USGS

Draft U.S. Geological Survey Chesapeake Bay Science Plan, FY2006-2010
(Updated draft 5/5/2005)

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EXECUTIVE SUMMARY

The Chesapeake Bay, the Nation's largest estuary, has been degraded due to water-quality problems, loss of habitat, and over-harvesting of living resources. Since the mid-1980s, the Chesapeake Bay Program (CBP), a multi-agency partnership which includes the Department of Interior (DOI), has worked to restore the Bay ecosystem. To enhance restoration efforts, the CBP created Chesapeake 2000, an Agreement that establishes restoration commitments for the next 10 years in the Bay and its watershed. In 2005, which is the mid-point for most of the restoration commitments in Chesapeake 2000 and marks over 20 years of restoration activities by the CBP, there is growing concern at all levels of government, and by the public, that many desired ecological conditions will not be achieved by 2010. There is an acute need for enhanced science to better document the reasons for the lack of significant ecosystem improvement, assess the types of restoration activities that will provide the greatest benefit, and forecast changes in human activities and their potential impact on the ecosystem so policy makers can adapt longer-term strategies to achieve ecologically sustainable development in the Bay watershed.

Since the beginning of the Chesapeake Bay restoration effort, the U.S. Geological Survey (USGS) has the critical role of providing unbiased scientific information that is utilized to document and explain ecosystem change to help assess the effectiveness of restoration strategies in the Bay and its watershed. With the new challenges facing the Chesapeake Bay, the USGS is revising its objective to provide science to help policy makers (1) better understand the lack of significant ecosystem improvement, (2) identify current strategies that will provide the greatest ecosystem improvement, and (3) adapt new strategies to promote ecologically sustainable growth in the Bay and its watershed. The interrelation of the factors influencing different components of the ecosystem must be understood in more scientific detail to explain current conditions and forecast potential changes. Based on initial interaction with the CBP, the DOI, and science partners, the revised USGS science goals for Chesapeake Bay are:
-The impact of human activities on land use;
-Factors affecting water quality in the watershed and delivery to the estuary;
-Function of near-shore areas on water quality in the estuary and providing habitat for aquatic-dependent living resources; and
-Deliver and synthesize information for assessing, forecasting, and restoring the Bay ecosystem (the Bay and its watershed).
The USGS Chesapeake Bay Studies will continue to coordinate with multiple USGS Programs to conduct additional studies, and increase partnerships with other scientific agencies, to meet these science goals. The USGS will also increase emphasis on delivery

of findings to resource managers and policy makers to help restore the Chesapeake Bay and other priority ecosystems of the Nation.

Restoration of the Nation's Largest Estuary and Need for Increased Science

The Chesapeake Bay is the Nation's largest estuary, which historically supported one of the most productive fisheries in the world. The Bay serves as the spawning ground for 70 to 90 percent of the striped bass in the Atlantic Ocean. The 64,000-square-mile watershed of the Bay provides vital habitat for migratory birds using the Atlantic Flyway. In addition to supporting aquatic communities and wildlife, the Bay's watershed serves the economic and recreational needs of 15 million people. Unfortunately, the commercial, economic, and recreational value of the Bay and its watershed have been degraded by poor water quality, loss of habitat, and over-harvesting of living resources. Additionally, the Bay was listed as an "impaired water body" in 1999 under the Clean Water Act, due to excess nutrients and sediment, and must meet regulatory water-quality standards by 2010.

Since the early 1980s, the Chesapeake Bay Program (CBP), which is a partnership between Maryland, Virginia, Pennsylvania, the District of Columbia, the Federal Government (including three Department of Interior/DOI agencies), and the Chesapeake Bay Commission, has been formulating and implementing restoration goals to reduce the amount of nutrients, sediment, and toxics entering the Bay and restore habitat to improve living resources. In 2000, the CBP recognized the need for an enhanced restoration effort and developed Chesapeake 2000, an Agreement that established over 100 restoration commitments for the next 10 years in the Bay and its watershed. The commitments were focused on achieving sound land use to reduce nutrient, sediment, and toxics and improve habitat to restore living resources in the Bay.

The technical needs have evolved since the signing of Chesapeake 2000 and include prioritization of the 100 restoration commitments into 10 “keystone” commitments. The keystone commitments are focused on improving sound land use (increasing land preservation and decreasing the rate of “harmful” sprawl) to help improve water quality (reduce nutrient and sediment to remove the Bay from the impaired water list) and vital habitats (watersheds and stream corridors, forests, wetlands and submerged aquatic grasses) to restore several key living resources (oysters and fisheries). Additionally, DOI increased its involvement in the CBP through the U.S. Fish and Wildlife Service (USFWS) Chesapeake Bay Ecosystem Team, and the National Park Service (NPS) “Gateways” Program. The USFWS Ecosystem Team has technical needs that match many of those in Chesapeake 2000, but also has an emphasis on migratory birds and their habitats. The NPS has been focused on explaining the cultural significance of the Bay and is expanding more toward watershed planning and protection of NPS resources.

The science community through the CBP Scientific and Technical Advisory Committee (STAC) completed *Chesapeake Futures* (Boesch and Greer, 2003), which presented projections of the potential conditions in the Bay and its watershed in 2030. Potential future scenarios suggested that even if many of the commitments of Chesapeake 2000 could be met, increasing human population and associated land-use trends will result in only modest improvements in habitats and production of important Bay fisheries. The report suggests that alternative strategies and emerging technologies must be considered

to improve the ecological and economic health of the Bay and its watershed. Based on these findings, STAC has prepared documents outlining and prioritizing the scientific and technical needs for fulfilling the Chesapeake 2000 commitments (STAC, 2005).

In 2005, which is the mid-point for most of the restoration commitments in Chesapeake 2000 and marks over 20 years of restoration activities by the CBP, there is growing concern at all levels of government, and by the public, that many desired ecological conditions will not be achieved by 2010. There is an acute need for enhanced science to better: (1) document the reasons for the lack of significant ecosystem improvement, and (2) assess the types of restoration activities that will provide the greatest benefit to restoring the ecological and economic health of the Bay and its watershed. Additionally, with continued population growth and the associated land-use trends in the Bay watershed, new science is needed to forecast changes in human activities and their potential impact on the ecosystem so policy makers can adapt longer-term strategies to achieve ecologically sustainable development in the Bay watershed. Ecologically sustainable development is the balance between population growth and the associated human activities (agricultural and urban land-use changes), and the condition of the natural ecosystem (Marten, 2001).

The Role of the USGS in the Chesapeake Bay Restoration Effort

Past and current activities

The USGS has the critical role of providing unbiased scientific information that is utilized to document and explain ecosystem change to help assess the effectiveness of restoration strategies in the Bay and its watershed. The USGS began research and monitoring studies in the late 1970s to document the amount and trends of nutrients entering the Bay, and the factors affecting the degradation of submerged aquatic vegetation (SAV). When the Bay Program was formed in 1983, the USGS was one of the original Federal partners. Efforts increased significantly in the mid-1990s, when the USGS selected the Chesapeake Bay watershed as one of its priority ecosystems for study. At that time, the USGS began a multidisciplinary effort focused primarily on assessing the climatic and human factors affecting the sources, transport, and delivery of nutrients through the Bay watershed and determining the impact on selected environmental indicators of the Bay system (SAV and fish). The studies were expanded with the inclusion of the National Biological Service into the USGS in 1998.

