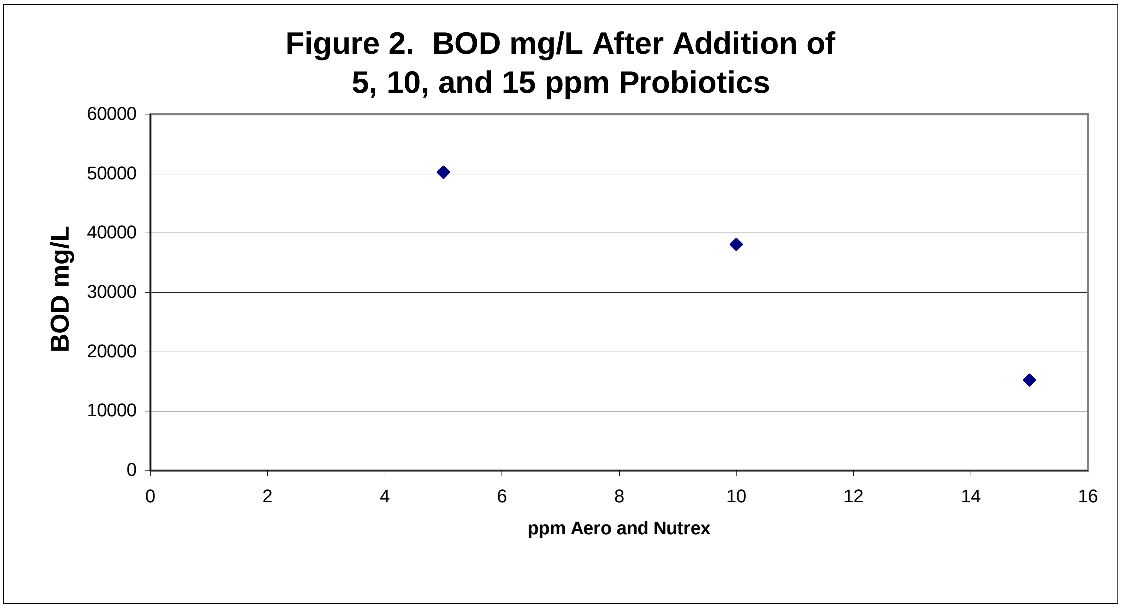
Probiotics have been used for many years in the field of veterinary medicine. Now a new line of Probioitics for other biological systems and bacterial populations as well as turf and aquaculture has become available. The purpose of this research was to determine if certain Probiotics, namely Biofeed's Nutrex™, Chetrol™, Aero™, Biorem™, and Cozyme 50™ are effective as bioremediation stimulants in various different wastes. The various waste streams in this study were ponds, lagoons, anaerobic digesters, acid mine drainage streams, poultry processing wastes, heavy metals wastes, and oil wastes.

All the probiotic products mentioned above are in liquid form and is typically applied at the rate of 3 parts per million. All products have the ability to buffer pH extremes, increase dissolved oxygen levels, and restore biological systems to optimum health conditions. Chetrol is also a powerful chelating agent and is used in the bioremediation of heavy metal wastes to immobilize the metals to prevent the contamination of other materials. The primary goal of all of the studied probiotics is to energize the natural biological systems present with the studied waste streams through aeration and biostimulation. All products contain a mix of enzymes, amino acids, and humic acids.

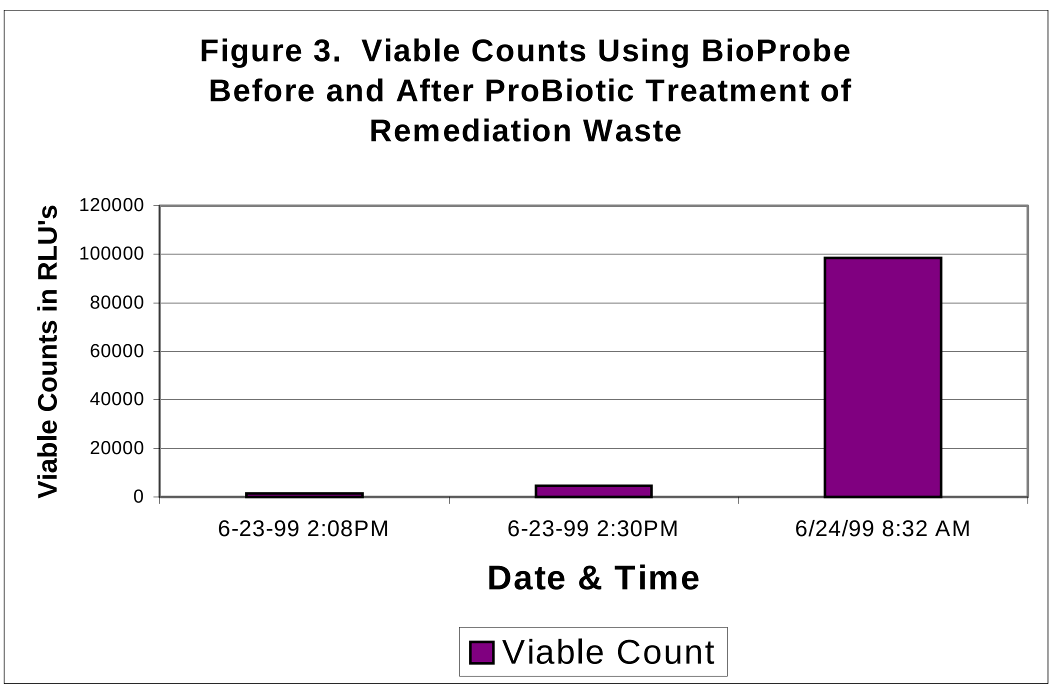
The results of all the above mentioned waste streams showed a increase in dissolved oxygen and alkalinity, and a stabilization of the pH between 7-9 pH units. Odor reduction was also observed where there was a problem. Other benefits included a decrease in total suspended solids (Figure 1.), a reduction in the size of sludge layers, and a reduction in metals, particularly iron, chromium, copper, lead, and mercury. The biggest impact on the bioremediation of processing waste was the reduction of chemical oxygen demand (COD) and biological oxygen demand (BOD) [Figure 2].

Figure 1. %TSS Reduction After Using 5 ppm Probiotics in the Treatment of Municipal Solid Waste

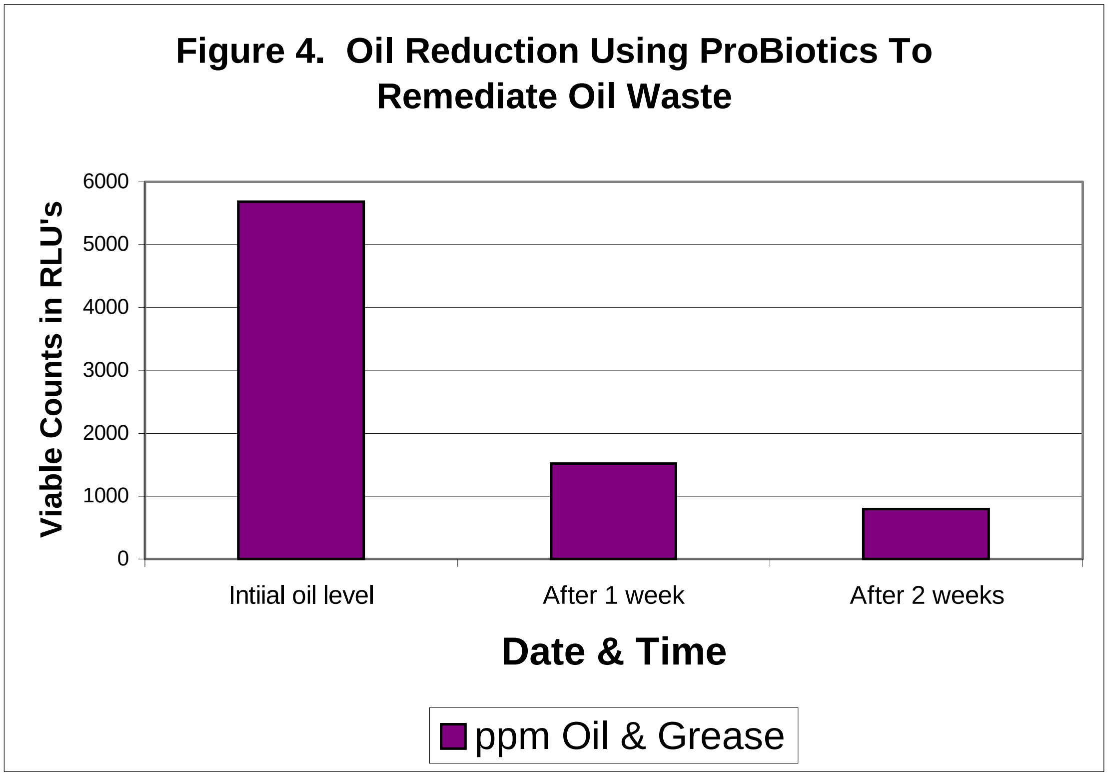




The study showed that the Nutrex and Aero has significant stimulatory properties when used in biological systems such as ponds and lagoons. Figure 3 shows the increase in viable counts after the addition of these two probiotics. All viable counts were performed on the Bioprobe luminometer made by Huges Whitlock of Cardiff Wales. This test is based on the lucifer/luciferase reaction and is completed in about 10 minutes as compared to 48 to 72 hours using plate techniques. BART tests show a increase in sulfate reducing, nitrifying, and denitrifying bacterial populations. A reduction in pathogen indicators such as fecal coliforms and e.coli were also observed during the study.



Biorem has also been shown effective in reducing hydrocarbons. This is shown in Figure 4.



Biofeed's probiotics are under further research to determine if they can compete economically with the use of limes, ammonia, and caustics in the treatment of acid mine drainage. Nutrex and Aero show a nice buffering capacity with additional pH adjustment due to the breakdown of amino acids into ammonia. After reviewing the results from this study's treatment of AMD, Biofeed's formulators are working on new products that may be more beneficial to the mining industry.

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"YOU CAN'T JUDGE A STREAM BY ITS COLOR"
A Video Presentation

By

Jeff Skousen, Craig Mains, and Ron Hamilton

Abstract

Water quality of streams and rivers in the U.S. has captured the attention of many citizens, local businesses, and state and county governments because of the quality of life and economic development that pure water brings to an area. Drinking water and water recreation are important to everyone. In response to the growing interest in water quality issues, watershed organizations have been established in many parts of the U.S. The mission statements of most watershed organizations include educating the public about the intricate beauty and value that water resources provide, partnering with local interested parties on the watershed development, and promoting the restoration and preservation of water bodies.

The U.S. Environmental Protection Agency (USEPA) and other federal and state governments have recently made money available to watershed organizations to help clean up streams and rivers. For example, USEPA has provided substantial amounts of money (>$100,000) to Friends of the Cheat, a northern West Virginia watershed organization, to construct water quality improvements on the Cheat River in West Virginia. The State of West Virginia, through its Governor's Stream Restoration Program, also provides money to watershed organizations. In order for Friends of the Cheat and other watershed organizations to receive construction money, a defined project with predicted water quality improvement results were required. Therefore, a thorough knowledge of the flows and water quality of various streams during the year in the watershed must be achieved.

The methods to document water flows and water quality are well known to scientists involved in such studies. However, these methods are generally unknown to most of the public and to individuals within watershed organizations. At past USEPA acid mine drainage (AMD) watershed conferences, workshops were given that demonstrate to the attendees the methods for measuring water flows, the field kits available to measure water quality, the proper techniques for taking water samples, and ways for determining benthic macroinvertebrate populations. All of these things then can be used to evaluate the quality and health of a stream.

Many active individuals in watershed organizations do not have the means or time to attend watershed conferences to gain the knowledge necessary to allow them to determine water quality of their streams. Therefore, a training video was created that illustrates the methods for determining the water quality of streams.

Jeff Skousen of West Virginia University and Craig Mains of Downstream Alliance have teamed up with Ron Hamilton of Telestrella Productions to produce a video entitled "You Can't Judge A Stream By Its Color." This video is based on workshops that Mr. Skousen and Mains have taught at USEPA conferences. The video has been developed and produced, and is available from Telestrella Productions. A proposal has been submitted to the Canaan Valley Institute for final production costs and to copy the video and distribute it to watershed organizations in West Virginia.

Influence of Turbidity on the Foraging Success of Brook Trout and Smallmouth Bass

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The impacts of sedimentation on stream habitat and the reproductive potential of fish have received much attention, but information on the effects of sedimentation and suspended solids on the individual is lacking. Brook trout (*Salvelinus fontinalis*) and smallmouth bass (*Micropterus dolomieu*) are top predators in many cold and warm water streams, and their habitats are easily influenced by the landuse practices of man. Individuals of each species were held in an artificial stream channel to test the effects of varying levels of turbidity on reactive distance, probability of prey recognition, and probability of successful foraging attempts. A video camera mounted above the artificial stream channel was used to observe and record feeding behavior. Three individuals of one of the species were tested at a time. This introduced competition between the fish and encouraged a strike by the first individual recognizing the prey. Thus a measurement of maximum reactive distance could be obtained. Each species was tested at turbidities ranging from 0 to 40 NTU's. Turbidity had a negative effect on the maximum reactive distance of both species with reactive distances at high turbidities being significantly lower than those in clearer water. The proportion of prey items recognized by each species also declined significantly with elevated turbidity, however, once a prey item was recognized, the probability of successfully capturing and ingesting that prey item did not change with turbidity. Encounter rates between predator and prey are a function of reactive distance. Decreased reactive distance in turbid water leads to fewer encounters between predator and prey. This could result in decreased growth rates of fish living in streams which have chronically turbid waters.

THE YSI CHOLORPHYLL TECHNOLOGY

Rick Fielder, YSI, Inc.

WHAT IS CHLOROPHYLL?

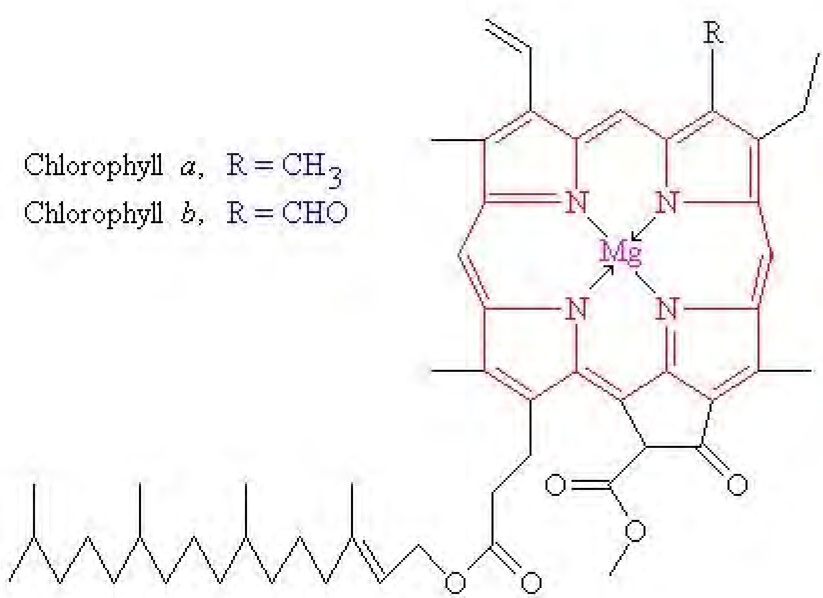
Chlorophyll, in various forms, is bound within the living cells of algae and other phytoplankton found in surface water. Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, the critical process in which the energy from sunlight is used to produce life-sustaining oxygen. In the photosynthetic reaction, carbon dioxide is reduced by water, and chlorophyll assists this transfer.

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{Sunlight}} \underset{\text{(glucose)}}{C_6H_{12}O_6} + 6O_2$$

Photosynthesis

Chlorophyll is present in many organisms including algae and some species of bacteria. Chlorophyll *a* is the most abundant form of chlorophyll within photosynthetic organisms and, for the most part, gives plants their green color. However, there are other forms of chlorophyll, coded *b*, *c*, and *d*, which augment the overall fluorescent signal. These types of chlorophyll, including chlorophyll *a*, can be present in all photosynthetic organisms but vary in concentrations.

Chlorophyll enables plants and other chlorophyll-containing organisms to perform photosynthesis. Chlorophyll is a chelate, or a central metal ion, in this case magnesium, which is bonded to a larger organic molecule, called a porphyrin. The porphyrin molecule is composed of carbon, hydrogen, and other elements such as nitrogen and oxygen. The magnesium ion bonded within this ring is thought to be responsible for electron transfer during photosynthesis. (See structure below).



HOW IS CHLOROPHYLL MEASURED?

There are various techniques to measure chlorophyll, including spectrophotometry, high performance liquid chromatography (HPLC), and fluorometry. All of these methods are published in *Standard Methods for the Examination of Water and Wastewater*, 19th Edition.

Spectrophotometry is the classical method of determining the quantity of chlorophyll in surface water. It involves the collection of a fairly large water sample, filtration of the sample to concentrate the chlorophyll-containing organisms, mechanical rupturing of the collected cells, and extraction of the chlorophyll from the disrupted cells into the organic solvent acetone. The extract is then analyzed by either a spectrophotometric method (absorbance or fluorescence), using the known optical properties of chlorophyll, or by HPLC. This general method, detailed in Section 10200 H. of *Standard Methods*, has been shown to be accurate in multiple tests and applications and is the procedure generally accepted for reporting in scientific literature (see Reference section). The fluorometric method also requires the same extraction methods used with spectrophotometry, then uses a fluorometer to measure discrete molecular chlorophyll fluorescence. However, these methods have significant disadvantages. They are time-consuming and usually require an experienced, efficient analyst to generate consistently accurate and reproducible results. In addition, they do not lend themselves readily to continuous monitoring of chlorophyll (and thus phytoplankton) since the collection of samples at reasonable time intervals, e.g., every hour, would be extremely time-consuming.

YSI has developed a sensor for chlorophyll determinations both in spot sampling and in continuous monitoring applications. It is based on an alternative method for the measurement of chlorophyll which overcomes these disadvantages, albeit with the potential loss of accuracy. In this procedure, chlorophyll is determined *in situ* without disrupting the cells as in the extractive analysis. The YSI 6025 chlorophyll sensor is designed for these *in-situ* applications, and its use allows the facile collection of large quantities of chlorophyll data in either spot sampling or continuous monitoring applications.

It is important to remember, however, that the results of *in-situ* analysis will not be as accurate as results from the certified extractive analysis procedure. The limitations of the *in-situ* method should be carefully considered before making chlorophyll determinations with your YSI sonde and sensor. Some sources of inaccuracy can be minimized by combining extractive analysis of a few samples during a sampling or monitoring study with the YSI sensor data. The *in-situ* studies will never replace the standard procedure. The <u>estimates</u> of chlorophyll concentration from the easy-to-use YSI chlorophyll system are designed to complement the more accurate, but more difficult to obtain, results from more traditional methods of chlorophyll determination.

USES AND DEVELOPMENT OF WATER QUALITY MONITORING TECHNOLOGY

***Jean Kozul and Lynn Haas, National Institute for Environmental Renewal*[1]**

Alternative technologies for water quality monitoring were used to develop an integrated environmental monitoring and data management system for watershed assessments. The system includes a GIS watershed visualization, model analysis and a decision support tool for stakeholder watershed management. The program was funded by a grant through the US EPA. This describes our experiences with data quality using ion selective electrode (ISE) technology for screening dissolved oxygen (DO) and nitrate levels in-situ and our plans for future technology evaluations. We performed the water quality monitoring from 7/98 through 9/98 in the Wissahickon Watershed. The Wissahickon is a 64 sq.mi. urban/suburban watershed in southeastern Pennsylvania (PA), located in the PA Appalachian Piedmont physiographic province. It enters the Schuylkill River in Philadelphia.

The PADEP, the US EPA, and others performed investigations of the Wissahickon in the last decade. Studies indicated impaired aquatic habitats and high nutrient levels in the watershed. In a recent study, nitrate concentrations ranged from not detected to 8.9 mg/l (Boyer, 1997). In 1998, 6 segments of the mainstem (~18 mi.) and several tributaries (~16 mi.) were listed on the 1998 303(d) list. Among the sources and causes of impairments identified by the PADEP were nutrients from wastewater treatment plant point sources and urban runoff and storm sewer nonpoint sources.

Our water quality monitoring program was designed to measure conventional water quality parameters: temperature, pH, DO, conductivity and turbidity, using continuous monitoring technologies in order to assess diel DO at areas of suspected nutrient impairment. We also evaluated ISEs for nitrate and ammonia. Two rounds of stream samples were collected using US Geological Survey flow-weighted sample collection methods for conventional laboratory analysis.

In ISE analysis, the electric potential between a sensing and a reference electrode due to the activity of a specific ion is measured and related to the concentration of the ion species through the Nernst equation. The electrodes are calibrated to standards and react with the sample ion species. The sondes used in this study had combination electrodes. These water quality sondes do not have mechanisms for adding reagent treatments that enhance the specific ion activity responses and measurements to the samples and reference standards (Standard Methods, 1999, 20th Ed).

In order to collect useable data and be able to evaluate its accuracy and reliability, we performed extensive quality assurance/quality control (QA/QC). We used high quality state-of-the-art sensors, which were factory calibrated and checked before use. We verified the DO levels ~ every 48 hrs with calibrated field instruments and recalibrated the DO probe in the field. We verified the DO probe and field instruments measurements using the Winkler titration method. On a weekly basis, we brought the sondes into our field lab and checked the range of the measurements for all parameters using standards. The probes were recalibrated and the calibrations were verified against a second source of certified standards. We kept detailed field and laboratory logs of the QA/QC results.

Fig. 1 is a composite graph of the DO measurements collected by 6 sondes in 17 different locations. In two months, we encountered a few DO sensor membrane failures. The membranes were replaced and the sondes resumed collecting measurements. We compared the means and ranges of the sonde DO data to the DO data from the baseflow sampling. Fig. 2 shows the concentrations of DO measured in baseflow samples, plotted in a longitudinal profile along the mainstem. The 17 sonde locations were at or near baseflow sampling locations. Although the sondes were not in all these locations at the time of baseflow sampling, the mean plots of the sonde

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measurements showed good agreement with the baseflow measurements. Except for the occasional DO membrane failure, fouling caused by algal growth or debris getting caught in the sondes, there was consistent agreement between the calibrated field checks, performed ~ every two days and the sonde measurements. Fig. 3 illustrates the DO concentrations measured by a sonde every 15 minutes over the time it was in one location (L4) in the watershed and the field verifications. Based on the QA/QC data collected over the course of the study, we have a high level of confidence that the ISE technology used gave reliable, good quality DO data.

The ISE technology nitrate measurements collected in this study did not provide a high level of confidence for reliable, useable data. The results of the baseflow laboratory analyses indicated that the nitrate levels in the stream ranged from not detected to 20 mg/l at various sample locations (Fig. 4). Fig. 5 shows the results of all the nitrate measurements collected by the sondes during the study period. The scale of concentrations was plotted from 0 to 100 mg/l to show the majority of the sonde results. Some data were in the 1000's and 10,000's of mg/l and plot off this scale. Most were outside the range of results reported in the 1998 baseflow sampling (0-20 mg/l).

A comparison of the baseflow sample laboratory analytical results to the sonde screening results indicates close agreement of results in only two instances (Figs. 6 and 7). Relative percent differences (RPD) in the close instances are 49.3%, 11.3% and 37.2. In a fourth case, the lab result was 18 mg/l and the sonde read over 5500 mg/l. The baseflow program had a high degree of field and laboratory QA/QC checks (field and method blank, duplicate and replicate samples). The reported results met all data quality objectives and are considered reliable and representative of water quality conditions at the time of sampling. The data comparison shows that as a screening tool, the ISE nitrate measurements were only reliable in isolated instances.

In order to have confidence in the nitrate ISE data, we would need to have significantly increased the nitrate ISE calibration frequency and observed better agreement between sonde measurements and quality control sample results. Unlike the DO probe verifications and recalibrations, which take only a few minutes to perform and cost very little, each nitrate ISE verification, recalibration and calibration check takes ½ to 1 hour to perform. Each sonde required up to 3 hours for testing and recalibration. The standards required for the calibration and QA/QC cost approximately a few hundred dollars. To significantly increase the frequency of the verification and recalibration appeared to be too time consuming and costly for the field screening program.

The potential sources of error in using this technology are pH variability in a stream; the presence of ion interference from other stream constituents; the stream sample contact time can be too brief; and, debris and membrane coating can cause misreading of the sensor. ISE stabilization during calibration often necessitated a "judgment call" on the part of the technician, as readings still drifted after ample calibration time had been provided. Solutions to potential sources of error will be evaluated in a future field program in which we field test some alternative technologies for this type of stream application. Technologies that incorporate flow injection or continuous flow delivery techniques with ISE analyses are under consideration. These techniques involve injection of a discrete or continuous stream sample into a continuously flowing reagent stream in a reaction manifold (or reverse flow injection) followed by ISE measurement.

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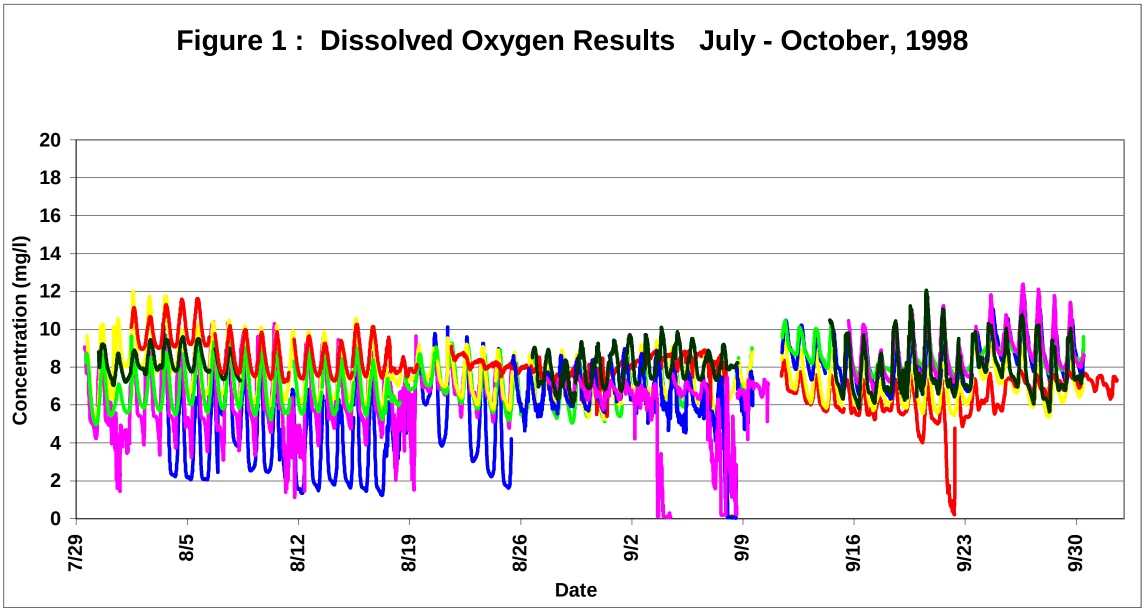


Figure 1 : Dissolved Oxygen Results July - October, 1998
Concentration (mg/l)
20
18
16
14
12
10
8
6
4
2
0
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
9/30
Date

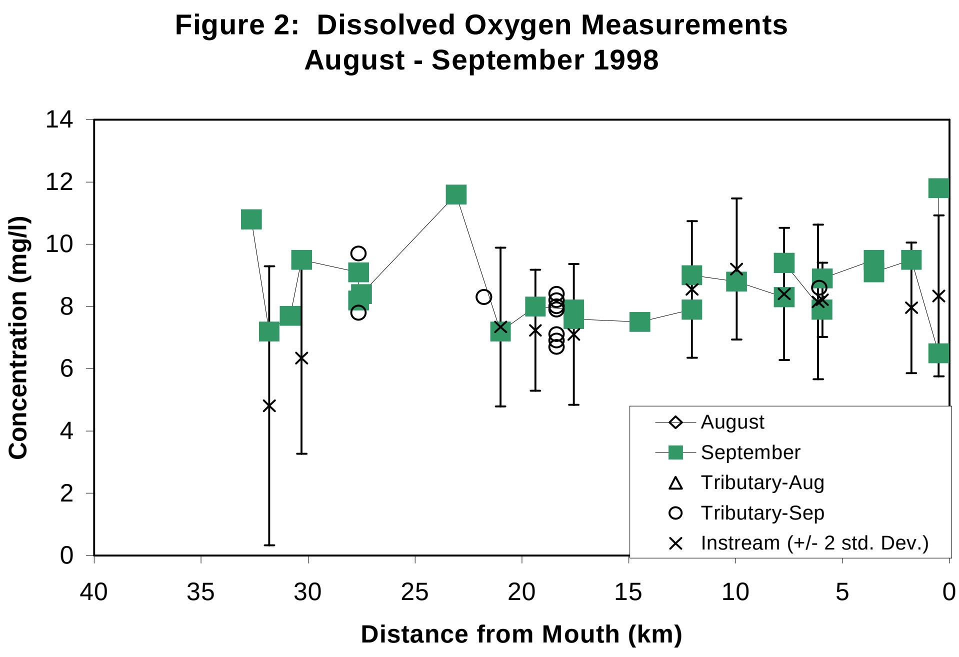


Figure 2: Dissolved Oxygen Measurements
August - September 1998
Concentration (mg/l)
14
12
10
8
6
4
2
0
40
35
30
25
20
15
10
5
0
Distance from Mouth (km)
August
September
Tributary-Aug
Tributary-Sep
Instream (+/- 2 std. Dev.)

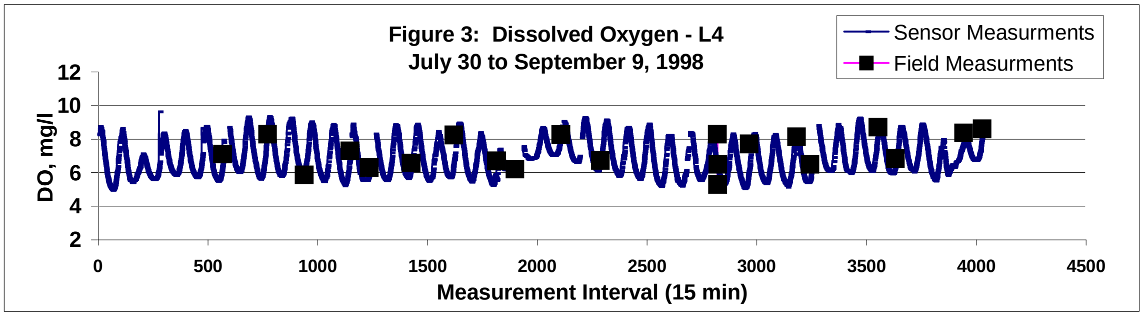


Figure 3: Dissolved Oxygen - L4
July 30 to September 9, 1998
Sensor Measurments
Field Measurments
DO, mg/l
12
10
8
6
4
2
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Measurement Interval (15 min)

Figure 4: Nitrate as N - August & September 1998

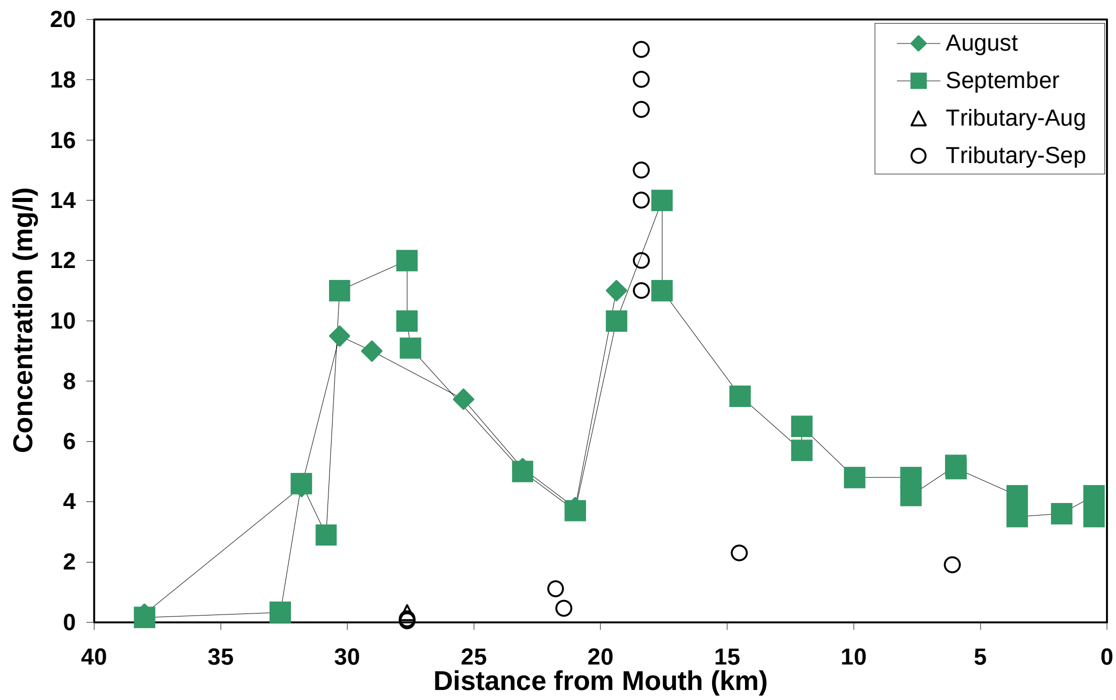
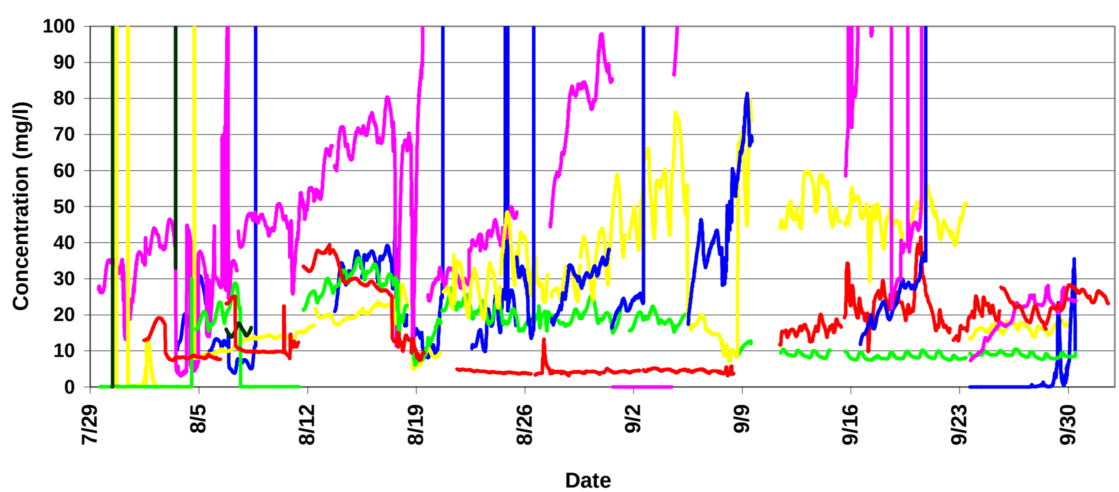


Figure 5: Ion Selective Electrode Nitrate Results
July - October, 1998



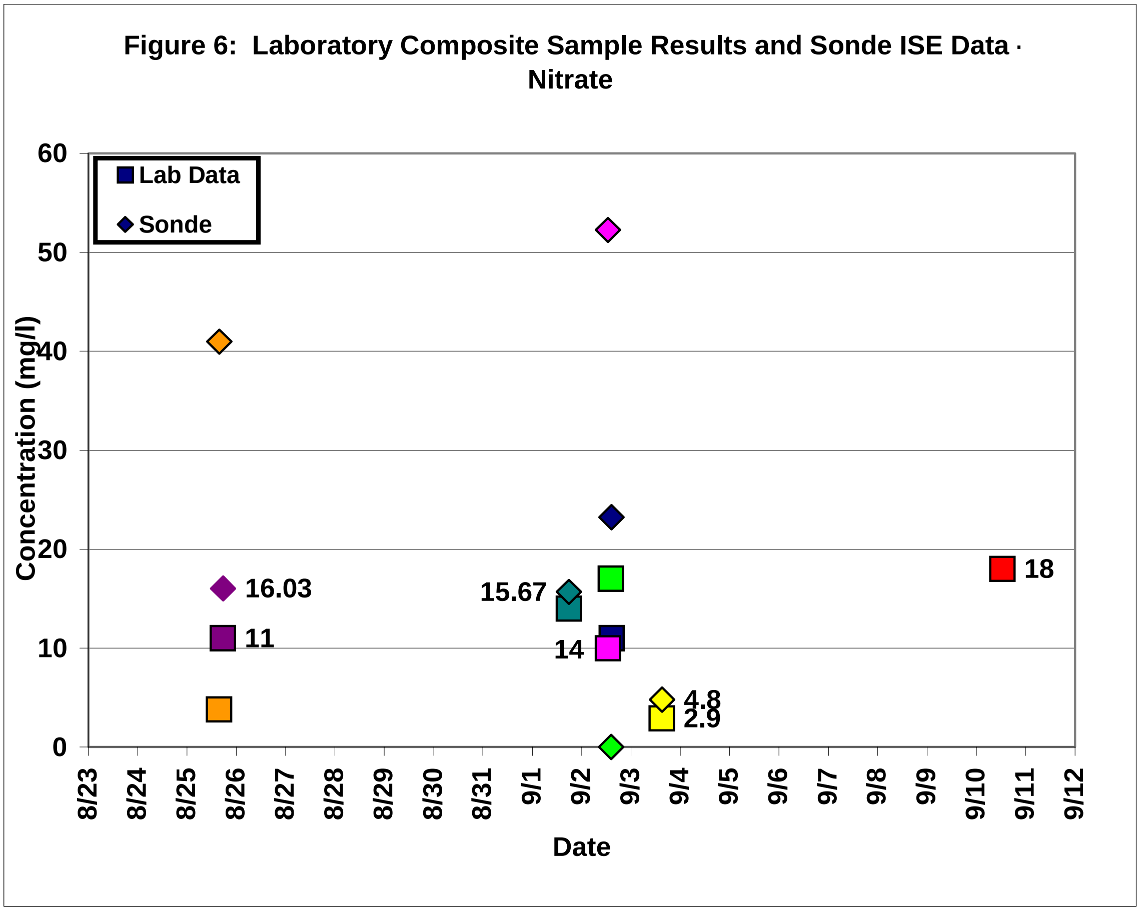


Figure 6: Laboratory Composite Sample Results and Sonde ISE Data - Nitrate
Lab Data
Sonde
Concentration (mg/l)
60
50
40
30
20
10
0
16.03
11
15.67
14
18
4.8
2.9
8/23
8/24
8/25
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
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9/6
9/7
9/8
9/9
9/10
9/11
9/12
Date

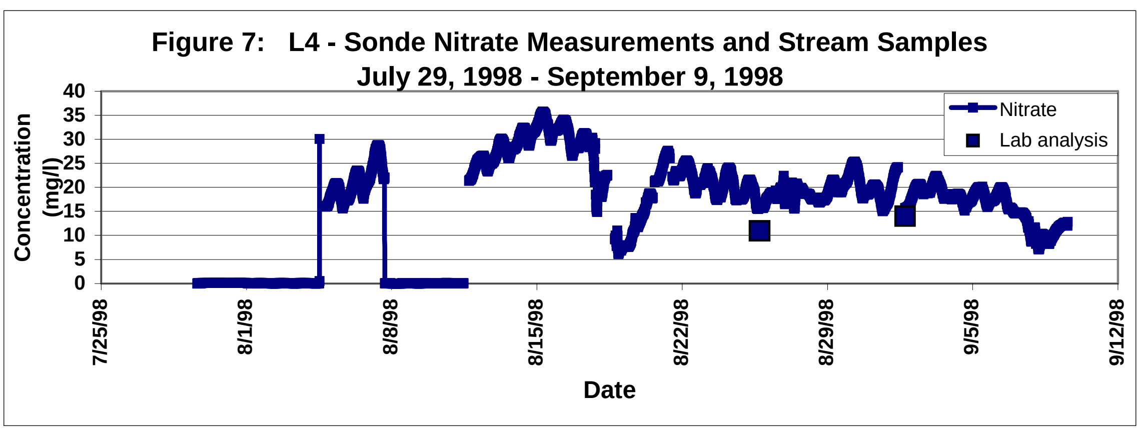

Figure 7: L4 - Sonde Nitrate Measurements and Stream Samples
July 29, 1998 - September 9, 1998
Nitrate
Lab analysis
Concentration (mg/l)
40
35
30
25
20
15
10
5
0
7/25/98
8/1/98
8/8/98
8/15/98
8/22/98
8/29/98
9/5/98
9/12/98
Date

Instrumentation for Multiparameter Water Quality Monitoring—
Spot Checking, Profiling and Long-Term Deployments.

Brian B. Wisehart
Hydrolab Corporation
12921 Burnet Road, Austin, Texas, 78727
800-949-3766, email bwise@hydrolab.com

For over 40 years, Hydrolab Corporation has manufactured multiparameter water quality monitoring instrumentation for reliable field measurements. We are and continue to be the world leader in multiparameter equipment. We had many industry firsts over the years, and parameter availability is expanding with each generation of instruments. Parameters now available include temperature, conductivity, resistivity, TDS, salinity, dissolved oxygen, pH, ORP, nitrate, chloride, ammonium, chlorophyll, transmissivity, ambient light, depth, total dissolved gas and turbidity, available with our new shuttered probe design.

