PROCEEDINGS

EPA SCIENCE FORUM 2004:
Healthy Communities and Ecosystems

June 1-3, 2004

United States Environmental Protection Agency
Mandarin Oriental Hotel
Washington, DC

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Acronyms

AAAS	American Association for the Advancement of Science
ADA	Americans with Disabilities Act
ATSDR	Agency for Toxic Substances and Disease Registry
ATtILA	Analytical Tools Interface for Landscape Assessments
CAA	Clean Air Act
CADDIS	Causal Analysis/Diagnosis Decision Information System
CDC	Centers for Disease Control and Prevention
CMAQ	Community Multi-Scale Air Quality
CREM	Council on Regulatory Environmental Modeling
DNA	deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DSSTox	Distributed Structure-Searchable Toxicity
ECOS	Environmental Council of the States
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPHT	Environmental Public Health Tracking
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GARP	Genetic Algorithm for Rule-Set Prediction
GIS	geographic information system
GPS	global positioning system
HAP	hazardous air pollutant
I-BEAM	Indoor Air Quality Building Education and Assessment Model
IBM	International Business Machines
IMAP	Inshore-marine Monitoring and Assessment Program
IRB	institutional review board
IRIS	Integrated Risk Information System
ISO	International Standardization Organization
LCD	liquid crystal display

Acronyms (continued)

LIDAR	light detection and ranging
LOAEL	lowest observed adverse effect level
MACT	Maximum Achievable Control Technology
MBSS	Maryland Biological Stream Survey
MOUs	Memoranda of Understanding
MMT	methylcyclopentadienyl manganese tricarbonyl
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NBII	National Biological Information Infrastructure
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NEBA	Net Environmental Benefit Analysis
NEPA	National Environmental Policy Act
NERL	National Exposure Research Laboratory
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NHEERL	National Health and Environmental Effects Research Laboratory
NIEHS	National Institute for Environmental Health Sciences
NIH	National Institutes of Health
NLCD	National Land Cover Data
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NRMRL	National Risk Management Research Laboratory
NSRC	National Science Resource Center
NWS	National Weather Service
OEI	Office of Environmental Information
OMB	Office of Management and Budget
ORD	Office of Research and Development
ORIA	Office of Radiation and Indoor Air
OTOP	Office of Technology Operations and Planning

Acronyms (continued)

OWOW	Office of Wetlands, Oceans, and Watersheds
P3	People, Prosperity, and the Planet
PAH	polycyclic aromatic hydrocarbons
PBPK	physically-based pharmacokinetics
PCB	polychlorinated biphenyl
PCR	polymerase chain reaction
PHASE	Public Health Air Surveillance Evaluation
PNEIR	Program Needs for Indoor Environmental Research
PM	particulate matter
QPCR	quantitative polymerase chain reaction
ReVA	Regional Vulnerability Assessment
R-EMAP	Regional Environmental Monitoring and Assessment Program
ROD	Record of Decision
SAR	structure-activity relationships
SCCWRP	Southern California Coastal Water Research Program
SoR	System of Registries
STAR	Science to Achieve Results
TMDL	Total Maximum Daily Load
TRI	Toxics Release Inventory
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Executive Summary

The Environmental Protection Agency (EPA) presented the *2004 Science Forum: Healthy Communities and Ecosystems* on Tuesday, June 1, through Thursday, June 3, 2004, in Washington, DC. This *Science Forum* highlighted EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, the use of science in decision making and policy making. The *Science Forum* also provided an opportunity for dialogue and interaction among EPA scientists, clients, stakeholders, and colleagues with over 1,000 attendees at this event, including EPA program, research, and regional staff; members of other Federal agencies; the scientific community; and the public.

The *Science Forum* consisted of a full day session of plenary speakers and a review of the relationship between the American Association for the Advancement of Science (AAAS) Environmental Fellows Program and EPA, and three two-day breakout sessions. Each breakout session examined a theme area—science and innovation to protect health and environment, using science to make a difference, and delivering science-based information to decision makers. The *Science Forum* included 223 posters and demonstrations on current EPA research activities and speaker-specific topics, EPA scientists/engineers present to discuss their research efforts, 11 exhibits/demonstrations of EPA and other Federal agency scientific and educational programs, and demonstrations of canine scent capability to detect vapor intrusion using an EPA-trained dog.

AAAS Session

The *Science Forum* opened with a panel discussion about the fellowship program sponsored by AAAS. Dr. Fran Sharples, Dr. Venkat Rao, and Dr. Terry Keating discussed their experiences with the different program stages (from the initial fellowship program to the present) and lessons learned through their experiences at EPA about the role of science in decision making and policy making.

Plenary Session

The purpose of this session was to provide plenary addresses on the role and value of science at EPA, new research and technology directions, and the partnerships supporting all of these activities. EPA Administrator Mike Leavitt provided a perspective on the successful growth of EPA into an internationally respected scientific organization and new directions such as the integration of social science and communication, networking of people and resources to overcome boundaries and solve challenging issues, and growth beyond the historic experience of environmental cleanup. The Regional Administrator for EPA Region IV, Jimmy Palmer, discussed the regional perspective on the role of science in environmental decision making and the importance of partnerships in how science is accomplished within EPA. EPA Science Advisor and Assistant Administrator for the Office of Research and Development (ORD), Dr. Paul Gilman, provided highlights of numerous science-related initiatives to address the science needs of EPA, strengthening of science within EPA, and emerging areas of computational toxicology and sustainability. Executive Director of the Environmental Council of the States, R. Steven Brown, addressed 10 science needs of the states, key areas of concern to states over the next 5 to 20 years, and the role of EPA and the states in developing the necessary science to support regulatory action. Chief Technology Officer for International Business Machines Corporation Federal services, Dr. David McQueeney, provided insights on the creation of market value from research, exploration of emerging high performance computing capabilities, and the use of E-business to harness value in unstructured data and support real-time decision making. Director of the Office of Science and Technology Policy, Dr. John Marburger, discussed the role and limitations of science in decision making and the need to consider potential consequences of emerging technologies.

Science and Innovation to Protect Health and Environment

This two-day session focused on innovative scientific approaches for protecting human health and the environment specifically, advanced remote sensing techniques, data resource and acquisition/use improvements, human exposure vulnerability, and correlations between air and water quality and human health. A key theme is the importance of partnerships and cross-collaboration to develop robust data sets, analysis tools, and data management systems

Advanced Remote Sensing. Terrence Slonecker, with the National Exposure Research Laboratory (NERL), led this session addressing applications of remote sensing technology in landscape analysis, indicator development, and remediation. James Wickam, with NERL, discussed the continued development of the National Land Cover Data (NLCD). K. Bruce Jones, with NERL, discussed the development of landscape indicators using the NLCD. Karl Hermann, Environmental Monitoring and Assessment Program (EMAP) Coordinator for Region VIII, discussed the application of EMAP in the Western United States to predict regional level landscape conditions. S. Taylor Jarnagin, with NERL, provided an overview of research involving the use of human-made surfaces as indicators. David Jennings, with NERL, discussed the use of light detection and ranging as a local-scale remote sensing tool. Mr. Steven Hirsh, Remedial Project Manager with EPA Region III, discussed the application of remote sensing for the detection and removal of chemical weapons.

Innovations in Risk Assessment: Improving Data Resources. George Woodall, Jr., with NCEA, led this session addressing improvements in data resources and data organization supporting risk assessment. Roy Smith, with the Office of Air Quality Planning and Standards, discussed the organization of data for use in regulatory decision making. Henry Abadin, with the Agency for Toxic Substances Disease Registry, discussed the development of toxicological profiles. Ann Richard, with the National Health and Environmental Effects Research Laboratory (NHEERL), discussed the development and application of a toxicological and structural database. Michael Waters, with the National Institute for Environmental Health Sciences, discussed the development of a toxicogenomics database on chemical effects in biological systems.

Human Data in Risk Assessment. John Vandenberg, with the National Center for Environmental Assessment (NCEA), led this session addressing the acquisition and use of human data in risk assessment. James Childress, with the University of Virginia, discussed the ethics of research involving human subjects. Bill McDonnell, with NHEERL, discussed the role of human subject research in developing air quality standards. Richard Sharp, with Baylor College of Medicine, discussed the ethical issues associated with genetic-based research.

Supporting Innovations in Science to Identify Children's Vulnerability to Environmental Exposures. Mr. Nigel Fields, with the National Center for Environmental Research, led this session addressing children's vulnerability to environmental exposures, how these exposures impact their health and development, and how these impacts differ from those seen in adults. Michael Weitzman, with the American Academy of Pediatrics, Center for Child Health Research, discussed the differences in health effects from environmental exposures in children and adults. Virginia Rauh, with the Columbia Center for Children's Environmental Health, discussed social and environmental conditions having pre- and post-natal health effects. Carole Kimmel, with NCEA, provided an overview of the upcoming National Children's Study.

Sustainability – Educating for the Future. Alan Hecht, Director of Sustainable Development in ORD, led this session on current initiatives in sustainability education, and discussed the concept of sustainability and education and capacity building within the environmental sector. Jaimie Cloud,

President of the Sustainable Education Center, Inc., described her organization's efforts in educating Kindergarten through Grade 12 students on sustainability, providing leadership training of administrators and teachers, and developing curriculum materials and outreach tools. Alan Elzerman, with Clemson University, discussed national efforts in sustainability education within higher education programs and the efforts of the National Council for Science and the Environment Council of Environmental Deans and Directors. Sally Shuler, Director of the National Science Resource Center, discussed mechanisms to incorporate environmental education and sustainability awareness into the educational curriculum.

Partnering with New York on Air Quality and Human Health: Issues, Challenges, and Perspectives. Val Garcia, with NERL, led this session addressing state and Federal initiatives to address linkages between air quality and human health. S.T. Rao, with NERL, discussed EPA efforts in partnering with EPA Regions, states, tribal governments, and local governments to enhance the understanding of air quality and its relationship to human health. Vickie Boothe, with the Centers for Disease Control and Prevention, introduced an Environmental Public Health Tracking Program that tracks hazards, exposures, and human health effects and a Public Health Air Surveillance Evaluation project. Paula Davidson, with the National Oceanic and Atmospheric Administration, presented the National Air Quality Forecast Capability program to predict ground-level concentrations of ozone and develop 1-day forecast guidance for ozone. Kenneth Colburn, with Northeast States for Coordinated Air Use Management, summarized regional challenges in using technology and innovations to better public health and the environment and to bridge the gap between these two areas of science. Robert Sliwinski, with the New York State Department of Environmental Conservation, described New York's air quality management program and its initiatives. Nancy Kim, with the New York Department of Health, summarized efforts in providing outreach and education, responding to health concerns, conducting research, and establishing an environmental public health tracking system.

State-of-the-Science Research on Swimming-Associated Health Effects and the Translation of Health Data to Water Quality Guidelines for Bathing Beaches. Alfred Dufour, with NERL, led this session on the health effects from human use of recreational waters. Timothy Wade, with NHEERL, summarized ORD's National Environmental and Epidemiologic Assessment of Recreational Water project, which focuses on research efforts to define any associations between human illnesses and recreational water quality as measured using rapid analysis methods. Kenneth Schiff, Deputy Director of the Southern California Coastal Water Research Project, and Mr. Jack Colford, with the University of California at Berkeley, discussed the complexities of non-point source pollution (i.e., animal contamination) in marine recreational waters in Southern California. Rick Hoffmann, with the Office of Water, discussed EPA efforts to address the requirements of the Beach Act to improve quality within the United States' beach waters.

Using Science to Make a Difference

This two-day section focused on regional efforts to use science for making real differences, specifically invasive species, research collaborations, and ecological forecasting. A key theme in these presentations is that the sound science needed to make wise decisions is best obtained through collaboration.

Can You Hear Us Now? EPA's Role in Invasive Species Research and Management. Michael Slimak, with NCEA, led a session addressing the control and ecological consequences of invasive species. Henry Lee II, Chair of EPA's Nonindigenous Species Working Group, discussed sources of invasive species; their direct and indirect ecological, economic, and regulatory effects; recent research findings; and areas for future work. Diane Regas, head of the Office of Wetlands, Oceans, and Watersheds, discussed ongoing and planned work within the Office for the control and prevention of the introduction of aquatic nuisance species. Judy Pederson, with the Massachusetts Institute of Technology's Sea Grant Program, discussed the results and management implications of a marine

bioinvasion rapid assessment survey. Mike Blum, with NERL, discussed genomic approaches to targeted screening of invasive species in ballast water. Michael Fritz, with EPA's Chesapeake Bay Program Office, discussed options for the management of non-native oysters in the Chesapeake Bay.

Monitoring and Assessment to Protect Tribal Health and Ecosystems. Valerie Bataille, with EPA Region I, led a session addressing monitoring and assessment projects sensitive to tribal-specific concerns. Fred Corey, Environmental Director of the Aroostook Band of Micmacs in Presque Isle, Maine, discussed the development of Native American-specific exposure pathways. Nancy Cost, Fond du Lac Water Project Coordinator, discussed monitoring of air, water, sediments, and biota to develop a better understanding of mercury fate and transport on the Fond du Lac Reservation. Steve Crawford, with the Pleasant Point Passamaquoddy Environmental Department, discussed the Primary Production Study of Coastal Waters in Maine to measure and monitor impacts from aquaculture and non-point sources.

Regional Environmental Monitoring and Assessment Program (R-EMAP): The Application of EMAP Indicators. Brian Hill, with NHEERL, led a session addressing the application of R-EMAP to various regional studies, and provided an overview of R-EMAP. Peter Kalla, with EPA Region IV, discussed the goals and initial findings of the Southeastern Wadeable Streams R-EMAP project. Daniel Boward, with the Maryland Department of Natural Resources, discussed the Maryland Biological Stream Survey and habitat assessment.

Great Places Demand Great Science. Rochelle Araujo, with NERL, led a session addressing the use of collaboration to solve environmental problems. Richard Batiuk, Associate Director for Science in the EPA Chesapeake Bay Program Office, discussed research outcomes from the Chesapeake Bay Program. John Lyon, with NERL, discussed collaborative research efforts in the Great Lakes. Quenton Dokken, Executive Director of the Gulf of Mexico Foundation, discussed ecological sustainability issues and concerns associated with the Gulf of Mexico.

Looking into the Future of a Region. Betsy Smith, with NERL, led a session addressing current and future regional ecological risks. K. Bruce Jones, with NERL, discussed the approaches, goals, and applications of ecological forecasting. Laura Jackson, with NHEERL, discussed models for assessing the effects of urbanization. James Wickham, with NERL, discussed the use of land-cover change in the determination of changes in non-point source pollution, its link to nutrient export and vulnerability assessments, and nutrient modeling. Earl Greene, with the United States Geological Survey, discussed the relationship between land use and groundwater vulnerability, and the results of statistical modeling of groundwater in the Mid-Atlantic Region. Daniel Kluza, with NCEA, discussed a model to forecast the distribution of native and non-indigenous species. Betsy Smith, with NERL, discussed future implications of land use change for the Mid-Atlantic Region.

Regional Research Partnership Program. Tom Baugh, with EPA Region IV, led a session addressing projects within the Regional Research Partnership Program. Bonita Johnson, with EPA Region IV, discussed the use of microbiological indicators to assess water quality. David Macarus, with EPA Region V, discussed the potential for using satellite data as a proxy for biodiversity. Dan Ahern, with EPA Region V, discussed exposure, health effects, and future research areas for manganese.

Community Air Toxics Projects. Henry Topper, with Office of Pollution Prevention and Toxics, led a session addressing the control and prevention of air toxics at the local level and EPA initiatives in this area. Madeleine Weil, with the City of New Haven, CT, discussed the development of a local hazardous air pollutants inventory and a risk reduction strategy for the City. Emily Andrews, Managing Partner for the St. Louis Community Air Project, provided an overview of this program and its partnerships. Jon Trout, with the Louisville Metro Air Pollution Control District, discussed the basis of the West Louisville Air Toxics Study, findings, and actions taken as a result of the findings. Steve Perry, with The Forum,

Industry Partners in Environmental Progress, discussed the purpose, participants, organization, and scope of the Mobile County, AL, Air Quality Study.

Science to Support Decisions: Climate Change. Michael Slimak, with NCEA, led a session addressing climate change assessment and issues. Michael MacCracken, with The Climate Institute, discussed the climate change issue, the factors that complicate the issue, and the potential impacts of climate change. William O'Keefe, with the George C. Marshall Institute, discussed issues for consideration in making policy decisions, the limitations of the current knowledge base of climatic effects, and actions to be taken to promote a broader knowledge base. Arnold Vedlitz, with Texas A&M University, discussed the use of science in Gulf of Mexico decision making involving climate change under an EPA cooperative agreement. Joel Scheraga, National Program Director of ORD's Global Change Research Program, discussed the feasibility of conducting regional and place-based climatic impact assessments.

Delivering Science-Based Information to Decision Makers

This two-day session focused on EPA development of environmental indicators, the use of geospatial tools to support decision making, mechanisms for environmental health information exchange, development of science-based information for coastal systems, scientific computing applications, improving the indoor environment, and tools for net environmental benefit analysis. These presentations included several pilot projects and public information/outreach activities, as well as partnerships among federal, state, and local governments. Key themes in all of the discussions were the development of sophisticated, computer-based tools, approaches, and systems to assist in evaluating large volumes of data supporting research, analysis, and decision making for environmental and human health.

The Future of EPA's Environmental Indicators Initiative and Report on the Environment. Michael Flynn, with the Office of Environmental Information (OEI), led this session addressing the development of environmental indicators and analytical tools to link environmental conditions and public health outcomes. Ms. Heather Case, with OEI, provided an overview of the Draft Report on the Environment, which highlights the conditions of air, water, and land in the United States and demonstrates their effects on life, health, and ecological conditions. Denice Shaw, with OEI, summarized the outcome chapters (human health and ecological condition) in the Draft Report on the Environment and trends identified from the large amount of collected information. Judy Qualters, with the Centers for Disease Control and Prevention, provided highlights of efforts to develop a National Environmental Public Health Tracking Program. Susan Norton, with NCEA, presented the Causal Analysis Diagnosis Decision Information System project, its goals to help investigators in states and tribes to identify causes of biological impairments, and its use as a web-based system providing guidance, examples, and links to information.

Using Geospatial Tools to Make Program Decisions. Brenda Smith and Wendy Blake-Coleman, with OEI, led this session addressing geospatial tools and their applications to decision making. Joe Anderson, with OEI, described the Emergency Response Analyzer—a geographic information system-based tool to aid in visualization and data integration/mapping for an emergency situation. Cary Roberts, with OEI, discussed projects in five urban areas that focused on the analysis of remote sensing data when determining trends of urban growth. Julie Kocher, with OEI, presented a Web-based tool to support analyses under the National Environmental Policy Act and to streamline data access as well as review/approval of environmental assessments and impact statements.

Delivering Consistent Information on Health and the Environment. William Sonntag, with OEI, led this session addressing the use of information technology to provide greater access to health and environmental information. Mike Frame, with the United States Geological Survey, provided an

overview of the National Biological Information Infrastructure program and its associated tools and services to provide access to data/information on biological resources in the United States. Molly O'Neill, with the Environmental Council of the States, introduced the Environmental Information Exchange Network, which is intended to promote data sharing to support better decision making among Federal agencies and regulators as well as to improve the data that are available. Larry Fitzwater, with OEI, introduced EPA's System of Registries to address the challenges of data access for EPA and other government agencies.

Developing Science-Based Information for Coastal Systems. Kevin Summers, with NHEERL, led this session addressing the development of science-based information for coastal systems. Henry Lee II, with NHEERL, discussed the Western EMAP coastal research activities and preliminary findings in California, Washington, Oregon, Hawaii, and Alaska. Diane Regas and Darrell Brown, with the Office of Wetlands, Oceans, and Watersheds, provided an overview of EPA's National Coastal Assessment program and the challenges of integrating local estuary program data into a national summary. Kevin Madley, with the Florida Fish and Wildlife Conservation Commission, summarized Florida's Inshore-marine Monitoring and Assessment Program and ongoing sampling activities. Phil Trowbridge, with the New Hampshire Department of Environmental Services, described ongoing coastal assessment activities and results for the shortest coastline in the United States. Henry Walker, with NHEERL, provided an overview of National Coastal Assessment Program activities in the Northeastern United States as well as research findings and their applications.

Scientific Computing. Rick Martin, with the Office of Technology Operations and Planning (OTOP), led this session addressing EPA's high performance computing mechanisms/tools and their respective program applications. Joseph Retzer, with OTOP, discussed the role of the Center of Excellence for Environmental Computational Science in meeting EPA's scientific computing capability need. John Smith, with OTOP, discussed EPA initiatives to expand data acquisition, storage, and manipulation by internal and external users. Terry Grady, with NERL, discussed the development and potential applications of EPA's Science Portal.

Healthy Communities—One Building at A Time. Elizabeth Cotsworth, with the Office of Radiation and Indoor Air (ORIA), led this session addressing scientific information exchange as a means of influencing public action and promoting healthy buildings and indoor environments. John Girman, with ORIA, provided an overview of indoor air pollution sources and effects as well as principles for managing its prevention and control. Jim Jetter, with the National Risk Management Research Laboratory, discussed current ORD research focusing on indoor environments. David Mudarri, with ORIA, discussed strategies for public outreach and involvement in improving indoor air quality. Sam Rashkin, with the Office of Atmospheric Programs, discussed the development and implementation of an Indoor Air Quality Label for new housing construction. Tracy Enger, with ORIA, discussed the mechanisms of turning research and guidance into action and the importance of social marketing.

Net Environmental Benefit Analysis. Ann Whelan, with EPA Region V, and Bill Robberson, with EPA Region IX, led this session addressing the Net Environmental Benefit Analysis (NEBA) approach. Bill Robberson discussed the use of NEBA in environmental decision making for emergency response, and Ann Whelan presented a case study of the application of NEBA to emergency response planning.

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Section I: Overview

The Environmental Protection Agency (EPA) presented a *Science Forum* at the Mandarin Oriental Hotel in Washington, DC, on Tuesday, June 1, through Thursday, June 3, 2004. The *EPA 2004 Science Forum: Healthy Communities and Ecosystems* was an opportunity to showcase the activities of EPA and other organizations in key areas of environmental research and to spotlight new initiatives and recent successes. As the third in a series of annual events, this *Science Forum* built upon the first two Agency-wide *Science Forums* held in May 2002 and May 2003, and was co-sponsored by the Office of Research and Development (ORD), the Office of Environmental Information (OEI), and EPA Region IV.

The *Science Forum* highlighted selected high priority topics and EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, how science influences Agency decisions. The *Science Forum* also provided an opportunity for dialogue and interaction among EPA scientists, partners, clients, stakeholders, and colleagues with over 1,000 attendees at this event. Attendees included EPA program, research, and regional staff; members of other Federal agencies; stakeholders; the scientific community; and interested members of the public. The *Science Forum* included 223 posters addressing current EPA research activities and specific topics addressed by speakers, discussions of research efforts by EPA and external scientists and engineers, 11 exhibits of EPA scientific and educational programs, and demonstrations of canine scent capability to detect vapor intrusion using an EPA-trained dog.

EPA Administrator Mike Leavitt opened the plenary session of the *Science Forum* with a perspective on the scientific credibility established by EPA in the past 30 years and important technical and cultural directions that will have a major impact on future EPA science initiatives. Other plenary speakers provided highlights of the regional perspective of EPA's science assets and future scientific needs, examples of the integration of information management and technology with sound science to solve environmental problems, ongoing initiatives to address the science needs of EPA and the quality of its scientific products, the science needs of the states, future trends in information technology and the impacts on data management and analysis for regulatory agencies, and upcoming challenges in addressing the new types of technologies under development. The opening day session also included a review of the American Association for the Advancement of Science (AAAS) fellowship program and the experiences of its alumni in supporting EPA activities.

Three two-day breakout sessions each examined a theme area—science and innovation to protect health and environment, using science to make a difference, and delivering science-based information to decision makers. The audience had an opportunity in each session to ask questions of the speakers. Poster sessions followed the plenary session and each breakout session addressing session-specific and related topics. EPA engineers and scientists were available at these poster sessions to provide additional information and to address attendee questions.

Section II: Plenary Session

Tuesday, June 1, 2004

The purpose of this session on the first day of the meeting was to provide plenary addresses on the role and value of science and partnerships to support environmental decision making and policy making, future research directions, and implications of information technology to data management and sharing. The plenary session also provided an overview of the AAAS fellowship program and the experience of several participants in supporting EPA initiatives.

The *Science Forum* opened with a panel discussion about the fellowship program sponsored by the AAAS. Dr. Fran Sharples, Dr. Venkat Rao, and Dr. Terry Keating discussed the different program stages (from the initial program to the present), the fellowship activities conducted at EPA, and the lessons learned about the role of science in decision making and policy making gained from this experience.

EPA Administrator Mike Leavitt opened the plenary session of the *Science Forum* with a perspective on the scientific credibility established by EPA in the past 30 years and important technical and cultural directions that will have a major impact of future EPA science initiatives. The Regional Administrator for EPA Region IV, Mr. Jimmy Palmer, discussed the ongoing regional review of science usage and the role of science in all EPA actions and decisions. EPA Science Advisor and Assistant Administrator for ORD, Dr. Paul Gilman, provided highlights of ongoing initiatives to address the science needs of EPA as well as the quality of the scientific products. The Executive Director of the Environmental Council of the States, R. Steven Brown, addressed the science needs of the states and the role of EPA in addressing those needs. Chief Technology Officer for International Business Machines (IBM) Corporation Federal services, Dr. David McQueeney, discussed future trends in information technology and the impacts on data management and analysis for regulatory agencies. The Director of the Office of Science and Technology Policy, Dr. Jack Marburger, addressed upcoming challenges in addressing the new types of technologies under development.

Opening Remarks

EPA Science Advisor and Assistant Administrator for the Office of Research and Development (ORD), Dr. Paul Gilman, welcomed all the attendees to this third annual EPA-wide *Science Forum: Healthy Communities and Ecosystems.*

AAAS Environmental Fellows Session

Dr. Paul Gilman, Assistant Administrator for ORD and the EPA Science Advisor, introduced a panel discussion by three former participants in the AAAS fellowship program about their experiences and contributions.

Dr. Fran Sharples was one of six pioneering members of the AAAS fellowship program class of 1981. At that time, the program involved 10 weeks in Washington and it was not until 1996 that the fellowship became a year in length. The program has grown significantly in 23 years involving over 200 fellows who have participated in an array of projects related to policy and the environment. Areas in which the fellows have participated include air and radiation, children's health/protection, environmental policy innovation, safeguarding the environment, and statutory responsibilities, among others. These AAAS fellows have supported numerous EPA program offices and laboratories. A key program goal is to demonstrate the value of science, technology, and economics in solving problems.

Dr. Sharples participated in the AAAS fellowship program about 3 years after graduate school and while working at Oak Ridge National Laboratory. Instead of pursuing an academic track, Dr. Sharples became involved in highly technical environmental work that in turn introduced her to environmental policy. The AAAS fellowship program was an opportunity to learn more about this topic and she was able to work on a project that had an unexpectedly large impact on her career. She supported the EPA Office of Exploratory Research (which no longer exists) on an effort to determine what problems might occur from the release of modified organisms (bacteria, plants). At the time, there was little literature on this particular topic but there was much analogous literature regarding the introduction of non-native species that might serve as a basis for extrapolation (prediction). The report she wrote from this effort was one of the first to appear on this topic and she was asked to testify at a Congressional hearing on the release of engineered organisms. The National Institutes of Health (NIH) subsequently asked her to participate on a research advisory committee, as few had considered this problem. She then found herself being publicly interviewed and being requested by AAAS and international organizations to write papers on this topic. This was a life altering experience that introduced Dr. Sharples to a new world in which science was a tool for decision makers to select from an array of choices rather than an end unto itself.

Dr. Venkat Rao participated in the AAAS fellowship program in 1992. This provided an opportunity for a scientist to interact with the policy process, which in turn changes the way we think and orient ourselves as well as how we grow and mature in our own careers. Until participation in the fellowship program, Dr. Rao was involved in scientific work regarding chemical carcinogens and how combinations in multiple exposures could produce different types of effects, with an emphasis on building models. The fellowship program was an opportunity for him to sit and work with EPA staff, become acquainted with the Agency leadership, and to be exposed to the policy aspects of science.

At that time, many of the Clean Air Act (CAA) Amendment issues were engineering-related and the office he supported felt that health should be key and was attempting to bring health into the decision making. As a board-certified toxicologist, he was able to look at the health dimensions of National Emission Standards for Hazardous Air Pollutants (NESHAPs) through a case study of a neighborhood, developing a regression model using multiple data sets, and using the model as a baseline to show how NESHAPs in this environment would be addressed. This helped in understanding how policy issues come into play. Another great experience during the fellowship was the opportunity to have lunch with Senator

Al Gore, and to participate in a discussion of Senator Gore's recently published book and sharing of ideas. Dr. Rao has continued to support the AAAS fellowship program as a member of the selection committee and sees a great spectrum of talent applying for this opportunity as well as increasing participation at EPA.

Dr. Terry Keating is a recent participant in the AAAS fellowship in one of the first year-long program classes and after a one-year extension became a permanent EPA employee. His experience prior to the fellowship was focused on academia although his education in air quality emissions and modeling had a policy component.

For his fellowship, Dr. Keating was assigned to the EPA Office of Policy Analysis and Review within the Office of Air and Radiation. He developed an eclectic portfolio of issues such as intercontinental transport and linkage of air quality and global climate change. Interdisciplinary thinking and problem solving was encouraged and this experience was an opportunity to learn new things. In his current position, this experience continues and offers the opportunity to teach scientific concepts to lawyers, economists, and Congressional staff as well as Agency leadership. The fellowship and the continuing position have provided opportunities to observe scientific policy making, educate decision makers, and make new connections between different disciplines.

Dr. Keating continues his participation in the fellowship program by serving as a mentor to an AAAS fellow for the past two years. The fellows are talented, knowledgeable, enthusiastic, and bring fresh ideas and a critical eye to the Agency. This also helps to bring a connection to the outside for the Agency.

A brief question and answer period addressed a range of topics, including the following:

- An important experience in the fellowship program is to move from the academic/research setting for communicating peer-to-peer to a policy setting that requires communication in ways someone outside your discipline can understand. This is learning to communicate with people who are not knowledgeable in the specific field or in science in general, as well as how to communicate complicated, technically-oriented information at a simpler level. A science policy analyst must be able to analyze, interpret, and present information in a simplified way because most decision makers in government are not scientists or may be specialists in another field.
- The AAAS fellowship program is only one source of personnel for EPA, which also has its own internship program and hosts presidential management fellows. Similarly, EPA is one of many hosts for AAAS fellows. Of the 90 AAAS fellows in Dr. Keating's class, approximately nine were at EPA.
- EPA places a high value on science as well as understanding what is and is not known. For each issue, there will be much debate on all sides and it is important to understand how credible the scientific arguments are on all sides by asking good questions, checking the literature, and discussing issues with knowledgeable persons. This helps to distinguish between what science is becoming accepted and what is considered "on the edge"—an important aspect for decision makers to understand. EPA is often criticized for not relying completely on science in making rules and policies; however, science is only one element of policy making. Other factors include cost, who is impacted, where they are, whether they are vulnerable, and whether there is disproportional impact. Often the policy makers desire a yes/no framework, yet it is difficult to explain science issues in that format. In addition, policy does not consider weight of evidence and policy decisions are made from a different set of issues and from a different way of thinking than science. A related point is that there is always scientific uncertainty and there is never enough science to determine "the answer."
- The AAAS selection process picks participants who can learn quickly, adapt, think well on their feet, and can absorb, synthesize, and recap a lot of information. Each fellowship class has a range of

experiences, background, and career stages. The actual fellowship experience also varies a lot in the exposure received to policy, value judgments, and balancing viewpoints.

- Many graduate programs do not prepare scientists to work in and contribute to the public policy arena. There is a great deal of work involved in making this transition, and academic programs often do not value this. An area of improvement is to help the academic world understand that this is something of value; for example, for someone in the academic world, it is useful to understand where future funding is coming from and how funding for an academic program can be obtained. Science education has changed little in 30 years despite the calls for curriculum reform, to identify legitimate science careers that are not academic/research, and making academic programs more multi-disciplinary. One approach may be to get more people who have had this experience to speak with academic departments about the experience and its value.
- Training a policy student in science/engineering is also difficult, and it may be harder to develop sufficient understanding of a scientific discipline. Examples do exist in the legal community where science and statistics may be used to support cases in the courtroom.
- There are no formal alumni activities, but AAAS tracks, maintains, and publishes a directory of former fellows. There also is a List Serve for email, sessions at the annual AAAS meeting, and other venues to stay in communication.

Plenary Addresses

Dr. Jack Puzak, Acting Director of the National Center for Environmental Research (NCER), opened the Plenary Session and welcomed attendees to the third annual Science Forum. Dr. Puzak also acknowledged the three partners in developing this event: the EPA program offices led by OEI, the Regional offices led by EPA Region IV, and the state environmental agencies. The EPA Administrator and six additional speakers provided opening addresses to Science Forum attendees on the role of science at EPA and in environmental decision making, current initiatives, and future directions.

EPA Administrator Plenary Address

EPA Administrator Mike Leavitt welcomed all attendees and discussed a recent opportunity to meet with 15 outside scientists (nobel prize laureates, distinguished academics, etc.) and hold discussions on identifying the leading edge scientific questions that EPA should focus on as an Agency. These free form, collaborative discussions addressed genomics, molecular biology, chemical climatology, disease registries, computational toxicology, and risk assessment. The Administrator then shared four observations from that experience.

The first observation involved the question of how EPA is doing to which the response was: "You've come a long way baby." This is reflected in the fact that in 34 years EPA has moved from formation as an Agency to being one of the most respected scientific bodies worldwide. It is a real privilege to attend an international meeting and to see the respect for EPA throughout the world for environmental protection. Over the next 5 to 7 years, most of EPA's scientists will move on to other efforts. This is a great challenge and a focus for the next few years—to make sure that the tradition continues.

The second observation involves the importance, in the future, of social science and communication as an integrated discipline. This is best illustrated by a recent experience in New Bedford, MA, where he went to see a Superfund site and met an elderly gentleman, who was fishing for stripers in front of a sign that said "Don't Fish Here." Asked how the fishing was, the gentleman said he had not caught any keepers lately. When asked if he ate what he caught because there was a need to limit the intake of fish taken from this area, he replied that he did not catch many keepers, but he does eat what he catches, so he was

limited in his intake because he does not catch a keeper very often. This demonstrates the importance of social science in knowing why people do what they do.

A third observation is that we are in a networking era. When the Agency started, there were main frame computers and now there are networked personal computers. Interdisciplinary approaches to science are the new frontier of human productivity. Solutions need to transcend political boundaries, not only those such as United States-Canada, United States-Mexico, Virginia-Maryland, and California-Nevada, but also boundaries between EPA and the Department of Energy (DOE), between DOE and the Department of Commerce, between the Office of Air and the Office of Water, and between cubicles in the same office building. There are many different kinds of boundaries. The 21st century will be defined by how we transcend those boundaries and collaborate. We have learned to make machines work together and the question now is whether we can get people to work together.

The fourth and last observation involves new thinking and old thinking. Sometimes values are interpreted as being partisan interest when they may really just be differences in new/old thinking. There is an opportunity through the course of the next 30 years to shape the Agency to be collaborative and to be preventative. We have learned how to clean up the environment and contamination, so efforts now become focused on how to prevent it, become informative, and become a key repository of scientific information and facts—to be focused on the big, leveraged questions of science and most important, to know what they are and maintain the global perspective.

EPA Region IV Administrator Plenary Address

The Regional Administrator for EPA Region IV, Mr. Jimmy Palmer, presented the regional perspective on the role of science in environmental decision making and the importance of partnerships in how science is accomplished within the Agency. EPA Region IV is a co-sponsor of this *Science Forum*, and is a lead EPA Region for research and information involving partnerships with ORD and OEI.

An initiative began last year for all EPA Regions to look at how science is being used, the obstacles to making the science work, and how to address those obstacles. This effort is now in its final stages and has involved both large and small teams focused on answering those questions, with preliminary findings anticipated to be presented by the end of the summer.

During 34 years in the environmental field in varying capacities (regulator, engineer, lawyer), he has seen much abuse of what many call science. One example involved a public hearing over a contentious proposition to issue permits to a landowner to start a swine operation. The opposition brought in an employee of a state agency to tell concerned citizens that if the operation can be smelled at the property line, people are being harmed. Many facilities (e.g., wastewater treatment plants, industrial facilities, and landfills) emit various odors at various concentrations that are not harmful. Another example involved plans to build a shopping center in a coastal region that required relocation of wetlands/streams on the property. Wetlands scientists had evaluated the site with the engineers and determined that the wetland systems on the property would remain functional but their functionality would decrease. However, citizens at the public meeting felt that any drop in functionality equated to destruction of the ecosystem.

Science drives all EPA actions and underpins all EPA decisions, whether approving a Total Maximum Daily Load (TMDL), making a decision on an attainment area, or approving a Record of Decision (ROD) for a Superfund site specifying a particular remedy. That is one reason for having this type of event, which provides a means to improve our approach to scientific issues and to grow the body of work that is the science in what EPA does.

OEI Assistant Administrator Plenary Address

The Assistant Administrator for OEI, Kim Nelson, discussed three key projects currently underway with ORD. The EPA mission is to protect human health and safeguard the natural environment, and this has always relied on sound science, which today requires sound information management and technology. These three projects focus on collaboration, help to improve EPA's strategic planning and ability to measure results, and demonstrate the use of leading edge information technology applications to solve environmental problems.

The first project is the Environmental Indicators Initiative, which has resulted in a product that has been widely and well received by the public, the decision-making community, and the scientific community. The first phase, the *Report on the Environment*, provides a strong foundation for moving forward. Efforts are underway to determine how to display this information electronically for everyday use rather than retaining a traditional report format.

The second project is the Environmental Science Portal, which provides a mechanism for sharing and accessing information to support collaborative work. This Portal will become the gateway that will provide the capability the EPA needs to bring science, scientific data, and advanced information technology solutions to environmental issue decision making. This involves collaboration, communication, and interdisciplinary partnership to help researchers come together and work together.

The third project involves high performance and grid computing. EPA is making progress in upgrading its information technology with a goal of using tomorrow's information technology solutions to address environmental problems today. High performance computing will help to address critical air quality issues that are computationally and scientifically challenging, central to the EPA mission, and critical to EPA partners (e.g., states, regions). This will require less time to run the more complex models that EPA has today and the data will support improved modeling and forecasting of air quality. EPA and DOE are also collaborating to utilize grid computing capacity for the most difficult and challenging environmental decisions and to investigate linkages between environmental condition and health condition with partners such as state agencies, the National Oceanic and Atmospheric Administration (NOAA), and the Centers for Disease Control and Prevention (CDC).

These advancements in information technology will help to support the environmental decision makers with the tools, computational resources, and the models they need no matter where they are located. This is a watershed opportunity to help EPA deliver on its mission. The environmental threats we face everyday do not recognize political or organizational boundaries, and the use of innovative information technology and tools is necessary to be able to work beyond those traditional boundaries.

EPA Science Advisor and ORD Assistant Administrator Plenary Address

Dr. Paul Gilman, EPA Science Advisor and Assistant Administrator for ORD, discussed science achievements and future directions across many EPA programs. Complementing this discussion was a slide show in the background providing covers of journals in which EPA scientists have published their work as well as awards given to EPA and its extra mural researchers.

The estimates that are performed of the consequence of EPA's work in air regulation represent a state-of-the-art analysis and require input from scientists and engineers. It is a challenging technical accomplishment to estimate the mortalities avoided due to a particular regulatory action or decreased hospital admissions. Even today, the quality of such estimates is rarely questioned and there is no better example of the progress that can be made when the science is done right. Five to 7 years ago, the EPA position on particulate matter (PM) was viewed with a great deal of skepticism and has now grown to

credibility having identified the mode of action for how PM acts on our health, morbidity, and mortality. We have moved from understanding results from ambient air monitors and contaminants to which we are exposed in our homes to a more fundamental understanding of the mechanisms of exposure. Yet there are many areas for which such understanding must still be developed.

There are 3.7 million miles of streams and rivers in the United States and 4 million miles of roads. There are 1.8 billion trips to the beach each year and coastal resources supply $54 billion in goods and services. It is easy to say that we are loving these water resources to death. Key to progress in this area is the collaboration among state and Federal agencies to understand the health state of coastal waters. In February 2004, the second version of the coastal assessment was released and enables the Agency to make specific statements about coastal health against a specific point in time. EPA progress in assessing all of our water resources is an emerging story for this decade.

Since the initiation of the "45 day" study of the use of science in EPA decision making, EPA has increased outreach and sharing of resources for collaborative work with other scientists and engineers. There is now a pamphlet that describes the EPA facilities that are available to support the research of others. Opening up the doors to these research resources will benefit not only EPA but also state/local government and the academic community.

Strengthening of science within the EPA is a continuing effort. A science inventory is underway to make available more than 4,000 science projects in the regional and program offices as well as ORD. This will include contact points, peer review information, etc. There is also a Council on Regulatory Environmental Modeling (CREM) that is addressing the computer modeling needs of EPA, which currently uses over 60 models. CREM is addressing how to develop, verify, and peer review models. In addition, peer review continues as a major initiative with over 650 work products (not journal articles) undergoing external peer review. Furthermore, efforts continue to develop new methods for measuring, to fix ones that may not be working well, and draw on the post-doctoral program to begin incorporating new scientific areas.

Computational toxicology is another example of collaboration at many levels. There are growing relationships between the Office of Pesticides and others to determine how to accomplish required assessments faster and at less cost and with less use of animal testing. EPA has gone from learning what new areas such as genomics can do to having the National Institute for Environmental Health Sciences (NIEHS) and other partners look to EPA to bring them tools in such areas.

Another emerging area, perhaps more of a resurgence, is sustainability, which draws on both science and technology. The EPA Web site has over 50 links on this topic. Key components being addressed are how to pull this together within the Agency—across cubicles, on the research side, how to make it happen in the regions—as well as external collaboration with the academic community. Activities include proposals seeking ways for engineering schools to incorporate green science into their curriculum and a student design competition entitled People, Prosperity, and the Planet (P3) for engineering students to put together projects for the next generation of prevention.

EPA has come a long way in 34 years, as noted by the Administrator, and has developed the foundation for a future based on science and technology.

Environmental Council of the States Plenary Address

The Executive Director of the Environmental Council of the States (ECOS), R. Steven Brown, addressed the science needs of the states, for both current and future issues. Together, the states and EPA spend over $20 billion each year to protect the environment. The states typically have well-equipped and well-

staffed programs for air, water, waste, etc., and while they may have some laboratories, they are less likely to have basic scientific research capability. A few years ago, only California, Illinois, and New Jersey had science programs, but those may not have survived recent budget cuts. Therefore, the states must rely on basic science support from EPA and state universities. This appears to be an appropriate division of roles—states having responsibility to implement delegated Federal programs and EPA supporting basic scientific research and development.