To support the expanded technical needs of Chesapeake 2000, the USGS summarized existing studies and wrote a 5-year science plan (Phillips, 2002) with new science goals to help guide project directions and expand information delivery. The USGS science goals were closely related to Chesapeake 2000 and the needs of DOI agencies involved with the Chesapeake Bay and included:

Improve watershed and land-use data and analysis.
Understand the sources and impact of sediment on water clarity and biota.
Enhance the prediction, monitoring, and understanding of nutrient delivery to the Bay.
Assess the occurrence of toxic constituents and emerging contaminants.
Assess the factors affecting the health of fish and water birds.
Disseminate information and develop decision-support tools.

The goals were modified in 2003 to include wildlife to better reflect some of the information needs of DOI and also merge nutrient and contaminant issues. The USGS is conducting

about 30 projects in the Chesapeake Bay and its watershed that address these goals and many of these projects will end in 2005 and 2006.

Rationale and Considerations for Future USGS activities

The USGS is revising its Chesapeake Bay science plan for 2006-2010 to meet the new challenges related to (1) better understanding the factors affecting change (or lack thereof) in the Bay ecosystem, (2) identifying and better targeting current restoration activities that will provide the greatest improvement in the ecosystem, and (3) forecasting future changes so resource managers can more effectively adapt management approaches to improve the Bay ecosystem and promote ecologically sustainable development. The USGS science plan will better reflect the new "keystone" commitments of the Chesapeake 2000 Agreement, have an increased emphasis on DOI needs, and promote more emphasis on partnerships with other science entities.

The USGS is interacting with scientists, managers, and partners, and has established the Chesapeake Bay Executive Advisory Team (CBEAT) to provide guidance on the issues and scope of the plan. Based on the peer review comments of the CBEAT and interaction with other stakeholders, the USGS should consider:

-Revising its Chesapeake Bay science goals so they continue to be related to the issues of concern (land use, water quality, habitat, and living resources) but being more focused given the level of funding.

-Of these issues, science goals related to land use and water quality should be the highest priority. The function of near-shore areas and habitats in the biogeochemical cycling of nutrients and sediment would be an important complementary topic for water quality. Additionally, synthesis and delivery of information is a continuing high priority topic for the USGS.

-Improvement of a conceptual model of the Bay ecosystem (the Bay and its watershed) would help the USGS better develop and focus future science efforts.

-Studies of the estuary and living resources are mostly being led by other agencies and institutions so the USGS should consider these as a lower priority that may be addressed by forming scientific partnerships. This may be accomplished through greater interaction with institutions in STAC, and further partnerships with agencies conducting restoration activities.

-Having a higher proportion of studies in the watershed than in the estuary since there is a significant need to understand the relation between changes in human activities, nutrient and sediment sources, and water-quality response in the watershed and delivery to the Bay. However, there was strong agreement that an important component of the science goals would be to improve the understanding of relation between the watershed and the estuary. Further study of the near-shore areas (nontidal/tidal interface) including the influence of the environmental framework (shallow geology and watershed characteristics) on the delivery of flow, nutrients, and sediment from the watershed to the estuary was suggest as a critical science need.

-There needs to be a balance between monitoring, modeling, research, assessment and communication. The USGS should strengthen efforts in having monitoring, assessment, and research to improve models. The uncertainty inherent in these models should be identified to help guide the type of process studies needed to improve the models.

-There should be an effective balance between regional and process scale studies with continued focus on assessing regional conditions in the watershed and major river basins.

Process scale studies should be conducted based on improving the understanding of regional conditions and models. One or two "focus" areas should be identified to conduct the process-scale studies.
-The integration, synthesis, and delivery of information to help policy makers understand the implications of science findings should have high priority. The USGS should clearly articulate how efforts will be better integrated so that findings can be used to improve indicators of ecosystem condition, change, and restoration.
-Evolve from having a collection of individual studies to having fewer and more integrated studies focused on the highest priorities.

Additionally, some of the findings of the National Research Council (NRC) study (2001) of future directions for USGS apply to Chesapeake Bay. The NRC recommended the USGS place more emphasis on multi-scale, multidisciplinary, integrated projects that address priorities of National scale. The NRC also recommended USGS information management should shift from a passive role of study and analysis to one that seeks to convey information actively. Further, the USGS should provide National leadership and coordination in (1) monitoring, reporting, and where possible, forecasting critical phenomena (including seismicity, volcanic activity, streamflow, and ecological indicators), (2) assessing resources, and (3) providing geospatial information. These recommendations were also considered to help revise the USGS science plan for Chesapeake Bay.

Revised USGS Chesapeake Bay Science Objective and Goals
The revised objective for USGS Chesapeake Bay studies is to provide science to further identify the interrelation of the factors influencing different components of the ecosystem to help resource managers adapt improved management approaches for restoration. This objective will help policy makers: (1) better understand the lack of significant ecosystem improvement, (2) better identify and target current restoration strategies that will provide the greatest ecosystem improvement, and (3) adapt new strategies to promote ecologically sustainable growth in the Bay and its watershed. Based on interaction with the CBP, DOI, science partners, and USGS scientists and managers, the revised USGS science goals for Chesapeake Bay are:
-The impact of human activities on land use;
-Factors affecting water quality in the watershed and delivery to the estuary;
-Function of near-shore areas on water quality in the estuary and providing habitat for aquatic-dependent living resources; and
- Deliver and synthesize information for assessing, forecasting, and restoring the Bay ecosystem (the Bay and its watershed).

The potential goals are fairly broad to reflect the large scope of technical needs of the partners and the subject of ecosystem restoration. The USGS will prioritize science activities for each goal based on the ability to plan and implement studies between multiple USGS Programs and partners.

Conceptual Model and Approach
The conceptual model for addressing the science goals helps provide an understanding of human, physical, and biogeochemical processes affecting conditions in different components of the ecosystem, and emphasizes the linkages between these components

(fig. 1). The conceptual model shows both the present conditions of the ecosystem and the desired conditions based on restoration goals and activities. The present conditions illustrate the impact of human activities on land use and the generation of chemical stressors (sediment, nutrients, and contaminants), alteration of habitat, and loss of living resources due to over-harvesting and disease. The transport of chemical stressors through the watershed and to the estuary depends both on physical and biogeochemical processes. Physical processes include climate variability and the environmental framework (topography, soils, and geologic framework) and their influence on stream- and ground-water flow. The biogeochemical processes includes the carbon content in soils and shallow geologic materials that will influence nutrient cycling and the function of biological communities (forests, wetlands, and stream communities) to process nutrients, sediment, and contaminants in the watershed. The desired conditions show that with reduction of sources of chemical stressors, and restoration of habitats that process the chemical contaminants and provide habitat for living resources, and sustainable levels of harvesting, there should be an improvement in water quality and an increase in living-resource populations.

To address the processes shown in the conceptual model, USGS studies will first be grouped to address conditions in the watershed and near-shore areas, respectively, because processes in these two components of the ecosystem are usually distinct and require different study methods. In the watershed, the primary topics will be the relation between human activities and water quality in streams in the watershed and delivery to the estuary (Science Goals 1 and 2).