In response to market demand for non-fouling turbidity measurements, Hydrolab has developed an advanced, dependable, accurate, state-of-the-art turbidity sensor for exacting water quality studies. With our new patent pending shutter design the market now has a sensor capable of providing reliable measurements in areas where fouling had precluded measurement in the past.

Hydrolab's shutter technology eliminates the problems associated with wiper designs. Wiped sensors attempt to clean a sensor that has experienced some degree of fouling between measurements, similar to a wiper on a dirty windshield. Hydrolab's sensor covers the optics between samples and opens only during measurements, which eliminates fouling on optical surfaces and therefore extends deployment times. Our sensor now employs a synchronous modulation of an infrared LED, eliminating the concern of ambient light interference. Hydrolab's sensor is equipped with quartz lenses as opposed to plastic materials employed by other instrumentation. Quartz is significantly harder, virtually eliminating the possibility of scratching the optical surfaces. Discussion about other parameters will be covered including steady-state dissolved oxygen measurements, benefits of sample circulation and field proven technology for chlorophyll, total dissolved gas and ambient light.

Water Quality Assessment of the Lower Youghiogheny River Basin

Karl T. Schroeder (DOE), Terry E. Ackman (DOE),

James I. Sams, III (USGS), J. Kent Crawford (USGS)

Abstract

This paper describes the use of the traditional synoptic survey to evaluate the water quality conditions in the lower Youghiogheny River basin from Connellsville, PA to McKeesport, PA. Field work and data analysis was performed as a joint effort of the U.S. Department of Energy, Federal Energy Technology Center (DOE-FETC) and the U.S. Geological Survey (USGS). Water quality sampling was completed during a low-flow period of October 1998. Historical data on mine drainage from 1970 to the present was also evaluated to better understand the current water quality conditions in this river.

The study concluded that the Youghiogheny River should be considered a fragile system. The river was shown to have low alkalinity concentrations which, because of the shear magnitude of flow, translate into a large alkalinity load. However, the river's full chemical potential for neutralizing any acidity produced by mine drainage can be realized only with complete mixing. But, there is an observable lack of mixing and additional inputs could have more serious impacts than the average chemistry would suggest. Consequently, additional or continued contamination could lead to degradation of selective portions of the river. One example would be along the riverbanks where visible iron plumes, deposited by tributaries, hug the edges of the river for miles as can be seen in Figure 1.

The sulfate ion was used to calculate a material balance and as a tracer in this study because of its relationship with mine drainage. As can be seen in Figure 2, Sewickley Creek was the most significant sulfate contributor in the lower Youghiogheny River Basin; it alone contributed nearly half of the load (44%). Historical data collected under similar flow conditions showed that two sites, Brinkerton Mine site and Wilson Run Mine site, accounted for up to 15% of the total Sewickley Creek load, 10% and 5%, respectively. Some care, however, must be taken in using the sulfate ion as a measure of mine drainage impact because it is present in both treated and untreated mine drainage, and there are a few permitted discharges in the watershed.

This synoptic (or summary) survey was completed by trained, experienced professionals, many of whom were familiar with the river. In addition, local conservation groups and various government agencies were consulted regarding all the potential sources of pollution prior to the survey. Yet, when the material balance was completed, over a quarter of the sulfate load was unaccounted for (Figure 2), indicating that some sources were missed. Segments of the river that overlie mined-out portions of the basin where artesian flow is known to exist were identified as the probable locations of the missing pollution sources. It is likely, based on visual observations of iron staining in the river channel, that a large percentage of this missing pollutant load is generated by artesian flow into the river through fracture systems.

The Youghiogheny River has contributed to an economic revitalization within the region, due to a broad range of recreational activities, and continued growth in this area is expected. At present, due to the extensive historical mining practices throughout this region, it is at perpetual risk of becoming inundated with mine drainage, which would have a detrimental effect on the nascent recreational activities. The unexpected and catastrophic discharge of mine drainage into the Casselman River in 1992 presented such a serious threat to the Youghiogheny River that it was thought that the buffering capability would be incapable of absorbing this pollution. Had not the upstream reservoir been available

and opened quickly by the US Corps of Engineers, the resulting acid would have wiped out all of its aquatic life.   Other threats within the river's basin include mine drainage treatment facilities that can fail and depend on the operating company's economic ability to maintain their operation for perpetuity. By addressing and remediating the significant abandoned mine drainage issues within this region, the ability of the Youghiogheny River to handle future environmental disasters, like the Casselman River incident, without dire consequences will be improved. This current load is about at the maximum amount of pollution that the river can handle now.

Figure 1. Sewickley Creek Entering the Youghiogheny River

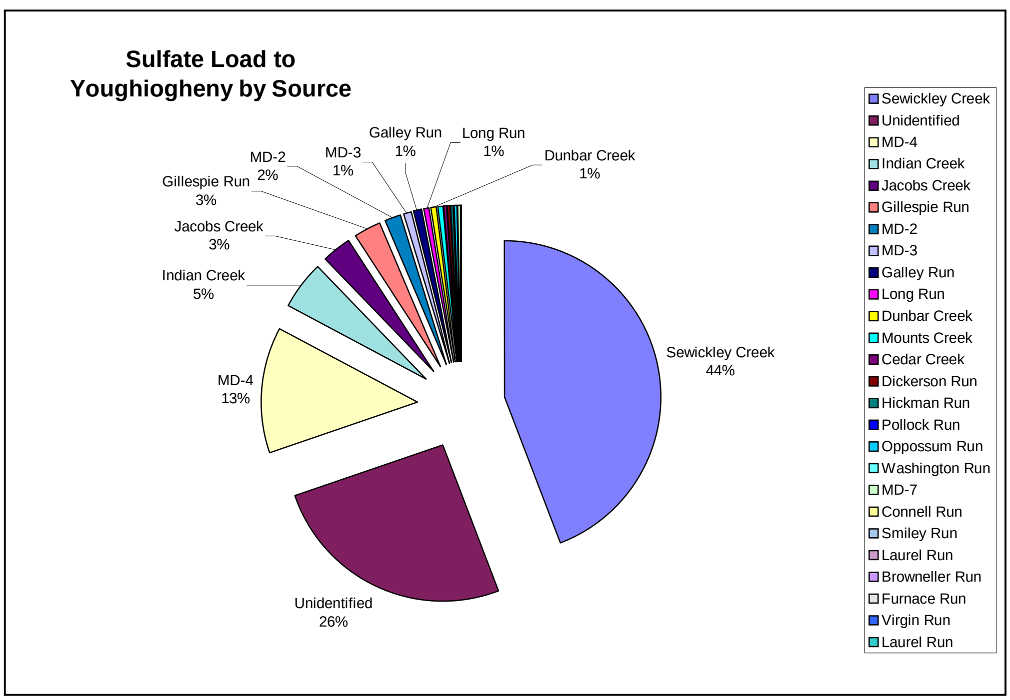

Figure 2. Sources of Sulfate in the Youghiogheny

Detecting River Inflows using Airborne Thermal Scanner Imagery

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Abstract

The modern airborne thermal scanner can be a powerful tool for detecting and mapping locations where inflows such as pipe discharges, tributary streams, and other point sources enter a river. This detectability is made possible by the thermal sensor's capability to measure and record water temperature differences on the order of 0.1 °C while flying over the river at speeds in excess of 100 miles per hour. Swath width of the thermal imagery is typically 2,800 ft (at 2-foot ground resolution), and hundreds of river miles can be covered in a single nighttime mission. Recent thermal mapping projects along Ohio and Kanawa Rivers provide dramatic examples of the nature and frequency of inflows, many of which appear to be associated with industrial activity. Once located on the thermal imagery, the significance of each inflow site can be evaluated by considering the thermal data in conjunction with other site information.

Figure 1. Example of industrial discharge emanating from under the water surface. Temperature patterns in the river have been visually enhanced by contrast stretching. Note the ambient river temperature varies at the surface producing a "mottled" appearance.

Figure 2. Example of point discharge from pipe into the river channel. In this instance the discharge is flowing into the river from above the water level.

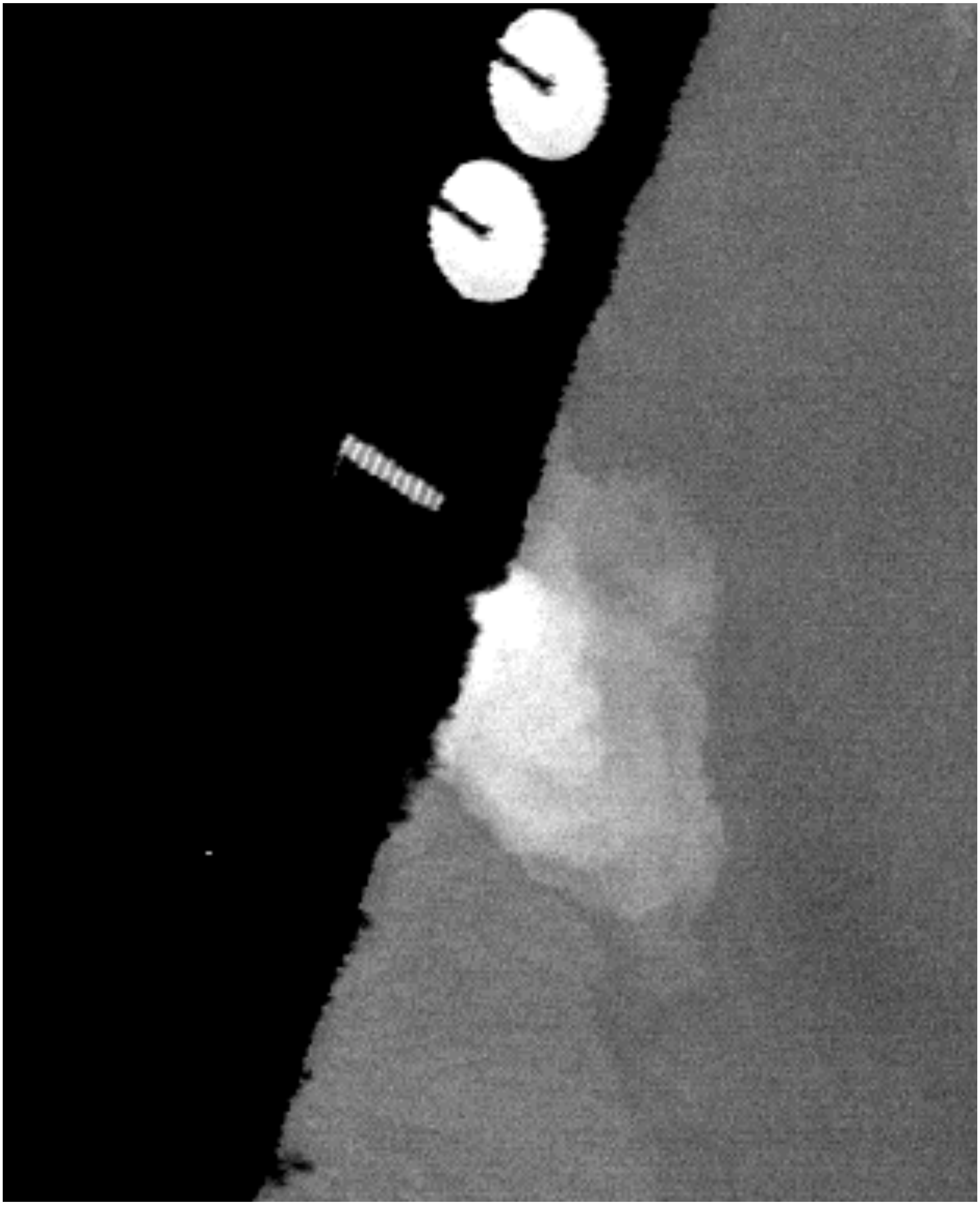

Figure 3. Example of diffuse flow into river channel from storage tank complex. No evidence of above ground discharge pipe was visible on the shore, suggesting source was relatively large drainage ditch or canal.

Figure 4. Example of underwater discharge from power-generating station temporarily blocked by docked coal barge. Discharge 7 degrees warmer than ambient river temperature in this instance.

Polluted Streams Near Colorado Ski Resorts: A Preliminary Study Using RiverTools

Scott D. Peckham
Research Systems, Inc.

Abstract

The Study Area

Nestled among 13000-foot peaks in the heart of Colorado, the scenery that surrounds the ski resorts in Summit County is so stunning that it might seem like the last place you'd find polluted streams. However, these same mountains are where the mining history of the state took place. Although most were abandoned long ago, these mines still contribute a steady stream of acid and heavy metals into otherwise pristine watersheds near the Continental Divide. One of the worst polluters is the abandoned Pennsylvania Mine, located in the Peru Creek subbasin of the Snake River basin in Summit County. Unfortunately, cleanup efforts have been stymied by a loophole in the Clean Water Act of 1972 (ammended by the Water Quality Act of 1987) that could hold those involved in a cleanup effort liable. So far, efforts to add a Good Samaritan clause to the Act have been unsuccessful. An estimated 22,000 abandoned mines are sprinkled throughout the state, with roughly 1,300 river miles suffering from severe water quality degradation.

In preparation for writing a grant proposal to study the area, I wanted to quickly learn as much as I could about the geography of Summit County and some of the affected watersheds. Using the RiverTools software from Research Systems, Inc. (RSI), I was able to learn a lot in a single afternoon, without most of the hassles that are usually associated with data acquisition and preparation, and without any programming. This included extraction of a flow grid and many of the other data layers that I would later need for further study and modelling of the local hydrology.

RiverTools is much simpler to use than a full-blown GIS, and has many built-in tools for doing things that are specific to the analysis of topography and river networks. However, it also has a suite of user-friendly command-line routines that can be used interactively in IDL for customized applications. (IDL, or Interactive Data Language, is the flagship product of RSI.) Furthermore, the data products created by RiverTools can easily be imported into a GIS or a customized model for further analysis. Here is a step-by-step outline of a small project that highlights the ease-of-use and a few of the novel features.

Downloading the Elevation Data

First, I used a hydrologic units map to find the bounding lats and lons for Summit County, Colorado. This map is available from the USGS and is called "Surface Water and Related-Land Resource Development in the United States and Puerto Rico." It shows the major river networks of the U.S. and is overlaid by lines of latitude and longitude with a 1-degree spacing. I found out that the Snake River basins straddled two 1-degree cells, and that the southeast corners of these cells had a latitude of 39 and longitudes of 106 and 107. I then used the lookup table in the Prepare > USGS 1-Degree DEMs menu to get the corresponding USGS map names from the lat/lon codes of 39106 and 39107. Given these map names, I was able to quickly download the two USGS 1-Degree DEMs that I needed from the USGS EROS Data Center by anonymous FTP (edcftp.cr.usgs.gov). I uncompressed them with the free gzip utility. After decompressing, these ASCII files are fairly big, about 9.8 MB. Using the Prepare > Convert DEM dialog in RiverTools, it was easy to convert these DEMs to a much more compact binary format and create RiverTools info files (a metadata file) for them.

Reading and Displaying the Data

The next step was to create a DEM for the Snake River basin by mosaicking and subsetting the two 1-degree DEMs. RiverTools has a simple Add and Remove type of dialog for mosaicking DEMs called Prepare > Patch Fixed-Angle DEMs. This tool displays shaded relief mock-ups of the DEMs with seams, and then lets you select a subregion with a rubber-band box. Since these USGS DEMs contain an extra row and column, the dialog has check boxes that allow chosen edges to be ignored. (Note that the bounding box info in the info file should also reflect the extra row and column; e.g. the north edge latitude was 40.000833.) I selected the Snake River basin and then created a new DEM and info file for it with a single mouse click.

Before moving on to the extraction of other data layers, I created several shaded relief images of the DEM with the Shaded Relief dialog in the Display menu. I tried several different color schemes and light source angles, and also used several of the interactive window tools like the Line Profile, Surface Zoom, Value Zoom, Add Scale Bar, and Flood Image tools to explore the topography. (The Vector Zoom and Channel Profile tools can't be used until a flow grid has been created from the DEM.) The Line Profile tool can be used to measure distances, since it reports distance and elevation info in the log window. This showed, for example, that the Pennsylvania mine is a mere 5.7 km from Arapahoe Basin (across a divide) and only 13.4 km from the Keystone ski area, which is located downstream. Dillon reservoir, which is at the outlet of the Snake River basin, was apparently created after the USGS DEMs were made. However, I was able to "add it in" with the Flood Image window tool.

It was also a snap to create a nice rainbow-colored contour plot for the region, and to display it with various map projections and alternating black and white "box axes" around the edges. (See Figure.) This vector-drawn plot looked great when saved and printed as color PostScript.

Extracting Hydrologic Information

After less than a half hour of prep work, I was ready to begin extracting hydrologic information from my new DEM. The Extract menu in RiverTools contains many fast and easy-to-use dialogs for computing a treasure trove of derived quantities, starting with only a DEM. The first dialog in the menu is a one-button utility for computing a D8 (deterministic - 8 flow directions) flow grid from the DEM. This routine first creates a depressionless DEM, if necessary, and like the other extraction routines, can handle extremely large DEMs. The speed and one-step simplicity are both impressive, especially for someone who has struggled to create flow grids with other software.

The next dialog in the Extract menu is a slick graphical tool for specifying the outlet location (as a pixel) for a basin of interest. You first click on a shaded aspect backdrop, and a streamline is drawn downstream from the pixel you selected to the edge of the DEM. You then move a slider to select a particular pixel in the DEM as an outlet from along this streamline. The location of the selected pixel is shown via a red/white interface on the streamline, and the lat and lon of the pixel are reported in a log window. (See Figure.) Once you've selected a pixel this way, you save the outlet information to a file with a mouse click. This outlet is then used for subsequent analysis (with other dialogs in the Extract menu) of the basin that drains into it. You can specify and analyze several basins in the same DEM this way, since each basin has its own "basin prefix" that can differ from the "data set prefix" that is used for the DEM and associated grids.
The View Basin Info dialog in the File menu gives a handy report of major basin attributes like drainage area (198.8 sq km for the Snake), relief, and outlet coordinates and elevation, etc. for the selected basin.

Using other dialogs in the Extract menu, I created a river network map and a basin boundary map from the flow grid. While creating the vector-based river map, a large number of attributes are automatically computed and archived in a vector format for each pixel, link and Strahler stream in the extracted river network. These include things like drainage density, Strahler order, channel length and slope, and contributing area. The Analyze menu has a large number of tools for analyzing and plotting this data. I also created several raster grids, including a flow distance grid and a topographic index grid. With the Surface Plot dialog in the Display menu I was able to drape these grids over a 3D surface plot. This was very useful for making a visual assessment of the surface geometry and for identifying regions that were most likely to become saturated with the spring snow melt.

Conclusions

While the analysis described above was exploratory in nature, I was able to learn a lot about my study area in a short amount of time. Since ski resorts in the area are proposing to extract more water from the Snake River for snowmaking, and since this polluted snow will eventually melt and run off into adjacent watersheds like Jones Gulch, I was particularly interested in the location of the Pennsylvania Mine relative to the ski resorts. Since runoff is roughly proportional to contributing area, the downstream dilution of contaminants is partially governed by the contributing area of the uncontaminated watersheds in the Snake River system. While RiverTools 2.0 rapidly computes many of the grids that are needed for a fully-distributed hydrologic model, the current version is geared toward the kind of fast and easy topographic analysis described above.

Remote Sensing for Acid Mine Drainage

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Abstract

Mine drainage is the most significant source of water pollution in the coal fields of the Appalachian region of the United States. Large volumes of acid mine drainage (AMD) flow out of the ground (by both gravity and artesian flow) in areas adjacent to, and within several of the region's rivers, including the Monongahela and the Youghiogheny Rivers. In the case of the former, there is significant potential for future problems as commercial mines that were closed about a decade ago are filling up with water and will likely discharge into the Monongahela River. In the case of the Youghiogheny River, mine drainage from early- to mid-century underground mines workings (pools) have been generating an adverse impact on the river's water quality for decades. The Youghiogheny River's ability to maintain aquatic life, and it's recreational and regional development potential remains threatened as the result of these early mining activities. Furthermore, several major tributaries also discharge polluted (metal-laden) water into the Youghiogheny River. DOE/FETC had teamed-up with the U.S. Geological Survey, the PaDEP and several regional watershed organizations to conduct a synoptic water quality survey of the Youghiogheny River to determine which source, tributaries or artesian groundwater flow in the river channel, is the most significant threat to the health of the river. Although the synoptic water quality survey quantified the sources of pollution, it could not specifically identify where artesian flow was entering through the river bottom due to accuracy limitations in existing river gaging technology.

A remote sensing technique, thermal infrared (IR) imagery, was successfully applied this past winter by the Federal Energy Technology Center (FETC) of the Department of Energy (DOE) for the diagnosis of water pollution problems on a watershed basis. This first-time application of the airborne thermal IR technology to mine drainage issues identified locations where the ground water contacts the cooler surface (land and water) within the following survey sites: (1) a 90-mile segment of the Youghiogheny River's lower basin, (2) a 167 square mile watershed (Sewickley Creek), (3) a 100-mile segment of the Monongahela River (from McKeesport, PA to the West Virginia state line); and (4) a five-mile segment of three streams in West Virginia (West Fork River, Buffalo Creek and Dunkard Creek), starting at their confluences with the Monongahela River. The objectives of applying remote sensing technologies to suspected or known environmental problem areas include: (1) quickly and efficiently identifying pollution sources on a regional and/or watershed basis, (2) accurately targeting subsequent ground-truthing activities and site-specific evaluations, (3) identifying specific hydrologic problems or pollution characteristics so that appropriate remediation strategies can be designed and/or implemented, and (4) providing a technical and scientific foundation for the development of regional watershed remediation plans.

The Remote Sensing Laboratory (RSL) operated by Bechtel Nevada (BN) for the Department of Energy in Las Vegas, Nevada conducted the thermal IR surveys with a Daedalus AADS1286 Multispecral Scanner System (MSS) configured with dual thermal infrared detectors as the primary sensor. This configuration allowed the 12 channel, "state-of-the-art" airborne electro-optical line scanner to use both 3-5 and 8-12 micron detectors to sense emitted thermal infrared energy. This sensor package was mounted on a MBB BO-105 helicopter and flown at an altitude of 1,300 feet and could detect temperature differences as low as a 0.1° centigrade. The ground sample distance (GSD) for this study was approximately one square yard or three square feet and the surveys were conducted at night to eliminate thermal loading from the sun. A total of 10 days of flight time were required to complete all surveys.

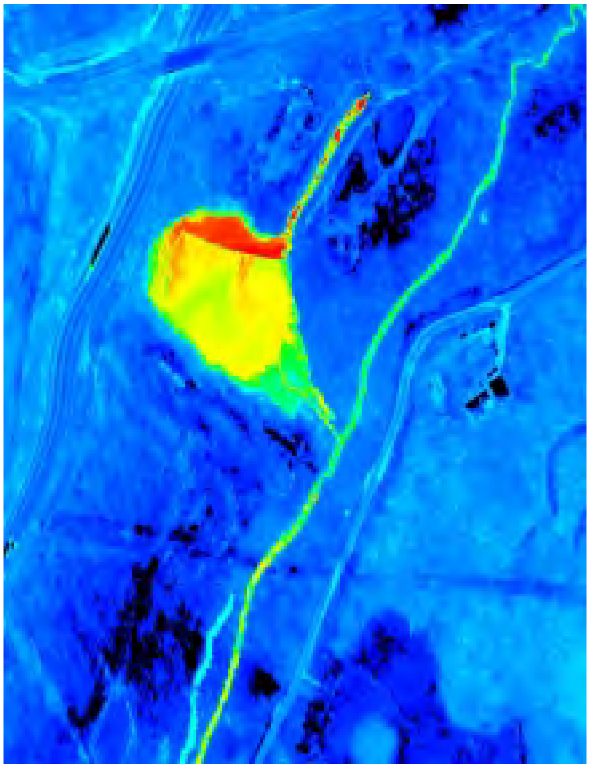

Figure 1. Thermal image of an abandoned mine site, which discharges to Wilson Run (a tributary of Sewickley Creek). The red and yellow colors indicate warmer temperatures. An artesian discharge from an old shaft enters the pond containing a baffle, and subsequently, enters Wilson Run.

Thermal IR images pinpointed areas of artesian discharge in the shallow river channel by showing thermal plumes or signatures. In addition, other locations where the warmer groundwater meets the cooler surface (on land and in streams and in wetlands) were identified. In the Sewickley Creek watershed many well-known mine drainage discharges were clearly identified by their thermal signatures. In addition, apparent septic tanks and sewage discharges were also identified. Ground-truthing/characterization of the numerous unknown targets is required and currently underway in cooperation with various government agencies and grass-roots organizations.

The primary issue being addressed with remote sensing technologies is the manageability of watersheds, which can be on the order of tens, hundreds, and even, thousands of square miles in size. The ability to locate, characterize and remediate water pollution sources on a watershed-basis or over large tracts of ground is overwhelming to both government agencies and watershed organizations. A "holistic" approach to watershed management, at present, is either rare or nonexistent. The size of watersheds typically prevents a holistic watershed approach from being pursued in a timely, efficient, and scientific manner. Rather, the norm is to select very manageable (e.g., small) subareas for analysis geared more toward investigating known, visible discharges and their impacts. This latter approach can detract from understanding the overall watershed condition and from identifying watershed restoration opportunities, including, in particular, non-point discharges. The holistic approach created by remote sensing generates new perspectives in terms of characterization and remediation. At present, there is a very short list of remedial options available to address the high volumes of water associated with underground mine discharges. Ground efforts need to expand the currently accepted characterization approaches and to focus on innovative water pollution prevention and treatment approaches.

THE LATEST TECHNOLOGIES TO CONTROL AND TREAT ACID MINE DRAINAGE

By

Jeff Skousen and Paul Ziemkiewicz
West Virginia University

Acid mine drainage (AMD) control technologies are measures that can be applied where AMD formation has already taken place or is anticipated. At-source control methods treat the acid-producing rock directly and stop or retard the production of acid, whereas treatment methods add chemicals directly to acidified water or direct the acid water through passive systems for treatment. Due to long term water treatment, its costs and liabilities, cost-effective methods which prevent the formation of AMD at its source are preferable. Some control methods are most suitable for abandoned mines and others are only practical on active operations. Others methods can be used in either setting.

Some of the techniques have been very successful, while others have been only partially successful. This may be due to several site-specific factors including: mining technique, rock type and chemistry, ground water flow rates, etc. While a technique that controls 80% of a site's acid production and reduces long term operation and maintenance costs may not relieve a mine operator of liability, the method may be suitable for active sites which meet certain criteria, abandoned mine reclamation programs, or watershed restoration projects. Removing a significant portion of the acid or metal load in a watershed by partially-effective control strategies may improve the health of a stream to a point of re-introducing some fish species or re-establishing some designated uses of the stream. Alternatively, the method may be combined with another partial control scheme to achieve effluent limits.

Alkaline recharge structures have received attention recently because several new alkaline materials (steel slag, kiln dust, AMD sludges) have been found that can generate high alkalinities. The highly alkaline water is then introduced into a backfill when it contacts AMD for neutralization. Recent studies have also documented the positive benefits of remining abandoned mine lands. Where AMD occurs, remining reduces acid loads to streams by 1) decreasing infiltration rates, 2) covering acid-producing materials, and 3 removing the remaining coal which is the source of most of the pyrite. Remining has been combined with alkaline addition and special handling to change water quality from acid to alkaline at many sites.

Chemical treatment of AMD to remove metals and acidity is often expensive and a long term prospect. However, limestone sand application has shown great success for restoring streams at low cost. Replenishing the limestone sand is needed every 3 to 4 months, so a system to generate money to prolong application is needed.

Passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to cleanse contaminated mine waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), vertical flow systems such as successive alkalinity producing systems (SAPS), and open limestone channels (OLC). At their present stage of development, passive systems can be implemented as a single permanent solution for many types of AMD at a much lower cost than active treatment. Selection and design of an appropriate passive system is based on water chemistry, flow rate, and local topography and site characteristics, and refinements in design are ongoing. In cases where theassive systems have not met treatment expectations, evaluations are being conducted to determine reasons for poor results.

Remediation of Acid Impaired Waters: From Idea to CRADA, and Beyond

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The Conservation Fund's Freshwater Institute

Barnaby Watten
USGS/BRD Leetown Science Center

Abstract

The Idea

Four years ago The Conservation Fund's Freshwater Institute (FI) and the US Geological Survey's Biological Resources Division (USGS/BRD) were both searching for a more economical and efficient technology for remediating acid impaired waters than those currently available. The partners already had a long-term relationship conducting research in the area of aquaculture process control. The Institute was interested in developing a technology for reclaiming acid mine drainage for use as aquaculture supply water, and for pH control within recirculating aquaculture systems. The USGS/BRD's interest was from the angle of watershed restoration. The two partners combined their resources and developed prototypes that effectively achieved these goals. The technology uses pretreatment of the influent water with carbon dioxide and pulsed limestone beds. Limestone dissolution is greatly enhanced with this technology and the armoring common to other limestone-based treatment systems is eliminated. As the original idea was the intellectual property of the USGS/BRD, patents were applied for and successfully attained by the agency. Both partners were confident that this technology had commercial viability and decided to enter into a Cooperative Research and Development Agreement (CRADA) to further develop the technology. The CRADA provides the government researcher with an opportunity to receive funds for the additional research that is needed and provides the private cooperator access to federal intellectual properties and licensing options.

The CRADA

A key feature of the Technology Transfer Act of 1986, CRADAs encourage federal and non-federal parties to work together and make optimal use of their technical and financial resources. The CRADA acts as an incentive for commercialization of federally-developed technology. Operating within a CRADA, the non-federal partner provides resources such as funds, facilities, and personnel, while the federal partner provides similar resources, but no funds. The primary components of a CRADA are the Statement of Work and the General Provisions. The Statement of Work outlines the work to be conducted and the responsibilities of the individual parties while the General Provisions constitute the legal framework of the agreement.

Benefits of a CRADA

- Enables both partners to leverage their research budgets and optimize resource use.
- Provides a means for federal and non-federal partners to share expertise, ideas, and information in an environment that protects intellectual property.
- Provides industry with access to a wide range of expertise in many disciplines.
- Allows partners to agree to share intellectual property emerging from the effort.
- The government may protect information emerging from the CRADA from disclosure for up to five years, if this is desirable.

CRADA Steps

1. Technology/Partner Search
2. Determine Validity of Partner
3. Development and Negotiation of CRADA Terms and Statement of Work
4. Federal Administrative Review
5. Federal Administrative Approval
6. Post-Project Evaluation

The Beyond

There is a distinct need within the field of acid mine drainage (AMD) treatment for alternatives to conventional active AMD treatment. Creating a simple and economical AMD treatment technology that utilizes limestone instead of the caustic materials typically used in active treatment systems will fulfill the needs of this clientele. The CRADA is intended to make commercially relevant improvements to the configuration and mechanics of the current technology through additional engineering efforts and utilization of field test results. The parties anticipate that re-engineering and field testing of the technology will allow them to develop a practical, cost effective, and easy to use AMD treatment system that has appeal to a wide variety of potential users. If the engineering and testing develops as planned the Institute anticipates licensing the technology or any improvements.

The Freshwater Institute has recently partnered with the Canaan Valley Institute (CVI) to develop cooperative approaches among public and private stakeholders in order to solve problems associated with watershed restoration in the four-state region served by CVI. Using a “collective expertise” approach, they will focus on technical innovation and leveraging of funding resources to address regional water pollution problems and restore aquatic systems. Through this alliance, and within the framework of the CRADA, the Institute will be able to provide technical assistance to the USGS at the Friendship Hill Demonstration Site, and develop a second AMD remediation site using the Leetown Technology at Mill Run, an acid impaired stream in Allegany County, Maryland. The work at this site will benefit the local community through restoring the stream’s aquatic resources, while at the same time providing further opportunity to develop key aspects of the Leetown Technology.

SEASONAL VARIATION OF DIATOMS AND MACROALGAE FROM STREAMS DRAINING ABANDONED AND RECLAIMED COAL MINES AND NON-IMPACTED SITES

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Ten streams along a gradient from acid mine drainage (2), reclaimed (6), clean streams (2) were sampled monthly for one year. The streams were placed into one of five categories according to the type of drainage received and regulation period under which strip mines were reclaimed (Table 1). Physical and chemical properties of the streams were measured and included the following: pH, conductance, aluminum, iron, manganese, sulfate, orthophosphate, nitrate, temperature, turbidity and current velocity. At each site macroalgae were evaluated over a 20-meter stream segment and voucher specimens collected. Diatoms were scraped from five rocks selected randomly from a riffle area. The diatoms were subsequently cleaned, identified and enumerated. For cluster analysis (not shown) and canonical correspondence analysis (CCA) data were grouped by season. Separate analyses were conducted on the diatom and macroalgal data sets. The significance of the first four CCA axes was tested utilizing Monte Carlo permutation tests (1000 permutations, $p = 0.05$). In the diatom analyses, the greatest amount of species variance was explained by the summer data set (85%), followed by the fall data (74.7%), spring data (47.9%) and the winter data (37.9%). Using the macroalgal data set the greatest amount of species variance was explained by the spring (72.4%) and fall data (70.2%). Spring (27 species) and fall (26 species) were the most species rich sampling seasons for macroalgae. In all CCA analyses, pH was highly correlated with the first axis, but current velocity, orthophosphate and sulfate were influential in

additional axes for particular seasons. Based on the algal analyses four groupings of streams were evident: AMD streams (BF, LH, DR), “teeter-totter” streams (MR, SC), intermediate water quality streams (UN1, UN2, MF) and clean streams (SR, WR). AMD streams seem to be characterized by a dominant flora of *Eunotia exigua*, *Frustulia rhomboides*, *Klebsormidium* sp. and *Microspora tumidula*. “Teeter-totter” streams fluctuate between acidic and circumneutral pH and have a greater abundance of *Brachysira vitrea* and *Fragilaria capucina* than other streams in this study. The diatom *Achnanthidium minutissimum*, which is known to be a disturbance resistant taxon, dominated intermediate water quality streams. The relationship among stream water quality, macroalgal presence/absence, diatom community and reclamation regulation will be discussed.

Table 1. Stream names with corresponding abbreviations and initial site classification.

Stream	Category
Brush Fork Long Hollow	Still receiving AMD from abandoned strip mines.
Dorr Run Minkers Run	Draining strip mines reclaimed prior to 1972.
Un-named 1 Scott Creek	Draining strip mines reclaimed prior from 1972-1982 under Ohio Revised Code 1513.
Mud Fork Un-named 2	Draining strip mines reclaimed after 1982 under SMCRA.
Spruce Run Wildcat Run	Clean reference site

Opekiska Pool Study
Monongahela River

Gary Bryant
USEPA, Region III

Abstract

Project Background

Underground coal mines on the west side of the Monongahela River have mined out hundreds of thousands of acres. While these mines are active, they must pump and treat water to keep the mines dry. Coal companies installed treatment facilities in the mid 70's to treat mine water, and this resulted in a dramatic improvement in the quality of the River. For example, the pH at Morgantown went from the low 4's to the mid 7's as these treatment units went on line. Many of those mines closed in the mid to late 1990's and their water treatment facilities have been shut down. The mines are now flooding and as the water levels rise in the mines the barriers between mines are stressed with increasing pressure. The many characteristics of connections between mines, both horizontally and vertically, become important factors in determining how large a mine pool will become and whether it will discharge to the surface.

An example of this occurrence is the "Fairmont Pool" located just north of Fairmont, WV, covering 27,000 acres. This pool was blamed for discoloration of Buffalo Creek in October 1996 and officials took action to avoid other discharges from boreholes as the pool level continued to rise. A siphon was installed in early 1997 to drain the "Fairmont Pool" mine water to an adjacent mine pool that could be pumped and treated by one of the large mine drainage treatment facilities which had recently been shut down. The "crisis" continues to be kept under control by this stop-gap measure.

There is a series of underground mine pools forming in the abandoned Pittsburgh Coal mines from Fairmont to Pittsburgh. These mines are generally west of the Monongahela River and dip to the west. The impact on the Monongahela will be felt as the water in these pools reaches a discharge level. The mainstem is impacted by two significant permitted discharges, that of the Fairmont sewage treatment facility and that of the Monongahela Power Company's coal fired power plant discharges. Some tributaries of the Monongahela are impacted by coal mine discharges and sewage overflows, while others are good quality streams.

Because there is a need to study surface water to complement the groundwater studies, several agencies have come together to outline a study plan. These agencies include Office of Surface Mining (OSM), Federal Energy Technology Center (FETC), United States Geological Survey (USGS), National Mine Land Reclamation Center (NMLRC), West Virginia Department of Environmental Protection (WVDEP), United States Army Corps of Engineers (USACE), and Environmental Protection Agency (EPA).

Objectives

Data collection and reporting will follow EPA standard operating procedures for stream sampling. The accuracy and precision shall be sufficient to evaluate compliance with stream water quality criteria, appropriate stream water uses, and computer models accuracy in predicting stream water quality. Finalized data will be stored in STORET or its successor for public access. All data will be subject to peer review by the design team as well as the Quality Assurance/Quality Control Officer for meeting quality objectives.

Project Procedure and Organization

Team Leader - USEPA
Flow Data - USGS
Riverbed Characteristics - USACE
Periodic Monitoring of Chemistry & Flow - OSM, EPA, & WVDEP
Stream quality assessment surveys - WVDEP & EPA
Low flow profiling of Opekiska Pool - USACE
Stream Chemistry Analysis - FETC
Computer Modeling - FETC & EPA TMDL staff

This project will monitor and develop a model of stream water quality in the Opekiska Pool of the Monongahela River. Data will include monthly sampling of selected stream stations on the tributaries and the mainstem for mine drainage parameters. WVDEP will also include these stream monitoring points as part of their ongoing effort assessing the current quality of watersheds across WV. The US Army Corps of Engineers will conduct their yearly survey of water quality in the Opekiska Pool during low flow conditions. Additional data will be available from the long term ambient monitoring from the Star City Bridge station and other monthly stream samples collected from the Opekiska Pool. WVDEP will conduct a chemical and biological survey of Flaggy Meadow Run. FETC contractors have already conducted thermal surveys of the lower five miles of Buffalo Creek, Paw Paw Creek, and the West Fork River. All these data will be shared with OSM and FETC for use in modeling groundwater and surface water at the Opekiska Pool area. The project will support efforts to scientifically establish effluent limits for facilities which treat water from flooded mines in this region and regions downstream.

Data will be collected using specified methodologies. For Flow Rate, USGS gages will be used on the Tygart Valley River at Colfax, on the West Fork River at Enterprise, on Buffalo Creek at Barracksville. The US Army Corps of Engineers flow values for gate openings will be used for the Opekiska Dam. Flow rate will be measured using area/velocity methodology at the sample locations on Paw Paw Creek, Indian Creek, Prickett Creek, and Whiteday Creek. Stream chemistry sampling and analyses will follow EPA protocol for ambient streams and the laboratories will be certified by WVDEP. Whenever feasible, streams shall be sampled at quarter points across the stream width and composited into a single sample. Finally, aquatic biology sampling and analysis will follow EPA s Rapid Bioassessment Protocol methodology.

Holistic Watershed Approach

Lindsay Abraham, Greg Adolfson, Eric Dannaway, Mike Sheehan, and Sheila Vukovich
West Virginia Division of Environmental Protection
Office of Abandoned Mine Lands & Reclamation
Stream Restoration Group [1]

Abstract

The Holistic Watershed Approach provides an all encompassing study of an entire watershed in which all treatment alternatives for polluted coal mine drainage (PCMD) from abandoned mine lands are evaluated and the concern of all interested parties are accommodated. By applying the Holistic Watershed Approach, six major benefits can be accomplished.

First, the approach *establishes* guidelines for a universal monitoring procedure applicable to multi-user needs. In the past, data has been collected by various federal, state, and local agencies, citizen groups, and industry according to their own needs. When the data is shared among the various users, many times parameters needed by the second party are missing.

Second, the Holistic Watershed Approach *delineates* the watershed wide impacts of PCMD from abandoned mine lands sources by providing a snapshot of the entire watershed for a range of flow conditions. Comprehensive sampling of all tributaries and mainstem stream segments throughout a watershed enables a selection of problem areas for treatment.

After the problem areas within a watershed have been identified, the Holistic Watershed Approach *prioritizes* affected stream segments and tributaries by comparing acid and alkaline loading based on flow and water chemistry data. The affected stream segments and tributaries near the headwaters receive a higher priority because the water from these affected areas will have detrimental affect on the entire watershed.

Once a high priority problem area has been determined, water chemistry and flow data of the PCMD source water and the receiving stream are collectd and analyzed. The Holistic Watershed Approach then *designates* the appropriate pollution treatment alternative based on stream and PCMD source criteria. Some treatment examples are: wetlands, limestone channels, and in-stream limestone treatment. In addition to PCMD, the Holistic Watershed Approach can be used to determine the affects of other pollutant sources within a watershed.

The approach allows uniform *documentation* of biological, chemical, and physical conditions in a watershed. The documentation provides criteria for comparison of water quality before treatment to water quality after treatment. Coordinated efforts of federal, state, and local government agencies; and citizen groups allows large scale biological, chemical, and physical

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1 . Stream Restoration Group members include: Lindsay Abraham, Greg Adolfson, Eric Dannaway, Mike Sheehan, and Sheila Vukovich.

surveys to be conducted within a watershed. A watershed survey could be too large of a scope for an individual agency or group, but can be accomplished through such coordinated efforts. Finally, the Holistic Watershed Approach *relates* to the public by providing highly visible, measurable environmental indicators of stream conditions based on aquatic organisms and stream usage. Public interest is stimulated by easily recognizable benefits.