Mr. Brown presented 10 areas that are currently of interest to ECOS members as identified from a meeting this spring, as follows (in no particular order):

1. Small drinking water systems—there is a need to develop treatment technologies suitable for small communities that are inexpensive and effective. Otherwise, these small systems are hard pressed to meet drinking water standards such as arsenic.
2. Monitoring and remote sensing—there is a lack of technologies to acquire data remotely. EPA support of research on motes and other small computer systems that can float down streams and report on their journey may be beneficial to meet this need.
3. Information management—states generate about 94 percent of the data in EPA's six largest databases. Problems have been experienced over the years with timeliness, quality, and standards for this information. States are currently working with EPA to develop a network to provide more accurate data and to do so more quickly. Data transfers have already begun and this will help EPA scientists get more reliable data from the field and do so more quickly.
4. Mercury—emission and transport remain one of our most important problems. Developing transport models for this may help with other pollutants as well, and may also help to develop an understanding of long-range transport from other countries to the United States.
5. Military facility impacts on the environment—this continues to be a concern for ECOS members and EPA assistance in helping the military to address this, as well as the growth around these facilities, will be advantageous.
6. Hazardous waste cleanup technologies—Interstate Technology Regulatory Council supports the implementation of cleanup technologies by reviewing their applicability and efficacy. EPA, the Department of Defense (DOD), and DOE are all supporting this, and it is hoped that EPA support will continue.
7. Cross-media pollutant transport—this continues to be an area of concern. Large municipal sewage treatment plants may have to install special equipment to remove fine PM emissions from the treatment facilities. This will result in having treatment facilities on top of treatment facilities, which may need to be reduced.
8. Environmental tracking and footprint—more help may be needed to track the source(s) of pollutants. Areas of assistance include broad issues such as interstate transport as well as local concerns. The footprint is the impact on the environment and technologies may be needed to lessen the impacts.
9. Toxicology—states rely heavily on EPA's toxicology work and it is important that EPA hears that message and continues to do that important work.
10. Environmental indicators—in shifting from outputs to results, we find a lack of indicators for many areas. This is of concern to both EPA and the states.

Mr. Brown also identified a number of state concerns for the next 5 to 20 years:

- Waterborne nutrients—the effects and contributions will continue to rise in importance. Technologies are needed to control area pollutant sources. In addition, contributions of nutrients and

other pollutants to problems in the Chesapeake Bay and the Gulf of Mexico need to be delineated as the existing problems are expected to get much worse.

- Biotechnology—growth in this area is reminiscent of the growth of the chemical industry 50 years ago without thought to environmental consequences. Biotechnology offers great promise towards cleanup and other applications, but the use needs to be thought out in great detail, which may be a major role for EPA.
- Nanotechnology—concerns about the growth in this area are the same as for biotechnology, but applications in this field are perhaps 10 years behind biotechnology. A program was created at NIH on the ethical, legal, and social implications of biotechnology, and recent legislation authorized such a program for nanotechnology. It is hoped that EPA will be active in this program.

A final recommendation was to continue the use of state government scientists on review panels that consider research proposals.

International Business Machines Corporation Plenary Address

Chief Technology Officer for IBM's Federal services, Dr. David McQueeney, discussed insights on developing and applying good science from his experience in research for IBM and others as well as exploiting technology to meet EPA's changing needs. The presentation addressed three primary topics: (1) evolution of the research value creation process, (2) exploration of supercomputing, nanotechnology, and pervasive computing, and (3) E-business on demand, which encompasses web services, autonomic computing, grid computing, and harnessing value in unstructured data for business optimization.

A major challenge is getting hard core science through the delivery chain from the laboratory to the customer. In the period from the 1940s to the 1970s, such investment in scientists/facilities was a business decision focused on making an impact on customers, with an emphasis on curiosity-driven research and technology transfer of an idea to a product. However, the yield from this investment was low because innovations did not get to customers or took too long to move from research into development, manufacture, and sales. In the 1980s, IBM began to connect these aspects more tightly in order to move the research to customers, to bring customer needs to the research, and to get rid of the chain that slowed down this process. In the 1990s, information technology made the first big transition from "something that happens in the back room" to being more involved in the front office (e.g., customer preferences, market segmentation). Some of the most interesting, cutting-edge applications were occurring with the customers, so if the researchers were not in those organizations, they were losing perspective of what was cutting edge. Now in the 2000s, the emphasis is on the use of information technology to produce results (e.g., business outcomes) rather than the details of how the technology performs. If researchers are to contribute value, they must understand what customers consider valuable.

Early research in information technology involved innovations in hardware (i.e., faster, better). In the 1980s, software began to emerge as a science in its own right and information technologies had to be able to merge the two together. From the 1990s to the present, the emphasis has been on ways to support the customer's business process or policy objective, and involves a more people- and services-oriented business. The question of how researchers can support a services industry is still a deep topic of discussion with the focus today on impacting end users and their customers.

Many of the information technology performance metrics (e.g., memory, storage, bandwidth) follow exponential growth curves, and eventually technology performance becomes "good enough." For example, when resolution on a screen reaches the limit of resolution detectable by the human eye, further improvements in resolution will not provide product differentiation in the market place. Therefore, efforts now focus on liquid crystal display (LCD) screens, which are less expensive, since the pixel count

is no longer important. Another example is that the functions of a personal computer have improved to the point where the price now begins to decrease, and storage technology is becoming "good enough" for consumer personal computers because it does not fill up by the time the computer is replaced. Yet, the storage capacity suitable for general consumers may not be good enough for managing environmental data or other applications.

These examples all illustrate how a commodity technology crosses a threshold that is "good enough," which involves the question "When is faster, cheaper, better, good enough?" Continued efforts to drive technology to new levels are noble, but may not be useful. For many customers, the important issue is not the absolute cost for the equipment, but how easy this equipment is to use/administer, which in turn depends on the skills and expertise of the users. An important engineering policy is to use some of the power of the system to make it less complex to users.

In the second topic area, advances in computing power can be applied to science, business, and policy challenges by taking off-line computing tasks into real-time, which supports continuous operations and provides for real-time business responses to changing conditions. We have seen a huge increase in calculation capability—more than exponential. For example, the airlines began scheduling equipment and manpower based on customer utilization. In 1992, the run time to identify projected demand took multiple days. Using today's equipment, this process takes about 10 minutes.

Scale is another factor—yesterday's super computers are today's desktop computers. As computer components get smaller, more can be included in the computer or on the components. However, there are limits to our ability to scale down the components. We are approaching atomic scale in some areas, such as new transistors.

There is a tremendous increase underway in computing power and estimates are that this is expected to increase by five to six orders of magnitude over the next 10 years. Networking of computers, such as grid computing, really increases the computing power. The transition has involved movement from networking to network sharing (e.g., the Internet), which in turn moved to the World Wide Web, and now moves to a computational power increase via the "grid." This is leading to a huge change in how computing is used in business and its applications in optimization.

Nanotechnology moves us from using atoms to make computers to moving atoms to make computations. Advances in fabrication enable placement of atoms individually in carbon nanotubes. To date, there is an experiment, a theory, and a new scientific capability, but we do not yet have the manufacturing capability. If deoxyribonucleic acid (DNA) replication is the manufacturing process, how do we utilize this?

Another example involves pervasive computing enabled by integration to obtain data in real time. Once all of the sensors can be placed on a chip, it is easy to scale it down.

The third topic area—E-business on demand—is IBM's vision for the next step in computing, which can help businesses to respond to changing conditions in real-time and make the infrastructure more resilient. At EPA, this approach would tie vertical systems together horizontally with the value coming from the connection of air-water, regulators-users, and state-Federal. Such horizontal ties and our ability to manage them is the next step forward for the advancement of science.

Everyone is facing the need to master the explosion of unstructured data resulting from information technology advances. Most data are unstructured and grow at a higher rate than structured data. A key research area involves improvement of search capabilities to move internet-scale searching beyond words and simple parsing of sentences toward more relational queries. A very promising area for collaboration is how to apply unstructured data mining technology to EPA's unstructured data.

In closing, base computing technology will continue to increase at current rates for the next 10 years, but we are close to the point where advancements will involve individual atoms and molecules, and to do this we are looking to the life sciences for solutions. EPA faces challenges similar to those in the commercial world—horizontal integration and managing complexity. The focus is shifting from having data to being able to harness it for a specific purpose.

Office of Science and Technology Policy Director Plenary Address

The Director of the Office of Science and Technology Policy, Dr. John Marburger, discussed his experience with environmental issues, policy, and science. As a university president for 14 years, he had responsibility for over 1,100 acres, a hospital, sewage plant, co-generation plant, nuclear physics accelerator, and agricultural animals all located on Long Island over a sole-source aquifer with environmentally conscious neighbors. He then became the Director of DOE's Brookhaven National Laboratory, which was facing closure due to a number of environmental issues. In this capacity, he found himself facing activists who were more technically knowledgeable than he and this was effective in giving credibility to deep-seated public fears even when the knowledge was inaccurate. With every environmental decision, he was always reminded that property values were at stake. In addition, a 1988 Memorandum of Understanding (MOU) between DOE and EPA established stringent requirements and milestones to accomplish for evaluating industrial processes and laboratory experiments as well as developing an environmental management system. Within 3 years, Brookhaven developed an International Standardization Organization (ISO) 14001-certified environmental management system, was recognized as the good neighbor of the year locally, and received a national award, among other achievements. This was accomplished by learning lessons, listening to the community, and trying to accomplish all that DOE and EPA set forth.

The United States Government is subject to much public scrutiny. Reporters look for hidden meanings and ulterior motives. Citizen groups and activist groups have much information and they use the processes of democracy to make their points and ask for action. In addition, the G8 environmental ministers have observed that Americans are more likely to accept new technologies (e.g., genetically engineered food) than their own people. This reflects the public confidence that our government, e.g., the EPA, the United States Department of Agriculture (USDA), and the Food and Drug Administration (FDA), regulates responsibly, which is a major factor in American attitudes. These public processes have direct consequences on our quality of life and economics, and must reside on sound science.

The industrial revolution centered on new energy sources, such as coal, steam, and oil, for electricity. Today, the emphasis is on the atomic understanding of matter, such as quantum mechanics and all of the extraordinary breakthroughs post-World War II and during the Cold War including new areas of biotechnology, information technology, and nanotechnology. These new technologies pose similar challenges to those of the industrial revolution—unintended consequences on health and the environment—and also provide new tools, such as improved detection and increased control over chemical/life processes (e.g., green chemistry and reduction of potentially hazardous by-products). The explosive development of information technology is magnified by the effectiveness of our government's engagement in public processes, including the media and Web-based information resources. Individuals who in the past may have had unrecognized concerns are now able to band together, and the World Wide Web is adding new dimensions to this effect.

New technologies have immense consequences. The only possible constructive government response to this is to link regulation as strongly as possible to science. There are too many variables for controlled experiments, and there is too much complexity and variability to determine a definitive guide to regulatory reaction in every case. Science is a way to test ideas about how nature works, but does not tell

us when our ideas are incomplete or incorrect, nor does it tell us truths about nature, nor how to change a condition that we have observed but do not like. We must invent plausible approaches and responses to what we find in nature.

The pace of science is slow and may reveal that a past decision was too conservative and, having been built into people's perception, is difficult to change. Similarly, if the past decision was found to not be conservative enough, there will be public outcry. Both outcomes can cause a negative reaction toward the regulators, but the second one is worse. Therefore, we tend to make conservative decisions. Some say changes should not be made if we do not know the science, but that also involves big risks. Societal change is faster than that and sometimes we must guess as to the right actions to take when the science is not yet understood. This is very difficult and those who make such decisions must put themselves on the line because of the risks to human health and the economy from these decisions.

EPA has done an excellent job to recruit the best scientists to its cause. The EPA peer review process is a model to other agencies as demonstrated by recent efforts by the Office of Management and Budget (OMB) to promulgate peer review best practices for all agencies, largely based on what EPA does.

Question and Answer Session

A brief question and answer period addressed a range of topics. These included: (1) assisting the public to come to their own conclusions on technically complex issues by making available the correct science (on Web-sites, in journals, and other venues) and having credibility in the supporting science; (2) how, when apprised of issues that may affect their health, the public focuses on the impact to themselves and wants reassurance that the people addressing this issue are taking it seriously and doing something about it; (3) the role of risk communication to listen to and address concerns rather than focusing on "getting out the science"; (4) the importance of forming an ongoing dialogue with the public to establish the trustworthiness of the government; (5) the importance of partnerships, coalitions, alliances, and access to other funding sources to accomplish the research that EPA will need for its programs, which cannot all be funded by EPA; and (6) how to think proactively about the impacts of the new technology revolution and conduct the research that may be needed, including changes in university training of chemical engineers and other disciplines to provide a greater understanding of the need for sustainability, environmental stewardship, green chemistry, and environmental considerations.

Closing Remarks

Dr. Puzak concluded the plenary sessions by thanking all of the speakers for taking time out of their schedules to address the *Science Forum*. Dr. Puzak reminded participants of the poster sessions, exhibits, and additional presentations throughout the *Science Forum*.

Section III: Science and Innovation to Protect Health and Environment

Wednesday and Thursday, June 2-3, 2004

The purpose of this breakout session on the second and third days of the meeting was to focus on advanced remote sensing techniques, improvements in data resources for risk assessment, acquisition and use of human exposure data, vulnerability of children to environmental exposures, sustainability initiatives, relationships between air quality and human health, and water quality issues for recreational waters. Each session included opportunities to respond to audience questions that provided additional information and insight on a variety of science, health, and environmental topics.

Terrence Slonecker, with the National Exposure Research Laboratory (NERL), led a session addressing applications of remote sensing technologies and data analysis for landscape evaluation, indicator development, and remediation. Presentations included updates to the National Land Cover Data (NLCD), development of indicators from NLCD analysis, landscape analysis at multiple spatial and temporal scales, applications of light detection and ranging (LIDAR) for hydrological landscape analysis, and use of photographic analysis combined with a geographic information system (GIS) to detect and remove chemical agents and weapons from a residential area.

George Woodall, Jr., with the National Center for Environmental Assessment (NCEA), led a session addressing improvements in data resources and data organization supporting risk assessment. Presentations included data organization for regulatory decision making, development of Toxicological Profiles, modifications of existing databases to enhance searchability and access, and development of a toxicogenomics database on chemical effects in biological systems.

John Vandenberg, with NCEA, led a session addressing the acquisition and use of human data in risk assessment. Presentations included the ethics of research involving human subjects, the use of human subject research in setting air quality standards, and the ethical issues associated with genetic-based research.

Nigel Fields, with NCER, led a session addressing exposure in children and differences in the impacts on their health and development from that in adults. Presentations included understanding differences between children and adults in order to understand exposure mechanisms and responses, social and environmental conditions with pre- and post-natal effects, and the National Children's Health Study anticipated to begin data collection in 2006.

Alan Hecht, Director of Sustainable Development in ORD, led a session introducing the concept of sustainability. Presentations included efforts by the Sustainable Education Center, Inc., to educate

students from Kindergarten through Grade 12 on sustainability, national efforts to address sustainability in higher education programs, and National Science Resource Center program goals to improve learning and teaching of sciences in the nation's 16,000 school districts.

Val Garcia, with NERL, led a session addressing state and Federal initiatives to address air toxics and to understand their health effects. Presentations included EPA efforts in partnering with EPA regions, states, tribal governments, and local governments to enhance the understanding of air quality and its relationship to human health, an overview of the CDC's Environmental Public Health Tracking Program and the Public Health Air Surveillance Evaluation project, NOAA's National Air Quality Forecast Capability Program, regional challenges in using technology and innovation to better public health and the environment, and experiences of the State of New York's air quality management program and Department of Health initiatives including an environmental public health tracking system.

Alfred Dufour, with NERL, led a session addressing health effects from human use of recreational waters. Presentations included research efforts to identify associations between human illnesses and recreational water quality using rapid water quality analysis techniques, complexities of non-point source pollution in marine recreational waters and associated health risks, and the EPA Beach Program developed in response to the Beach Act of 2000.

Advanced Remote Sensing

Following opening remarks by Terrence Slonecker, with NERL, six speakers addressed applications of remote sensing technology in landscape analysis, indicator development, and remediation. An audience question and answer period followed the presentations.

The Status of the 2001 National Land Cover Data

James Wickam, with NERL, discussed the continued development of a data set to provide consistent national land coverage information that in turn supports assessment and use of this important indicator. Many Federal agencies are involved in this mapping effort either by contributing labor or buying images, including: United States Geological Survey (USGS), EPA, NOAA, U.S. Forest Service, USDA, Bureau of Land Management, National Park Service, National Aeronautics and Space Administration (NASA), and the U.S. Fish and Wildlife Service. There is also some state participation by Illinois and Kentucky.

A database approach is being adopted for mapping the continental United States and Alaska. Image data are being used to obtain derivatives such as imperviousness and tree canopy, generate land cover maps, and develop ancillary data such as a confidence estimate in the classification, a node map, digital elevations, and decision rules. Classification is being conducted using a regression tree format, which is supported by the node map, and is the step involving cross-validation. Density maps and impervious surface maps are also developed using very high resolution imagery, such as digital ortho quarter quads, in conjunction with regression techniques to map across an entire area.

An example of a confidence map was presented in which a map is color coded for percent classification confidence. This technique is not new to image processing and this type of map shows how well the data fit into the envelope for each particular pixel.

A change detection product also is being prototyped that will help to compare the 1992 and 2001 versions of the National Land Cover Data (NLCD), but this is difficult because of technology changes. The original 1992 data are being overlaid with the 2001 map products, and a decision tree is being trained to reclassify the 1992 data using the 2001 methods. The result is a reclassified map, entitled as the adjusted 1992 NLCD, which enables more residential features to be seen. This helps to evaluate change by enabling comparisons between the 2001 NLCD and the adjusted 1992 NLCD, with areas of change color coded on the map.

The continental United States is divided into 66 segments for completion of this analysis, and each is in varying stages of completion. Three segments are currently completed for an area in Minnesota, an area in the Mid-Atlantic, and an area in the West.

Information dissemination methods are still in development as needs have changed since the original effort. In 1992, the only product available was the NLCD map. Now information users wish to acquire subsets of the data, which will require data bundling. Currently, data can be obtained via http://www.mrlc.gov.

Evaluating Environmental Quality Using Spatial Data Derived from Satellite Imagery

K. Bruce Jones, with NERL, discussed the development of landscape indicators using the NLCD. Landscape indicators and models enable retrospective risk analysis using archival information to identify current conditions and risk, such as the Environmental Monitoring and Assessment Program (EMAP) and TMDL prioritization. These also may be used to forecast and/or evaluate proposed management actions

under the Regional Vulnerability Assessment (ReVA) or in evolving areas such as evaluation of management and policy effectiveness at the community level or through TMDL action plans.

Combining geospatial layers provides fine-scale information that can be used to develop landscape metrics (e.g., riparian, aquatic) at watershed scale. Information from a roads database can be used to calculate road density. It is also possible to downscale wet nitrate deposition by understanding the relationship between elevation and deposition using EPA data and a network model. Other metrics of interest include forest and agricultural land cover as well as characteristics of specific catchments.

In the mid-1990s, EPA started to develop a set of metrics and indicators and to apply these metrics to specific catchments. An example is the development of the Mid-Atlantic atlas that color coded ecological quality across the region. The challenge now is how to develop such metrics into an indicator of some outcome and to create models, which requires quantification of relationships. Empirical models (multivariate), Bayesian, and process-based models can take land cover information and generate information about an end point like water quality.

The general approach is to select a specific endpoint of interest, collect and acquire field samples through existing monitoring programs, filter collected data based on selection criteria to obtain a consistent temporal data set, assemble spatial data at various scales on various land units (functional and arbitrary), generate metrics and/or other measures, then conduct statistical analysis. An example product is the density and type of land cover in a watershed. From this process, it is possible to develop a set of functions, for example, multiple step-wise regressions to analyze percent agriculture and nitrate deposition.

Another analytical technique, logistic regression, provides cross-validation and assesses the probability of exceeding a threshold based on a set of independent variables, such as landscape metrics and biophysical measures. An example showed the application of logistic regression analysis for exceeding TMDL points for fecal coliform and the use of a model to predict and map the probability of exceeding the TMDL for each watershed in South Carolina. In this case, the landscape metrics that were important included: percent urban, agricultural areas with more than 9 percent slope, and roads crossing streams.

An additional example involved a classification and regression analysis study of 177 watersheds in the Mid-Atlantic region to identify the important variables in watershed condition. This involves a layer-by-layer analysis (e.g., percent forest, then nitrogen deposition, then another layer, etc.) until the watersheds are broken down into terminal nodes to determine patterns. Classification and regression analysis also enables the distribution (spatially) of terminal nodes to be evaluated. This is a powerful inductive tool to generate hypotheses and identify patterns.

This analysis process can also integrate multiple endpoints. For example, grid cells were used to analyze changes in bird habitat quality from the 1970s to the 1990s. Analyses were separately conducted for nitrogen loadings to streams in the same areas. The two analyses were then integrated in a GIS to look at the spatial patterns.

Ongoing and future activities involve the development of landscape models that address horizontal interactions (cell-to-cell flow networks and continuing distance metrics) and development of Web-based analysis tools for decision support.

Development of Landscape Indicators for Potential Nutrient Impairment of Streams in EPA Region VIII

Karl Hermann, EMAP Coordinator for EPA Region VIII, addressed the application of EMAP to predict landscape conditions at the regional level in the Western United States. The landscape indicator concept in this study is that ecological stream condition is often a function of watershed disturbance.

The use of GIS enables derivation of landscape metrics. A landscape model can be developed once catchments for surface water monitoring and metrics for the catchments are developed. The NLCD is very important to this effort, which largely relies on the 1992 NLCD, and eventually the 2001 NLCD, in conjunction with monitoring data from 2000 to 2001.

Currently, all monitoring sites in the study region are incorporated, some Regional EMAP (R-EMAP) projects are also being added (Montana northern plains and southern Rocky Mountain areas), and catchments for the Montana sites have been generated. One question of interest is how far away is the influence for the identified watershed disturbance. The farther away the influence is from an existing monitoring location, the harder this is to evaluate. So, efforts are underway to identify the clipping distance for each monitoring location in order to address landscape characteristics in just that area. This involves mapping areas for which metrics can be generated. A number of distances from monitoring sites are being evaluated—ranging from ½ to 15 kilometers. Buffer distances from streams are also clipped with distance from study areas of interest.

To date, about 40 catchment definitions have been developed through clipping and buffering, and the NLCD land cover information is modified by adding roads, potential grazing impacts (from a region-wide model), and nitrogen deposition estimated from an Office of Water model, each in different GIS layers. The Analytical Tools Interface for Landscape Assessments (ATtILA), developed by EPA in the Las Vegas laboratories, is used to evaluate all of this information. Some of the catchments are still being processed.

Since grazing is important in the West, a potential grazing impact model was developed to support this analysis. Inputs to the model include weighted land cover for grazing (i.e., where cattle may preferentially be located), weighted administrative uses (to eliminate areas where grazing would not be allowed such as residential areas), density of cattle, and proximity to water.

For nutrient impairment, anthropogenic influence is one of the major factors. This involves various land cover classes, land use, and modeled atmospheric data. To assess nutrient impairment, these tools are used to relate nutrient landscape information to land metrics followed by application of a regression model.

The value of this analysis process is that it helps to target areas to be assessed for the TMDL process.

Multi-Scale Remote Sensing Mapping of Anthropogenic Impervious Surfaces: Spatial and Temporal Scaling Issues Related to Ecological and Hydrological Landscape Analyses

S. Taylor Jarnagin, with NERL, provided an overview of research involving human-made surfaces (e.g., roads, rooftops, driveways, swimming pools) as an indicator. These surfaces are easy to quantify and measure using remote sensing platforms, and they also act as indicators of changes associated with their presence, such as changes in topography, water runoff, and sewer sheds. This is important because the human impact on runoff to streams may be greater than what is seen from the surface topography or modeling.

This research involves different scales of study and their impact. For example, spatial scales are effects at the catchment (first order watershed) level up to regional scale, while temporal scale ranges from hourly, daily, monthly, and yearly to decades. When looking at the impact of an impervious surface on a stream, the primary change is the method for delivering water to the stream—by increasing the peak discharge rate, water delivery occurs in a shorter period of time and moves off at a faster rate, which reduces the lag time. This also affects groundwater recharge in which the impacts are typically delayed and may appear on a different time scale. The effects are most apparent at the first order subwatershed scale and at a daily time scale, but to address impacts it is necessary to look at this from the decades scale.

An illustrative example involved the Upper Accotink in Vienna, VA in which historical aerial photographs were used for analysis. In that area, impervious surfaces increased from 3 percent to 33 percent between 1945 and 2000. The stream flow per unit of precipitation increased and the median flow increased, but the amount of precipitation per event did not change. Long term effects included an increase in the number of times per year that both low and high flows occur. This has an ecological effect on stream biota as well as a physical effect on stream morphology.

A problem for this type of analysis is the lack of such extensive historical data sets in many places. Often data that would help in evaluating impacts over shorter timeframes are not available for the areas where development is occurring.

A current study in a special protection management area in Clarksburg, MD, involves the USGS, Montgomery County, and the University of Maryland Baltimore County Center for Urban Environmental Research and Education. Research questions include what effect does an urban riparian area have and the effectiveness of best management practices such as storm water collection and diffusion back into the environment rather than capture and release. This effort includes the use of remote sensing platforms (LIDAR, aerial photography, satellite imagery) and ground sensing platforms (for stream flow, precipitation, water quality, and biological indices). This will enable analysis of before and after conditions. The study includes a rapidly developing area as well as an area that will not be developed.

Another project underway involves an accuracy assessment at medium spatial/temporal scale. Collaborators on this project are USGS and the Chesapeake Bay Program. The research question being addressed is the accuracy of remotely-sensed estimates of impervious surfaces, including how, when, and where remotely-sensed estimators of impervious surfaces can be used and how good they are. Remote sensing includes LIDAR, aerial photography, and satellite imagery.

In addition, historical impervious data studies are continuing to use imagery data. These efforts focus on correlating historical time-series estimates of impervious surface change and development with changes in stream flow over time.

The context for impervious surface analysis is the pattern of urban growth. In Virginia, from 1900 to present, there is linear growth starting about at 1950 as a combination of population growth and immigration. If the population increases, then there is an increase in the impervious area. Another evaluation examined changes in urban, suburban, and rural populations since 1950 in the same area. The largest growth area is suburban and that is where the largest environmental impacts are occurring.

LIDAR: A Remote Sensing Tool for Determining Stream Channel Change?

David Jennings, with NERL, provided background on LIDAR, examples of topographic LIDAR, accuracies and advantages of this local-scale tool, and an example of LIDAR application. LIDAR is an integrated, aircraft-mounted system that pulses energy (in the form of light) to the ground that returns to a

sensor. The system includes a global positioning system (GPS) and an inertial measurement system that compensates for the aircraft and the laser.

The energy return provides topographic (vertical) data and represents various above ground components, such as forest, underbrush, and buildings. The system can deliver multiple returns, and other research is underway that involves waveform analysis to assess multiple returns from the same pulse. The intensity of the return pulse is also of interest and may provide useful information.

LIDAR data are exported as simple ASCII x, y, and z data points. The data set is simple and involves easting, northing, elevation, and intensity information.

LIDAR image products provide more actual landscape information than aerial photography (ortho-image) products. An example demonstrated how the LIDAR image product (bare earth) provided greater ability to view a stream running underneath the Baltimore beltway than that shown in an ortho-image product. In addition, LIDAR images enable evaluation of vertical exaggeration. Example products included a 2-dimensional plan view (from above) and a morphological view with vertical exaggeration showing variation in stream channel side depths and the stream slope from upstream to downstream. Horizontal accuracy is 1 meter or less and vertical accuracy is 15 to 60 cm depending on slope and vegetative conditions. LIDAR imagery is especially good for open areas such as asphalt, but is less accurate in densely foliaged areas.

The promise of topographic LIDAR includes the following:

- Accurate, high resolution, terrain model to drive hydrologic prediction models at multiple scales
- Ability to identify subtle terrain/drain features such as depressional wetlands, vernal pools, and side channels
- Provide a means to assess morphological change of stream channels and topography
- Ability to provide assessments of large areas rather than traditional field surveys.

These potential advantages are being confirmed through research. The ability to provide large area assessments may be the most important aspect of LIDAR applications to evaluate morphological change.

A comparison of LIDAR with a resolution of 0.5 meters against National Elevation Dataset with a resolution of 30 meters demonstrated that LIDAR provided much better resolution and therefore is believed to be a much better input for modeling.

Another example showed a side view of a LIDAR image with vertical elevation changes. In general, this aspect of LIDAR is replicating actual field conditions quite well. However, LIDAR does not provide a return in deep water.

LIDAR is currently the only method for determining change in a large geographic area. Montgomery County, MD, needs a quick, effective way to assess the effectiveness of Best Management Practices to mitigate impacts of development on stream channel and landscape topography. Currently the County relies on field surveys, but it is not possible to do enough of these. Therefore, LIDAR is being incorporated into the Clarksburg, MD study, discussed in the previous presentation, for evaluation as a potential replacement for field surveys.

This research effort involves the development of a conceptual model that relates stream channel change to landscape development. This analysis requires both original and changed land cover and hydrograph data, with LIDAR being used to obtain channel information. Best Management Practices come into play

between the land cover changes and the stream hydrographs, and therefore should mitigate changes in channels. Because of this relationship, it may be possible derive some sort of quantitative assessment of the effectiveness of Best Management Practices. To date, LIDAR data have been collected in December 2002 and March 2004, land use and land cover change data have been collected for both periods, and four out of five USGS stream gauge stations are in place. Results may be available in the next year.

The Use of Remote Sensing in the Detection and Removal of Chemical Weapons in Spring Valley

Steven Hirsh, a Remedial Project Manager with EPA Region III, presented an example of remote sensing applications for a high profile and difficult site area in Northwest Washington, DC involving buried munitions from World War I that are in poor condition and still contain toxic materials. Special aspects of this project involve very old data, new techniques, and operations in a residential area (1,600 homes) as well as the use of historians and photo analysts to reduce the invasiveness of the investigations and remediation activities to the homeowners.

In 1917, the Army conducted research on chemical agents at a 50-acre facility owned by American University in Northwest Washington, DC. The area involved lots of open farmland and a reservoir among other features. There are many pictures taken at the time of that Army research effort as well as information from that time that enables us to know precisely what was going on in specific buildings. Efforts are currently underway to identify where specific operations occurred and where the wastes were placed.

Chemical agents in World War I included mustard gas, lewisite, phosgene, ricin, and arsenicals. Research at this site involved laboratory testing of these chemical agents on mice, then larger animals, and then humans. Other research activities involved the development of offensive capability (e.g., ordnance, delivery) and countermeasures (e.g., personnel protection). Efforts are underway to trace where bullets and other ordnance landed from field firings on the site. Many shells did not explode and efforts are also underway to find the unexploded ordnance.

The challenge is using the photographs taken at the time of operations to identify where specific activities occurred, then translating that location information into the present time. Researchers are able to use calculation and geometry techniques to find sites from historic pictures that have buildings whose locations are known. Subsequent efforts involve translation of this information to identify current locations so as to minimize disruption of homeowner's land as remediation activities proceed.

Historical aerial photograph research, acquisition, and interpretation are key aspects of this effort. This information has been placed into a GIS in order to map physical feature locations as well as elevated contaminant levels to support "what if" analysis. This involves the creation of hundreds of layers—for utilities, cut/fill, and land surface in 1918, among others. The project has access to an aerial photograph from 1918, many terrestrial photographs from the 1910s and 1920s, and documents that specify locations where activities occurred. Aerial photographs from earlier years are also being reviewed to see where vegetation is not growing.

As an example of the GIS application, persistency tests were conducted in 1918 to determine how long mustard gas would last in the environment. These locations can now be overlaid with current residential areas in order to identify sampling locations. Ground scars are also being evaluated to identify trenches and other land features that were constructed to help with the chemical agent research at that time.

A research activity underway by the U.S. Army Corps of Engineers (USACE) Vicksburg District involves the hyper-spectral identification of contaminants and/or affected vegetation. This includes the

planting of many ferns to determine if contaminants of interest can be concentrated, which will also help to identify locations of contaminants and former site activities. Hyper-accumulation is also of great interest for contaminant removal in lieu of more invasive remediation techniques as it may help to avoid removing trees or otherwise disturbing the landscape of this mature residential neighborhood.

Future activities include continued support for ongoing removal operations, GIS support for partners in this remediation and research effort, and completion of the hyper-spectral study.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the importance of urban riparian buffers in regulating flow through sewer sheds and minimizing impacts to aquatic life; (2) the need to determine whether engineering solutions (such as partially impervious surfaces), point source controls, and other Best Management Practices are having the desired impacts on watershed quality; (3) the need for multi-temporal accuracy assessment for NLCD data points; (4) availability of information from these projects of which some is available now (1992 NLCD) and other data, such as being developed for Montgomery County, that may not be available for 4 or 5 years; and (5) sources for more recent photographic data for chemical agent remediation activities and the challenges of obtaining recent aerial photographs resulting from the difficulties of accessing Washington, DC airspace since the events of September 11th, 2001.

Innovations in Risk Assessment: Improving Data Resources

Following introductory comments by George Woodall, Jr., with NCEA, four speakers discussed methods to manage and assess large volumes of data for decision making. An audience question and answer period followed the presentations.

The Need for Scientific Data in Regulatory Decision Making

Roy Smith, with OAQPS, discussed the ways to better organize dose-response data for use in regulatory decision making. The Air Toxics "universe" can be viewed as n-dimensional space, consisting of many aspects that are related to each other in different ways. GIS can be used to map such information density in n-dimensional space as presented in this session.

The multi-dimensional view of the Air Toxics "universe" includes the following dimensions:

- "Width" (first dimension) consists of 174 source categories and 96 NESHAPs developed to date. The National Air Toxics Assessment activities include a monitoring network, an inventory of emissions, assistance to communities in conducting local risk assessments (e.g., guidance, interaction), and a national-scale assessment every 3 years, as well as completion of a one time set of "boutique assessments" (e.g., mercury, power generation).
- "Length" (second dimension) involves the needs of every assessment, such as emissions, dose-response, and exposure analyses. The exposure analyses alone take significant effort. Therefore, dose-response may receive less consideration.
- "Depth" (third dimension) involves the 188 hazardous air pollutants (HAPs), of which 20 are "categories" whose members vary widely in toxicity. EPA activities include identifying substances that are not currently on the list and perhaps should be, as well as conducting assessments to remove substances from the list of HAPs.
- Dimensions four through six for the 188 HAPs, involve inhalation and multi-pathway exposures, chronic and acute exposure time scales, and human and ecological receptors.

There are many ways to cope with these assessment needs through tiering. This may range from screening using lookup tables or a simple dispersion model to more refined approaches ranging up to full blown probabilistic analysis. The overall approach involves a series of steps and the use of multiple iterations:

- Initial screen – toxicity-weighted scoring
- Tier 1 – simple, conservative screen focused on important stressors/sources
- Tier 2 – more complex models, real receptors
- Tier 3 – best available analysis including human behavior (moving in/out of area).

At each stage of the assessment, resources focus on the small number of stressors and sources that really affect risk and eliminate the assessment of aspects that are not relevant to exposure. For example, dose-response assessments are typically generic until Tier 3 analysis, which uses only the newest and best existing assessments. If newer data are available, they must be considered credible. Note that many HAPs lack such assessments.

Existing dose-response values are useful for most, but not all, risk assessments. However, if it is necessary to add/remove a HAP from the regulatory list, reduce emissions, or take similar actions, the best possible information must be used in the assessment. Better organized toxicological data would help with this analysis. An emission reduction example was the need to use risk estimates based on the physically-based pharmacokinetics (PBPK) model developed for the plywood Maximum Achievable Control Technology (MACT) emissions standard. Other examples were offered for residual risk analysis, removal of a HAP from the regulatory listing (i.e., demonstrate the absence of risk), and addition of a HAP to the regulatory listing (i.e., demonstrate the presence of risk).

The Integrated Risk Information System (IRIS) develops 10 assessments each year for all programs. The universe of HAPs under the CAA includes hundreds of substances. Therefore, a well-organized toxicological database/system could help to prioritize which substances to do next—either for IRIS assessments or for toxicological research studies.

The ATSDR Experience in Using the Supplemental Documents Database in Developing Toxicological Profiles

Henry Abadin, with the Agency for Toxic Substances Disease Registry (ATSDR) Division of Toxicology, addressed the Toxicological Profiles Program, supplemental documents, and a related database. The Toxicological Profiles developed by ATSDR succinctly characterize the toxicological and adverse heath effects information for specific substances, determine levels of exposure (e.g., acute, intermediate, chronic) that present a significant risk to human health, and identify research areas needed to fill data gaps. These profiles undergo independent peer review, typically three to seven peer reviewers, and are made available for public comment.

The contents of each Toxicological Profile cover a wide spectrum of topics, including a public health statement that addresses in layman's terms what is in the profile, health effects (route of exposure, acute measures, system affected), toxicokinetics, mechanisms of action, biomarkers, chemical and physical properties, production/import/use/disposal, environmental fate, analytical methods, regulations/advisories, identified data needs, children's health, PBPK, methods to reduce toxic effects, endocrine disruption, and wildlife impacts (as sentinels for human exposure). ATSDR also prepares a public health statement in both English and Spanish as a stand-alone portion. The Toxicological Profiles have evolved over the

years to bring in more information. Therefore, those completed earlier will look different than those completed more recently.

ATSDR developed a list of chemicals found at hazardous waste sites, and this provided the basis for preparing the Toxicological Profiles. ATSDR must update published profiles every 3 years. ATSDR has also developed Toxicological Profiles for DOE that address ionizing radiation and uranium; efforts are currently under way to address americium, cesium, cobalt, iodine, and strontium.

The Toxicological Profiles have widespread application in public health practice, such as emergency response, developing public health assessments, consultations, health advisories, and environmental alerts, among others. The Toxicological Profiles are available on the Web and there is a search engine to help users find information. ToxFAQs is a public summary of the profiles and is also available on the Web. These profiles also are distributed to about 70 countries worldwide, based on requests received. In 2002, ATSDR began placing the Toxicological Profiles on CD-ROM.

The profile development process includes literature search, article retrieval, and preparation of a supplemental document to pull together all the information that someone may need about the quality of the studies and data to extract into the profile. This includes the number of animals, species, exposure duration, route of exposure, parameters monitored (histology, clinical signs, other things), doses, no observed adverse effect level/lowest observed adverse effect level (NOAEL/LOAEL) values, calculations, study description, and comments (such as limitations of the study). This helps to determine the level of confidence in the information. ATSDR developed a set of criteria that are given to contractors to conduct the literature search.

Data are then extracted into a table addressing levels of significant exposure. ATSDR typically uses studies that have the most data on acute, intermediate, and chronic exposure; organ system affected; NOAEL/LOAEL values; what occurred, etc. These data are used to prepare a "levels of significant exposure" figure that shows all of the data in graphical form. This database of information is developed to enable data extraction to support HazDat (which contains detailed data from Toxicological Profiles, site data, and toxicological and health information); the TopHat database (formerly the Federal facilities information management system developed for DOD sites); the Toxicology Profile and Health Assessment ToolKit; and IRIS.

ATSDR and EPA are working to develop an MOU to continue collaborations in this area.

Distributed Database Approach to Sharing Data

Ann Richard, with the National Health and Environmental Effects Laboratory (NHEERL), discussed the development and application of a toxicological and structure database now available on the Web. A challenge faced by EPA is that there are too many chemicals requiring testing and a lack of sufficient data on those chemicals. A potential solution for this is to use computational toxicology, which is the application of mathematical and computer models and molecular biological approaches, to improve prioritization of data requirements and perform risk assessments.

Gathering relevant information is one of many steps in the risk assessment process. The first step is the conduct of chemistry-based data mining and exploration to look for chemical-specific data. Since there is typically little data found, the search expands to structural or chemical analogs that have similar properties (biological or mechanistic) to the chemical of interest. This involves the establishment of structure-activity relationships (SARs), in which activity is a function of structure, which may be identified through analogy, heuristics, machine-learning inference, and statistical correlation.

An existing model can be applied, if one exists, to accomplish structure-based screening and prioritization. If enough information exists, it also may be possible to develop a new SAR model or to mine existing data for analogs. Each of these steps requires data. However, there are limitations that include: scattered sources, nonstandard formats, diverse information content, and a lack of chemical structure annotation. This is a significant issue as this is important to analog searches and limits access to the full database, which is necessary for model development, yet most lacking in the literature.

Development of a Distributed Structure-Searchable Toxicity (DSSTox) database is underway to address these limitations. This effort involves the standardization of chemical structures to aid in data searches, to open public access and partnerships to help advance this database concept, and to bridge diverse toxicity disciplines to bring in many potential information sources. This will help to improve coordination and collaboration, access to and utilization of toxicity data, and toxicity prediction modeling.

Currently, data files are found in many locations and have diverse content. This effort involves the annotation of public toxicity databases with chemical structure information and the creation of SDF files that can be imported to other uses (e.g., models, database). The data files are found at http://www.epa.gov/nheerl/dsstox, which is both a resource and portal in that it provides links to outside resources. Four databases have been published to date: carcinogenic potency, water disinfection by-products with carcinogenicity estimates, EPA fathead minnow toxicity, and estrogen receptor binding. Each database is a separate repository and associated with each database is a series of modules that can be downloaded.

The database is designed to integrate toxicological data with chemical structures and properties. Activities are underway to create files that bridge these two user communities. Toxicological data are typically compiled to support risk assessors and do not usually involve a chemistry component. So, this project is trying to provide some general context such as chemical structure and property fields useful to both user communities.

The database development effort is incorporating certain standards, such as data file format, file naming convention, chemical structure information fields, documentation requirements, and publishing requirements (i.e., how to get a database onto this Web site). The standard chemical fields are extensive and enable searches across the four databases. Minimum structure annotation is also provided in order to cover the diversity of databases of interest. Structure data include the tested form simplified to parent, general form, active ingredient of formulation, other ingredients (typically found in pesticides and pharmaceuticals), and monomeric form of the polymer. The standard fields are well defined and well characterized for others to successfully reproduce these fields in order to publish their data on this database.

The next steps are to develop general toxicological fields as was done for chemistry, such as species, sex, and strains, to facilitate data searches; expand the databases being converted to standard format; and provide resources to encourage the use of chemical relational databases, especially among those who are not chemists or toxicologists.

Collaboration with the Chemical Effects in Biological Systems (CEBS) database is also underway to develop useful relational tools to search through this diverse data. An example is how to establish a linkage from a chemical structure standpoint for historical data. If the same standard fields are applied to genomics, proteomics, and other new data types, natural linkages may be found that are applicable to older data and this may be the only method to bind this information together in a useful way. This would improve relational searching capabilities and obtain improved understanding of biofunctional classification, which in turn improves the ability to predict toxicity.

Adoption of this approach will lead to increased use of chemical structure searching, improved public access to toxicity data, and improved predictions based on chemical activity structure.

The Chemical Effects in Biological Systems Knowledgebase

Michael Waters, with NIEHS, discussed efforts by the National Center for Toxicogenomics to develop the CEBS Knowledgebase, which relies on toxicogenomics and systems toxicology. Toxicogenomics is the study of the response of a genome to environmental stressors and toxicants, and combines genetics, transcriptomics, proteomics, metabonomics, and bioinformatics with conventional toxicology. Systems biology is a complete description of how the components of a biological system work together, while systems toxicology is a complete description of the toxicological interactions within a system. The goal is to be able to describe a biological system, perturb it, measure changes, and then develop a better model.

The CEBS Knowledge base uses data and information to carry out tasks that create new information and new understanding. This is heuristic in that the system learns from relationships and develops new data. CEBS aims to be dynamic in order to integrate large volumes of disparate information in a framework that continually changes. CEBS will evolve both in content and capabilities to become a system for predictive toxicology.

CEBS will enable comparison of the toxicogenomic effects of chemicals/stressors across species. In order to phenotypically anchor these changes with conventional toxicology data (i.e., classify effects as well as disease phenotypes), it must be possible to bring together these two data sets, identify signatures, relate these to known phenotypes, understand what is adaptive, and define biomarkers, sequences of key events, and modes/mechanisms of action.

Two hallmarks of the CEBS Knowledgebase are: (1) sequence anchoring (anchoring the genomic sequence to chromosome coordinates) to help understand the genome and to interpret resulting data sets; and (2) phenotypic anchoring in which toxicological effects (expression profiles or outcomes) are anchored in phenotype using a controlled vocabulary.

The interpretive challenges for building such a knowledge base are formidable. Chemical structure is one, as described in the previous presentation, and CEBS will be able to link up to those resources. Annotation information will be brought in from multiple genes/proteins using CABio developed by the National Cancer Institute with a focus on gene/protein categories (functional characterization). Efforts are also underway to address sequential events (pathways and processes). These three efforts lead to an understanding of integrated responses by networking this information and using toxicology/pathology (e.g., adverse effects) to map chemical structure.