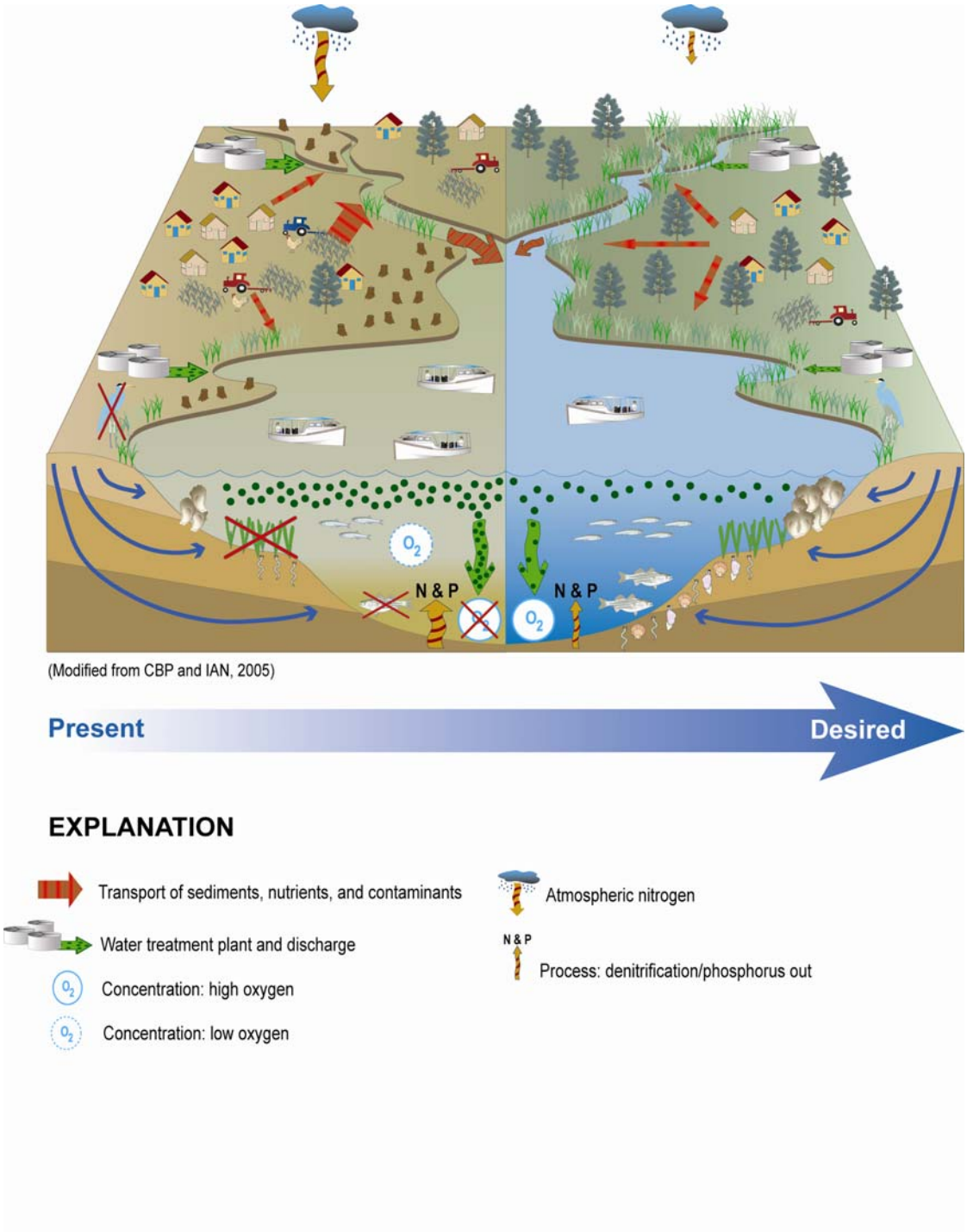

Figure 1. Conceptual model of current and desired condition of the Chesapeake Bay ecosystem.

The geographic scope will be the watershed areas above the River-Input Monitoring stations (fig. 2). For Science Goal 3, which addresses the near-shore areas, the primary emphasis will be to understand the function of near-shore areas on the delivery of nutrients and sediment to the estuary and the relation to shallow-water quality, and providing habitat to support key aquatic-dependent communities. The geographic extent of the near-shore area is the Coastal Plain and the estuary (fig. 2). This is an important area because it contains the interface between nontidal and tidal waters and almost 40

percent of the nutrient load to tidal waters is believed to be located in the Coastal Plain. The investigators for Science Goals 1-3 will collectively work to integrate studies and findings to deliver and synthesize information for assessing, forecasting, and restoring the Bay ecosystem (Science Goal 4). The USGS approach will have a combination of monitoring, modeling, assessment, research, and synthesis to address the science goals.

The science goals will be addressed by conducting both regional and local (Focus Area) studies. Regional studies will be conducted to provide an assessment of sediment and nutrient sources, transport, and delivery to the Bay. The regional scales will include (a) the entire watershed, (b) the major rivers entering the Bay, and (c) greater emphasis on the Coastal Plain area. To explain the factors influencing regional conditions, more local, process-oriented studies will be conducted within two focus areas (Mid-Delmarva Peninsula, and the Potomac Basin and Estuary (fig. 2). In these focus areas, information from past and ongoing process-oriented studies will be synthesized to determine the scope of future process-oriented studies. The Potomac River and Estuary system was selected because it represents the second greatest freshwater flow to the Bay and has a large influence of urban land on water quality and living resources. The Mid-Delmarva Peninsula area represents high agricultural land use in the Coastal Plain, and is an area that contains major DOI land holdings including the Blackwater National Wildlife Refuge. The Refuge is threatened by changing land use near its property and loss of wetlands due to sea-level rise and changes in hydrologic patterns, and is planning a large restoration effort.

Overall, FY2006 will be a transition year that will include completion of current studies, synthesis of their results, and analysis of existing data to plan and begin to implement new studies (or modify existing efforts). The majority of field efforts for new studies will occur in FY2007-2008, with final interpretations and publications in FY2009 and FY2010. Information from both the regional and focus area studies will be used to help the CBP evaluate and revise the effectiveness of restoration strategies in spring, 2007, assess whether the desired ecosystem improvement is being achieved by 2010, and begin to consider new restoration strategies for the future.