By applying the Holistic Watershed Approach through cooperative efforts of the West Virginia Division of Environmental Protection Office of Abandoned Mine Land & Reclamation, other government agencies, industry, and the public, the natural splendor of the streams and ecosystems of the state can be restored.

West Virginia Division of Environmental Protection
Office of Abandoned Mine Lands & Reclamation
Stream Restoration Group's

HOLISITIC WATERSHED APPROACH PROTOCOL

I. Define the *study area*.

- Select mainstem stream and determine watershed boundary.

II. Establish *comprehensive monitoring network* within the *study area*.

- Select and number stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations and at extensive locations throughout the mainstem tributary stream reach.
    - Establish project name and nomenclature.
    - Number all stream sampling stations in ascending order, beginning with the most downstream station.

III. Obtain coordinates and map *comprehensive monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data
    - Collect sampling station positions using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name, date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.
    - Update Stream Restoration Group Project Coordinates Log
        - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
    - Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
- Generate project map of all sampling stations.

IV. Implement sampling sweeps of the *comprehensive monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
  - Prepare chain of custody (COC) form for laboratory.
    - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
      - Stream sampling variables include: flow; field temperature, pH, and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
  - Prepare sampling equipment for field use.
    - Calibrate electronic field equipment.
    - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
  - Prepare sampling stations for water sample collection.
    - Stake sampling stations as close to collection point as possible.
      - Label stake with sampling station number.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
      - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
      - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
      - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
  - Perform field measurements.
    - Obtain insitu values of water quality measurements at all sampling stations.
      - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
      - Measure uniform width segments of the total water cross section utilizing a tagline.
        - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
      - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
      - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.

            - Record water depth (tenths of feet).
            - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
            - Record velocity (feet per second)
            - Calculate and record total flow (cubic feet per second).
                - Σ (average width x depth x velocity) = flow
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
        - Record field notes.
        - Sketch and photograph sampling station.
    - Update Stream Restoration Group Project Log.
        - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

- Conduct *Biological and Physical Study* one time between April and November.
    - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
        - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of bioassessment.
    - Perform fish survey at selective stream sampling stations only.

V. Review all data collected. (If watershed is large continue. If watershed is small skip to VIII.)

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
    - Represent *Water Quality Study* data graphically.
    - Compare *Biological and Physical Study* data.

VI. Establish *streamlined monitoring network* within the *comprehensive monitoring network*.

- Select and number stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations only.
    - Stream sampling station numbers remain the same as in *comprehensive monitoring network*.

VII. Implement sampling sweeps of *streamlined monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
  - Prepare chain of custody (COC) form for laboratory.
    - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
      - Stream sampling variables include: flow; field temperature, pH and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
  - Prepare sampling equipment for field use.
    - Calibrate electronic field equipment.
    - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
  - Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing “grab” sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
      - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
      - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
      - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
  - Perform field measurements.
    - Obtain insitu values of water temperature, pH, and specific conductivity.
    - Obtain stream flow.
      - Measure uniform width segments of the total water cross section utilizing a tagline.
        - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
      - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
      - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
      - Record water depth (tenths of feet).
      - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.

        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
        - Record field notes.
        - Sketch and photograph sampling station.
    - Update Stream Restoration Group Project Log.
        - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

VIII. Review all data collected.

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
    - Represent *Water Quality Study* data graphically.
    - Compare *Biological and Physical Study* data.
    - Prioritize mainstem tributaries according to degree of impairment.

IX. Define *focus study area*.

- Select impaired tributary within *comprehensive monitoring network* and determine watershed boundary.

X. Establish *focus area monitoring network* within the *focus study area*.

- Locate polluted coal mine drainage source sampling stations within impaired tributary watershed.
    - Research existing data.
        - Search historical maps, reports, and data.
        - Communicate with local citizen groups or individuals.
        - Communicate with State, Federal, Local agencies.
        - Communicate with local Private Industry.
        - Review Abandoned Mine Lands Inventory, new project priority list, and OSM51/ Environmental Assessments.
            - Communicate with Abandoned Mine Lands North/South Planner to determine water quality projects.
    - Receive notification from Abandoned Mine Lands Realty Administrator that Exploratory Rights of Entry have been obtained at Abandoned Mine Lands water quality projects.
    - Field review entire impaired tributary watershed.
        - Field review Abandoned Mine Lands water quality projects within impaired tributary watershed with Abandoned Mine Lands North/South Planner.

    - Establish Project Point of Contact (PPOC).
    - Establish project name and nomenclature.
    - Establish project boundaries.
    - Establish source sampling stations.
      - Number source sampling stations within each project beginning with 100 and incrementing by hundreds to allow numbering space for additional stations which may be encountered.
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
      - Record field notes.
      - Sketch and photograph project area.
  - Field review remainder of impaired tributary watershed to locate additional polluted coal mine drainage sources which are not associated with Abandoned Mine Lands water quality projects.
    - Establish Project Point of Contact (PPOC).
    - Establish project name and nomenclature.
    - Establish project boundaries.
    - Establish source sampling stations.
      - Number source sampling stations within each project beginning with 100 and incrementing by hundreds to allow numbering space for additional stations which may be encountered.
    - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
      - Record field notes.
      - Sketch and photograph project area.
    - Report project to Abandoned Mine Lands North/South Planner.
- Select and number stream sampling stations throughout impaired tributary watershed.
  - Select impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage influx.
  - Select receiving stream sampling stations upstream and downstream of the confluence with the impaired tributary.
  - Number all stream sampling stations in ascending order, beginning with the most downstream station.
- Add projects to Stream Restoration Group Water Quality Assessment Index (WQAI).
  - Include project name and nomenclature, point of contact, water quality assessment type, number of monitoring points, hydrologic region, watershed, receiving stream, 7.5’ USGS topographic map, purpose of assessment, county, coal seam, priority list date, and exploratory right of entry completion date.

XI. Obtain coordinates and map *focus area monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data:
    - Collect sampling station positions using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.
    - Update Stream Restoration Group Project Coordinates Log
        - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
    - Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
- Generate project map of all sampling stations.

XII. Implement sampling sweeps of *focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times spanning a range of hydrologic and climatologic conditions.
    - Obtain project reclamation number.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, project reclamation number, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH specific conductivity and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, calcium, aluminum, and manganese.
            - Pollution source sampling variables include: flow; field temperature, pH, specific conductivity, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Prepare sampling stations for water sample collection.
        - Stake stream and source sampling stations as close to collection point as possible.
            - Label stake with sampling station number.

    - Dig collection basin at pollution source origin.
- Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect pollution source water sample at origin. (When several seeps co-mingle, it is necessary to collect a sample of the combined discharge.)
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
            - Ferrous and ferric iron analyses are not necessary at source stations when the water is impounded and the origin of the source is not "free flowing" accessible.
- Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
        - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
        - Measure temperature, pH, specific conductivity, and dissolved oxygen at source sampling stations.
            - Dissolved oxygen measurement is not necessary at source stations when the water is impounded and the origin of the source is not "free flowing" accessible, or the origin is not inseparable from other sources.
    - Obtain stream flow.
        - Measure uniform width segments of the total water cross section utilizing a tagline.
            - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.

        - Record average width of segments (tenths of feet).
        - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
        - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
        - Record water depth (tenths of feet).
        - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
    - Obtain source flow. (When several seeps co-mingle, it is necessary to measure the flow of the combined discharge.)
        - Dig exit channel from source collection basin.
            - Channel must be wide enough to accommodate wading staff base.
            - Water in channel must be deep enough to submerge velocity sensor.
        - Measure uniform width segments of the total water cross section utilizing a tagline.
            - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
        - Record average width of segments (tenths of feet).
            - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
        - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
        - Record water depth (tenths of feet).
        - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
- Complete Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.
- Update Stream Restoration Group Project Log.
    - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, downstream flow measurement.
    - Include project status for source sampling stations.

        - Update Stream Restoration Group Water Quality Assessment Index (WQAI).
        - Add project reclamation number and monitoring starting date.
        - Report any portion of project for which polluted water abatement appears infeasible to the Abandoned Mine Lands Design Administrator.
            - Infeasible polluted water abatement areas include: seeps located at or near the stream edge, and seeps or mine openings discharging extremely small flows, if the seep, mine opening discharge, or receiving stream is inaccessible to earthmoving equipment.
        - Cease sampling of any portion of project for which polluted water abatement appears infeasible, unless otherwise instructed by the Abandoned Mine Lands Design Administrator.
        - Report any additional polluted coal mine drainage sources found on project sites to Abandoned Mine Lands North/South Planner.
    - Conduct *Biological and Physical Study* one time between April and November.
        - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage project areas.
            - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
        - Update Stream Restoration Group Project Log.
            - Record project name and date of bioassessment.

XIII. Review data.

- Analyze *focus area monitoring* network data.
    - Represent *Water Quality Study* data graphically and tabularly.
- Field review *focus area* pollution sources with all Stream Restoration Group members.
    - Review Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form notes and sketches.

XIV. Report findings.

- Prepare preliminary pre-design *Water Quality Study* report of findings and suggestions.
    - Determine extent of impairment polluted coal mine drainage contributes to the *focus area* impaired tributaries.
    - Determine site specific polluted coal mine drainage remediation technology for the sources at each project area.
        - Evaluate chemical suitability of selected polluted coal mine drainage remediation technology.
            - Apply Stream Restoration Group Polluted Coal Mine Drainage Remediation criteria flow chart.

            - Reference variables include alkalinity, acidity, dissolved oxygen, total iron, ferrous and ferric iron, and aluminum.
        - Evaluate physical suitability of selected polluted coal mine drainage remediation technology.
            - Reference variables include flow and geography.
    - Determine instream polluted coal mine drainage remediation technology for stream benefits in addition to, or in lieu of site specific polluted coal mine drainage remediation.
        - Reference variables include acidity and flow.
- Submit pre-design *Water Quality Study* report to Abandoned Mine Lands Chief, Design Administrator, Construction Administrator, Project Engineer, North/South Planner, Stream Restoration Group Supervisor, In-House Design Administrator or Design Consultant, and File.
    - Modify preliminary pre-design *Water Quality Study* report, if necessary.
        - Participate in on-site mapping meeting upon request of Abandoned Mine Lands Project Manager.
        - Participate in on-site pre-issuance meeting upon notification from Abandoned Mine Lands Project Manager.
        - Update Stream Restoration Group Water Quality Assessment Index.
            - Record name of project design consultant upon notification from Abandoned Mine Lands Construction Administrator.
        - Participate in any meetings relative to the project upon request of Abandoned Mine Lands Project Manager.
        - Incorporate on-site findings and suggestions into final *Pre-Design Water Quality Study* report.
            - Study will include:
                - Description of impacted stream length and boundary of impacted area
                - Chemical, physical, and biological water quality data
                - Maps
                - Photographs
                - Suggested polluted coal mine drainage remediation technologies for each source or combined sources and/or stream
- Update Stream Restoration Project Log.
    - Record name and date pre-design *Water Quality Study* report was sent.

XV. Establish *post construction focus area monitoring network* when polluted coal mine drainage remediation is complete in the *focus study area*. (If initial *study area* contains other impaired tributaries which have not been addressed, repeat IX through XIV.)

- Locate constructed polluted coal mine drainage remediation systems within polluted coal mine drainage remediation projects.

        - Receive notification of polluted coal mine drainage remediation project construction completion date from Abandoned Mine Lands Construction Administrator.
            - Update Stream Restoration Group Water Quality Assessment Index.
                - Include construction completion date, name of contractor, and construction cost.
        - Field review polluted coal mine drainage remediation project site with Abandoned Mine Lands Project Inspector.
            - Obtain project map.
            - Establish project boundaries.
            - Establish untreated and treated source sampling stations.
            - Number untreated and treated source sampling stations.
                - Number untreated source sampling stations as previously designated for pre-design *Water Quality Study*.
                - Number treated source sampling stations in ascending order beginning with the station nearest to the untreated station.
            - Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
                - Record field notes.
                - Sketch and photograph project area.
    - Select and number stream sampling stations throughout *focus study area*.
        - Select the previously impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage remediation project influx.
        - Select receiving stream sampling stations upstream and downstream of the confluence with the previously impaired tributary.
        - Number all stream sampling stations as previously designated for pre-design *Water Quality Study*.
    - Update Stream Restoration Group Water Quality Assessment Index (WQAI).
        - Include water quality assessment type and number of monitoring points.

XVI. Obtain coordinates and map *post construction focus area monitoring network* for Geographical Information System (GIS) input.

- Process Global Positioning System (GPS) Data:
    - Collect positions for any sampling stations added since pre-design *focus area monitoring network* was established using Global Positioning System data capture equipment.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of Global Positioning System coordinate collection.
    - Correct Global Positioning System data.
    - Enter Coordinates into Q&A database.

    - Update Stream Restoration Group Project Coordinates Log
        - Record project name and nomenclature; sample number, latitude, and longitude; and horizontal precision.
    - Provide Q&A database to TAGIS for Geographical Information System (GIS) analysis.
    - Generate project map of all sampling stations.

XVII. Implement sampling sweeps of *post construction focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times per year during the initial first year period; four times during the second year period; and two times per year during the third and every subsequent year period spanning a range of hydrologic and climatologic conditions.
    - Prepare chain of custody (COC) form for laboratory.
        - Chain of Custody form includes project nomenclature and name, project reclamation number, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH specific conductivity and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, calcium, aluminum, and manganese.
            - Untreated pollution source sampling variables include: flow; field temperature, pH, specific conductivity, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
            - Treated pollution source sampling variables include: flow; field temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, ferrous and ferric iron, calcium, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.
        - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
    - Prepare sampling stations for water sample collection.
        - Stake stream and source sampling stations as close to collection point as possible.
            - Label stake with sampling station number.
        - Dig collection basin at pollution source origin.

- Perform water sample collection.
- Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect untreated source water sample at origin if possible.
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
            - Ferrous and ferric iron analyses are not necessary at source stations when the water is impounded and the origin of the source is not "free flowing" accessible.
    - Collect treated source water sample at polluted coal mine drainage remediation system outflow.
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
            - Ferrous and ferric iron analyses are not necessary at polluted coal mine drainage remediation system stations where the water is aerated.
- Perform field measurements.
    - Obtain insitu water quality measurements at all sampling stations.
        - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
        - Measure temperature, pH, specific conductivity, and dissolved oxygen at untreated source sampling stations.

        - Measure temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen at treated source sampling stations.
            - Oxygen Reduction Potential and dissolved oxygen are not necessary at polluted coal mine drainage remediation system stations where the water is aerated.
    - Obtain stream flow.
        - Measure uniform width segments of the total water cross section utilizing a tagline.
            - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
        - Record average width of segments (tenths of feet).
            - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
        - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
        - Record water depth (tenths of feet).
        - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
    - Obtain treated source flow at polluted coal mine drainage remediation system outflow.
        - Measure uniform width segments of the total water cross section utilizing a tagline.
            - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
        - Record average width of segments (tenths of feet).
            - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
        - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
        - Record water depth (tenths of feet).
        - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
- Complete Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.

        - Update Stream Restoration Group Project Log.
            - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, downstream flow measurement.
            - Include project status for source sampling stations.
        - Update Stream Restoration Group Water Quality Assessment Index (WQAI).
            - Add monitoring starting date.
        - Report any anomalies noticed at the project during routine monitoring to the Abandoned Mine Lands Construction Administrator.
        - Cease sampling of project if it requires maintenance or modifications unless otherwise instructed by the Abandoned Mine Lands Construction Administrator.
        - Resume monitoring of project upon notification from Construction Administrator of project maintenance completion.
            - Notification should include explanation of maintenance and any modification which could affect *focus area monitoring network*.
    - Conduct *Biological and Physical Study* one time between April and November, at least one year after completion of project construction.
        - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage remediation project influx.
            - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
        - Update Stream Restoration Group Project Log.
            - Record project name and date of bioassessment.

XVIII. Implement sampling sweeps of the *comprehensive monitoring network* when polluted coal mine drainage remediation is complete throughout initial *study area*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
    - Utilize chain of custody (COC) form prepared for laboratory during initial monitoring of the *comprehensive monitoring network*.
        - Chain of Custody form includes project nomenclature and name, station number and description, and required field and laboratory analyses.
            - Stream sampling variables include: flow; field temperature, pH, and specific conductivity; lab pH, specific conductivity, total hot acidity, alkalinity, sulfate, total iron, aluminum, and manganese.
    - Prepare sampling equipment for field use.
        - Calibrate electronic field equipment.

    - Gather all necessary equipment, forms, maps, keys, and personal needs for sampling.
- Prepare sampling stations for water sample collection.
    - Stake sampling stations as close to collection point as possible.
        - Label stake with sampling station number.
- Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method. Sample is collected in the middle of the stream channel, at mid depth, downstream of mixing zone of any influx.
        - Label collection bottle with sample station nomenclature and number, date and time, and preservative.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Obtain insitu values of water quality measurements at all sampling stations.
        - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
        - Measure uniform width segments of the total water cross section utilizing a tagline.
            - Each segment should represent no more than 10 percent of the total cross section of the water in the channel.
        - Record average width of segments (tenths of feet).
            - Average width = (distance from previous measurement point + distance to next measurement point ÷ 2)
        - Measure water depth at the water edges and at each uniform width segment between, utilizing a self adjusting wading rod.
        - Record water depth (tenths of feet).
        - Measure water velocity at water edges and at each uniform width segment between, utilizing a Marsh-McBirney flow meter.
        - Record velocity (feet per second)
        - Calculate and record total flow (cubic feet per second).
            - Σ (average width x depth x velocity) = flow
- Complete Stream Restoration Group Acid Mine Drainage Assessment (AMDA) Form.
    - Record field notes.
    - Sketch and photograph sampling station.
- Update Stream Restoration Group Project Log.

        - Record project name, date of collection, number of samples, number of sampling personnel, hours sampled, hours traveled to site, and downstream flow measurement.

- Conduct *Biological and Physical Study* one time between April and November.
    - Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
        - Habitat assessment and benthic macroinvertebrate survey comply with United States Environmental Protection Rapid Bioassessment Protocol II.
    - Update Stream Restoration Group Project Log.
        - Record project name and date of bioassessment.
    - Perform fish survey at selective stream sampling stations only.

XIX. Review data.

- Analyze changes in stream water quality.
    -
- Analyze effectiveness and efficiency of constructed polluted coal mine drainage remediation systems.
    -
    -

XX. Report findings.

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- Submit final *post construction Water Quality Study* report to Abandoned Mine Lands Chief, Design Administrator, Construction Administrator, Project Engineer, Stream Restoration Group Supervisor, In-House Design Administrator, and File.
    - Determine the effect of constructed polluted mine drainage remediation systems on the polluted mine drainage sources, *focus area monitoring networks*, and *comprehensive monitoring network.*
    - Study will include:
        - Introduction and History of Project
        - Drainage Area
        - Sampling protocol
        - Water Quality Data
        - Mapping
        - Personnel Involved
        - Photos
        - Design Construction Map
        - Materials used for Construction
        - Construction Cost
        - Time Frame
        - Water Quality Improvements:

        - Acid Reduction through Project
        - Metal Reduction through Project
        - Reduction in Acid Load to Receiving Stream
        - Biological Assessment, (Upstream verses Downstream)
    - Graphs and Charts

ARC View Pictorials

XX. Return to I.

West Virginia Division of Environmental Protection
Office of Abandoned Mine Lands & Reclamation
Stream Restoration Group's

HOLISITIC WATERSHED APPROACH PROTOCOL

I. Define the *study area*.

- Select mainstem stream and determine watershed boundary.

II. Establish *comprehensive monitoring network* within the *study area*.

- Select stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations and at extensive locations throughout the mainstem tributary stream reach.

III. Obtain coordinates and map *comprehensive monitoring network* for Geographical Information System (GIS) input.

- Collect sampling station positions.
- Generate project map of all sampling stations.

IV. Implement sampling sweeps of the *comprehensive monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity, and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
- Perform fish survey at selective stream sampling stations only.

V. Review all data collected. (If watershed is large continue. If watershed is small skip to VIII.)

- Analyze changes in tributary and mainstem stream segments and compare tributaries.

VI. Establish *streamlined monitoring network* within the *comprehensive monitoring network*.

- Select stream sampling stations.
    - Select mainstem stream sampling stations representing mainstem stream segments.
    - Select all mainstem tributary sampling stations at the mouth locations only.

VII. Implement sampling sweeps of *streamlined monitoring network*.

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.

VIII. Review all data collected.

- Analyze changes in tributary and mainstem stream segments and compare tributaries.
- Prioritize mainstem tributaries according to degree of impairment.

IX. Define *focus study area*.

- Select impaired tributary within *comprehensive monitoring network* and determine watershed boundary.

X. Establish *focus area monitoring network* within the *focus study area*.

- Locate polluted coal mine drainage source sampling stations within impaired tributary watershed.
- Select stream sampling stations throughout impaired tributary watershed.

- Select impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage influx.
- Select receiving stream sampling stations upstream and downstream of the confluence with the impaired tributary.

XI. Obtain coordinates and map *focus area monitoring network* for Geographical Information System (GIS) input.

- Collect sampling station positions.
- Generate project map of all sampling stations.

XII. Implement sampling sweeps of *focus area monitoring network*.

- Conduct *Water Quality Study* sweeps six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect stream water sample for laboratory analysis employing "grab" sample method.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect pollution source water sample at origin.
        - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
        - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
        - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
- Perform field measurements.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
    - Measure temperature, pH, specific conductivity, and dissolved oxygen at source sampling stations.
    - Obtain stream flow.
    - Obtain source flow.

- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessment and qualitative benthic macroinvertebrate survey upstream and downstream of polluted coal mine drainage project areas.

XIII. Review data.

- Analyze *focus area monitoring* network data.

XIV. Report findings.

- Prepare *Water Quality Study* report of findings and suggestions.
- Determine extent of impairment polluted coal mine drainage contributes to the *focus area* tributary.
- Determine site specific polluted coal mine drainage remediation technology for the sources at each project area.
    - Evaluate chemical suitability of selected polluted coal mine drainage remediation technology.
        - Reference variables include alkalinity, acidity, dissolved oxygen, total iron, ferrous and ferric iron, and aluminum.
    - Evaluate physical suitability of selected polluted coal mine drainage remediation technology.
        - Reference variables include flow and geography.
- Determine instream polluted coal mine drainage remediation technology for stream benefits in addition to, or in lieu of site specific polluted coal mine drainage remediation.
    - Reference variables include acidity and flow.

XV. Establish *post construction focus area monitoring network* when polluted coal mine drainage remediation is complete in the *focus study area*. (If initial *study area* contains other impaired tributaries which have not been addressed, repeat IX through XIV.)

- Locate constructed polluted coal mine drainage remediation systems within polluted coal mine drainage remediation projects.
- Select stream sampling stations throughout *focus study area*.
- Select the previously impaired tributary sampling stations at mouth location and at extensive locations throughout the tributary stream reach, including stations upstream and downstream of polluted coal mine drainage remediation project influx.
- Select receiving stream sampling stations upstream and downstream of the confluence with the previously impaired tributary.

XVI. Obtain coordinates and map *post construction focus area monitoring network* for Geographical Information System (GIS) input.

- Collect positions for any sampling stations added since pre-design *focus area monitoring network* was established.
- Generate project map of all sampling stations.

XVII. Implement sampling sweeps of *post construction focus area monitoring network***.**

- Conduct *Water Quality Study* sweeps six times per year during the initial first year period; four times during the second year period; and two times per year during the third and every subsequent year period spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
  - Collect stream water sample for laboratory analysis employing “grab” sample method.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
  - Collect untreated source water sample at origin if possible.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
  - Collect treated source water sample at polluted coal mine drainage remediation system outflow.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, calcium, and manganese.
    - Collect hydrochloric preserved water sample for laboratory analyses of ferrous and ferric iron.
- Perform field measurements.
  - Measure temperature, pH, specific conductivity, and dissolved oxygen at all stream sampling stations.
  - Measure temperature, pH, specific conductivity, and dissolved oxygen at untreated source sampling stations.
  - Measure temperature, pH, specific conductivity, Oxygen Reduction Potential, and dissolved oxygen at treated source sampling stations.
  - Obtain stream flow.
  - Obtain treated source flow at polluted coal mine drainage remediation system outflow.

- Conduct *Biological and Physical Study* one time between April and November, at least one year after completion of project construction.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys upstream and downstream of polluted coal mine drainage remediation project influx.

XVIII. Implement sampling sweeps of the *comprehensive monitoring network* when polluted coal mine drainage remediation is complete throughout initial *study area*. (Repeat IV.)

- Conduct *Water Quality Study* sweeps three to six times spanning a range of hydrologic and climatologic conditions.
- Perform water sample collection.
    - Collect and refrigerate unpreserved water sample for laboratory analyses of pH, specific conductivity, total hot acidity, alkalinity**,** and sulfate.
    - Collect nitric acid preserved water sample for laboratory analyses of total iron, aluminum, and manganese.
- Perform field measurements.
    - Measure temperature, pH, and specific conductivity.
    - Obtain stream flow.
- Conduct *Biological and Physical Study* one time between April and November.
- Perform stream habitat assessments and qualitative benthic macroinvertebrate surveys at all stream sampling stations.
- Perform fish survey at selective stream sampling stations only.

XIX. Review data.

- Analyze changes in stream water quality.
- Analyze effectiveness and efficiency of constructed polluted coal mine drainage remediation systems.

XX. Report findings.

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- Prepare *post construction Water Quality Study* report.
- Determine the effect of constructed polluted coal mine drainage remediation systems on the polluted coal mine drainage sources, *focus area monitoring networks*, and *comprehensive monitoring network.*

XXI. Return to I.

RECHARGING OF APPALACHIAN AQUIFERS WITH MOUNTAIN TOP REMOVAL APPLICATIONS

by

L.C. NELSON
W.K. SAWYER
L.Z. SHUCK

RECHARGING APPALACHIAN AQUIFIERS
USING
WATERSHED SPECIFIC TECHNOLOGY AND METHODOLOGY
AND
TECHNICAL CONSIDERATIONS RELATIVE TO MOUNTAIN TOP REMOVAL

by L. C. Nelson, W. K. Sawyer, and L. Z. Shuck

Introduction

Rapid runoff of surface water in Appalachia has many catastrophic effects not only on people, but all aspects of watershed, stream and river ecosystems. Rapid runoff contributes to at least five major problems, which themselves create other problems. Namely, 1) flash floods, 2) serious erosion, 3) less than capacity aquifer recharging, 4) altere seasonal variation in flows and total volumes of water in Appalachian branches, creeks, streams, and rivers. Implications include filling up of dams, reservoirs, and river bottoms with eroded soils, loss of human lives and hom aquatic life habitat impairment or eradication, reduction or elimination of capacity to support various aquatic specie changing the characteristics of streams in general, and eventual extinction of species. Last, but far from least significant, is the Appalachian region economic impact. The economic impact is not just limited to flood disaster damages, but includes the number two industry in WV of tourism and recreation, loss of use of valuable property in flood prone areas, and less residence time of rainfall-based water in Appalachia enroute to the Gulf of Mexico and th Atlantic Ocean.

Salvaging a higher percentage of rainfall to recharge Appalachian aquifers needs to be a direct objective and goal of industrial and environmental activities. The aquifers of concern here are not the ones that usually come to mind that include ground water and those directly associated with water wells. The aquifers of interest here are the ones that control the flow rates of springs out of the mountainside, seeps, and small flows in branches, creeks. These are the temporary storage aquifers above the elevations of the hollows with the branches or small streams up to large rivers. These are called temporary storage aquifers because they are "above-drainage" aquifers. They are the aquifers that provide the storage volumes and pressure to maintain and meter the flows during the three to four months of low rainfall in the summer and fall.

The recharging of these above-drainage aquifers should have major priority and consideration. Like half charged batteries, aquifers undercharged with less hydrostatic "head" pressure suffer lower current flow rates through the porous, permeable, and fractured reservoir rocks, as well as a reduced capacity to deliver low temperature (52 to 60 purified water to streams during the several months of low seasonal rainfall. This results in a higher percentage or concentration of surface contaminated water in creeks, streams and rivers, and higher water temperatures. Unfortunately, natures filtration-purification-cooling process for streams is being bypassed as a result of human activities of timbering, mineral and energy resource extraction, concrete and asphalt roads, cities, malls and parking and ditches, sanitary and storm sewer lines, roof gutter water concentrations, etc. The basic **distributed**, spongy system has been altered to a **concentrated**, channeled, accelerated-flow, aquifer-bypassing system. Such activities a timbering, especially clear cutting, greatly accelerate the rapid runoff of water down the mountainsides, creating gullies, huge erosion problems, and the huge problem no one seems to talk about, or even know about, **the bypassin of above-drainage aquifers** and temporary storage reservoirs. These above-drainage aquifers are fed by rainfall entering the more open vertical natural fracture systems that serve as conduits down to different layers of porous, permeable sandstones that store the water until it can be further metered out through the combined fractured and por lower rock formations and into the branches and streams in the hollows. These phenomena of fracture systems and water seeps or flows may be observed along all Appalachian highway cuts through the hilltops.

First, we have to understand the realities of the system of layered media, some porous and permeable, and some wit negligible permeability or porosity, but with a network of vertical natural fracture systems. Second, it is required to develop the technology and methodology with intestinal fortitude to restore the more natural, gradual processes, or improve upon them. This paper attempts to realistically characterize aquifer systems and the recharging process. It coincidentally implicates the highly emotional and controversial issue of mountain top removal as runoff mitigation methodology is examined. **In fact, this paper introduces a concept for solving two major Appalachian region problems with one single plan.** The roles natural fracture systems, joints, faults and other types of discontinuities ir strata play in in-situ mineral extraction or hydrologic processes are often ignored in analysis methodology, and seldc used in design. Calculations are made and illustrated here using simple, easily visualized models to illustrate the importance of such technical considerations, and the availability of a huge body of technology developed over 30 ye at costs exceeding 100 million dollars that is available to focus on the problem.

Aquifer Characteristics

It is instructive to briefly consider the origin and history of aquifers that leads to their present day characteristics. Although widely varying, many of the aquifer rocks of interest here in Appalachia that are above drainage were forn by sediments in deep lakes and riverbeds during the Quaternary or Paleozoic Ages and Permian and Pennsylvanian Periods, many millions of years ago. Every several thousands of years some catastrophic event would abruptly, in geologic times, alter the types of aquatic life and mineral matter settling to the bottom, thus creating alternating layer of sand, clay, lime, and carbonaceous matter that became solidified under high pressure over millions of years. That why we have relatively uniform layers of sandstone, limestone, shale, coal, red rock, slate, and clay, varying from several inches to hundreds of feet thick, making up the complex stratigraphic column found throughout the Appalachian Basin. Then, along came the Appalachian orogeny when the continents collided and created the Appalachian mountain range. This cataclysmic event, along with more recent tectonic events, over thousands of year gave us the beautiful mountains of folded, faulted, fractured, up and down thrusted rock layers, and sloping, undulat coal beds. A magnificent cross section of about 1,100' of exposed rocks can be observed along U.S. Rt. 19 S up Pow mountain (which is a potentially great geological observatory that remains a WV undeveloped resource). Just about every conceivable geological feature can be observed in this section. At the top of Rt 52 in a narrow highway cut ab 500' above Bluefield State College in Bluefield, WV, rock layers thrusted up over 75 degrees can readily be observe It should easily be visualized and understood that the rock layers making up aquifers are not just large masses of isotropic, homogeneous substances. Thousands of feet of the Appalachian mountains have now been eroded away o thousands of years, stress relieving the rocks created under high pressures and temperatures. For thousands of years until a few hundred years ago, these mountains were capped with trees and dense vegetation, and now mankind has dramatically changed it. One might speculate philosophically, that man has removed the sponge and time-delay mechanism nature built in to protect its amenities of streams full of life, and protect itself from self-destruction.

One interesting feature man has not changed, but usually ignores, is the major and minor sets of natural fracture systems that extend across different layers and often continuously, with minor offsets, for hundreds and thousands o feet both vertically and horizontally. All rocks in Appalachia have these fracture networks to a greater or lessor degr as do most parts of the earth. Some of these fractures, of varying width from inches to feet, are partially open. Most partly filled and propped open with porous infiltrated matter from above or below, and remain highly permeable, although some are sealed by a squeezing of the lower shear modulus, viscoplastic clay layers. These fracture networ constitute the major conduit system for recharging aquifers since impermeable clay layers periodically separate the porous layers of rocks. Water flows down the fractures rapidly, and then more slowly out into the different layers of porous rocks recharging the bottom layers first, and as they fill up, the next higher layers progressively absorb the water.

The aquifer storage capacities are actually the large volumes of porous, permeable sandstone, limestone or shale laye with large pore volumes of 5 to 30 percent, and permeabilities (connectivity of pore volumes) ranging from a few milidarcies to a few darcies through which the water seeps. The permeability of the rock may also vary with directio by a factor of 2 or more. The fracture systems vary in orientation, but quite often the major system has a general N4 trending orientation, and the minor, less continuous system is usually more or less than 90 degrees forming an approximate orthogonal network. The permeability of these above-drainage fracture systems is often an order of magnitude greater than the adjacent strata, which makes them a **primary** consideration in recharging aquifers. This i true in the above drainage cases where the eroded valleys have created isolated mountaintops and have removed the horizontal in situ stress fields, allowing greater expansion of the vertical fractures. These are the fracture systems an layered porous aquifers that are of interest for stream recharging, as opposed to the deeper, below drainage aquifers typically used for well water and most ground water studies. The orientation and characteristics of these fracture systems and the orientation of principal in situ stresses greatly influence mining, oil and gas extraction, and groundwater flow, yet receive no consideration, and not even mentioned in mountain top removal, for example. For sake of illustration, a couple of sets of conditions will be used along with a sophisticated, tested and proven, comput reservoir simulation program to calculate and show the huge differences resulting from different mountain (original back-filled) slopes. Other calculations can readily be made to illustrate the significance of natural fracture system orientations.

Consider two geometrical conditions consisting of 1) a flattened mountaintop with a small 4-degree inward slope to form a slight concave surface, and 2) a conventional, 25 degree slope. Then consider a stratigraphic column of layere media including topsoil, and a series of varying thickness, porosity and permeability layers with a vertical fracture network or grid. **The same stratigraphic column with the same porosity, permeability, and thickness layers is used for both the concave (4-degree) and 25 degree slope cases. For the sake of illustration, the usual irregula spacing between fractures that typically ranges from 2' to 50' is taken as an average of 25' for both cases. The permeability of the major fractures is often 3 times or more greater than the permeability of the minor set. Tl permeability of the major fracture system is assumed to be a factor of 20 greater than the top strata. The percents of incident rain absorbed or captured that do not run off are calculated and compared with the resu of two forest covered mountains, one of zero and the other a 25 degree slope. A rainfall rate of 0.5"/hr for a period of 24 hours is assumed. The properties of each layer of rock are the same for each calculation. A panel arbitrarily chosen here as 500' wide by 1,000' long.**

Computer simulation of the flow conditions was used to calculate the percent of rainfall captured versus runoff for comparison purposes to illustrate the importance of such considerations. This is not intended to be a comprehensive simulation of any specific, complex, actual strata, but rather an illustration to emphasize that consideration should be given to technical aspects of aquifer recharging, especially in conjunction with a created resource opportunity involv mountaintop removal.

Summary, Conclusions, and Considerations Based upon Science and Technology, and Simulation Model Calculations

I. Enhancing aquifer recharging in Appalachia is essential for sustainability of economy and watershed ecosystems with the continued industrial and other accelerated land use development in Appalachia. Continued development, as in the past, will result in unacceptable degradation of our watershed, stream and river ecosystems at some time in the near future, and a correspondingly substantial economic impact will also be realized. The simulation shows that 45% or more of the rainfall would be lost(i.e. not available for aquifer recharge) due to runoff an/or retention by mountain foliage. Normally, channeling occurs and deep gullies down hillsides form quickly in sloped loose clay or topsoil shortly during onset of rain. Mountain surfaces are mostly curved as opposed to planar, such that real runoff flows are not

Summary, Conclusions, and Considerations Based upon Science and Technology, and Simulation Model Calculations (Cont'd)

I. (Cont'd)
uniformly distributed, which gives a much worse runoff condition than the ones calculated and illustrated here. The actual, typical runoff and non-capture rates are probably at least 50% higher than those calculated here, which means that we typically may capture less than 20% of the incident rainfall in the above drainage aquifers. This is a very serious problem for small streams in Appalachia.

II. Mountaintop removal can create a real asset for capturing rainwater and preventing runoff. Today, the flattened mountaintops are being rounded and sloped so that water will run off and quickly leave the Appalachian Basin. **This is just the opposite of what science and technology tells us we should be doing**. Back-filling, although aesthetically pleasing, is also the worst possible thing to do in so far as recharging of aquifers from rain water.

III. Creating a very shallow circular or elliptical crater with an inward slope less than 6 degrees, that would store water only 5 to 10 feet deep temporarily at the center and deepest point based upon largest estimated rainfall rates, and aligned properly with fracture patterns would capture 100 percent of the incident rain and snow fall. Such temporary storage ponds on valley-fills and immediately under the removed coal could **simultaneously serve FIVE VALUABLE PURPOSES**: 1) capture 100 percent of incident rainwater and snow, 2) recharge local above drainage aquifers, 3) provide the best flood and erosion control measure available, that is, **stopped at the source**, 4) serve as a great wetland for treating acid rain, and for wildlife, and 5) serve as an accelerated method of reforestation, because the trees would have a much larger quantity of available water. Water loving tree forests or other water loving vegetation crops for periodic harvest could be planted. These are serious benefits that need to be publicly recognized and quickly implemented into reclamation plans all across Appalachia.

This time-delay, capture process gives aquifers time to soak up the water at their own rates based upon their own peculiar characteristics **better than the original forested mountaintops**.

IV. The earth's real features of natural fracture systems and in-situ stresses that produce highly directional flow characteristics in the recharging of aquifers need to be given special consideration, with reclamation designs and protocols based upon them, not an arbitrary shape or slope angle backfill regulation/rule.

V. Special geometric configurations conducive to temporary storage of rainwater for periods of hours, several days, weeks, or months, could be integrally designed into valley fills and mountain top leveling so that fills breakout and other undesirable features can be circumvented.

VI. The result of valley fill and mountaintop leveling can be a huge asset condition, for slight further modification and improvement for recharging Appalachian aquifers. Back-filling or sloping outward destroys this opportunity, and also creates the worst condition for aquifer recharging**. We must base our reclamation designs upon science and technology, not emotion and news media hype.**

VII. Reclamation pools can improve entire watershed and stream ecosystem habitats by sustaining higher flow rates of purified water from aquifers into streams during a critical period of the annual 1/4 year cycle of decreased rainfall. Likewise, retention times, and larger volumes of rainfall can be conserved and effectively used in Appalachia to improve watershed ecosystems before leaving for the Gulf of Mexico. Small branches, creeks and streams are critical sources of the food chain for aquatic species, spawning, other vital processes, and thermal pollution for larger streams and rivers. These are the streams in which aquatic life are stressed the most, and generally impacted the most, during the dry season. That is why this process is so important to the overall health of all Appalachian stream and river ecosystems.

VIII. Erosion damage can be virtually eliminated from mining and valley fill operations, even below the original forested level, in future industrial development areas by mountaintop removal and valley fill enhanced designs.

IX. Reclamation pools on top of valley fills are actually a better long-term flood control process than dams across rivers, because 1) the dams across rivers and their storage capacity will fill up in 50 years or so, and 2) Erosion is stopped at the source so that it does not occur in the first place.

X. Recharging aquifers using time-delay, fracture absorption designs above drainage should be a major consideration in all aspects of industrial development, environmental problem mitigation, recreational and other land use in Appalachia in the future.

XI. Recharging the above-drainage aquifers will also help recharge below drainage aquifers and the groundwater that flows into water wells. Destroying the above-drainage aquifers can be a major reason the below-drainage aquifers are readily pressure depleted and domestic water wells go dry.

XII. Mountaintop removal has many negative implications which have been highly publicized and polarizing. Yet, aside from a method for safe and economical coal recovery and reclaimed land use possibilities, the opportunity to enhance recharging of our aquifers is very attractive. Here is an opportunity to take a very negative situation and turn it around into a positive situation, by using it as a resource to create something very beneficial to our streams and their ecosystems.

XIII. As part of the State's and Federal Government's plans, the mountaintops were supposed to be utilized for recreational or economic development. Recharging Appalachian Aquifers and the several other benefits stemming from this process should certainly qualify in all respects for this part of the plan.

XIV. It is therefore recommended that a Feasibility Demonstration Project be developed in Southern West Virginia at the earliest possible date.