Immediate objectives are to capture, store, and analyze gene expression data produced from toxicogenomic experiments in different laboratories; interrogate gene expression data using queries from the genomic, experimental, and toxicological domains to understand the molecular interface; and gain knowledge of relationships between gene expression changes and toxicological endpoints. The main challenge is to provide internally consistent data to enable comparisons among the many data sets.

NIEHS is looking at potential data sources for CEBS and is developing intramural and extramural partnerships including government agencies such as EPA, private industry, and international organizations to facilitate data transfer. EPA collaborations include Metabonomics Center of Excellence with NERL, SAR interface with DSSTox with NHEERL, and toxicogenomics applications in risk assessment with NCEA. In addition, the Environmental Science Portal may be, in the future, a way to bring CEBS into the EPA system.

Data acceptance began in 2003 and there are about 25 gene expression experiments included at this time. CEBS provides data processing options and resources to help view data sets and do gene analysis via data tables and various pathway diagrams.

Toxicogenomics will change the way toxicology is performed and will contribute new methods, new data, and new interpretations to environmental toxicology. CEBS will be a key component in toxicological interpretation, providing the ability to link transcriptomics, proteomics, metabonomics, and toxicology to generate new knowledge and assist in evaluating various dose-response paradigms.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the need to integrate a vast amount of disparate dose-response information and to be up-to-date on what is already available; (2) the potential to expand DSSTox to include chemical fate/exposure aspects such as toxicity and bioavailability, which are linked to chemicals and structures; (3) attempts to address dose-response in CEBS and the challenges of projecting gene expression to identify signatures, chemical structures, and mode of action; (4) the impact of new technologies such as carbon nanotubes; (5) how to verify toxicological outcomes extrapolated from structures or other analogies, how to develop confidence in such extrapolation when such data may not be available, and the need to use/leverage existing data; (6) the need for an intelligent way to query an entire dataset as to the gene or mechanism through gene annotations, integration of array data, and other mechanisms; and (7) the need for methods to use all of the classical toxicological data in risk assessment that are already available.

Science and Innovation to Protect Health and Environment

Following opening remarks by John Vandenberg, NCEA, three speakers addressed evolving research guidelines for human participants and diverse ethical considerations involving existing and new research methods. An audience question and answer period followed the presentations.

The Ethics of Research Involving Human Subjects

James Childress, with the University of Virginia, discussed the current ethical framework for research involving human participants such as third party dosing studies conducted by EPA. The Belmont principles were established in the *Federal Register* in 1979 and called for beneficence, respect for persons, and justice. These principles resulted from a Congressional request of the National Commission for Protection of Human Subjects of Biomedical and Behavioral Research. Respect for persons involves the respect for autonomous agents, the protection of persons with diminished autonomy (e.g., cannot make own choices), and use of informed consent. Beneficence involves not doing harm, maximizing possible benefits, and minimizing possible harm. Justice involves fair distribution of the benefits and burdens of research including fair selection of research subjects.

The Belmont principles are a general framework, and Federal agencies and other groups have come up with additional guidelines. Yet, there was widespread negative reaction to intentional dosing studies conducted for EPA regulatory purposes even though analogies exist between such studies and Phase I testing of new drugs by pharmaceutical companies. The hope was for human testing to address the difficulties encountered in conducting interspecies extrapolations of effects.

In 2004, the National Research Council set up an interdisciplinary committee to prepare a report and make recommendations. The report stressed an integrated review of science and ethics. The committee applied existing standards including the Belmont report and the Common Rule (Federal Policy for the Protection of Human Subjects) adopted in 1981 by the government, and did not try to create or invent

ethical standards. The existing guidelines cannot simply be applied because they require interpretation and there are gaps in areas addressed.

Subject protection generally involves review of proposed research by an institutional review board (IRB) and informed consent. The Common Rule provides guidance for IRB review, but does not require approval. Key elements are the importance of minimizing risks to subjects, determining that risks to subjects are reasonable in relation to anticipated benefits, equitable selection of subjects, informed consent and its documentation, and maintaining confidentiality.

Criteria for evaluating research proposals/subjects, in terms of scientific and ethical acceptability standards, include:

- Prior research including animal studies and, if available, human observational studies
- Whether there is a demonstrated need for the knowledge
- Adequacy of research design and statistical analysis to address an important scientific or policy question, which is where ethics and science merge as there is bad science from exposing subjects to risk that is of little benefit
- Whether there is an acceptable balance of risks and benefits as well as minimization of risks to participants.

Other risk-benefit considerations include:

- Possible societal benefits from improving accuracy of reference doses and providing public health or environmental benefits
- Justification of research to improve scientific accuracy only when there is reasonable certainty that human subjects will experience no adverse effects
- Justification of greater risks to human participants if the research will produce a benefit, but only if addition ethical conditions are also met, including a precondition requiring a protocol related to ethics.

Participant selection must be equitable (fair, just), use of persons from vulnerable populations (i.e., possible exploitation) must be convincingly justified and the research protocol must include additional protective measures, and use of individuals at increased risk for harm must be convincingly justified and the researchers must have protective measures to reduce risk. These factors come together for children who are vulnerable in both senses as they are unable to give informed consent and are in a developmental stage so they are at greater risk. A recommendation to EPA is to adopt Subpart D of the Regulations for Protection of Human Research Subjects, or to at least adhere to them, as these standards are quite stringent, when children are used in research.

Payment for participation is an unsettled area. A variety of perspectives indicate the appropriateness of receiving payment for taking part in a research project, but care must be taken as to how much and why (e.g., time, inconvenience, and/or level of risk). The amount cannot be so high that it is inducement or so low as to be attractive only to socio-economically disadvantaged persons.

With regard to compensation for research-related injuries:

- Participants should receive needed medical care for research-related injuries, without cost to them
- EPA should study whether broader compensation for research-related injuries should be required, such as for lost wages, death, job loss, etc.

In addition, the Common Rules state that participants should be informed if compensation will not be provided for research-related injury.

Best practices for informed consent means that the participant understands the information provided about the research protocol. Recommendations to EPA in this area are to develop and disseminate a list of best practices in this area, encourage their adoption in third-party studies, and require their adoption in studies it sponsors or conducts.

IRB review of intentional dosing studies is useful. There are precedents for a human studies review board for an integrated science and ethics review. This helps to ensure public trust and build experience. Such requirements are preferred to be mandatory but legal and logistical issues may make this difficult. At a minimum, research protocols should be reviewed in advance (through voluntary submission) and study results should be reviewed after completion.

If ethically problematic studies are conducted after the new standards are adopted, EPA may face challenges in regulatory decisions. However, there may be exceptions where studies provide valid data to support a standard that provides greater public health protection. It may be useful to have these evaluated by a special, outside panel with public members as well as experts. If ethically problematic studies are conducted before the new standards are adopted, EPA can accept them if the studies provide valid information that leads to greater health benefit.

Ethical principals for research can justify some intentional dosing studies if several conditions are met as described above, but these conditions should apply to both third party and EPA-conducted research.

EPA Clinical Research: Implications for Air Quality Standards

Bill McDonnell, with NHEERL, discussed the role of clinical research in developing air quality standards. In controlled human exposure studies, human volunteers are assigned to exposure groups, undergo exposure to a pollutant under controlled conditions, and health effects are measured and compared to a control group. This information supports the development of effective standards, which have a high probability of meeting the requirements of the law, and optimal standards, which are both effective and are not unnecessarily restrictive.

Health information that is needed to identify an optimal standard includes whether the pollutant causes a health effect and accurate estimates of human health effects and the associated uncertainty. The more uncertainty there is in the human health data decreases the probability of identifying an optimal standard, and if there is too much uncertainty, the standard may be set at a level that is more restrictive than necessary. Sources of uncertainty in health data include extrapolation from one species to another, individual variability in effect, difficulties in establishing causality in epidemiological studies, and issues of precision or accuracy in measurements. If there is limited data, there will be uncertainty about the effects measured.

Some of the strengths of clinical studies involving human participants are that the subjects are the species of interest and it is possible to control and accurately measure exposure, so modeling becomes much easier. Ethical limitations include the ability to only study pollutants with limited, acute, and reversible effects; difficulties in studying the populations of greatest interest because they are the most susceptible and are unlikely to be included in the study because the health effects will be more pronounced; and limited health endpoints (e.g., few people willing to undergo a brain biopsy). Logistical limitations include small sample sizes in which interactions and rare outcomes are difficult to study, short duration, and volunteers who may not be representative of the population.

Examples were presented where clinical studies directly contributed to standards setting efforts. The first example involved the relationship between ozone and eye irritation; clinical studies showed that ozone alone (without other air pollutants) did not irritate the eye. Another example is the relationship between ozone and asthma attacks. A number of epidemiological studies showed a relationship between ozone levels and hospital admissions for asthma. Since it was not possible to study asthma attacks (rare in occurrence and should not be induced), researchers investigated whether ozone has mechanistic causes such as promoting a response to allergens. Researchers were able to obtain information that increased the certainty regarding the epidemiological observations. A third example addressed whether long-term exposure to chlorine causes nasal lesions; clinical studies compared chlorine uptake in the human nose to that in animals in order to quantify interspecies differences and to determine differences in tissue sensitivity.

The final example involves the National Ambient Air Quality Standards (NAAQS) for ozone in which the effect of interest can be directly measured. The first NAAQS for ozone was set in 1971 at 0.08 ppm with a 1-hour averaging time based on experience in Los Angeles where quick peak spikes and drops were encountered. In 1979, the 1-hour averaging time was retained, but the standard was changed to 0.12 ppm. Then in the 1980s, it became evident that the pattern encountered in Los Angeles was not the predominant pattern, particularly on the East Coast where the pattern was slower and broader. Questions then arose whether the standard was adequate to protect people in those situations. As a direct result of those studies, EPA promulgated a revised standard at 0.08 ppm ozone with an 8-hour averaging time. This has gone through the courts for 6 years and is now being implemented.

A clinical study looked at a 2-hour ozone exposure at various concentrations (up to 0.4 ppm) in healthy young adults. This study alternated rest and heavy exercise, then looked at symptoms. Elevation of coughing was identified in all cases, but at increased ozone concentration there were more significant changes in lung function that were not comfortable but were reversible. The study was repeated a year later and the individual ozone responsiveness remained consistent. In addition, younger adults were more responsive to the effect than older persons. In another study using 6.7 hour exposures in healthy young adults with differing ozone concentrations up to 0.12 ppm with alternated moderate exercise and rest, ozone clearly had an effect well below the standard. These studies demonstrated causality, provided accurate estimates of effect, and identified individual variability and some sensitive subpopulations. Researchers have been able to use these data to create exposure-response models and to develop estimates of precision. These studies served as the foundation for regulations we have today.

Conclusions from this experience are that, under the right circumstances, clinical studies can directly establish causality and provide accurate and precise estimates of effect. In less optimal circumstances, clinical studies can complement animal and epidemiological data and can decrease uncertainty.

Research with Human Subjects: Future Challenges and Opportunities

Richard Sharp, with the Baylor College of Medicine, discussed genetics research, current efforts to decipher gene-environment interactions, and several ethical issues associated with these activities. The general public does not realize that the vast majority of genetic research is not on genetic diseases. The human genome project warranted investment for the resulting ability to address more generalized susceptibility (e.g., the strong dominant alleles found to be associated with disease such as the breast cancer gene are very useful in predictability) rather than genetically-based diseases. In addition, some genes have limited use in predicting disease.

Environmental exposure is another pathway to disease. Actions within the human body in response to exposure include taking up contaminants, repairing cellular damage, and getting bad materials out of the

body. If there are defects in the enzymes that perform these functions, they will play a role in the exposure process. This is a potentially important area for EPA. Some environmental response genes identified to date include the CYP2E1 gene, which in the presence of benzene leads to an increased risk of leukemia, and the TGF-alpha gene, which in the presence of maternal smoking leads to an increased risk of facial clefts in newborns.

His definition of toxicogenomics is the use of genomics and genetic resources to identify potential human and environmental toxicants, and their mechanisms of action. Specifically relevant to EPA work in this area is the use of toxicogenomic tools to identify biomarkers of susceptibility, biomarkers of exposure, and biomarkers of early clinical effect (early disease processes).

The promise of toxicogenomics is in the potential ability to accomplish the following:

- Develop less expensive ways to assess chemical and other agent toxicity
- Improve understanding of toxicity mechanisms
- Provide more precise estimates of exposure levels
- Measure biological effects earlier, perhaps before there is evidence of toxicity
- Provide measures of unknown toxins by using patterns to determine exposure
- Identify individuals and subpopulations with increased sensitivity to specific substances.

There are many ethical issues associated with toxicogenomics, particularly regarding how scientists should present the promise/limitations of emerging scientific technologies to the public. Much of the current literature includes many statements with "hype" and promotion, and these are largely found in peer-reviewed journals rather than the lay press. This representation does not appear to provide an appropriately balanced discussion that includes some of the limitations of these toxicogenomic technologies. Without balanced discussions, the nonscientist is likely to misunderstand the information. For example, the suggestion of genetic predisposition may lead to conclusions about predetermination for depression, intelligence, criminal behavior, infidelity, etc., when there in fact may be multiple causal factors.

A second ethical issue is the potential to use genetic information in ways that are discriminatory. The genetic influence on exposure-induced disease processes may depend upon the level or timing of the exposure, whether there are concurrent exposures, or whether other genetic mutations combine to increase the likelihood of disease occurring. The effects of environmental response genes may be altered by changes in behavior or environmental conditions; for example, eliminating exposure to benzene will eliminate the action of the benzene-sensitive CYP2E1 gene discussed above. Since variability in sensitivity genes is common, the biological implications of these genetic variants is often unclear and may be more complicated than simply having an altered gene.

This situation offers more opportunity for misuse of such genetic information because it is easy to find differences, but difficult to interpret their meaning such as risk. Concerns have been raised regarding health insurance and the use of this information, and there are an increasing number of statutes being enacted to address this. In addition, businesses may choose to remove genetically sensitive workers rather than address a workplace hazard. As an example, Burlington Northern Santa Fe Railroad required workers with work-related carpal tunnel claims to provide blood testing for genetics. While there is a gene for palsy, there is not one for carpal tunnel. This testing was not intended to benefit the health/welfare of tested employees, there was no informed consent, and the tests themselves were scientifically questionable. Yet the company was not doing anything illegal. However, a lawsuit under the Americans With Disabilities Act (ADA) resulted in this practice being banned.

A third ethical issue is how knowledge of genetic sensitivities leads to informed decisions about health impacts. An example involves a person applying for a job at a DOE facility where beryllium exposure will occur. Genetic testing was performed that revealed the individual was at risk for developing a beryllium-related disease. The individual still took the job, and eventually acquired the disease. The ethical question is whether this person is responsible for his condition. In general, there are inherent problems in assigning responsibility for poor health outcomes. There are excusing conditions, such as the choice may not have been fully voluntary because of limited employment options, or the choice may not have been fully informed. There also are justifying conditions such as a greater benefit to his family to take the risk. It is easier to blame someone than to put responsibility on broader social issues that channel a person to a specific path.

A fourth ethical issue involves donor attitudes regarding the use of stored biological materials for genetic research. It is very difficult to do certain studies without large numbers of data sources. An example is a children's study involving 100,000 participants in which the genes will be defined over the course of the study, not at the beginning. As a result, consent provided by the parents of these children will be generic and open-ended. IRBs find this problematic and want the consent to specify the genetic test for those involved in a study. In Mr. Sharp's studies of participant attitudes, he is finding that many are happy to have their biological sample support a number of studies.

There are many types of genetic research available today that may help EPA. This will introduce a number of ethical challenges. How to respond to those challenges and also develop quality science is still an open question.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the range of considerations to take into account in deciding whether to use scientific information that is unethically obtained while discouraging companies from engaging in unethical research that promotes their interests over that of the public/environment or with deliberate intention to harm participants or violate human rights; (2) how decision making on ethical issues is a process of reasoning rather than yes/no; (3) how an ethics group is working with consent protocols and consent renewals for the EPA children's study; (4) how Johns Hopkins obtains new consent for each new study using stored biological materials; (5) potential indemnification issues arising out of EPA review of established university research protocols or requiring university protocols to provide additional measures such as further compensation for injury or loss of life; and (6) an example of a manufacturer that allows prospective workers to have a genetic test and receive genetic counseling, while the company chooses not to see the data and the offer is made after the employment offer is issued but before employment occurs thereby addressing ADA requirements.

Supporting Innovations in Science to Identify Children's Vulnerability to Environmental Exposures

Following opening remarks by Nigel Fields, with NCER, three speakers addressed health and exposure differences between children and adults, a study of environmental exposure impacts on young children, and the upcoming National Children's Study. An audience question and answer period followed the presentations.

Children's Health and Environmental Exposures: The Most Important Unanswered but Answerable Questions

Michael Weitzman, with the American Academy of Pediatrics, Center for Child Health Research, discussed the differences between children and adults in terms of health effects and how genetics and exposures in children set the stage for chronic illnesses that beset adults and the elderly. Children are different from adults, from animals and juvenile animals, from each other, and from themselves at different ages/stages. The differences are age-, stage-, and substance-specific.

Age-specific drug effects include tetracycline staining of teeth, fluorosis (leading to enamel problems), blindness from administration of oxygen to premature babies, grey baby syndrome from chloramphenicol administration, ciprofloxacin-related cartilage damage, and agitation from phenobarbital, which acts as a sedative in adults.

At this time, we are at a critical juncture to begin to understand the interface between children's health and development. We know more about changing exposure rates, but we often jump to the conclusion that the exposure causes the problem. We also have much exposure information, but little information on consequences, especially in children. We have had increasing rates of asthma that appear to have leveled off, increasing rates of obesity and autism, and decreasing age of puberty onset in girls. We are also beginning to understand differences in long-term effects from low-level exposure and acute poisoning, such as childhood lead poisoning, which leads to subtle but serious dysfunctions; there is little in the literature on long-term effects other than this. We also are beginning to understand childhood antecedents of adult disease. However, the medical community does not yet recognize that there are different forms of substances, which may have different medical effects, such as the many different forms of mercury.

Much more is known about drugs than chemical exposures and effects. There is much more clinical trial data for drugs, yet there is concern with acute poisoning and about long-term effects of the use of drugs in young children that were originally developed for adults. Examples are the use of statin drugs to control obesity and what a lifetime of altered liver metabolism resulting from this drug will do. For environmental exposure, there are no clinical trials, yet there is concern about the subtle or long-term effects of low-levels of exposure.

The vast majority of medications and prescriptions are subject to regulations that restrict the types of research that can be done in children. As a result, we face the same type of interspecies extrapolation problems in human form—extrapolating from adult studies to children. This is difficult because physical growth is non-linear and children are closer to the ground, explore constantly, have greater surface area, and have a greater metabolic rate than adults. This may lead to greater exposure potential, but their bodies may be more resilient as well.

The ontogeny of drug disposition also is nonlinear and therefore it is not possible to equate maturation of a specific organ system with a specific pathway for metabolism of a particular drug or environmental exposure. For example, different fields of research indicate that there is a window of vulnerability to infant botulism in children (30 days to 4 years of age) relating to digestive tract development. A completely different pattern is found for the drug diazepam, which is most efficiently metabolized at ages 1 to 30 days and the ability to metabolize it subsequently decreases with age. In addition, there are some drugs that will damage the liver in an adult but not in a child. There also are differences in disease impacts, with diseases such as chicken pox, polio, and Severe Acute Respiratory Syndrome being worse in adults than children.

There are many diseases of unknown etiology or mechanism, and some or all of these may involve environmental exposures. Examples include Sudden Infant Death Syndrome, pyloric stenosis from

treatment for chlamydia infections with systemic erythromycin, infantile colic, Kawasaki's disease, autoimmune diseases, nephrotic syndrome, Intussusception, appendicitis, asthma, and cancer. In reviewing cases of children, etiology or mechanisms of action or influencing factors are rarely discussed. These may be environmental and EPA work may help to address this issue.

Several examples were offered of the subtle effects of childhood exposure. These included potential changes in the Intelligence Quotient for each increase in blood lead concentration, behavioral problems in children who are prenatally exposed to tobacco if a certain allele is present, and cognitive impacts from mercury and other chemicals. Another example involved how cigarette smoke and other factors affect retention and performance in Kindergarten through the third grade, which correlated with findings that those who have problems in high school are already having difficulty in the third grade.

Genes, health services, environment, and behavior all contribute to children's health and ultimately to adult health. Key to understanding the impacts to children's health are: (1) children are different and sometimes are more sensitive, resistant, or resilient than adults, (2) generalities do not work, (3) there are critical windows of exposure, (4) animal models and juvenile models are critical to understanding things like tobacco exposure, (5) there are many uncertainties, (6) there are less data on environmental exposures than drugs, and (7) children in low socio-economic conditions are more vulnerable and may show greater effects for the same environmental exposure.

Highlights from the Columbia Center for Children's Environmental Health: Studying Air Pollution in Community Context

Virginia Rauh, with the Columbia Center for Children's Environmental Health, discussed research activities that examine the juncture of environmental and social sciences in partnership with NIEHS, EPA, and a number of private foundations. A primary interest of this Center is the health response from social and physical "toxicants."

Evaluations of exposure and susceptibility indicate that children and fetuses are quite susceptible, more so than adults. Exposures include air pollutants from fossil fuel, pesticides, environmental tobacco smoke, allergens, and social stressors. Susceptibility includes inadequate nutrition, genetic factors, and social stressors. Key questions involve what can cross the placenta to cause *in utero* effects and what factors make whole groups of children more susceptible.

Neural development and asthma are two endpoints being evaluated in a study of 730 mother and newborn pairs involving non-smoking African American and Dominican participants resident in northern Manhattan and the South Bronx in New York City. A high proportion of the mothers are single parents, who are on Medicaid, have little education, lack basic necessities, are poor (low income), and have an average age of 28 plus/minus 5.1 years. While the study group does not have much variability in income, there is a range in the levels of deprivation—some went without food, housing, clothing, and/or health care during pregnancy while others did not. This is material hardship and demonstrated how people do different things with money they have. The study involved the acquisition of air samples (via a backpack) and biologic samples (placental, blood, and urine, among others), as well as measurements of a variety of insecticides.

This study found significant pre-natal and post-natal exposure to polycyclic aromatic hydrocarbons (PAHs) from fossil fuels, pesticides (resulting from cockroach and other inner city type issues), and environmental tobacco smoke. A significant decrease in the air and blood levels of insecticides was found after an EPA regulatory action was taken in 2000. A significant number of participants reported at least one material hardship. This study shows that impacts occur from social conditions and chemical exposures, and those who can least afford it carry the biggest burden. In addition, there may be some

race/ethnic differences in patterns of socially stressful conditions that were found to exist despite similarities in educational level and income. These may be due to the support network or other factors.

The study also found, using biomarkers to indicate fetal exposure and differential susceptibility, that exposure occurs across the placenta. Prenatal PAH exposure is associated with decreased birth weight and head circumference among African Americans in this study. Lower birth weight, even in the normal range, is associated with adverse effects on health as well as physical and cognitive development.

The EPA pesticide ban implemented in 2000 appears to have had a measurable effect. A study reported in the news media indicated that birth weights increased after the EPA pesticide ban, and similar results were seen in the cohort study data. There were also some associations found between fetal growth and cord blood organophosphorus levels that also underscored the success of the EPA ban. Of note is that the City of New York has an integrated pest management program, which has a tremendous commitment to intervention, including intervention on an entire building to reduce pest populations thereby reducing antigen levels and morbidity in children.

Post-natal assessments are seeing cohort children with much delayed development in cognitive abilities, as well as a rise in the proportion with mild/moderate delay from 12 to 24 months. Also, a study by Bellinger showed increased effects of tobacco smoke exposure in low income situations. Other studies showed similar outcomes as a result of material hardships. This implies that socio-economically disadvantaged situations may have fewer mechanisms to offset the exposure than in a more affluent environment. In addition, material hardship may be a marker for exposure to other types of toxicants.

Conclusions from this initial study are that 100 percent of the babies in the study had prenatal exposure to multiple neurotoxicants; the children had increased risk including a significantly heightened fetal susceptibility to PAH-induced DNA damage (on order of 10-fold); there were adverse effects from prenatal exposure PAH, pesticides, and environmental tobacco smoke on birth outcomes; there are direct benefits of pesticide regulation on fetal development; and there is evidence for interaction between PAH-DNA adducts and environmental tobacco smoke on fetal growth. In addition, conclusions are: environmental pollutants are disproportionately distributed in society; pollutants rarely occur in isolation, so environmental risk is cumulative; processes thought to link social conditions and health frequently involve adverse conditions; socially and physically toxic exposures are stressful; and there is emerging evidence that such interactions are biologically based.

Future directions for this research include expansion of the size of the cohort to follow the children through age 78. Researchers are also trying to incorporate additional biomarkers using genomic and proteomics, and to incorporate additional biologic measures of response to psychosocial stress.

The take home message is that researchers must begin to consider the social context when framing environmental research so there is access to these other measures, the need to consider biomarkers of social stress, and the possible use of genomics to obtain some of these answers. There also may be a need for a national cohort study and to examine all social conditions in order to understand the finer gradations.

More information on the Center for Children's Environmental Health, Columbia University, Mailman School of Public Health can be found at http://www.cumc.columbia.edu/dept/sph/ccceh/index.html.

The National Children's Study

Carole Kimmel, with NCEA, provided an overview of the National Children's Study, its current status, and planned activities. This effort began with a Presidential Executive Order in 1997 that led to the President's Task Force on health risks and safety risks to children and the planning of a national

longitudinal study of environmental influences on children's health and development. Passage of the Children's Health Act of 2000 authorized the Director of the National Institute of Child Health and Human Development, together with EPA, CDC, and later NIEHS, to conduct this study.

The National Children's Study is a high quality longitudinal study of children, their families, and their environment, involving about 100,000 participants from before birth to adulthood. This study is national in scope and will look at a common range of environmental exposures; less common outcomes (such as autism); chemical, biological, and psychosocial factors; and the basic mechanisms of developmental disorders, environmental risk, and genetic expression. State-of-the-art technology will be used to track, measure, and manage data.

This study will address issues important to health risk assessment, including understanding of the following:

- Ranges/types of exposures throughout development
- Role of environmental factors in children's health
- Contribution of exposure to the burden of disease in children
- Long-term health effects from early exposure of children and their parents, such as asthma, cancer, cardiovascular disease, obesity, diabetes, and neurologic conditions that are all linked to environmental factors in early development.

The study will also address factors that alter susceptibility to environmental agents, immune deficiencies and increased risk of asthma, early allergen exposures enhancing immune function, differences in responses to environmental exposures by age or life stage, effects of aggregate exposures to a chemical or cumulative exposures, and disparities in health outcomes due to race, ethnicity, poverty, housing, etc.

Study efforts began in 2000 with a pilot study and methods development work. A 5-year planning effort is underway with the full study anticipated to begin at vanguard centers by mid-2006. Current activities involve the finalization of specific hypotheses and development of the study design. Once the full study begins, data analysis will occur regularly, with data distribution anticipated to begin by 2009-2010. The study will continue to collect data through 2030.

Protocol development has focused on when to contact participants and collect samples, what measures to look at, sample design, and selection of geographic locations and participants. Timing of recruitment is another aspect of protocol development. The desire is to acquire participants at the preconception stage (helpful to establish conditions before pregnancy), early in pregnancy (less than 4 weeks), and later in pregnancy.

A number of workshops have been held on specific issues to consider in this study and how to measure them, such as mild traumatic brain injury incidence/outcome, placental measurements, psychosocial stress effects on pregnancy and the infant, physical activity, herbal and dietary supplements, effects of media on activity/behavior, impact of rurality, sampling design, estimating date of conception, possible roles for inclusion of a study of cancer markers, measurement of maternal/fetal infection and inflammation, questionnaire and diary-based methods for early assessment of asthma-related health outcomes, gene-environment interaction, and the regulation of behavior. These activities are ongoing and there will be additional workshops.

Methods development activities and pilot studies are focused on developing low-cost, low-burden methods and alternative exposure measurement (validation) designs, methods for newborn assessment, utility of frozen breast milk, feasibility of using 3-dimensional ultrasounds for fetal assessment, methods

to elicit community involvement, subject recruitment and retention, and lessons learned from EPA/NIEHS children's environmental health center research on outcomes and exposure useful to this study.

The information technology infrastructure is in development and the scientific support from NIH and EPA is in place. Procurements are anticipated to be issued and awarded during the next year for a clinical/data coordinating center, biological/environmental sample studies, laboratory services, and vanguard sites.

Approximately $20 million was allocated for the planning phase through FY03. Startup (FY04-05) has a budget of approximately $12 million for this year with $26 million estimated to be needed for FY05. Implementation during FY05 through FY29 is estimated at $2.7 billion over the 24 year period.

Additional information may be found at the Web site at http://NationalChildrensStudy.gov. Interested parties may join the List Serve for news and communication.

Wrap Up and Discussion

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) inclusion of indoor and outdoor air in the Children's Health Study; (2) the correlation of vaccinations to children's health and potential side effects, which is not a primary question of the Children's Health Study; (3) opportunities for involvement in the Children's Health Study and its workshops with suggestions to contact the study developers via the Web site; and (4) an August time frame for the Science Forum proceedings to become publicly available.

Sustainability – Educating for the Future

Following opening remarks by Alan Hecht, Director of Sustainable Development within ORD, four speakers addressed current initiatives in sustainability education. An audience question and answer period followed the presentation.

Education for Sustainability Initiatives

Alan Hecht, Director of Sustainable Development within ORD, discussed education and capacity building within environmental sectors. According to Dr. Paul Gilman, ORD Assistant Administrator and EPA Science Advisor, "There is nothing more essential in moving toward the long-term goal of sustainability than teaching the next generation how to incorporate sustainability principles into their work."

Part of ORD's mission is to further information and education. Training the next generation and sharing information today is essential and requires that today's decisions be based on sound science and research. ORD education and sustainability initiatives are based on the themes of capacity building, professional training, Kindergarten through Grade 12 foundations, and public education and communication. One huge step in achieving educational and sustainability goals was ORD's participation in the World Summit for Sustainable Development, in Johannesburg, South Africa in 2002. This was an important event because the Institute for Sustainable Development was created during the summit, an effort led by the Smithsonian Institution, NOAA, USDA, NASA, and EPA. While Congressional participants and policy makers determined action plans during the summit, other participants attended educational workshops and training. Training manuals and educational materials that could serve as model materials for many organizations were available to participants.

The world faces many challenges in sustainability:

- 2.8 billion people live on less than $2 per day
- 1.1 billion people lack safe drinking water
- 2 billion people live in areas without access to modern energy supplies
- 2.3 billion people live in areas that lack access to sanitation
- 3 billion additional people by 2050 with 99 percent of these in developing countries.

These statistics result from the lack of information and education, not just technology.

Social marketing can enable improvements in these situations and, therefore, non-governmental organizations, CDC, and other agencies are educating communities on how to maintain clean waters in the home, globally. In Zambia, social marketing resulted in a disinfectant sales increase from 3,558 in 1998 to 1,107,168 in 2002.

Another initiative involves the United Nations' Decade of Education for Sustainable Development whose goals include:

- Promote and improve high quality, relevant basic education
- Reorient existing education policies and programs to address social, environmental, and economic knowledge
- Develop public understanding and awareness of the principles of sustainable development
- Develop training programs to ensure that all sectors of society have the skills necessary to perform their work in a sustainable manner.

To further these efforts, EPA is promoting the following initiatives for the next generation: student design competition, engineering and chemical school curricula, information and tools kits, university and schools as centers for sustainable operations, and a *Report on the Environment*. One effort in supporting these next generation goals is the P3 award, which ORD is promoting by sending requests to schools to design new technologies to address sustainable development issues. The United States Peace Corps and the National Academy of Engineering participated with this effort as well. Submissions from students have just been received, and the first competition for the award winners will be hosted sometime next year. This has served as an education experience, as well as an educational tool. More information on the P3 award initiative is available at http://www.epa.gov/P3. Other outreach efforts include:

- The EPA and the National Science Foundation sponsored workshop at the National Academy of Engineering, *The Engineer of 2020, Visions of Engineering in the New Century*
- ORD's request for proposals in supporting the effort, *Benchmarking the Integration of Sustainability into Curricula at Colleges and Universities*, to stimulate more discussion on sustainability at Untied States universities and schools
- ORD's report *Science and Technology for Sustainability, P3: Promoting prosperity, benefiting people, protecting the planet.*

More information on ORD efforts in achieving and promoting sustainability awareness can be found at http://www.epa.gov/sustainability. This Web site provides a road map for all program offices to provide information on practicing sustainability, planning for sustainability, and measuring sustainability efforts.

Every EPA program office should be credited for their efforts in education and sustainability awareness. Their research and data gathering efforts can be seen at the EPA Envirofacts Web site, the one-stop

source for environmental information. Capacity building, training the professionals, and educating the public are three essential efforts in ensuring sustainability.

Principles and Practice of Sustainability Education in Schools

Jaimie P. Cloud, President of the Sustainability Education Center, Inc., discussed the education of students on sustainability. The Sustainability Education Center provides a foundation to educate for a sustainable future. When considering students, the Center hopes to answer the questions:

- What would students know, be able to do, and be like if they were educated for a sustainable future?
- What habits of mind will they demonstrate?
- What core content will they study?

When considering schools, the Center hopes to answer the questions:

- What are our schools already doing?
- What do our schools need to do differently?

Environmental and sustainability awareness and education have grown slowly but surely over the past years, beginning with *Silent Spring* which was published in 1962. When considering student education on sustainability, the Center is considering what habits of mind students will demonstrate, such as: understanding of systems as the context for decision making, intergenerational responsibility, understanding the implications and consequences of actions, protecting and enhancing that which we all hold in common or for which we have common responsibility, awareness of driving forces and their impacts, assumption of strategic responses (we want youngsters to take responsibility for their actions), and paradigm shifts.

In order to integrate sustainability awareness, the following core content areas are recommended for inclusion in the school curricula:

- Ecological literacy (i.e., mimicking the way the world works)
- System dynamics and "systems thinking"
- Multiple perspectives
- Place (i.e., what lives here with me)
- Sustainable economics
- Citizenship (e.g., participation and leadership)
- Creativity and visioning of the future and the bigger picture.

Within these core content areas, it is important to include environmental science and education, sustainable economics, and social awareness (e.g., global, ecological design and architecture education, holistic education, future studies, organizational learning and change, environmental ethics, and philosophy).

Currently, many schools in the United States are concentrating on state content and performance standards, applied research on instructional methodologies, improving student experience in the classroom, and utilizing the community as a resource. Also, there is a big movement in authentic instruction that would enable students to feel as if they are doing work and learning educational skills for a real reason or for the purpose of individual education.

To support these efforts, the Sustainability Education Center provides leadership training of school administrators and teachers, helps to develop curriculum materials, builds capacity, assesses teacher and student outcomes resulting from sustainability outreach efforts and research and development activities. The Sustainability Education Center first based its efforts and activities on global education, but began to concentrate on sustainability in 1995. Currently, the Center provides sustainability and other training to teachers in order to connect standards and the real world in the classroom and to provide information on the mathematics of global change. As motivation for teacher participation, the Center's training classes also provide education credits for teachers, which should positively impact teacher salaries. Another step for the Center is to develop partnerships with other schools, communities, government, and industry, as well as a partnership with the Society for Organizational Learning.

Selected teacher learning outcomes resulting from these training classes include changes in knowledge and attitudes about sustainability, teaching practices, and behaviors related to consumption patterns, materials cycling, and political involvement. In the future, the Center hopes that selected student learning outcomes resulting from sustainability awareness and teacher training will include:

- Understanding the concept of sustainability and its application in business practices
- Understanding and applying systems thinking into business plans
- Recognizing the moral and ethical, social, and ecological reasons for sustainable business practices
- Developing the ability to think critically and systematically
- Thinking creatively in terms of problem solving and decision making
- Demonstrating collective respect for oneself and the commons
- Developing an awareness of human choices and their consequences.

This new method of education needs to cross over to other disciplines (e.g., business), not just science, in order to get sustainability to the forefront. Also, the Federal government is encouraged to provide continued forums for discussion and mechanisms to coordinate and encourage Federal agencies to support education for sustainability in Kindergarten through grade 12; create education for sustainability centers around the country to serve as clearing houses for information, research, practitioners, and to host conferences and trainings; and provide legislation for funds to encourage sustainability education.

Many organizations currently are supporting these efforts within school systems across the country, including the Foundation for Our Future, Northwest Environment Watch, New Jersey Sustainable School's Network, Vermont Department of Education, Creative Change Educational Solutions, Creative Learning Exchange, National Science Teachers Association, and the Lawrence Hall of Science (University of California, Berkeley).

More information on the Sustainability Education Center can be found at http://www.sustainabilityed.org.

National Efforts in Sustainability Education

Alan Elzerman, with Clemson University, discussed sustainability education, which includes participation by educational institutions, government agencies, non-government organizations, not-for-profit organizations, businesses, professional societies, and others. Sustainability goes beyond environmental education. There is no single prescription for sustainability, and there is no one curriculum.

Sustainability education is analogous to environmental protection. There is a need for a global perspective and, therefore, there is a need to look beyond the United States. In addition, scientists and engineers must look at systems approaches to address questions about quality of life and how to evaluate it, as well as whether risk assessment is necessary or sufficient.

The term sustainability means " to meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987). There are a number of other definitions of sustainability, such as understanding the consequences of our decisions and actions, giving thoughtful consideration to input from and impact on all systems and people affected, and making rational choices.

In order to achieve sustainability, it is necessary to understand its links with economic security, ecological integrity, and social equity, which differs from environmental education.

Highlights of sustainability efforts in higher education include:

- A tremendous variety of structures, characteristics, components, approaches, and compositions of education programs
- Diversity, which requires understanding commonalities, goals, needs, and how to benefit from one another
- Curriculum, core competencies, and professional issues that require discussion, definition, and focused efforts.

The objectives of the Council of Environmental Deans and Directors are to assure that the members of universities know the environmental, social, and economic impacts of their actions on the world. It is intended that the universities will serve as models for sustainability. There are a number of state programs supporting these efforts, as well as not-for-profit organizations and non-government groups, including the National Council for Science and the Environment.

In order to achieve all of these goals, scientists, engineers, professors, teachers, and decision makers must use creativity, encouragement, guidance, cross-fertilization and coordination, empowerment, and metadisciplinary education. They must also communicate sustainability concepts to the public and foster business leadership of sustainable practices.

Building Partnerships for Sustainable Science Education

Sally Shuler, with the National Academies of Science and the Smithsonian Institution, Director of the National Science Resource Center (NSRC), provided background on the NSRC and suggested several mechanisms to incorporate environmental education and sustainability awareness into the education curriculum. The goal of NSRC is to improve the learning and teaching of science in the nation's 16,000 school districts. All students should have access to a research-based program that will lead to improved attitudes about science.

Approximately 760 school districts have participated in NSRC-supported activities in order to develop infrastructure changes. Infrastructure changes begin with the teachers and administrators to achieve improvements in teacher performance and student achievements. For example, in the State of Washington, effective changes in the infrastructure are improving student education in science because of their involvement with NSRC. Within all school districts, there are several stages for integrating environmental education and sustainability awareness into their programs. The first step is initiation (1 year), then implementation (5 years), and then institutionalization (10 or more years).

The current state of science education in schools is poor. In the past, most children grew up on farms and had real interaction with life and death, hard work, etc. and, therefore, understood how science and the environment affected everyday life. Now, children have no concept of life cycles, science, the environment, or the general idea of how things work in the world. The number of children and young adults pursuing careers as scientists and engineers is steadily declining. Students in the United States are last in the world in science education. The United States' best advanced placement students are last in the world when comparing test scores. Therefore, we need to improve on many things, starting with education.

The answer to moving forward and pursuing the vision of improving science education and sustainability awareness is valuing science and teaching in this country. Partnering with the business community to bring science to the forefront in the educational curriculum is the first step to achieving this goal. There is a need to form private and public sector partnerships. Students must increase their interest in science, teachers must demonstrate the wonder of discovery while helping students master the rigorous content of science education, and education boards must acknowledge the professionalism of teachers.

What is being suggested is a revolutionary, comprehensive system change, placement of science education programs in Kindergarten through grade 12, and development of thinking skills and sustainable themes in students' efforts. There is no longer a need for pilot projects and curriculum building. Efforts only need to be placed on what is working now and simply scale them up to a national level.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the need to include both science education and engineering education in improved curricula in the nation's schools; and (2) improvements in economics education in Kindergarten through grade 12 curricula.

Partnering with New York on Air Quality and Human Health: Issues, Challenges, and Perspectives

Following opening remarks by Val Garcia, with NERL, six speakers addressed the relationship between air quality and human health.

Federal-State Partnerships for Enhanced Understanding of Air Quality and Health Relationships

Dr. S.T. Rao, with NERL, summarized the Agency's current need to understand air quality and human health relationships. NERL partnered with EPA regions; state, tribal, and local governments; and other organizations in a collaborative effort for air quality studies in New York, North Carolina, and the Western United States. Through these partnerships, NERL hopes to facilitate the use of air quality planning applications through grid computing, prototype air quality forecasting for PM 2.5 (New York only), and assist in surveillance of human health-air quality relationships (New York only). This work also is being supported by other agencies within the Federal government, as well as internal EPA partnerships.

For the New York pilot study, NOAA and EPA will provide remote access to daily air quality forecast guidance for ozone. The State of New York will develop local forecasts and inform the public about mitigation actions, and will apply the Community Multi-Scale Air Quality (CMAQ) model to prototype predictions of PM 2.5 and other pollutants. In addition, NASA and NOAA will work to improve air quality modeling and forecasting of PM 2.5.

The actual data used in these modeling efforts are the most critical pieces. In support of these pilot studies, EPA has a substantial number of air monitoring sites to gather actual data. However, there are limitations with the data. For example, some measurements are taken weekly for PM 2.5, and the networks are sparse rather than dense. There are approximately 1,000 stations for monitoring ozone across the United States, but this is not the case for PM 2.5. Also, the PM 2.5 monitoring sites that do exist are in urban areas only because of the higher levels of pollutants expected in these areas.

There are tools and methods that are statistically acceptable to use for modeling with actual data, but problems exist because of the lack of data stations. Also, there are issues with different data sources (i.e., data from different networks) that have been gathered using different methodologies and protocols. In addition, there are uncertainties such as clouds and other media that interfere with data collection from satellites. Modeling tools are useful in simulating air quality levels. However, the usefulness and efficiency of the modeling tools depend upon model input and data quality.

Enhanced tools (e.g., optimized CMAQ and satellite data) and information technology methodologies (e.g., grid computing) should be used to improve air quality applications. Air quality applications that could benefit from such enhancements include policy analysis, state implementation plans, air quality forecasts, public health tracking, and detecting and tracking progress of the air quality applications. Gathering and publishing air quality enhancement program information on a routine basis will help the public as Federal, state, local, and tribal governments, as well as other stakeholders, can then assess the progress made by the Agency and its partners.

Environmental Public Health Tracking and the Public Health Air Surveillance Evaluation Project

Vickie Boothe, with the CDC National Center for Environmental Health, described CDC's Environmental Public Health Tracking Program and the Public Health Air Surveillance Evaluation (PHASE) Project. In response to findings of the Pew Environmental Health Commission stated in the *Environmental Health Review 2001 Report* in 2001, CDC established the National Environmental Public Health Tracking Program, two Centers of Excellence (Johns Hopkins University and Tulane University), created planning and capacity building activities, and established infrastructure enhancement and data linkage demonstration projects in several states. Most of the funding went to the state partners to obtain community input on priorities, implement programs, and track progress.

The Environmental Public Health Tracking Program is an ongoing, systematic evaluation used to track hazards, exposures, and health effects, and to get this information back to the stakeholders and decision makers. The Program focuses on chronic diseases and others with possible environmental etiology (non-infectious), provides information to address the effects of exposure and disease, and provides for surveillance (tracking) of the data rather than data research. The Environmental Public Health Tracking Program will provide the results, not the causes driving the data.