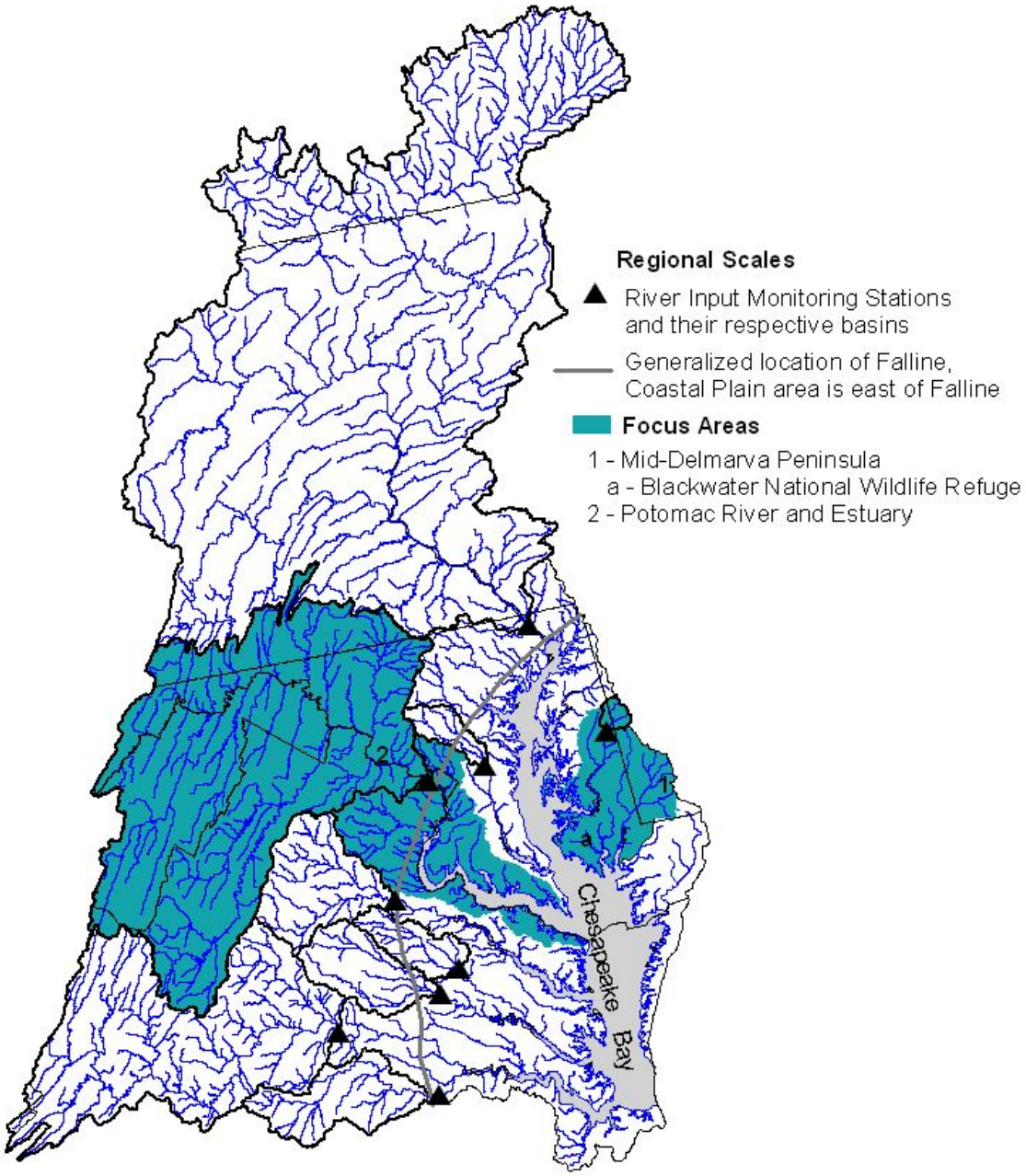

Figure 2. Study scales and focus areas for USGS Chesapeake Bay Studies.

Science Goal 1: **The impact of human activities on land use.**

Issues and technical needs

Increasing human populations and the associated land-use changes continue to be the primary factors causing water quality and habitat degradation in the Bay and its watershed. Human populations, and associated urban areas, are expected to grow to 19 million people by the year 2030 and will be the major factors impacting restoration of the

ecosystem (Boesch and Greer, 2003). The CBP recognized this issue in Chesapeake 2000 and subsequently has identified two "keystone" commitments related to land use: (a) permanently preserve from development 20 percent of the land area in the watershed by 2010, and (b) by 2012, reduce the rate of harmful sprawl by 30 percent. DOI agencies also have priorities related to sound land use and land preservation. The USFWS has a goal to focus on long-term protection and/or acquisition of sufficient high-quality habitats to restore and maintain sustainable populations of fish and wildlife resources. The NPS recently completed a Special Resource Study that defined a larger role in watershed planning and protecting areas near NPS parks. Some of the technical needs associated with these issues are to (a) better document patterns of land-use change and their relation to changes in water quality, habitat, and living resources, (b) better document the socio-economic factors causing changes in the human activities that impact land use, (c) improve models to include socio-economic and other factors influencing human activities to forecast land-use change, and (d) better integrate land-use change models with water- quality models to better assess the potential for meeting restoration goals and promoting ecologically sustainable development.

USGS studies and accomplishments, 2001-2005

In 2001, the USGS science goal for these issues was "improve land-use and watershed data and analysis to understand changes in water quality and living resources." Some of the USGS accomplishments toward this goal included:

-Producing data on land cover and hydrography for the Bay watershed,

-Generating information on land cover and watershed characteristics to improve the two primary predictive models of nutrient and sediment sources and transport in the Bay watershed. An enhanced database of the information is near completion.

-Generating information on the land-cover change and watershed characteristics to better interpret the sources of sediment in the lower Susquehanna Basin.

-Establishing the CBP/USGS Land Data Manager, who oversees and guides data compilation and analysis at the CBO office.

-Helping to develop the Resource Lands Assessment, which identified critically important economic and ecologic lands in the Bay watershed.

-Beginning to develop and test models to forecast land-use change.

Future directions

The USGS is revising the science goal to meet three objectives (1) improve the understanding of the ecosystem by better defining the human activities that are causing the land-use changes, (2) provide enhanced information on the patterns of land-use change to help improve the targeting of land-preservation efforts, and (3) couple land-use growth models and water-quality models to forecast impacts of future growth to help resource managers consider future restoration strategies. For FY 2006-2010, some potential activities and products include:

(a) Continue assessment of land-cover/land-use monitoring needed to support analyses of land-use change and models and work with the CBP and partners to draft a plan for a land-cover monitoring program;

(b) Further document the socio-economic and other factors affecting changes in the human activities that are impacting land-use change;

(c) Develop improved data of changes in land-use activities and restoration activities to better document changes in nutrients and sediment sources and important habitat;
(d) Enhance development and evaluation of models to forecast changes in human activities and land use;
(e) Couple models of land-use change with water-quality models to better predict potential changes in water quality and ecosystem conditions; and
(f) Use the improved information to enhance the CBP Resource Lands Assessment to help identify areas for land preservation and restoration.

Some of the potential products for these activities include technical reports and papers, environmental indicators of human activities and land-use change, and improved models of population growth and land-use change. The expertise needed to achieve these activities includes geographer(s) with experience in land-use change modeling, analyzing socio-economic data to help determine factors affecting land-use change patterns, and relating land-use change to water-quality and habitat change.

Potential Partnerships

Internal

The current studies and potential future directions meet some of the new directions of the USGS Geography Discipline, which has two new science goals, one of which is forecasting landscape change. USGS Chesapeake Bay studies will enhance interactions with the USGS Geographic Analysis and Monitoring Program to develop approaches and data to improve models to forecast land-use change and to further define the human activities causing the land-use change.

External

The USGS is currently working, and will continue to work directly with the CBP on this Science Goal by having a USGS employee serve as the Land Data Manager. The Land Data Manager has membership on the CBP Land Growth and Stewardship and Modeling Subcommittees. Other potential future partners for developing and improving land-use projection models include the Maryland Office of Planning and the Woods Hole Oceanographic Institute. Additionally, interaction with USEPA and the University of Maryland will be enhanced through the National River Restoration Science Synthesis effort, which is compiling and analyzing restoration activities in major ecosystems of the Nation. Finally USEPA Region III has an interest in developing improved tools to document the impact of human activities on land use.

Science Goal 2: Factors affecting water quality in the watershed and delivery to the estuary.