RECHARGING OF APPALACHIAN AQUIFERS

by

L. C. NELSON
W. K. SAWYER
L. Z. SHUCK

RECHARGING OF APPALACHIAN AQUIFERS

WITH MOUNTAIN TOP REMOVAL APPLICATIONS

RECHARGING
OF
APPALACHIAN AQUIFERS

- **ACTION PLANS NEEDED FOR ABOVE DRAINAGE AQUIFERS**

- **NEED SCHEMES & PROCESSES OF LARGE IMPACT APPLIED AT STRATEGIC SITES**

- **MINOR ADJUSTMENTS NOT SUFFICIENT TO COUNTER 50 YRS OF INDUSTRIAL, COMMERCIAL & RESIDENTIAL IMPACTS**

- **MINOR ADJUSTMENTS INSUFFICIENT TO COUNTER LAND DEVELOPMENT RATES**
  - **HIGHWAYS, PARKING LOTS**
  - **ROOF DRAINS TO STORM DRAINS TO RIVERS**
  - **TIMBERING, FOREST TO GRASSLAND, YARDS**

RESULTS:

1. **RAINWATER RETENTION TIME DWINDLING**
2. **MANY STREAMS ECOSYSTEMS SEVERELY STRESSED**
3. **MUST CAPTURE MORE OF THE RAINFALL IN AQUIFERS**

WHAT IS HAPPENING?

RAPID RUNOFF IS BYPASSING THE ABOVE DRAINAGE AQUIFERS THAT PROVIDE THE SEEPS AND SPRINGS THAT ORIGINALLY PROVIDED SUSTAINED FLOWS DURING 3 TO 4 MONTHS OF YEAR

PROBLEMS?

•LESS WATER, LOWER FLOW RATES IN STREAMS

•HIGHER TEMPERATURES OF CREEK WATER

•HIGHER % OF CREEK WATER IS SURFACE WATER

•GROUND WATER PURIFIED AND 55 TO 65 ^{o}F

•SURFACE WATER POLLUTED AND 75 TO 85 ^{o}F

•STREAM BEDS DRY & POLLUTANTS CONCENTRATED

OPTIONS?

SMALL IMPACT BY CITY PLANNING---NO SPACE
SMALL IMPACT BY BUFFER ZONES, REVEGETATION

- **LARGE IMPACT IDEAS NEEDED**
- **ABOVE DRAINAGE AQUIFERS NEED TO BE RECHARGED BY CAPTURE OF MORE RAIN WATER --- ON MOUNTAIN TOPS**

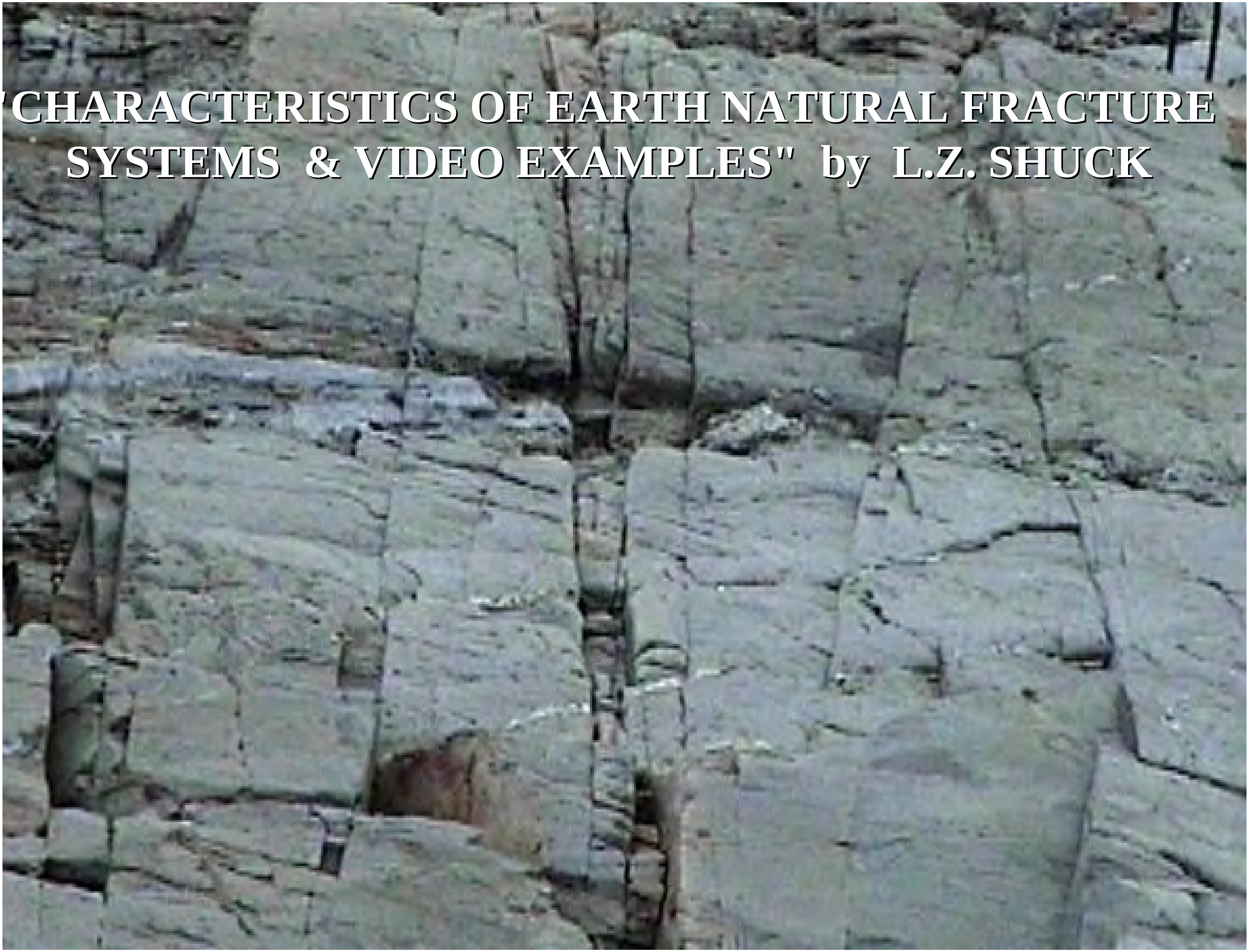
HOW?

A CONCEPT FOR YOU TO CONSIDER

- **PLATEAUS OR FLATTENED MOUNTAIN TOPS FROM MINING THAT ARE STILL 150' OR MORE ABOVE DRAINAGE COULD BE CONVERTED TO STORAGE RESERVOIRS AND WETLANDS BY MAKING TOPS CONCAVE TO TRAP AND POOL RAINWATER A FEW FEET DEEP.**

- **100 % INCIDENT RAIN CAPTURED**

- **HUGE BODY OF TECHNOLOGY AVAILABLE FOR IMMEDIATE APPLICATION**


"CHARACTERISTICS OF EARTH NATURAL FRACTURE SYSTEMS & VIDEO EXAMPLES" by L.Z. SHUCK

"FRACTURED RESERVOIR MODELING AND SIMULATION TECHNOLOGY DEVELOPED OVER 30 YEARS & $ MILLIONS, & A MOUNTAINTOP RESERVOIR SIMULATION EXAMPLE"

by W.K.SAWYER

"SUMMARY, CONCLUSIONS, AND RECOMMENDATION",

by L. C. NELSON

Improved Aquifer Recharge With Mountain Top Removal

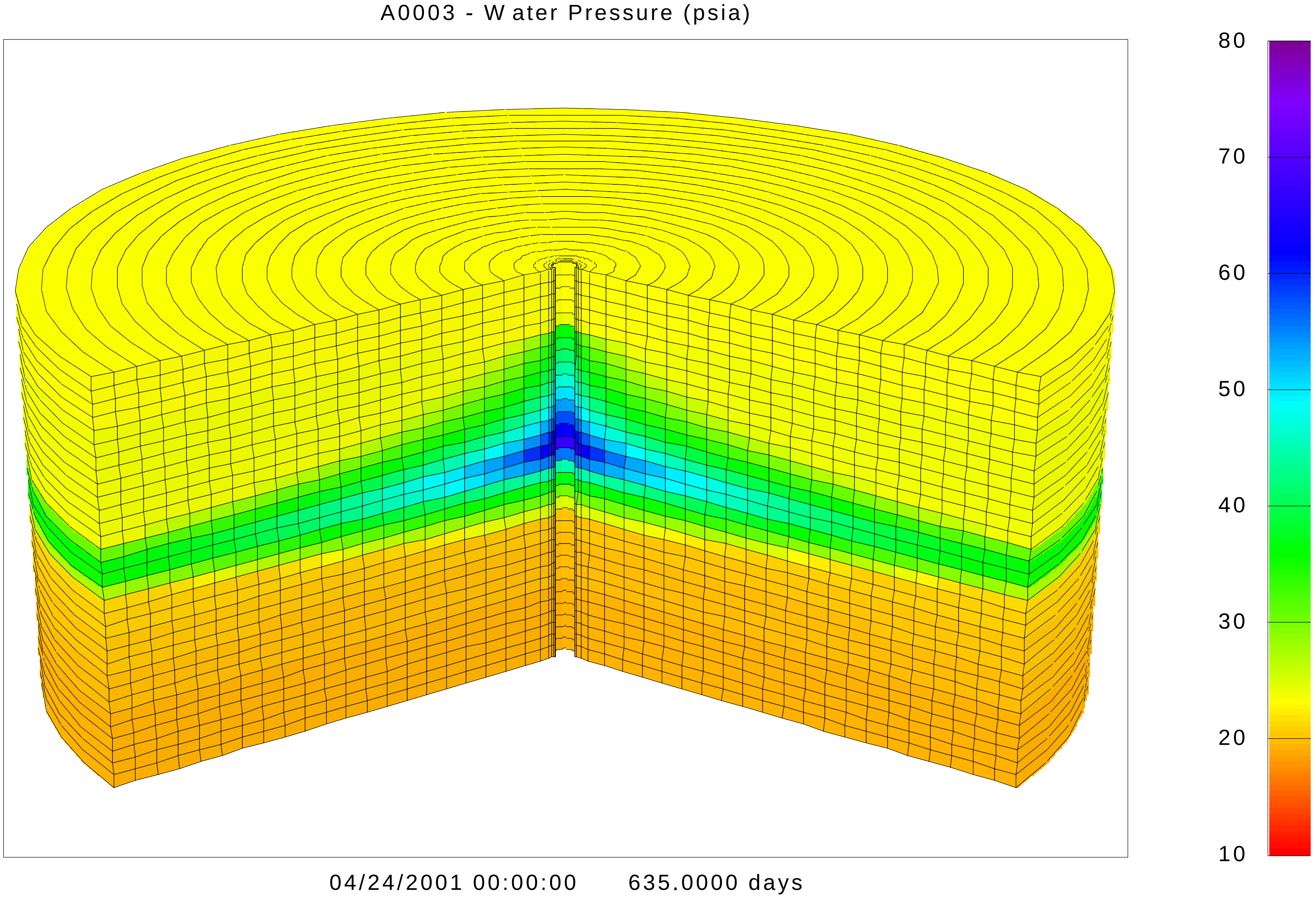
by
Walter K. Sawyer

Holditch - Reservoir Technologies Consulting Services

Pittsburgh, Pennsylvania

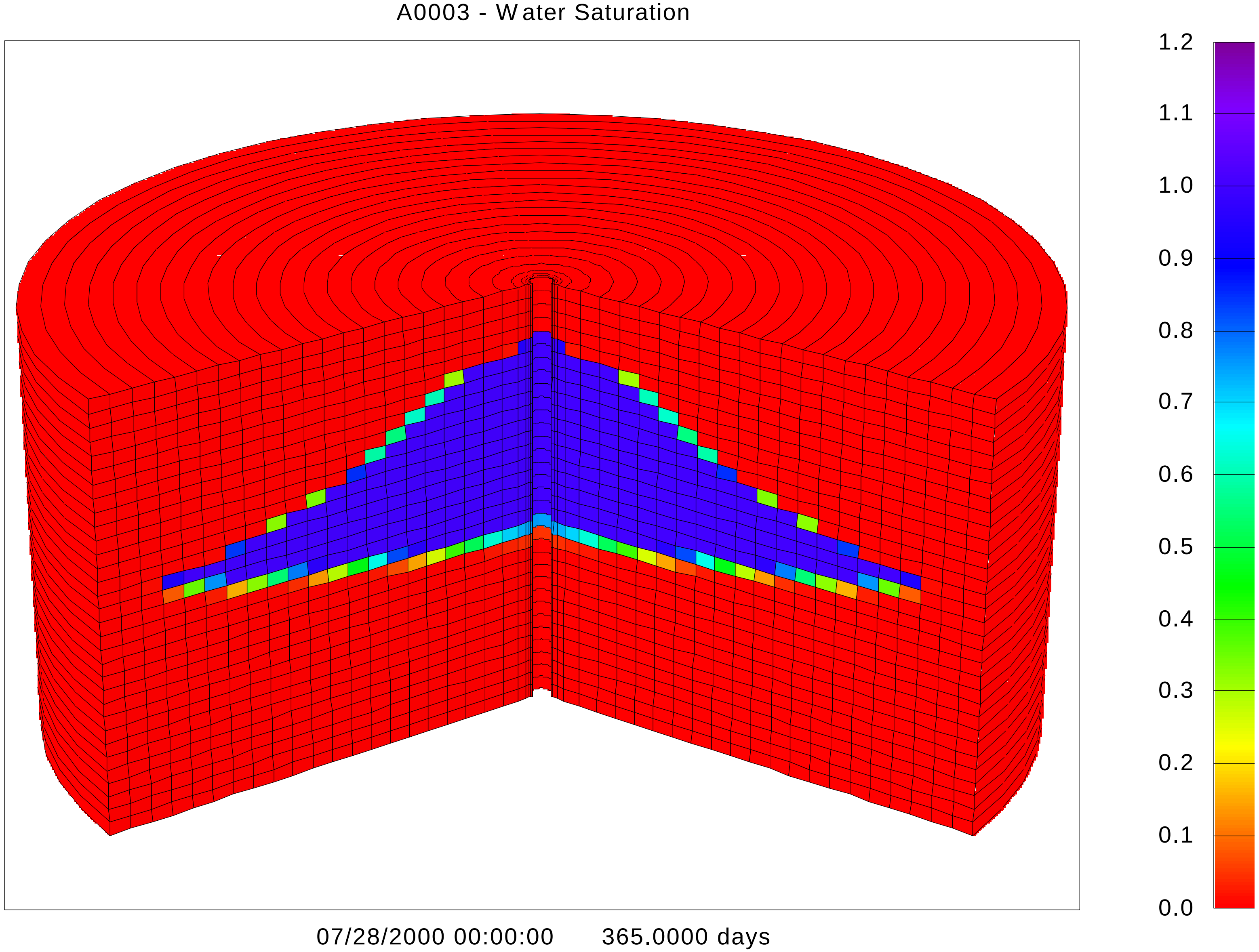
Water Injection into Vertical Wellbore - Radial Geometry

Pressure distribution after 635 days

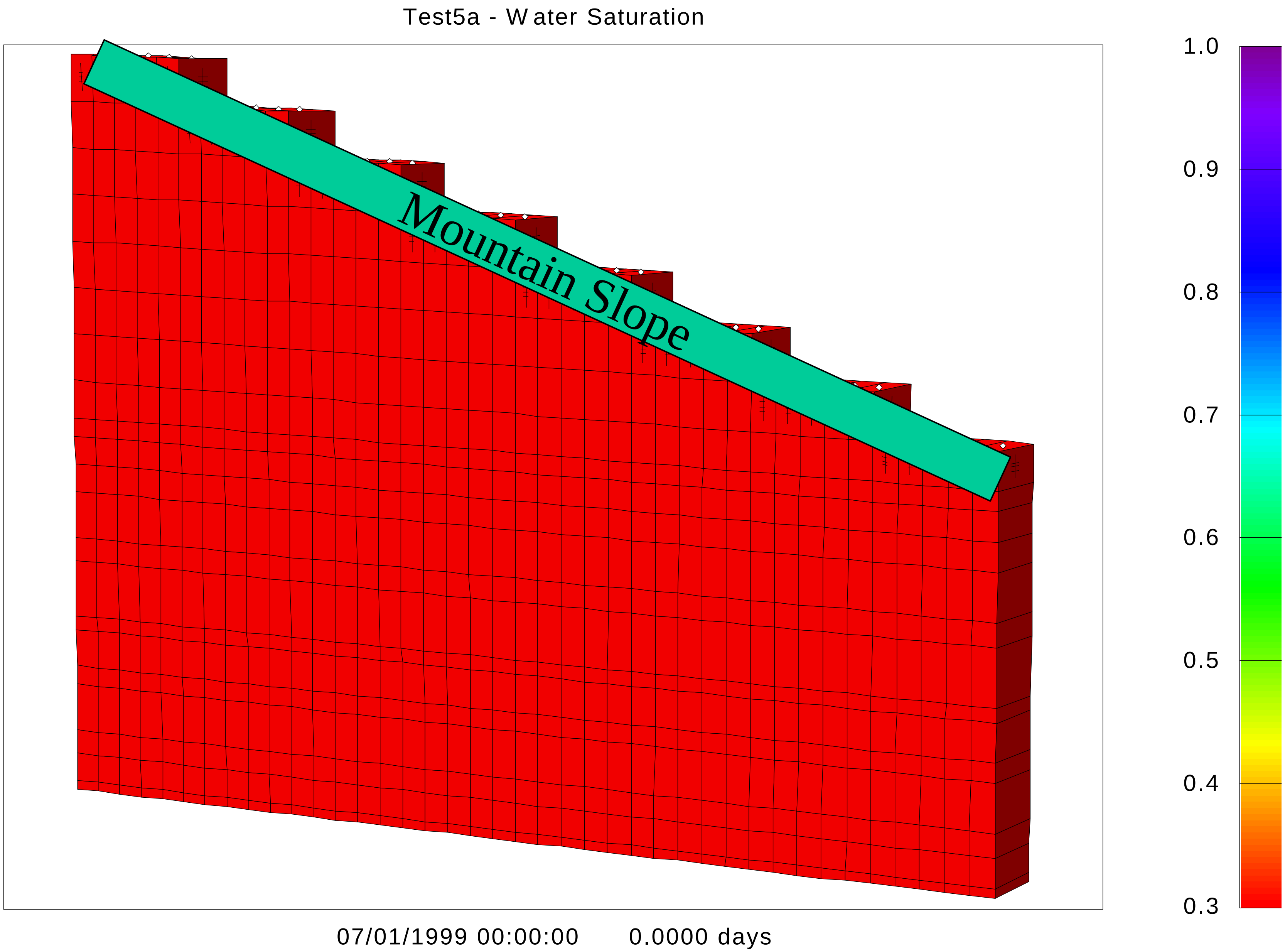


Water Injection into Vertical Wellbore - Radial Geometry

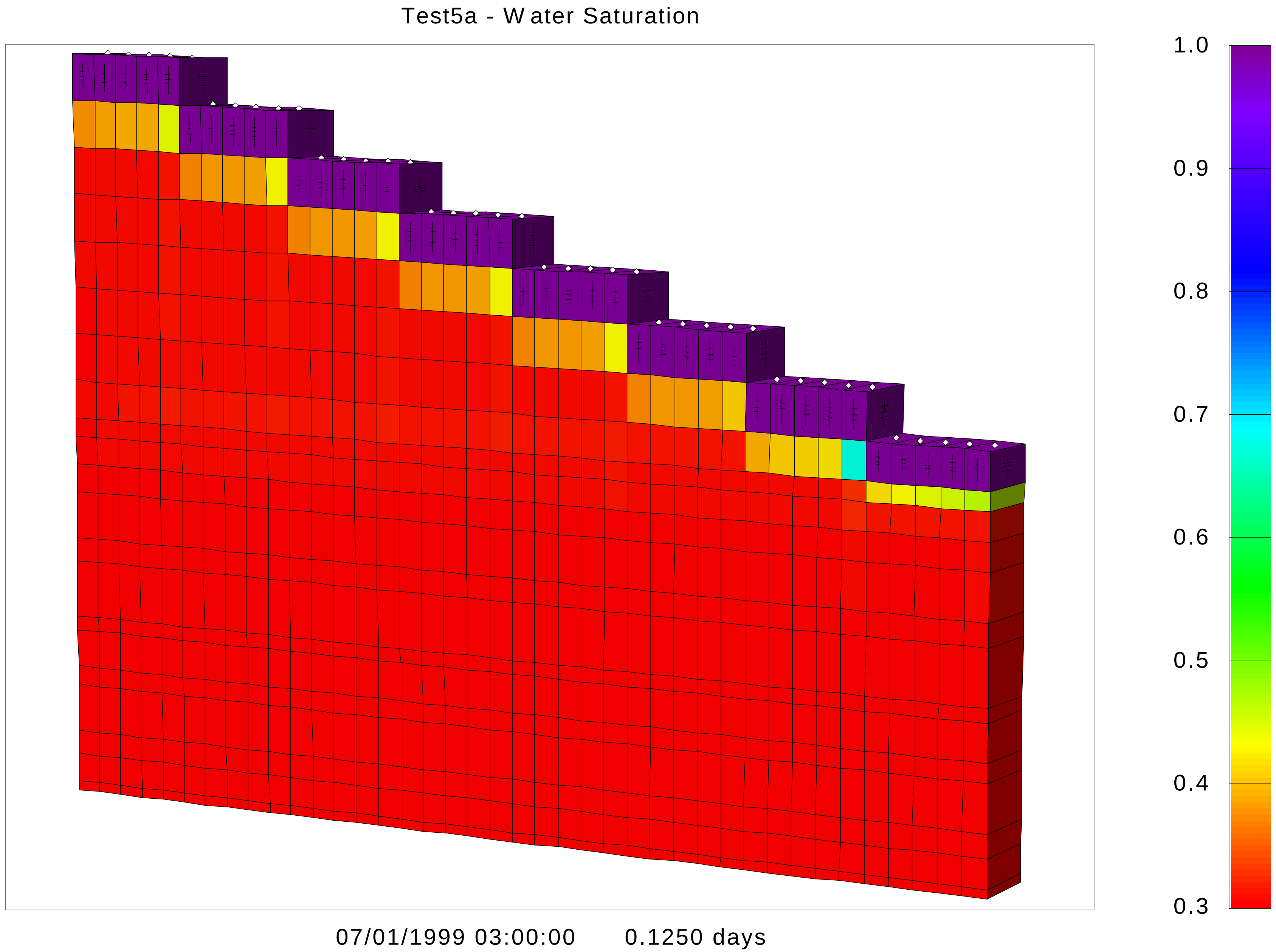
Water saturation distribution after 365 days



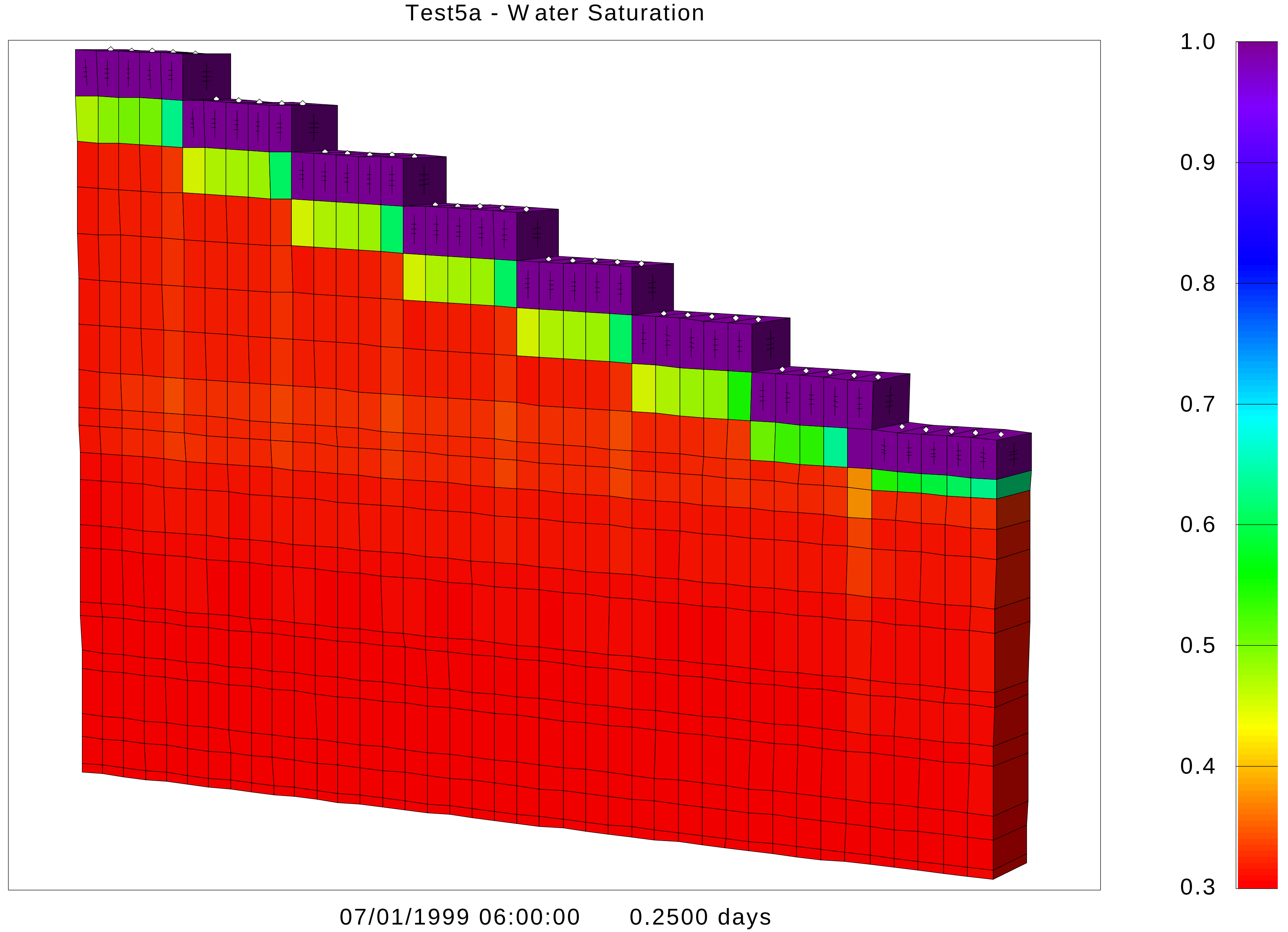
Initial Residual Water Saturation With Mountain Slope