The conceptual model by which an environmental agent produces adverse effects is as follows: (1) an environmental contaminant effects air, water, food, and soil; (2) humans are exposed to these media by external exposure, absorbed dosage, or targeted organ dosages; and (3) once exposed, humans may suffer from subclinical effects, morbidity, or mortality related consequences. The Environmental Public Health Tracking Program will provide hazard tracking (i.e., tracking environmental contamination and contamination of media types), exposure tracking (i.e., tracking how humans are exposed to these environmental agents), and health effect tracking (i.e., tracking human health effects resulting from exposures to environmental agents). With this Program, CDC hopes to identify populations at risk; respond to clusters, outbreaks, and emerging threats; examine relationships between health effects and

hazards; guide and evaluate interventions and prevention efforts; identify, reduce, and/or prevent harmful environmental risks; and develop and disseminate information to policy makers and the public.

CDC also determined the need to evaluate whether different air quality characterization methods improve capabilities for tracking environmental public health. Therefore, CDC established the PHASE project to develop and evaluate alternative air quality characterization methods for environmental public health tracking. This involves the study of air pollutants (e.g., ozone and PM 2.5) and health endpoints (e.g., acute cardiovascular diseases and asthma). Three state partners support the PHASE project—Maine, New York, and Wisconsin.

EPA is seeking better ways to measure the success of its programs and these projects offer new possibilities for improving the characterization of air quality data. Such new approaches may improve our ability to understand relationships between air quality and public health.

NOAA-EPA's National Air Quality Forecast Capability

Paula Davidson, the National Weather Service (NWS) Program Manager for Air Quality Forecasting at NOAA, described efforts to predict ground-level concentrations of ozone. The initial goal of the National Air Quality Forecast Capability project is to develop 1-day forecast guidance for ozone. The guidance will be developed and validated in the northeastern portion of the United States by September 2004 and deployed nationwide within 5 years. The intermediate goal (5 to 7 years) is to develop and test capabilities to forecast PM 2.5 concentrations. The longer-range goal (within 10 years) is to extend the air quality forecasting range to 48 to 72 hours and to include a broader range of significant pollutants.

The National Air Quality Forecast Capability project is based on an initial operating system that includes a linked numerical prediction system, gridded forecast guidance products, verification basis, and customer outreach and feedback from state and local air quality forecasters as well as public and private sector air quality constituents. The linked numerical prediction system utilizes data from NOAA and the National Center for Environmental Prediction that are drawn from weather observations and EPA emissions inventory data, as well as data from the EPA Data Management Center. The prediction of ground-level ozone concentrations will be based on 1-hour averages.

During 2003 to 2004, NWS developed an end-to-end integrated weather-air quality forecast model system; conducted real-time test runs through September; analyzed system performance and identified upgrades needed for pre-deployment testing in 2004; and has been testing potential upgrades for improved performance utility. In the summer of 2004, NWS is preparing to deploy initial operational capabilities, engage in parallel testing or evaluation of expanded "developmental" domain, and experiment with coordination between NWS forecasters and air quality forecasters outside of NWS and EPA.

Overall, NOAA hopes to produce air quality forecast guidance twice daily. The experimental forecast products should be placed on NWS and EPA data servers in the summer of 2004 with gridded data (grids approximately 12 kilometers in size) evaluated on an hour-by-hour basis through midnight, providing data the next day. In September 2004, the products will be provided and tested in the Northeastern United States, and in 5 years, expanded to a nationwide level.

Further information on the status and progress of the NWS National Air Quality Forecast Capability can be found at http://www.nws.noaa.gov/ost/air_quality.

Air Quality: A Regional Perspective

Kenneth Colburn, with the Northeast States for Coordinated Air Use Management, provided a regional perspective on the use of technology and innovations to better public health and the environment. Historically, environmental protection grew out of public health concerns. As science and engineering progressed, environmental protection and public health systems grew further apart and have almost become stand-alone areas. The outcome of this separation is the lack of traceable environmental public health tracking. Currently, there are trends in combining and relating these two global concerns, and Federal, state, tribal, and local governments, as well as not-for-profit organizations and other stakeholders, have been closing this gap.

The overall vision for EPA is to bridge the gap between the two disciplines by building infrastructures and partnerships, increasing greater air quality standard data accessibility, and providing more surveillance and accessibility to the states and air quality forecasters. Implementation is not simple and requires communication and partnerships among Federal, regional, and state agencies.

For regions, there are issues that must be addressed in order to support the partnerships between Federal and state agencies. Many air quality problems are increasingly regional, and few states find it possible to run the CMAQ model and address air quality standards. Also, greater in-house expertise is needed in order to analyze, interpret, and apply monitoring and modeling data to exposure assessments. The regions will need to address:

- Economies of a scale and leveraging scarce resources into broader geographic coverage
- Consistent, coordinated building blocks of monitoring, modeling, and public health data to be developed under one roof
- Research, development, and coordination of regional regulatory response strategies
- Need for some original research.

There is also the concern of being able to identify all areas geographically. An example involved a carbon black incident that took place in a small town near Boston, MA. Air quality forecasters could not provide the public with the appropriate information regarding environmental and public health effects of the incident because the town was not included in air quality surveillance. This brings up the question of how to interpret, track, and make available environmental and public health data when a specific location is not on the map in the first place.

In order to address these challenges, the following recommendations were offered:

- Monitoring sites for environmental public health tracking and NAAQS
- Identifying and prioritizing the best regulatory strategies and workplace practices to reduce exposures and improve public health
- Improving the effectiveness of environmental public health messaging
- Demonstrating public health benefits.

It is important to involve regional organizations to expedite the improvements and advancements desired. However, government agencies and other parties must target education and intervention programs in order to ensure success of the effort. Also, there is the need to develop and integrate public health accountability practices "up front" into air quality regulatory processes. Finally, there must be effective public health communication that provides information to the public in an understandable manner.

Air Quality Management and Challenges in New York State

Robert Sliwinski, with the New York State Department of Environmental Conservation, provided an overview of the air quality management program in New York administered by the Division of Air Resources, which has about 280 technical and scientific staff in nine regional and central offices. The Division of Air Resources reports air inventories to EPA, maintains and manages a monitoring network of more than 50 sites that are located in urban and remote rural areas, and conducts measurements of air toxics and acid deposition as well as criteria pollutant monitoring. Throughout the State, the Division of Air Resources controls 25 continuous PM 2.5 monitors and 32 ozone monitors.

The State's criteria pollutants, including lead, sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM 10, all meet NAAQS. Ozone and PM 2.5 are the only pollutants exceeding national standards. Designation of the attainment/non-attainment areas is ongoing with the State Implementation Plans due in 2007 and 2008.

The State of New York has many air pollution control programs, including Reasonably Available Control Technology, Low Emission Vehicle, Inspection/Maintenance, Title IV, NOx State Implementation Plan Call, Summer Fuels for Upstate, Governor's Acid Rain Initiative (2005 to 2006 timeframe), Regional Greenhouse Gas Initiative, and the Ozone Transport Commission model rules for volatile organic compounds and NOx. Another big initiative involves programs targeting dry cleaners to help use closed loop systems, decrease the amounts of harmful chemicals used, and apply better chemical disposal methods.

The State of New York also faces a few challenges with their air quality work. Currently, the State has recognized that pollutant transport into New York is a major concern. This requires an assessment of the 8-hour ozone concentrations and PM 2.5 issues. There is a lack of data on PM 2.5, which makes it difficult to control. In addition, there is an increased effort in gathering toxics emissions to address acute and epidemiological problems. The Division of Air Resources needs to maintain a balanced approach between monitoring air toxics and criteria pollutants under the proposed regulatory framework.

In the future, the State of New York may see a reduction in funds for air quality monitoring programs, which would require the Division of Air Resources to focus on only a few criteria pollutants. Therefore, New York, as well as other states, may not be able to maintain current or future monitoring systems. With this in mind, modeling, not monitoring, will be the answer to air quality concerns.

Health Activities Related to Air

Dr. Nancy Kim, with the New York Department of Health, provided an overview of the Department's activities in outreach and education, responding to health concerns, conducting research, and establishing an environmental public health tracking system.

Outreach and education activities include efforts with CDC for a several years to determine and communicate exceedances of standards. The New York Departments of Environmental Conservation and Health provide this information in press releases and notifications to the public through State, regional, and local health department contacts; the New York Department of Education; and other interested individuals. The Department also provides Web publication of health effects and health trends so that the public has access to this information. Other State agencies can use this information as well; for example, the New York Department of Transportation uses this information to change work practices if there are air quality warnings to consider.

Research activities include a study of air contaminants and acute asthma attacks in urban areas, the Breathe Easy Project, and studies of childhood asthma hospitalization trends and ambient air sulfur dioxide concerns in the Bronx in New York City.

The Department of Health's efforts in responding to health concerns involve issuing unscheduled air releases, addressing odors and visible emissions complaints, and addressing requests for health studies. For example, in one incident of reported fog and visible emissions from a nearby manufacturing plant, residents of a small town participated in a community study and used the Bucket Brigade method (5-gallon buckets, pumps, and Tedlar bags) to obtain samples to document emissions episodes. The results of the study showed that samples taken with the Bucket Brigade method were higher than the annual average values for methylene chloride, toluene, ethylbenzene, and xylenes. Another example involves concerns that exposure to operations at a nearby stone quarry could result in cancer, asthma, lupus, and other auto-immune diseases. The Department of Health conducted two incidence studies and found trends in cancer incidences and hospital admissions for asthma and other respiratory diseases.

The Department of Health's environmental public health tracking activities include the following:

- Linking ambient air pollution data to reproductive outcomes, asthma development, and childhood death in focused study areas
- Investigating the association between health outcomes and air pollution throughout the State
- Tracking the space-time patterns in asthma and air pollution throughout the State
- Using maps, graphs, and spatial statistics to identify patterns and trends in time and space
- Testing for associations between air pollution and asthma hospitalizations using regression and other statistical models.

State-of-the-Science Research on Swimming-Associated Health Effects and the Translation of Health Data to Water Quality Guidelines for Bathing Beaches

Following opening remarks by Alfred Dufour, with NERL, three speakers addressed research and epidemiology studies of human health impacts from the use of recreational waters. An audience question and answer period followed the presentations.

The National Environmental and Epidemiologic Assessment of Recreational Water: The Relationship Between Novel Indicators of Water Quality and Health

Tim Wade, with NHEERL, introduced the National Environmental and Epidemiologic Assessment of Recreational Water project supported by ORD, with participation by NHEERL, NERL, and CDC. This project hopes to determine whether there is an association between illness and recreational water quality as measured by rapid methods of determining water quality (i.e., methodologies supplying results in less than 2 hours).

Prompted by the Beach Act of 2000, NHEERL was tasked to determine microbial indicators for beach water quality, develop efficient protocols for monitoring, assess human health risks, and provide guidance to beach managers. The overall approach to the National Environmental and Epidemiologic Assessment of Recreational Water project includes water sampling during the summer weekends, and interviewing and surveying beach-goers to establish background health assessments. Participants were contacted by telephone 12 days after initial contact in order to evaluate their health conditions.

Two fresh water beach sites on the Great Lakes were involved in the 2003 study: one near the Great Lakes National Park on Lake Michigan and one near Cleveland, OH, on Lake Erie. The sites are examples of fresh water sources vulnerable to point-source human contamination. They also have large populations. Researchers did not target any specific population or ethnic group during interviews and surveys.

Testing of the fresh water occurred at 8am, 11am, and 3pm, and samples were taken at two different depths at each site—0.3 meters and 1.0 meters. Six samples were collected at each time during the day. Methods used for water quality testing included *Enterococci* Method 1600 and a DNA-based quantitative (real-time) polymerase chain reaction (QPCR) method for *enterococci* and bacteroides. Both methods used intestinal tract bacteria.

Researchers also categorized human risk exposures as "any contact" with water; "body contact" meaning that the body is immersed in water, and "head under" meaning that the total body, including the head, is under water. Health outcomes identified in this study include gastrointestinal illness, skin rash, ear ache, eye irritation, and respiratory illness.

Event sampling, as well as interviewing and sampling took place from May 31, 2003 to August 3, 2003 at Lake Michigan and from July 27, 2003 to September 14, 2003 at Lake Erie. The Lake Michigan study resulted in 20 days of surveying and 2,877 completed interviews, while the Lake Erie study resulted in 16 days of surveying and 2,840 completed interviews. The studies held 67 percent and 60 percent completion rates, respectively.

Data analysis showed that for most days of the study the indicator concentrations were well below the geometric means. At Lake Michigan, there were only 3 out of 20 days where exceedances of the current fresh water standards (33 colony forming units/100ml) occurred. At Lake Erie, the water quality was worse. A total of 6 out of 16 days of sampling had exceedances of the current standards. Also, the relationship between the QPCR (measuring bacterial DNA) and *enterococci* Method 1600 (measuring *E. coli* colonies) laboratory protocols were well correlated, but not exact.

Finally, survey results of the two sites showed that swimmers engaged in recreational activities at very different levels. For example, at Lake Michigan, 75 percent of the swimmers had "any contact" with the fresh water, whereas only 46 percent of the swimmers did at Lake Erie. "Body contact" with the fresh water differed too. At Lake Michigan, 58 percent of the swimmers had "body contact" with the fresh water, whereas only 27 percent of the swimmers did at Lake Erie.

This study found that there is increased risk for illness for swimmers over non-swimmers, with swimmers 2.2 times more likely to have gastrointestinal illness. Rash was also commonly associated with swimming.

There is preliminary evidence that QPCR appears to be a promising predictor of gastrointestinal illnesses from fresh water exposure. Trends were not observed for respiratory illnesses or for rash, ear ache, or eye ailments, but more data may be necessary to evaluate this further.

Epidemiology Study of Swimmers in Nonpoint Source Polluted Marine Recreational Waters from San Diego, California

Kenneth Schiff, Deputy Director of the Southern California Coastal Water Research Project (SCCWRP), and Jack Colford, with the University of California at Berkeley, discussed the complexities of non-point source pollution (i.e., animal contamination) in marine recreational waters. Southern California has a tremendous amount of beach use with approximately 175 million beach-goers visiting the area's beaches

yearly. The largely growing tourism population brings in money, and money brings more industry and businesses. Therefore, there is a constant effort to keep the waters clean. The State of California spends $3 million each year in beach monitoring.

Another result of largely populated areas is a large amount of sewage disposal. Most of the treated sewage is discharged more than five miles offshore, and is not really affecting the marine recreational waters. The questions are where is the contamination coming from and whether it is from animal waste.

Because there are a number of announced beach closings, there is an effort to find out the causes and effects of the contamination seen in Southern California beaches. One beach highlighted in this discussion was Mission Bay, which is a heavily used aquatic park that has no discharges. However, Mission Bay had more than 100 days of beach postings for contamination in 1998. Mission Bay has numerous storm water drains, and wildlife (e.g., birds) serve as another possible non-point source of contamination.

SCCWRP aims to answer the following questions:

- Is there a health risk of swimming in Mission Bay? This question can be answered by comparing the exposure level and health of swimmers versus non-swimmers at Mission Bay.
- Can we relate the health risk to traditional health indicator (e.g., bacterial indicator) concentrations and non-traditional health indicators (e.g., virus and phage, as well as bacteriodes and *enterococci*)?

The first step in this research involved a pilot study to determine when and where most swimming occurs. The design of this coastal water project mimics the National Epidemiology Study and requires use of intensive water quality measurements to describe exposure. SCCWRP utilizes an almost identical questionnaire in order to compare study results to other beach studies.

The pilot study included helicopter surveys of swimming activity and a focus on six beaches to represent over 75 percent of the swimming activity. Since historical water quality trends prove unpredictable in forecasting in space and time, sampling was conducted at all times of the day. At each of the six sites, project researchers, set up study centers and approached beach-goers with a short questionnaire. After obtaining contact information for study volunteers, project researchers contacted the volunteers within 2 weeks to ask about illnesses possibly resulting from their recreational water exposure and to complete a 30-minute questionnaire.

At each site, project researchers visited every weekend and holiday during the summer in order to get a good number of people to participate. The goal was to involve 8,000 beach-goers during the summer. Researchers achieved about 70 percent participation from the volunteers from beginning to completion of the entire project.

In the study results, there were approximately 5,000 swimmers, while approximately 600 of the participants were non-swimmers. The participants were largely Hispanic, followed by Anglo-Saxon, and then others.

Study results showed that peak swimming times occurred during 12pm to 4pm. Therefore, peak sampling events occurred during the same time. The researchers sampled hourly from 12:30pm to 3:30pm, and also obtained grab samples (e.g., single beach composite samples) at 12:30pm.

Preliminary water quality analysis showed that most of the study beaches were clean, based on *enterococci* concentrations. Also, researchers found that beach water quality suffered during peak

vacation or holiday times (i.e., July 4) and that there was a random generation of contamination from non-point source pollutants.

The next steps for the SCCWRP are to examine other factors contributing to the random generation of contamination from non-point source pollutants and to attempt to determine if an actual point source leads to contamination. For example, results show that there is an increase in *enterococci* concentrations that directly correlates to an increase in the number of people at the beach. In the next phase of this project, researchers will address whether higher values of *enterococci* only result when there are more people at the beach, and whether the higher values result from accidental fecal releases in humans or result from more animal waste (e.g., seagulls waste) since humans bring more food to the area, which could lead to more food for the seagulls.

Also, researchers must compare the uses of indicators in this marine recreational water study and address whether study results indicating human health effects and illnesses depend on traditional bacterial indicators, such as *E. coli* and *enterococci*, or newer bacterial indicators, such as bacteroides. In the next phase, researchers will attempt to determine if using different sampling and laboratory methods affect study outcomes. Questions to consider include whether the laboratories should rely on membrane filter or IDEXX methodologies and whether researchers would benefit from using composite samples.

Additional steps in this research project include the commencement of epidemiological data analyses in August 2004, a presentation of SCCWRP at the National Beach Conference in October 2004, and completion of the final SCCWRP report in December 2004. More information on SCCWRP may be found at http://www.sccwrp.org.

Partnerships: Linking EPA Beach Research with State and Local Beach Programs

Rick Hoffmann, with the Office of Water, reviewed EPA efforts to address the requirements of the Beach Act to improve quality within the United States beach waters. EPA was prompted to tackle the beach water issues because of inconsistent recreational water monitoring and notifications provided to the public. The Agency was also concerned with the fact that there were inconsistent standards among the nation's beaches and there are trends in illnesses reported due to human exposure to pathogens during swimming activities.

The Beach Act amended the Clean Water Act in October 10, 2000, by adding Section 406 to strengthen the existing water program at the Agency. As a result, EPA created its Beach Program to ensure that there are consistent standards for pathogens, make available grants and funds to enable states to participate in studies and conduct research, provide guidance and performance criteria for state programs, and improve data collection, electronic data transfer, and public reporting. In general, the Beach Program is tasked to reduce the risk of infection to users of recreational waters through improvements in recreational water programs, communication, scientific advances, and research.

All coastal states of the United States and its territories must adhere to regulations under the Beach Act. Therefore, states must adopt water quality criteria for coastal recreation waters as published by EPA for *E. coli* and *enterococci*. EPA also must propose regulations for those states that did not adopt the standards or did not submit more stringent standards to EPA for approval by April 10, 2004.

The Beach Program uses an indicators concept to correlate pathogens and acute gastrointestinal illnesses. Fecal indicator levels (such as levels of bacteria *E. coli* and *enterococci*) are measured and used to determine the pathogens that cause acute gastrointestinal illnesses drawing on historic trends that link specific bacteria and pathogens to illness. Study findings and results will soon become available. Based on these research and results, EPA is tasked with publishing the new criteria by November 10, 2005.

In regards to the Beach Program's monitoring and notification requirements, states and tribes are eligible to receive Beach Program grants to monitor local beaches and to notify the public when water quality standards are exceeded. The Office of Water also is planning to develop program guidance using ORD and other research to include recommended sampling depths, frequency of sampling events, etc. Public notification plans and procedures also will be included in the program guidance documents.

In addition, the Beach Act requires EPA to collect, store, and display beach data in a public database. Information technology developments to achieve this requirement include the creation of a national database to store beach program monitoring, notification, standards, and grants information, and the creation of an Internet display that will allow users to migrate through and understand this information easily. Data integration is a necessary process in this step. Database functions will rely on other EPA program links, and the Office of Water will use the Waters Architecture Internet display to house this information. For example, the Beach Program database can utilize data from National Pollutant Discharge Elimination System (NPDES) permits, assessments and listings of criteria data (e.g., general monitoring guidance, TMDL, and 303(d) and 305(b) monitoring reports), planning documents, and local beach information in real time.

More information on EPA's Beach Program, including the EPA Clean Beaches Plan for 2004, grant information, water quality standards, and local beach data, can be found at http://www.epa.gov/beaches.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) requests for Office of Water guidance or information regarding beach closings and advisories by states and local communities; (2) concerns with quality data for recreational waters that may be prompting additional epidemiological study research; (3) recommendations on getting states to adhere to new water quality criteria and guidelines, from an EPA Regional perspective; (4) composite and batch sampling sites utilized in the SCCWRP; (5) use of IDEXX, culture laboratory testing, and plate laboratory testing in SCCWRP; and (6) consideration of younger populations (i.e., children) when predicting or evaluating illnesses, such as ear aches, resulting from exposure to recreational waters.

Section IV: Using Science to Make a Difference

Wednesday and Thursday, June 2-3, 2004

The purpose of this breakout session on the second and third days of the meeting was to focus on regional research being conducted regarding invasive species, monitoring and assessment to protect tribal health, the application of indicators, ecological forecasting, air toxics, and climate change issues. Each session included a panel discussion or opportunities to respond to audience questions that provided additional information and insight on a variety of regional topics.

Michael Slimak, with NCEA, led a session addressing EPA's role in invasive species research and management. Presentations included overviews of invasive species and aquatic nuisance species research, marine bioinvader rapid assessment surveys, descriptions of genomic approaches to screening for invasive species, and an evaluation of non-native oysters in the Chesapeake Bay.

Valerie Bataille, with EPA Region I, led a session addressing monitoring and assessment projects sensitive to tribal-specific concerns. Presentations included identification of Native American exposure pathways, monitoring as a means to better understand mercury fate/transport, and a coastal waters study.

Brian Hill, with NHEERL, led a session addressing the Regional Environmental Monitoring and Assessment Program and the application of EMAP indicators. Presentations included an overview of the regional program and regional studies in the southeastern United States and in Maryland.

Rochelle Araujo, with NERL, led a session addressing the use of collaboration to solve environmental problems. Presentations included lessons learned from the Chesapeake Bay Program, an overview of collaborative science efforts in the Great Lakes, and an evaluation of the role of science, management, and activism in sustainability of the Gulf of Mexico.

Dr. Betsy Smith, the ReVA Program Director at NERL, led a session addressing current and future regional risks. Presentations included ecological forecasting and its applications, approaches for projecting land use change and resultant ecological vulnerability, a statistical groundwater model, methods to forecast species distribution, and forecasting land cover changes to assess risk/vulnerability.

Tom Baugh, with EPA Region IV, led a session addressing the Regional Research Partnership Program. Presentations included the use of microbial source tracking, the use of land cover diversity as a proxy for biodiversity, and the relationship of terrestrial ecosystems to manganese emissions from wood burning.

Henry Topper, with the Office of Pollution Prevention and Toxics, led a session addressing air toxics at the local level. Presentations included development of an air toxics emission inventory and reduction strategy, and descriptions of air toxics programs in St. Louis, MO, Louisville, KY, and Mobile, AL.

Michael Slimak, with NCEA, led a session addressing climate change issues. Presentations included an evaluation of the feasibility of conducting climate change impact assessments, an overview of the role of science in decision making in the Gulf of Mexico, and alternative approaches to climate change assessments.

Can You Hear Us Now? EPA's Role in Invasive Species Research and Management

Following opening remarks by Michael Slimak, with NCEA, five speakers provided an overview of invasive species, ongoing and planned aquatic nuisance species research, marine bioinvader rapid assessment surveys, genomic approaches to screening for invasive species, and non-native oysters in the Chesapeake Bay.

Snakeheads, Green Crabs, and Other Nasty Things: An Overview of Invasive Species

Dr. Henry Lee II, Chair of EPA's Nonindigenous Species Working Group, discussed sources of invasive species; their direct and indirect ecological, economic, and regulatory effects; recent research findings; and areas for future work. Snakehead fish invaded the Maryland area last year. Green crabs from Europe invaded the East Coast over 100 years ago and the West Coast 10 years ago, and in the West Coast have now spread from San Francisco to Puget Sound. Thinking about invasive species requires breaking out of the pollutant-centric mindset since pollutants break down while invasive species increase rapidly over time. The presence of an invasive species can increase the abundance of other invasive species.

Ballast water discharge is a major source of invasive species, and an International Treaty in Ballast Water Treatment is underway. Other sources of invasive species include ship fouling and drilling platforms, recreational boating, aquaculture, stocking of fish and shellfish, canals and water diversions, aquarium and horticulture industries, the live seafood industry, research facilities and public aquaria, and habitat restoration and dredging.

Invasion rates in the San Francisco Estuary are still rising, which is not surprising given the rate of international trade over the last 10 years. Although aquatic invaders are harder to control, some sites have had at least partial success with eradication or management of aquatic invaders. In some cases, such as the case of *caulerpa taxifola* in southern California, the rapid response was completed within a month. Other response efforts took significantly longer.

Invasive species have direct and indirect ecological effects. The general consensus is that they are the second most important cause for declines in both biodiversity and endangered species, and that they may be the most important cause for declines in lake biodiversity by 2100. Furthermore, invasive species can fundamentally alter ecosystem processes, such as nutrient fluxes and sedimentation. For example, plant invaders in riparian zones are nitrogen fixers.

The economic costs of invasive species totaled $97 billion in damages from 1901 to 1991. The current predictions are for $137 billion per year in damages and losses in the United States. A significant amount of damage and loss will be agricultural, but some will also be aquatic. Given the costs of invasive species, it is economically sensible to control them.

EPA regulations and goals already address invasive species under Executive Orders; NPDES; TMDLs; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Clean Water Act; and the National Environmental Policy Act (NEPA). For example, the use of an invasive species in a laboratory may constitute noncompliance of the Invasive Species Executive Order. Another example is the ability to use the pesticide emergency exception under FIFRA against a new invader.

Spatial pattern research in the San Francisco Estuary and the Small Pacific Coast Estuaries has revealed that San Francisco Bay subtidal benthos are numerically dominated by non-indigenous species. This research used clustoral organization to examine assemblages. With the exception of a small, sandy section, 45 to 90 percent of the species were alien. EMAP data on the relative abundance of non-

indigenous species in small estuaries by biogeographic province show that northern California rivers appear to be less invaded than San Francisco. Additionally, EMAP data on small estuaries in Oregon, Washington, and California have shown that non-indigenous species are more widespread stressors than contaminants or low dissolved oxygen. These small estuaries have never been exposed to ballast water or agriculture, and yet they are invaded. This is evidence of the need to have a regional, as opposed to a local, view of such species, and NHEERL is currently working with the USDA on this issue. Data from the Pacific Coast Estuarine Information system show similar distributions of native and non-native species, and also show a pool of invasive species that can potentially invade the rest of the West Coast.

Invasive species directly and indirectly affect the ability to achieve EPA's mandates and goals. However, EPA has a unique niche in invasive species research and management. Steps to be taken by the Agency to develop an understanding of the patterns of invasion in Pacific Coast estuaries at multiple spatial scales include the development of local, estuary, and regional-scale indicators of invasion; prediction of vulnerable ecosystems and potential distributions of new invaders; and prediction of the impact of invasive species on estuarine goods and services.

Office of Water and Aquatic Nuisance Species: What's Underway and What's Planned

Head of the Office of Wetlands, Oceans, and Watersheds (OWOW), Diane Regas, discussed how OWOW, other EPA offices, and other Federal agencies are working to develop a strategy to control and prevent the introduction of aquatic nuisance species. In addition to invasive species, OWOW responsibilities include TMDLs and non-point source issues. The U.S. Fish and Wildlife Service, NOAA, and others are members of a task force created to address aquatic nuisance species.

The aquatic nuisance species issue is tremendously challenging, because these species have already had a dramatic impact on our ecosystems. There are over 298 non-indigenous vertebrates and algae, 109 non-indigenous species of fish, and 200 species of non-indigenous vascular plants that have become established in the coastal waters of the United States. Known significant impacts include lower water tables and reduced water flow. Other impacts include significant economic effects, potential health threats, and both economic and quality of life recreational industry impacts.

OWOW has developed an invasive species action plan to serve as a management tool, and is actively conducting work on vessels, one of the major sources of invasive species' introductions. Vessel regulation negotiations are being held on an international scale. In 1991, the Marine Environment Protection Committee of the International Maritime Organization began discussions and developed guidelines to prevent the introduction of unwanted organisms and pathogens from ship ballast water and sediment discharges. In 1997, this group began to develop legally binding requirements for ballast water management and, in 2004, this group developed text for a treaty. Ratification will require the support of 30 countries, representing 35 percent of the world's shipping tonnage; however, the position of the United States on this treaty has not yet been established. The draft treaty involves a control scheme based on ballast water discharge standards, but the standards are almost three orders of magnitude less stringent than those preferred by the United States. Therefore, there is concern that the standards will not be protective enough. Another drawback to the draft treaty are the limitations placed on the ability of individual parties to approve the use of treatment systems that use active substances, such as biocides, to achieve those standards. A better understanding of the effects of those limitations is needed before the United States government can take a position on the treaty.

OWOW is working with the United States Coast Guard and Navy on vessel-related rulemakings. The United States Coast Guard is the lead on developing ballast water standards for vessels, and OWOW is supporting that effort by lending expertise and helping to develop the Environmental Impact Statement

(EIS). The United States Navy is working to develop discharge standards for their vessels; this provides OWOW with the opportunity to work with cutting-edge engineers and technologists to experiment with strategies and to get the successful ones built into standards.

Once established, invasive species are nearly impossible to eradicate. Therefore, it is essential to take all necessary actions to try to prevent or reduce their introduction, limit their spread, and respond rapidly when they are introduced. To address this, OWOW is identifying barriers to rapid response and is developing guidelines for states and localities to use when they are trying to navigate Federal guidelines.

A good estimate of the potential impacts of aquatic nuisance species is needed and should include estimates of national and watershed level economic impacts as these have not been defensibly quantified. The Office of Policy, Economics, and Innovation will be working with OWOW to develop a framework for such an economics impact assessment, which is awaiting funding.

Currently, OWOW is investigating which of their projects are funding the use of invasive species, and is reviewing their regulatory authorities and non-regulatory tools to determine if there are other means not yet being explored that could help reduce the spread of invasive species. OWOW is investing in education and outreach through a number of projects, including traveling exhibits, and the Aquatic Nuisance Species Task Force has developed an overall strategy for education outreach. OWOW's goal is to support that task force rather than develop its own path.

There is not a single government entity to address the invasive species issue. Instead, this must be a collaborative effort on the local, state, and Federal levels, with most of the work conducted at the state and local levels. Approximately 15 states have already taken aggressive approaches. Other areas to address in the future include:

- Supporting the needs of those at the forefront of this effort, with tool development considering the end user
- Understanding economic impacts, which is crucial
- Investing in predictive models
- Developing tools to provide an understanding of the issue to communities and to understand the relative risks in order to convey this information to the public and decision makers
- Developing new tools for prevention, treatment, and control of ballast water
- Understanding treatment effectiveness and determining which approaches are going to deliver the desired difference.

In addition, scientific and technological analyses are needed to support requests made to invest in and implement technologies to put onto ships.

Rapid Assessment Surveys in Northeast National Estuaries: Identifying Marine Bioinvaders in Fouling Communities

Dr. Judy Pederson, with the Massachusetts Institute of Technology's Sea Grant Program, discussed a marine bioinvasion rapid assessment survey, its results, management implications, future directions, and the need to more effectively communicate the bioinvader issue. Additional research is needed in order to understand the life histories and quantify the vectors and potential uses of biological control.

Many vectors are responsible for introduction of bioinvaders. Intentional vectors include aquaculture, agriculture, ornamentals, and aquaria pets. Unintentional vectors include ballast water, shipping, escapes,

and spillage. Invasive species create problems that are usually measured in human terms. However, they may also impact ecosystems.

The Rapid Assessment Survey is used to identify native and non-native species in floating dock communities. Taxonomic experts visited approximately 20 sites to identify species on the dock and in the laboratory. This information is used to support management actions to prevent, reduce, and manage invasive species. Taxonomic expertise used in the Rapid Assessment Surveys in 2000 and/or 2003 included experts on mollusks, hydroids, pericaridans, tanaeids, polychaetes, barnacles, sponges, bryozoans, sea slugs, tunicates, nemerteans, flatworms, and crustaceans. An interactive map that identifies the locations where species were identified can be accessed at http://massbay.mit.edu. Surveys, scientists, and divers provided the information contained in the map.

As a result of the survey, 260 to 300 species were identified. The Massachusetts and Rhode Island surveys were conducted consecutively in 2000, while the New England survey was conducted in 2003. The percent of total introduced and cryptogenic species ranged from 10 to 20 percent.

Styela clava is an example of one of the invasive species identified as growing in Prince Edward Island where everything growing on the island is an introduced species. This organism has major influences and has caused major problems, and is evidence that species can become something different in different environments.

Didemnum is a compound tunicate from the Pacific that has been found in Georges Bank gravel beds, which are prime scallop beds. The affected area is six and a half square miles, 80 percent of which is covered with the organism. A rapid response could not be conducted at the site. This example is the first case of an invasive organism being found in waters of that depth.

Approximately $130 billion is spent annually in the United States to address invasive species in all ecosystems. However, there is poor documentation for the marine environment.

Future research directions include economic studies, ecological studies, communication and outreach, early detection, rapid response, regional ballast water management, and general management issues.

Targeted Screening for Invasive Species in Ballast: Genomic Approaches

Mike Blum, with NERL, discussed traditional approaches for identifying species found in ballast water, a targeted screening research project, potential applications of the research, the design of allele-specific polymerase chain reaction (PCR) primers, and future directions of the targeted screening research. Ballast water is the dominant transport vehicle for invasive species. The frequency or number of introduction events required for a species to become established is not known. Many of the invasive species are unknown or cannot be recognized. Green crab and zebra mussels are two species of great concern in the United States.

Morphological taxonomy is the traditional approach for identifying species found in ballast water. Classification is dependent on adult traits and requires broad knowledge of major taxonomic groups with identification typically limited to the family or genus level. Such data do not provide a basis for comparison across studies, and, therefore, the data have very limited applicability. In addition, larva and egg forms in ballast water pose a very difficult question since the adult forms do not present themselves for identification during ballast water examinations.

Bioinformatics coupled with DNA taxonomy is an alternative approach to identify species found in ballast water. Classification is dependent on genomic variation and does not require broad knowledge of

major taxonomic groups with identification at the species or subspecies level. This approach provides an objective standard for comparison across studies and, therefore, the data have broad applicability.

Targeted screening research, supported by the Regional Methods Program, is a novel application of allele-specific PCR methods and DNA sequencing technology. The research includes the development and application of bioinformatic databases. The research objectives are the exploratory characterization of species diversity in ballast water, and targeted screening of ballast water for invasive species. Potential applications of the research include:

- Early detection and monitoring of non-indigenous species of concern, cryptic invasions, and introgressive hybridization between non-indigenous and endemic species
- Assessing compliance with treatment requirements
- Risk assessment
- Characterization of invasion events.

This research project was initiated in December 2003 with laboratory work underway on ballast water samples from the Great Lakes secured in February and May 2004. Contracts have been drafted to sample ship traffic between San Francisco, Columbia River, and Puget Sound. Sampling of Pacific Coast ship traffic will begin in late summer 2004 and will continue through Spring 2005. Collaboration is necessary to the success of the project because of the difficulty in gaining access to ballast water samples.

The research is designed to derive sequences from sludge samples by the following sequence of activities: eggs → purification → amplification → bacterial cloning → develop sequences → analysis. Designing allele-specific PCR primers for preferential amplification of targeted species or groups of species requires identification of:

- Primer binding sites that are identical among individuals within a target group or absent/ineffective among members of excluded groups
- Amplicon gene regions that are consistent within the target group and variable among members of different target groups.

Diagnostic markers can be used to differentiate between sister species and hybrids.

Much of the data generated has been deposited into a repository that is accessible on the Internet.

Molecular approaches such as these can provide powerful tools for exploratory characterization of ballast water content and targeted screening for species of concern. Additionally, molecular data function as a common denominator and, therefore, have broad applicability. Future directions for genomic approaches to targeted screening for invasive species in ballast water include:

- Application of techniques to support early detection and monitoring programs, and to assess compliance with ballast water treatment regulations
- Development of streamlined molecular tools for detection and monitoring
- Development and implementation of non-indigenous-species-focused bioinformatics databases
- Further integration of multidisciplinary data to support risk assessment and vulnerability analyses of coastal regions.

Non-Native Oysters in Chesapeake Bay

Michael Fritz, with the EPA Chesapeake Bay Program Office, discussed three options for the management of non-native oysters in the Chesapeake Bay, guidance for choosing the appropriate management option, myths associated with the introduction of non-native species, ongoing EIS and field trials, risk management guidance, and issues for EPA consideration. Over 90 percent of the oysters in the Chesapeake Bay are from the Gulf of Mexico. In the late 1940s and 1950s, as technology improved, diseases were discovered in the Chesapeake Bay, which have been attributed to the introduction of an Asian oyster. In addition, current restoration efforts are not working.

The first of the three management options addresses the outright prohibition of the use of non-native oysters in the Chesapeake Bay, either for controlled aquaculture or for deliberate release into open waters. The long-term risk of such a prohibition is dependent upon the potential success of restoration programs for the native Eastern oyster. Researchers addressed a risk they perceived of a rogue introduction of a non-native oyster, a practice that is compared to bootlegging.

The second management option addresses the contained aquaculture of triploid *C. ariakensis*. Containment such as this provides an opportunity to research the potential effects on the ecology of the Bay of either extensive triploid-based aquaculture or the introduction of reproductive non-native oysters. The utilization of this sterile oyster management option offers research options as well as economic benefits for the oyster industry and watermen.

The third management option addresses the introduction of diploid oysters into the Chesapeake Bay. Research has concluded that it is impossible to predict the impacts that a controlled introduction of reproductive *C. ariakensis* would have on either the oyster fishery or the ecology of the Chesapeake Bay.

Overall, the research has suggested that the second management option, contained aquaculture, be utilized, but that it should be considered as only a short-term or interim action undertaken to provide researchers with the opportunity to obtain the biological and ecological information on the non-native oyster necessary for risk assessment. This option allows for more management flexibility in the future depending on the status of the native oyster and the success of restoration efforts. However, stringent regulations will be necessary to oversee this kind of development to ensure that it does not result in the establishment of a self-reproducing population in the Chesapeake Bay region. Such a result would have significant effects up and down the East Coast.

There is no quick fix for the oyster problem in the Chesapeake Bay, the oysters will not improve the water quality in the Bay, and the problems are much bigger than any oyster restoration program can resolve. The research has concluded that native oyster restoration has not failed, but rather has not been given enough effort. Therefore, it is premature to give up on native oyster alternatives. Additionally, the research has indicated that the existing regulatory and institutional framework is inadequate.

An EIS is needed before field trials can be furthered. The U.S. Army Corps of Engineers is currently developing a proposal in collaboration with the State of Maryland and EPA. The purpose of conducting the EIS is the economic recovery of the fishery. However, additional benefits include water quality improvement and reef habitat restoration. The States of Maryland and Virginia are applying pressure to complete the EIS in 1 year. However, scientists are predicting a 5-year timeline for the completion of the research.

Ongoing field trials include the introduction of 800,000 triploids in Virginia and small-scale in-water research conducted in Maryland. Many parameter assumptions were made in the Virginia project due to

the lack of life history parameters, but permit conditions have been set. Fluorescent dye dispersion projects will be conducted to determine the dispersal potential from spawning.

The focus of the risk assessment is on the adult oyster population. A population of greater than two adults per square meter is necessary for establishment of the species. The areas of greatest uncertainty in the assessment involve size-specific fecundity varying within the genus, the use of fertilization efficiency from another phylum, and the possibility that larval dispersal may be non-random.

The Chesapeake Bay Program Office strives to balance accommodation of the experimentation with these species and keeping the risks at a minimum. The EIS is needed before good judgments about risk management needs in the future can be made. Risk will continue to be modeled as it has been up to this point, using empirical data on size (length/size ratios) and through continued *gameta genesus* monitoring. Additionally, the hydrodynamics of dispersals and dispersal evaluations will be applied in the adaptive risk management.

Issues for EPA consideration include jurisdiction under the Clean Water Act, determination of the adequate amount of science, determination of an acceptably low level of risk, and long-term restoration in a short-term world.

Monitoring and Assessment to Protect Tribal Health and Ecosystems

Following comments by Valerie Bataille, with EPA Region I, three speakers addressed the development of Native American exposure pathways, monitoring as a means of developing a better understanding of mercury fate and transport, and a coastal waters study. An audience question and answer period followed the presentations.

Protection of Tribal Cultural Practices Through the Development of Native American Exposure Pathways

Fred Corey, Environmental Director of the Aroostook Band of Micmacs, discussed the reasons that necessitate the development of Native American-specific exposure pathways, the project approach, and the expected project results. The project represents a Direct Implementation Tribal Cooperative Agreement between EPA and the following five tribes: Aroostook Band of Micmac Indians, Houlton Band of Maliseet Indians, Passamaquoddy Tribe Indian Township, Passamaquoddy Tribe Pleasant Point, and Penobscot Indian Nation. Undertaking this project enabled EPA to fulfill its trust responsibility to protect the tribal resources, and ensure that tribal lands are suitable for tribal usage.

There are more than 6,000 enrolled tribal members in Maine inhabiting tribal land holdings in excess of 250,000 acres. These land holdings represent different types of ecosystems, including wetlands, uplands, farmland, developed land, and frontage on rivers, streams, lakes, ponds, and the Atlantic Ocean. In Maine, tribal food, medicinal, spiritual, and recreational practices are linked to water resources. Therefore, water resource protection is essential to ensure the health and safety of tribal members engaging in their cultural practices. The use of plants and animals must be safe to ensure the preservation of cultural practices.

The purpose of this project is to document the cultural practices and resource utilization patterns of the five Native American tribes in Maine through the development of multi-pathway exposure scenarios to support the development of appropriate water quality standards for tribal lands. Typically, EPA focuses on uses such as drinking water and recreation, and does not consider special tribal uses such as plants, animals, and sweat lodges. Standards are needed that will be protective of such tribal uses, and development of exposure scenarios is essential to human health protection. The project seeks to protect

the most vulnerable portions of the tribal population, which are the tribal members who live off the land, ingest a lot of resources, have a lot of contact with the environment, or are children.

Although the project approach combines some elements of consumption surveys, it relies heavily upon anthropological research to determine historic tribal natural resource utilization patterns. To demonstrate that the approach is scientifically sound and legally defensible, experts will assist in assembling the information, which will undergo peer review by a tribal panel and EPA risk assessment experts. However, personal/confidential information will be proprietary to the tribe because they are unique to a given tribe. There must be a balance between protecting confidential information and providing adequate information to risk assessors to demonstrate that the approach is scientifically sound.

Consumption survey issues include suppressed consumption associated with fish consumption advisories, land use constraints, depleted natural resources, social oppression, and economic factors. Specific causes of suppressed consumption include over-harvesting, land mismanagement, and the presence of contaminants. The survey does not consider increased exposures associated with exposure from living off of the land. The goal of the tribes in Maine is to re-establish tribal fisheries and to use the resources in the way that they were used 500 years ago.

Tribal scenarios or exposure factors intersect in three areas: anthropology or ethnography, ecology, and toxicology and risk assessment. Anthropology or ethnography describes the use of natural resources in the context of traditional lifeways. Ecosystems provide insight into what is important in terms of environmental restoration and what is culturally important. Toxicology and risk assessment are essential for determining exposure routes and understanding the implications of diet and the frequency, duration, and intensity of environmental contact. Examining these three areas enables the calculation of actual exposures.