Issues and technical needs

Degradation of water-quality conditions due to excessive nutrients and sediment and loss of habitat continues to be the primary issue impacting the Bay ecosystem. In spite of 20 years of restoration efforts, there has been only modest improvement of water-quality conditions in some tidal tributaries of the Bay and the streams in the watershed. In 1999, the Chesapeake Bay was listed as an impaired water body under the Clean Water Act. The CBP addressed water quality in the Chesapeake 2000 Agreement and subsequent "keystone" commitments: (a) by 2010, correct nutrient- and sediment-related problems in the Bay and tidal tributaries to remove them from the impaired waters list; and (2) by

2010, develop and implement watershed management plans in two-thirds of the Bay watershed to address protection, conservation, and restoration of stream corridors, riparian forest buffers, and wetlands for the purpose of improving habitat and water quality. In 2003, the CBP finalized criteria for dissolved oxygen, chlorophyll, and water clarity in the tidal waters and set targets for reduction of nutrients and sediment in the watershed. Jurisdictions are working to implement revised strategies to reduce nutrients and sediment between now and 2010, and there will be an assessment of progress during 2007. The CBP also addressed the components of what should be contained in watershed management plans. The USFWS has very similar goals for the protection, improvement, and restoration of fish, wildlife, and their habitat from water-quality degradation and environmental contaminant impacts. However, the impact of toxic constituents is more localized in the Bay ecosystem and therefore is not considered as high a priority as nutrient and sediment.

Information needs listed by STAC for water quality include: (a) better information and technologies for management practices and ecosystem response to these practices, (b) improve long-term monitoring of components of the ecosystem (land, atmosphere, and water) for model, trend, and ascertaining uncertainties, (c) improve the integration of modeling, monitoring and encourage multiple models to better determine forces driving land-use changes, best management practices (BMPs), and economic sustainability of resource-dependent activities, and (d) improve interpretation of the relationships between water quality and living resources. STAC has also listed the need for an improved understanding of the relationship between landscape pattern and ecosystem function with respect to critical habitats and human alteration of the landscape in the watershed.

USGS studies and accomplishments, 2001-2005

In 2001, the USGS developed three science goals related to water quality including (a) understand the sources and impact of sediment on water and biota, (b) enhance the prediction and monitoring of nutrient delivery to the Bay, and (c) assess the occurrence of toxic constituents and emerging contaminants. The USGS has significant accomplishments for these goals including:

- Providing study results of water clarity, SAV, and historical changes in dissolved oxygen levels to help with the development of water-clarity and dissolved oxygen criteria for the Bay.
-Leading the CBP sediment workgroup in completion of a report that summarized existing sediment information for the Bay and its watershed. Findings from the report were used to help develop an approach for assessing sediment-reduction strategies and begin improvement of predictive models.
-Developing techniques to fingerprint the sources and erosion of sediment, and use the results with historical monitoring data to identify areas of high sediment generation.
- Using the results from the USGS SPARROW model to help states develop revised nutrient-reduction strategies.
-Leading the design of a nontidal water-quality network that will be used to help assess progress for reducing nutrients and sediment.
-Summarizing the factors affecting nutrients and sediment in the watershed including results on the discharge, nitrogen, and residence time of ground water to help understand the implications for implementing nutrient-reduction strategies and improving simulation in water-quality models.

- Identifying the occurrence of arsenic, pesticides, and antibiotics in bottom sediments of some systems that can impact the microbial populations that affect the cycling of nutrients.

Future directions

The USGS is going to merge its separate science goals for nutrients, sediment, and contaminants into one revised goal related to water quality. Most of the focus will be on nutrients and sediment since that is the issue of highest importance to the stakeholders. Additionally, because the information needs associated with this issue are vast, the USGS will have one science goal to focus primarily on the watershed (Science Goal 2), with another to focus on the near-shore areas of the Coastal Plain and the estuary (Science Goal 3). Objectives in the watershed include (a) improve monitoring and assessment of nontidal water quality, (b) improve information on the influence of watershed properties (for example, organic content of soils, slope, and shallow hydrogeologic framework) and the function of habitats (wetlands, forests, and stream corridors) to better explain nutrient and sediment concentrations in streams and delivery to the estuary, (c) improve simulation of these processes in water-quality models, and develop additional tools to better target restoration actions to improve water quality for the 2007 re-evaluation, the 2010 assessment, and develop new strategies in future years.

Some of the potential activities and products to be conducted during FY2006-2010 include:

(a) Provide leadership for implementation of the nontidal water-quality monitoring network, and real-time water-quality monitoring, and enhance techniques and diagnostic tools for trend and load computations;

(b) Improve the understanding of sources and processes affecting nutrient and sediment impact on streams and delivery to the Bay. This will include completion of ongoing efforts to provide information on the watershed and major river basins to help with the re-evaluation of nutrient and sediment allocations for tributary strategies in spring, 2007. Further study will focus on the interrelation of the influence of physical processes (watershed and geologic characteristics, and climate variability), and biological factors (function of wetlands and riparian forest buffers, and carbon content in soils and aquifer materials) on nutrient and sediment transport and the information needed to improve simulation of these processes;

(c) improve simulation and targeting of restoration activities though enhancement of existing models (the CBP Phase V WSM (HSPF model) and USGS SPARROW models), developing ground-water models that can be integrated with current models, and developing other tools to improve understanding of the interrelation of sources and processes affecting nutrient and sediment; and

(d) Use findings and modeling of human activities and land-use changes and couple them with improved water-quality models to better explain changes in water quality, identify activities and areas that provide the highest benefit for water-quality improvement, and implications for future changes in water quality.

Potential products for these activities include technical reports and papers, enhanced environmental indicators of watershed conditions, and improved models and tools for targeting of restoration activities. The expertise needed to achieve these activities includes hydrologists with experience in (a) surface- and ground-water quality (nutrients and

sediment) assessment and processes, (b) surface- and ground-water modeling, and (c) statistical analysis of water-quality and flow data; geologists with experience in (a) mapping the geologic framework and conditions that impact ground-water movement ,and (b) the geomorphic characteristics and climate factors that impact generation and transport of sediment; and geographers with expertise in analyzing the watershed and human factors affecting water quality.

Partnerships

Internal

The missions of the Hydrology National Research Program, Hydrology State-Federal Cooperative Program, National Water-Quality Assessment (NAWQA) Program, and the Hydrologic Networks and Analysis Program are met with these potential activities. Study of the shallow geologic framework and nutrient transport would meet the mission of the National Cooperative Geologic Mapping Program. The influence of climate variability and geologic features on generation and transport of sediment in the watershed and delivery to the estuary would meet the mission of the Earth Surface Dynamics Program.