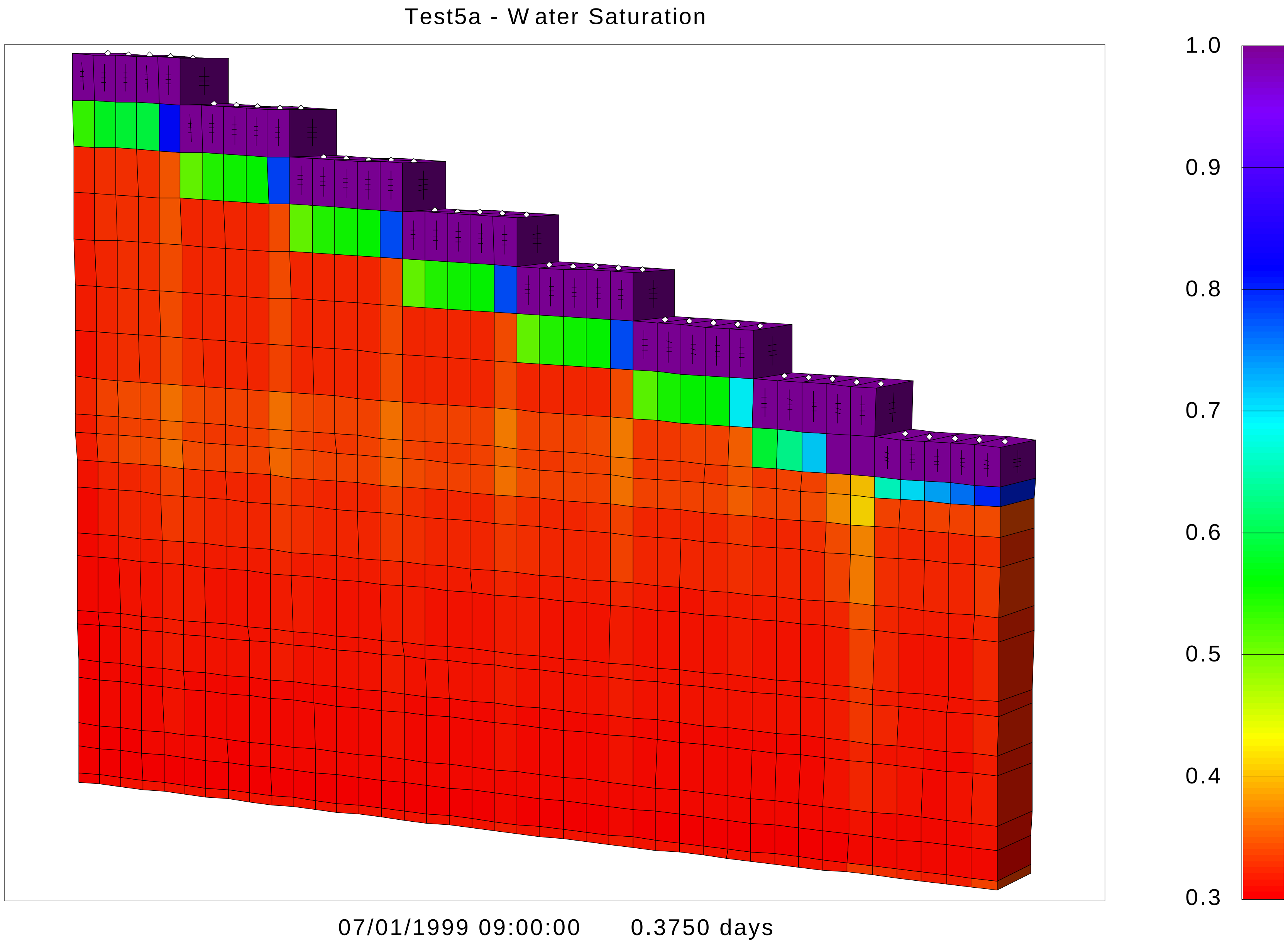
Water saturation after 3 hours



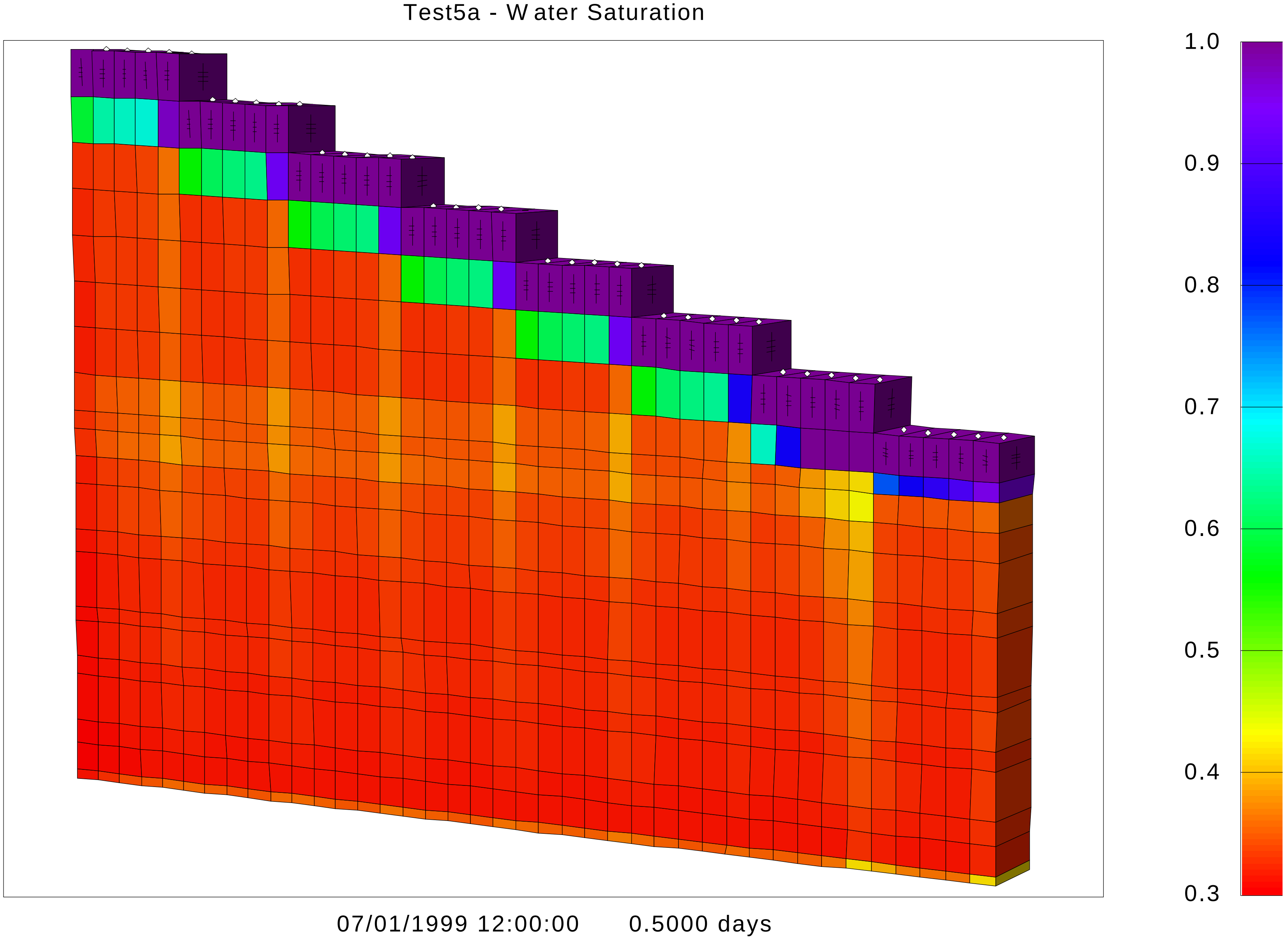
Water saturation after 6 hours



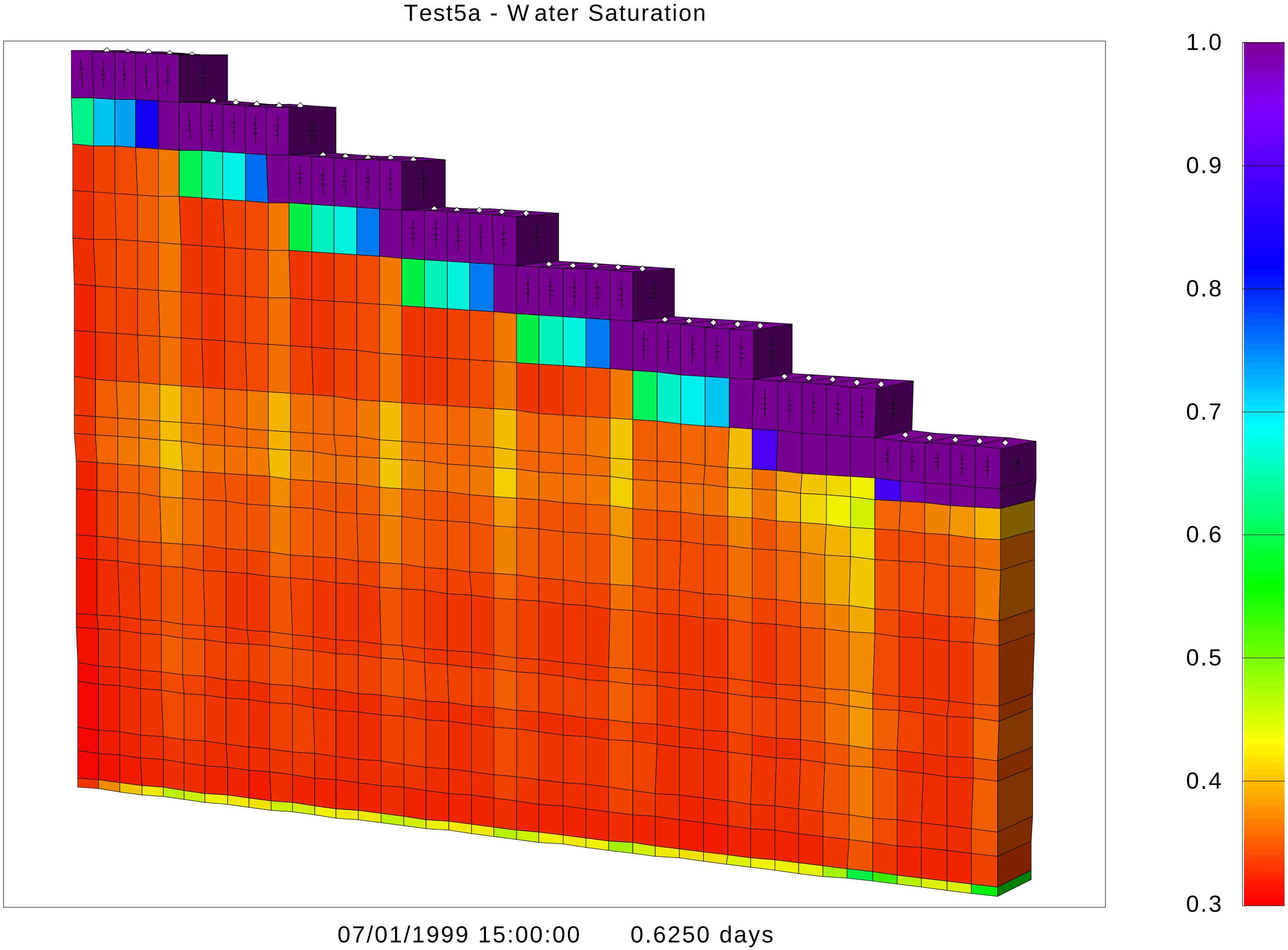
Water saturation after 9 hours



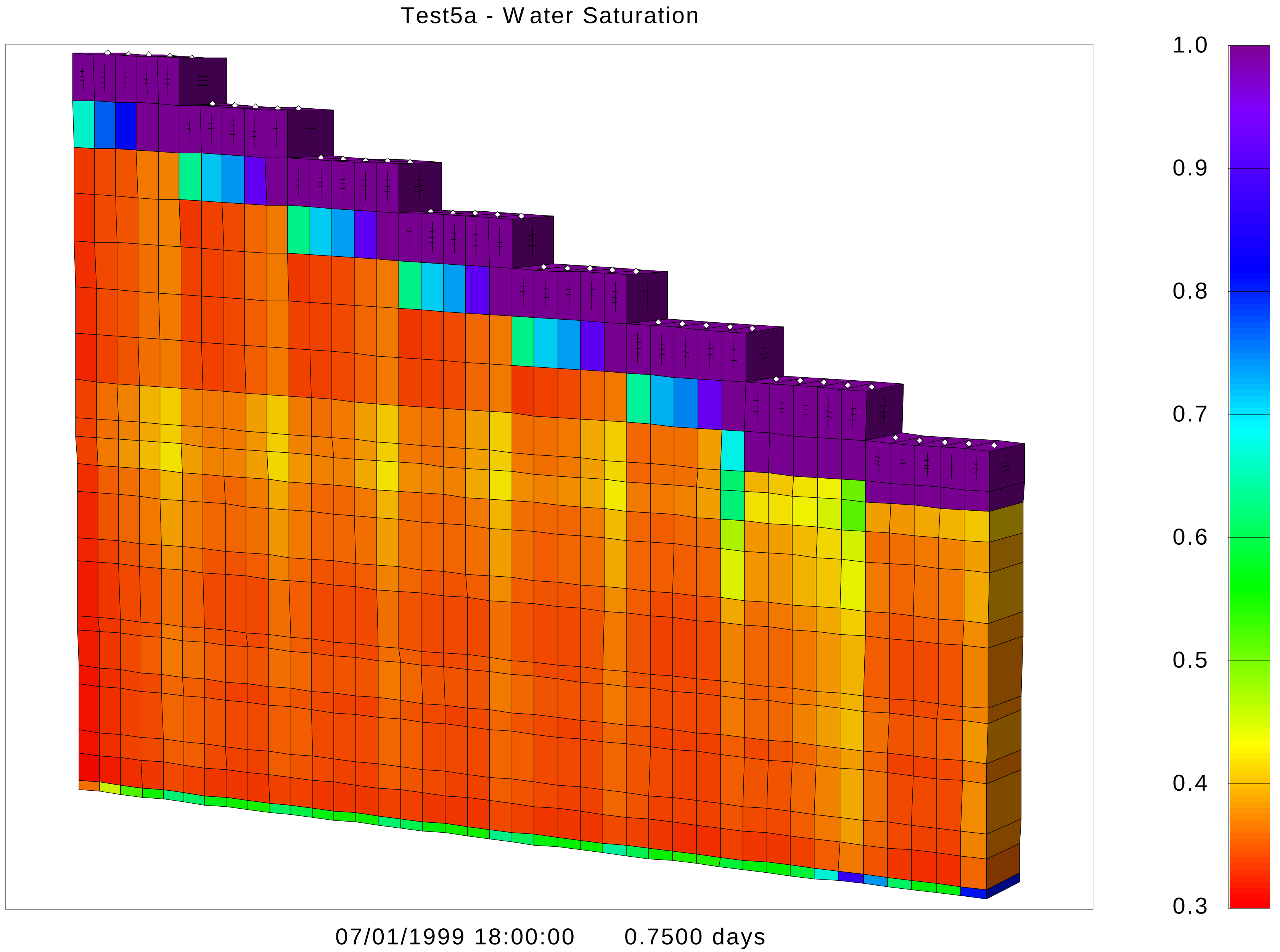
Water saturation after 12 hours



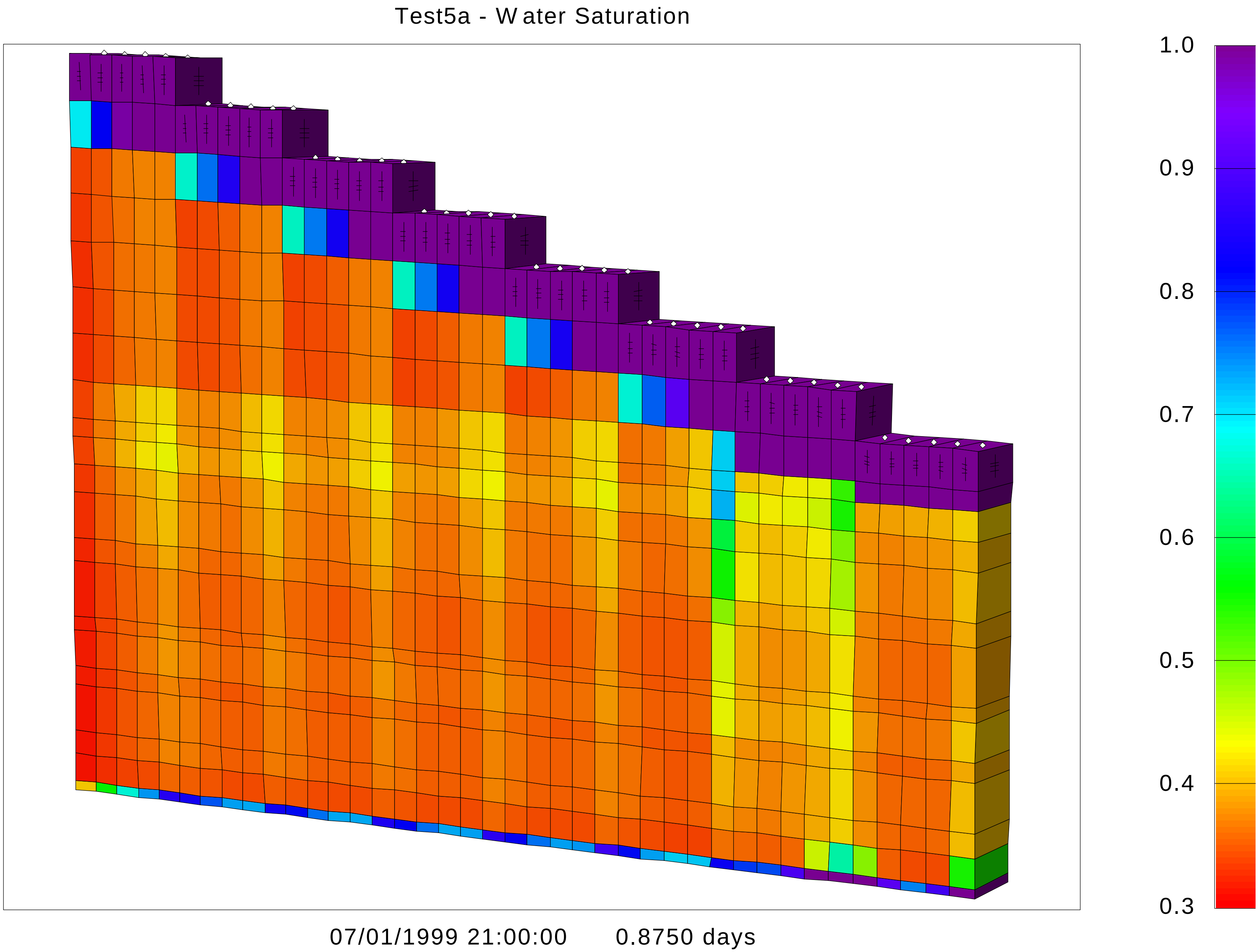
Water saturation after 15 hours



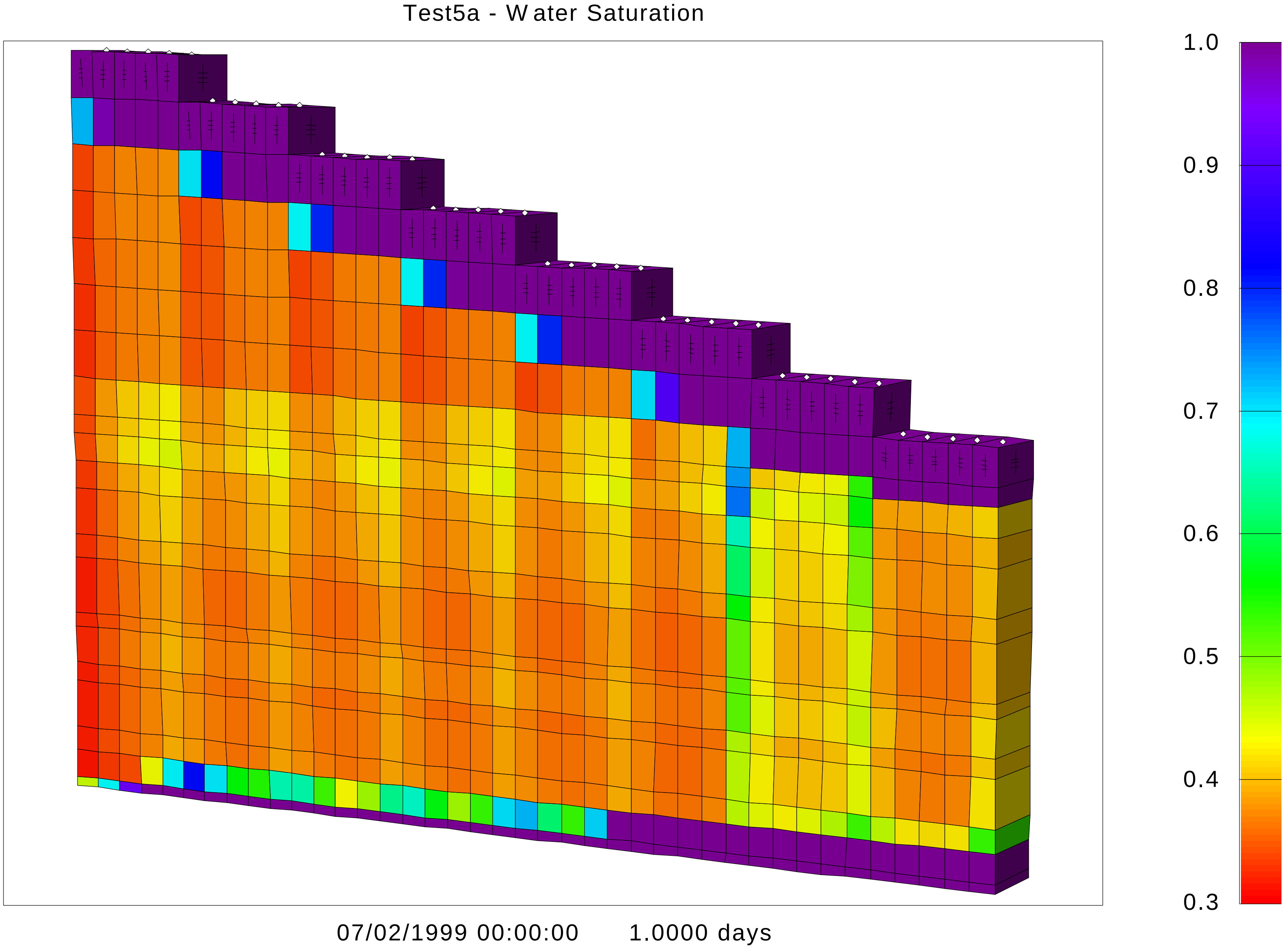
Water saturation after 18 hours



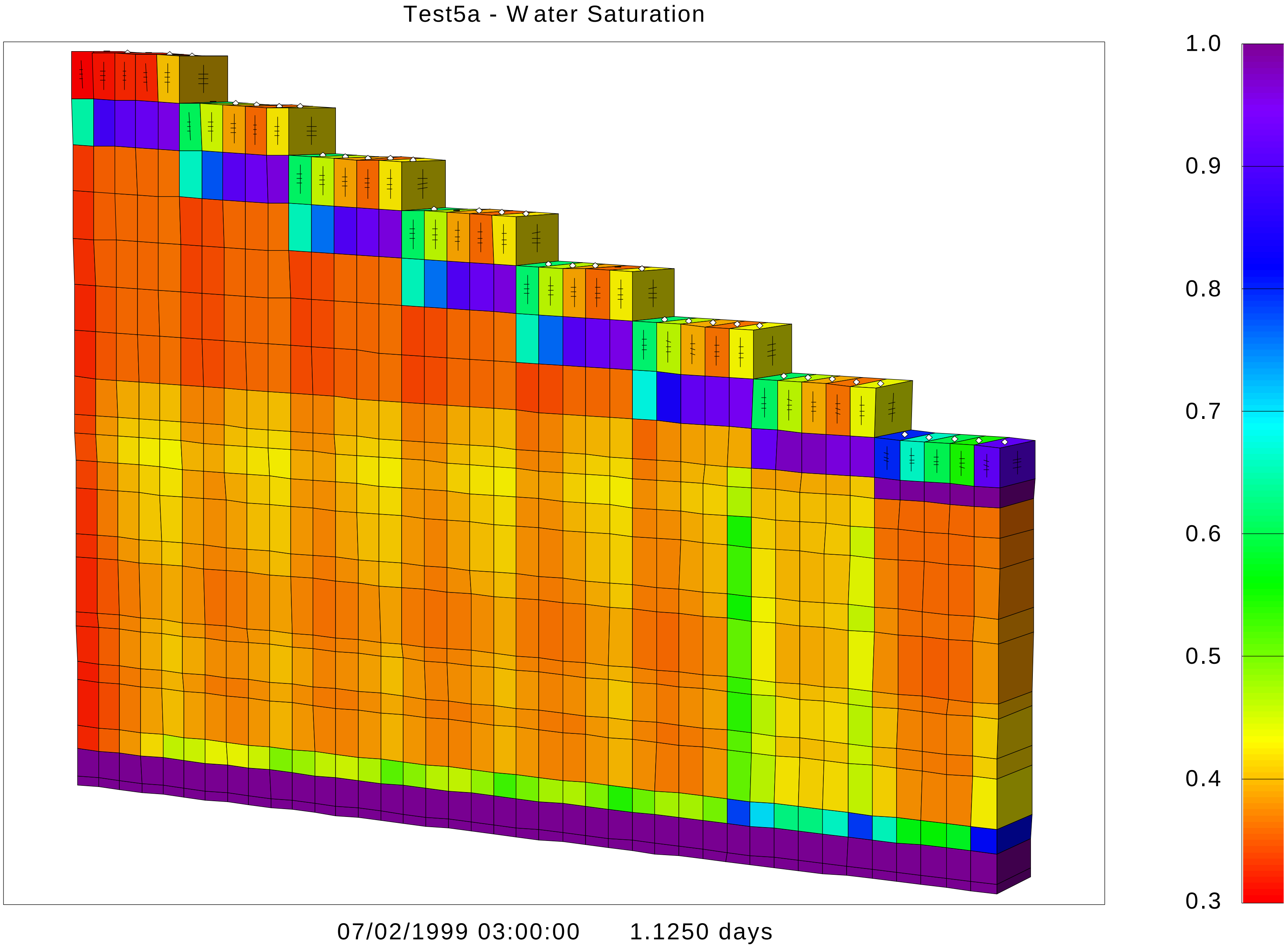
Water saturation after 21 hours



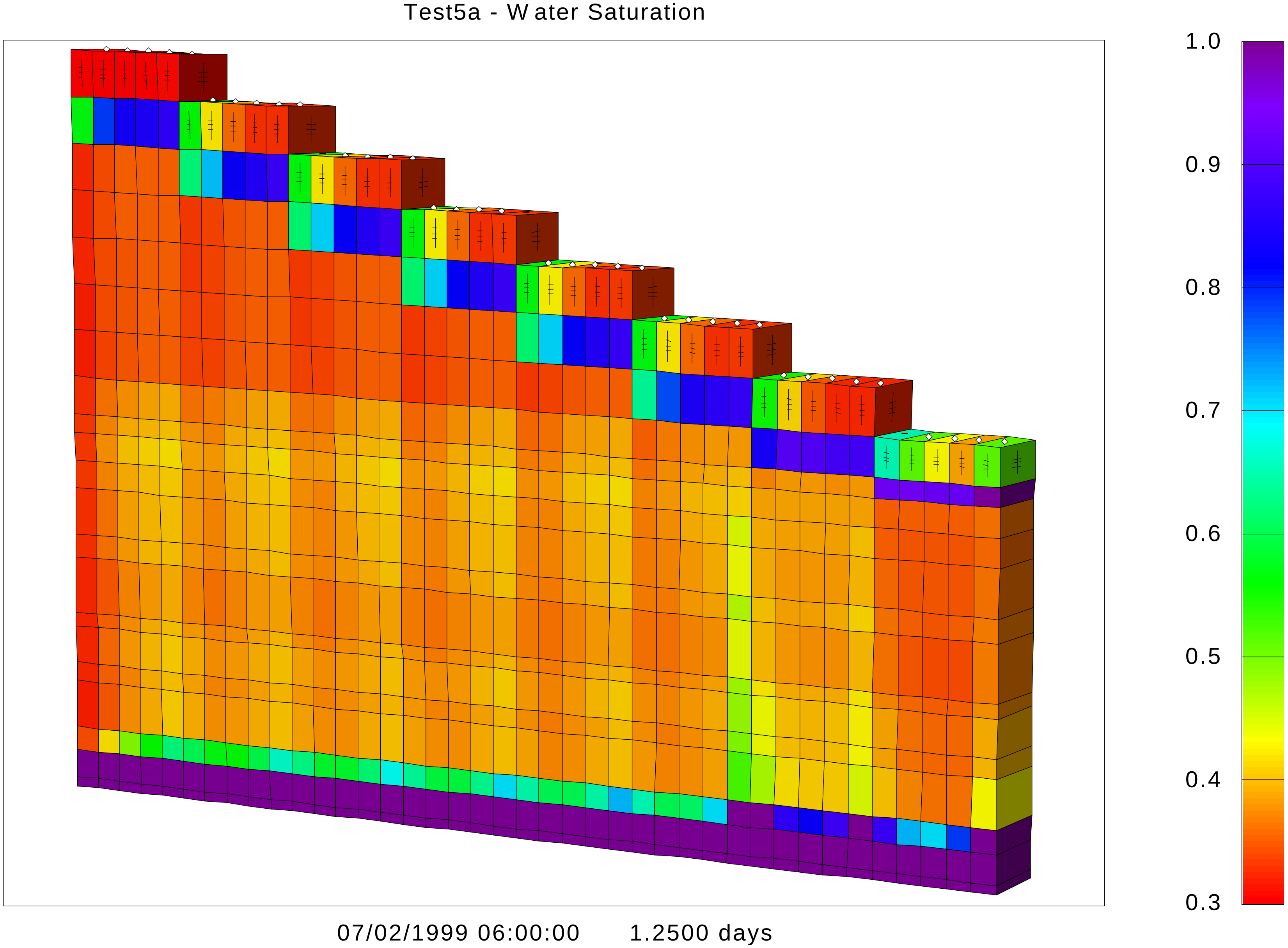
Water saturation after 24 hours - End Rainfall



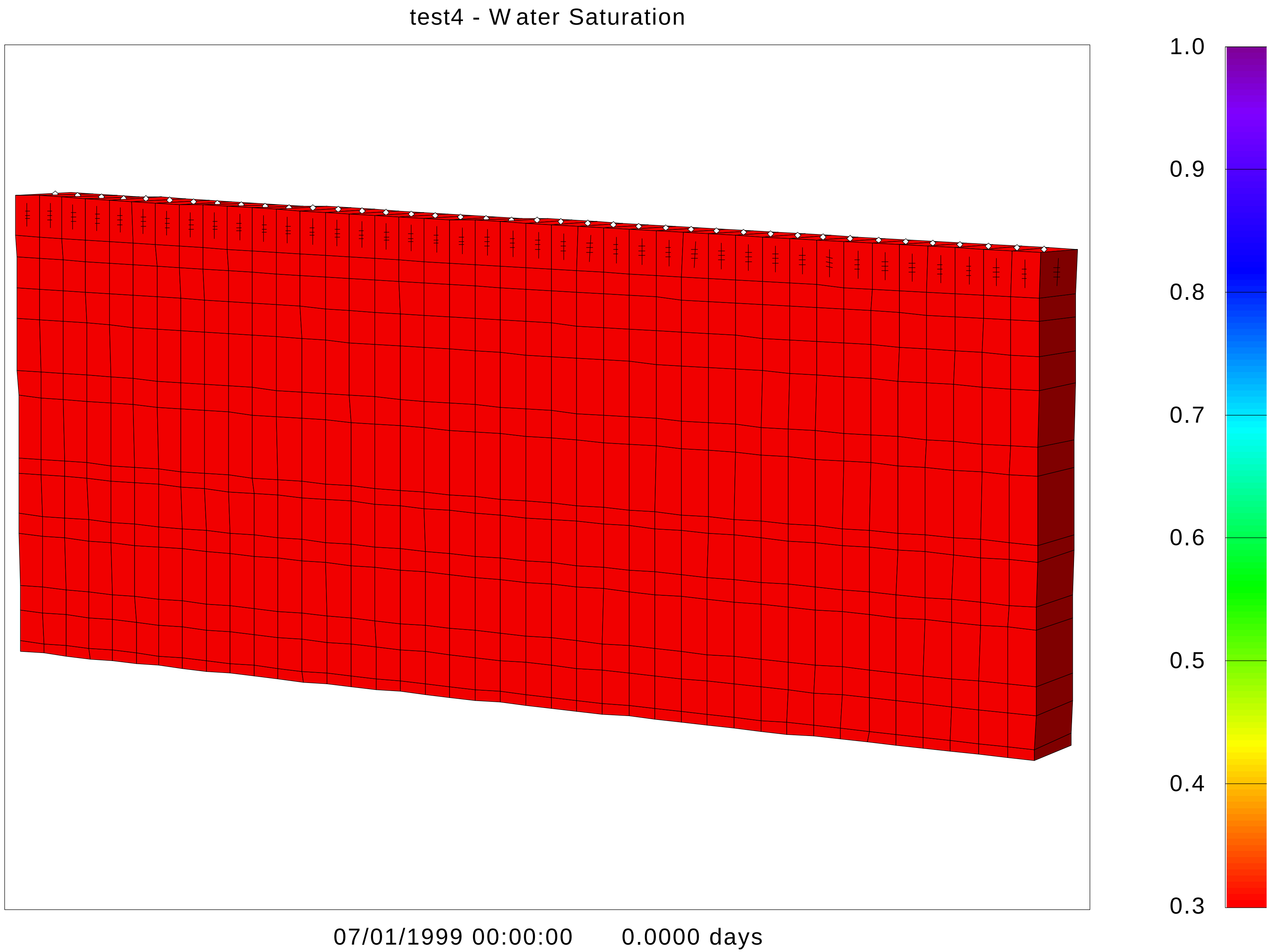
Water saturation after 27 hours



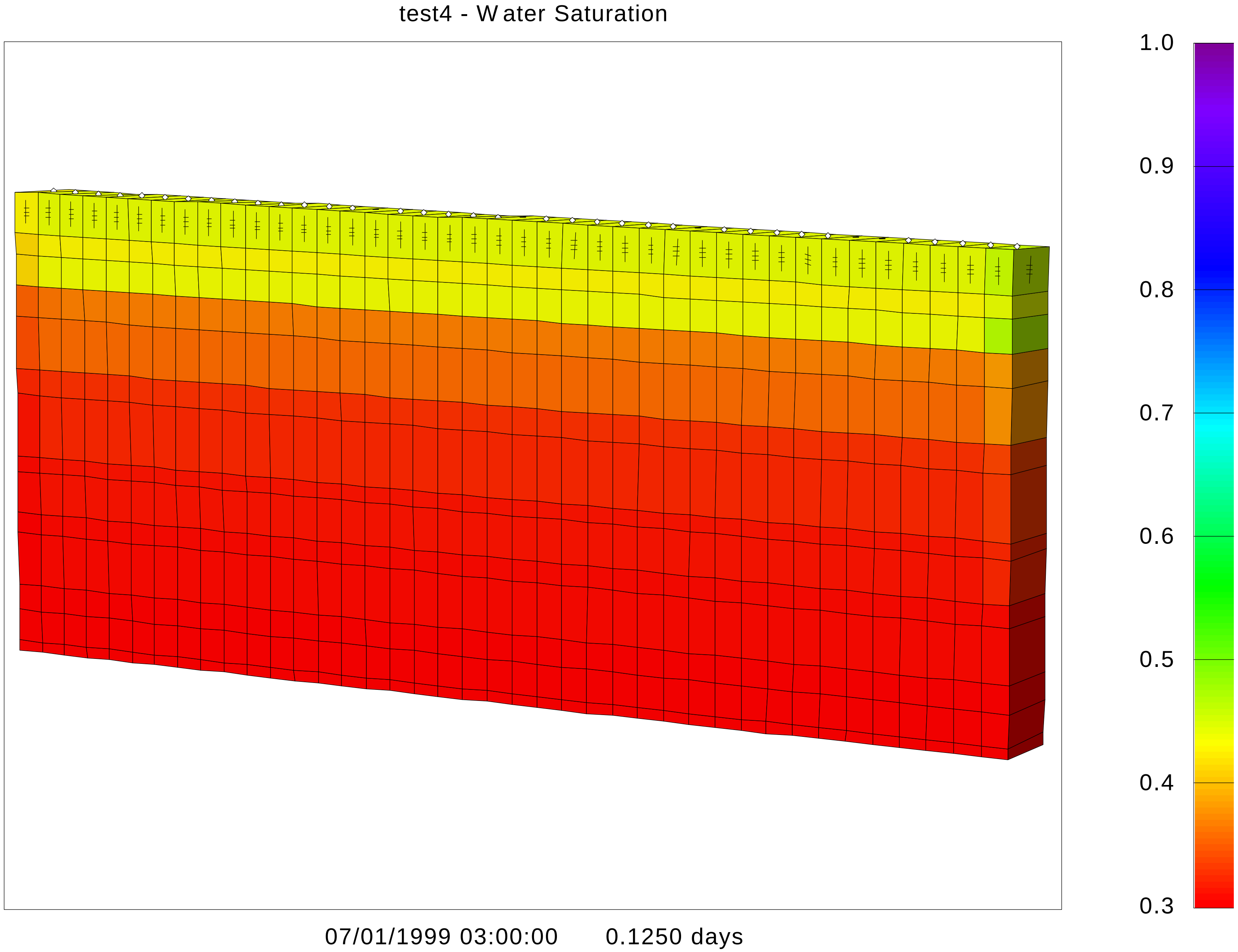
Water saturation after 30 hours



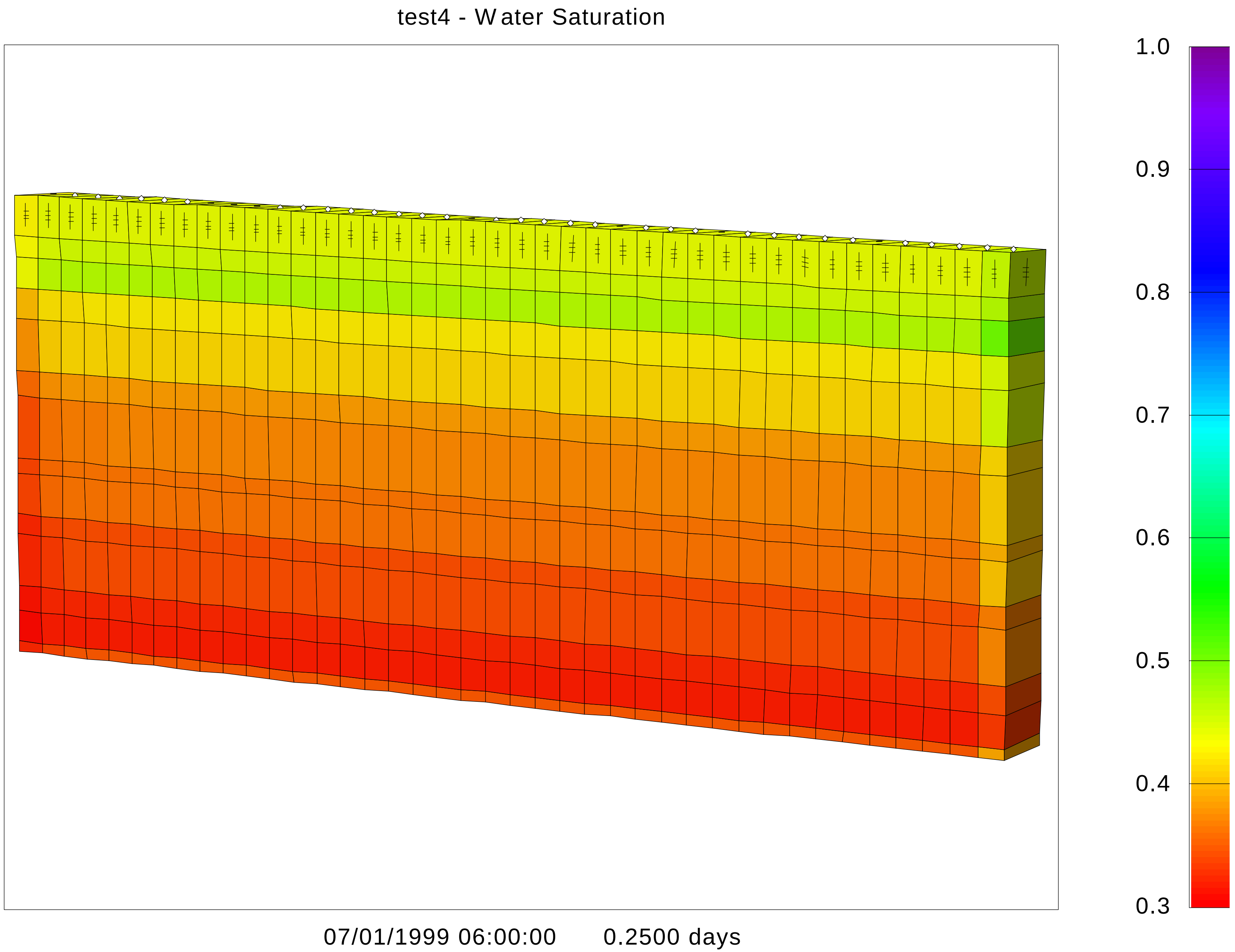
Initial Residual Water Saturation With Mountain Top Removal