The expected results of this project are exposure scenarios indicative of fresh water and marine natural resource utilization patterns. These scenarios will be used to develop water quality standards to sustain the cultural traditions of the Maine tribes.

Towards a Better Understanding of Mercury Fate and Transport on the Fond du Lac Reservation: Monitoring Air, Water, Sediments, and Biota

Nancy Cost, the Fond du Lac Water Project Coordinator, discussed the reasons why mercury is problematic in the lakes of the Fond du Lac Reservation, the tribal air monitoring program, sediment assessments, results of these assessments and other studies pertaining to cultural uses of the natural resources on the reservation, and areas for future research. The Fond du Lac Reservation, located approximately 15 miles inland from Lake Superior, encompasses approximately 40,000 acres of wetlands. Because these wetlands support the most important natural resources to the tribe, water resource protection is critical.

Although there are no significant point sources of pollutants, the boreal forest/wetland ecoregion is especially sensitive to mercury deposition. In this ecoregion, ionic and elemental forms of mercury are more likely to be methylated, creating greater bioavailability to the aquatic food web. Bioaccumulation in higher trophic levels has been seen in piscivorous fish, eagles, osprey, loons, kingfishers, mink, otters, and people. The aquatic food web is of increasing importance due to the recent resurgence of tribal members moving back to the Reservation to practice their cultural traditions.

The tribal community relies upon natural and cultural resources such as wild rice, fish, waterfowl, and game for sustenance. The use of these resources is compromised by the health concerns associated with

exposure to environmental contaminants. Therefore, it is important that monitoring and protection efforts acknowledge risks posed by mercury.

Tribal air monitoring has included participation in the National Atmospheric Deposition Program since January 1997. Participation in this program provides information on acid deposition and chemistries, and allows the tribe to review any air permit within 50 miles of the Reservation, including those for some nearby power plants. Additionally, the tribal air monitoring program includes monitoring for mercury and methyl mercury in precipitation. The close proximity of the Reservation to academic and Federal laboratories enables the tribe to take advantage of their expertise and laboratory capabilities.

Two sediment assessments were conducted on the Fond du Lac Reservation. The first studied 12 lakes in an effort to characterize sediments; assess contaminant levels in the bioavailable portion for mercury, polychlorinated biphenyls (PCBs), and lead; and conduct toxicity tests. Each sample was analyzed for total mercury and other parameters. However, funding was not adequate to sample for all parameters in every sample. An outcome of the study was the development of a sediment quality database. The results of the study indicate higher total mercury values associated with organic sediments, one-third of the sites sampled were in the zone where the possibility exists for effects to aquatic biota, and shallow lakes had consistently higher mercury levels. Data collected in the database were used to rule out PCBs as a contaminant of concern, but did not support the elimination of lead from consideration.

The second sediment assessment project studied 12 St. Louis River sites using the same parameters of the first study with the addition of methyl mercury. Archived samples taken during the first assessment were also evaluated for methyl mercury and the results were added to the sediment quality database.

Graphical interpretation of the data revealed the following:

- A significant relationship exists between the presence of high volatile solids and high total mercury
- Shallow lakes continued to have high mercury levels, and lakes that had both shallow and deep ends showed lower mercury levels in the shallow end sediment samples than in the deep end sediment samples
- A relationship exists between the size of the watershed and total mercury in sediment, with larger watersheds showing consistently higher mercury levels
- Lakes that had higher total suspended solids levels also had higher mercury levels in sediment
- Lakes that were well buffered had low mercury concentrations
- Mercury levels have no relationship with conductivity and pH.

In analyzing the data, it is important to note that water quality chemistries differ from site to site. Color is currently being measured, and there are plans to conduct dissolved oxygen concentration measurements to ensure that color is a good proxy for dissolved oxygen concentration.

The tribe partnered with the Minnesota Department of Health to study fish contaminants in an effort to develop culturally sensitive guidelines for fish consumption. The study targeted species commonly collected from Reservation waters and eaten by tribal members. Results of the study indicated that mercury drives consumption restrictions, and PCBs, organochlorine pesticides, and toxaphene could be ruled out as consumption restriction drivers.

In partnership with the University of Minnesota, and funded by the Minnesota Sea Grant, the tribe also conducted a study to determine if the cultural and nutritional benefits of wild foods, as compared to market alternatives, offset contaminant exposure. One driver for this study is the fact that tribal members

have seen an increase in nutritional and metabolic disorders (e.g., diabetes) since moving away from the more traditional diets. The study concentrated on food harvested from the aquatic environments on the Reservation. Food sources including wild rice, waterfowl, and moose were analyzed for mercury and lead. The study revealed that waterfowl and fish have comparable mercury levels. Therefore, waterfowl should be considered in risk assessments.

Recommendations for future research studies include additional waterfowl sampling, continued fish tissue analysis, continued atmospheric deposition monitoring, and investigations into potential sediment mercury mitigation techniques.

Primary Production Study of Coastal Waters of the Bay of Fundy

Steve Crawford, with the Pleasant Point Passamaquoddy Environmental Department, discussed the goals of the Primary Production Study, sources of major impacts on the Quoddy region of the Gulf of Maine, the resulting impacts to aquatic life and farming, and methods to measure primary production. The goals of the Primary Production Study of the Quoddy Region are to measure and monitor photosynthesis and to monitor algal species biomass on clam flats to establish a baseline for nutrients.

Aquaculture, non-point sources, industry, and sewage treatment can all be sources of major impacts on coastal waters, yet there is no baseline. Although species composition data exist, there are no data on primary production in the area. Another problem is the philosophy that an impact does not exist if there is no science to support an impact determination. Defining any environment as being impacted is based on perspective.

Aquaculture can be a good thing in moderation. However, there are many salmon farms in concentrated areas with 22,000 metric tons of salmon in the Quoddy Region. This generates 4,000 metric tons of feces and 2,000 metric tons of uneaten food. Another impact from salmon farming is the slice used to treat fish lice, which is specific to arthropods, yet researchers have found this in a shellfish (mussel) in a location 1 mile away from the nearest salmon farm. This discovery of such accumulation in mussels raises the question of the severity of the impact of this material on copepods.

Sewage treatment has the potential to cause major impacts in coastal waters. For example, 30 percent of the sewage coming in from St. John in untreated.

Impacts seen thus far include suffocating green slime, increased red tides, altered ecosystems, unknown chemical pollution (slice), and eutrophication. Green slime, which grows in the flats, is made up of over 20 species. The suffocating effect of the slime has impacted the waters to the point that tribal members can no longer make a living harvesting clams because there are too few to harvest. Salmon farms are not believed to be the cause of green slime. A clam restoration project was undertaken involving the planting of clams in flowerpots. Although the data are still being analyzed, preliminary results indicate that the area is no longer useful for growing clams.

Although red fallar traditionally migrated into the Quoddy Region by the millions in the month of August, this migration has not been seen since 1989. Another indication of ecosystem alteration is the disappearance of cod greater than 24 inches in length, the legal limit for cod tagging. All of the specimens that have been caught and examined have been healthy but none have been over 24 inches. It is not known why the large cod have disappeared.

Another problem exists with the approaches used to measure primary production, which involve the use of light-dark bottles and chlorophyll A. Each approach has limitations. For example, when using a

spectrophotometer in the laboratory, some plants hold the chlorophoticity much better than others. Other interferences include organic matter.

Panel Discussion/Question and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing upon questions from the audience.

A brief question and answer period addressed the following topics: (1) the length of the research programs; (2) potential use of a specific fish species as an indicator because of its tendency to change color in certain water quality conditions; and (3) the use of exposure pathways in guideline development.

R-EMAP: The Application of EMAP Indicators

Following opening remarks by Brian Hill, with NHEERL, three speakers addressed EMAP applications to regional projects. A panel discussion including an audience question and answer period followed the presentations.

The Past, Present, and Future of the Regional Environmental Monitoring and Assessment Program

Brian Hill, the National Coordinator of the Regional Environmental Monitoring and Assessment Program (R-EMAP), discussed the program's approach, design components, regional program histories, and future research directions. EMAP has been in existence for over a decade, and the goal of R-EMAP is to build the scientific basis as well as the local, state, and tribal capacity to monitor for status trends in the condition of the nation's aquatic ecosystems in a cost-effective, scientifically defensible, and representative manner, utilizing quantifiable trends and supporting performance-based management.

The United States spends more than $650 million per year on environmental monitoring, most of which is targeted to individual chemicals and to physical conditions at specific sites. Point source problems have been greatly reduced; however, conventional monitoring does not address all issues.

The EMAP approach is proven to be cost effective. An example is the study of eutrophication of lakes in the Northeastern United States in which 2,756 non-random lakes were censused using conventional monitoring. EMAP research reached the same conclusions by censusing only 344 lakes.

The EMAP approach has a sound scientific basis. More than 600 peer reviewed EMAP publications exist. While there once was a lot of criticism, the publications are now viewed as valid.

Examples of environmental decisions made using EMAP science include mountain top removal mining impacts in EPA Region III, the State of Streams Report in Maryland, the revised coho salmon assessment program in Oregon, and the fish consumption advisory for mercury in Maine.

Although the EMAP approach has been successful, unanswered monitoring questions remain including:

- How much of our state/national aquatic ecosystems are healthy?
- Are we targeting the right problems to make a difference?
- How do we measure trends in the condition of aquatic ecosystems?
- How do we determine that this is a cost-effective, scientifically-defensible, and credible approach?
- How do we aggregate this information from the local to the state and then to the national levels?

The EMAP approach is the only statistically valid approach to determining state and national aquatic ecosystem conditions. It has stood the test of time and is scientifically defensible. Reasons for the validity of the EMAP approach are that it uses biological indicators as integrators of aquatic ecosystem conditions, establishes measurable baselines for health of aquatic ecosystems and assesses trends in condition, reduces costs and identifies the most important areas and stressors, and provides monitoring designs for consistent aggregation of data from local to national levels.

EMAP utilizes multi-tier monitoring designs. The three tiers are landscape characterization, regional surveys, and index sites. This scale-defined design allows aggregation and interpretation of monitored data in a tiered manner.

EMAP research is divided into four categories: index sites, indicators, remote sensing, and geographical surveys. Index site research includes acid rain effects and Science to Achieve Results (STAR) program research. Indicator research focuses on biocriteria and STAR program research. Remote sensing research includes Multi-Resolution Land Characteristics, landscape atlas, and STAR program research. Geographical surveys include R-EMAP, Mid-Atlantic Integrated Assessment, Western Pilot, Coastal Initiative, and Great Rivers. The Western Pilot and Coastal Initiative are in their last year of data collection and analysis. The Great Rivers survey will begin this year.

Since 1993, R-EMAP projects have been conducted in all 10 EPA Regions, with funding of nearly $20 million. Other funding for these projects has amounted to over $27 million. Partnering on these projects has proven to be very successful for all those involved.

Future directions of EMAP and R-EMAP include adjusting designs to support the 303(d) listing, TMDLs, and restoration; new efforts to support 305(b) assessments of large, floodplain rivers including designs, methods, and establishing reference conditions; conducting a National Stream Survey anticipated to begin in the summer of 2004; and developing designs and methods, and establishing reference conditions for wetlands and the Great Lakes.

Southeastern Wadeable Streams R-EMAP: Overview, Interim Findings, and Status

Dr. Peter Kalla, with EPA Region IV, discussed the Southeastern Wadeable Streams R-EMAP project, the basis of the sampling process, aquatic parameters, media and analytes, data interpretation, and landscape factors. The goals of the Southeastern Wadeable Streams R-EMAP project are to develop statistical characterization of wadeable streams region-wide; complement state random and non-random sampling; and be a component of the Regional Ecological Assessment Program. This project supports the update of the Fish Consumption Advisory database, assessments of beneficial use, and assessments for watershed restoration action strategies.

The process for this project included the acquisition of R-EMAP sample points; expanding the scope of data; adding ecoregional reference sites; using contractor support to obtain permission for access, reconnaissance, sampling, and identification; developing descriptive, spatial, and temporal statistics; and developing multivariate analyses. Additional sampling parameters were added once the project was underway. Ecoregional sites recommended by state partners were also examined.

Over the course of this project, researchers developed a better understanding of what should not be targeted. Out of the 96 streams selected for sampling in 1999, 37 sites were actually sampled. In 2001, 52 sites out of the originally selected 120 streams were sampled.

Aquatic community parameters included benthic macroinvertebrates, periphyton, and fish.

Graphical interpretation of the data indicates that approximately 55 percent of the streams are below suboptimal habitat levels.

Aquatic media and analytes included water, forage fish, and periphyton. Water was analyzed for: conductivity, dissolved oxygen, pH, temperature, nitrogen series, total and dissolved phosphorus, algal growth potential, and total suspended solids. Forage fish were analyzed for total conventional and whole-body mercury. Periphyton was analyzed to determine Autotrophic Index levels.

The researchers used low water grab samples, and sampling was conducted during the summer because it was logistically easier to do so. Mercury was examined in forage fish (blue gills) and paraffin levels also were examined. Almost all stream miles showed no conductivity effect. Specifying sample sources is important because every random sample taken will have an inflection point. This could be a starting point for setting a standard.

Mercury values in samples were comparable to mercury values observed in the Everglades. The data also indicated with a high degree of certainty that 45 to 65 percent of watersheds are at risk for mercury contamination.

It is important to consider landscape factors in risk determinations since a stream network integrates everything that happens on the landscape. Landscape factors for consideration include sub-watershed land use, riparian cover, channel conditions, road and bridge density, the percentage of impervious area, and drainage ditch density.

Maryland Biological Stream Survey: Science for Streams

Daniel Boward, with the Maryland Department of Natural Resources, discussed the Maryland Biological Stream Survey (MBSS), survey designs and methods, management, science for the public, and information dissemination. The MBSS used both its own methods and those used by the State of Maryland. Both methods were comparable. Thirteen sites will be examined this year using EPA and standard MBSS methods as part of the assessment.

The MBSS relies heavily on GPS. Field crews mark off 75-meter sampling ranges around midpoints chosen by consultants. Ninety percent of the landowners agreed to sampling on their land in 2000. However, that percentage has since decreased for reasons unknown.

The MBSS has a random design, and involves sampling of 1st to 4th order fresh water streams stratified by medium-sized watersheds. Over 2,000 sites are sampled each year, and the sampling cycle is 5 years. Fish and benthos are the two indicators used in the survey. Field crews use backpack-based electroshocking units to conduct a two-pass electrofishing effort in the 75-meter sampling area. Every fish caught over one inch is counted and measured. Benthos sampling occurs at the same time as fish sampling, using an EPA accepted protocol. Volunteers are used in sampling activities.

The physical habitat assessment was conducted using an EPA recommended approach, which included examination of the condition of banks, the riparian zone, and the amount and variety of habitat in the stream from a fish and invertebrates perspective. A limited suite of water chemistry sampling consisted primarily of acid-related constituents and nutrients. The majority of the project funding is obtained from the surcharge on electric bills in Maryland (i.e., the Environmental Trust Fund). The University of Maryland's Appalachian Laboratory was used to analyze the samples.

Upstream landscape factors were examined by delineating the catchments upstream and evaluating land use. The percent of impervious surface located upstream of all of the sites was estimated to understand stressors. Land use in Maryland is urban, agricultural, forest, wetlands, and water.

A great amount of effort was spent in developing indicators. The intent of this effort was to relay information about stream health to managers and the public in a non-technical way. Multimetric indicators are fish, benthic macroinvertebrates, and physical habitat.

Metrics based on indexes for biotic integrity for fish are grouped into three categories, depending on the location within the State: coastal plain, eastern Piedmont, and highland. Several of the metrics repeat across the IBIs. Maryland benthic macroinvertebrate IBIs are divided into the two categories of coastal plain streams and non-coastal plain streams. Both fish and benthic IBI scores are rated on a scale from one to five, with one being very poor and five being good.

Stream salamanders are good indicators of environmental health due to their wide distribution and abundance. Knowledge of their life history, their physiology, and their responsiveness to multiple stressors are other factors that make them good indicators.

Water quality, physical habitat, and aquatic life were also examined. Streams were sampled for acid related constituents, and the results indicated that Western Maryland streams are not very well buffered. Artificial wetlands containing buffering materials were constructed to aid in the restoration of these systems. This information has been used to guide others in the construction of acid mitigation projects.

MBSS also included nutrient sampling, given interest in the impacts of agriculture land use. Many of the Maryland streams have elevated nitrate levels that seem to be related to the amount of agricultural activity located upstream from the sampling sites. The Maryland Department of Natural Resources is defining an elevated nitrate level as being any value over one.

Physical habitat assessments included the examination of the quality of the stream channels, stream banks, and riparian zones. A large number of stream miles in major river basins are channelized. Stream banks and the vegetation (or lack thereof) that holds the stream banks together were assessed. The best approach for restoring stream banks is to plant trees. MBSS data may be useful to those involved in stream restoration projects.

Aquatic life studies focused on fish. Long time resident species, such as brook trout, are smaller in number because they have lost competition for food, and urbanization is believed to be the cause. It is vital to identify potential signs of stress prior to population decline. If researchers can identify the locations where the fish are most unhealthy, they can focus on those areas.

The Stream Waders program is an adult volunteer program in which aquatic invertebrate samples are collected using MBSS protocols. Response to this program has been overwhelming, with 700 volunteers collecting nearly 3,000 samples from 2000 to 2004. Through this volunteer program, 75 percent of all subwatersheds in Maryland have been sampled. Data collected by the volunteers will be used in the MBSS, and volunteer sites are being plotted on the annual report.

Many groups in the Maryland Water Monitoring Council are using the MBSS methods including seven counties, the City of Baltimore, two State agencies, MNCPPC, three colleges, the Smithsonian Institution, the U.S. Fish and Wildlife Service, the National Park Service, and the U.S. Army Corps of Engineers.

The searchable MBSS database contains photographs as well as habitat and stream information. It can be accessed at http://www.dnr.state.md.us/streams/mbss/index.html.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) examination of the of uncertainty, variability, and variance of data; (2) the use of habitat restoration as opposed to concrete to channelize streams; (3) prioritization of different types of restoration actions; and (4) the difficulty in identifying trends in the stream surveys.

Great Places Demand Great Science

Following introductory remarks by Rochelle Araujo, with NERL, three speakers addressed lessons learned in the Chesapeake Bay Program, collaborative science efforts in the Great Lakes, and the role of science, management, and activism in sustainability of the Gulf of Mexico. An audience question and answer period followed the presentations.

Defining Restored Water Quality, Allocating Load Caps, and Implementing Reduction Actions: Chesapeake Bay Lessons Learned

Richard Batiuk, Associate Director for Science in the EPA Chesapeake Bay Program Office, discussed the basis of the Chesapeake Bay Program, the program drivers, the importance of providing a strong motivator for change, and the development of the Chesapeake Bay document. The Chesapeake Bay Program is not limited to EPA as it includes six states, 26 Federal agencies, and other partners. Effective research must begin with comprehensive scientific studies and the synthesis of existing knowledge. Key lessons learned from 1978 to 1983 are the need to define the research driver, to define what to achieve, and to build science as an underpinning for policy commitments.

Underwater grasses are the driver in the Chesapeake Bay because they affect species' survival. Over 90 percent of the Chesapeake Bay and its tidal rivers are impaired due to low dissolved oxygen levels and poor water clarity, which are related to nutrient and sediment pollution. Without oxygen and grasses, crabs, oysters, and fish cannot survive and thrive in the Chesapeake Bay.

A strong science basis and a strong motivator are needed to convince people, including farmers, to do what is best for the Chesapeake Bay. It is important to define what to achieve and to provide the science objectives behind the reasoning. The Chesapeake Bay Program desires to achieve a "water quality that supports abundant fish, crabs, oysters, and underwater grasses in the bay and its rivers." This achievement could not have been defined 20 years ago because the program lacked the necessary scientific basis.

Building science as the underpinning for policy commitments is accomplished through three steps, which are simple questions that serve as the basis of the research program:

- What is the water quality of a restored Bay?
- How much pollution do we need to reduce?
- What actions do we need to take to reduce pollution?

The Chesapeake Bay Program Office answered these three questions in 1983 and 1987, and is still building upon the base that those answers provided.

Two decades of science have gone into defining clean water as having fewer algae blooms and better fish food, clearer water and more underwater Bay grasses, and more oxygen and improved habitat for more

fish, crabs, and oysters. Seven states agree on this definition of clean water. Defining restored water quality involved developing dissolved oxygen criteria, refining designated used for the Chesapeake Bay and tidal tributary waters, developing a series of models to measure nitrogen loads, and estimating Chesapeake Bay responses to pollution reductions.

All of this science was drawn together to develop a Chesapeake Bay document. As of 2002, progress had been made in nitrogen loads in the tidal Chesapeake Bay. Although point sources are shrinking, agriculture is still the primary source of nitrogen loads. The research has indicated that nitrogen and phosphorus reductions improve oxygen levels in the Chesapeake Bay. Sediment was similarly analyzed, and findings indicated that as sediment loads were reduced, the underwater grasses increased. The goal is to restore the Chesapeake Bay to its 1950 s condition.

A tremendous amount of science went into developing the Nutrient and Sediment Cap Load Allocations chart. The driver was a 55 percent total reduction in nitrogen loads. Tributary strategies associated with nitrogen load reduction include river specific; local action driven nutrient/sediment pollution clean up plans; local stakeholder refinements; actions and schedules for reducing point sources and agricultural, urban, and septic loads to the Chesapeake Bay; and funding strategies.

Implementation of these reduction actions will require unprecedented involvement of the farming communities and significant point source reductions. The State of Virginia is asking that its farmers increase the amount of crop land under conservation tillage from 56 percent to 96 percent by 2010, amounting to 74,000 additional acres. Point sources have been reduced by approximately 20 million pounds per year, but the 2010 goal is to reduce them by an additional 30 million pounds per year.

Science must be used as the foundation for decision making such as determining where thresholds should not to be exceeded and determining the safe level. The bottom line is to synthesize information in the beginning, find the drivers, employ people who can bridge the pieces, adopt new science, and lock in new policy opportunities.

The Great Lakes: Collaborative Science to Inform and Help Frame Policy

John Lyon, with NERL, discussed environmental issues within the Great Lakes, the benefits of and need for research collaboration, the Great Lakes Observing System, invasive species studies, and lessons learned. Collaboration is essential to doing anything ambitious. Constituents and clients want practical solutions that they can understand. Research efforts are complex and multi-jurisdictional. Because existing funds and resources are limited, it is vital to leverage funds. Collaboration fills in the gaps of participation, fosters dialogue and understanding with scientists and decision makers, and results in high quality science, engineering, and technical support.

Cooperative efforts in the Great Lakes region have been ongoing for years. Thus far, these cooperative efforts have identified critical uncertainties, projected alternative futures, formulated management strategies, and evaluated trade-offs for regional sustainability. In addition, these collaborations address issues vital to human health and the environment including invasive species; water quality and land cover issues; water quality, sediments, and toxics issues; recreational waters; air quality and toxics; and community growth. The collaborative network includes multi-national groups, Federal agencies, Canadian groups, the Canadian Provinces of Quebec and Ontario, the states bordering the Great Lakes, and others. Collaborations have included the Great Lakes Environmental Research Laboratory, the Great Lakes Water Resources Management Decision Support System Project, the Great Lakes Observing System, and invasive species analyses. The long-term goal of these collaborative research programs is the development of a scientifically defensible, reliable ecosystem forecasting capability for the Great Lakes.

The focus of the Great Lakes Observing System is the coordination of data collection between the United States and Canada; integration of large data holdings and data archives; facilitated discovery, evaluation, and access to data (including access to the public); and new product development. The user community includes interest groups such as commercial and sports fishing groups, recreational boaters, emergency responders, national security groups, restoration management groups, coastal researchers, and the commercial shipping industry.

Lessons learned from the Great Lakes collaborations include science, innovation, and collaboration protect human health and the environment; place-based assessments demonstrate true potential; science-based information dissemination is critical to facilitate dialogue; and collaborative processes generate management strategies.

Ecological Sustainability of the Gulf of Mexico: The Role of Science, Management, and Activism

Dr. Quenton Dokken, Executive Director of the Gulf of Mexico Foundation, discussed population and coastal growth, economic and resource trends, environmental quality issues, and the role of science in sustaining the Gulf of Mexico. Historically, the Great Lakes and Chesapeake Bay regions have received a great amount of attention. However, the Gulf of Mexico is 20 years behind those regions in terms of receiving the attention required to address its ecological problems. EPA's Gulf of Mexico program has grown and matured and is starting to provide substantial management to the region, but much work is still needed. The Gulf of Mexico is the largest economically successful water body, and strong science and activism is needed to sustain the ecological quality of the region.

The Gulf of Mexico Foundation takes the approach of managing the people responsible for sustainment of the resources, as opposed to managing the resources themselves. This approach is necessary due to the increase in coastal population. Quality of life and industrialization have transformed coastal cities into international centers of trade and commerce. Thirty-four percent of the population in the United States lives in a state adjoining the Gulf of Mexico. Coastal communities, including Brownsville, Houston, and Galveston, TX; New Orleans, LA; and Cape Coral and Key West, FL, continue to experience significant population increases.

Although population growth improves economic conditions, it also places an enormous burden on the environment. The once held belief that the ocean and coastal resources were inexhaustible and, therefore, could be exploited, has been replaced in recent years with a heightened understanding of the environment and the impacts that increased economic development has on the coastal region and its environmental resources.

Marine-related economic activities including outdoor recreation and tourism, waterborne commerce, energy and mineral resources production, fisheries resources, and food supply account for two percent of the gross national product in the United States. Recreation and tourism activities, which include residential and commercial development, account for 50 percent of the economic activity in coastal areas. Six of the 10 major ports in the United States are located in the Gulf of Mexico. Fifty percent of the nation's undiscovered oil and gas supply is thought to be located in the Gulf of Mexico, which is expected to lead to a 60 percent increase in offshore activity by 2010. Over fishing, including both commercial and recreational fishing activities, has resulted in the ocean and coastal waters reaching the maximum capacity on the production of fish.

A host of environmental quality issues are impacted by coastal population increases. Estuaries and coastal waters are being increasingly stressed by point source pollution, non-point source pollution, and

habitat loss and degradation. Municipal and industrial waste discharge and ocean/coastal dumping are the two major sources of point source pollution in the Gulf of Mexico. Four of the five states most responsible for the greatest amount of toxic chemical discharge to surface waters are Gulf coast states (Alabama, Louisiana, Mississippi, and Texas). Recent attempts to control and limit point source pollution have included the construction of wastewater treatment facilities and enforcing limitations on the dumping of dredged material. The majority of non-point source pollution is attributed to urban and agricultural activity. Contaminants of non-point source pollution include sediments, nutrients, animal wastes, pesticides, and toxins. Powering industrial processes and motor vehicles produces most of the air pollution in the region, and coastal habitats have been changed, degraded, and destroyed by anthropogenic activities. As a result, many important species occupying these habitats are threatened. Sensitive and important Gulf coast habitats include wetland, upland, dune, beach, oyster/coral reef, mangrove, and pond/stream habitats.

Good science produces accurate facts from which truth can be determined. It is essential to ensure that the science produced is used and reported as it was intended. Pressure from political, judicial, and special interest groups as well as practitioner biases can impact science. Additionally, political, economic, and time constraints make producing good science more challenging. The science produced is typically at a 95 percent confidence level; this is of importance because, five percent of the time, the scientific results could be incorrect.

Management of the Gulf of Mexico requires great science, which must include long-term monitoring. EPA is a key player in the production of the required science and successful management of this region.

Wrap-Up and Discussion

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics including: (1) mercury levels in the Great Lakes as compared to the levels found in the fish; (2) salinization in coastal wetlands; and, (3) selling local benefits as well as downstream benefits when trying to convince communities to make changes.

Looking into the Future of a Region

Following introductory comments by Dr. Betsy Smith, the ReVA Program Director at NERL, six speakers addressed ecological forecasting, ecological vulnerability resulting from land use change, statistical groundwater monitoring, forecasting species distributions, and alternative scenarios for land cover change. An audience question and answer period followed the presentations.

Ecological Forecasting: An Introduction

K. Bruce Jones, with NERL, discussed the approaches, goals, and applications of ecological forecasting. There are two general approaches used in forecasting: to attempt to predict the future using predictive models that carry with them a level of uncertainty, and to derive a best estimate from a method, mode, or individual, which has the benefit of public understanding that this estimate may not be true.

Ecological forecasting has broad goals that primarily focus on conducting vulnerability/risk assessments based on both current and potential future environments and adopting management approaches to reduce vulnerability and risk. Accomplishing these goals entails the extensive use of models that relate ecological endpoints and important processes to biophysical variables (conditions) and natural and anthropogenic stress; development of scenarios of future conditions of biophysical variables and stressors to evaluate the consequences of certain types of changes; and development of scenarios of change as opposed to prediction.

Applications of ecological forecasting include assessment of vulnerability to the spread of invasive species, ecological resource vulnerability (e.g., consequences of landscape change projections/scenarios on ecological endpoints and processes), and vulnerabilities of important estuary and coastal water processes and resources to future climate change scenarios. Other applications of ecological forecasting include disaster forecasting, assessment of the consequences of alternative future urbanization, assessment of the impact of alternative landscape futures on multiple resources, and use by the Interagency Working Group on Earth Observations.

Although very helpful to many assessments, ecological forecasting has its limitations and issues, including:

- Many assumptions that are made about future changes
- "Space-for Time" construction of models for determining consequences of future change
- Change models based on historic patterns of change that may not accurately reflect future changes
- Complexity of ecosystems
- Scaling
- Limited number of fixed monitoring sites to establish the pattern of historic change and relationships to drivers of change.

A Weight-of-Evidence Approach to Projecting Land-Use Change and Resulting Ecological Vulnerability

Laura Jackson, with NHEERL, discussed the results of urbanization and models for assessing the effects of urbanization. The idea of examining land use change across an area is daunting, and this project is a result of the cumulative effects of citizens and governments. Urbanization is the most rapidly increasing driver of environmental degradation in the Mid-Atlantic Region. Examples of its direct and indirect effects include habitat conversion/fragmentation, polluted and excessive runoff, polluted air and deposition, increased invasive species, longer commute times, and over use of natural areas.

Alternative futures of land use change is a scaled approach to evaluating risk that involves a region-wide analysis, study of large-scale sensitive resources, and high-resolution land use models. Developing this approach began with an examination of underdeveloped models that had undergone some scientific review. These models were then overlaid with what was already known about sensitive resources, and R-EMAP hexagons were also considered. Finally, finer scale models that were more specific to localities were applied.

The first model examined includes census projections and formulas for estimating how much land the future populations will use and how many total acres will be consumed by new development. Using these formulas, projections were made through 2010 focusing on the growth in metropolitan areas such as Philadelphia, PA, Washington, DC, and Research Triangle Park, NC. The second model examined, the Research Economics Model, is more complex and is used to determine whether or not land will have a high value for urban development or agricultural uses. The model indicates that urban areas are losing more land and are becoming more metropolitan. Confidence on these two models is limited, and, therefore, the certainty of their projections in unknown.

SLEUTH is a cellular model. Once guidelines are entered, it produces urban cells in a Monte Carlo simulation. Each pixel is assigned a percentage, and 51 percent was chosen as the cut off point for this assessment. Cells assigned percentages of 51 percent or higher were the ones identified to be urban by 2010. Pittsburgh, PA and Charleston, WV continually fell into that category. The model, based on the

location of current urbanization, was run against a past date then run again against a future date to generate the projections.

Another model examined utilized two methods for prediction. The first method examined Department of Transportation road plans to capture outlying areas. Since growth and roads are circular, new roads result in new construction such as gasoline stations and strip malls. This method estimated that any county having 10 kilometers or more of new or widened roadway would have urbanization by 2010. The second method examined the number of projected new jobs and the unemployment rates by county. Counties were ranked on a sliding scale based on their current unemployment rates and expected numbers of new jobs. Using this ranking, half of the counties in the Mid-Atlantic Region were forecasted for urbanization by 2010. Because this estimation did not sufficiently narrow down the areas, overlays including forest cover, native birds, fish, reptiles, and exotic species populations were applied to rank each county as being rich or low in these areas.

In the end, counties that were projected to have land use change by at least two of the models were ranked. Another outcome of this project was the identification of outlying areas (e.g., mountains and beaches). This is important considering that these areas represent what is left to lose to urbanization and the purpose of the project was to help development, not impede the natural resources.

Alternative Scenarios and Land-Cover Change: Examples Using Nutrient Export

James Wickham, with NERL, discussed the use of land cover change in the determination of changes in non-point source pollution, its link to nutrient export and vulnerability assessments, and nutrient modeling. Alternative scenarios use forecasts of future regional urbanization patterns to distinguish between risk and vulnerability. Land cover change is linked to nutrient export and vulnerability using more traditional EPA endpoints in order to use land use change to determine resulting changes in non-source point pollution.

Forecasting links land use change to risk. Land cover change is one of the major factors for regional vulnerability forecasting in EPA because it is an indicator of the occurrence of temporal change. EPA examined the relationship between land cover change and nutrient export in an effort to develop export coefficients. Associated risk can be estimated by choosing a distribution in the study region.

Two model performance results were examined. The first performance result, labeled "A" for adequacy, is the ability of the model to replicate the entire range of observed data. The second result, labeled "R" for reliability, is a measure of how often the model produces results unobserved in the monitoring data. Reliability is an interesting issue because there may be value in learning more about unobserved results.

A small area of the Mid-Atlantic Region was divided into 5-kilometer cells. A nutrient model was first run using the current land cover map, and then land cover change was imposed upon it by examining the distribution of roads. The relationship between the proportion of urbanization in the land cover map and the road density was used to determine future land cover change.

The results indicated that the largest changes are occurring in some of the major cities along the I-95 corridor. Nitrogen risk was more predominant in the Ohio watersheds that drain through the Mississippi River, and the phosphorous risk was more predominant in the Mid-Atlantic watersheds that drain through the Chesapeake Bay and Delaware. Vulnerability was defined as a change in risk that was exceeding the model error in both the nutrient export and the forecast.

Land cover change effects on variance are an important issue. Because an increase in variance is an increase in sensitivity to outside factors, it makes environmental management more difficult. *Pfiesteria*

variance is of major concern because this toxin has been implicated as the primary cause of major fish kills and fish disease events in many Atlantic and Gulf Coast states. Research has indicated that human activity, such as excessive nutrient loading, increases the activity of *pfiesteria*, leading to greater fish fatalities.

Land cover changes impacting nitrogen and phosphorus export variances were also examined to determine the location of gaps between the mean and the variance. The steps taken in these examinations include:

- Compiling forest, agriculture, and urban proportions by watershed for early- and late-date land cover data
- Running nitrogen and phosphorus export simulation models on temporal land cover data to estimate mean and variance
- Repeating the simulations 150 times to generate confidence intervals for means and variances
- Comparing confidence intervals and declaring significance when a positive difference (gap) is seen between mean and variance ranges over time.

A study conducted in eastern Maryland showed that, on average, an 11 percent loss in forest was required to change the mean and variance. The amount of forest loss required to significantly change the variance increased as the percentage of forest decreased. These study results indicate that watersheds with more forest (i.e., more than 70 percent forest) are more vulnerable to increased nutrient export than watersheds with less forest. Vulnerability is distinguished from risk by means of statistical significance tests.

Statistical Modeling of Groundwater: Vulnerability in the Mid-Atlantic Region – Present and Future

Earl Greene, with the USGS, discussed the relationship between land use and groundwater vulnerability, the benefits of using input functions in modeling to increase their predictive power, and applications of model predictions. Land use change predictions can be used to make predictions for groundwater vulnerability. The goal is to build statistical models for predicting the probability of any kind of constituent in groundwater for which data exists. Nitrate was used in this study because it is considered an overall indicator of groundwater health. This kind of modeling can be adjusted to any specified management threshold, and can define and predict areas where groundwater is most vulnerable. This information is important to managers in determining which areas require the implementation of best management practices and in collaborating with county governments for protection of groundwater resources.

Land use variables, soil variables, and geologic variables are used to determine and predict what is going to happen with groundwater quality. An input function was added to the model to improve its power of prediction. The input function can be sources such as inorganic fertilizer, organic fertilizer, or atmospheric deposition. Other potential input functions that have not yet been tested include septic tanks and home septic systems.

The study analysis consisted of identifying the thresholds, determining the appropriate management concentration level, and characterizing the response variable (nitrates) as either below or above the specified concentration. The nitrate concentration data obtained from the laboratory is converted into a binary value, and a logistic regression model is used for the modeling work. Logistic regression is used to identify a relationship between a categorical dependent variable (nitrates) and independent variables (geology, land use, etc). Parameters developed for the logistic regression model are computed on the

samples. The model, based on those samples, is then applied to the entire region. Use of the model is tedious and time intensive.

Model results have indicated that manure patterns are very important, and show the impacts of high cultivation on nitrates. Geology is also a very significant variable (e.g., limestone is very vulnerable).

This type of modeling is useful for increasing knowledge of groundwater quality and developing vulnerability maps for mangers to use at the regional, watershed, and county scales. This study has been investigating the use of the groundwater model to conduct site-specific analyses or applications of this work. Maps developed using the model are used to determine future monitoring.

Forecasting Species' Distributions: The Shape of Things to Come

Daniel Kluza, with NCEA, discussed the Genetic Algorithm for Rule-set Prediction (GARP) model, the results of a case study utilizing the model to predict the locations of areas in the Mid-Atlantic that may be vulnerable to non-indigenous species habitation, and additional applications of the model results. Forecasting results in indications of what might happen, and predictive modeling uses a few different sets of rules, the end result of which is a basic rule set. GARP describes relationships between occurrence and environment using multiple rules and demonstrates excellent predictive ability through the use of a genetic algorithm and an artificial intelligence application for generating rules.

GARP is a very robust model that looks for non-linear relationships between data. The model determines a potential distribution, and it is important to note that individual species do not always inhabit all of their potential habitats because of factors such as predators, parasites, competitors, barriers to dispersal, or the dispersal ability of the species itself. However, GARP has been proven to be a strong predictor of the distributions of non-indigenous species.

A case study was conducted involving the application of GARP to determine which parts of the Mid-Atlantic Region are potentially inhabitable by a particular non-indigenous species, the giant salvinia, which grows in the extreme southern part of North Carolina. Graphical interpretation of the data indicates that the potential distribution of the giant salvinia depends upon dispersal, management action, and/or inaction. Changes in climate, precipitation, and temperature are also potential factors in the distribution of giant salvinia.

GARP has other regional applications such as modeling distributions of native species and assessing the effects of climate change. Modeling the distributions of native species, conducted to assess threatened and endangered species, can reveal biodiversity (i.e., hotspots and coldspots) and can provide insight into the potential impact of future changes in land cover and use. The effects of climate change on native species, the ecosystem (including nutrient cycling), and the economy can also be effectively predicted by GARP application. Such predictions allow scientists to anticipate the changes and decision makers to be proactive rather than reactive.

Putting it All Together: Implications for the Mid-Atlantic Region in 2020

Dr. Betsy Smith, the ReVA Program Director, discussed future scenarios, the determination of watershed conditions and vulnerability now and in the future, the patterns of watershed vulnerability, and the application of the ReVA approach to decision making. One of the most important aspects of the ReVA program is that it examines all available information to determine which areas are in need of additional work or finer-scale models. Thus far, the program has focused on integrating all of the information. However, different methods are needed to integrate spatial data to develop useful information. ReVa

collected information on more than 150 coverages, but this amount of information was too large to be utilized by decision makers. Therefore, a Web-based tool was built to synthesize the data for use.

The following were examined as drivers of land use change (e.g., migration scenarios, groundwater vulnerability, landscape indicators, and nitrogen, phosphorus, and sediment loadings); mining; risk of timber harvest; "Clear Skies" scenarios for ozone, PM, nitrogen, and sulfur; human population demographics; and risk of non-indigenous species (with and without climate change).

Because ReVA is intended to be an integrated assessment, it is essential to examine human health impacts. Census data were used to identify vulnerable humans (i.e., the young, old, and economically deprived) and to examine the health impacts they could expect in the future.

The assessment tool is portable and Web-based, and NERL is collaborating with EPA Region III to ensure they agree with the future scenarios. The assessment tool will be publicly available by the end of this fiscal year. NERL is also collaborating with Pennsylvania, Maryland, and local governments to assess how future changes might affect their areas and what actions they might need to take in response.

Simple methods involving the use of low environmental quality values were used to determine which watersheds are currently in the worst condition in the overall ecological region. Currently, the Washington, DC, and Baltimore, MD, area watersheds are in the worst condition. However, an urban area location does not necessarily mean that a watershed will be in bad condition. For example, some watersheds actually improved when land use changed from agricultural to urban. This improvement is attributed to nitrate removal.

The watersheds that were in the best condition had a lot of resources. These watersheds might be of real significance based on the number of resources present. Improvements seen in some watersheds are largely attributed to improvements in the Clear Skies program. The areas that fall out of the "best" category are the ones to watch closely.

Determining which watersheds will be the most vulnerable in the future includes assessing ecological conditions in the current scenario. This type of assessment provides information for restoration and protection activities. Most changes within a watershed are the result of increasing growth in the region.

Determining patterns of vulnerability in watersheds involves the assessment of both resources and stressors. Watersheds examined are those that currently have a lot of resources whose future can be confidently predicted and have a number of stressors acting upon them. This type of assessment reveals cumulative effects of the stressors on watershed resources.

Irreversible change is a critical point that ecosystems typically reach once they have been under stress for awhile, and it indicates that the ecosystem will collapse and never revert back to its previous state. Determining how the pattern of watersheds vulnerable to irreversible change will change in the future is essentially a measure of how far ecosystems have already declined and how far they are likely to decline in the future.

The next step of the process involves application of the ReVA approach and information to decision making. Applications include the evaluation of alternative "Smart Growth" strategies, identification of where to set aside land for conservation, assessment of impacts of alternative incentives for pollution prevention, investigation of solutions for "cross boundary" issues associated with air and water quality, estimation of impacts of new road development, and tracking of progress and performance.

Questions and Answers

The speakers had the opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the application of land use models at the local and municipal levels; (2) examples of where the land use change information is being used in decision-making processes; (3) choosing the appropriate thresholds for modeling; and (4) the use of an overlay approach in modeling.

Regional Research Partnership Program

Following introductory remarks by Tom Baugh, with EPA Region IV, three speakers addressed microbial source tracking, the use of land cover diversity as a proxy for biodiversity, and the relationship of terrestrial ecosystems to manganese emissions from wood burning. An audience question and answer period followed the presentations.

Microbial Source Tracking: the Application of a DNA-Based Molecular Approach to Identify Sources of Fecal Contamination

Bonita Johnson, with EPA Region IV, discussed the use of microbiological indicators to assess water quality, the significance and purpose of using a DNA-based approach, and the PCR and Agarose Gel Electrophoresis approach. Pathogens are known to cause harmful, potentially deadly, infectious diseases. Primary sources of pathogens include agricultural operations, septic tank systems, drinking water systems, wastewater treatment systems, and recreational waters. They typically enter and contaminate surface and groundwater via flood events, abandoned and poorly constructed wells, and spills. Indicator organisms are used to detect the presence of pathogens in water because they are easily isolated, have a longer survival rate than most disease-producing organisms, and are expected to be present in water containing enteric pathogens.

Total coliform is the indicator primarily used for potable water assessment. Fecal coliform, *E. coli*, and *enterococci* are used to assess wastewater and other non-potable water quality, fresh water quality, and marine water quality, respectively. Studies are typically looking for the presence of fecal coliform. However, *E. coli* and *enterococci* are better indicators than fecal coliform.

Microbial Source Tracking is an innovative approach based on the assumption that specific species and strains of bacteria are associated with specific hosts. Microbial Source Tracking was introduced in 1999, and is considered to be the best available tool for identifying sources of fecal pollution in water. There are currently about nine other technologies being explored for the same use.