External

The USGS is currently coordinating, and will continue to coordinate with the CBP on this Science Goal by having a USGS employee serve as the CBP Monitoring Coordinator, having membership on the Nutrient, Modeling, and Monitoring and Analysis Subcommittees, and expanding membership on the Living Resources Subcommittee Nontidal Habitats workgroup. Interaction with DOI Bureaus will be carried out with the USFWS to help understand and restore the health of stream corridors and wetlands, and with the NPS to improve watershed planning. Other partnerships include continuing monitoring efforts for nutrients and sediment in nontidal rivers with the Maryland Department of Natural Resources (MD DNR) and the Virginia Department of Environmental Quality (VA DEQ) at River-Input Monitoring sites, and enhanced interaction with other State agencies to implement the nontidal monitoring water-quality network. Continued improvement of the CBP watershed model will be done in cooperation with the CBP modeling team, the Maryland Department of the Environment (MDE), the Interstate Commission on the Potomac River Basin (ICPRB), and the Virginia Department of Conservation and Recreation. Additionally, the USGS will explore development of additional models with the Community Modeling Project, which is being overseen by the Chesapeake Research Consortium. Development of improved nutrient and sediment information will be carried out with the U.S. Department of Agriculture and the associated Mid-Atlantic Regional Water Quality Program. Potential new partnerships could occur with other universities in the watershed if the Potomac or Susquehanna areas are chosen for study by the Consortium of Universities for the Advancement of Hydrologic Science, Incorporated (CUAHSI).

Science Goal 3: **Function of near-shore areas on water quality in the estuary and providing habitat for aquatic-dependent living resources.**

Issues and technical needs

The health and vitality of the Bay's living resources and their associated habitat is a primary focus of Chesapeake 2000. The Agreement recognizes the complex interaction

between the Bay's living resources, their vital habitat, water quality, and harvesting of the resources. The CBP has identified several “keystone” commitments for this topic, including: (a) by 2010, correct nutrient- and sediment-related problems in the Bay and tidal tributaries to remove them from the impaired waters list, (b) by 2010, restore 25,000 acres of tidal and nontidal wetland, (c) conserve existing forests along all streams and shorelines, and (d) implement a strategy for protection and restoration of SAV. These near-shore estuary habitats, and their ecological function, are being lost due to sea-level rise, land-use change, water-quality degradation, and invasive species. The CBP also has “keystone” commitments for living resources that depend on these habitats, including a commitment to develop multi-species management plans for fisheries by 2005 and to implement these plans by 2007, and to have a ten-fold increase in oysters by 2010. The USFWS has similar goals to protect and restore essential aquatic habitats including wetlands, SAV, and stream corridors because of their use by fish, birds, and other wildlife. While migratory birds are not a “keystone” commitment of CBP, the Bay watershed is in the heart of the Atlantic Flyway and provides habitat for both domestic and migratory water birds. The DOI and CBP are working to restore 20 species of water birds as obligated under the North American Waterfowl Management Plan.

To develop the strategies to conserve and restore the ecosystem, scientific information is needed to understand the function of near-shore areas on (1) delivery of nutrients and sediment to the estuary and impact on water quality, and (2) providing habitat for aquatic-dependent living resources. Information is needed on the factors affecting the loss, and techniques for restoration, of these near-shore habitats. STAC also recommends some specific needs related to living resources, developing effective monitoring of fish resources and harvest activities, advance knowledge of predator-prey interactions, and species-habitat relationships. The USFWS also had specific technical needs related to fisheries, including providing data to restore, improve, or protect aquatic and riparian habitats of essential value to anadromous and other interjurisdictional fishes, including development of fish passages and removal of tributary blockages, and evaluating the impacts of disease on fish populations, including mycobacteriosis and striped bass.

USGS studies and accomplishments, 2001-2005

In 2001, the USGS had two science goals related to habitats and living resources including (a) the relation between sediment, water clarity, and biota, and (b) assessing the factors affecting the health of fish and water birds. The second goal was refined in 2003 to include fish, wildlife and their habitats in an attempt to better reflect the needs of the USFWS and on-going studies by USGS.

Some of the accomplishments related to these goals include:

-Led the CBP Sediment workgroup to summarize information on sediment sources, depositions, and transport in the estuary. The information resulted in not setting near-shore sediment-reduction goals because of too much uncertainty associated with data and existing models.

-Conducted investigations to further identify sediment sources to the estuary that will help formulate improved sediment-reduction strategies by 2007.

-Conducted interpretation of the relation between river flow, sediment loads, and changes in water clarity and occurrence of SAV in the major tributaries of the Bay. USGS also continued work in the Potomac and Pocomoke Rivers during 2003 to understand the importance of light transmittance, water quality, propagule availability, sediment quality, and other biotic and abiotic factors on SAV. These findings were used to help set the water-clarity criteria for the Bay.

-Began to determine the relative contributions of TSS (inorganic and organic material), chlorophyll, and other components affecting water clarity in shallow water zones of the Potomac Estuary, and continued study of factors affecting growth of SAV. These results will help to guide the balance of nutrient and sediment controls in different areas of the Bay.

-Monitoring and analysis of habitat loss and displacement due to sea-level rise and other factors at the USFWS Blackwater National Wildlife Refuge, which showed that wetland loss is being impacted by both sea-level rise and subsidence of the land surface. The information is being used to help plan wetland restoration.

- Investigations of wetland and near-shore restoration were continued at Poplar Island and the Anacostia watershed to help determine approaches and suitability of using dredge materials for reconstructed wetlands. Additionally, techniques were developed to assess exposure to, and effects of, organic and inorganic contaminants in reconstructed wetlands on wildlife.

-Improved the understanding of the factors affecting the population of seaducks that winter in the Chesapeake Bay including study of the movement, habitat use, and feeding ecology of seaducks to better assess the potential degradation of feeding habitat in Chesapeake Bay.

-Conducted an assessment of the distribution of the Diamondback Terrapin, which is the only brackish water turtle species in the United States. Over 1,500 terrapins were tagged in the Chesapeake Bay to establish baseline monitoring of the population, and help develop options for protection and conservation.

-Completed a study with the USFWS to determine the cause of the decline in night heron populations in Baltimore Harbor, and identify potential effects of environmental contaminants on reproduction of osprey nesting in the regions of concern in the Bay watershed (Baltimore Harbor, Anacostia River, and the Elizabeth River). The USGS also completed an assessment of the available contaminant data to determine impacts on wildlife near Chesapeake Bay.

-Conducted studies to better understand the causes of the numerous outbreaks of fish lesions/disease and fish kills in the Chesapeake Bay and its tributaries. Studies included (1) assessment of *Pfiesteria* (a toxic dinoflagellate)-related fish kills and *Aphanomyces* (an invasive fungal pathogen) in menhaden, (2) *Mycobacteria* (a systemic bacterial infection) in striped bass, and (3) a comprehensive health assessment of white perch in five tributaries.

Future Directions

The USGS will revise our original science goal of habitat and wildlife to now address the function of near-shore areas on (1) delivery of nutrients and sediment to the estuary and the relation to water quality, and (2) providing habitat for aquatic-dependent living resources. The near-shore area, which is defined as the Coastal Plain, includes many of the habitats that are considered vital to the Bay ecosystem including estuary water quality, forests, tidal wetlands, and SAV. The USGS objectives for this goal will include (a) improve the understanding of the delivery of nutrients and sediment from near-shore areas to the estuary, (b) improve the understanding of the function of these near-shore areas to support living resources, (c) provide implications of both the water-quality and habitat function in different areas to help prevent inappropriate sediment/nutrient controls from being applied in critical habitat areas, and (d) work with partners to improve the knowledge of the function of near-shore areas on the water-quality conditions in the estuary, and health of fisheries and aquatic wildlife that depend on these habitats.