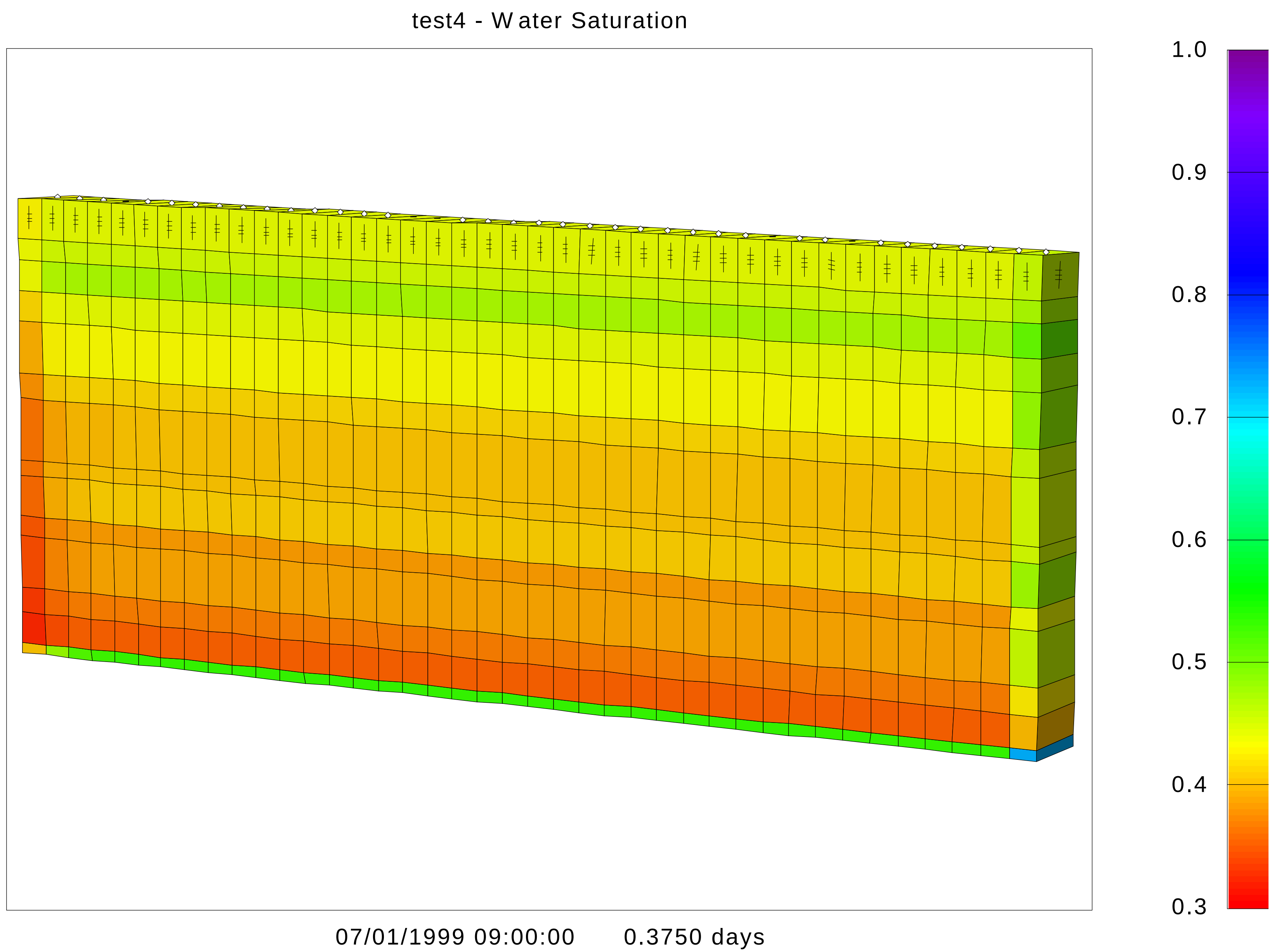
Water saturation after 3 hours



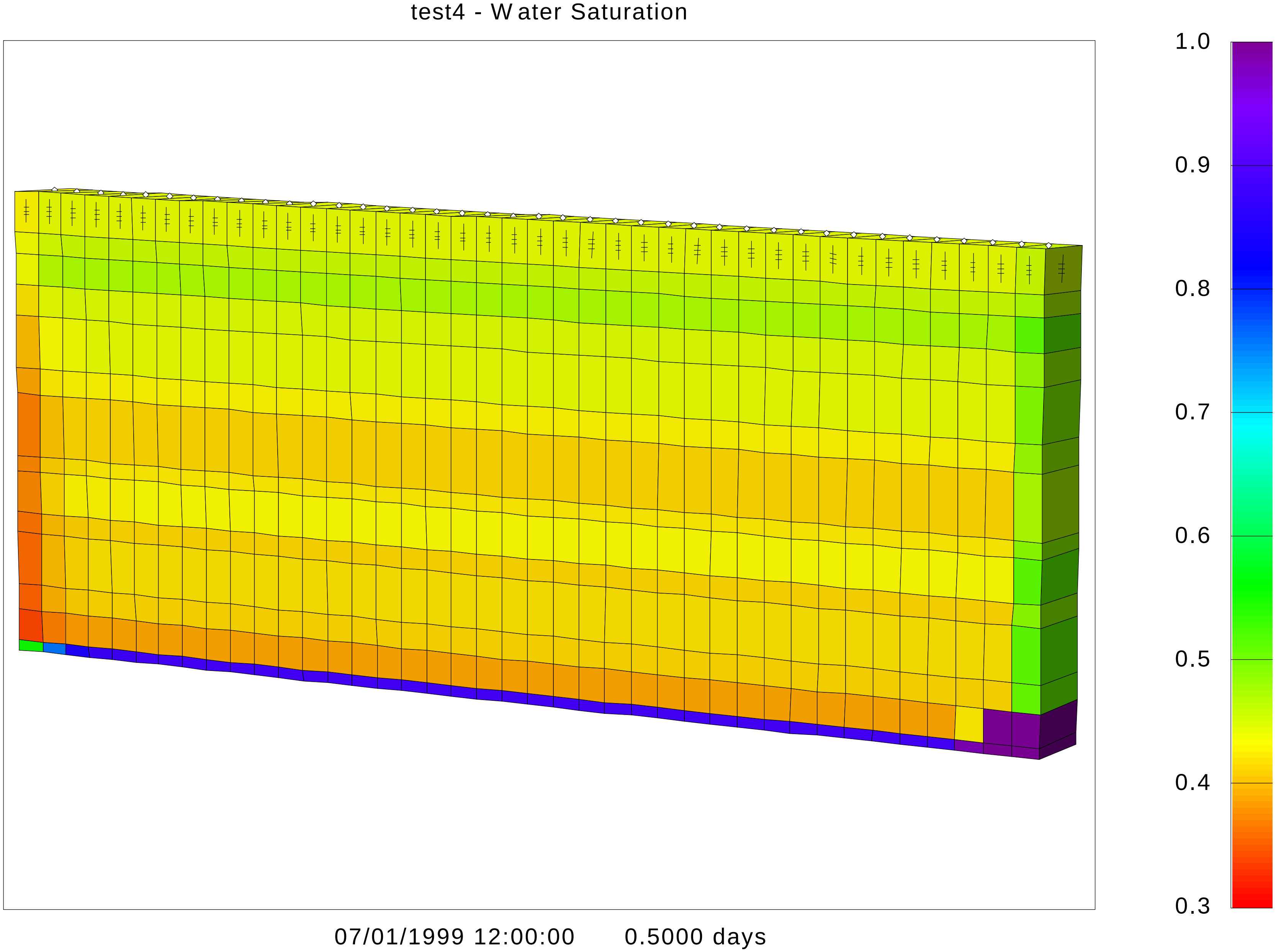
Water saturation after 6 hours



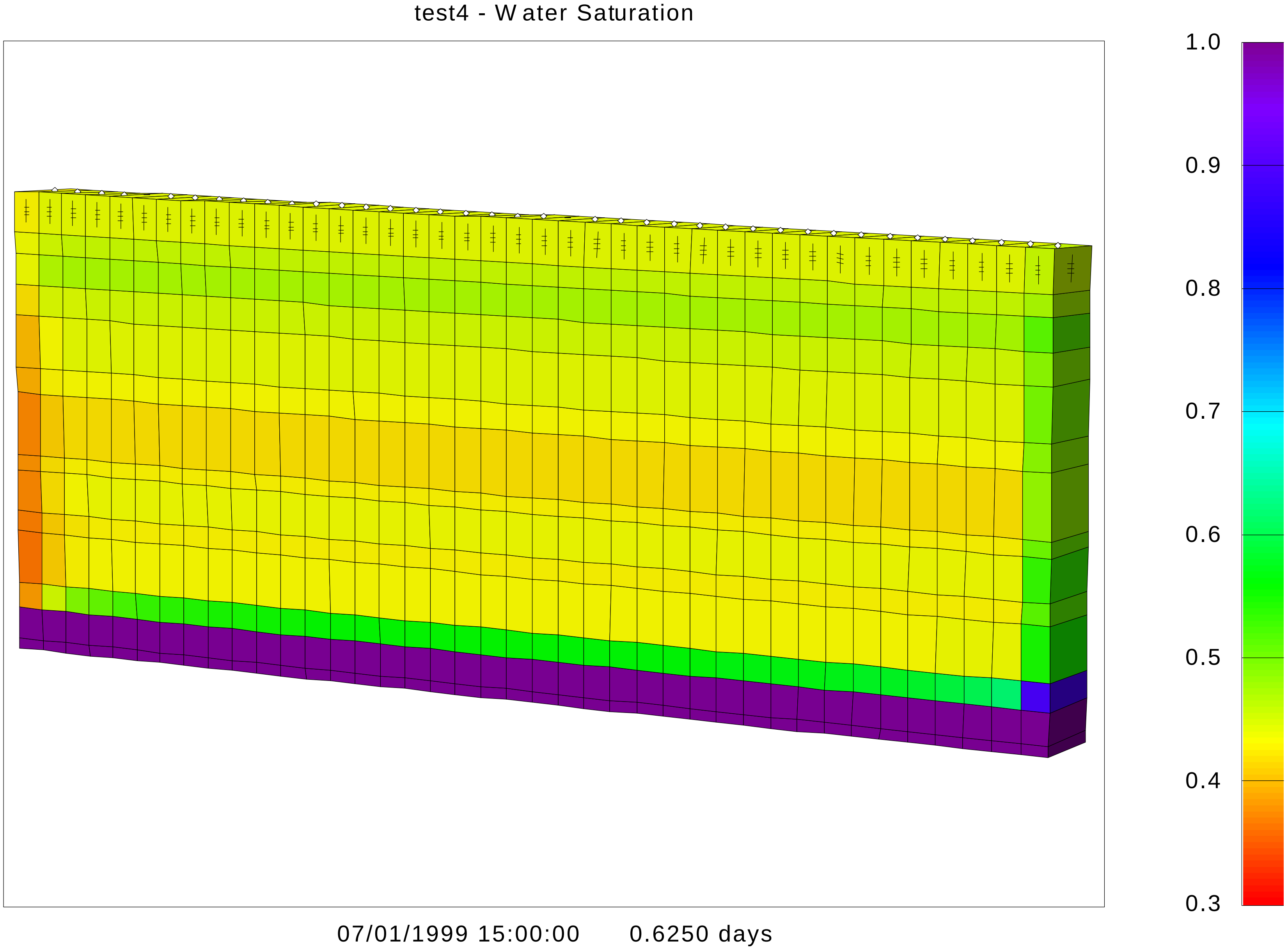
Water saturation after 9 hours



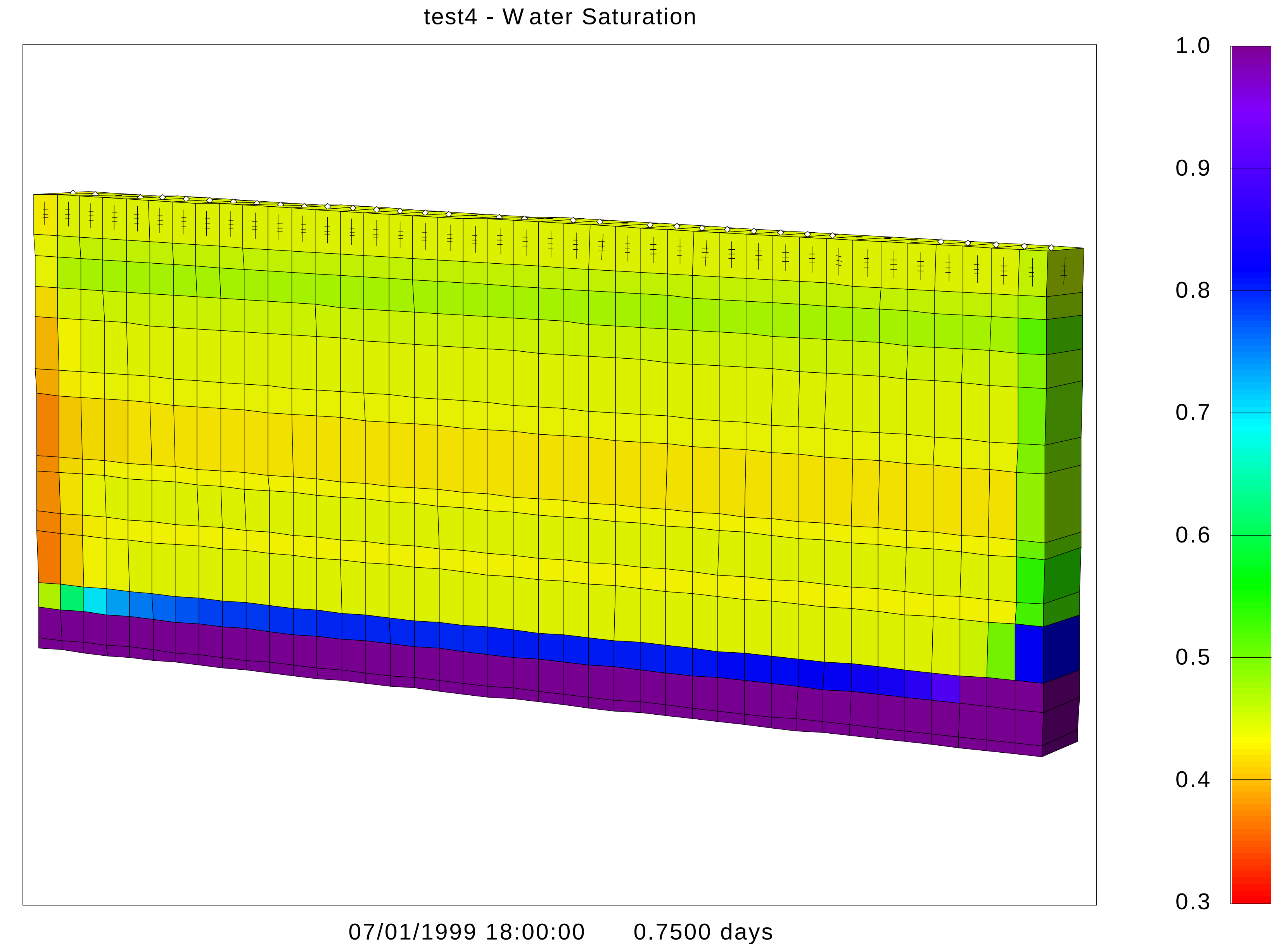
Water saturation after 12 hours



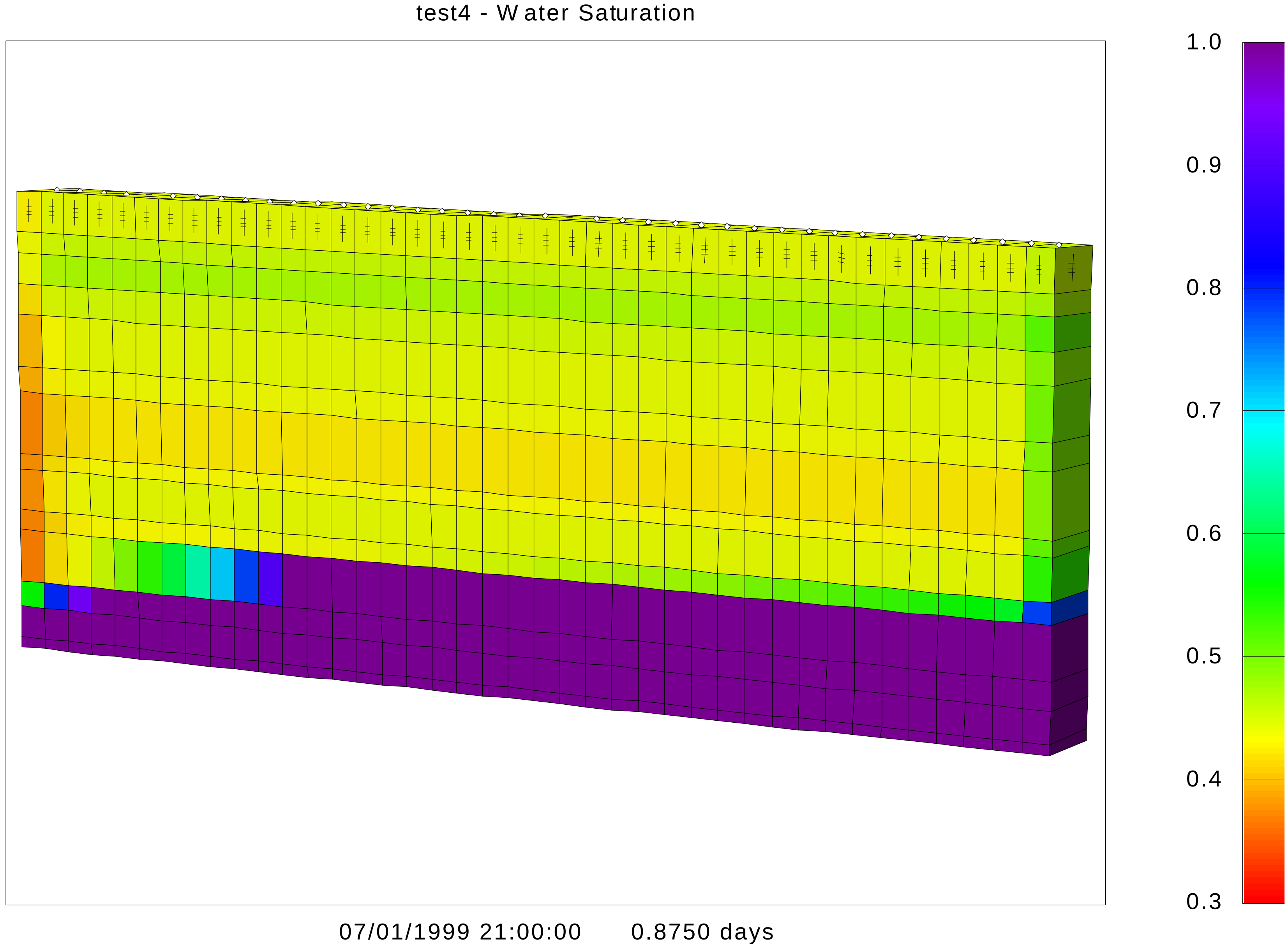
Water saturation after 15 hours



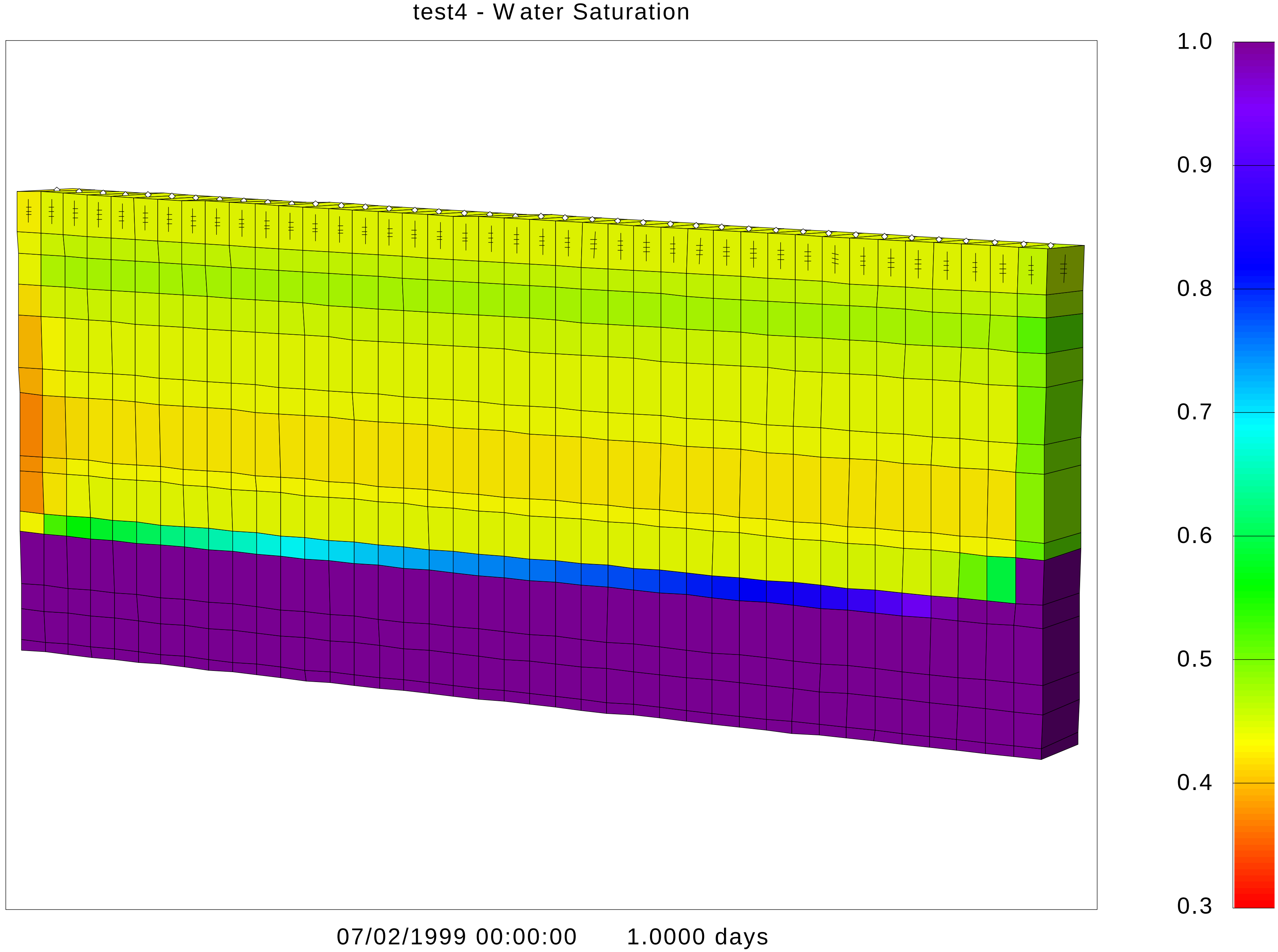
Water saturation after 18 hours



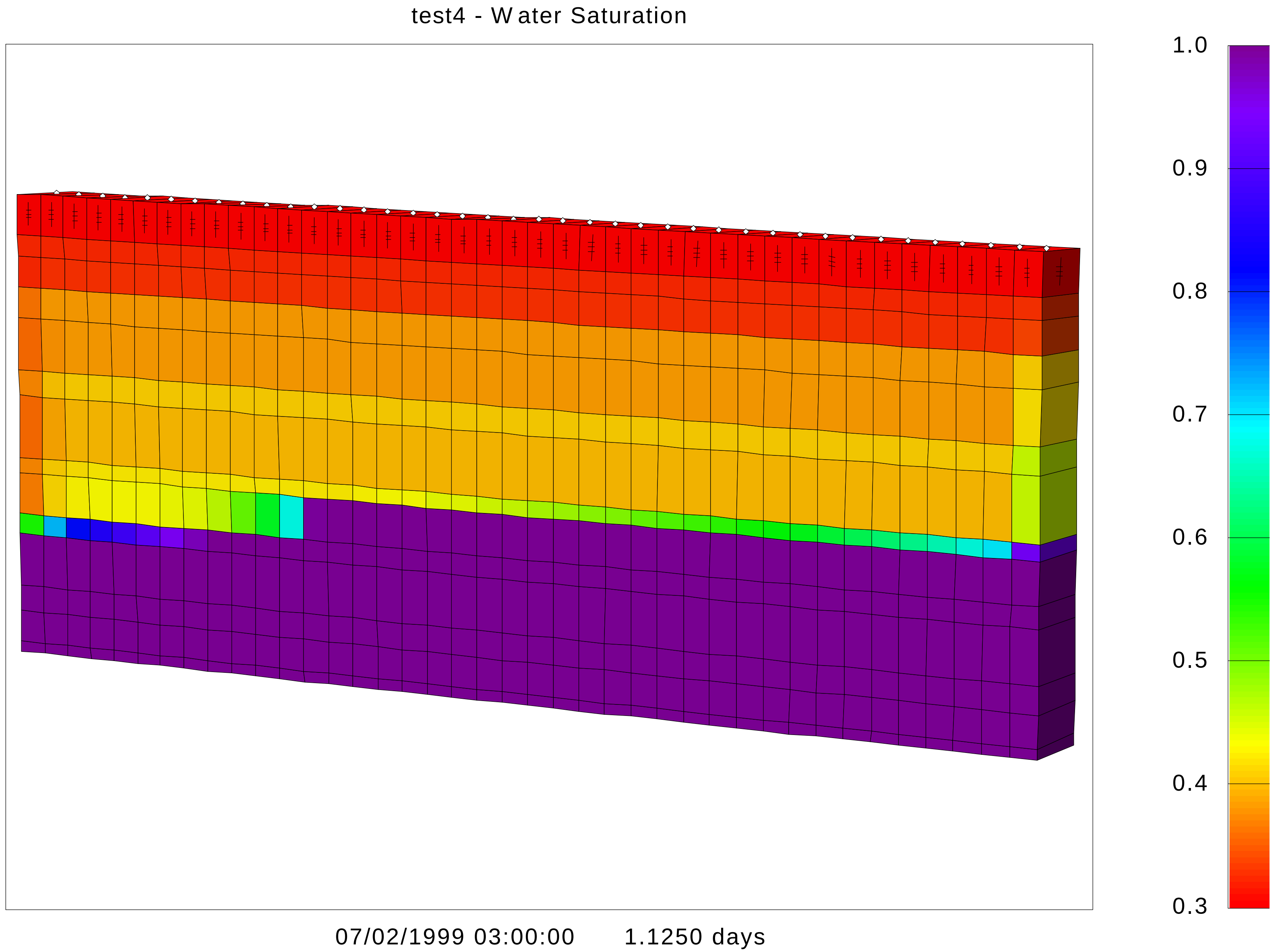
Water saturation after 21 hours



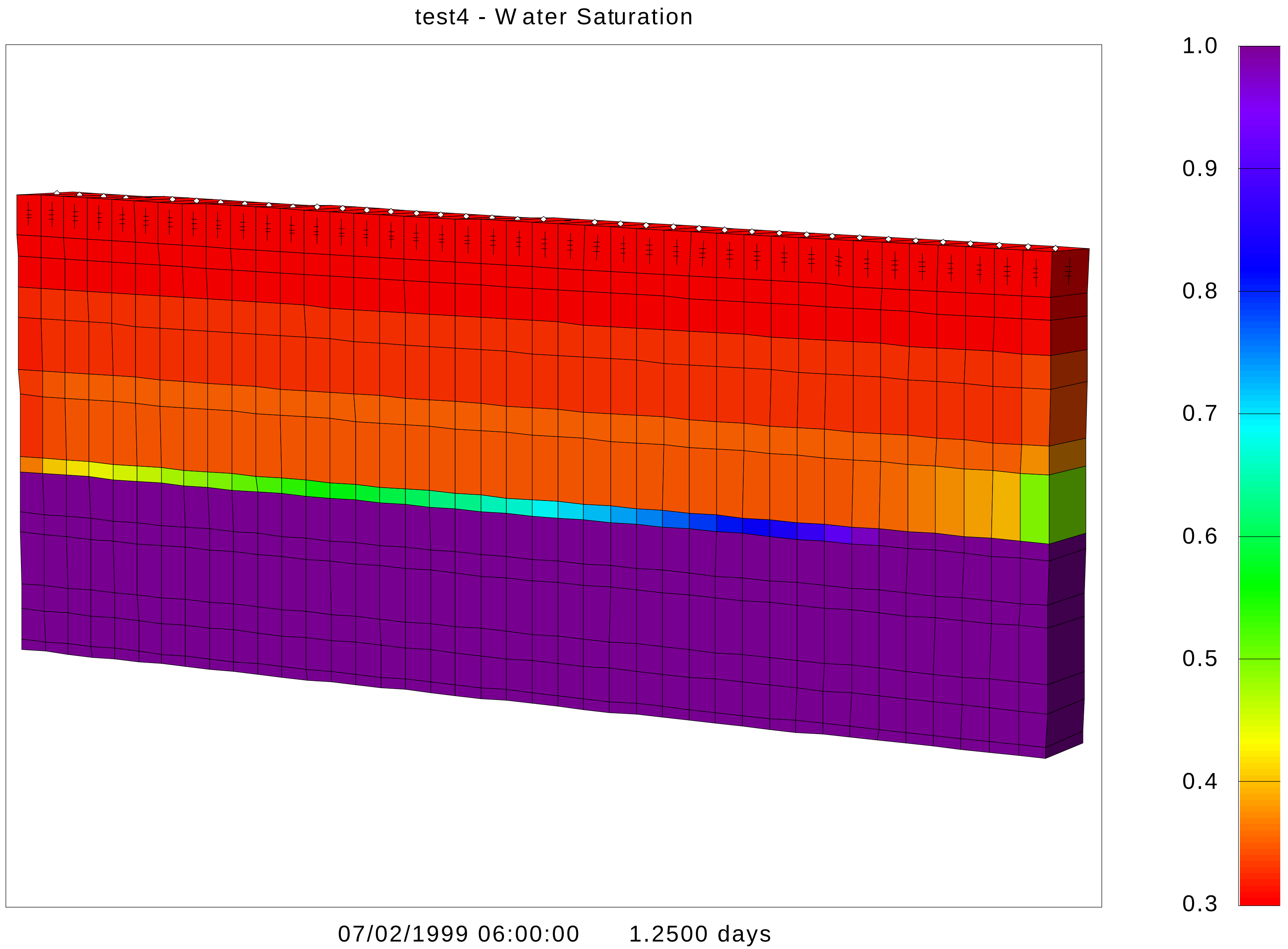
Water saturation after 24 hours - End Rainfall



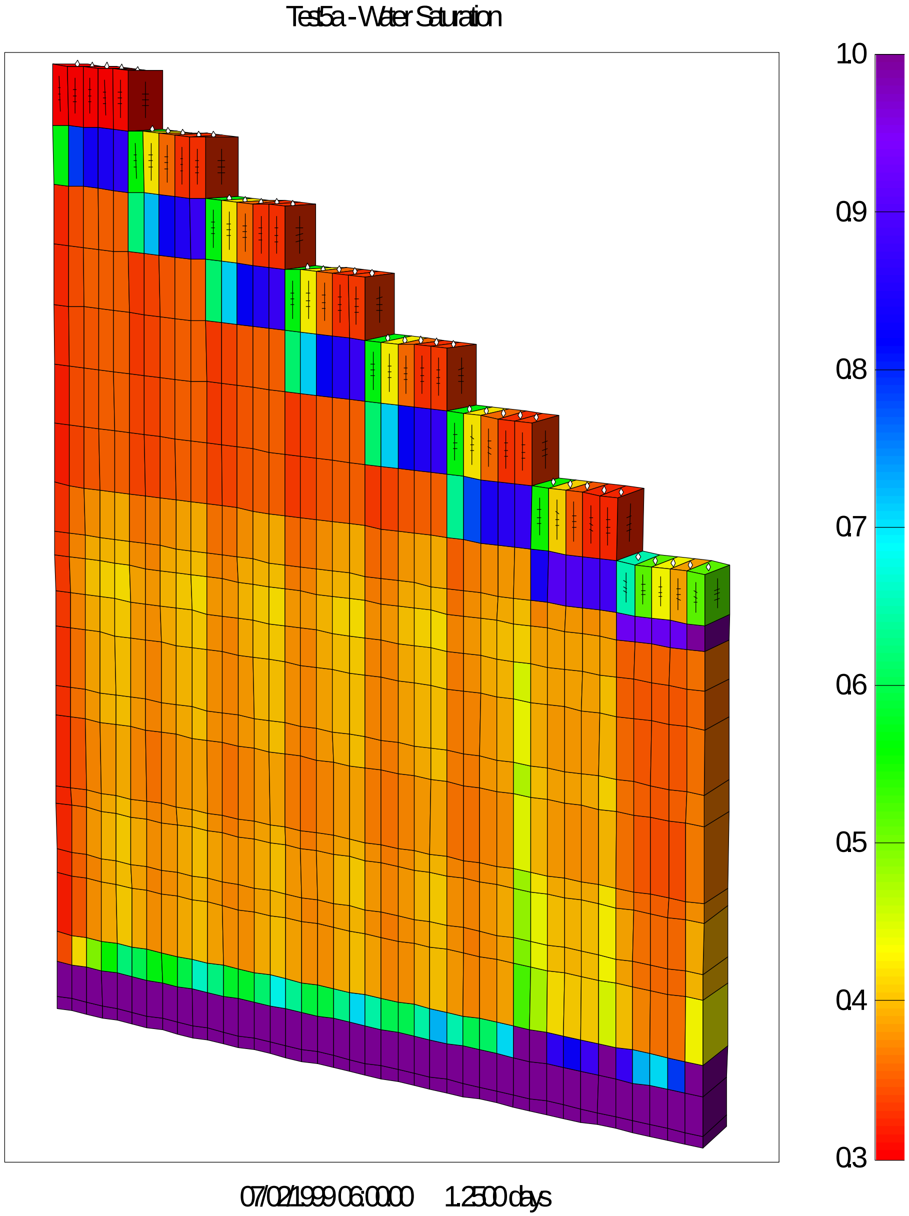
Water saturation after 27 hours

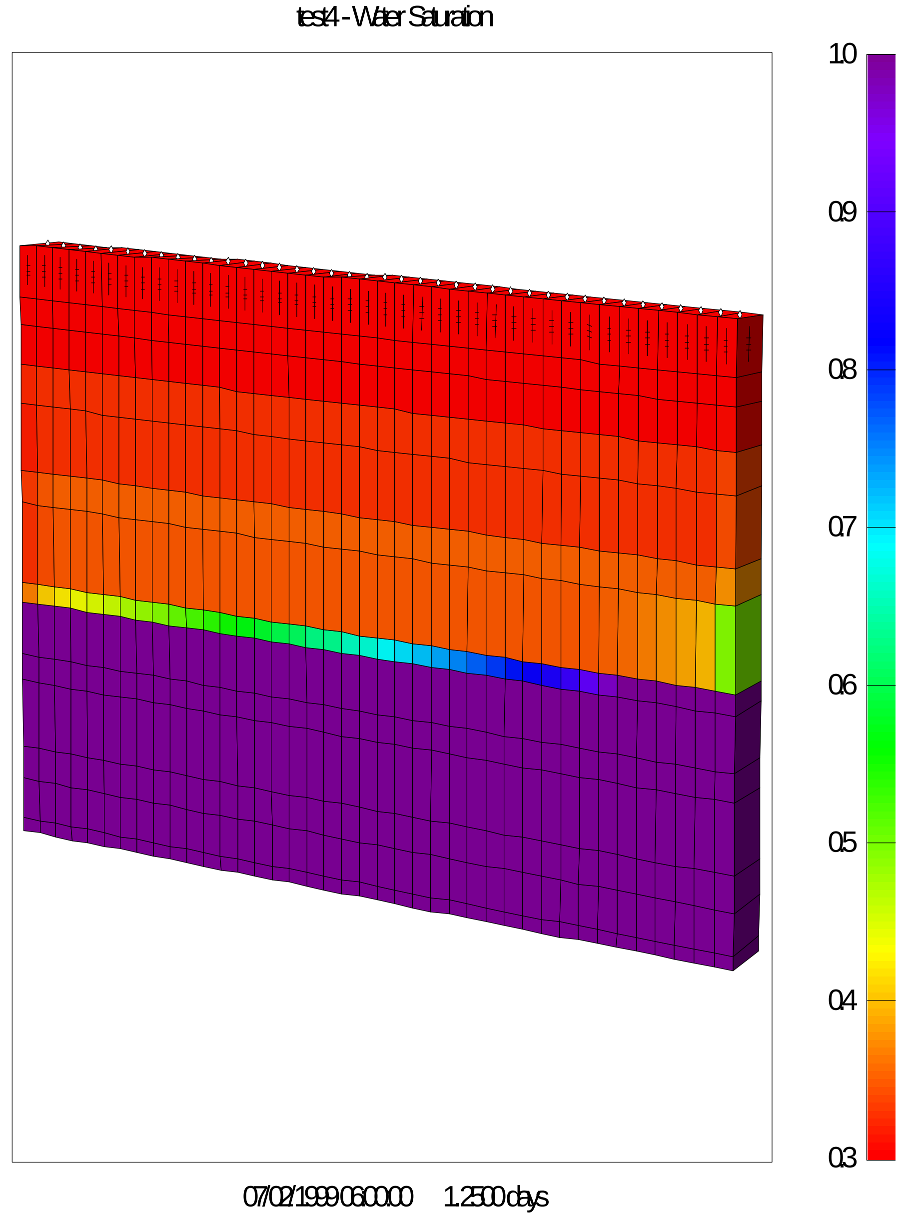


Water saturation after 30 hours



Increased Capture of Rain Water With Mountain Top Removal





VITA: LEONARD C. NELSON

EDUCATION

Bachelor of Science Degree in Mechanical Engineering, Iowa State University, Ames Iowa
Master of Science Degree in Mechanical Engineering, University of Missouri at Rolla Missouri
Doctor of Philosophy Degree in Engineering, Northwestern University, Evanston Illinois

PROFESSIONAL EXPERIENCES

Mechanical Engineer, Fisher Body Division of General Motors Corporation, Detroit Michigan
Engineering Officer, United States Navy
Assistant Professor of Mechanical Engineering, University of Missouri at Rolla Missouri
Associate Professor of Mechanical Engineering, North Carolina State University at Raleigh North Carolina
Professor of Engineering, West Virginia Institute of Technology at Montgomery West Virginia
Dean, West Virginia Institute of Technology
President, West Virginia Institute of Technology

SPECIAL RECOGNITIONS

Member, Tau Beta Pi, Engineering Honorary Fraternity
Recipient, Murphy Foundation Scholarship and Pure Oil Fellowship at Northwestern University
Honorary Doctorate of Engineering, West Virginia Institute of Technology
Leonard C. Nelson College of Engineering, Named by Faculty of West Virginia Institute of Technology

PROFESSIONAL AND CIVIC ACTIVITIES

Member Board of Directors and President for Two Terms, Montgomery Chamber of Commerce
Member Board of Directors, Upper Kanawha Valley Economic Development Association
Member, American Association of State Colleges and Universities

BIOSKETCH
OF WALTER K. SAWYER

Experience

33 years professional experience including: laboratory research, computer modeling, project management, university teaching, and consulting services in the oil and gas industry.

Founder and President, Mathematical and Computer Services, Inc. (1980 – Present)
Senior Petroleum Engineer, H-RT Consulting Services, Schlumberger (1995 – Present)
Associate Professor Petroleum Engineering, WVU (1978 – 1982)
Research Mathematician, U.S. Dept. of Energy (1966 – 1978)

Education

Glenville State College – B.S. Chemistry (1965)
West Virginia University – M.S. Mathematics (1973)
Industry Schools:

- Pennsylvania State University: Numerical Reservoir Simulation (1972)
- The University of Tulsa: Well Test Analysis (1973)
- Scientific Software Corporation: Reservoir Simulation (1976)
- Texas A&M University: Advanced Petroleum Reservoir Engineering (1977)
- Physics International, Inc.: Continuum Mechanics (1976)
- Joshi Production Technologies: (Horizontal Drilling (1990)

Publications and Presentations

22 Publications
6 Short Courses

- "Reservoir Simulation as an Engineering Tool," U.S. Department of Energy, Morgantown, WV, September 1983.
- "Simulation Methane Reservoir Engineering," Eastern States Exploration Company, Alexandria, VA, August 1991.
- "Advanced Coalbed Methane Reservoir Engineering," University of Alabama, College of Continuing Studies, April 6-8, 1994.
- "Applied Reservoir Simulation," CNG Transmission Corporation Clarksburg, WV, April 1997.
- "Coalbed Methane Engineering," University of Alabama, College of Continuing Studies, May 1999.

Professional Affiliations

Registered Professional Engineer, PA
Society of Petroleum Engineers of AIME
Pi Epsilon Tau
Pi Mu Epilson

BIOSKETCH
OF
L. ZANE SHUCK

EXPERIENCE

42 years professional experience, including: college and university teaching, research and administration; planning, conducting and managing national energy research programs; consulting with industry; oil and gas well operator in WV & OH including developing over 65 wells; conducting interdisciplinary research in biomechanics and rheology; and, proprietor and executive officer in consulting and R & D companies. Inventor, and real estate developer.

President, Technology Development Inc. (1980-present)
Founder and President, The WMAC Foundation (1997-present)
WVU, Professor Mechanical Engineering and Associate Director, Engineering Experiment Station. Member Graduate Faculty, master and doctoral theses advisor (1976-80). Adjunct Professor (1980-85)
US Dept. of Energy, Supervisory Mechanical Engineer(1970-76)
National Science Foundation Science Faculty Fellow, & Res. Engineer WVU (1965-70)
WVa Tech, Associate Professor & Chairman, Dept. of Mechanical Engineering(1960-65)

EDUCATION

BSME - W.Va. Institute of Technology, 1958
MSME -West Virginia University, 1965
Ph.D. - West Virginia University, 1970
Graduate, post-doctoral, and summer programs at Iowa State University, Wayne State University, and Massachusetts Institute of Technology

PUBLICATIONS AND PATENTS

62 publications, 12 patents (including first patent ever awarded through WVU), Producer 4 technical films for U.S. Dept of Energy

ANCILLARY INFORMATION

Registered Professional Engineer WV & OH; Certified by National Council of Engineering Examiners; Science Advisor WV Governor John D. Rockefeller IV (78-81); Science and Technology Coordinator WV Legislature(79-80); ASTM Award (70); ASME Ralph James National Award (80); Editor Transactions Journals and Symposia Proceedings; Licensed Surveyor WV

PROCEEDINGS

APPALACHIAN RIVERS

A COOPERATIVE INDUSTRY, GOVERNMENT, ACADEMIA, AND WATERSHED ORGANIZATIONS CONFERENCE AND WORKSHOP

PROCEEDINGS

APPALACHIAN RIVERS I

A COOPERATIVE INDUSTRY, GOVERNMENT, ACADEMIA, AND WATERSHED ORGANIZATIONS CONFERENCE AND WORKSHOP

Time: 8:00 A.M. - 5:00 P.M.

Date: April 23, 1998

Location: West Virginia High Technology Consortium (WVHTC), Fairmont, WV

A CONFERENCE AND WORKSHOP OF INVITED PARTICIPANTS TO ADDRESS DEVELOPMENT AND APPLICATIONS OF ADVANCED TECHNOLOGIES TO APPALACHIAN RIVERS

MOTEL RESERVATIONS AND ARRANGEMENTS

Michelle Cameron 304-366-0774
7001 Mountain Park
Drive, Suite C
Fairmont, WV 26554

TABLE OF CONTENTS
OF ABSTRACTS

"WELCOME" BY CONFERENCE CHAIRMAN

Good Morning, I am Zane Shuck, Organizer of this conference.

I would like to welcome you to this first annual Appalachian Rivers Conference, Workshop and Exhibit, and thank you for your participation. I individually invited each of you because you are the experts in river matters. I also thank you for your efforts in monitoring our rivers, and to clean up our streams and rivers. I also think the general public needs to know more details about the good work you are doing.

At this time, I would like to introduce some people who helped make this conference happen. Introductions of Damita Pagan, and Michelle Cameron of NEW-BOLD Enterprises, Inc., and Nancy T. NewBold, President, NEW-BOLD Enterprises, Inc.

Shelly Montgomery, JoEllen Markley, Heather DuPont, Tammy Rebrook, and Dave Walker of WVHTCF. Thank you very much for your assistance with the arrangements and support throughout this project.

Barbara Weaver, Vice President of Administration, WVHTCF, (also a watershed organization officer), this conference could not have happened without your assistance and suport. And, thank you to Larry Milov, President of WVHTCF.

I would also like to recognize a few who helped in the planning of this conference.

Tom Keech, President, Process Dynamics
Dr. Joe Marshall, Biology Professor, WVU
Craig Means, Downstream Alliance and WVU NRCCE
Dr. Jerry Fletcher, WVU Resource Management
Dr. George Case, Biochemist, Biosensor paper, biotechnologies
Rich Little, Geologist, Coast Guard Auxiliary, Dunkard Creek Watershed Organization
Ramada Inn, Catering Service performs excellent on all occasions here.

I would like to especially thank the exhibitors. We have with us exhibiting their products and to discuss water chemical property measurements in rivers and harsh environments the world's two leading quality monitoring instrument manufacturer's representatives from:

Hydrolab: Phyllis Crutchfield and Jason Harrington
YSI: Steve Fondriest and Gayle Rominger
B. Preiser Scientific: Don Meyers
Polaroid: Darryl Rosenberg.

The format of this meeting is 10 minute briefings by each author in order to maximize the number of topics and communicate as much information as possible in a one day meeting.
These short briefings should be informative and interesting to all of the diverse groups of river stewards, academic and industry researchers, government representatives, manufacturers, and small business representatives without anyone getting bored.

OPENING REMARKS BY CONFERENCE ORGANIZER AND CHAIRMAN -- L. ZANE SHUCK

I would like to give you my interpretation of what this conference is about and why I think it is important to review the roles of advanced technology in the monitoring and clean up of rivers at this time(slide). In the past two to three years laptop computers, microprocessors, and software systems and computer based instrumentation systems have reached a level of capability that will permit us to realistically think differently about how we monitor river processes. We need to review and apply these new emerging technologies. There also continues to be improvements in stream and river cleanup processes, and we all need to be made aware of emerging problems.

Rivers and there ecosystems are very complex, dynamic, hydrodynamic, geobiochemical processes. There are many different disciplines associated with a large variety of issues that comprise the river ecosystem puzzle(slide). There are many government agencies and many different scientific and engineering fields associated with the monitoring and study of these different facets of rivers. This is one reason it is so very difficult to grasp an overall perspective of what the status is of each activity, and who is doing what and how.

The question addressed here today is "What can technology do for us?" (slide)
I have chosen to organize river and stream matters into four categories for the purpose of applying advanced technology. These four categories represent actions in which technology can be applied. These categories formed a basis for organizing this conference and selecting the topics and issues for presentation and discussion.

(slide) It is also logical and convenient to categorize the basic sciences associated with river ecosystems into four groups. These four basic science systems are: 1) the water or the media, 2) the microbes existing within the media, or water, 3) the macro aquatic plants and habitats, and 4) the macro aquatic animals living within the media (biota, fish), and the macro animals living in the benthic zone(benthos).

The degree to which we can develop and apply technology to achieve an action or result is dependent upon how good, or well developed and understood, the science is for each area of basic science. It appears that the basic science is very limited in some areas. We must acknowledge that each of these four basic science systems is interdependent upon each of the other three. Simply stated, this results in coupled phenomena, and the solution of more than first order simultaneous equations. Now, and only now, do we have the technology that will permit us to realistically untangle some of the mysteries and improve our basic science level of knowledge and databases for these basic science systems**. This is what technology can do for us.**

(slide) This slide shows how technology can work interactively in a feedback mode to: 1) improve our knowledge of the basic science systems, and 2) learn how they are related in a quantitative manner so they can be integrated into simulation models for further analysis and understanding.

Finally, as illustrated in this slide, our ultimate goal must be to generate realistic, highly capable models as tools, for river stewards to analyze and clean up streams and rivers, and for public administrators to use in carrying out their missions and formulating reasonable and meaningful public policy. These are the roles for technology as I see them in river affairs.

I look forward to your presentations and learning more about each of the basic science areas, and the technology developments that you bring here as the subjects of this conference.

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT

A REVIEW OF

CURRENT ACTIVITIES AND CAPABILITIES

AND

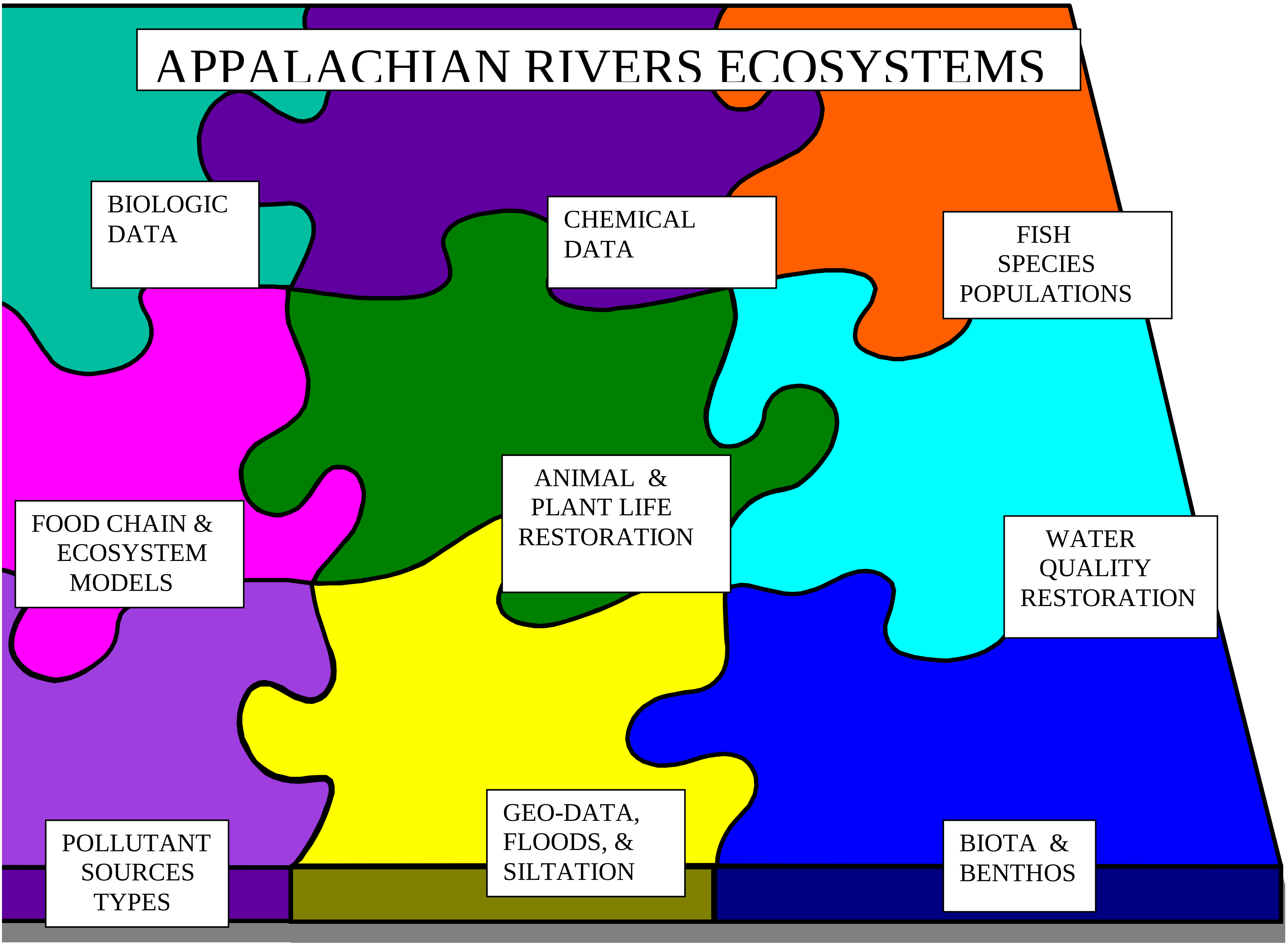
EXPRESSION OF NEEDS

ROLES FOR

ADVANCED TECHNOLOGIES

IN STREAM AND RIVER CLEANUP

AND ECOSYSTEM STUDIES


APPALACHIAN RIVERS ECOSYSTEMS
BIOLOGIC DATA
CHEMICAL DATA
FISH SPECIES POPULATIONS
ANIMAL & PLANT LIFE RESTORATION
FOOD CHAIN & ECOSYSTEM MODELS
WATER QUALITY RESTORATION
POLLUTANT SOURCES TYPES
GEO-DATA, FLOODS, & SILTATION
BIOTA & BENTHOS

RIVER AND STREAM TECHNOLOGY APPLICATIONS

WHAT CAN TECHNOLOGY DO FOR US ?

1. MONITOR & OBTAIN DATA from Basic Science Systems
- **a. WATER -- Chemical, Flows, Erosion**
- **b. MICROBES -- Plant, Animal**
- **c. MACRO -- Plants and Habitats**
- **d. AQUATIC ANIMALS -- Biota (fish) and Benthic**

2. DATA AND INFORMATION
- **a. GATHER -- multiple sources, chem,bio,geo, formats**
- **b. FORMAT --universal compatibility**
- **c. STORE -- universal access data bases**
- **d. INTEGRATE -- basic science sources**

3. COMPUTER MODELS
- **a. ASSIMILATE, ANALYZE, and SYNTHESIZE**
- **b. ASSIST interpretation and understanding**
- **c. SIMULATE for process design and control**

4. CHANGE, MODIFY, REMEDIATE, RESTORE -- to near self sustaining ecosystem (minimum human welfare status)
- **a. WATER QUALITY -- chemical and biological**
- **b. FLOODS -- small streams and large rivers**
- **c EROSION and SILTATION-- sources**
- **d. MICROBE -- populations**
- **e. MACRO AQUATIC PLANTS**
- **f. AQUATIC ANIMALS -- fish and benthos**

BIOSKETCH
OF
L. ZANE SHUCK

EXPERIENCE

40 years professional experience including college and university teaching, research and administration, planning, conducting and managing national energy research programs, consulting with industry, conduct interdisciplinary research in biomechanics and rheology, and proprietor and executive officer in consulting and R & D companies.

President, Technology Development Inc. (1980-present)
Founder and President, The WMAC Foundation (1997-present)
WVU, Professor Mechanical Engineering and Associate Director Engineering Experiment Station
Member Graduate Faculty, master and doctoral theses advisor
WVa Tech, Associate Professor and Chairman, Dept. of Mechanical Engineering
US Dept. of Energy, Supervisory Mechanical Engineer

EDUCATION

BSME - WVa. Institute of Technology, 1958
MSME -West Virginia University, 1965
PhD - West Virginia University, 1970
Graduate, post-doctoral, and summer programs at Iowa State University, Wayne State University and Massachusetts Institute of Technology

PUBLICATIONS AND PATENTS

62 publications, 13 patents(including first patent ever awarded through WVU), Producer 4 technical films for U.S. Dept of Energy

ANCILLARY INFORMATION

Registered Professional Engineer WV & OH, Certified by National Council of Engineering Examiners, National Science Foundation Science Faculty Fellow, Science Advisor WVa Governor John D. Rockefeller IV (78-81), Science and Technology Coordinator WV Legislature(79-80) ASTM Award (70), ASME Ralph James National Award (80), Editor Transactions Journals and Symposia Proceedings

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Gary S. Casuccio

RJ Lee Group, Inc

Evaluating Source/Receptor Relationships using the Automated Scanning Electron Microscope

Determining the source of river sediment can be of interest due to environmental concerns. This is especially true if the sediment contains toxic metals (e.g., lead, cadmium, arsenic, mercury) and there is a need to identify the principal responsible party (PRP). Receptor models based on computer controlled scanning electron microscopy (CCSEM) data offer great potential to provide increase insight in this area. Receptor models have been developed to estimate the contribution of a source(s) at a receptor location (e.g., river sediment). These models use physical and chemical characteristics of particles measured at the source and receptor to identify and quantify source contributions to receptor concentration. Receptor models have been historically used to apportion source impacts on ambient air quality. The techniques developed to evaluate ambient air quality are appropriate for river sediment.