Bacterial source tracking is conducted using two methods: molecular (genotype) and biochemical (phenotype). Molecular methods are referred to as "DNA fingerprinting" because they are based on genetic makeup of fecal bacteria. Biochemical methods are based on an effect of an organism's genes that produce a biochemical substance. The intended end result of this research is to construct a library or database of isolates obtained from samples of known sources such as humans, cows, and deer. The size of the library will be contingent upon the number of potential major sources of fecal pollution in the target area.

Enterococci is the targeted indicator and was selected because it persists longer in the environment than *E. coli*, survives in adverse conditions, is more source specific than *E. coli*, and is found in 80 to 90 percent of clinical isolates taken from infected humans. The sampling plan collected surface water and cow manure samples from a farm in Athens, GA that is located in the Broad River Watershed, which is impaired due to excessive nutrients and pathogens. Samples were taken once a month at sites above and below the farm. EPA Method 1600-mEI agar was the method used to isolate *enterococci*.

PCR is a technique that replicates the DNA present in a cycling reaction run that typically takes about 2 hours. Because the project is ongoing, the actual mixture or cycling cannot be revealed. The final PCR product is then subjected to electrical voltage to cause DNA fragments to migrate. The molecular weight and number of base pairs of the DNA fragments are related to the distance that they migrate. *Enterococci* isolates identified thus far in water and/or manure include *E. faecalis, E. faecium, E. columbae, E. avium, E. casseliflavus, E. hirae,* and *E. raffinosis.*

Ongoing related work in EPA Region IV includes continued determinations of the species of *enterococci* isolates obtained for the Broad River Watershed, maintenance of in-house PCR/Electrophoresis and Microbial Source Tracking capabilities, and the development of a national Microbial Source Tracking guidance document.

Land Cover Diversity Measured by Satellite as a Proxy for Biodiversity

David Macarus, with EPA Region V, discussed research on the potential for using satellite data as a proxy for biodiversity. Dr. Mary White, with EPA Region V, and others developed a model for identifying ecosystems. The research driver was the question of whether or not land cover diversity can be used as a proxy for community development.

Sites in Wisconsin, Arkansas, and Texas were chosen to compare land cover diversity to vegetative community diversity. The research used data from the national land cover database because satellite data are relatively inexpensive because they already exist, airplane fly over data are more expensive to acquire, and ground-based data can be very expensive and is not available everywhere.

To determine if the research project data were good, the community diversity data from the developed model was compared to data from an actual community. Ten such comparisons were made with the Shannon Wiener Diversity Index and, with the exception of the Wisconsin data, the results were not very good. The model is based on shape correlation (i.e., the circularity of the area being examined), which is a possible explanation of the results.

An important aspect of the regional research partnership program is its flexibility. For example, Dr. White spent 1 week per month at the EPA laboratory in Las Vegas and completed computer work at her home laboratory. Regional scientists may be encouraged to participate in the Regional Research Partnership Program by a schedule such as that.

Lessons learned as a result of this project include:

- ORD scientists are eager to collaborate with the EPA Regions
- Use of the land cover diversity index is valid in the EPA Region V geographical area
- ORD computing facilities offer advantages over those available in the regional facilities.

The Relationship of Terrestrial Ecosystems to Manganese Emissions from Wood Burning

Dan Ahern, with Region V, discussed the medical effects and exposure routes of manganese, the element's relationship to plants, its emissions from burning, and areas for future manganese research. Manganese is the number one relative risk for EPA Region V. Discovered in 1774, manganese is the twelfth most abundant element. More than 90 percent of all manganese is used for steelmaking and in other metallurgic processes.

Although considered an essential nutrient for plants and animals, manganese is a neurotoxin at high levels. It affects the central nervous system causing manganism, a disease with symptoms similar to Parkinson's disease. Safe levels are uncertain, but the inhalation safe level dose is approximately one-fifth of the inhalation safe level for mercury. Manganese appears to have effects on children similar to those caused by lead, although the supporting data are uncertain. Manganese exposure has been linked to violent behavior. An example of this link is the increase in the rate of violent crime in Canada after the country introduced methylcyclopentadienyl manganese tricarbonyl (MMT) in gasoline. However, there is no correlation between ambient manganese levels and violent crime statistics. The impacts of manganese exposure are irreversible and persist after exposure has ceased.

Studies on workers who were tracked for 10 years after exposure to manganese showed that while the their manganese concentrations decreased over time, their symptoms continued to increase. Additionally, Parkinson's disease studies are showing onset of the disease 15 to 20 years earlier in welders than in other workers. The critical manganese exposure route is inhalation. The liver and blood will protect the body from ingestion exposures.

Manganese is an essential nutrient to plants. The major factor in manganese levels in plants is the pH of the soil. The range is from 10 to 7,000 ppm, but the average level is about 600 ppm. Low soil pH can lead to high manganese levels that can be toxic to plants. Manganese levels in boiler wood vary from 4 to more than 100 mg/kg. Most of the research conducted on manganese levels has studied leaves and stems of plants. Bark has been shown to have much higher levels of manganese than wood.

This research project considered three emission sources: wood-fired boilers, residential fireplaces and stoves, and wildfires and prescribed fires. Of the three sources, wood-fired boilers produced the highest levels of manganese emissions, typically two orders of magnitude greater than emissions from stoves or wildfires. The difference in emissions is attributed to the fact that most organics are burnt out in boilers and end up in the fly ash, whereas wood stoves and wildfires are not as efficient and most of the metals and manganese end up in the bottom ash. The new MACT regulation is aimed at controlling particulate emissions, and therefore manganese emissions. It has been estimated that wood-fired boilers complying with MACT will reduce their manganese emissions to levels emitted by stoves and wildfires. MACT will require the use of electrostatic precipitators and scrubbers.

Areas for further research include Toxics Release Inventory (TRI) and ambient manganese air concentrations. CAA Title V permits are reporting different emissions for the permit and for TRI. This may result from under reporting as a result of the TRI 25,000 pound threshold level, or from understatement of anthropogenic burning in material flows, mobility issues, and gasoline additives, such as MMT.

Panel Discussion/Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the effect of pH soil levels on manganese availability; and (2) using equipment in research studies that can feasibly be used in the EPA Regions and states.

Community Air Toxics Projects

Following introductory comments by Henry Topper, with the Office of Pollution Prevention and Toxics, five speakers addressed support for community air toxics programs, the development of an air toxics emission inventory and reduction strategy, and community air toxics programs in St. Louis, MO, Louisville, KY, and Mobile, AL. An audience question and answer period followed the presentations.

Addressing Air Toxics at the Local Level

Henry Topper, with the Office of Pollution Prevention and Toxics, discussed EPA actions to address air toxics at the local level. The CAA categorizes air toxics as being a criteria pollutant, a mobile source pollutant, or a HAP. The six criteria pollutants include ozone (O_3), NO_2, SO_2, lead, carbon monoxide, and PM. The mobile source pollutant category consists of 21 chemicals and mixtures, while the HAPs category contains 188 chemicals and compounds.

EPA has been working on air toxics for some time. Recent research efforts have revealed that many of the problems originate at the local level. Therefore, in addition to government-mandated approaches, EPA is working on community-led approaches at the county, city, and neighborhood levels. It is believed that the community-led approach will be the key to the overall success of this project.

Available resources include a national database, guidance materials, training courses, and emission reduction information for mobile, stationary, and indoor sources. Ongoing work to develop additional resources includes the development of a reduction activities matrix for indoor, stationary, and mobile sources; creation of a publicly available library of reference information and Web sites; and an effort to coordinate and pool resources from all Agency programs for integrated assistance to communities.

EPA and its partners have a new vision to help communities which includes:

- Identifying the appropriate mix of analysis and risk reduction efforts at the local level
- Understanding that each community has different needs, abilities, and interests
- Helping communities to identify and prioritize risks and risk reduction options, educate the public, and find the needed resources.

The Air Toxics Program is part of a larger effort within EPA that includes the Communities for Renewed Environment Program, the Environmental Justice Collaborative Problem Solving Grant Program, the new Administrator's emphasis on collaboration and local solutions, and the Agency Framework for Cumulative Risk Assessment. Additionally, the new Agency focus includes resources and tools for addressing environmental health issues at the local level.

Developing a Local HAP Inventory and Reduction Strategy in New Haven, CT

Madeleine Weil, with the City of New Haven, CT, discussed the development of the HAP inventory, its results, and lessons learned as well as the development of a risk reduction strategy. The purpose of this project was to develop an inventory of local HAPs emissions from point, area, and mobile sources, and to design and implement an air toxics reduction strategy focused on priority pollutants and sources identified by the inventory. The project began with an $80,000 Air Toxics Inventory grant from EPA Region I. The Comprehensive Plan of Development (in 2003) emphasized environmental health and sustainability as components of quality life, provides guidance for development policies and regional planning initiatives, and addresses environmental justice.

The primary project questions addressed the identification of HAPs emission sources, pollutants of concern, and the location of HAPs concentrations. Secondary project questions addressed the accessibility of air toxics data by local governments that lack emissions inventory expertise, the identification of technical and systemic challenges to data gathering, and innovative methods resulting from a "rookie" project.

Point sources were inventoried individually, and 33 facilities reported 114 tons of total HAPs emissions per year. Sources of the HAPs emissions included surface coating, degreasing, petrol tank farms, and power plants. Thirteen of the 33 facilities accounted for 96 percent of all of the emissions. The following are lessons learned from the point source assessment: up-front National Emissions Inventory training would be useful, existing inventories are inconsistent, Connecticut lacked a HAP inventory, and partnerships with record-keeping staff at regulatory agencies are essential.

Area source emissions were assessed through the use of surveys, experts, utility requests, existing research, per capita information, and employee information. Graphical interpretation of the data revealed that architectural and industrial surface coating and solvent cleaning produced more than 75 percent of the emissions. The following are lessons learned from the area source assessment: groundwork improves the accuracy of activity data, the method still relies on EPA emission factors, and the factors were developed for national-level inventories.

Mobile source emissions were assessed in two categories: on-road and non-road. Methods to assess on-road source emissions included the 1999 National Emissions Inventory county-level emissions; variables such as vehicle mix, traffic patterns, and speed; and a local vehicle classification mix. The results indicated that light duty gas vehicles, light duty gas trucks, and heavy duty diesel vehicles produce the vast majority of on-road source emissions. The following are lessons learned from the mobile on-road source assessment: heavy-duty diesel vehicle emissions were potentially underestimated, high ambient levels of PM 2.5 exist, and port-related traffic, including idling trucks, slow speeds, and heavy loads, is a factor for consideration.

Methods to assess non-road source emissions included the use of aircraft landing-takeoff data, locomotive fuel consumption data, waterborne commerce statistics for commercial marine vessels, and National Emissions Inventory county data. Results indicated that construction and landscape activities and commercial marine vessels produced the vast majority of non-road source emissions.

Overall, the results indicated that point, area, on-road, and non-road sources are responsible for 11, 22, 39, and 28 percent of the total emissions, respectively.

Health risk prioritization is an important part of the assessment because it evaluates relative risk; examines cancer, chronic, and acute health risks; and focuses the reduction strategy on high ranking pollutants. Lessons learned in the health risk ranking include: assistance from toxicologists and air pollution experts is essential, health risk analyses must follow inventory development, and the risk reduction strategy should reflect a reduction in risk as opposed to amounts of emissions.

The risk reduction strategy examined mobile, stationary, and indoor risks, and was funded by a $50,000 EPA Healthy Communities Grant in 2003. The strategy targeted diesel and passenger vehicles, gasoline stations and fossil fuel combustors, and indoor tobacco smoke. Reduction strategy lessons learned included: the strategy should dove-tail with other priorities, there are pre-existing constituencies, and the "Big-Tent" approach leverages the City's power to catalyze change.

St. Louis Community Air Project

Emily Andrews, Managing Partner for the St. Louis Community Air Project, provided an overview of this program, the partnership team and advisory board, and solutions developed by the program. The goal of the project is to ensure healthier air and was the result of the community's interest in knowing more about air pollution and its health effects. The project involved close data collection collaborations with the state, city, and region.

Data were collected from three monitoring stations located south of St. Louis for a period of 1 year. Data collected on 250 pollutants and diesel particulate matter were compared to previously set health benchmarks for cancer and non-cancer incidents to examine long-term health effects. The analyses identified six pollutants of concern: acetaldehyde, arsenic, benzene, chromium, formaldehyde, and diesel particulate matter.

The partnership team met every 3 months for 3 years. The team believes in the collaborative efforts of EPA, scientists, and community with local, state, and Federal agencies to solve air pollution problems. Modules developed to educate the public on air toxics will soon be used as part of an outreach program.

One of the challenges of providing information to the partnership team is that not all members of the group are familiar with scientific terminology. Therefore, it is important to present scientific data in such a way that all partners can comprehend it and participate in the decision-making process. As a result, the project developed tools to facilitate data presentation. Visuals were found to be particularly helpful for information presentation.

Another challenge is determining the amount of information required in order for individuals to begin making better decisions regarding their health and the environment. Too much information can be overwhelming. Yet, people ask questions that science cannot answer such as:

- What is in the air that is causing my child's asthma?
- What is the cumulative effect of all these pollutants on our health?
- What is causing my friend's cancer?

"In the Air" provides tools for conveying information about airborne toxics. More information about these educational modules can be found at http://www.earthwayshome.org/intheair.

Ultimately, the goal is to increase knowledge on air pollution and to make correlations between behaviors and air quality.

Louisville 2004: Risk Management Actions

Jon Trout, with the Louisville Metro Air Pollution Control District, discussed the basis of the West Louisville Air Toxics Study, findings, and the actions taken as a result of the findings. The West Jefferson County Community Task Force is comprised of citizens, industry, academia, and government. Funded by resources from EPA, the State of Kentucky, the University of Louisville, and the Louisville Metro Air Pollution Control District, the West Jefferson County Community Task Force has chosen monitoring site locations and air toxics to be monitored, and has developed a risk assessment work plan and a risk management plan.

The West Louisville Air Toxics Study is a 1-year study conducted from April 2000 to April 2001 that monitored for volatile organic compounds, semi-volatile organic compounds, formaldehyde, hydrochloric acid, hydrogen fluoride, and metals. The study results indicated that there were 17 carcinogens posing a risk greater that one in one million. The carcinogen with the greatest risk was 1,3-butadiene.

The analysis portion of the risk management plan involves source identification, option selection, and implementation. Options included public awareness, education of sources, education of health providers, technical assistance, pollution prevention, political action, economic assistance, public health initiatives, and regulatory and legal actions. To fulfill the public awareness option, the *Courier-Journal* reported 2001 emissions of 1,3-butadiene by three companies. Political actions taken under the risk management plan included meetings between the Mayor of Louisville and the three companies. All three of the

companies promised to implement emission reduction actions in response to the Mayor's request for voluntary emissions reductions.

The following issues are raised under the regulatory response option:

- Which compounds should be included in draft regulations?
- What is the acceptable level of emissions?
- Who sets the standards and how?
- Which sources should be regulated?
- Multiple pollutant consideration?
- How is acceptability determined?

Mobile County, Alabama Air Quality Study

Steve Perry, with The Forum, Industry Partners in Environmental Progress, discussed the purpose, participants, organization, and scope of the Mobile County, Alabama Air Quality Study. The mission of this study was to evaluate the existing air quality of Mobile County, determine community-based expectations for the county's air quality, and propose and implement the necessary actions to achieve and maintain the community-based air quality expectations.

The study was designed by a group of local citizens to address local issues, only considered air toxics (not criteria pollutants), and was not designed to be a regulatory study, a health study, or an ongoing monitoring program. Key participants in the study included the City of Mobile, Mobile County, Mobile Bay Watch/Baykeeper, the Mobile Area Chamber of Commerce, and The Forum, Industry Partners in Environmental Progress. Participation of local partners was very important to the study. Mobile Bay Watch/Baykeeper is the primary environmental group in the area. All partners came to the table with different agendas.

The study organization consisted of a steering committee, a fiscal agent, a management group, a citizen panel, a technical task force, and contractors. The technical task force contributed to the study up to the point of defining the scope.

The initial cost estimate of the study was $750,000 to $800,000. However, the final funding costs are estimated to be approximately $1.2 million. EPA and the State of Alabama provided the additional funding.

The scope of the study is air monitoring, air modeling, and community-based expectations. Air monitoring included volatile organic compounds, carbonyls (formaldehyde and acetaldehyde), metals, and PAHs, among others. Monitoring locations included industrial, traditional, and high population areas as well as a background site. Sampling occurred on randomly selected dates for a period of 1 year, and 60 samples were taken at each location.

Modeling was conducted using the Assessment System for Population Exposure Nationwide model, which was chosen because EPA had previously used this model for some other assessments. Coastal zones are difficult to model and, therefore, modeling was a challenge.

Community based expectations were the core of this project. A work group of 25 to 30 people spent 6 to 9 months being educated on monitoring and modeling. There were no pre-conceived ideas of what form the expectations would take (e.g., qualitative, quantitative, risk based, or concentration based). The

process for determining community-based expectations included establishing rules, agreeing on educational needs, setting targets, establishing a subcommittee and consideration of their reports, issuing recommendations to the steering committee, and sharing information via a Web site.

The approach for carcinogens was determined as follows:

- Risk at less than 1 in 1,000,000 is acceptably low
- If the sum of all risks in an area is between 1 and 10,000 and 1 in 1,000,000, then some evaluation will necessary
- If the sum of all risks in an area is greater than 1 in 10,000, the cause should be examined and reductions should be considered based on political, social, economic, and engineering implications.

The approach for noncarcinogens was determined as follows:

- Exposure to any individual chemical at less than its reference concentration is acceptable
- Exposure to multiple chemicals with a hazard index of less than 1 is acceptable
- If a hazard index for an individual chemical is greater than 1, risk evaluation and risk management will be conducted.

Monitoring results are just now becoming available and will be used in modeling. Lessons learned are that it is important not to be bound by convention, take time to educate, and embargo data.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the nuances of regulation; (2) industry involvement in the Louisville project; (3) the completeness and accuracy of TRI self-reporting; (4) use of actual source data to ensure the accuracy of results; and (5) the likelihood of the success of voluntary emission reduction programs.

Science to Support Decisions: Climate Change

Following comments by Michael Slimak, with NCEA, four speakers addressed the feasibility of assessing climate change impacts, decision making involving climate change in the Gulf of Mexico, and alternative approaches to conducting climate change impact assessments. An audience question and answer period followed the presentations.

Climate Vulnerability and Impact Assessments Can Provide Useful Insights and Guidance – Now

Michael MacCracken, with The Climate Institute, discussed the climate change issue, the factors that complicate the issue, and the potential impacts of climate change. The issue of climate change is divided into three key questions:

- How is the climate expected to change and are we already seeing the early signs of these changes?
- What are the environmental and societal impacts that are expected, and to what extent can adaptation ameliorate the projected negative consequences?
- What are the options for limiting the human-caused factors and how rapidly and economically can they be implemented?

Answering these questions is complicated by the following factors:

- The changes in climate, the impacts of the changes, and the implementation of options all have century-long time horizons
- Projection of a range of possibilities is all that can be expected
- This is a global issue that is international in scope.

Under the guidance of the United Nations Framework Convention for Climate Change, the Intergovernmental Panel on Climate Change assesses expert understanding of these three key questions. The United Nations Framework Convention for Climate Change is comprised of representatives of more than 150 countries.

Climate models provide consistent projections of the expected climate changes. However, they are better at predicting temperature than precipitation. The Intergovernmental Panel on Climate Change projects that there will be intensifying changes in climatic measures during the 21st century, including increases in surface temperature, precipitation, and evaporation rates as well as a rise in sea level.

Impact assessments evaluate the potential vulnerability to scenarios of projected change in climate. The scenarios are not predictions. A range of approaches can be used to generate plausible scenarios. However, two important points are that the wide range of possible changes in climate does not directly affect impact assessments of potential vulnerability, and only generalized projections are possible.

Key findings of the United States' National Assessment include the following:

- Increased warming is projected across the United States
- Climate change and impacts will vary regionally
- Many ecosystems are highly vulnerable and their goods and services will be costly if not impossible to replace
- Water is an issue in every region, but the nature of the vulnerability varies
- The agriculture sector is likely to be able to adapt to a climate change
- Forest productivity will likely increase for a few decades and then possibly decrease over the long-term
- Increased damage is projected for coastal and permafrost areas
- Adaptation is likely to help protect much of the population in the United States from adverse health outcomes
- Climate change is likely to magnify other stresses, such as air and water quality
- Significant uncertainties remain and surprises are likely.

The United States Government is responsible for reporting likely consequences to the United Nations every 4 years. Even with the limitations in available information, particular regions and sectors can enhance the basis of their long-term planning using these assessment results. For example, global warming affects snowmelt in the West, which affects the water resources that are very important in California.

Although the impact assessments can provide useful information, they cannot provide details.

It is important to communicate science to the stakeholders so that they have a basis for their decisions on whether to take action. Climate change should always be considered when making long-term decisions.

The Feasibility of Conducting Climate Change Impacts Assessments: Opposing Viewpoints

William O'Keefe, with the George C. Marshall Institute, discussed issues for consideration in making policy decisions, the limitations of the current knowledge base of climatic effects, and actions to be taken to promote a broader knowledge base. Historically, there has not been enough attention placed on providing information to the public and policy makers that would be useful in making wise decisions. The public has not been properly informed on the issues, which has led to confusion. Wise policy requires wise decisions and an understanding of the trade-offs and their consequences.

In order for information to be valuable to policy makers, it is important to be clear on the following:

- The limits of data, models, and analyses
- What is known, what is unknown but knowable, and what is unknown and may not be knowable any time soon
- Science can illuminate our understanding, but cannot solve climate change problems
- Policy should flow from our state of knowledge, reflect the reality that actions have consequences, and be capable of being adjusted one way or another as knowledge increases
- Creating new knowledge has a high priority and should be driven by the value of the information and the likelihood of being able to produce it
- Hedging strategies reflecting the enormous uncertainties in our understanding of the climate system have great value but have not been adequately explored
- Scenarios have value to the extent that they help to illuminate implications for capital investment, changes in capital stock, new technology, and economic and population growth
- The time horizon for planning and action is inversely related to the extent of uncertainty.

The first National Assessment for the United States was a noble effort, demonstrating the limits of knowledge and the limits of models, but it did not help the policy-making process. Two of the best climate models in the world produced conflicting climate forecasts in many regions. These conflicting estimates should have led to a serious discussion of model limitations, why long-term regional assessment simply cannot be done at this time, and what can be done about the regional impacts of today's climate. In spite of the severe limitations of the climate models, they are being made more complex rather than improved in their capability to accurately capture variables. A better approach is to limit their use and focus more on building the knowledge base and the data that would eventually enable these models to be relevant to policy making.

Models that cannot be validated have limited value as policy tools. Calibrating them to replicate past temperature is appropriate for research purposes, but inappropriate for forecasting the future and for decision making. As a result, modeling should have a lower priority in the government's research agenda and a higher priority should be given to research on key climate variables such as water vapor, feedback, cloud formation, solar variability, ocean currents, and aerosols. A better understanding of those variables is critical to gaining insights about natural variability and climate sensitivity.

Limits on knowledge and constraints on our ability to radically alter either our economic or energy systems in the short-term should be matched by constraints on our planning horizon and actions. Actions driven by apocalyptic visions of the future rob us of needed flexibility. Large organizations have a hard time achieving and sustaining flexibility and creativity. Problems associated with incentives, communications, and cohesion lead to processes that promote efficiency and order. The inertia of large organizations makes it difficult to quickly recognize the value of new information, alternative approaches, or the need to change direction.

Effective planning should address these problems at the outset. Providing mechanisms to encourage creative tension without promoting chaos is one way. Promoting healthy and constructive dissent is the hallmark of a healthy organization, but it requires an understanding of the need to compensate for organizational inertia.

The way to invest wisely is be clear about priorities, objectives, measures of success, and mechanisms for bringing an end to work that does not meet expectations. Until there is a better understanding of natural variability, climate feedback, climate sensitivity, and the like, there cannot be understanding of the extent of human influence.

Policy proposals that fly in the face of economic and energy realities have little hope for long-term survival. In the end, climate policy is energy policy, and has economic impacts.

Actions that can be taken to create options and deal with adaptation include mitigating the effects of current climate extremes, investing in infrastructure, curbing subsidies for excessive water use, and development. It is important to stop pretending that we can accurately forecast future climate and its impacts.

Use of Science in Gulf of Mexico Decision Making Involving Climate Change

Arnold Vedlitz, with Texas A&M University, discussed the purpose of an EPA cooperative agreement project, its framework, and the anticipated results. The ongoing project is multi-disciplinary, employing the expertise of representatives of Texas A&M University, EPA, the University of New Orleans, the University of Louisiana at Lafayette, the Florida A&M University, and stakeholder advisors and informants, and attempts to address the issues of how science can be useful as a tool for decision making. The team interacts on a weekly basis.

The purpose of this project is to educate decision makers and the public on the uncertainties surrounding complex scientific information so they can make or influence informed policy decisions. The project goals are to:

- Investigate the salience of climate change for Gulf of Mexico stakeholder groups
- Examine how stakeholder groups use climate change science information in decision making
- Describe unfilled information needs on this topic
- Recommend strategies for making climate change information more useful to decision makers.

The conceptual framework of the project includes social construction of problems, setting agendas, and social amplification of risk. Data sources include unstructured interviews, document analysis, observation of group processes, and focus groups.

The project in divided into four phases. Phase I involves a research team workshop, a stakeholder workshop, and the selection of research locations, endpoints, and stressors. Phase II involves the

collection of documentary evidence, preliminary analyses of media coverage, and field work preparation. Phase III involves field work and continuing document collection. Phase IV involves data analysis and preparation of the project report.

The plan is to conduct interviews with 600 major decision makers. Wave 1 is a completely undirected set of interviews, the first 100 of which did not focus on climate change. Wave 2 of the interviews will focus attention on potential events that might occur and how climate change will influence the results of those potential events.

Preliminary findings of the Wave 1 interviews identified some problems involving population growth effects on organization's budgets, problem definition variability between organizations, and linking environmental problems to economic considerations. The interviews also provided insight into how Gulf Coast stakeholders acquire and use scientific information as well as links between scientists and stakeholders.

Once completed, the project will:

- Explain how issues such as climate change become identified as problems
- Describe how information relevant to climate change is received and processed
- Identify valued and trusted information sources
- Identify the most accessible, useable, and understandable information types and formats
- Describe how information providers can best frame, package, and deliver objective science and technological information for most effective consumption and utility by policy makers and the public.

Alternative Approaches to Climate Change Impacts Assessments: Success Stories

Joel Scheraga, National Program Director of ORD's Global Change Research Program, discussed the debate regarding the feasibility of conducting regional and place-based climatic impact assessments with much of the debate coming from the modeling community. A broader understanding of which tools can be used can be obtained by examining the tools from a user's perspective. The objective is to determine which model will provide answers to the questions surrounding the issue. Frequently asked questions include:

- Is climate change an issue of concern?
- Is it possible to develop a better understanding of the vulnerability of a system to climate change?
- Do opportunities exist for increasing resilience to both climate variability and climate change?
- Are there actions that will foreclose future options?
- Can potential maladaptive practices be identified?

Five categories of insight are used to answer these questions: effects of concern, potential variabilities, win-win opportunities, preventing foreclosure of future options, and potential maladaptive practices. Use of these insight categories has proved to be successful in projects regarding drinking water, heat wave mortality risks, riparian buffer zones, rolling easements, and sea level rise as well as shipping industry changes necessitated by water level changes.

The climate and science community should recognize that models are not the only way to assess potential effects of climate change. Using these categories of insight is another way to successfully link sound science and sound decision making.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the best approaches for communicating scientific knowledge to the public; (2) the local impacts of climate change; (3) making the effort to engage stakeholders from the beginning of the research process; (4) testing the validity of models; (5) educating the public (through organizations holding the public's trust) on climate change, the true state of knowledge; (6) basing predictions on information other than what has happened historically; and (7) the difficulties associated with predicting years into the future.

Section V: Delivering Science-Based Information to Decision Makers

Wednesday and Thursday, June 2-3, 2004

The purpose of this breakout session on the second and third days of the meeting was to focus on the development of environmental indicators, the use of geospatial tools to support decision making, mechanisms for environmental and health information exchange, development of science-based information for coastal systems, scientific computing applications, improving the indoor environment, and tools for net environmental benefit analysis. Each session included opportunities to respond to audience questions that provided additional information and insight on a variety of science-based information, analysis methods, and tools.

Michael Flynn, with the OEI Office of Information Access and Analysis, led a session addressing the development of environmental indicators and analytical tools to link environmental conditions and public health outcomes. Presentations included an overview of the Report on Environmental Indicators and its status, examples of integrated environmental monitoring and public health data systems, and a causal analysis diagnosis decision information system to identify causes of biological impairments.

Brenda Smith and Wendy Blake-Coleman, with OEI, led a session addressing the use of geospatial tools in support of decision making. Presentations included the development and implementation of an emergency response analysis system, analysis of remote sensing data to determine trends of urban growth and impacts of urbanization, and a Web-based tool enabling interested agencies and organizations to obtain information on how specific projects will affect surrounding communities and the environment.

William Sonntag, with OEI, led a session addressing the use of information technology to provide greater access to health and environmental information. Presentations included an overview of the National Biological Information Infrastructure that provides access to data and information on biological resources in the United States, an overview of the Environmental Information Exchange Network that was created to share environmental information and promote information exchange over the Internet in a secure network environment, and an overview of the EPA System of Registries, which supports metadata and serves as a gateway for searching diverse EPA metadata repositories.

Kevin Summers, with NHEERL, led a session addressing the development of science-based information for coastal systems. Presentations included the development of an integral network within the states and tribes in the Western United States to assess environmental conditions of coastal areas, an overview of the National Coastal Assessment Initiative to improve the overall health of coastal aquatic ecosystems nationally and regionally, a State of Florida in-shore marine monitoring program, State of New

Hampshire efforts to assess estuaries and develop indicators, and National Coastal Assessment Program activities in the Long Island Sound and Narragansett Bay areas.

Rick Martin, with the OEI Office of Technology Operations and Planning (OTOP), led a session addressing enhancements in EPA's high performance computing capability. Presentations included the implementation of a new high performance computing system; EPA initiatives to expand data acquisition, storage, and manipulation by internal and external users; and a desktop of the future for information access and analysis for decision making in the form of an Environmental Science Portal.

Elizabeth Cotsworth, with the Office of Radiation and Indoor Air (ORIA), led a session addressing how science can be shared to influence public action for healthy buildings. Presentations included sources of indoor air pollution and their prevention/control, research underway to understand and document the health effects of indoor air pollutants, guidance and other materials developed to help the public take the actions necessary to improve indoor air quality, development and implementation of an Indoor Air Quality Label for new housing construction, and strategies for public outreach and engagement.

Ann Whealan, with EPA Region V, and Bill Robberson, with EPA Region IX, led a session addressing net environmental benefit analysis. Presentations included the use of this tool in environmental decision making for emergency response and a case study of its application in planning.

The Future of EPA's Environmental Indicators Initiative and Report on the Environment

Following opening remarks by Michael Flynn, Director of the Office of Information Access and Analysis, four speakers addressed indicators of healthy communities and ecosystems, the EPA Report on the Environment, environmental public health tracking, and a causal analysis and diagnosis decision information system. An audience question and answer period followed the presentations.

Indicators of Healthy Communities and Ecosystems

Heather Case, with OEI, provided an overview of the EPA *Report on the Environment*, which highlights the conditions of air, water, and land in the United States and demonstrates their effects on life, health, and ecological conditions. The OEI Environmental Indicators Team is working to report on what is known and not known about the condition of the environment, improve the indicators and information available to report on the condition of the environment, and support the use of indicator information for EPA decision making (e.g., strategic planning, budget decisions, policy).

The *Report on the Environment* is a step in the overall initiative of the President's Management Agenda of improving environmental indicator uses and relating the science behind indicator results to human health and ecological conditions. The main goal of the *Report on the Environment* is to demonstrate how EPA activities to protect the environment actually lead to positive outcomes, which are defined as changes in emissions, ambient concentrations, exposure, and disease trend or condition of an ecoystem. The key to enhancements of environmental indicator activities is to understand the degree to which EPA program activities support these improvements. The Report identifies indicators (measures of environmental results), describes the status and trends in the environment and in human health, and describes what EPA knows about the current state of the environment at the national level and how it is changing. A shorter report is available to the public and a longer technical report is available to environmental professionals.

The data and information in the *Report on the Environment* underwent peer review and are supported by sound experimentation, data management systems, and quality assurance procedures. This Report uses data and results from EPA databases, as well as other sources outside of EPA, including other Federal agencies, states, tribes, and non-governmental organizations.

The format of the *Report on the Environment* follows a hierarchy of indicators, as described below:

- Administrative Indicators
  - Level 1 – EPA, state, tribal, or other government regulations and activities
  - Level 2 – actions and responses by regulated and nonregulated parties
- Environmental Indicators
  - Level 3 – changes in pressure or stressor quantities
  - Level 4 – ambient conditions
  - Level 5 – exposure or body burden and uptake
  - Level 6 – ultimate impacts or changes in human health and/or ecological condition.

Some findings from the *Report on the Environment* include the following:

- Air emissions of six criteria pollutants and their precursors have decreased by 25 percent in 30 years

- The percentages of days in which at least one criteria pollutant exceeds an air quality index of 100, which is known as Code Orange, were at their lowest levels in more than 10 years in 2000 and 2001
- Acid rain continues to decline in the East and Midwest
- Stratospheric ozone levels declined over Seattle, Los Angeles, and Miami between 1979 and 1994.

ROE: Focus on Human Health and Ecological Condition Chapters (Overview of the Outcome Chapters)

Denice Shaw, with OEI, summarized the outcome chapters in the *Report on the Environment*, which focus on air, water, and land. These chapters answer the question "How do we understand and interlock the information received from environmental indicators when assessing the status of our air, water, and land?" A human health chapter focuses on the health of the American public, which is generally good and improving when compared to statistical health data from other nations. However, there is no direct relationship between the trends found in human health and disease assessments to trends in exposure levels to specific pollutants.

EPA has an abundance of information about the environment and human heath, but linking trends and noting cause and effect relationships cannot be done with confidence. Historically, there were circumstances where the correlation between trends was clearer. For example, reductions in lead in gasoline resulted in a clear reduction in blood lead levels, but there is no clear connection between blood lead levels and human health. The incidence of waterborne disease is declining, but uncertainty exists as to whether the decline results from exposure to sources of drinking water, well water, or recreation such as swimming. Similar examples include human health chronic obstructive pulmonary disease studies along with cancer and asthma. Asthma attacks can be the result of exposure to air pollutants, as well as other causes. When studying cancer deaths, many pollutants are carcinogens, but cancers also are associated with many other factors.

When considering human health, the EPA has a real opportunity to more clearly identify the missing links and to successfully overcome these issues with new goals, initiatives, and activities. When considering ecological conditions, there are significant gaps in the availability of environmental indicators and data that make it impossible to report on status and trends nationally. For example, there are data on the ecological condition of forests in the United States based on the Forest Inventory and Analysis program, which provides nationwide, representative snapshots of tree conditions and ozone damage to trees in the United States. After studying these data, EPA realized that ozone information was not collected in the same way as the data for the Forest Inventory and Analysis. Similar findings were discovered when looking at coastal waters in which NOAA and EPA use an EMAP probability design to provide nationwide, representative data for coastal water assessments.

In summary, the chapters on human health and ecological conditions show that there is a wealth of information being collected, and some trends have been found. However, there is a great need to improve the links and the assessments.

Environmental Public Health Tracking: Moving Into the New Millennium (Human Health Trends and Outcomes)

Dr. Judy Qualters, Chief of the Environmental Health Tracking Branch at CDC, introduced recent trends in tracking environmental public health. Currently, we do not understand how environmental hazards relate to health effects in the United States. Scientists have the most data, but there is little sound knowledge of how to link environmental and human health assessments to current trends. There also is a

lack of data and data access, as well as a lack of tools. Therefore, there is a need to build capacity, as well as standards to improve the data.

Congressional funding was provided to develop and implement a nationwide environmental public health tracking network and to improve capacity in environmental health at state and local health departments. The goal of this CDC National Environmental Public Health Tracking (EPHT) Program is to provide information from a nationwide network of integrated environmental monitoring and public health data systems so that all sectors may take action to prevent and control environmentally-related health effects. The CDC National EPHT Program goals include building a sustainable, national environmental public health tracking network, increasing environmental public health tracking capacity, disseminating credible information, advancing environmental public health science and research, and bridging the gap between public health and the environment.

Environmental tracking means surveillance. This initiative requires looking at hazards, exposures, and health effects; linking data within a tracking network; disseminating information to stakeholders; and then improving the environment and human health. Ideal characteristics of the National EPHT Network include:

- High quality, timely mortality and morbidity data with high resolution geographic coordinates
- A wide range of information on exposures based on biomonitoring, personal monitors, or exposure modeling
- Relevant, high quality, timely emissions data and monitoring data for air, water, soil, and food (all based on temporally and spatially appropriate sampling schedules)
- Updated population data for denominators to calculate rates with adjustment for migration and socio-demographic factors
- Ability to link geographically and in some situations, individually
- Resolution that is fine enough to enable evaluation of effects from localized environmental exposures in small areas.

Tracking data will enable scientists, analysts, and decision makers to quantify the magnitudes of environmental issues, evaluate trends and risk groups, present hypotheses and data to support the hypotheses, develop information for better clinical care and individual health actions, and facilitate planning.

Program components include information technology and standards, communications, training, research, legislation and policy, and scientific methods. The National EPHT Program also requires partnerships among stakeholders and government agencies, and these partnerships and collaborations are key. For CDC, these partnerships have involved state and local health departments, academic centers of excellence, national public health and environmental professional organizations, advocacy groups, EPA, and NASA.

CDC has funded 21 states at different levels for demonstration or pilot projects of environmental public health tracking. Thus far, each state has its own initiative or program for gathering information and conducting research. Also, to support the goal of partnering and collaboration, the states were not eligible for funding unless the state health department worked with the local health and environmental departments. As a result of these pilot projects, CDC is hoping to create a state model that can be followed by other states in the future.

Also, EPA and the Department of Health and Human Services have partnered with CDC and ATSDR to advance efforts to achieve mutual environmental public health goals and strengthen the bridge between the environmental and public health communities. These efforts include linking agency databases, sharing timely and reliable environmental and public health data from agency networks, and increasing interaction and enhancing collaboration between the agencies.

An example of partnering projects between CDC and the states is the New York Pilot Data Exchange Project. The purpose of this project is to implement and test a system for exchange of air monitoring data between the New York State Departments of Environmental Conservation and Health, examine interoperability issues between CDC and EPA databases, and provide lessons learned to CDC and other partners. Other examples include the Wisconsin Environmental Public Health Tracking Data Linkage Demonstration Project; the Public Health Air Surveillance Evaluation Project with the states of Maine, New York, and Wisconsin; and the Health and Environmental Linkage for Information Exchange with the city of Atlanta.

All activities focus on moving into an implementation phase in late 2005. More information can be found at http://www.cdc.gov/nceh/tracking.

CADDIS: The Causal Analysis/Diagnosis Decision Information System

Susan Norton, with NCEA, provided an overview of the Causal Analysis/Diagnosis Decision Information System (CADDIS), which is supported by NCEA, NERL, several EPA offices, the Idaho Department of Environmental Quality, the Connecticut Department of Environmental Protection, the Maine Department of Environmental Protection, Ohio State University, and the Minnesota Pollution Control Agency. CADDIS helps investigators in states and tribes to identify causes of biological impairments and serves as a Web-based system providing guidance, examples, and links to information.

Determining the cause of a biological impairment is a continuous planning process, and the causal analysis approach is based on the EPA 2000 Stressor Identification Guidance. The causal analysis approach provides a logical method for analyzing evidence, making a case, and identifying useful information. CADDIS supports state and tribal communities and users of the stressor identification guidance with the goals of bringing together guidance, tools, information, and case experiences. CADDIS provides links to relevant information, helps to analyze and interpret evidence, and helps to organize, quantify, and share results. Also, CADDIS can be used for coastal evaluations of real cases.

CADDIS, which can be found at https://cfpub.epa.gov/caddis, includes a step-by-step guide, an interactive flowchart of the process, and examples of CADDIS activities. Each step ends with an output statement so that the user can expect the next step. CADDIS also provides a complete listing of all blank worksheets as word processing documents, a conceptual model, example projects and full case studies, external data and information links, a list of references, site map, and search glossary.

In the near future, CADDIS also will include databases of empirical stressor-response studies, analytical tools for users, a conceptual model library, and case study examples. In addition, a new exposure-response database will bring in field data and research, not just laboratory data or research reports. Case studies with states and tribes are continuing, and these results will be included on their Web sites so that other groups can review the cases and model their own approach accordingly. The overall goal is to help EPA link its efforts in biological assessment and biocriteria to environmental outcomes by working with states and tribal partners.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) improving outcome measures in order to address the lack of broad data, data access, and data standards; (2) harmonizing data collection efforts and initiatives among Federal, state, local, and tribal agencies and workgroups; and (3) providing users of databases with the correct results and conclusions.

Using Geospatial Tools to Make Program Decisions

Following opening remarks by Brenda Smith and Wendy Blake-Coleman, with OEI, three speakers addressed the use of geospatial tools for emergency operations, to assess urban growth and land cover trends, and environmental impact reviews. An audience question and answer period followed the presentations.

OEI Support for EPA HQ Emergency Operations Center: Emergency Response Analyzer

Joe Anderson, with OEI Office of Information Access and Analysis, described efforts to develop custom software to support the EPA Headquarters Emergency Operations Center. After the September 11, 2001 terrorist attacks, the EPA realized that there was a need to renovate and improve the Emergency Operations Center. A main goal is visual observation of an emergency situation and the need to determine the result of any situation. Therefore, GIS technology is crucial in determining the location and results of emergency situations, as well as the integration of tabular data and mapping. The outcome of this initiative is the Emergency Response Analyzer.

A pilot exercise for the Emergency Response Analyzer was completed in EPA Region II. As part of this pilot exercise, scientists and engineers simulated a fire at a warehouse where there were incidences of injuries, fatalities among the firemen, etc., that resulted in the mobilization of the regional operations center. EPA and firemen were on the scene, and the goal was to coordinate mapping and simulations to establish occurrences and results of the fire. The mapping technology used during the pilot exercise was demonstrated during this presentation.

OEI and EPA Region II integrated aerial photography and various map layers in order to visualize the fire scene. The warehouse was located in an urban area, and major highways were nearby. The scenario also included closure of nearby highways that prompted other routes to be used during the rescue effort.

Another layer added to the visual, aerial photography was a view of other, nearby, EPA-regulated facilities to determine and assess effects of the fire. For example, with a top tier risk facility nearby, the goal may be to evaluate the chemicals at the facility and determine ways these chemicals may be affected by the fire. Also, effects on the community would be evaluated based on the facility and its chemicals. An additional goal was to visualize the size of objects, buildings, land areas, etc. When measurements are determined, scientists and engineers can better assess how many workers and rescuers are needed, as well as the logistics of a rescue effort.

The Emergency Response Analyzer also can be used to predetermine any land area and to evaluate what is already there. For instance, a polygon is drawn over a land area with the mapping tool to represent a zone of concern. This allows users to look at the weather, wind, and other conditions in order to determine the effects of an emergency situation. Users also could retrieve data on the number of homes, EPA-regulated facilities, ecological areas, and populations within this area. Thus, sensitive areas would then be protected as best as possible.

Currently, OEI has an abundance of data and detailed information to determine the facilities located within a particular area, a detailed facility report for each site, and a list of hazardous wastes for each site.

This information is accessible depending upon which EPA database receives the facility-submitted information (i.e., Biennial Reporting, TRI, etc.). Users also can determine if there are environmental, regulatory non-compliance problems. This integration theme is extremely useful when evaluating the effects of an emergency situation.