Potential activities and products include:
(a) Better define the function of near-shore areas on delivery of nutrients and sediment to the estuary. The scope could include: (a) better define the magnitude and extent of direct ground-water discharge and associated nitrogen to the tidal waters, (b) better quantify the extent of nutrient and sediment storage and processing in tidal wetlands and near-shore forests and the delivery to tidal waters, (c) link the information on near-shore areas to help better explain the primary causes and sources of water-quality impairments (nutrient or sediment) in different tidal tributaries, and (d) relate changes in water clarity and better identify controlling factors affecting changes for different species of SAV.
(b) Identify and map areas of important near-shore habitat (tidal wetlands, forests, SAV, and other near-shore areas) that are used by aquatic-dependent living resources (fisheries and water birds).
(c) Synthesize the data on critical habitat areas with information on major controls impacting water clarity to help evaluate improved nutrient- and sediment-reduction actions for the 2007 re-evaluation of water-quality progress. These findings would also be used to help prevent inappropriate sediment/nutrient controls from being applied in critical habitat areas.
(d) Further investigate the processes controlling the loss of near-shore habitats including sea-level rise, herbivory, water-quality changes, and man-induced impacts to identify factors controlling loss in different areas, help assess different approaches for restoration, and their function in processing nutrient and sediment from the watershed to the estuary.
(e) Improve ecosystem-based understanding of factors (disease, habitat changes, over-harvesting, and management actions) affecting important fish and water-bird species in the Bay to improve ecosystem-based models and restoration activities.

Some of the potential products include technical reports and journal articles, Geographic Information System (GIS)-based tools to identify areas having different functions on the delivery of sediment and nutrients to the estuary and providing habitat to support living resources, and development of environmental indicators for the health of fish and water birds. The expertise needed to address the future activities includes geologists and hydrologists to study direct ground-water discharge; geologists, ecologists, and chemists to address sediment and nutrient processing in near-shore areas; and chemists and biologists to address the link to estuary water quality and fisheries and aquatic-dependent living

resources. Geographers are needed to develop GIS-based tools displaying the function of different near-shore areas.

Partnerships

Internal

USGS Programs with goals related to these potential activities include: Biology Program Areas missions related to Fisheries and Aquatic Resources, Contaminants, Wildlife, Invasive Species, and Ecosystems, the Hydrology National Research Program related to sediment and nutrient processing and estuary water quality, and the Coastal and Marine Program to address direct ground-water discharge to the Bay, and the National Cooperative Geologic Mapping Program to address the shallow geologic framework and its influence on nutrient transport.

External

The near-shore areas and estuary are being studied by many Federal, State, and academic institutions. The USGS will build upon existing relationships, and form new, collaborative partnerships to address these issues. The USGS will continue to have active membership on the CBP Monitoring and Assessment Subcommittee (MASC) and associated workgroups that are addressing the factors affecting estuary water quality. The USGS will increase membership on the Living Resources Subcommittee of the CBP and associated workgroups that are addressing near-shore habitats. The USGS will continue to interact with partners in the CBP sediment workgroup, including the Maryland Geological Survey, to address sediment erosion from near-shore areas. The USGS will work closely with the USFWS to address the water-quality and habitat function of near-shore areas around the Bay and the drainage area of the Blackwater National Wildlife Refuge. The Refuge is threatened by changing land use near its property and loss of wetlands due to sea-level rise and changes in hydrologic patterns, and is planning a large restoration effort. The USGS will continue its relationship with MD DNR and the University of Maryland Center for Environmental Science, which collects water-quality data at SAV sites in the Potomac, and the Virginia Institute of Marine Sciences (VIMS) to address the relation of near-shore areas to estuary water quality and habitat. The USGS will increase collaboration with National Oceanic and Atmospheric Administration (NOAA) and the Smithsonian Environmental Research Center (SERC) to address habitat understanding and restoration in the near-shore areas. Finally, the USGS will improve collaboration with NOAA on ecosystem models of the Bay fisheries.

Science Goal 4: Deliver and synthesize information for assessing, forecasting, and restoring the Bay ecosystem (the Bay and its watershed).

Issues and Information Needs

USGS expertise on the Chesapeake Bay and its watershed is needed by the CBP to help explain changes in the ecosystem and evaluate restoration strategies to provide the greatest benefit. The CBP consists of Federal (over 25 agencies and three from DOI), State (6 States and the District of Columbia), and local customers and partners. There is a need to improve information delivery and synthesis of information to these partners. The USGS

Chesapeake Bay science information also has critical relevance for the restoration of ecosystems throughout the United States. Therefore, multiple approaches and the associated infrastructure are needed to disseminate and synthesize information not only for the CBP, but also to other target audiences that include the DOI, the USGS, scientific organizations, nonprofit organizations, and representatives of Congress. There is a need to provide improved assessment of the condition and progress in restoring the ecosystem, better tools for targeting restoration activities based on improved understanding of the ecosystem, and forecasting of future conditions to help resource managers develop new restoration goals.

Current studies and accomplishments

Since 2001, the USGS has conducted activities to deliver information for assessment of restoration on the Bay ecosystem. Some accomplishments include:

-Continued participation in CBP subcommittees, workgroups, and STAC Chesapeake Bay workshops.

-Prepared several synthesis products to help the CBP develop the strategies to reduce nutrient and sediment so the water-quality criteria can be achieved. These documents included "A Summary Report of Sediment Processes in Chesapeake Bay and Watershed" (WRIR 03-4123) and "Influence of Ground Water on Nitrogen Delivery to the Chesapeake Bay" (FS-091-03).

-Increased emphasis on presentations to the USFWS Chesapeake Bay Ecosystem Team. Based on the presentations, the USFWS requested that USGS become members of the team to increase interaction between the two agencies.

-Presentations at numerous National meetings including the World Watershed Summit, National Conference on Ecosystem Restoration, and the American Association for the Advancement of Science (AAAS).

-Continued progress on development of web-based decision-support tools that focused on delivering information from the USGS SPARROW model and water-quality monitoring data. There is enhanced dissemination through development of an Internet Mapping Service (IMS) in partnership with the USGS *National Map*.

Future directions

The USGS objectives will include improving delivery and synthesis of information to (a) improve the assessment of the ecosystem (the Bay and its watershed), (b) use the understanding of past conditions to help forecast future changes in the ecosystem, and (c) develop decision tools to help resource managers improve the development and implementation of restoration activities. The USGS investigators from Science Goals 1-3 will collectively work to integrate studies and findings to deliver and synthesize information for assessing, forecasting, and restoring the Bay ecosystem. Some of the potential activities and products include:

-Produce synthesis product(s) that would summarize findings of USGS studies conducted during 2001-2005;

-Work with the CBP partners to improve the environmental indicators of current conditions of the Bay, its watershed, and progress of restoration activities.

-Improve dissemination of USGS Chesapeake Bay information and findings through increased presentations to CBP subcommittees, workgroups, seminar series, and science meetings and workshops;

-Enhance the USGS Chesapeake Bay web site with improved methods to access USGS publications and highlight the information on feature pages;
-Further develop and implement an Internet Mapping Service (IMS) and other tools to serve USGS GIS information and other key data sets;
-Communicate findings to other target audiences through presentations and briefings to Congressional staff, Office of Management and Budget, and USGS; and
-Integrate scientific findings of USGS studies into a summary report in 2010 that will assess progress, forecast, and provide implications for restoring the Bay ecosystem.