The receptor model process requires knowledge on the nature of emissions from the source(s) that has a measurable impact at the receptor location. Information on source emissions is obtained through analysis of samples collected from the suspected source(s) of interest. By mathematically comparing the source concentration data to the concentrations observed on the receptor sample, an estimate can be made on the amount each source or source category contributes to the total mass.

Although traditional bulk analytical techniques (e.g., XRF, AA, ICP) offer better accuracy and sensitivity than microscopic methods, they provide no information on particle size, morphology or phase. Particle specific data is often necessary to determine the source of the particulate matter. An example of the power of scanning electron microscopy (SEM) data is provided in Figure 1. In Figure 1A, the elemental spectrum associated with a fly ash particle (by-product of coal combustion) is provided. Energy dispersive spectroscopy (EDS) analysis indicates that this particle is composed primarily of silicon with smaller amounts of aluminum and oxygen. A minor amount of carbon and potassium was also identified. The composition of this fly ash particle is similar to that found on a typical soil particle (see Figure 1B), yet they originate from different sources. Information of this nature (i.e., morphology and composition of individual particles) can be critical to the apportionment of particulate matter and can only be obtained through microscopic analysis. Thus, SEM analysis offers additional resolution and allows for further separation of source types that are indistinguishable by the traditional bulk analytical techniques.

While the SEM is a powerful analytical tool, receptor models require quantitative concentration data as input. To be able to quantify microscopic results, particles must be characterized in sufficient numbers to ensure representation of the entire population. With CCSEM, the size, shape and elemental composition of individual particles can be analyzed very quickly (i.e., seconds per particle) making quantitative characterization of
particles economically feasible. This permits large numbers of individual particles to be analyzed building a database representative of the entire sample. Furthermore, CCSEM enables each particle to be tested against the same analysis parameters which assures uniformity of the analysis. This technology has been used in numerous studies involving the apportionment of particulate matter.

Individual particles characterized during a CCSEM analysis can be grouped into particle type (species) classes based on their elemental composition and shape. The CCSEM particle type data can then be summarized into number distribution and mass distribution tables. The individual particle results can also be combined to provide for a representation of the overall sample chemical characteristics. Thus, CCSEM is able to provide information on a sample's bulk characteristics while retaining its microscopic properties.

The CCSEM particle type data can be used as input to receptor models. Most recently, the CCSEM particle data was used as input to the Chemical Mass Balance (CMB) receptor model. The CMB has been designed to determine the amount each source or source type contributes to the receptor sample. The CMB receptor model is based on the conservation of mass and uses an effective variance least squares analysis to fit the chemical compositions of the source samples with that of the receptor sample. Through evaluation of the source profiles (i.e., the fractional amount of particle types in the source emissions) and the receptor concentrations, along with their associated uncertainty estimates, an estimate can be made of the amount each source or source category contributes to the total mass. The CMB model requires that the potential source contributors have been identified; that a sufficient number of source and receptor samples have been collected with accepted sampling technology; and that the source and receptor samples have been analyzed using appropriate techniques to determine particle characteristics. The U.S. Environmental Protection Agency (EPA) has approved the CMB receptor model for use in air quality studies.

The solution provided by the CMB model consists of a source contribution estimate (SCE) and the standard error (STDERR) associated with it for a particular source. In addition to the primary output indicators (i.e., the SCE, STDERR and concentration of a species), the CMB is also equipped with several performance statistics and diagnostics (e.g., R-square, Chi-square) that indicate the goodness-of-fit of the specified input data. With the help of these diagnostics, the CMB7 model can be used in an interactive mode to determine a mix of sources and their contribution to the mass measured at the ambient monitor site.

An example of the CMB output is provided in Table 1. In this example, a ambient PM_{10} sample was apportioned against a road sample (SS4) collected in the vicinity of the ambient monitor. These samples were obtained as part of the Salt River Air Quality

Study in Phoenix, Az. The CMB results indicate that this source accounted for approximately 98 percent of the mass collected on the ambient sample. The high R-square (0.98) and low chi-square (0.12) values indicate a that the source concentrations are in close agreement to the ambient data. This can be seen in Table 1 by comparing the measured concentrations to the calculated concentrations based on the source profile for SS4.

In summary, evaluation of source/receptor relationships associated with river sediment can be performed using receptor modeling techniques originally developed for ambient air quality. Using CCSEM data as input to the receptor model will provide additional resolution on source and receptor constituents which can assist greatly in the apportionment process. It is anticipated that the CCSEM receptor model approach will be of unique value in apportioning river sediment containing toxic metals that are in multiple phases.

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G.S. Casuccio has over 15 years of experience in evaluating source/receptor relationships using receptor model techniques. He has performed over 100 receptor model studies for industry and governmental agencies. He is a consultant and advisor to the EPA in the use of CCSEM as a source apportionment tool.

Table 1. Example of CMB Output

SOURCE CONTRIBUTION ESTIMATES - SITE: Salt River DATE SAMPLED: 6/12/95
SAMPLE DURATION 24 HOURS SAMPLE TYPE: PM-10
R SQUARE .98 PERCENT MASS: 99.7
CHI SQUARE .12

	SOURCE	SCE(UG/M3)	STD ERR	TSTAT
4	SS4	.9971	.1283	7.7694

	PARTICLE TYPE-I		MEAS. CONC	CALC. CONC	RATIO C/M	RATIO R/U
1	MASS	T	1.00000+-.15000	.99713+-.12834	1.00+-.20	-.0
2	Si-ric	*	.11800+-.04800	.11268+-.04886	.95+-.57	-.1
3	Si/Al	*	.20100+-.03900	.17948+-.04188	.89+-.27	-.4
4	Si/Al/	*	.35800+-.04100	.36395+-.04188	1.02+-.17	.1
5	Si/Mg	*	.02700+-.02500	.03390+-.03689	1.26+-1.79	.2
6	Si/Ca	*	.07000+-.03200	.07080+-.03390	1.01+-.67	.0
7	Ca-ric	*	.04400+-.03200	.06780+-.03191	1.54+-1.33	.5
8	Ca/Si	*	.02800< .02900	.03490< .03390	1.25< 1.77	.2
9	CaSiAl	*	.08700+-.03100	.06681+-.03390	.77+-.48	-.4
10	Ca/Mg	*	.01000< .02700	.01895< .02692	1.89< 5.78	.2
11	Ca/S	*	.01800< .02000	.00100< .01496	.06< .83	-.7
12	Misc.	*	.03800+-.03100	.04687+-.03091	1.23+-1.29	.2

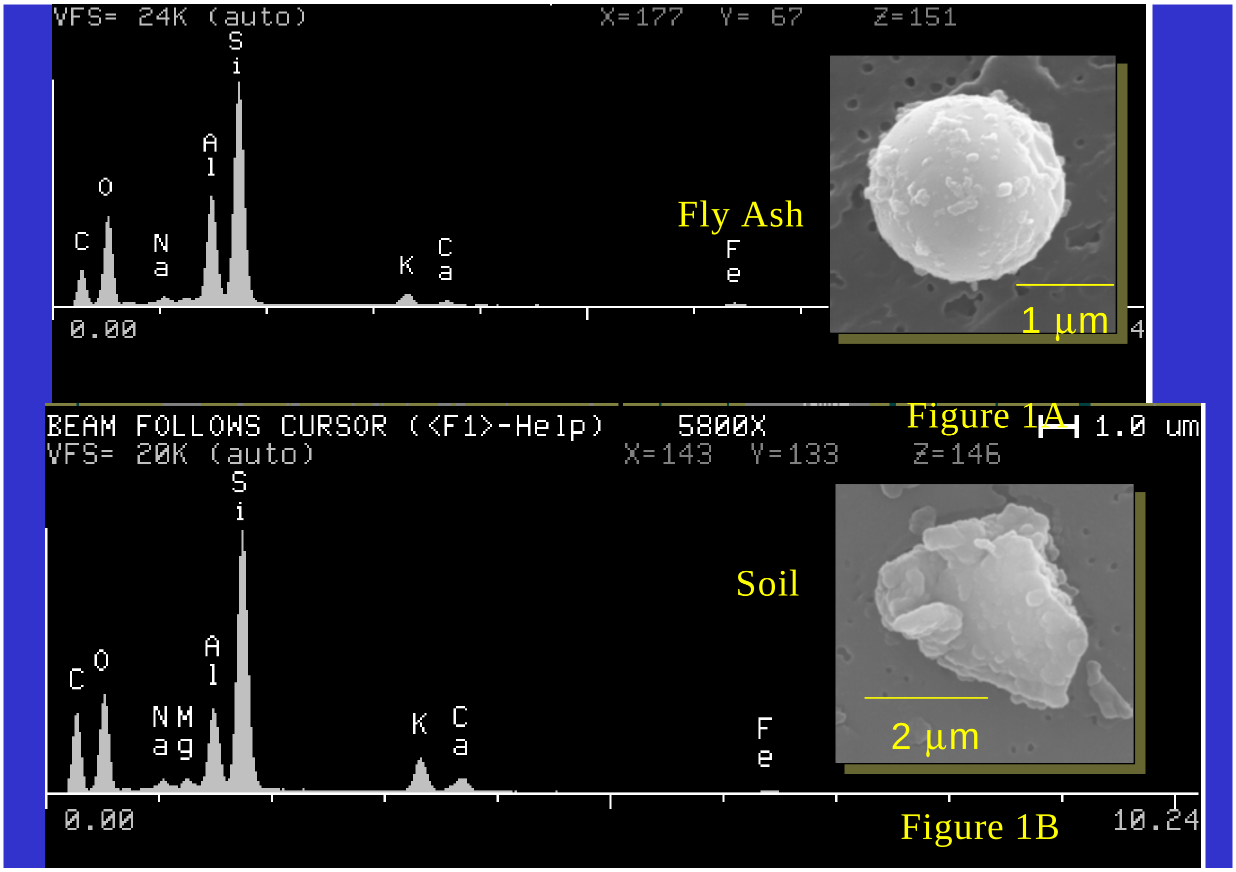

Figure 1. SEM image and elemental spectrum of fly ash and soil particles.

Sharon Whetzel,
Department of Agriculture, West Virginia,

The Use of Bioluminescense Analysis of River Water for Microbial Enumeration

Gus R. Douglass, (Commissioner), David Miller, (Deputy Commissioner), Janet Fisher (Assistant Commissioner), Department of Agriculture, West Virginia.

Dennis Crabtree, Taylor and Thomas Environmental Inc. Florida and West Virginia, and David Stafford, Hughes Whitlock Ltd, Wales.

INTRODUCTION

The enumeration of microorganisms in rover waters is becoming an important aspect of water quality, particularly in regard to effluent discharges from sewage treatment plants, farms and food processing industries. In the interests of public health, water samples taken from rivers should be tested regularly to confirm their freedom from such contaminations as total coliforms, *E. coli* and fecal streptococci. The baseline enumeration of such microbes is determined with conventional place counts using selective media. As the number of microbes present may be low in number per 100 ml of sample taken, membrane filtration techniques may be employed before use of selective media or other methods of augmenting the microbial signal tried including pre-incubation in peptone water. All such methods are usually historical in nature in that several days elapse before either a qualitative or quantitative measure of microbial contamination can be made.

RAPID METHODS

Rapid methods are available which allow for an immediate determination of microbial contaminations to be made and remedial measures taken in real time. Similarly point source pollution detection can be made where agricultural run off is correlated with total microbial counts. These counts in turn may be related to the presence of one or more pathogenic microbial discharges normally associated with human, agricultural sludges or effluents. Such quantifiable enumeration is discussed in this paper.

BIOLUMINESCENCE

The microbial enumeration of microbes using bioluminescence has been employed for several decades and within the last 10 years instruments and kits have been made available commercially, (Gehle, Presswood and Stafford, 1991). The application of the technology to measure small numbers of microbes with highly sensitive portable luminometers has also recently been made available (Stafford, Willis, and Bryant, 1995). The relationship between such highly sensitive techniques and conventional plate counts will enable its use in rapid enumeration of total viable counts as well as perhaps determining the presence of specific organisms such as total coliforms. This data acquisition possibility would enable real time analysis to be made for quality control evaluation in river water samples. Early warning of a point source discharge would enable monitoring of river water quality to be effective. The correlation with plate counts is an important aspect of the ongoing analysis and significant associations are expected to be determined during the correlation test procedures.

ADVANTAGES OF BIOLUMINESCENCE APPLICATIONS

One of the more problematic aspects of conventional plate count tests are the presence of non-culturable microbes, which will contribute to a falsely low count. These false negatives are not encountered with the bioluminescence technique since all microbes present are counted. All microbes contain ATP, which is detected with the luciferin/luciferase enzyme used in the analysis.

Sometimes the river samples will contain algae and/or protozoa as well as prokaryotic bacteria. The kit developed by Hughes Whitlock Ltd enables the sample to be treated to either remove the eukaryotic ATP or measure it separately. In this way the protozoal - algal species can be determined in real time together with the bacterial counts. If the eukaryotic count is more closely related to agricultural run-off because of the relationship with algal blooms, (especially during summer months), then a very quick confirmation can be made available with the application of such techniques.

The program, as determined, is intended to continue studying the correlations with chemical testing, conventional plate counts and the novel bioluminescence technique, to show the efficacy of this rapid method for providing useful data for determining the quality of river waters in the Potomac area of West Virginia.

IMPLICATIONS FOR EFFLUENT TREATMENT FACILITIES AND MICROBIAL ENUMERATION

The bioremediation of waste waters from food plant facilities or from sewage treatment and farm activities has been shown to be effective using aerobic, or anaerobic processes, as in the case of the Power Project at Moorefield West Virginia, (Stafford and Crabtree, 1996). The monitoring of rivers using bioluminescence technology may indicate the efficacy of the treatment process by determining the discharge quality at the river/effluent interface. The technology can also be applied to determine the chemical nature of a discharge to a water course in terms of its effect on sensitive bacteria. This application is expected to be applied in future programs.

Certainly it has been shown that treatment plants can be monitored using such technologies, (Johnson and Stafford, 1984), and the discharge quality may be monitored in facilities where biological treatment is an essential part of effluent management before discharge to a river.

The correlation of the Bioprobe technique with conventional microbial procedures will be presented and the implications for river analysis discussed.

George Constantz
River Network

Techno Wishes of a Field Ecologist

During 1989-92, Pine Cabin Run Ecological Laboratory assembled the ecological baseline of the Cacapon River in northeast West Virginia. The project involved 149 trips to 106 study sites along the River's entire 120-mile continuum. Based on previous studies and on current and expected landuses, we chose to study the following 8 parameters: mean daily discharge, water temperature, turbidity, pH, alkalinity, ammonia, phosphate, and fecal coliform bacteria. The baseline revealed that the River was relatively healthy, but in certain reaches at specific times it was degraded by nonpoint source pollution originating in the upper third of the watershed.

We learned from tax maps that the River's riparia are almost totally held by private landowners. This caused access problems: specifically, upriver landowners, where much of the contaminants originated, were least likely to grant permission to cross their land to reach the River. This is not an unusual problem in privately owned river corridors. Thus, in many areas river stewards need remotely sensed data to evaluate the ecological condition of privately owned stretches. How do we fix this problem?

Here are a few thoughts on what will not work. Continuous water samplers (e.g., Sigma) require frequent physical access to the site. Remotely accessed in situ detectors (e.g., Hydrolab wired to a phone line) require occasional access for installation and maintenance. Further, both are subject to vandalism.

Here is what I would like to have had, in increasing order of priority: (1) the ability to fly low over the River, lower a sampling device, collect water samples, and return the water samples to the lab for analysis; (2) the ability to fly high over the River, photograph or videotape the water, return to the lab, and interpret the images to estimate specific parameters. Both of these have the advantage of not requiring landowner permission, but neither allow real-time monitoring. (3) Even more useful would have been real-time data transmitted from a LANDSAT-type satellite to my personal computer.

What would I want to measure via a satellite? At a minimum, I would like to be able to monitor the River's water level in real-time. I could then convert water height to discharge volume. An expanded wish list would include the other water quality parameters. My ultimate techno wish would be to have all my remotely sensed data automatically acquired by the GIS residing in my personal computer.

Because nonpoint source pollution involves acute spikes in the concentrations of some pollutants, real-time monitoring of discharge is crucial. Water level should be

monitorable along the entire river continuum and in all tributaries, with an alarm set to sound at a preset water height. This would allow the monitors to mobilize at any time of day or night to document water quality during important discharge events.

I close with a personal wish. I would like this conference to lead to a commitment to a process for developing a strategic plan that would make high technology more accessible to grassroots river and watershed conservation groups. Such a plan would identify needs, assemble a list of available resources, develop a strategy to fill the gap between needs and resources, propose ideas for funding these resources, and suggest how to distribute the new tools. I'm ready to help.

River Network Watershed Program Manager
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PhD, Zoology, Arizona State Univ, 1976
fish ecologist, Academy of Natural Sciences, Philadelphia, 1976-82
Biology Teacher, Hampshire High School, Romney WV, 1982-91
Director, Pine Cabin Run Ecological Laboratory, High View WV, 1985-93
Coordinator, Watershed Conservation & Management Program, WV Division of Natural Resources, Elkins WV, 1993-95
Environmental Resources Specialist, Watershed Assessment Program, WV Division of Environmental Protection, Charleston WV, 1995-98
Watershed Program Manager, River Network, Portland OR, 1998-present
15 research papers, 3 review chapters in edited symposia, 1 book (Hollows, Peepers, and Highlanders: an Appalachian Mountain Ecology, Mountain Press)

Lisa K. Ham
US Geological Survey

USGS Activities in the Ohio River Basin in West Virginia

The U.S. Geological Survey (USGS) has three major programs involved in collecting and analyzing data in the Ohio River Basin: the Hydrologic Surveillance program; the Kanawha-New River National Water Quality Assessment (NAWQA) program; and the Ohio River Studies program. Each of these three programs work in parallel to one another and rely on resources and data from each other to obtain optimal results.

The Hydrologic Surveillance program monitors river stage and flow from over 100 sites across the State of West Virginia. The data is retrieved using satellite and IFLOW transmissions and telecommunication. The satellite transmissions are available through the internet on the USGS real time web site http://www-wv.er.usgs.gov/rt.html. Flow records are used for flood warning, operating reservoirs and hydropower facilities, managing releases of wastewater, conducting environmental assessments, determining the magnitude and probability of future floods and droughts, and designing highways and bridges.

NAWQA is designed to describe the status and trends in regional water quality and to identify natural and human factors associated with observed water quality conditions. In the Kanawha-New River basin during 1996-98, the program monitored the quality of streams, using 12 indicator and integrator sites; the quality of ground water, using 90 wells for sub unit and land-use surveys; and the ecology of streams, using community surveys, fish tissue, bed sediment, and habitat indicators. Similar studies were performed in the Allegheny-Monongahela River NAWQA.

The Ohio River Studies program focused on monitoring, understanding, and modeling dissolved oxygen in barge-navigable rivers. During the summers of 1992-95, continuous dissolved oxygen monitors were maintained and scheduled longitudinal surveys completed in Belleville and Pike Island pools in support of operation and permitting for hydropower facilities. Oxygen transfer efficiencies were measured at 11 dams on the Ohio River in 1995 and 1996, using in situ methane gas as a surrogate tracer. Similar work is scheduled at 3 dams on the Kanawha River in the summer of 1998. Currently, the USGS is proposing to model the dissolved oxygen concentrations and river discharges from data collected in the Belleville and Winfield pools in order to develop dissolved oxygen budgets and to offer a better tool for managing the resource.

The USGS intends to continue applying science to improve our understanding of changing water-resource conditions in the Ohio River basin. Water-quality data for some sites will be added to the satellite transmission network. The Kanawha-New River NAWQA plans to sample 60 stream sites in coal mining areas for chemistry and ecology during summer 1998. The NAWQA will continue to collect monthly water-quality samples at 11 sites through September 1998, and maintain sampling at one or two sites through 2005. Interpretative reports will be generated by NAWQA personnel from 1998 to 2000. Future plans for the Ohio River Studies program are to investigate total maximum daily load issues, to restart the continuous monitor study, to begin a dioxin study, and to model the dissolved oxygen results.

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I have worked for the USGS for 11 years on water-quality projects. My experience includes 3 years in ground water, 4 years on lakes, and 4 years on surface water. Currently, I am the surface-water lead for the Kanawha-New River National Water Quality Assessment (NAWQA) program.

Barbara Taylor
West Virginia Division of Water Resources
Office of Water Resources

West Virginia Water Quality Monitoring

In 1995, the Office of Water Resources (OWR) created the Watershed Assessment Program. This was the beginning of a larger state-wide initiative to move toward a watershed-based approach to better manage the environment.

In order to develop a consistent monitoring approach that would result in a greater quantity of timely data available for environmental decision-making, the state was divided into its 32 hydrologic regions. A five-year cycle was developed to assess waters in each of the hydrologic units resulting in an assessment of 20% of the states' waters annually. Data to be collected in the watersheds included chemical parameters, biological information, and habitat quantity and quality. Additionally, OWR maintains a network of about 35 ambient monitoring stations where data is collected on a quarterly or semi-annually basis.

Since initiation of the Watershed Assessment Program, data has been collected in the Upper Ohio River North, Cheat, Youghiogheny, South Branch Potomac, Shenandoah, Tygart, Lower Kanawha, Coal, Elk, and North Branch rivers.

Information assembled thus far for West Virginia's 1998 305(b) water quality status report indicates that the Cheat, Youghiogheny, South Branch, Shenandoah, Upper Kanawha, and Northern Ohio rivers or river segments, are negatively affected by a range of conditions that include fecal coliform, habitat alteration, flow alteration, elevated metals concentrations, pH violations, siltation, among other impacts. Not each watershed is affected by all of the above conditions.

Technology can significantly improve the data collection and analysis process. The OWR partners with many other state and federal agencies to leverage water resource management expertise and ability. However, specific areas where technology could assist OWR efforts includes improved models available for development of total maximum daily loads, greater use of geographic information systems in analyzing environmental conditions, access to public and private sector water quality data in an electronic format, and human and financial resources necessary to implement technology.

Gary Bryant
USEPA

Water Migration in Abandoned Coal Mines

Underground mines exist beneath hundreds of thousands of acres in the Appalachian coal fields. The Pittsburgh coal seam demonstrates the environmental threats that occur as mines close. The pools of water in flooding underground mines threaten stream water quality. Current technology does not enable anyone to accurately predict where mine pools will discharge and what will be the water quality and quantity that needs treated. A "flooded mine rover", similar to a small submarine, is proposed to explore coal mine passages to measure voids and monitor differences in water quality. Computer modeling of groundwater and streams is needed to design systems to meet the threat to the environment.

Ron Preston
Canaan Valley Institute

Assessments of Appalachian Streams

The Mid-Atlantic portion of the Appalachian Region contains over 100,000 miles of streams that flow through a variety of ecological systems including forests, farmlands, wetlands and urban areas. These streams range in size from small headwater streams to large rivers such as the Ohio and Susquehanna. Stream quality and stream health is currently the focus of several regional, watershed and state assessments. Ongoing stream assessments include the US Environmental Protection Agency's Mid-Atlantic Highlands Assessment and the Mid-Atlantic Integrated Assessment; the US Geological Survey's National Water Quality Assessment Program in the Potomac, Susquehanna, Allegheny-Monongahela and the Kanawha-New River basins and the Maryland Department of Natural Resource's state wide stream survey. Agencies within the state governments of Pennsylvania, Virginia and West Virginia have begun updated or new state wide stream assessments.

Even though these assessment programs may have different objectives and monitoring designs, the agencies are interested in determining the " state of condition" of the streams in the Mid-Atlantic/Appalachian region. Further, these programs use similar protocols based on measuring ecological parameters to assess stream health. The suite of ecological characterization includes fish and benthic macroinvertebrate communities, habitat and water quality.

The preliminary analyses and interpretations of the results of the Mid-Atlantic Highlands Assessment provide the following observations for the region: the small, headwater streams have limited fish communities and less than half have sport fishes; approximately two-thirds of the streams are judged to meet expectations for balanced fish communities and approximately one-fifth do not meet expectations, the remainder are judged immediate; fish community analysis indicates (based on the fish index of biotic integrity) a dominance of poor conditions exist in the Allegheny-Monogahela watersheds and more frequent poor conditions in the Ohio drainage than the drainages of the Atlantic slope; the water quality indicates a greater frequency of streams reflecting the effects of acid deposition in the North Central Appalachian Ecoregion than other Mid-Atlantic ecoregions and an even greater proportion of the streams in that ecoregion are affected by acid mine drainage; almost one-quarter of the Highland streams have poor habitat conditions; over one-third of the streams contain nonnative fish; and almost half of the stream miles of the Mid-Atlantic region show evidence of watershed disturbance.

Two significant stressors (nonnative fish and habitat alteration) are nonchemical.

These assessments are applying the integration of several indicators to better characterize the condition of the streams of the region. Further integration between the programs are underway and as these analyses evolve, improved understanding of the stressors and their sources will provide a sound foundation for making management decisions relative to the future of the region's environment and economy.

Jason Harrington
Regional Sales Manager
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Austin, TX

Hydrolab Corporation: Water Quality Monitoring Systems

Hydrolab is the leader in providing reliable instrumentation systems for in situ water quality data collection. For over 40 years, Hydrolab has designed and produced multiprobes to monitor parameters including temperature, dissolved oxygen, specific conductance, pH, turbidity, ammonium, redox, depth, and many others. All sensors are contained in a single, rugged, portable housing. Whether you are monitoring water quality in fresh water, salt water, ground water, or waste water, Hydrolab instruments provide reliability, accuracy, and ease of use. And whether you do simple spot checking or profiling; in situ or pumped sampling ground water monitoring; or wish to set up unattended, continuous monitoring stations, Hydrolab instruments will fit your needs. This presentation will look at the above applications, Hydrolab's technological firsts, and some of the emerging technologies.

Harry M. Edenborn
USDOE, FETC

Redox Gel Probe (RGP) Technology for the Evaluation of Heavy Metal Stability in Sediments

The redox gel probe (RGP) was developed to evaluate the stability of metals precipitated within the sediments of constructed wetlands used to remove metals from acid mine drainage. Over the past 5 years, it has been repeatedly field tested and has proven to be easy and inexpensive to use and readily adapted to site-specific environmental concerns. Solid redox-sensitive compounds, such as manganese dioxide (MnO_2), are incorporated into gels held in rigid plastic holders, leaving one longitudinal surface of the gel exposed. These probes are pushed vertically into sediments and are left *in situ*. After an incubation period of hours to weeks, the probes are removed from the sediment, and the depths where compound dissolution, transformation and/or redistribution have occurred are determined relative to the location of the sediment-water interface. Gel probes placed along surveyed transects and grids in wetland sediments have yielded maps of compound stability that reflect the beneficial and detrimental influence of various environmental variables on pollutant retention and diffusive metal flux from sediments. In one example, gel probes containing particulate manganese compounds (MnO_2, $MnCO_3$, and MnS) were placed along a surveyed grid in the sediment of a wetland built to remove Mn from coal mine drainage at a site in western Pennsylvania. The stability of these compounds within the wetland was shown to be highly variable both temporally and spatially, suggesting that long-term manganese retention in sediments was unlikely. The method has its most likely application to fine-grained metal-contaminated river sediments where the stability of metal species in sediments is in question. Recent experiments using live bacteria incorporated within the RGP gel matrix and the potential applications of this approach will be discussed.

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Steve Fondriest and Gayle Rominger
YSI

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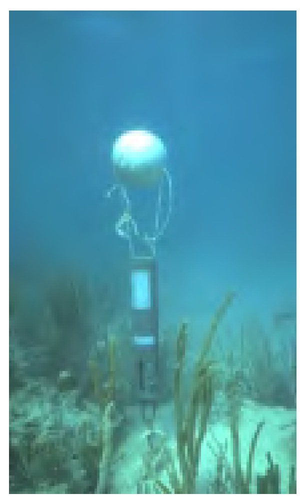

Kyle J. Hartman
WVU Fish And Wildlife Service

Application of Hydroacoustics to Large Appalachian River Fisheries

Fisheries hydroacoustics is a technique that involves transmission of pulsed sound through the water to determine the sizes and abundance of fish or other targets (e.g. plankton) within the water column. The advantage of this technique for fisheries stock assessment is that it can provide near-real time analysis of the sizes, abundance, and spatial distributions of fish over large areas. The acoustic transducer is towed underwater alongside a research vessel at speeds of up to 6 knots. This allows mobile surveys to cover large sections of river in a relatively short time and also permits more thorough sampling of aquatic habitats than standard active capture techniques. The technique does still require some active capture to verify the identity and size of acoustic targets.

The acoustic system we use if a 120 kHz split-beam system manufactured by SIMRAD. We do not use their processing software. We have developed our own software that allows us to "unlock" more of the data available in the technology than is possible with the SIMRAD proprietary software. The system "pings" at 3 times per second providing information on the size and locations of fish within the acoustic "beam". We employ a "down-looking" technique for mobile surveys that permits us to detect fish within 10 cm of the river bottom.

During 1997 I had the opportunity to compare hydroacoustic data with that collected via lock rotenone surveys conducted by the WVDNR in the Ohio River. Comparison of the acoustic and rotenone data showed that abundance of fish < 250 mm TL and > 250 mm TL were very similar between the two techniques. Further, size distributions within each size group were also similar. Overall, hydroacoustics reported slightly higher abundance of fish than rotenone. However, this was expected as previous studies with long-term pick up of fish showed that short-term pick up of fish in rotenone surveys will underestimate true abundance by 30-50% depending upon the species and size of fish involved.

I believe this technique has excellent potential for use in the Ohio and other rivers in the Appalachian area. It can provide reliable estimates of fish density and abundance and will help to elucidate fish distributional patterns which can be important to shoreline development (e.g. power plant siting, etc.). The limitations of this approach are that the gear is not terribly effective in shallow areas such as embayments. Some of this limitation might be reduced through the application of "side-looking" fisheries sonar techniques. However, even if we use this equipment in the "down-looking" application for these rivers, the technique will provide and excellent tool in studying mainstem areas of rivers.

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7. Biosketch:

I have been at WVU since 1996 as an Assistant Professor of Ecology in the Division of Forestry. I received my PhD from the University of Maryland, Chesapeake Biological Laboratory in 1993. Prior to that I received my M.S. (1989) and B.S. (1984) from The Ohio State University. My research has involved a variety of topics including: fisheries stock assessment, behavioral ecology, feeding and trophic relationships, and bioenergetics of fish. Within West Virginia I have began studying the sub-lethal effects of land-use practices on water quality and these impacts upon fish and invertebrate production in Appalachian streams. I have also initiated a study to examine the habitat use of juvenile through adult largemouth bass on the Ohio River and conducted studies comparing the sizes and numbers of fish from the Ohio River using lock rotenone and hydroacoustic techniques.

W. Neil Gillies
Pine Cabin Run Ecological Lab

Water Quality Studies in a Watershed Dominated by Integrated Poultry Agriculture

Poultry production in the Potomac Headwaters region of WV has more than doubled since the early 1990s. Concerns over the water quality impacts of integrated poultry production are widespread. This talk presents a case study of nutrient emissions in the Lost River, Hardy County, WV and focuses on lessons learned about water quality sampling for nutrients in an agricultural non-point source (NPS) dominated basin.

The Lost River basin (179 sq. mi. drainage area) contains 20% (185) of the Potomac Headwaters 870 poultry houses in only 2% of the region's drainage area. It contains a greater density of poultry houses (>1 house per square mile) than any other Potomac Headwaters area. Fields in the floodplain are often plowed down to the rivers edge, with no riparian forest and few buffer strips. Poultry litter is applied green or composted virtually year-round. Phosphorus (P) from long term litter application is known to be building up in the basin's soils but studies by the USGS and Cacapon Institute between 1988 and 1995 did not detect elevated levels of P in the rivers of this region. Both of these groups looked for orthophosphate only, and neither study was specifically designed to detect nutrient pollution in a region dominated by non point sources.

In March of 1997, we started an intensive study of P (parameters: total phosphorus, orthophosphate and turbidity) in the Lost River; nitrate and fecal coliform bacteria were added as regular parameters in November 1997. Eight tributary and 4 mainstem sites were selected. Each site represents a different mix of land uses. Scheduled sampling initially occurred weekly, now bimonthly, with all samples collected within a 2-3 hour period. Intensive sampling is also included during and following storms. The study was designed to answer three questions: 1- are the nutrients accumulating in the basin's agricultural soils entering the river; 2- do streams with different land use characteristics contribute different nutrient concentrations; and 3- what are the peak nutrient loadings.

The spring of 1997 was very dry, and P concentrations were consistently low at all sites. A big storm in early June produced a very large but short lived flush of P and sediment out of the basin. Concentrations remained high the following day in only one tributary - Upper Cove Run. The first storm demonstrated that the basin can generate a large P load, that the basin flushes quickly in a big storm (in only 8 hours the main slug of pollutants was detected leaving the basin), and that the basin's tributaries flush very quickly. Due to the rapid flushing of tributaries, the storm sampling regime was redesigned to be more narrowly focused during future events.

Upper Cove Run (UCR) was studied during a July storm to see why P and turbidity remained high in that tributary following the early June storm. UCR is a small tributary (9 sq. mi. drainage area) that contains a small town, the greatest density of poultry houses in the Lost River basin (3.2 / sq. mi.), light residential development and a flood control dam construction site well upstream. The sampling results demonstrated that the dam construction site was the main source of turbidity and phosphorus - peak concentrations of 28 mg/l total phosphorus and 37,000 NTU turbidity were detected immediately below the dam site. Later study demonstrated that the site, which had been covered with mature second growth forest prior to construction, had naturally high levels of P (up to 5000 lbs per acre) in some deep soils exposed by excavation. A smaller flush of phosphorus off the main poultry site along UCR was obscured by the construction site runoff.

A major storm on November 7, 1997 saturated the basin and signaled the end of near drought conditions prevailing throughout the summer. It coincided with the introduction of nitrate as a regular parameter and provided an opportunity to compare the behavior of NPS P to that of nitrate in this basin. As observed during previous storms, elevated P levels were short lived. At the most downstream mainstem site, peak total P load and concentration (350 lbs per hour and 0.87 mg/L, respectively) were detected on the day of the storm. P concentrations at this site fell to 0.1, then 0.05, and finally to 0.035 mg/L one, three and four days after the storm, respectively.

As with P, the peak nitrate load (1380 lbs/hr) and concentration (3.2 mg/L) at the most downstream mainstem site were detected on the day of the storm. However, rather than falling precipitously like P, the nitrate load fell gradually over the next several weeks. Nitrate concentrations fell to 1.9 then 1.8 mg/L in the three days following the storm, but then increased to 2.4 mg/L on the fourth day and then fell slowly over the next few weeks. The increase in nitrate concentration coincided with a falling river level and appears to be due to an influx of groundwater high in nitrate.

Nitrate concentrations at six of the studies' sample sites were followed closely for several weeks following the November 7 storm. Three of the sites had considerable upstream acreage in floodplain cropland that receives poultry litter applications, three sites had none. Nitrate concentrations were highest and increased with falling river level only at the cropland sites. The highest nitrate concentrations (6.8 mg/L) were observed at the most upstream mainstem site from four to six days following the storm. Riverside land use upstream of this site consists largely of agricultural floodplain land.

Summary

Elevated phosphorus concentrations in this basin are extremely episodic, and have been observed only during storms that produced overland runoff. Sources positively identified thus far include naturally occuring P in exposed soils from a construction site and agricultural P in runoff from a poultry house site during both light and heavy overland runoff events. No definitive evidence of P leaching from soils has been observed.

Elevated nitrate levels are closely tied to riverside cropland. Nitrate concentrations in the river reflect movement of this nutrient by both overland and in-ground pathways and high concentrations can persist for weeks following a saturating rainfall.

Problems that Might be Solved by New Technology

1. Access to the land and access to agricultural practices information is the single greatest impediment to understanding the potential for pollution from agriculture in the Lost River watershed and the Potomac Headwaters generally. For example, one important question raised by the nitrate data above is: "Do high nitrate levels reflect litter application keyed to crop needs, or dumping of excess material?" The answer to that question would help government agencies determine the correct response. Since access to farmland is likely to remain politically difficult for the foreseeable future, remote sensing of soil nutrient levels would provide a timely tool to help in the interpretation of water quality data.

2. Because of the extremely episodic nature of particulate NPS pollution (including P and fecal coliform bacteria) and the relatively stable concentrations of dissolved, fairly unreactive pollutants like nitrate, the cost of continuous monitoring in a watershed like the Lost River would probably not be worth the expense. However, bringing technology to bear in capturing storm events would be extremely helpful. At present, capturing peak pollutant loads is largely a matter of luck added to an intimate knowledge of and proximity to the basin. On-site, real-time water analysis for nutrients and bacteria during storms would take much of the guesswork out of the process.

3. We currently lack detailed, accurate land use data. This is needed for both the riparian corridor and basinwide.

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Stephen K. Kennedy
RJ Lee Group

Automated Scanning Electron Microscope for the Characterization of Particulate Materials

The scanning electron microscope (SEM) and its energy dispersive spectrometer (EDS) element analyzer collects information that can be used to describe the size, shape and composition of particulate materials. The SEM may be perceived as an instrument that can be used to collect highly detailed information on particulate materials, but, being a manual procedure, is not is not suitable for the analysis of the large number of particles required for characterization of particle populations with any statistical certainty. Modern SEMs, however, can be computer controlled, can obtain images in a digital format amenable to image processing, and are integrated with the EDS system, making computer controlled scanning electron microscopy (CCSEM) possible. In this way, hundreds to thousands of particles can be characterized in a reasonable amount of time, and result in statistically meaningful data. ZepRun, the CCSEM program operating on the RJ Lee Instruments PERSONAL SEM™ will be described.

The SEM can obtain a secondary electron image (SEI) or a backscattered electron image (BEI) as shown in Figure 1A and 1B. The SEI with light shading conveys a three dimensional aspect whereas the BEI conveys general compositional information. More backscattered electrons are produced by materials of high average atomic number and produce a brighter portion of the image than those materials of low average atomic number.

When particulate material is placed on a substrate of low atomic number (e.g., polycarbonate filter), it is brighter than that background and can be recognized as a particle. The CCSEM program finds the particle center then draws a series of 16 cords from the particle periphery through the particle center. From this series, various measures can be defined (including the average diameter, the maximum diameter, the diameter perpendicular to the maximum diameter, the aspect ratio, the perimeter length, and the area) and saved to a file. Once the particle has been sized, the elemental composition can be determined and saved in the file as the spectral peak area related to each element as shown in Figure 1C. Analysis continues for each particle in a microscope field, and additional fields are analyzed until some stopping criterion is met.

The data then consist of a table of physical and compositional information. As an option, an SEM microimage and the full EDS spectrum of each particle can be saved. Because the storing of images is rather space consuming, there is the option to establish rules to define particle types and make operational decisions based on the particle type. For example, some particle types may not be interesting and few images of low pixel resolution may be desired. Other particle types may be interesting and more images of higher resolution may be desired.

The automated analysis can take further advantage of operation in the backscattered electron imaging mode. The common rock forming minerals are relatively low in average atomic number. The CCSEM program can be set to ignore these particles and only analyze relatively high atomic number particles. This is referred to as a high-Z run where Z is the average atomic number. In this manner, the relatively rare particles, such as those consisting of heavy elements, can be detected in quantity. For example, the size and specific phase of lead-bearing particles have been described for soils in which the lead content is a few hundred parts per million. Lower levels can be detected given a longer time of analysis.

Once acquired, the CCSEM data are summarized and can be presented in a variety of formats. Commonly, the data are reported in a series of tables where, for each particle type, some aspect of quantity (number, area, volume, mass) is presented according to some aspect of particle size (average diameter, maximum diameter, aerodynamic diameter).

This type of analysis is particularly useful when particle by particle information is required. Wet or instrumental chemistry techniques are superior for the determination of average chemical composition, but cannot provide information on particle size, morphology, or specific phase present. These data are important in source identification and apportionment, remediation, and assessing the potential for adverse health effects. CCSEM analysis has been extensively applied to a wide variety of particulate (especially airborne and soils) and can applied to river sediment as well.