Future goals are to include more modeling that will enable scientists and engineers to pull in parameters of the release associated with an emergency situation and to predict behavior and results. Currently, EPA can determine wind and weather conditions at an emergency site situation, but a better capability would be to use an interactive, real-time feed of weather conditions at a specific site.

The Emergency Response Analyzer (at http://intramap17.rtpnc.epa.gov/era/em4er.asp) is only accessible within EPA.

Assessing Urban Growth and Land Cover Trends Using Remote Sensing Imagery and Landscape Metrics

Cary Roberts, with OEI Office of Information Access and Analysis, discussed projects in five urban areas that focused on the analysis of remote sensing data when determining the trends of urban growth or urbanization, and resulted in new technology and imagery science. Urbanization is commonly defined as an increase in human habitation, combined with increased per capita consumption and extensive modification of the landscape. To determine urbanization, we must look at direct and indirect impacts of the urban environment to determine loss of natural resources, environmental degradation, land consumption, and fiscal constraints. Assessments of urban growth and land cover trends are designed to provide a historical perspective on urban growth, to evaluate growth, and to develop indicators.

These five projects provide a historical perspective of land use change in urban areas; assess spatial patterns, rates, trends, and impacts of urban growth using remote sensing and GIS; and illustrate urban growth as a pressure on environmental resources (e.g., source water, air quality, and habitat) that can be measured by indicators. The five areas of interest include Chicago, IL; Detroit, MI; Minneapolis, MN; Phoenix, AZ; and Raleigh-Durham, NC. Data resources and reference data used in these project areas are extensive, and include NLCD, North American Land Cover imagery, multi-resolution land characteristics imagery, USGS digital orthophoto quarter quads, United States population (census) data, Texas Transportation Institute for transportation data, and state and local government economic data sources.

The projects also require the following image processing and analysis steps:

- Acquire, subset, and re-project imagery
- Geo-register images
- Mosaic imagery using histogram matching
- Clip imagery to final study area
- Classify land cover for 1970s, 1980s, 1990s, and 2000 data
- Produce land cover change analysis products
- Calculate land cover metrics and indicators.

Crosswalks among data sets also were necessary in order to classify data where needed. Visual editing was used to identify likely errors and provide quality control checks.

Landscape indicators are quantitative measurements of environmental condition or vulnerability. ATtILA was used to determine landscape indicators/land metrics over the last 30 years for each metropolitan area. ATtILA is an ArcView extension that requires input from land use/land cover, elevation and slope, streams, roads, population, and precipitation. ATtILA outputs results into spreadsheets and as ArcView shape files. Metric data were combined with census, transportation, and air and water quality data to generate urban environmental indicators in each project.

Other activities include:

- Development of site specific descriptive stories using the ATtILA landscape metrics
- Assessing relationships among the metrics and land use development trends and patterns
- Evaluating water quality and aquatic indicator correlations with landscape indicators
- Expanding external partnerships and developing a refined methodology to share with partners
- Continuing development of the urbanization and land cover trends Web site (at http://www.epa.gov/urban), that provides access to data and analytical tools for data visualization.

The main Web site provides links to all five projects, a general background of each city, animated changes within the urban area, and review summaries of the overall trends.

NEPAssist: A Web-Based Mapping Application for Environmental Review

Julie Kocher, with OEI Office of Information Access and Analysis, discussed the development of a Web-based tool to support analyses under NEPA, which requires all government agencies to assess their land use projects by gathering data on potential environmental impacts associated with their project. These assessments are time-sensitive, very costly, and require EPA approval. There are many requests for environmental project assessments from Federal offices, and there is a great need to simplify the process of filing and reviewing EISs and environmental assessments, providing better access to core geo-data, conducting environmental screenings of all proposed projects, and streamlining the review process.

EPA created the NEPAssist GIS tool to assist with this streamlining. NEPAssist is a Web-based tool that requires no licensing, data loading, desktop configuration, or training. NEPAssist is a distributed application (via Web services), includes consistent data sets, and is available to any government agency user.

A pilot project was conducted in EPA Region II with study areas selected using the NEPAssist Web site. When a Federal, state, local, or tribal project group is interested in a particular area, these government agency users are able to select or indicate their area of interest with the NEPAssist GIS tool and to obtain information on how particular projects will affect their surrounding community, etc. Users are able to review strategic planning and multimedia program options, as well as look at proposed projects and planning.

Generally, the NEPAssist Web service provides the following data for any predetermined area of interest:

- Area measurements
- Nearby rivers within 400 meters
- Nearby drinking water sources and associated drinking water contaminants of concern
- Wetland information
- Critical habitats for endangered species

- Flood protection
- Environmental justice issues
- Nearby coral reefs
- National ambient air quality data
- TRI screening data
- National-scale air toxics data
- Nearby state and local parks, fish and wildlife service refuges, national forests, and national estuary program study sites.

Users of NEPAssist also can obtain environmental justice reports that provide a socio-economic and population-driven background of the area, based on 2000 census data.

In addition, users can submit an application form via the NEPAssist Web service in order to seek approval of a project or planned area and to obtain status reports of the review process. Once users have completed the NEPA review, an EPA reviewer can submit the approval letter and send it to the applicant via the NEPAssist Web service.

NEPAssist also helps to raise important environmental issues at the earlier stages of land use project development, results in performance improvements, provides easy access to region-specific geo-data and customized regional assessments, and streamlines the review process. OEI is reviewing feedback and comments from the EPA Regional reviews and Federal partners, is planning for a national expansion with EPA Regions III, V, VI, and VIII, and is establishing other regional partnerships.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) useful links to assist with the Emergency Response Analyzer; (2) partnerships with other agencies, such as NOAA and CDC, to gather other associated data that would be useful in spill response scenarios; (3) current uses of remote sensing and ATtILA within communities; (4) data standards and commonality among outside data sets when using NEPAssist; (5) cumulative effects analysis using NEPAssist; (6) actual compliance history within NEPAssist predetermined review areas; (7) use of state-specific data within NEPAssist; and (8) initiatives to identify historic backgrounds affecting urban growth, as well as use of historic backgrounds to make better decisions for watersheds, environmental communities, etc.

Delivering Consistent Information on Health and the Environment

Following opening remarks by William Sonntag, OEI, three speakers addressed several initiatives to manage and array metadata on biological resources, to promote environmental information exchange, and to improve data access. An audience question and answer period followed the presentations.

National Biological Information Infrastructure: Collaborative Opportunities in Ecoinformatics

Mike Frame, with the USGS, provided an overview of the National Biological Information Infrastructure (NBII) program and introduced NBII tools and services. NBII is a broad, collaborative program to provide access to data and information on biological resources in the United States. This information is

needed for environmental projects and initiatives. There are similar efforts underway in Mexico, Canada, and other countries to promote data sharing.

There are a number of collaborative efforts underway between the USGS NBII program and EPA including the Ecoinformatics Working Group, metadata standards promotion and propagation, Integrated Taxonomic Information System, interagency biotechnology efforts, BioEco Interagency Group, EMAP Partnership meeting, EPA representation on the NBII Science Advisory Committee, and biodiversity and ecosystem grants and workshops.

NBII nodes include thematic, regional, and infrastructure project efforts. These nodes yield products, standards, tools, and services for biodiversity data management and delivery. The goal of the NBII program is to use thematic data, regionally and locally, and to provide and share the data nationally. The USGS has produced a national Web site for NBII at http://www.nbii.gov. The NBII Web site and its associated links provide large quantities of information, as well as on-line mapping tools that allow users to conduct trend analyses. The Web site also provides a searchable clearinghouse on principal nodes. For example, with the fisheries node, users can obtain fishing resource data by state, fishing conditions by state, National Fish Strain Registry data, Pennsylvania Fisheries Explorer data, and Delaware River Mapping data. With the bird conservation node, users can obtain population and habitat data on migratory birds. Users of the NBII Web site also have access to a biocomplexity thesaurus that provides a broader and more complete list of definitions of terms used by different agencies.

Content management is a key initiative. The standard for cataloguing Web resources is based upon the Dublin Core Metadata Initiative, with modifications for the biological community, and an NBII-wide standard.

In the future, NBII is expected to host an individualized Web site, my.nbii.gov, which will allow users to alter information available on the main Web site to fit individual needs and interests. The individualized Web site will support remote offices and the NBII network (e.g., network operations, partner intranet, information sharing and collaboration, leveraging of resources, and private information). The Web site will also enable research (e.g., scientific collaboration, integration of data, peer review, and data analysis) and deliver useful information to the public. With the use of GIS tools, the individualized Web site will support access to the BioSafety project, Open Mapping Application, and BioBot search.

Future NBII program priorities include the following:

- Reporting trend information
- Implementing a public portal
- Fully implementing Web resources standards
- Adding more nodes, such as Gazetteer and Address Finder
- Developing simple data capture for reporting of events
- Ongoing peer review of current and new applications
- Hosting semi-annual geospatial and information technology workshops
- Expanding museum records, partnerships for content creation, and data holdings.

The USGS NBII program hopes to continue supporting ecoinformatics and GIS/mapping activities; collaborate with the NBII Fisheries and Aquatic Resources Node; host interagency biodiversity and ecosystems workshops; and provide metadata integration, tools sharing, and standards support.

Environmental Information Exchange Network

Molly O'Neill, with ECOS, introduced the Environmental Information Exchange Network, which is intended to promote data sharing to support better decision making among Federal agencies and regulators as well as to improve the data that are available. Currently, EPA and state agencies require better access to environmental information among partners, better approaches to information exchange because current stovepipe approaches are inefficient and burdensome, and better integrated information technologies and approaches. Also, states are modernizing their information systems and are migrating away from EPA's national systems. States and EPA are using different information to assess environmental conditions, the status of land areas, and human health.

As a result, there is a need to collaborate and improve data standards, which is supported by the shared vision between EPA and states: "The States and EPA are committed to a partnership to build locally and nationally accessible, cohesive, and coherent environmental information systems that will ensure that both the public and regulators have access to the information needed to document environmental performance, understand environmental conditions, and make sound decisions that ensure environmental protection." The Environmental Information Exchange Network is an approach to move towards this goal and to share data among EPA, states, and the tribes. Efforts began in 2000 to design the implementation of this network and in July 2002, the first stage of implementation began.

The Environmental Information Exchange Network takes data and results from several partners and shares this information via the Internet over a secure network. The information available to government partners is based on data standards and the use of XML as the universal language for the data and information exchange.

There are network nodes that represent Web services. These network nodes provide the hardware and software used to exchange information on the Environmental Information Exchange Network. The nodes can work with any type of data in order to share information.

Trading partner agreements support data exchange efforts and are provided in order to protect the partners. These agreements detail the data that partners agree to exchange and how often. States, tribes, and EPA can submit data or acquire the data from one another. Currently, there are 37 states building their nodes and systems, and approximately 10 states have operational staged nodes and systems.

The following are a few examples of key partnership projects and data sharing initiatives of the Environmental Information Exchange Network:

- eDMR Challenge Grants – developing electronic Discharge Monitoring Reports with states and EPA
- Pacific Northwest Surface Water Quality Exchange Challenge Grant – exchanging surface water monitoring data between states with a focus on multi-state boundary watersheds and bringing in community data for the first time
- Drinking Water Laboratory Challenge Grant – delivering drinking water laboratory results directly into state systems, providing timely and better quality data.

Future goals and applications for the Environmental Information Exchange Network include the following:

- Better quality data exchange
- Data standards embedded in XML

- Close coordination with the state and EPA Data Standards Council for new data standards to incorporate
- Use of machine-to-machine technology to minimize data entry errors
- Additional data exchange among new partners
- Application of the infrastructure to new data exchange types (such as new partnerships involving health-related information from CDC) while connecting this information to environmental indicators
- More state-to-state data exchange
- More timely data, where data can be published and exchanged as soon as partners agree.

The Environmental Information Exchange Network already is successful in reducing the effort to verify that exchange systems are communicating (i.e., interoperability of Web services), reducing and eliminating the costs of duplicate data entry, and providing infrastructure and mechanisms to support new data flows between existing and new partners. More information on the Environmental Information Exchange Network is available at http://www.exchangenetwork.net.

EPA's System of Registries, A Foundation for Consistent Environmental Information

Larry Fitzwater, with OEI, discussed the challenges of data access for EPA and other government agencies and a tool, the EPA System of Registries (SoR) to addresses this. The SoR provides a gateway to EPA registries and search capabilities for linked Agency registries. The SoR also provides identification information for objects of interest to EPA (e.g., data elements, XML tags, data standards, substances of concern, terms, facilities, regulations, and data sets), and supports the Agency's data standards program and technology initiatives.

An abundance of data and metadata exists within EPA, and there is a need to document and keep track of this data. OEI has done this from a standards-based perspective with SoR, which physically integrates application records in the Registry of EPA Applications and Database, data elements in the Environmental Data Registry, data in the Substance Registry System, and terms in the Terminology Reference System. Also, SoR provides links to data sets in the EPA Environmental Information Management System and facility records in the Facility Registry System. An overview of each of these systems is as follows:

- Registry of EPA Applications and Database – an information system inventory that also integrates registries, forms the basis for physical or virtual linkages among EPA metadata collections, and links to the Environmental Data Registry, Terminology Reference System, and the Enterprise Architecture Repository, among others.
- Environmental Data Registry – based on data element metadata, code sets and value domains, and data standards, and provides a source of well-formed data elements, related XML tags, and value domains. This system also promotes the reuse of data in EPA systems; enables data sharing, data integration, and data comparability; and supports data standards development processes, metadata access, and distribution.
- Substance Registry System – obtains information about 85,605 chemicals and biological organisms from more than 1,000 different information resources, relates chemicals to regulations, and provides business object registry. This system enables searches across chemicals, biological organisms, and physical properties; records metadata in one place; links standard nomenclature with the way substances are named in regulations; and relates substances found in a variety of information resources. In addition, the Consolidated Health Informatics Initiative selected this system to store

non-medicine chemicals. This system requires updating because of the multiple chemical abstract system numbers assigned to different chemicals.

- Terminology Reference System – houses EPA definitions and terms (11,977 terms from 229 sources), data from the General Multilingual Environmental Thesaurus, and terminology from EPA program offices, information systems, regulations, and state collections. This system serves as a single resource of environmental terminology for the Agency.
- Environmental Information Management System – includes data set information, geographic data sets, and ORD information products.
- Facility Registry System – includes information about places of interest, implements EPA's facility identification standard, and provides a business object registry.

There is also an XML registry that stores trading partner agreements between states and EPA.

EPA's SoR relies on consistent environmental information; semantic management, including tools for Web resources for data management, meanings documentation, and structured terminology; content management of Web pages, documents and records, data in applications systems, and data sets; knowledge management; grid computing; and data and metadata management. More information on the SoR can be found at http://www.epa.gov/sor.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) ways to assess the credibility of data being integrating into all of these new databases and system networks; (2) preparing for the enormous growth of data that is going to be available and the ability to handle it; and (3) criteria to determine when Environmental Information Exchange Network systems are ready for use or if a state is in operational mode.

Developing Science-Based Information for Coastal Systems

Following opening remarks by Kevin Summers, NHEERL, six speakers addressed the National Coastal Assessment Program, and coastal assessments for the Pacific Coast, Florida, New Hampshire, and the Northeastern United States.

From Tropical Beaches to Fjords, An Overview of Western Coastal EMAP, Western Pilot Study

Henry Lee II, with NHEERL, summarized the Western EMAP, which is a part of the National Coastal Assessment Program. Researchers supporting the Western EMAP hope to build capacity within the western states and tribes of the United States to monitor for status and trends in the condition of the nation's coastal ecosystems, and to complete a second National Coastal Condition Report.

The sampling program supporting the coastal component of the Western EMAP utilized sites in small estuaries of Washington, Oregon, and California (1999); large estuaries of Washington, Oregon, and California (2000); coastal systems of Hawaii and south central Alaska (2002); estuarine tidal areas of Washington, Oregon, and California (2002); continental shelf of Washington, Oregon, and California (2003); and additional estuaries in Washington, Oregon, California, Hawaii, and southeast Alaska (2004). Sampling activities have involved many partnerships for this long-term effort.

Based on the sampling efforts in 1999 and 2000, coastal sites were ranked as poor, fair, or good if a predetermined number of contaminated sediment samples fell within certain ranges when compared to values for "effects range median" (where adverse effects occur 50 percent of the time) or "effects range low" (where adverse effects occur 10 percent of the time). Sediment contamination appears to be localized with only about three percent of the sites ranked "poor," and these involved the San Francisco and Los Angeles harbors, the Columbia River near Portland, OR, and some areas in Puget Sound.

Only one percent of the sites received a "poor" ranking for dissolved oxygen; however, 36 percent of the sites received a "poor" ranking for water clarity. The poor water clarity may be a natural phenomenon involving high rainfall, steep coastal terrain, and high tides. These studies are also addressing arthropod toxicity, chlorophyll levels, nitrogen levels, and invasive species.

In 2002, the study included sampling of intertidal areas, which are important on the West Coast as they have extensive tidal flats and about 50 percent of these areas are tidal. This required development of new sampling strategies to address these challenges. Two pilot studies evaluated wetlands and used a landscape approach in addition to a biomass sampling approach. These studies evaluated landscape conditions based on the ratio of tidal flat to tidal marsh, patch size frequency distribution of tidal marsh, connectivity to tidal marsh patches, marsh edge area ratios, and percentage of land border undeveloped. Data from these studies are just now becoming available.

Also in 2002, studies were initiated in Hawaii and Alaska. A coastal survey was conducted of all the Hawaii Islands. This again required modification of the sampling approach to address issues associated with coral and the need to use scuba equipment; this study also analyzed samples for bacteria, which is of particular interest to the State of Hawaii given some problems encountered in certain areas. The effort in Alaska encountered a particularly challenging study environment given that the coastal area is quite large, the water is deep, and the sampling season is short as well as difficulties encountered in sampling site selection complicated by the presence of glaciers.

In 2003, a pilot study sampled areas of the continental shelf from the border of the State of Washington to the United States border with Mexico. This involved sampling in 30 to 120 meters of water as well as sampling inside and outside of marine sanctuaries.

One of the advantages of probabilistic sampling design as is used in EMAP is the ability to evaluate the area of a resource meeting certain conditions. Thus, many of the results are presented in mapped form.

The Western Coastal EMAP is providing the first regional-scale assessment of ecological conditions of coastal ecosystems in California, Oregon, Washington, Hawaii, and Alaska. Preliminary findings of these coastal sampling and assessment efforts include the following:

- By sampling from the intertidal to the continental shelf areas, Western Coastal EMAP provides a spatially-comprehensive assessment of the coastal conditions for three states
- Results from the 1999-2000 sampling efforts indicate that ecological conditions are generally good, but there are some exceptions for water clarity and invasive species
- Sampling new habitats and environments presented a number of challenges and required developing new techniques.

Partnerships were key to the successful data collection and research efforts of the Western EMAP coastal sampling program.

The Utility of NCA-type Monitoring Data for EPA Decision Making

Diane Regas, with OWOW, described efforts to assess and evaluate coastal conditions of the nation, and Darrell Brown, with OWOW, provided an overview of EPA's coastal management program and associated goals. EPA funds 28 National Estuary Programs to develop the National Coastal Assessment, and these efforts are supported by partnerships with local and state governments, Federal agencies, and local fishermen residing in or utilizing these coastal areas.

EPA's Strategic Plan provides the background that requires these efforts, as indicated in the Ocean and Coastal Goals 2 and 4:

- Goal 2, Clean and Safe Water
  - Ensure drinking water is safe
  - Restore and maintain oceans, watersheds, and their aquatic ecosystems to protect human health
  - Support economic and recreational activities
  - Provide healthy habitat for fish, plants, and wildlife.
- Goal 4, Healthy Communities and Ecosystems – protect, sustain, or restore the health of people, communities, and ecosystems using integrated and comprehensive approaches and partnerships.

By 2008, the National Coastal Assessment Program will enable the EPA to improve the overall health of coastal aquatic ecosystems nationally and regionally as well as aquatic system health for the 128 estuaries that are part of the National Estuary Program. Progress will be measured using the National Coastal Condition Report indicators.

OWOW is using two response indicators and three stressor indicators in the first National Estuary Program report being developed for publication in 2006. The two response indicators are the benthic invertebrates index and the fish contaminants index. Stressor indicators include the water quality index, sediment quality index, and coastal habitat index. Research efforts will help to answer questions such as:

- How are local, regional, and national plans connected?
- How do the goals and activities at the National Estuary Program watershed (or sub-watershed) level compare with the national goals?

A current program need is to aggregate and inter-relate the information being developed at the local estuary level, through the National Estuary Program, to the national level. The Lower Columbia River Program was offered as an example of the assessment of an estuary condition, which at a broad scale involves the entire Pacific Coast, and at an even broader scale involves large marine systems. It may be necessary to relate the story of coastal health at all of these different levels, which is what is important to the National Coastal Assessment and its mission to identify targets for improving coastal and estuary waters. This involves the aggregation of 2,000 national sampling sites under the National Coastal Assessment along with the sampling sites from 128 National Estuary and other programs.

The next steps for the National Coastal Assessment Program involve inter-relating the National Strategic Plan, Regional and Great Waterbody Strategic Plans, and state and local strategic plans. The National Estuary Program Report is anticipated to be published in 2006. OWOW is partnering with local scientists, NOAA, USGS, the U.S. Fish and Wildlife Service, and coastal states to complete these activities.

Florida's Inshore-Marine Monitoring and Assessment Program

Kevin Madley, with the Florida Fish and Wildlife Conservation Commission, summarized the Inshore-marine Monitoring and Assessment Program (IMAP), which is Florida's statewide initiative under the National Coastal Assessment Program. The primary focus of IMAP is coastal sampling. This season is the last of the 5-year process.

The sampling design is a two-tiered, probabilistic design following the EMAP criteria. In the sampling design, researchers divided Florida's coastal areas into two scales—coastal/statewide and regional. IMAP samples annually, addressing several locations throughout the State to cover a wide range of areas. Sampling occurs in late-summer each year with a total of 180 stations sampled annually because of the large coastal line in Florida.

A total of 30 sites were sampled each year (2000 to 2003), and the same number will be sampled in 2004. Five sites are fixed, and the remaining sites are randomly selected. There are 19 different estuaries within the sampling locations, and researchers utilize indicators such as water, sediments, benthic infauna, nekton, and submerged aquatic vegetation to determine coastal conditions. These indicators are the same for each sampling site within Florida.

Typical water quality measurements are taken at each station, and sediment sampling is also completed. Researchers also use structural indicators, since dynamic indicators are not used in sampling efforts, as well as light measurements to indicate water characteristics.

Although there have been large data collection efforts in the state of Florida, IMAP is the first program where national and state data are reported and evaluated. IMAP is only for coastal areas, but it is a part of the Integrated Water Resource Monitoring Network, which is an umbrella study under which marine, fresh water, and groundwater monitoring are all conducted within a probabilistic framework. IMAP also can be used to increase data availability for future National Coastal Condition reports and to fill in gaps of the National Coastal Condition Report II (e.g., fish tissue contaminant concentrations). IMAP data from 2000 to 2004 will be available for the next round of TMDL assessments, and can be used in annual 303(d) reports and biennial 305(b) reports to the Florida Department of Environmental Protection.

National Coastal Assessment: A Successful State-Federal Collaboration in New Hampshire

Phil Trowbridge, with the New Hampshire Department of Environmental Services, described ongoing coastal assessment activities and results. The New Hampshire Department of Environmental Services developed a partnership with EPA in 2001 to support their efforts in the National Coastal Assessment Program, enabling the Department of Environmental Services, for the first time, to assess 100 percent of the estuaries within the State. This partnership also includes the University of New Hampshire to support data collection.

The National Coastal Assessment Program provides standardized indicators and methods, probabilistic sampling design, national coverage, and the flexibility to add other indicators or designs as needed at the state level. The New Hampshire Department of Environmental Services utilizes the national coastal assessment to improve 305(b) reports and assessments that look at the use of aquatic life. Use of probabilistic surveys, which are unbiased, provides better coastal assessment data and more useful results.

The national coastal assessment data also are being used to optimize study designs so that they include more random samples and, therefore, provide better data quality. This random sampling approach was utilized in studies of the Cochoco River, Southeast Great Bay, Salmon Falls River, and Piscataqua River,

where New Hampshire national coastal assessment data were compared to actual samples of mercury. The New Hampshire coastline is only 18 miles and benefited this study because sampling sites were so close together and the data points were very tight. This enabled researchers to look at spatial correlation and its effects on coastal assessments.

The National Coastal Assessment Program provides valuable insight into the bigger picture of the effects of mercury in the Northeastern Region. In the past, New Hampshire ranked at the top of the region for mercury concentration evaluations. However, upon visual representation of the national coastal, researchers realized that the mercury results for New Hampshire directly result from the distribution of the data.

In the field of technology transfer, New Hampshire's role has expanded over the last 5 years. Previously, New Hampshire would collect data and send it to others to perform the interpretation. Now, most data interpretation is done in-house.

In summary, the National Coastal Assessment Program has been a very successful partnership between EPA and the New Hampshire Department of Environmental Services. National coastal assessment data has been used to meet the State's needs to complete 305(b) reports in a cost-efficient manner, and national coastal assessment technology has built capacity in the State for coastal monitoring.

National Coastal Assessment: Approach and Findings in the Northeast

Henry Walker, with NHEERL, provided an overview of the National Coastal Assessment Program activities in the Northeastern United States, which are supported by partnerships between EPA, EPA Regions, and several states. The goals of these program activities are to assess ecological conditions of estuarine resources, based on unbiased data of known quality; determine reference conditions for studies on ecological responses and stressors; and build capacity in states and EPA regions. In order to achieve this, Federal and state agencies must partner in collecting, processing, and analyzing data samples; developing state and regional infrastructure; and providing for communication and education of findings. The value of this effort will be seen more clearly in one or two decades from now. The baseline data used in the National Coastal Assessment is based on sound science, and an effort of this large magnitude has not been done before. Benefits of this program are illustrated by the experience of the State of Maine, which did not have a coastal assessment structure to test waters when this program first started, and now has methodologies and an approach unique to the State to evaluate their waters.

The National Coastal Assessment Program approach uses consistent, measured indicators and a probability survey design that allows extrapolation and addresses 305(b) requirements. This Program includes water quality indicators, sediment quality indicators, habitat indicators, and biota indicators.

The coastal assessment approach also has the potential to incorporate existing monitoring programs and hybrid monitoring designs. When considering a merger of existing monitoring data and thereby using both predetermined site and random site selections, researchers faced the question as to whether the states would be able to use both data sets or discard the results of past sampling efforts (i.e., lose previous monitoring investment). Additional questions related to the merger of existing monitoring data include:

- How to use pre-existing sites without being biased to historical data?
- If all existing sites are replaced with randomly selected stations, do we risk the ability to track trends and therefore lose valuable data?

In order to answer these questions, researchers used a combined set of data taken from the Long Island Sound site, and incorporated the combined data set into the national coastal assessment probability design. Comparison of the two data sets resulting from this effort indicated that they measured up

statistically and basically provided the same answers. Therefore, using both data sets—historic data from predetermined sites and data from randomly selected sites—would provide more reliable, accurate reporting of coastal assessments based on percent area and "good, fair, and poor" area condition evaluations.

Preliminary findings of the coastal assessments in the Northeast are summarized in Chapter 3 of the Draft National Coastal Condition Report II. The Northeast Region is a very urbanized area, housing more than 125 people per square mile, and has a number of legacy pollutants because of the many industrial areas. The spatial distribution of water quality components, including dissolved inorganic phosphorus, dissolved inorganic nitrogen, and surface chlorophylls, among others, are being mapped to look for patterns, gradients, and percentage of area affected.

An interactive tool has also been developed to visualize and analyze data found in the Northeast Region. This tool enables researchers to pull up data in Excel, map the data using a GIS component, and evaluate data on a percent area basis, with ratings of "good, fair, and poor." This tool also enables researchers to evaluate the effects of changing the rating thresholds on the outcome of the analysis.

In the near future, researchers will be able to use electronic, Web-based reporting with possible links to National Coastal Assessment data, analysis tools, National Estuary Programs, and state environmental management programs.

National Coastal Assessment: Monitoring and Modeling in Support of TMDL Calculations

Henry Walker, with NHEERL, presented research findings from the National Coastal Assessment Program. An important goal of this Program is to report, in 2008, additional research and findings to address current problems that have been identified in the coastal regions of the United States.

The assessment process begins with a survey of present conditions and, if applicable, requires follow-up monitoring. Questions faced by researchers in performing the assessment include the following:

- Where is follow-up monitoring needed?
- Will opportunities to address other important issues be missed by supporting follow-up monitoring in a designated area?
- Should sampling occur during another vulnerable period and where?

An example involved the issue of low levels of dissolved oxygen in the stratified waters of Narragansett Bay, RI. In the summers of 1997 and 1998, sampling efforts showed that the dissolved oxygen content of the upper Bay area was lower than expected. Researchers thought that this could be caused by nutrient loadings from the rivers flowing through, as well as the large number of wastewater treatment facilities. Although there were low levels of dissolved oxygen in the Narragansett Bay, this did not cause the Bay to be placed on the list of impaired waters of the Northeast at that time. However, researchers wondered whether continuous, follow-up monitoring efforts should be conducted to avoid problems in the future. In August 2003, an episodic fish kill confirmed that there was a problem.

This is a great example of the potential need for diagnostic monitoring. National coastal assessment data are used only to explain the present conditions of coastal areas. The data alone cannot be used to predict future problems or future problem areas, nor do the data provide suggestions for regulatory changes or management actions to protect areas of concern. However, diagnostic monitoring can assist in these efforts.

In the case of Narragansett Bay, diagnostic monitoring was used to anticipate, to a spatial extent, an acute dissolved oxygen event. This prediction was based on observations of low oxygen content in the surface layer being less than the chronic criterion for a 10-day period, and low oxygen content at 0.5 meters above the bottom being less than the acute criterion for a 5-day period.

The National Coastal Assessment data can also be used for problem solving such as for the issue of nitrogen overloading. Using the SPARROW model, the product of a partnership between EPA Region I and the USGS, researchers were able to input National Coastal Assessment data that detailed atmospheric deposition and different types of nutrient fluxes from several agricultural areas and forested lands. The model provided estimates of conditions in lakes and streams as well as fluxes of nutrient loadings in a predetermined area, and enabled researchers to determine point sources of nutrient loadings. Efforts have also been successful in integrating data from the SPARROW model and the Estuary Nitrogen model to determine nitrogen levels in Narragansett Bay. When comparing the combined model output with actual sampling data from a past sampling event, the results showed that model output for nitrogen concentrations was within 0.2 mg/L of sampling results.

Use of diagnostic monitoring as described above can help to identify when impairments are expected and why. From this information, management and regulatory decisions can then be determined.

Scientific Computing

Following opening remarks by Rick Martin, with OTOP, three speakers addressed mechanisms and tools for high performance computing and their applications to EPA programs.

The Center of Excellence for Environmental Computational Science

Joseph Retzer, with OTOP, discussed the need for scientific computing capability at EPA and the evolving role of the Center of Excellence for Environmental Computational Science. Scientific computing is the provision of high performance computing services and infrastructure on demand. Major drivers for enhanced scientific computing capability at EPA include:

- Increased internal and external collaboration between scientists and the associated need to interface with other computing systems and data repositories with different data security requirements
- Tremendous shift toward *in silico* science
- Creation of enormous amounts of new data (up to terabytes in size) with associated management, storage, and transfer issues
- Evolution of technology including opportunities to cluster computers (i.e., link together a number of different computers) and to develop the scientific desktop of the future, which links high-end desktop computers across a grid.

The Center of Excellence for Environmental Computational Science involves an EPA team (from OEI, ORD, and other Offices) that brings together cutting-edge science with information technology solutions to upgrade and enhance EPA's scientific capabilities. This initiative has three goals:

- Build a network for environmental research with improved collaboration tools, a research subnetwork, and grid computing
- Develop a science portal to provide the tools and information needed by EPA decision makers and scientists
- Upgrade high-end computational capability.

Information technology collaboration is essential to EPA science and this Center of Excellence. EPA has developed an efficient, effective, and tight system that now receives positive recognition from outside the Agency. EPA now faces the need to enhance collaborative capability, which may require adjustments beyond just the firewall or how EPA handles information security. Therefore, in the fall of 2003, EPA began to investigate the information technology impediments to scientific collaboration, and identified a number of specific issues:

- Difficulty with electronic file transfer (i.e., those files not suitable for email)
- Web seminar attendance/hosting
- Difficulty connecting to databases outside the EPA firewall
- Log-in capability to other systems
- Difficulty of others to log into the EPA system
- Difficulty for employees to log in from home or on travel
- Help desk abilities/understanding to be able to support scientific applications
- Obtaining EPA security practices supportive of scientific needs and outside interface/collaboration.

Decisions and actions taken in early 2004 to address these issues include the establishment of a scientific server for electronic file transfer, adding a Scientific Access Coordinator to work with scientists who are having access difficulties, and establishing a work group to specifically address collaboration issues. The Scientific Electronic File Transfer Server Project has developed a system without "per use" or other access fees and is accessible to outside collaborators while maintaining adequate security. The new server has 3.5 terabytes of storage to support large files, and has become available internally beginning in May 2004 to ORD scientists; access by all EPA users is anticipated to occur in the summer of 2004. The Scientific Access Coordinator responds to firewall and other external collaboration issues. This Coordinator understands the information technology access needs of the scientists as well as the limits imposed by EPA's computer security systems, and can work with the EPA security team to find solutions for scientific access needs.

EPA also has begun a process to identify desirable design features of a separate EPA scientific subnetwork. Some of the issues being addressed include how to use a secure shell for data encryption, access to computers outside of EPA, connecting scientific applications to databases from outside EPA, providing remote access for scientific users, and obtaining approval for passive file transfer protocols through the EPA firewall.

The next steps include the addition of features such as electronic signature to initiate accounts, building out the science grid and portal that will become major collaboration tools, and further defining requirements for the scientific subnetwork.

Current Projects and High Performance Computing and Visualization Direction

John Smith, with OTOP, discussed the new computing system installed in February 2004, the growth in data, and grid computing. EPA has several hundred servers and a mainframe at Research Triangle Park. The new computing system has multiple nodes dedicated to interactive processing, input/output, and batch processing that will enable enhanced support to long-running calculations, with a processing capacity of 768 Gflp/sec. The new system also has a high performance file system (16 terabytes) to ensure that the file system is not limiting the computing speed. This new computer system is the latest in a series of high performance computing expansions that began in 1992 with the acquisition of EPA's first supercomputer.

This recent computer acquisition will ease computing constraints encountered by EPA. There has been a significant increase in computation processing demand, which is currently running at over 40 percent of the new system's capacity, and is anticipated to be at nearly 100 percent of system capacity later this summer. Projected mass data storage requirements are anticipated to increase dramatically over the next 2 years. The costs of storing and managing the data are significant.

Grid computing is a form of distributed computing that involves coordinating and sharing computing, application, data, storage, or network resources across dynamic and geographically dispersed organizations. The new computer system will be part of a grid to help share data and resources. There is a strategic long-term plan that includes the use of clusters that can support certain types of processing. Currently EPA has islands of computing capability with data that few can access and the intention is to integrate all of that.

There are two types of grid technology—data and computing. The data aspect focuses on moving data, provides the ability to integrate distributed data (e.g., from clusters), and provides mechanisms for data access as well as external access to multiple data sources. The computing aspect involves the sharing of computing resources across a grid. Not every application is amenable to that type of architecture and security (e.g., access, policy, authentication, authorization) is important. This approach helps to use resources efficiently.

The first phase of this effort was to deploy a data and computational grid across no more than two locations. This has been completed and was extremely successful. Both locations are in Research Triangle Park, and it has been possible to access the grid from other locations to process computing jobs. Efforts are also underway to identify applications that may be suitable for the grid. Commercial-off-the-shelf and open source grid technologies are being used in order to avoid new development and custom techniques/equipment as much as possible.

The second phase is addressing the management aspects of grid computing (e.g., performance, obtaining certificate authority, funding after August, MOUs), to identify other grid-worthy applications, to extend the grid beyond the EPA firewall to external partners, and to provide access to the grid through the Science Portal without any security incidents.

Growing the Environmental Science Portal

Terry Grady, with NERL, discussed the development of the Science Portal and its potential applications. There is a need for better informed environmental decisions and improved science products. Both of these depend on collaboration, knowledge sharing, better use of available data, and more widely available tools/models. The overall goal is better decisions, uses, and outcomes for the science. The Science Portal is anticipated to be a significant tool to advance and implement the Agency's science.

What is a portal? " . Applications that enable (organizations) to unlock internally stored information, and provide users with a single gateway to the *personalized* information and knowledge to make [collaborative] informed business decisions."—Merrill Lynch, Inc.

What does a portal do? OEI developed a plan for an Environmental Science Portal with a certain basic set of capabilities that encourages a self-directed work environment, allows users to leverage content and integrate data, provides an easy-to-use interface across applications supporting manipulation on the same screen, and provides smart, effective, secure access to internal and external systems. This type of portal has management systems for content, identity, and data sorting/sifting beyond application integration and information delivery.

The Environmental Science Portal will provide many capabilities such as shared work spaces, document and data repositories, real-time interactions between workers, desk-top visualization, discussion forums, and audio/video conferencing. This Portal will also provide access to a network of high-end scientific computing resources such as the EPA computer grid, shared control of instrumentation via the Web, and use of advanced models, tools, and applications via the Web (e.g., GIS, visualization). The emphasis in its design is on users such as decision makers and risk managers.

Advantages of the Environmental Science Portal include:

- Business or science on demand that provides access to EPA information through a single access point
- Customization to individual users to organize information for their ease of use
- Personalization that enables users to tailor pages to user preferences, job functions, characteristics, and use history
- Content management
- Collaboration tools
- Modular structure to provide a framework for rapid integration of independent applications
- Efficiency through a single point of entry to display everything at once to users.

The Portal also provides identity management and access control that will support EPA employee access from work, home, or travel as well as access by Regions, states, tribes, and other trusted partners.

The prototype Environmental Science Portal is developed and is being demonstrated at this *Science Forum*. The first test version in anticipated to be released in September 2004 with the first public version anticipated to be released in May 2005.

Closing and Questions

The speakers had an opportunity to address questions from the audience, and a demonstration of the Environmental Science Portal was provided.

A brief question and answer period addressed a range of topics. These included: (1) EPA participation in the overall government revitalization efforts in the areas of supercomputing and computer networking; (2) significant decreases in high performance computer system cost in conjunction with significantly increased processing capacity (e.g., the Cray supercomputer cost $10 to 12 million in 1992 and the new EPA computing system cost just under $2 million); (3) establishment of an interdisciplinary team within EPA to bring together security, policy, contracting, contractors, and others to address the many issues raised by the scientific community, which includes data storage; (4) movement toward a storage area network or a storage grid strategy to make better use of existing data storage and to ensure that EPA data are carefully protected; and (5) the need to communicate the availability of this additional high performance computing capability across EPA as there are potential users beyond those in ORD.

A demonstration of the Environmental Science Portal followed the audience question period.

Healthy Communities—One Building at a Time

Following opening remarks by Elizabeth Cotsworth, with ORIA, five speakers addressed the sharing of science to influence public action and to promote healthy buildings and indoor environments.

Indoor Air Quality: Knowledge Base and Gaps

John Girman, with ORIA, provided an overview of indoor air pollution, its sources, and its effects. There are many sources of indoor air pollution, including building materials, paints/finishes, products (ranging from cleaning to personal care), human activities, and outdoor air. All building types are affected, including residences, offices, and schools.

There are a variety of health effects from indoor air pollution, such as lung cancer, asthma, irritation effects, and neurotoxic effects. These effects are similar to those experienced from outdoor air exposure, but indoor exposure levels may be different. For example, indoor exposures to pollutants are higher (often 2 to 5 times higher) than outdoor exposures, and people spend up to 90 percent of their time indoors. In addition, risks from indoor air pollution are high as shown in risk assessments for radon and environmental tobacco smoke. Risks from other pollutants without risk assessments (such as air toxics, mold) are also believed to be significant.

The basic principles for managing indoor air quality, in order of priority, include source control (i.e., remove, substitute, or modify the source), ventilation (general and spot), and air cleaning, which is somewhat less effective than the first two methods.

Research is underway to understand the various types and sources of indoor air pollution. A recent building assessment, survey, and evaluation report examined the activities that occurred in 100 buildings, which produced a very rich data set that is just beginning to undergo evaluation. The study examined the types of rooms and usage that occur within buildings, and found unexpectedly high occurrences of laboratories and graphic arts/print shops (around 25 percent). Office renovations were also examined and the study found that painting occurred almost continuously in about one-third of the buildings; in addition, renovations also include installation of new carpet and partition/wall work, which require different strategies for air quality.

Another area of investigation involved the occurrence of water damage and leaks (which support the potential for mold to occur), and the findings indicated that 45 percent of the buildings evaluated have current water damage and about one-third of the buildings have leaks in occupied spaces. This indicates deficiencies in how buildings are built/operated, and either products/systems are being used that are not easily maintained or there is a problem in how the buildings are put together.

Building maintenance activities include heating, ventilation, and air conditioning system balancing that 44 percent of the buildings surveyed did not perform. There also were a high number of instances of monthly (or more frequent) pesticide applications that occupants may not know occur.

The study also examined median indoor to outdoor concentration ratios. This provides information about the source (from outside or from inside) of specific substances. Initial findings indicate that the buildings themselves are contributing toluene, luminine (lemon scent that also is an irritant), and other contaminants.

There also have been a number of studies that link dampness and mold to respiratory health, which is a leading cause of school and work absences. These studies have shown that high ventilation rates and low pollutant concentrations will help improve health and productivity. A Danish field study in 2000 examined three offices in two countries, and found a two to six percent increase in the Intelligence Quotient through changes in ventilation and removal of old carpeting. This has been confirmed in other field studies.

ORIA has developed a research planning document entitled *Program Needs for Indoor Environments Research* (PNEIR). This is a list of topics (such as pollutants, sources, health effects) that support planning for additional activities in this area.

The ORIA indoor environment programs are largely voluntary and there is much emphasis on outreach and guidance. Ongoing programs address radon testing/mitigation, smoke-free homes, asthma, indoor air quality tools for schools, design tools for schools, and the Indoor Air Quality Building Education and Assessment Model (I-BEAM) for office buildings. Additional information may be found at http://www.epa.gov/iaq.

Indoor Environmental Research Base

Jim Jetter, with the National Risk Management Research Laboratory (NRMRL), discussed ongoing research within ORD that is directly related to the indoor environment. These research projects measure sources and levels, and develop models to evaluate mitigation and prevention options. NERL uses these results to more extensively develop exposure models and measure exposure in field studies, while NHEERL uses the information from this research to determine effects and to assess risk.

Research facilities include a small chamber laboratory for testing small samples and a large chamber facility to test emissions from larger items and to study pollutant interactions in a controlled space. There is also a research house for real world testing, and a Biological Chamber laboratory to study mold and other biocontaminants. Research projects usually start with small chamber laboratory testing followed by development of models that are subjected to large chamber testing. The models are further improved and then tested in the research house.

Pollutant sources addressed in this research include carpeting, interior paint, furniture, cabinets, and office equipment. Activities include collaboration with industry and EPA program offices and industries, and the development of standard test methods for voluntary adoption by industries and other programs.

Mold is an important indoor environment issue. Research in this area includes evaluating treatment of building materials to inhibit mold growth, developing methods to evaluate mold growth on porous surfaces, testing products for mold remediation and bacterial decontamination, and developing identification techniques for mold. Asthma and allergens are another important area, which includes research on mold and biocontaminants that exacerbate asthma and collaboration with NHEERL in an asthma study.

There are also research activities underway in collaboration through cooperative agreements with Syracuse University and others. These include quantifying the productivity/performance benefits of indoor environmental quality to help promote improvement of the indoor environment, investigating the resuspension of fine PM from indoor human activities, and evaluating the transport of air, moisture, pollutants, and energy in buildings.