Potential products will include a revised USGS Chesapeake Bay web site, development of information delivery and decision-support tools that are part of the web site, publication and presentation of scientific reports and articles, and technical workshops to increase interaction of resource managers and scientists in the CBP. The expertise needed includes science writers, information technology specialists, geographers, and collective efforts of scientists working on all the USGS Science Goals.

Partnerships
Internal
The Chesapeake Bay Studies will interact with *The National Map* and the Comprehensive Urban Ecosystem Studies (CUES) in the Bay watershed to improve decision-support tools through an IMS. There is opportunity to improve interaction with the USGS Geographic Information Office (GIO) on this subject. We will continue to work with the Mid-Atlantic Regional Executive, Eastern Region, and Office of Communications to plan and conduct briefings to different target audiences. We will also attempt to interact with the USGS Science Impact program to disseminate the policy implications of the science.

External
The USGS will work with the CBP partners, under the auspices of MASC, to improve environmental indicators to assess the current condition and progress in restoring the Bay and its watershed. The USGS will enhance interaction with the CBP Communications Office to deliver information through their revised communication strategy and methods. This USGS will also enhance partnership with the Integrated Analysis Network (IAN) at the University of Maryland Center for Environmental Science to improve conceptual models and indictors for the Bay watershed. The USGS will continue to increase interaction with the DOI (USFWS and NPS) partners to provide science to protect and restore DOI lands and trust resources.

Approach to Implement Revised Chesapeake Bay Studies
The USGS will implement the revised goals of the revised plan through coordination of multiple USGS programs in order to conduct more integrated studies to address the potential activities. The USGS will also increase interaction with other scientific entities to conduct the studies. Unfortunately, attempting to conduct more integrated studies within the USGS has several challenges. These challenges include:
-The current management structure of USGS does not promote integrated science. Individual Programs and Cost Centers all have specific missions and goals, making it

difficult to conduct integrated science projects to address multiple topics. There is a lack of collective priorities to be accomplished by the USGS and its organizational units.
-The reward system for research scientists promotes being the first author on publication of journal articles. Integrated science needs more of a team approach that does not promote individual accomplishments. Additionally, the time needed to interact with resource managers and policy makers can take away from the promotion potential of research scientists.
-Attempting to integrate results from individual projects is difficult given the multiple projects scientists are often conducting. Funding levels are usually not adequate to promote this integration and synthesis.

Measures of success and potential actions to implement USGS Chesapeake Bay studies

The primary measure of success for USGS Chesapeake Bay studies is to provide and communicate science to help policy makers (1) better understand the factors affecting the ecosystem so they can make (2) more informed decisions for targeting current restoration activities, and (3) consider future strategies to promote ecologically sustainable growth in the Bay and its watershed.

The USGS Chesapeake Bay Studies are designed to meet the both the science needs related to Chesapeake Bay, and the goals of participating USGS National Programs and Cost Centers. We will enhance attempts to jointly plan and execute coordinated efforts between USGS National Programs, Cost Centers, and scientists to enhance interdisciplinary investigations of the Chesapeake Bay and its watershed. Some of the proposed actions and tactics needed to meet the measure of success are:

(1) Develop a study approach that addresses the critical science needs for the restoration of the Chesapeake Bay and its watershed.
-Obtain stakeholder input on issues and associated technical needs of the “keystone” commitments of Chesapeake 2000, DOI, and the science community.
-Revise the USGS Chesapeake Bay science plan to meet the priority science needs and build on the strength of USGS capabilities.
-Have the Executive Advisory Team provide continual feedback on the plan and implementation of studies to meet the goals of the plan.

(2) Enhance coordination among all levels of USGS (Programs, Regions, Cost Centers, and Scientists).
-Improve joint planning of revised projects between Programs, Cost Centers, Region, and scientists.
-Increase interaction with scientists from other institutions to share results and potentially conduct joint studies.
-Revise USGS science teams to help coordinate projects within revised USGS science goals. Have leaders as members of the USGS Interdivisional Technical Team (IDTT).
-Improve the function of the USGS IDTT, which is chaired by the USGS Chesapeake Bay Coordinator, to coordinate and integrate studies and findings among science goals.
-Have the USGS Regional Executive and USGS Chesapeake Bay Coordinator increase engagement with USGS National Program Managers and Cost Center managers to ensure projects meet the goals of all parties.

-Write and annually update a USGS Chesapeake Bay Operational Plan to reflect projects, funding amounts and accomplishments.

(3) Ensure that USGS information is used to help guide restoration of the Bay and its watershed.
-Increase involvement of USGS scientists in CBP subcommittees and associated workgroups.
-Improve USGS information delivery and decision-support tools to provide resource managers and policy makers with needed information.
-Demonstrate how USGS information is being used to protect and restore the Chesapeake Bay and its watershed, so it may be applied to other ecosystems in the Nation.

Role of USGS Programs and Cost Centers
The USGS Chesapeake Bay Studies depends on the coordination of multiple USGS Programs and Cost Centers that have a scientific interest in the Bay restoration. Over 40 USGS scientists located in offices throughout the Bay watershed and at the CBP are involved in scientific investigations and information dissemination. The missions of many USGS National Programs and their respective field operations can be met through their involvement in the Chesapeake Bay Studies. Where possible, the USGS is planning and executing integrated efforts among USGS National Programs to enhance interdisciplinary approaches to technical issues.

Some of the participating National Programs and their roles include:
Biology Program Areas missions related to Fisheries and Aquatic Resources, Contaminants, Wildlife, Invasive Species, and Ecosystems would be met through investigations carried out at the *Leetown and Patuxent Science Centers* addressing important habitats to support fisheries and aquatic-dependent wildlife. The Ecosystems Program also as the USGS *Global Climate Change Studies* whose mission would be met through research on wetland and habitat loss due to climate change and sea-level rise.
Coastal and Marine Geology Program--Program mission would be met through research on direct ground-water delivery of nutrients to the estuarine systems and using remote sensing to address sediment sources and dynamics affecting water clarity and SAV.
National Cooperative Geologic Mapping Program--Program mission would be met through creation of maps of geologic and geomorphic characteristics of sediment and nutrient transport in watersheds and adjacent tidal areas.
Earth Surface Dynamics Program--Program mission would be met through research on effects of land-cover change and climate variability on sediment transport and deposition.
Geographic Analysis and Monitoring Program--Program mission would be met through research and application to document and forecast the impact of human activities on land-cover and land-use changes, and the relation to water quality and habitat changes through process models.
Hydrology National Research Program--Program mission would be met through research of sediment sources, transport, and delivery in the selected watersheds and adjacent tidal systems and their relation to shallow-water habitats for SAV. Also the mission would be met by research being conducted on nutrient cycling in surface-water and ground-water systems and research conducted to define the abundance and extent of SAV coverage in relation to sediment, seasonal water quality, and hydroclimatology.

Hydrology State-Federal Cooperative Program--Program mission would be met through enhanced surface-water monitoring and modeling efforts to document sediment and nutrient loads, trend analysis, and factors affecting loads and trends.
National Water-Quality Assessment (NAWQA) Program--Program mission would be met through work under the Potomac/Delmarva study to understand nutrient and contaminant relation to land use and processes affecting geochemical cycling and Regional studies in major river basins in the Mid-Atlantic area.
Priority Ecosystem Science --Goal of providing science for restoration of priority ecosystems through coordinating and integrating efforts of the USGS National Programs would be met through investigations in Chesapeake Bay and its watershed.

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