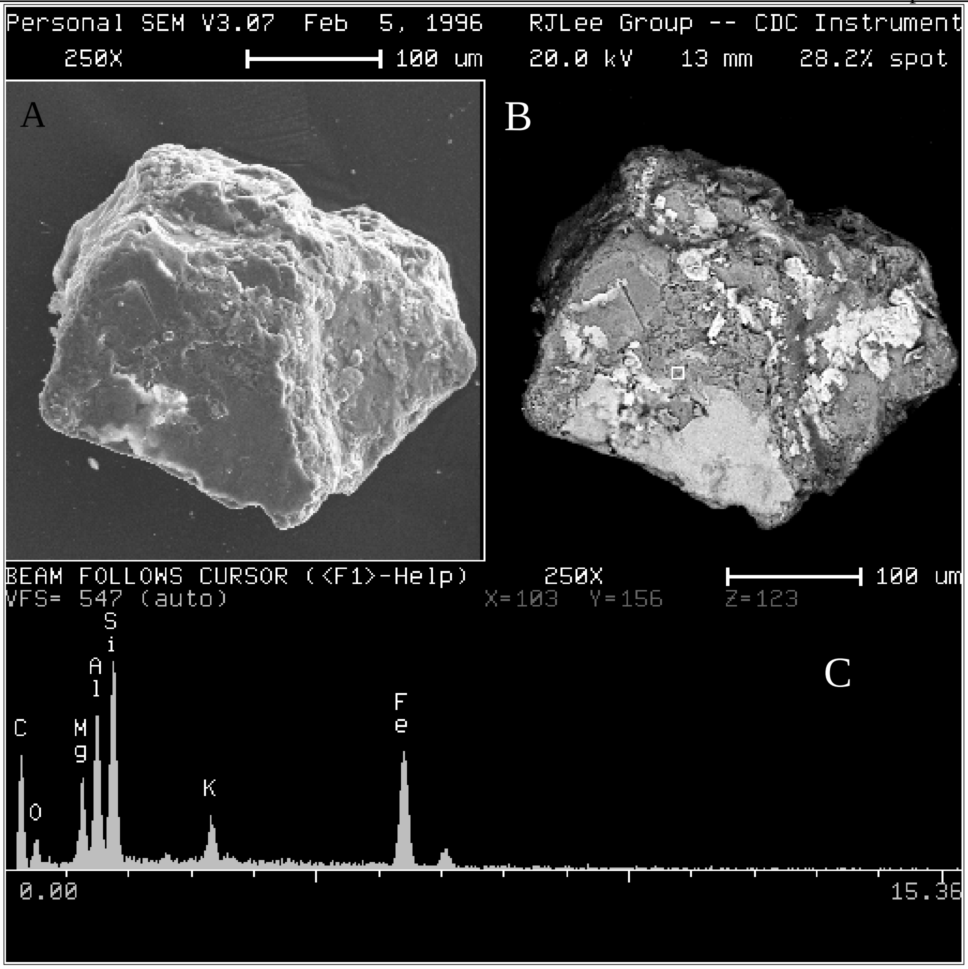

Figure 1 - Information obtained by the digital SEM. A) SEI of river sand grain showing morphology and surface texture. B) BEI of the same grain showing multiple phases. C) EDS spectrum of brighter region of B indicating a ferro-magnesium silicate composition.

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Darryl Rosenberg
Polaroid

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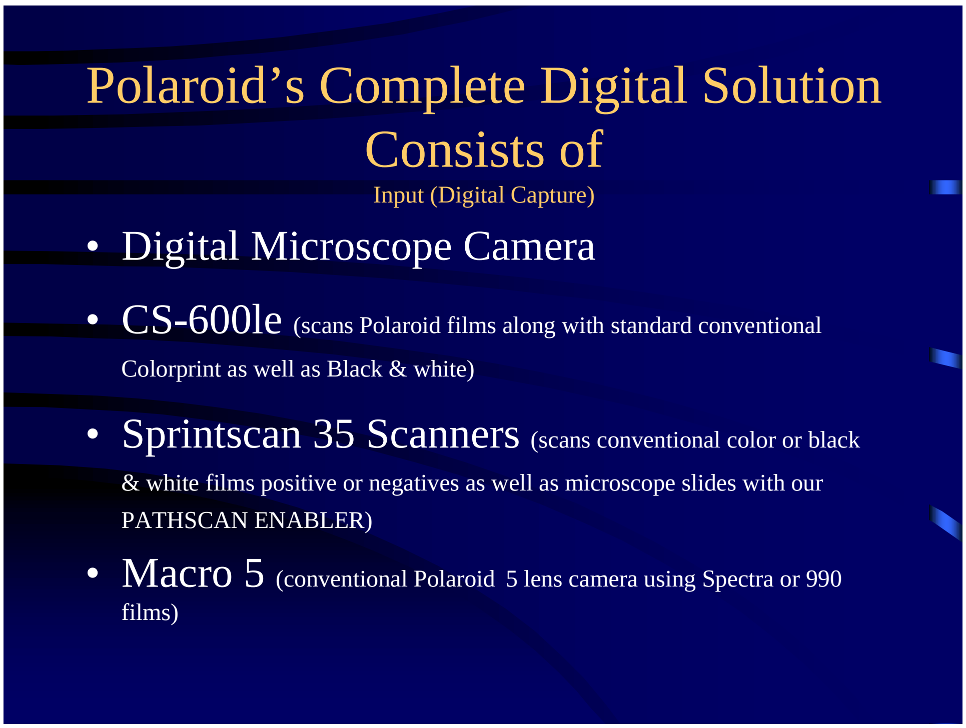

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Courtney Black
WVU NRCCE

The Environmental Technology Division (ETD) of the NRCCE at WVU is a recognized entity for multi-disciplinary environmental research. Located on the Evansdale Campus of West Virginia University in Morgantown, WV, the National Mine Land Reclamation Center of the ETD and NMLRC are funded through grants and contracts from private and federal agencies. Currently, projects funded by various mining companies, the Department of Energy, National Institute for Occupational Safety and Health (NIOSH), the U.S. Office of the Environmental Technology Division occupies a unique niche in the WVU structure. The Division functions as a program development agency, an administrative unit and a research unit. The Division concentrates on project progress and completion, which the NMLRC has extensive experience in project design, monitoring, and reporting. Additionally, NMLRC can effectively coordinate the resources of a research university to address the problems of the public and private sectors.

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Control of Acid Mine Drainage by Passive Treatment Systems

Acid mine drainage (AMD) pollutes about 5,000 miles of streams in the Appalachian region. Chemical treatment of AMD neutralizes acidity and removes metals, and the water must meet specific water quality criteria before it can be discharged to streams. There are various types of chemicals for neutralization but this technique of treating water is very expensive, and it must continue indefinitely. Ninety percent of AMD comes from abandoned coal mines (mostly underground mines) where no individual is responsible for treating the water with chemicals. Passive treatment systems, including the use of wetlands and anoxic limestone drains (ALD), offer an inexpensive alternative to treat many of these discharges without continual addition of chemicals and maintenance costs. Wetlands and ALDs have been installed on more than 100 sites and water quality improvements have been demonstrated through monitoring of flows and acid concentrations in the water.

Researchers at WVU have intensively monitored several passive AMD treatment systems in West Virginia. They treat flows ranging from 1 to 250 gpm and acidity concentrations from 170 to 2,400 mg/L. Five wetland systems reduce acidity by 3 to 76%, and iron concentrations by 62 to 80%. Iron and acid reductions were consistently greater in wetlands with limestone incorporated into the substrate. Eleven ALDs reduce acidity by 11 to 100%. Based on our successes and failures in building and monitoring ALDs, the following conclusions have been reached: 1) organic matter should not be placed in drains owing to microorganism growth on the limestone, 2) the amount of limestone in the passive system shows little correlation to effectiveness and acidity reductions, 3) larger limestone particle size (1 to 6 inch) helped maintain water flow through the drain especially when some aluminum, iron, and grit accumulated in the drain, 4) oxygen intrusion into the drain reduced effectiveness, and 5) pipes installed in drains must be large in diameter with large perforations and to reduce the chance for plugging.

Greens Run, a tributary of the Cheat River, is heavily polluted by AMD. Several point sources of acid water were located in the watershed. With the help of WVU researchers, Anker Energy designed and installed passive treatment systems to treat the acid drainage. An ALD was constructed in the fall of 1995 and water quality from the limestone drain has improved from a pH of 3.1 to 6.0, acidity concentrations have been reduced from 840 to 0 mg/L. More passive treatment systems are being planned for other tributaries of the Cheat River. Treating the water at their sources in Pringle, Heather, Lick, Morgan, and Greens Run, as well as Muddy Creek before the water reaches the Cheat River is a cost-effective way of cleaning up the river for recreational, aesthetic and human uses.

An underground mine discharge empties 500 to 3,000 gpm of AMD into the North Fork of the Blackwater River near Thomas, WV. The water has a pH of 3.1 and acidity concentrations around 500 mg/L. Treating the AMD with chemicals would be a long-term and expensive option (about $100,000 per year for this water). The West Virginia Division of Environmental Protection asked WVU researchers for help in designing a passive AMD treatment system, which does not require continual addition of chemicals and maintenance costs. If AMD contains little dissolved oxygen and primarily ferrous iron, it can pass through limestone without armoring the rock surface. Wetlands underlain with limestone function in a manner similar to an ALD and extend ALD use to partially-aerated AMD by scavenging dissolved oxygen and promoting microbial reduction of ferric to ferrous iron. Due to the oxidation status of the Thomas water and the specific metal concentrations, a wetland or an ALD by themselves would not treat the water adequately. Therefore, the passive system designed for this site was an innovative combination of a wetland and an ALD. The innovative system was designed in two cells. The first cell had 5 ft of organic matter over 1 ft of limestone, while the second cell had 2 ft of organic matter over 6 ft of limestone. In total, the system is 2,600 ft long containing 19,000 tons of limestone and 6,600 cubic yards of organic material. The system was constructed on the site in the fall of 1993. Acid mine drainage was introduced into the system in July 1994.

The Thomas wetland/ALD successfully improved effluent water quality over a 12-month period. However, it is likely that this system is not functioning in an optimum manner. Poor substrate permeability in Cells I and II has led to significant overland flow, resulting in minimal treatment in the wetland portion and insufficient contact with the underlying limestone. It is likely that declining performance in this system is primarily attributable to hydrologic factors and not to clogging and coating of the limestone. This observation is consistent with continuously alkaline water from bottom samplers throughout the drain, continuing precipitation of iron in the system, and lack of ferrous iron in the effluent water.

Abandoned coal mines cover about 200,000 acres in West Virginia. The Abandoned Mine Land Program (administered by the West Virginia Division of Environmental Protection) has been reclaiming these areas for 18 years with an average of $20 million spent annually, and only about 4 percent of the potential abandoned lands have been reclaimed. Remining allows an operator to remove remaining coal reserves that were left on the site and reclaim the entire abandoned mine site to current reclamation standards. Remining operations provide income through coal production, create jobs in the coal industry, and afford environmental enhancement through reclamation of previously-affected areas.

Remining is the surface mining of previously-mined and abandoned surface and underground mines to obtain remaining coal reserves. Remining operations create jobs in the coal industry, produce coal from previously-disturbed areas, and improve aesthetics by backfilling and revegetating areas according to current reclamation standards. Remining operations also reduce safety and environmental hazards by sealing existing portals and removing abandoned facilities, enhance land use quality, and decrease pre-existing pollutional discharges. Ten sites in the Appalachian Coal Region were selected to 1) compare the costs associated with remining and reclaiming a site to current standards versus costs associated with reclaiming the site by abandoned mine land (AML) programs, and 2) evaluate water quality before and after remining. All of the remining operations in our study resulted in environmental benefits. Dangerous highwalls were eliminated, spoil piles were regraded, coal refuse left on the surface was buried, and sites were revegetated to provide productive post-remining land uses. In all but two cases, coal mined and sold from the remining operation produced a net profit for the mining company. While AML reclamation removes hazards and improves aesthetics on AML sites, remining these 10 sites saved the AML reclamation fund an estimated $4 million. Water quality after remining improved in all cases. Impediments to remining AML sites should be removed so that mining companies will actively select previously-disturbed and abandoned sites for remining and reclamation.

Acid mine drainage (AMD) from an Upper Freeport abandoned deep mine near Masontown was eliminated by remining the deep mine workings and adding alkaline overburden material during backfilling and reclamation. About 6,500 tons/ac of alkaline shale were hauled to the remined Upper Freeport site from a nearby Bakerstown surface mine, and the shale was placed on the pit floor and compacted around toxic material placed “high and dry” in the backfill. No AMD has come from the site during the past five years since reclamation. The cost of hauling the alkaline material to the site was about $4,000/ac. Chemical treatment costs of AMD previously coming from the site before remining ranged from $800 to $1,500 per year. The receiving stream is Mountain Run, a tributary of Bull Run of the Cheat River, and its quality has improved due to remining.

Randy Robinson
WVU Education

The West Virginia K-12 RuralNet Project Watershed Education Workshop

Forty K-12 teachers from the Cheat River watershed and throughout West Virginia met this past summer in Preston County for a workshop on how to teach watershed related concepts in K-12 classrooms. Alpine Lake Resort near Terra Alta was the site for the three day workshop which ran July 27-30, 1997 and featured 20 speakers, three field trips, Internet training sessions and a whitewater trip on the Cheat River Narrows.

The workshop was sponsored and planned by the West Virginia K-12 Ruralnet Project at West Virginia University. The Ruralnet project is funded by the National Science Foundation and based in West Virginia University's College of Human Resources and Education. The primary work of the Ruralnet Project is to train and assist West Virginia science and mathematics teachers to use the Internet in a variety of ways that will enhance classroom instruction. Project partners are Bell-Atlantic Corporation and Marshall University.

Terra Alta Middle School's computer lab hosted the Internet sessions which introduced teachers to the Ruralnet Project web pages and on-line resources. Ruralnet teacher-leaders Kirk Lantz and Sally Kelly were instrumental in recruiting teachers and coordinating lab sessions. Sarah Easterbrook of the Ruralnet Project organized the web-based registration and made sure on-site sessions ran smoothly.

The goals of the West Virginia watershed education workshop were:

> To enhance science teaching by observing and discussing, with working researchers, the design and operation of current projects or field studies in environmental restoration, environmental protection and natural resource management.
>
> To explore methods of incorporating watershed studies into existing K-12 curriculum with an emphasis on integrating and relating science concepts to other subjects and "hands on" activities for students.
>
> To provide resources and contacts for teachers in various local, state, and national organizations and how to access these resources, data, and information via the Internet.
>
> To use the Cheat River watershed as a model for watershed studies that could be replicated in other watersheds, schools and communities throughout West Virginia.
>
> To introduce teachers to on-line resources provided by the Ruralnet Project such as the West Virginia watershed switchboard, database, and lesson frameworks which are all accessible via the World Wide Web.

Featured speakers and topics included:

State Initiatives:
West Virginia Watershed Assessment Program
George Constantz - WV Division of Environmental Protection

Watershed and Community Initiatives:
Friends of the Cheat
Dave Bassage, Executive Director

NGO Initiatives:
West Virginia Rivers Coalition
Roger Harrison, Executive Director

Regional Initiatives:
Canaan Valley Institute/WV Watershed Network
Kiena Smith, Executive Director, CVI

Mid-Atlantic Highlands Coordinating Council
Ron Preston, Executive Director

MAHA Student Project: Biological Database Mapping
John Young, Fish and Wildlife Biologist (GIS Specialist)

Overview of AMD and Hydropower impacts on fish populations of the Cheat and Tygart:
Frank Jernejcic - WV Division of Natural Resources

Fish Survey Methods:
Dan Cincotta - WV Division of Natural Resources

Mapping Your Watershed:
Craig Mains - Downstream Alliance

Science and Natural History of the Cheat River Watershed:
Ben Stout - Wheeling Jesuit College

Hydrodynamics of Squirt Boating:
James Snyder - Friends of the Cheat
Curriculum Integration Strategies:
Bill Moore - Hampshire High School

Stream Table Demonstration:
Dan Cincotta - WV Division of Natural Resources

Watershed Curriculum Resources: GREEN, SOS, Give Water a Hand, and others: Joyce Meredith - WVU Extension Specialist – Science, Randy Robinson - Ruralnet Project.

Establishing a Statewide Network of Educators:
Kiena Smith - Canaan Valley Institute
Bill Moore - Hampshire High School

Three concurrent full day field sessions were a highlight of the workshop. Teachers had to choose just one of the three trips to join but many later commented that they would like to have been able to participate in all three!

Watershed Restoration:

The lower Cheat River watershed has had severe ecological impact from acid mine drainage (AMD). Paul Ziemkiewicz and Courtney Black from the National Mine Land Reclamation Center at WVU lead a tour of current restoration work. Chemical (active) and biological (passive) methods of AMD control were demonstrated at several sites. This group also attended the River of Promise ground-breaking ceremony for the EPA funded Sovern Run restoration project.

Canaan Valley National Wildlife Refuge and Blackwater River/Wetlands: Biologist Ben Stout lead a tour and discussed his Canaan Valley wetland studies. Chemical, biological & physical stream assessment techniques were demonstrated. The group visited the Douglas Reclamation site on the Blackwater River (AMD neutralization and fisheries restoration). Rounding out the day was a visit to the Canaan Valley Institute. Paul Kinder demonstrated how a Geographic Information System (GIS) can be used to map and correlate biological data with other spatial data sets such as soil type or elevation.

National Project WET (Water Education for Teachers) and WV-SOS (Save Our Streams):

Hands on workshops for K-12 teachers who want to learn proven methods for helping students understand watershed related concepts and stream monitoring techniques.

Rose Long of the WVDEP and WV Coordinator for Project WET facilitated a workshop in which teachers tried out a number of activities and lessons from the Project WET Activity Guide. After completing this workshop teachers received the Activity Guide which gives complete instructions for over 100 lessons/activities designed for K-12 students.

Alvan Gayle of the WVDEP Citizens Monitoring Program demonstrated biological methods for stream monitoring using the Save Our Streams (SOS) program which is widely used in schools throughout the country. This technique is relatively inexpensive and provides an enjoyable way for students to learn about data collection, aquatic ecosystems and bio-diversity. Craig Mains of Downstream Alliance demonstrated chemical and physical monitoring techniques and the use of various test kits and equipment that students might use. Craig recently completed a 3 yr. study and water quality mapping of tributaries in Preston Co. Participants studied Snowy Creek near Alpine Lake and learned how a local school integrates stream studies into their science curriculum. Craig later provided a fall follow-up session at the Fellowsville School in Preston County.

Science and mathematics education is changing across West Virginia and the nation. This change to a more coordinated, thematic, hands-on approach requires innovative strategies for augmenting the curriculum. A number of educators are using the Internet as a powerful tool for developing or enhancing these innovative strategies.

To provide participating teachers with a model of how Internet resources might be utilized in the classroom, the Ruralnet project has developed on-line resources for school / community based stream and watershed investigations. The activities associated with these investigations provide an excellent link between the new West Virginia State Science Curriculum framework and Internet-based resources. Through their observations and data collection, students can become active producers of information about their watershed.

Students learn that science is not isolated from other social, political and economic issues. They also learn that partnerships are necessary to get things done. Watershed studies encourage partnerships between schools, communities, businesses, watershed associations, local and state governments and non-governmental organizations. Increasingly, these entities are coming on-line and communicating.

Ruralnet teachers are not only provided a model for integration that can be extended to other subject areas, but also have the opportunity to involve their students in authentic and meaningful science through involvement with stream monitoring activities and local watershed assessments.

On-line resources to support this work were developed by Steve Storck, Sarah Easterbrook and Randy Robinson of the Ruralnet Project and include the WV watershed database, url database, collaborative projects and acompilation of web sites related to environmental science and watershed studies. Links to these resources can be found at the WV Watershed Switchboard:

http://www2.ruralnet.wvu.edu/Rnet/portfolio/

One example from the Cheat watershed database was contributed by Rowlesburg School teachers Devra Deems and Henrietta Bolyard who assisted their kindergarten and 8th grade students in conducting a biological study of Fill Hollow and Saltlick Creeks this past fall . Their results can be viewed by going to the url listed above and then selecting links to WV watershed database, Cheat watershed and Rowlesburg School.

The workshop wrapped up with a sunny afternoon trip down the Cheat River Narrows with Appalachian Wildwaters outfitting rafts and inflatable kayaks. Extra water from a summer storm in the headwaters gave plenty of action and a fun finishing touch.

Teacher evaluations of the watershed education workshop were very good. A number of teachers and speakers alike commented that this was one of the most productive workshops they had ever attended and would like to see these workshops continued.

If your agency or association is interested in co-sponsoring or hosting a summer '98 watershed workshop for teachers please contact Randy Robinson at the address below.

The Ruralnet Project will again offer Internet training workshops for K-12 teachers during the summer of '98. These workshops are provided free of charge through funding from the National Science Foundation.

Teachers who would like to participate can request more information at:

The West Virginia K-12 Ruralnet Project
West Virginia University
609 Allen Hall
PO Box 6122
Morgantown, WV 26506-6122

Randy Robinson
rrr@wvu.edu
Phone 304-293-5913 x-1817

Visit the Ruralnet homepage at:
http://www.wvu.edu/~ruralnet

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Biosketch

Randy R.Robinson

Randy Robinson is a doctoral student in the College of Agriculture, Forestry and Consumer Sciences at West Virginia University. He works as a research assistant with the Ruralnet Project at WVU which provides Internet training for WV K-12 science teachers. His research interests include Internet based electronic field trips and other web based resources for environmental science education.

His work with the Ruralnet project includes:

Facilitating Internet training workshops for teachers.

Development and implementation of on-line graduate courses.

Mentoring and evaluation of on-line course work.

Planning and implementation of watershed studies as a framework for integrating science across the K-12 curriculum.
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Randy holds a bachelors degree in environmental education and teaching certifications in environmental education, geography and science. After serving with the US Navy at communications stations in the Philippine Islands and Morocco, he completed the masters degree in secondary education at WVU.

Working in West Virginia's whitewater industry since 1976, Randy worked as a river guide, trip leader and staff trainer. In 1986 he began a video production business that specializes in outdoor recreation and environmental science education topics. Randy's goal with the Ruralnet Project is to help develop Internet based watershed studies and stream monitoring programs for West Virginia schools.

Watershed studies integrate environmental science topics with the K-12 curriculum and encourage partnerships between schools and their surrounding communities. Randy R. Robinson
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Frank Gmeindl
National Technology Transfer Center

National Technology Center

The National Technology Transfer Center's (NTTC) mission is to transfer National Aeronautics and Space Administration (NASA) and other federal technologies to the private sector. This presentation describes the evolution of the NTTC and its recent creation of a Commercialization Center. The Commercialization Center offers the following advanced product development services: Computer Aided Design/Computer Aided Manufacturing (CAD/CAM), engineering drawings, models, technical search, product/process redesign, and rapid prototyping. It also offers business services including: business planning, market analysis, sales & distribution planning, capitalization assistance, production planning, partnerships and virtual corporations. The Commercialization Center targets the following industries: indigenous local industries, environmental, materials, information technology and computational modeling, sensors, and biotechnology.

"Feasibility of Measuring Total Dissolved Gas Pressure, Dissolved Oxygen and Carbon Dioxide Based on Head-Space Partial Pressures"

By

Barnaby J. Watten [1]
and
Michael F. Schwartz [2]

Dissolved gas constraints are often corrected through application of air-water or oxygen-water gas transfer equipment. Given that influent dissolved gas levels can vary hourly or seasonally depending on the water source, operating costs are reduced through use of equipment designed to match gas transfer rates with gas transfer needs.

Feedback control loops satisfying this requirement have been described but rely on accurate and robust dissolved gas sensors. Unfortunately, biological fouling of the wetted, gas-permeable membrane used by polarographic and galvanic dissolved oxygen (DO) probes inhibits gas transfer and hence probe performance. This problem was circumvented by designing a DO monitoring system that eliminates the need for submerging analytical components. Dissolved oxygen is calculated using Henry's Law, water temperature, and the partial pressure of oxygen that develops within the head space of a vertical gas-liquid contacting chamber. Water enters the chamber as a spray, then exits into a receiving basin through a cone diffuser designed to minimize bubble carryover. Head-space gas composition, measured with a galvanic oxygen sensor, changes as an equilibrium is established between gas-phase partial pressures and dissolved gas tensions.

Calculated DO concentrations were compared with those obtained by Winkler analysis (n=67) over a range of DO (0.0 - 18.0 mg/1), water temperature (11.5 - 27.5 degree C), and dissolved nitrogen conditions (73.4 - 107.0% saturation). Differences between the two analytical methods averaged just 0.25 mg/1 (range -0.51 to 0.86 mg/1). The precision of DO estimates established in a second test series was good; coefficients of variation (100 SD/x) averaged 0.88% at 10.2 degree C (n=6) and 1.21% at 25 degree C (n=6). The time required to reach 90% and 100% of equilibrium DO concentrations averaged 8.6 min (range 7-10 min) and 17.4 min (range 15-23 min), respectively. This response was sufficient to adequately follow changes in DO of up to 26.3 mg/1 hr. The instrument developed has also been modified to allow for the continous monitoring of dissolved carbon dioxide. Here gas phase partial pressures were determined with either an infrared detector or by measuring voltage developed by a pH electrode immersed in an isolated sodium carbonate solution sparged with head space gas.

Tests conducted over a wide range of operating conditions (N=96) established statistically significant correlations between head space and titrametrically determined dissolved carbon dioxide concentrations.

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7. Biosketch: Barnaby holds a BS degree in Aquatic Biology, a Masters degree in Agricultural Engineering and Ph.D. in Fisheries and Allied Aquaculture. His research has in the last 20 years supported intensive fish production and pollution abatement in industry as well as State and Federal programs, primarily in the area of gas transfer. He is past President of the Bioengineering Section of the American Fisheries Society, is currently a Board Member of the Aquacultural Engineering Society and is a member of The Standard Methods Committee of the American Public Health Association. He has also served as an Editorial Board Member for the Journals Aquacultural Engineering and the Progressive Fish Culturist.

[2] Michael F. Schwartz
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GEORGE CASE

APPLICABILITY OF A FIELD BIOSENSOR FOR CARCINOGENIC TOXICITY EVALUATION OF SEDIMENTS AND OTHER WATERSHED MEDIA

GEORGE CASE

APPLICABILITY OF THIN MEMBRANE SENSOR MEDIA FOR SAMPLING AND DETECTION OF MERCURIALS AND HYDROPHOBIC POLLUTANTS

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APPALACHIAN RIVERS CONFERENCE, WORKSHOP, AND EXHIBIT PARTICIPANT LIST (Page 1)

April 23, 1998

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APPALACHIAN RIVERS CONFERENCE AND WORKSHOP
THURSDAY, APRIL 23, 1998

ALAN B MOLLOHAN INNOVATION CENTER--MAIN CONFERENCE ROOM
WEST VIRGINIA HIGH TECHNOLOGY CONSORTIUM
1000 TECHNOLOGY DRIVE
FAIRMONT, WEST VIRGINIA 26554

INSTRUCTIONS TO SPEAKERS

A. Submit a one to three page abstract of your presentation to be published in the proceedings either by **Email** or on 3-1/2" floppy to Michelle Cameron (304-366-0774) at: nbe@access.mountain.net, or 7001 Mountain Park Drive, Suite C, Fairmont, WV 26554 by **April 17, 1998**. You may use either MSWORD or WORDPERFECT. Please plan on a TWELVE minute presentation briefing and a three minute discussion period.

B. In your presentation, **as one engaged in river monitoring or cleanup**, please emphasize some of the following:

1. In your stream/river activities, what problems do you incur that new technology might help?
2. What data would you like to have that you presently do not have?
3. Would river data received: a) quicker after collection, or b) in a better format, help your efforts?
4. Would a) higher sampling rates or frequency of sampling , or b) more sample locations, help?
5. Would on-site, real- time data reduction, analysis and display benefit your projects? How?
6. Would on-site computer models using real time data benefit your projects? How?
7. What variables not measured would make the greatest impact if measured and available?
8. What technology would you like to see further developed to help in your mission?
9. What emerging stream/river problems do you foresee?
10. What are the greatest chemical or biological monitoring, analysis, and cleanup technology needs?

C. In your presentation, **as one providing or developing river applicable technology**, please emphasize:

1. Ultimate potential uses of your technology
2. Intermediate steps or improvements needed to make your technology more useful to river applications
3. Any partnering or joint efforts you would welcome to demonstrate or develop your technology

D. Please use the following general format for submitting your abstract and other information.

"PRESENTATION TITLE"
by
"Your Name"

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxx-----------------------3/4" margins all sides, 12 pt font preferred

(ONE TO THREE PAGE ABSTRACT)

----

1. Affiliation **2. Title** **3. Mailing address**
4 Office telephone **5. Fax telephone** **6. Email address**
7. Biosketch

APPALACHIAN RIVERS CONFERENCE AND WORKSHOP
THURSDAY, APRIL 23, 1998

ALAN B MOLLOHAN INNOVATION CENTER--MAIN CONFERENCE ROOM
WEST VIRGINIA HIGH TECHNOLOGY CONSORTIUM
1000 TECHNOLOGY DRIVE
FAIRMONT, WEST VIRGINIA 26554

INSTRUCTIONS TO EXHIBITORS

B. You are invited to submit an abstract and/or literature describing your exhibits to be included in the proceedings of the conference. The material should show clearly when copied with a conventional copying machine, and all pages submitted should not exceed 3 pages. At your option, I would suggest a one page written description with all pertinent information such as specifications, contacts, distributors, telephone numbers, email addresses, etc. For this one page, please follow the procedure below. You may submit two other pages of hard copy literature describing the products as long as it copies well.

C. Submit a one page abstract describing your exhibits to be published in the proceedings either by **Email** or on 3-1/2" floppy to Michelle Cameron (304-366-0774) at: nbe@access.mountain.net, or 7001 Mountain Park Drive, Suite C, Fairmont, WV 26554 by **April 17, 1998**. You may use either MSWORD or WORDPERFECT. **You may also submit a good original typed version** of your one page exhibits abstract , if you prefer, **along with the two other pages of product literature to Michelle**.

C. The exhibit area will be in the same large room as the morning speakers conference and the afternoon work group sessions, the catered buffet luncheon, and the evening social hour from 5:00 p.m. to 7:30 p.m. You will be provided access to this conference room from 2:00 p.m. (Wednesday afternoon, the day before the conference) until 6:00 p.m. Registration for the conference begins at 7:30 a.m. the next morning, and the conference program begins promptly at 8:00 a.m., so there will be only about one - half hour setup time available Thursday morning. One six foot long by three foot wide table will be available for you to use. You may bring your own curtain backdrop or table spread and front table drop cover if you prefer to do so. The available space for your exhibit is about eight feet wide maximum. Someone will be available during the 2 to 6 p.m. period on Wednesday the 22nd, to show you the exhibit area.

D. The people doing the exhibiting are invited to participate in the conference questioning after each speaker, and in the work group sessions in the afternoon.

E. There is no charge for this exhibit or the abstract in the proceedings. This is a courtesy to you for coming to exhibit at this conference. We thank you, and look forward to your participation. If you have further questions, please feel free to call Michelle at 304-366-0774, or, L. Z. Shuck, conference chairman, at 304-292-7590.

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT
WORK GROUP 1
RIVER CHEMICAL MONITORING TECHNOLOGY

As a river steward looking for pollution sources and keeping a vigilant watch over streams and rivers what technologies or new tools could help the most to make your job more efficient and effective? Respond as an experienced government agency scientist, or a local chemist watershed organization volunteer, or a university researcher, who would like to help improve the local stream quality.

1. What chemical and physical properties need to be monitored every few minutes for 24 hours year around to give comprehensive baseline data for normal diurnal/nocturnal and seasonal variations in Appalachian region rivers? Assume data are to be used for comprehensive computer simulation, watershed and river ecology research, and long term history matching/comparison studies.

1.	6.	11.	16.
2.	7.	12.	17.
3.	8.	13.	18.
4.	9.	14.	19.
5.	10.	15.	20.

2. As terrorism spreads throughout the world should we consider a special alert monitoring program to protect drinking water supplies which come from rivers in most Appalachian cities? Yes___ No___
Why?, Why not?

3. The variables typically monitored today at fixed river stations on an hourly (more or less) basis include: DO, temp, pH, total conductivity, ammonium/ammonia, nitrates, turbidity, TDS, and chloride. As a river steward making stationary or traverse water chemical property measurements, list the additional variables most important that need to be quickly measured onsite rather than taking samples back to the laboratory for analysis.

1.	6.	11.	16.
2.	7.	12.	17.
3.	8.	13.	18.
4.	9.	14.	19.
5.	10.	15.	20.

4. Should a combination of river continuous, real-time monitoring instruments and an onsite computer flow simulation program be used at key river locations to detect spills or pollution sources around the clock in order to send an alarm and back calculate to locate the point of entry of the source? Yes___ No___
Considering the costs/benefits, should we locate such a system:
a) one mile or so above each city water supply intake? Yes___ No ___
Why?, Why not?
b) a mile or so below each city or high risk industrial area? Yes ___ No ___
Why?, Why not?
c) on major creeks and streams passing through populated or industrialized communities just before they enter into larger rivers? Yes ____ No____
Why?,Why not?
5.What new portable chemical measuring instruments or measuring techniques/capabilities would you like to have and see developed for stream and river monitoring ?

1.	4.
2.	5.
3.	6.

OTHER CHEMICAL PROPERTY ISSUES YOU THINK NEED TO BE DISCUSSED

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT

WORK GROUP 2
RIVER BIOLOGICAL MONITORING TECHNOLOGY
MICROBIAL(PLANT OR ANIMAL)

As a river steward looking for pollution sources or ecosystem problems and keeping a vigilant watch over streams and rivers, what technologies or new tools could help the most to make your job more efficient and effective? Respond as an experienced government agency scientist, or a local scientist watershed organization volunteer, or a university researcher, who would like to help improve the local stream/river quality OR detect abnormal or unhealthy ecosystem characteristics.

1. What MICROBIAL properties <u>need</u> to be monitored HOURLY, or DAILY up to MONTHLY year around to give comprehensive baseline data for normal diurnal/nocturnal and seasonal variations in the Appalachian region ? Assume data are to be used for comprehensive computer simulation, river ecology research, and long term history matching/comparison studies.

1.	**6.**	**11.**	**16.**
2.	**7.**	**12.**	**17.**
3.	**8.**	**13.**	**18.**
4.	**9.**	**14.**	**19.**
5.	**10.**	**15.**	**20.**

2. As terrorism spreads throughout the world should we consider a special <u>microbe</u> alert monitoring program to protect drinking water supplies which come from rivers in most Appalachian cities? Yes___ No___ , Why?, Why not?

3. As a river steward making <u>stationary</u> or <u>traverse</u> water biological-microbial property measurements in rivers and small tributaries, list the parameters/variables most important that need to be quickly measured onsite rather than taking samples back to the laboratory for culture and microscopic analysis.

1.	**6.**	**11.**	**16.**
2.	**7.**	**12.**	**17.**
3.	**8.**	**13.**	**18.**
4.	**9.**	**14.**	**19.**
5.	**10.**	**15.**	**20.**

4. Assume quick response real time microbial (plant or animal) monitoring instruments were commercially available. Should a combination of stream/river continuous, real-time monitoring instruments and an onsite computer flow simulation program be used at key river locations to detect new microbial sources around the clock in order to send an alarm and back calculate to locate the point of entry of the source? Yes___ No___

Considering the costs/benefits, should we locate such a system:

a) one mile or so above each city water supply intake? Yes___ No ___
Why?, Why not?

b) a mile or so below each city? Yes ___ No ___
Why?, Why not?

c) on major creeks and streams passing through populated or industrialized communities just before they enter into larger rivers? Yes ____ No____
Why?, Why not?

5.What new <u>portable</u> biological-microbial measuring instruments or measuring techniques/capabilities would you like to have and see developed?

1.	**3.**
2.	**4.**

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT

WORK GROUP 3
RIVER BIOLOGICAL MONITORING TECHNOLOGY
AQUATIC MACRO PLANT OR ANIMAL

As a river steward looking for environmental problem sources or ecosystem problems and keeping a vigilant watch over streams and rivers, what technologies or new tools could help the most to make your job more efficient and effective? Respond as an experienced government agency scientist, or a local scientist watershed organization volunteer, or a university researcher, who would like to help improve the local stream/river quality OR detect abnormal or unhealthy ecosystem characteristics.

1. What are the most important macro plant and animal data that really <u>need</u> to be obtained, and how frequently, in order to establish well defined improvement/deterioration trends in the overall health of rivers and their ecosystems? What are the prime indicators?

1.	6.	11.	16.
2.	7.	12.	17.
3.	8.	13.	18.
4.	9.	14.	19.
5.	10.	15.	20.

2. There seems to be a need to capture biological data and represent it in a digital format so that it can be processed in a computer and compared with chemical and other data for a wide variety of reasons in the study of ecosystems. Considering all aquatic animal and plant species, diversity and population size, what parameters would you give the highest priority for measuring and digital comparison with water chemical or other properties for overall river ecosystem health evaluation or ecosystem studies?

1.	6.	11.	16.
2.	7.	12.	17.
3.	8.	13.	18.
4.	9.	14.	19.
5.	10.	15.	20.

3. As a river steward doing surveys of rivers and watersheds, what features, and of what individual plants, would you want to digitally record in or along the river by use of a digital camera in order to use some type of digital processing, such as pattern recognition, filtering, size, shape, spectral reflectance, or other computer based analysis techniques?

1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

4. What new <u>portable</u> computer based instruments or measuring techniques/capabilities would you like to have and see developed for capturing macro plant and animal life features for ecosystem studies and evaluation?

1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

OTHER RELATED TOPICS YOU WOULD LIKE TO PURSUE OR HAVE INVESTIGATED & GENERAL COMMENTS:

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT

WORK GROUP 4
THE BASS MYSTERY

ASSUME THE FOLLOWING

The changing industrial base in West Virginia has led to TOURISM as the number two industry in the State exceeding 4 billion dollars per year. Fishing is a significant part of the tourism business. This trend will likely continue or increase in the future. Bass fishing is the historical favorite in most Appalachian streams and rivers. Large bass populations could greatly increase the number of bass tournaments in the State and other fishing activities that would have a large economic impact.

In addition to the financial incentives, a more fundamentally important ecological issue lurks in the rivers. The mystery is why are the bass populations below historical levels, and below the levels "healthy" rivers support.

TASKS

You are charged with five tasks to unravel this mystery by scientific investigation and correct it:

1. **Offer a list of possible reasons for low bass population density with supporting arguments.**
2. **List the likely food diet options through a 12-month cycle assuming a serious siltation condition.**
3. **Trace the likely food chain assuming a serious stream condition of siltation and all else OK.**
4. **List the most important things you think can be done to increase bass populations in WV rivers and the technologies needed to help achieve the results.**
5. **Outline a scientific protocol or list of experiments for obtaining the supporting data to prove the contribution each of the possible reasons makes in a given stream through a 12-month cycle.**

QUESTION: If these tasks or questions cannot be comprehensively answered with existing information and scientific data, is such a research project to answer them warranted? Yes___ No___

TASK 1---List possible reasons for low bass populations, and explain why.
i) List both the stream problems, such as siltation, pH, TDL, and the problems they create for bass.
ii) List such considerations as spawning problems, over fishing, diet deficiencies, pollutants.
iii) Consider the impact of each problem on each of the possible food chain ingredients.
iv) Bass are near the top of the food chain. Do other predatory fish eat bass ? Explain.

1. Siltation 1. 2. 3.

2.

3.

4.

5.

WORK GROUP 4

THE BASS MYSTERY

(Cont'd)

TASK 2---Likely food diet through a 12-month cycle
The likely food diet (top 5 foods) assuming a serious siltation stream problem

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1												
2												
3												
4												
5												

TASK 3 ---List the likely food chain links leading up to the top of the chain, the bass, assuming that a serious siltation stream condition exists and all other conditions are normal.

TASK 4 ---List the most important things you think can be done to increase bass populations in WV streams and rivers, and the technologies needed to help achieve the results. Include anything from regulatory to biotechnologies that you think could be useful.

Things to be done:

1.	**9.**
2.	**10.**
3.	**11.**
4.	**12.**
5.	**13.**
6.	**14.**
7.	**15.**
8.	**16.**

Technologies needed

1.	**7.**
2.	**8.**
3.	**9.**
4.	**10.**
5.	**11.**
6.	**12.**

TASK 5 ---Outline a scientific protocol or list of experiments for obtaining the supporting data to prove the contribution each of the possible reasons makes in a given stream through a 12-month cycle. Disregard the costs of making the measurements to provide the data. List the chemical and biological parameters that need to be measured.

APPALACHIAN RIVERS CONFERENCE, WORKSHOP AND EXHIBIT

WORK GROUP 5

DATA AND INFORMATION

1. Does a list exist of all of the agencies, organizations, and businesses that collect water chemical property data in WV on WV creeks, streams and rivers? Yes ____ No_____
If answered "yes", what place and address? ____
Does this list include names of independent and municipal water companies? Yes ___ No___
Does this list include collection by private companies or organizations? Yes ____ No____

2. Is there a central database or repository where all chemical data are stored in addition to STORET? Yes ___ No ____
Does this database include chemical data collected by all drinking water companies? Yes ___ No___
Does this database include chemical data collected by private companies who volunteer it?

3. What groups are using this state-wide collection of data to do global WV analyses or modeling?
What types of models are being used?

4. Does a list exist of all of the agencies and organizations that collect biological data in WV on WV creeks, streams and rivers? Yes ____ No_____
If answered "yes", what place and address? ____
Does this list include names of drinking water companies? Yes ___ No___
Does this list include collection by private companies or organizations? Yes ____ No____

5. Is there a central database or repository where all WV biological data are stored? Yes ___ No___
Does this database include biological data collected by all drinking water companies? Yes ___ No___
Does this database include biological data collected by county health departments? Yes ___ No___

6. What groups are using this state-wide collection of data to do global WV analyses or modeling?

7. Are there GIS maps showing the locations of all known chemical and biological data collection sites and the respective types of data collected in WV? Yes ___ No ___
Comments:

8. Educating and sensitizing the public to pollution problems may be one of the best ways to reduce pollution. What new technology tools can be most useful in this effort?

9. How helpful would it be to all of the state and federal agencies and other river stewards if more data, information, and advanced technology tools were provided to them at the local level?
What tools from monitoring instruments to computer simulation programs would be most beneficial?

10. In Minnesota, school children discovered that 50% or so of the frogs in a three-state area had serious deformities. Watershed organizations are increasing, but often play relatively low-tech roles of helping clean up rivers and the environment. Can we amplify the efforts of our river stewards by enlisting high tech neighborhood assistance from watershed organizations? What high technology tools and efforts would be most helpful?