NERL research in this area includes multi-media method development (e.g., air, dust, residues, water, diet), laboratory- and pilot-scale studies such as pesticide fate and transport at the research house, measuring exposure in field studies, and modeling exposures and dose (e.g. SHEDS model). NERL is also conducting research involving PM, air toxics, pesticides, and persistent organic chemicals with a focus on measuring exposure concentrations/factors, sources, routes, pathways, and other indoor environment variables for susceptible populations and the general population. Examples include several recently completed studies such as the PM Panel studies and the Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants study.

NHEERL is conducting studies of mold allergens that may induce allergic asthma and indoor contaminants that induce or exacerbate asthma (e.g., dust mites, cockroaches, and mold allergens). Identification of biomarkers of exposure and effects is of specific interest.

There are several future research strategy drivers, including the ORD Strategic Plan and Multi-Year Plans, the Healthy Buildings document, the Healthy People document, and PNEIR. EPA also participates in an Interagency Committee on Indoor Air Quality that provides for information exchange among Federal agencies involved in research on indoor air quality. In the future, other clients, such as the EPA regions, will also drive research activities.

Delivering Technical Assistance

David Mudarri, with ORIA, provided an overview of how the information, developed from the research described in the two previous presentations, is shared with other organizations and helps to encourage the public to take the voluntary actions necessary to improve their indoor air quality. An important aspect in developing these outreach products is to maintain a certain level of scientific leadership in this field. This presentation focused on three different product/subject areas: office and institutional buildings, green buildings, and schools. All of the products discussed may be found at http://www.epa.gov/iaq.

Office and Institutional Buildings

ORIA has developed guidance and tools to address mold and building management for a healthy indoor environment. The goals were to develop quality documents that sell themselves, offer practical and feasible guidance, and respond to user needs. There is a guidance document on mold that has been very well received and has been downloaded from the ORIA Web site 150,000 times every month for the last 18 months. This speaks very well for EPA that the document is so popular. Moisture and mold in existing buildings and new construction are currently topics of great public interest.

I-BEAM is another ORIA product, and is a self-contained guidance software package that is accessible via the Web. This tool provides information to building managers and building professionals on healthy and cost-effective building management techniques. I-BEAM provides, in one place, a series of educational tools, management tools, detailed maintenance tools, and budgeting tools. I-BEAM can be used as guidance or as a training tool. The presentation included a brief demonstration of the I-BEAM software, which involves a series of windows, like chapters in a book, and helps the user to diagnose a problem, develop an energy retrofit program, develop a management program, or to figure out heating, ventilation, and air conditioning system needs for indoor air quality protection. I-BEAM is also available in WORD format that users can modify for their own uses.

Green Building Guidance

The green building field is growing rapidly and much interest has developed in this type of guidance. Some state and local governments have guidance, but EPA desired to take a leading role in order to improve the quality of the information being disseminated. As a result, ORIA has developed very comprehensive guidance that is undergoing review, with posting on the Web anticipated to occur in the fall of 2004.

Program for Schools

ORIA has developed an extensive and very popular indoor air quality program for schools. This includes design tools in the form of Web-based guidance with a focus on school systems and those who design schools. The program materials provide background information, core guidance, and a tool kit that links

to EPA tools. The program materials also provide links to guidance and other information that is available from EPA and others such as the State of California, which tends to be a leader in this area.

EPA's New Indoor Air Quality Label

Sam Rashkin, with the Office of Atmospheric Programs, discussed the Energy Star program (that addresses documented energy savings) and a joint cooperative partnership to develop a similar label for indoor air quality. This is an example of how to make science work in the market place.

The platform for developing the indoor air quality label is the existing Energy Star program for homes. This is a voluntary program that provides credibility from a government-backed program, sets a standard for an energy-efficient home, and includes third party verification. Such a program must be profitable; otherwise it will not work on a voluntary basis. The program involves a home energy rating system that includes field inspections and diagnostics. Every builder claims to build energy efficient homes, and the Energy Star symbol indicates that the claim is verified.

Typical measures of an Energy Star home include properly installed insulation (which is more important than the R-value), a continuous air barrier, advanced windows that trap heat in the winter and keep heat out in the summer, efficient equipment with more guarantees and quieter/better performance, and tight ducts to reduce the amount of heated/cooled air that is lost to the outside. These measures do not include indoor air quality components, but they do provide indoor air quality benefits.

The Energy Star program is showing significant popularity as evidenced by a huge growth in homes labeled with Energy Star—from nearly zero to 115,000 homes between 1996 and 2003 with the number doubling in the last 2 years. The key to this success is involving the production builder whose participation then steers the rest of the industry. This program is particularly popular in the Southwest, Northeast, and Texas with participation also seen in Florida and the Midwest. Nearly 20 to 40 percent of housing starts in these areas may have the Energy Star label.

The recently developed indoor air quality label indicates that the home is constructed with the following features:

- Moisture control through proper grading away from the home and measures such as foundation sealing and drain tile installation to keep moisture from coming into the home
- Drainage to remove water from behind siding
- Continuous air barrier to prevent moisture from entering wall assemblies
- Radon control systems and barriers
- Screens and barriers, including a foundation shield, for pest detection and control
- Properly sized heating, ventilation, and air conditioning systems with tightly sealed (with mastic) and balanced ducts as well as proper air filtration
- Combustion safety to protect from and remove fumes from fossil fuel, such as vents for the furnace and water heater
- Use of nontoxic materials.

Moisture control and ventilation are important to controlling water damage and mold. Important elements are barriers to prevent attraction of moisture to a low moisture home, draining every surface on the exterior of the home, and protecting building materials before they are placed in new construction to

prevent the introduction of moisture, mold, and insects. Once constructed, interior doors should not be kept shut as this practice prevents proper ventilation and causes air to push out into other areas.

The new label is very simple for the consumer: Energy Star with Air^{+}. This new label system adds quality to Energy Star homes and will help to inform consumers about indoor air quality. This is also expected to provide consumer savings, value, and payback as the Energy Star approach and other programs have demonstrated that consumers will pay for lower risk (e.g., buy bottled water rather than drink tap water).

Lessons learned from implementation of the Energy Star program will be used in the implementation of the indoor air quality label. The message to consumers is that an investment of less than 75 cents a day will yield over 100,000 cubic feet of fresh, filtered outdoor air and additional protection against mold/mildew problems, radon exposure, harmful pests and termites, harmful formaldehyde and volatile organic compounds, combustion safety, and wet basements. The incentive for builders includes reduced callbacks for problems, reduced liability, increased revenues, ability to meet a growing buyer preference, and, possibly, in the future, reduced insurance costs.

The indoor air quality label will be finalized in the fall of 2004, with a pilot program anticipated to be launched in November 2004 in three test markets. Subsequent activities will involve negotiating reduced rates with the insurance industry and evaluating pilot program results with the desire to have the new label in place and working by November 2005.

Indoor Environments Program Strategy

Tracy Enger, with ORIA, discussed how research and guidance is turned into action, because without taking action, there is no protection. This is the basis of social marketing, which is a series of offers and requests to obtain a social benefit. Social marketing is therefore important to voluntary programs, such as those sponsored by ORIA, because voluntary programs do not have a "stick" such as enforcement, only "carrots."

Such initiatives start with the best science possible to develop guidance and policy, then development of a system for achieving results that is packaged in a way to attract interest and voluntary implementation. Who delivers the message to the public can be important and sometimes that may not be EPA—other sources may be considered more credible or people may more likely follow them. Also, not everyone is compelled to action by the same kinds of information. For some individuals, health concerns rather than productivity may be of more interest.

Several examples were provided of ORIA products that demonstrate this process. One example involves I-BEAM, which is an interactive, user-friendly package that has been well-received by building operators. Another example involves the indoor air quality products for schools. ORIA developed a package that compiled all of the research information and provided the package to school administrators/staff to convince them to take the necessary actions. The package was designed to be low cost, presented information in an appealing manner, was adaptable to individual school/district needs, did not require specialized training to implement, and presented a common sense approach for voluntary actions. Also, to address current interest in mold and the public desire to take action, ORIA developed a guidance document entitled Mold Remediation in Schools and Commercial Buildings. There are also many ORIA products developed in the area of radon.

Another example of this process involves the asthma issue. EPA commissioned a report to identify the components of indoor air that were causing asthma; this report also addressed exposures and asthma onset, exposures and worsening asthma, and effectiveness of interventions. From this research, EPA was

able to identify five things on which the public could take action that might make a difference—second hand smoke, dust mites, pets, molds, and pests. EPA then created guidance on how to clear the home of these types of asthma triggers. To achieve voluntary action, each request must also involve an offer. In this case, taking action on these five asthma triggers may help to improve health.

To help deliver these types of messages to the public, EPA has developed interrelationships (formal associations) with other organizations who are respected, credible sources of information. EPA may ask these organizations to present the information to the public, as the public may be more likely to take action if this information comes from them.

A public information campaign may need other tools. For example, one way to help deliver a message to the public is to develop symbols that represent a cause, such as showing a goldfish out of water to represent asthma; many children with asthma describe the difficulty in breathing as being like a fish out of water. Another example involves the development of kits, brochures, a media message, and a "take the smoke-free home pledge" to address concerns with second hand smoke.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) EPA interactions with the Building Green Council, Lead Homes, and the Association of Home Builders to promote indoor air quality and the challenges of interfacing with programs that have a different mission or may not be as comprehensive as desired; and (2) the availability of guidance to help homeowners address indoor air quality in existing homes and in renovations.

Net Environmental Benefit Analysis

Following opening remarks by Ann Whelan, with EPA Region V, two speakers addressed the Net Environmental Benefit Analysis decision-making tool and its application to emergency response planning.

Developing Consensus for Environmental Decision-Making in Emergency Response

Bill Robberson, with the EPA Region IX Regional Response Team, discussed the Net Environmental Benefit Analysis (NEBA) process to help develop consensus in emergency response or in any complex, planning process with an environmental component. NEBA is an advance-planning oriented, resource management tool designed to improve the quality and results of environmental decision making. An actual emergency is not the time to get to know everyone involved and is not the time to address differing viewpoints about what to protect and when.

The NEBA process is about bringing science to decision makers. Every time an action is taken to solve a problem, other problems are created. The NEBA process helps decision makers to look at trade-offs and the impacts to resources from the various options. This tool has been used successfully in EPA Region IX, and has proven very helpful in developing information about possible emergencies/responses in advance of their occurrence.

The National Contingency Plan, whose authorities come from the Comprehensive Environmental Response, Compensation, and Liability Act and the Clean Water Act, defines and establishes the Regional Response Teams. These Teams have responsibility for ensuring that resources are available in an emergency and that these resources exist prior to an emergency. The San Francisco Bay Area Committee, one of six committees for the Southern California Regional Response Team, sponsored the

first ecologic risk assessment for San Francisco Bay as a means for preparing for emergency response. This effort took about 6 months and involved academia as well as local, state, and Federal agencies. Participants included resource managers, responders, and emergency managers who had to identify the concerns, their resources for natural resource management/protection, and spill response expectations.

NEBA was used in this planning effort and the process was as much the product as the resource ranking and response option comparison outcomes. The goal was to create a culture among all the resource trustees and responders about how to honor someone else's opinion. A key finding is that to achieve consensus at a meeting, it must be built beforehand.

The framework for this ecological risk assessment was an oil spill. The realities of an oil spill are that there will be injury to the environment and the response question becomes how to minimize or eliminate the damage. Oil spreads and oil can be hard to see, so it is not possible to remove all of the spilled oil from the environment. In addition, wildlife will get into the oil, and birds, for example, can die from very small amounts; so, the question becomes what damage and injury can be avoided in consideration of both short- and long-term impacts to habitat and species. All decisions regarding oil spill response—whether to use mechanical, chemical countermeasures, or in-situ burning, or no response at all (natural attenuation)—have inherent trade-offs. Therefore, it is important to have as many options identified in advance as possible to minimize the damage.

The overall goals in responding to an oil spill are to protect human life, prevent additional/continuing loss of oil, and to prevent/mitigate environmental damage. The assessment team established a consensus that, in responding to such a spill, it was important to protect sensitive habitats and species, with habitat possibly being more important (a trade-off). The assessment team also decided that, in the open ocean, the goal was to get to the spill while it was small in order to stop oil leakage, release, and spread. This was deemed necessary to protect birds, which the NEBA process had determined were a real resource driver and huge priority in the California coast. An important observation is that there will be different priorities in different geographic areas. A major challenge in such activities is to achieve consensus among stakeholders on what damage is likely to occur, and the best ways to avoid or minimize it. Contributing factors include the lack of scientific information, bias or misinformation, inadequate communication and information dissemination, and differences in ecological reference framework.

A risk-based approach is implicit in response planning, with risks coming from a stressor. There are different risk analysis frameworks, such as comparative risk and ecological risk assessment. Under a comparative risk framework, the response is contingent upon response options in a tool box; selection of the response option depends on the nature of the spill, resources to protect, route of exposure, and how to protect the resources. In addition, selection of resources to be protected is based on evaluating the risk to each habitat and its species compared to all others.

An ecological risk assessment, on the other hand, evaluates possible ecological consequences of a disturbance, and emphasizes comparison of exposure stressors with an ecological effect, and involves problem formulation, analysis, and risk characterization. Problem formulation involves: (1) the selection of a scenario for analysis (such as worst case) that occurs in a specific time of year (which may be limiting in scope since flora, fauna, and environmental conditions vary by time of year), (2) identification of resources of concern and associated assessment thresholds, and (3) preparation of a conceptual matrix to guide subsequent analyses. Analysis characterizes exposure, relates the exposure to ecological concerns for each identified response option, and determines relative risk. Risk characterization addresses other contributing factors such as political issues, social factors, economics (e.g., cost-benefit), regulatory and legal requirements, technological feasibility, etc. Since the consequences of risk management are huge, it is important to agree on their impacts and the resources.

The NEBA process examines more factors than those described for ecological risk assessment. The two processes are very similar, but the NEBA process is more focused on dialogue to identify stressors and to define interactions with resources, endpoints, and habitats/resources of concern. Since response planning involves the development and consideration of options that can be controversial, the NEBA process provides a format for conflict resolution, opportunities to identify critical issues for discussion, and an interactive education tool that encourages full participation. In addition, the NEBA process provides a basis for comparing and prioritizing risk.

Lessons learned from past experiences with spill response decision making include the following:

- Collection of spilled oil (removal) is preferred to chemical countermeasures, but it is rarely successful, therefore the main objective becomes how to manage the impacts of the spill
- It is not possible to plan for everything that might occur
- No matter who is trained to respond, someone else will show up in their place
- Resource and management conflicts seem inevitable.

Therefore, the goal becomes having a framework for constructive discussion and consensus decision making, such as NEBA. This decision making includes being prepared for the skills needed in response, developing common ground, and examining the ecological trade-offs associated with potential solutions.

How is this process unique? The emphasis is on potential rather than actual risk and brainstorming "what if" scenarios. A facilitator often helps the process to build off what the assessment team previously has done together and to frame outcomes in black-and-white to help the response decision maker.

Steps to accomplishing a NEBA for an oil spill include the following:

- Assemble the project team, involving specifically identified participants/specialists. The team generally involves 25 to 35 individuals, which can be broken into smaller groups, and includes all stakeholder groups (e.g., spill response managers, natural resource managers, subject matter experts, non-governmental organizations). This is an important step in the process and should involve those with relevant knowledge who will actively participate. A robust discussion from multiple representatives of specific areas (i.e., different perspectives) is important to the outcome.
- Develop the scenario in a way that is realistic. For example, type of oil, volume of oil, time of year, location, tidal situation, etc.
- Gather data and participants. Have team members pull together all the data that the project team may need in the analysis, and have participants conduct the analysis together.
- Define response options for consideration, including the "no response" option. Identify those responses that are commonly used and those that may be viable. Define each option further to determine if action A is taken, what is involved and what are the impacts. Note the limitations and outcomes if nothing is done; for example, if no action is taken, the emulsion of oil can result in volumes two to three times more than originally spilled.
- Estimate the fate of the oil and the potential for exposure to resources of concern.
- Define environmental resources of concern. This is extremely important and may include distribution data, population data, and species of special concern. Other aspects include which resources are drivers, such as essential fish habitat, and consider the multiple ways in which these resources can be valued. Also, eliminate resources from consideration that are not in the exposure chain.

- Consider all of the important relationships and develop a conceptual model. Identify exposure pathways and stressors (e.g., air pollution, aqueous exposure) in tabular form to create a conceptual model matrix with habitat across the top and stressors down the left side. Add to this a list of hazards at the bottom and fill in the hazard for each habitat-stressor box.
- Connect response options to resources and develop an understanding of their interrelationships.
- Define effects and develop thresholds to estimate the sensitivity to oil of the resources at risk. For example, if toxicity is the concern, identify which species and how much is toxic for each. Possible thresholds include the proportion of organisms in a population potentially within the trajectory of the spill. It is also necessary to include the laboratory toxicity data, data from field studies and related experiments, and data from real spills that will help to evaluate specific thresholds.
- Conduct the analysis. This is the heart of the process, which is to create a risk ranking matrix and to determine the level of concern about potential effects. A tabular format is useful to organize the information and to show the relationships between hazards, data, and possible thresholds.
- Prepare the Relative Risk Summary that pulls together what was done and what it means.
- Document the risk assessment and complete the Relative Risk Summary.

Each step and analysis activity must be a consensus decision among the participants. It is also important to identify specific endpoints. Examples include: prevent/minimize taking of protected species, prevent/minimize degradation of water quality, prevent/minimize degradation of sensitive habitats, or prevent/minimize long-term disturbance of relative abundance and diversity of communities within habitats (i.e., the "no net loss" statement for chronic effects).

Determining the level of concern about potential effects is the key step to the risk ranking process. An example showed a four box risk matrix where the x-axis is recovery (e.g., irreversible, reversible/negligible) with ranges of time (in years) and the y-axis is magnitude such as percent of resource (e.g., trivial, severe). This results in four possible risk relationships—1A, 1B, 2A, and 2B—that can be applied to the analysis. Color coding, a consensus decision of the working group, can also be used to overlay the risk matrix with levels of concern (e.g., high, medium, low concern).

Such a risk matrix helps to compare the hazard or threat to different resources and to identify areas where impacts are not clearly defined (i.e., uncertainty or lack of knowledge). This in turn allows for comparison of possible response options, definition of likely consequences of the spill and response, and management of expectations.

This type of approach requires the assessment team to come to conclusions about the planning, response options, and information needs, and helps participants understand what is and is not known. The process works well using a workshop approach and focus groups, but this must be well managed.

NEBA is both a planning tool and an education tool that can be completed as a planning exercise in real time. This process will not be useful if applied for the first time during a spill, but it does improve spill response if the analyses have been completed beforehand.

There is always an element of uncertainty in this analysis and it is important to look at sources of variability. If this example had been a large-scale, detailed risk assessment, quantitative estimates might have been conducted. As described here, the process is based on expert opinion, but it is well documented.

A brief question and answer period addressed a range of topics. These included: (1) defining consensus as "can you live with it" rather than agreement by all participants; (2) the use of facilitation to ensure

participation by nonspeakers, particularly in consensus-building; (3) use of risk communication and message mapping to present relative risk determinations of this process to the public; (4) primary responsibilities of organizations other than the Regional Response Teams for earthquake response, which is another potential application for NEBA; and (5) how this process fits into an Environmental Management System or other larger process as addressed in the next presentation.

Case Study of Isle Royale

Ann Whelan, with EPA Region V, presented a case study illustrating the application of NEBA to emergency response planning for Isle Royale, Michigan. The Isle Royale area involves a very complex international biosphere including a series of islands, a main island with a lake, an international boundary (with Canada), a national park, extremely sensitive natural resources, Federally listed endangered species (e.g., eagles, gray wolf), and limited local response capabilities. This area is very isolated, predominantly wilderness, occupied only part of the year, and is home to the longest predator-prey study since wolves went over to the main island in 1949 via an ice bridge.

The NEBA process was initiated through an area committee already in existence and with jurisdiction over the national park. EPA was asked to collaborate with this committee regarding problems in responding to Isle Royale in an emergency. The nature of the location and the overall situation resulted in much more Federal agency involvement in this process than might be found for other situations. Preliminary work involved the development of a sensitivity atlas that identified and mapped sensitive species, since the NEBA process at this location is species driven.

The initial meeting was held in Duluth in January 2004. This involved a group of experts, including biologists, ecologists, response contractors, EPA, United States Coast Guard, Department of Interior, National Park Service, Great Lakes Commission, Michigan Department of Natural Resources, and Michigan Pollution Control Agency, among others. The group first identified potential threats, which included the following:

- International shipping lane within 1 mile of Isle Royale, involving approximately 600 ships (1,200 round trips) annually
- Vessel fuel loads of approximately 200,000 gallons per vessel with approximately three percent of the cargoes involving liquids
- Heaviest shipping traffic during the late fall and early winter, which is a known hazard period for ships/boats in Lake Superior (e.g., the sinking of the Edmund Fitzgerald and several groundings on Isle Royale)
- Oil storage on Isle Royale itself.

The potentially impacted, high priority species identified as drivers for this assessment included the gray wolf, common loon, bald eagle, coaster brook trout, arctic shoreline plants, boreal chorus frog, and fresh water mussel beds.

The scenario selected for analysis was not the worst case oil spill; it involved a grounded freighter with a fuel release of 30,000 gallons (not the entire fuel capacity) that impacts the northeastern tip of Isle Royale and occurs in late April/early May. That time of year was selected in order to maximize the number of species that might be harmed so as to drive the dialogue about the worst possible resource impacts (e.g., fish had spawned but fingerlings were still around, birds were nesting, etc.). Of important note is that this is a less politicized environment than the coastal California example in the previous presentation and the public tends to think of oil spills as a coastal/ocean problem rather than something that may occur in the Great Lakes.

The assessment team identified in advance the following impacted habitat zones: terrestrial, coastal wetlands, shorelines, nearshore (there are reefs—a shipping hazard), reefs, and open water. Impacted resources (species categories) included vegetation, mammals, birds, herpetiles, fish, macro-invertebrates, and micro-invertebrates.

The assessment team discussed and ranked specific response strategies, including natural recovery (no action), mechanical/manual recovery, shoreline chemical cleaners, and in-situ burning of shoreline only; dispersants were not considered because they do not work in fresh water. Since there are inherent problems with each response technique, it was necessary to determine which response options were optimal. For example, mechanical recovery requires a lot of people, a lot of equipment, a place to stage the equipment, and a place to store recovered oil. An important consideration was the proximity of Canada, but the inability to access that equipment. Another example of response-specific considerations involved in-situ burning. Isle Royale is located in Michigan, which does not have pre-approval for in-situ burning. However, there is a U.S. Forest Service equipment cache for fire fighting located 3 hours away. This appeared advantageous because the U.S. Forest Service might be able to respond quickly and has the knowledge and capability to conduct a burn in this environment. Drawbacks included U.S. Forest Service inexperience with the ignition and control of petroleum fires. Therefore, there was a need to have an interagency agreement to train personnel as they move in/out of the area, etc.

The assessment team developed the Relative Risk Matrix, as described in the previous presentation, and assigned risk in tabular form for each species group under each of the four identified response options. These participants did not like using percentages to define impact, as done in the California example, because some of the animal populations (i.e., wolves) were very small and even a small percentage could be more catastrophic in impact to some species than to others. Instead, this team opted for additional ranges of color coding options, for example, the use of three different reds.

The assessment results were graphed in three dimensions to visually demonstrate how optimal response techniques were derived for each species. For example, the graph showed that leaving the oil there (no response) and aggressively cleaning up the oil both resulted in a higher spike for damage to resident species than other response options. The assessment outcomes included a map of optimal recovery that showed what techniques might work best in which geographic location, with the recognition that those are not the only actions that can be taken.

The information developed from this process must be put together with a lot of other work about what is possible/practicable for any given location in order to come up with what can or should be done to protect specific species. Being able to identify that the response options are so limited enabled the Park Superintendent to begin looking at other options such as prevention, seed banking, and gathering more equipment.

A brief question and answer period addressed a range of topics. These included: (1) the ability to use both species-based and habitat-based approaches since some response techniques do not work in every environment; (2) the greater importance of habitat in coastal/ocean area studies; and (3) the challenges of solely using habitat for inland zones where habitat is more integrated, different species use the same habitat in different ways, and species are much more compacted, which results in either small habitat changes that are not worth considering or the need to do a NEBA for each habitat.

Appendix A: Meeting Agenda

EPA 2004 Science Forum: Healthy Communities and Ecosystems
June 1-3, 2004, Washington, DC
FINAL AGENDA

TUESDAY, JUNE 1, 2004

10:00 AM – 11:30 AM — AAAS Session (*Oriental Ballroom A/B*)

The American Association for the Advancement of Science (AAAS) has organized a session that kicks off the Science Forum events on Tuesday morning. The session is designed to review the relationship between the AAAS Environmental Fellows Program and the U.S. Environmental Protection Agency. The session will be chaired by Fran Sharples, Director of the National Research Council's Board on Life Sciences. Presentations by current and recent Environmental Fellows will address the history of this AAAS/EPA relationship, its accomplishments, and prospects for its future activities.

Chair: Fran Sharples, Director, Board on Life Sciences, National Research Council

Panelists: Terry Keating, Senior Environmental Scientist, EPA/OAR and Venkat Rao, Director, Health Research & Informatics, Computer Sciences Corporation

10:00 AM — Poster and Exhibit Room Opens (*Grand Ballroom and Foyer*)

Plenary Session (*Oriental Ballroom*)

1:00 PM — Mike Leavitt, EPA Administrator

1:15 PM — Michael Steele, Lieutenant Governor, Maryland

1:30 PM — Jimmy Palmer, Regional Administrator, EPA Region 4

1:45 PM — Kim Nelson, Assistant Administrator, Office of Environmental Information, EPA

2:00 PM — Break

2:20 PM — Paul Gilman, Assistant Administrator, Office of Research and Development, EPA

3:00 PM — R. Steven Brown, Executive Director, Environmental Council of the States

3:15 PM — Jack Marburger, Director, Office of Science and Technology Policy

3:30 PM — David McQueeney, IBM

5:00 PM – 7:00 PM — **Poster Session & Awards Reception** (*Grand Ballroom*)

The Poster Session will highlight EPA research related to the three themes, allowing presenters the opportunity to quickly and efficiently communicate their research in an easy-to-view format conducive to walk-through traffic. The Poster Session will include over 220 posters and will allow participants to study the information and discuss the posters one-on-one with the presenters.

List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
AAAS	American Association for the Advancement of Science
AKC	American Kennel Club
BEACH	Beaches Environmental Assessment and Coastal Health Act
CA	California
CDC	Centers for Disease Control
CHAMACOS	Center for Health Analysis of Mothers and Children of Salinas
CT	Connecticut
DEC	Department of Environmental Conservation
DOH	Department of Health
DNA	Deoxyribonucleic Acid
DNR	Department of Natural Resources
ECOS	Environmental Council of the States
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
FL	Florida
GIS	Geographic Information Systems
HQ	Headquarters
IAQ	Indoor Air Quality
MD	Maryland
MIT	Massachusetts Institute of Technology
NAS	National Academy of Sciences
NBII	National Biological Information Infrastructure
NCA	National Coastal Assessment
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NEPA	National Environmental Protection Act
NERL	National Exposure Research Laboratory
NESCAUM	Northeast States for Coordinated Air Use Management
NH	New Hampshire
NHEERL	National Health and Environmental Effects Research Laboratory
NIEHS	National Institute of Environmental Health Sciences
NOAA	National Oceanic and Atmospheric Administration
NRMRL	National Risk Management Research Laboratory
NYS	New York State
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
OEI	Office of Environmental Information
OIAA	Office of Information Analysis and Access
OPPT	Office of Pollution Prevention and Toxics
ORD	Office of Research and Development
ORIA	Office of Radiation and Indoor Air
OST	Office of Science and Technology
OTOP	Office of Technology, Operations and Planning
OW	Office of Water
OWOW	Office of Wetlands, Oceans, and Watersheds
REMAP	Regional Environmental Monitoring and Assessment Program
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey

WEDNESDAY, JUNE 2, 2004

	Science and Innovation to Protect Health and Environment (ORD) Sessions Oriental Ballroom A	Using Science to Make a Difference (Region) Sessions Oriental Ballroom B	Delivering Science-Based Information to Decision Makers (OEI) Sessions Oriental Ballroom C
8:30 AM – 10:00 AM	**Advanced Remote Sensing** Introduction – *Terrence Slonecker, EPA/ORD/NERL* The Status of the 2001 National Land Cover Data – *James Wickham, EPA/ORD/NERL* Evaluating Environmental Quality Using Spatial Data Derived from Satellite Imagery – *K. Bruce Jones, EPA/ORD/NERL* Development of Landscape Indicators for Potential Nutrient Impairment of Streams in EPA Region 8 – *Karl Hermann, EPA Region 8* Multi-Scale Remote Sensing Mapping of Anthropogenic Impervious Surfaces: Spatial and Temporal Scaling Issues Related to Ecological and Hydrological Landscape Analyses – *S. Taylor Jarnagin, EPA/ORD/NERL* LIDAR: A Remote Sensing Tool for Determining Stream Channel Change? – *David Jennings, EPA/ORD/NERL* The Use of Remote Sensing in the Detection and Removal of Chemical Weapons in Spring Valley – *Steven Hirsh, EPA Region 3*	**Can You Hear Us Now? EPA's Role in Invasive Species Research and Management** Introduction – *Michael Slimak, EPA/ORD/NCEA* Snakeheads, Green Crabs, and Other Nasty Things – An Overview of Invasive Species – *Henry Lee II, EPA/ORD/NHEERL* OW and Aquatic Nuisance Species – What's Underway and What's Planned – *Diane Regas, EPA/OW/OWOW* Rapid Assessment Surveys: Marine Bioinvaders in the Northeast – *Judith Pederson, MIT Sea Grant College Program* Targeted Screening for Invasive Species in Ballast: Genomic Approaches – *Michael Blum, EPA/ORD/NERL* Non-native Oysters in Chesapeake Bay – *Michael Fritz, EPA/Chesapeake Bay Program Office*	**The Future of EPA's Environmental Indicators Initiative and Report on the Environment** Introduction to the Draft Report on Environmental Indicators – *Michael Flynn, EPA/OEI/OIAA* Overview of the Outcome Chapters – *Denice Shaw, EPA/ORD* Human Health Trends and Outcomes – *Judy Qualters, CDC* Questions and Discussion – *Heather Case, EPA*
10:00 AM – 10:30 AM	**Break**		
10:30 AM – Noon	**Innovations in Risk Assessment: Improving Data Resources** Introduction – *George Woodall, Jr., EPA/ORD/NCEA* The Need for Scientific Data in Regulatory Decision-Making – *Roy Smith, EPA/OAR/OAQPS* The ATSDR Experience in Using the Supplemental Documents Database in Developing Toxicological Profiles – *Henry Abadin, ATSDR* Distributed Database Approach to Sharing Data – *Ann Richard, EPA/ORD/NHEERL* The Chemical Effects in Biological Systems Knowledgebase – *Michael Waters, NIEHS*	**Monitoring and Assessment to Protect Tribal Health and Ecosystems** Introduction – *Valerie Bataille, EPA Region 1* Protection of Tribal Cultural Practices Through the Development of Native American Exposure Pathways – *Fred Corey, Aroostook Band of Micmacs* Towards a Better Understanding of Mercury Fate and Transport on the Fond du Lac Reservation: Monitoring Air, Water, Sediments and Biota – *Nancy Costa, Fond du Lac Reservation Environmental Program* Primary Production Study of Coastal Waters of the Bay of Fundy – *Stephen Crawford, Passamaquoddy Tribe at Pleasant Point*	**Using Geospatial Tools to Make Program Decisions** Introduction – *Brenda Smith, EPA and Wendy Blake-Coleman, EPA* OEI Support for EPA HQ Emergency Operations Center: Emergency Response Analyzer – *Joe Anderson, EPA/OEI/OIAA* Assessing Urban Growth and Land Cover Trends Using Remote Sensing Imagery and Landscape Metrics – *Cary Roberts, EPA/OEI/OIAA* NEPAssist: GIS Tool to Support Work on the National Environmental Protection Act – *Julie Kocher, EPA/OEI/OIAA*
Noon – 1:00 PM	**Lunch**		

WEDNESDAY, JUNE 2, 2004 continued

	Science and Innovation to Protect Health and Environment (ORD) Sessions Oriental Ballroom A	Using Science to Make a Difference (Region) Sessions Oriental Ballroom B	Delivering Science-Based Information to Decision Makers (OEI) Sessions Oriental Ballroom C
1:00 PM – 2:30 PM	**Using Human Data in Risk Assessment**	**R-EMAP: The Application of EMAP Indicators**	**Delivering Consistent Information on Health and the Environment**
	Introduction – *John Vandenberg, EPA/ORD/NCEA* The Ethics of Research Involving Human Subjects – *James Childress, University of Virginia* EPA Clinical Research: Implications for Air Quality Standards – *Bill McDonnell, EPA/ORD/NHEERL* Research with Human Subjects: Future Challenges, and Opportunities – *Richard Sharp, Baylor College of Medicine*	The Past, Present, and Future of the Regional Environmental Monitoring and Assessment Program – *Brian Hill, EPA/ORD/NHEERL* Southeastern Wadeable Streams R-EMAP – *Peter Kalla, EPA Region 4* Maryland Biological Stream Survey: Science for Streams – *Daniel Boward, MD DNR*	*William Sonntag, EPA/OEI* Collaborative Opportunities in Ecoinformatics – *Mike Frame, USGS NBII* Environmental Information Exchange Network – *Molly O'Neill, ECOS* *Larry Fitzwater, EPA/OEI*
2:30 PM – 3:00 PM Break			
3:00 PM – 4:30 PM	**Supporting Innovations in Science to Identify Children's Vulnerability to Environmental Exposures**	**Great Places Demand Great Science**	**Developing Science-Based Information for Coastal Systems**
	Introduction– *Nigel Fields, EPA/ORD/NCER* Children's Health and Environmental Exposures: The Most Important Unanswered But Answerable Questions – *Michael Weitzman, American Academy of Pediatrics Center for Child Health Research* Highlights from the Columbia Center for Children's Environmental Health: Studying Air Pollution in Community Context – *Virginia Rauh, Columbia Center for Children's Environmental Health* The National Children's Study – *Carole Kimmel, EPA/ORD/NCEA* Wrap-Up and Discussion	Introduction – *Rochelle Araujo, EPA* Next Generation Chesapeake Bay Nutrient and Sediment Loading Caps: Two Decades of Estuarine Science at Work – *Richard Batiuk, EPA Region 3* The Great Lakes: Collaborative Science to Inform and Help Frame Policy – *John Lyon, EPA/ORD/NERL* Sustainability of the Gulf of Mexico: The Role of Science, Management, and Activism – *Quenton Dokken, Texas A&M University* Wrap-Up and Discussion	Introduction – *Kevin Summers, EPA/ORD/NHEERL* From Fjords to Tropical Beaches, EMAP's Assessment of Coastal Conditions on the Pacific Coast – *Henry Lee II, EPA/ORD/NHEERL* The Utility of NCA-type Monitoring Data for EPA Decision-making – *Diane Regas, EPA/OW/OWOW* *Use of Coastal Monitoring Data in Management Decision Making in Florida* – Gil McRae, FL Fish and Wildlife Conservation Commission National Coastal Assessment: A Successful State-Federal Collaboration in New Hampshire– *Phil Trowbridge, NH Department of Environmental Services* National Coastal Assessment: Approach and Findings in the Northeast – *Henry Walker, EPA/ORD/NHEERL* National Coastal Assessment: Monitoring and Modeling in Support of TMDL Calculations – *Henry Walker, EPA/ORD/NHEERL*

	Science and Innovation to Protect Health and Environment (ORD) Sessions Grand Ballroom A	Using Science to Make a Difference (Region) Sessions Grand Ballroom B	Delivering Science-Based Information to Decision Makers (OEI) Sessions Grand Ballroom C
8:30 AM – 10:00 AM	**Sustainability – Educating for the Future** *Education for Sustainability Initiatives* – Alan Hecht, EPA/ORD Principles and Practice of Sustainability Education in Schools – *Jaimie Cloud, The Sustainability Education Center, Inc.* National Efforts in Sustainability Education – *Alan Elzerman, Clemson University* Building Partnerships for Sustainable Science Education – *Sally Shuler, NAS & Smithsonian Institution* Summary and Open Discussion	**Looking into the Future of a Region** Ecological Forecasting – *K. Bruce Jones, EPA/ORD/NERL* A Weight-of-Evidence Approach to Projecting Land-Use Change and Resulting Ecological Vulnerability – *Laura Jackson, EPA/ORD/NHEERL* Land-Cover Change, Alternate Future Scenarios and Nutrient Export in the Mid-Atlantic Region – *James Wickham, EPA/ORD/NERL* Statistical Modeling of Ground-Water Vulnerability in the Mid-Atlantic Region: Present and Future – *Earl Greene, USGS* Forecasting Species' Distributions: The Shape of Things to Come – *Daniel Kluza, EPA/ORD/NCEA* Putting It All Together: Implications for the Mid-Atlantic Region in 2020 – *Betsy Smith, EPA/ORD/NERL*	**Scientific Computing** Introduction – *Rick Martin, EPA/OEI/OTOP* The Center of Excellence for Environmental Computational Science – *Joseph Retzer, EPA/OEI/OTOP* Current Projects and High Performance Computing and Visualization Direction – *John Smith, EPA/OEI/OTOP* Growing the Environmental Science Portal – *Terry Grady, EPA/ORD/NERL* Closing and Questions – *Joseph Retzer, EPA/OEI/OTOP*
10:00 AM – 10:30 AM	**Break**		
10:30 AM – Noon	**Partnering with New York on Air Quality and Human Health: Issues, Challenges and Perspectives** Federal-State Partnerships for Enhanced Understanding for Air Quality and Health Relationships – *ST Rao, EPA/ORD/NERL* Tracking Public Health – *Vickie Boothe, CDC* *NOAA-EPA's Air Quality Forecast Capability* – Paula Davidson, NOAA/National Weather Service Air Quality: A Regional Perspective – *Kenneth Colburn, NESCAUM* Air Quality Management and Challenges in New York State – *David Shaw, NYS DEC* Health Surveillance – *Nancy Kim, NYS DOH*	**Regional Research Partnership Program** Introduction – *Tom Baugh, EPA Region 4* Microbial Source Tracking: The Application of a DNA-Based Molecular Approach to Identify Sources of Fecal Contamination– *Bonita Johnson, EPA Region 4* Land Cover Diversity Measured by Satellite as a Proxy for Biodiversity – *David Macarus, EPA Region 5* The Relationship of Terrestrial Ecosystems to Manganese Emissions from Wood Burning – Dan Ahern, EPA Region 4	**Healthy Communities – One Building at a Time** Introduction – *Elizabeth Cotsworth, EPA/OAR/ORIA* *John Girman, EPA/OAR/ORIA* Indoor Environment Research Base – *Jim Jetter, EPA/ORD/NRMRL* Delivering Technical Assistance – *David Mudarri, EPA/OAR/ORIA* EPA's New IAQ Label – *Sam Rashkin, EPA Tracy Enger, EPA/OAR/ORIA*
Noon – 1:00 PM	**Lunch**		

	Science and Innovation to Protect Health and Environment (ORD) Sessions Grand Ballroom A	Using Science to Make a Difference (Region) Sessions Grand Ballroom B	Delivering Science-Based Information to Decision Makers (OEI) Sessions Grand Ballroom C
1:00 PM – 2:30 PM	**State-of-the-Science Research on Swimming-Associated Health Effects and the Translation of Health Data to Water Quality Guidelines for Bathing Beaches**	**Community Air Toxics Projects**	**Net Environmental Benefit Analysis**
	Introduction – *Alfred Dufour, EPA/ORD/NERL* The Relationship Between Novel Indicators of Recreational Water Quality and Health – *Timothy Wade, EPA/ORD/NHEERL* Epidemiology Study of Swimmers in Nonpoint Source Polluted Marine Recreational Waters from San Diego, CA – *Kenneth Schiff, Southern California Coastal Water Research Project and Jack Colford, University of California, Berkeley* Partnerships: Linking EPA Beach Research with State and Local BEACH Programs – *Rick Hoffmann, EPA/OW/OST*	Introduction and EPA Support for Community Air Toxics Projects – *Henry Topper, EPA/OPPT* Developing an Air Toxics Emissions Inventory and Reduction Strategy in New Haven, CT – *Madeleine Weil, City of New Haven, CT* Community Air Toxics Projects – *Emily Andrews, St. Louis Community Air Project* Louisville 2004: Risk Management Actions – *Jon Trout, Louisville Metro Air Pollution Control District* Mobile, Alabama – Community Based Expectations of Air Quality – *Steve Perry, The Forum, Industry Partners in Environmental Progress*	Net Environmental Benefit Analysis Decision-Making Tool – *Ann Whelan, EPA Region 5 and Bill Robberson, EPA Region 9*
2:30 PM - 3:00 PM	**Break**		
3:00 PM – 4:30 PM		**Science to Support Decisions: Climate Change**	
		Introduction – *Michael Slimak, EPA/ORD/NCEA* The Feasibility of Conducting Climate Change Impacts Assessments: Opposing Viewpoints – *William O'Keefe, George C. Marshall Institute and Michael MacCracken, U.S. Global Change Research Program* Use of Science in Gulf of Mexico Decision Making Involving Climate Change – *Arnold Vedlitz, Texas A&M University* Alternative Approaches to Climate Change Impacts Assessments: Success Stories – *Joel Scheraga, EPA/ORD/NCEA*	

POSTERS & EXHIBITS (*Grand Ballroom and Foyer*)

The Poster Session will highlight EPA research related to the three themes, allowing presenters the opportunity to quickly and efficiently communicate their research in an easy-to-view format conducive to walk-through traffic. Each Forum Poster will provide a broad perspective of an environmental issue, the scientific approach to resolve the issue, partnerships in both conducting the work and applying the results and the impact that EPA science has made or expects to make on the issue.

The Poster Session will include over 220 posters and will allow participants to study the information and discuss the posters one-on-one with the presenters. Posters and organizational exhibits will be on display from Tuesday morning through Wednesday afternoon (breakdown to occur after the afternoon break at approximately 3:00 PM).

DRINKING WATER RESEARCH TRAILER (MOBILE LAB) (*Maine Avenue Entrance*)

The Drinking Water Research Trailer will be on display outside the Maine Avenue entrance (Ballroom Level) of the Hotel from Tuesday through Wednesday.

DOGS & POLLUTION PREVENTION (*Grand Ballroom*)

Demonstrations on how dogs can be used in pollution prevention will be held in the Grand Ballroom on Tuesday and Wednesday. In this demo, an AKC registered Swedish Vallhund demonstrates his unique skill of vapor intrusion detection.

PRODUCT EXPO (*Grand Ballroom*)

This year's Forum will include a Product Expo, which will highlight several "ready-to-use" EPA Products. EPA developed a list of health and environmental questions for which we have one or more "ready-to-use" EPA science products, such as models, maps, databases or guidance documents.

We asked a group of Regional, State, and Tribal Senior Managers to select 8-10 questions, which they would like to see addressed, as related to high priority environmental science issues. Their input was used to make the final selection of Product Expo Exhibit questions and products, as follows:

Water Quality

- How do I prioritize where to focus my TMDL Program? How do I locate impaired waters and develop targets to remove their impairments?
- What rapid-response technologies are available to determine if our beaches are safe?
- What help is available for small drinking water systems?
- What technologies are available to help small drinking water plants meet the 10 ppb arsenic drinking water standard?

Air Pollution

- Are technologies available for my electric utility to remove mercury from their air emissions?
- Can a national mold standard be developed using EPA-patented technology?
- How can area source emissions of air pollutants be measured in near real-time to support state and regional air quality objectives?

Ecosystem Protection

- What ecological resources should be evaluated in an ecological risk assessment?

Human Exposure

- What exposure databases and models are available to help me determine human exposures to specific pollutants and how age (i.e., children vs. adults) and human activities affect these exposures?