Severn River Commission
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ANNE ARUNDEL COUNTY
MARYLAND

Severn River Watershed Management Master Plan Phase I Final Report

Vol. I: Report



KCI TECHNOLOGIES

CH2MHILL

February 28, 2002

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Submitted to:

ANNE ARUNDEL COUNTY
MARYLAND

Submitted by:

KCI TECHNOLOGIES

In Association with:

CH2MHILL

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1.0 Introduction

Anne Arundel County has begun preparation of a Watershed Management Master Plan for the Severn River. This is the County's second of twelve watershed plans to be done, following the South River Plan which was recently completed. KCI Technologies, teamed with CH2M HILL has been contracted to conduct a study to provide the technical data needed to assist with the Master Plan. The study will characterize the watershed's land use, natural resources, water quality and hydrologic conditions; assess future conditions with computer models of drainage and water quality; identify and rank problems, and recommend potential improvement projects.

Two other key tasks are to identify and involve watershed stakeholders and to develop a Watershed Management Tool which links watershed data and models to give County planners information on how changes in land use, zoning, BMPs, and other watershed conditions affect the Severn River and its tributaries.

The project is being conducted in two phases. The original proposal called for a large effort, with the bulk of the work in GIS data updates, environmental field work, and watershed modeling. The consultants and the County agreed that it would be more cost-effective to begin the study with an initial phase which would develop enough information to accurately scope these larger tasks. As a result, Phase I, which is now being completed, was begun in February 2001. The tasks in this phase were as follows:

Task 1	**Project Initiation and Coordination**
1.1	Project Initiation Meeting
1.2	Presentation to Severn River Commission
1.3	Presentation to Department Directors
1.4	Phase I Conclusion Meeting
Task 2	**Public Involvement**
2.1	Initial Stakeholder Identification
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5.1	Outline GIS Tool

The sections of the report that follow give more detail on the tasks and procedures that were carried out, along with conclusions. The final section summarizes Phase I and briefly describes the work of Phase II which will follow this effort.

2.0 Public Involvement

The Phase I public involvement activities focused on enhancing the data collection process. There were three elements in this phase: identifying and involving stakeholders, conducting a public survey by mail, and putting up a website. Stakeholders were introduced to the Severn River Watershed project and asked to identify environmental concerns and problems within the watershed, identify data sources that can help with various elements of the Phase II analysis, and identify additional stakeholders to participate in the project. The survey was designed to elicit information on problems in the watershed, and the website gave basic information on the study.

In addition to strengthening the data collection and evaluation, the public involvement process helps to develop a better understanding of the issues involved in watershed management and the tradeoffs involved in watershed protection.

2.1 Stakeholder Involvement

Two public stakeholder workshops and a mailing distributed to over 3,500 residents of the Severn River watershed were used to achieve this objective. The mailing contained a survey and a project fact sheet and map of the Severn River Watershed. A final public workshop to discuss the conclusions of Phase I and the approach for Phase II was held on August 2, 2001.

Workshop One

The first public stakeholder workshop on May 3 featured a presentation on the history of development in the watershed and various aspects of the watershed master planning process. Various potential functions of the Watershed Management tool were also described. Participants at this meeting identified overall watershed issues and concerns and identified specific problems within the watershed. Stakeholders were given colored dots and were asked to identify specific problems by placing the dots on a large watershed map. The dots were color coded according to category (water quality, flooding and erosion, impacted uses, and critical areas or special protection areas). Meeting attendees grouped the overall watershed concerns into six major categories. Meeting participants went through an exercise to prioritize their most important issues facing the Severn River Watershed.

Workshop Two

The second public stakeholder workshop on May 17 included a summary of the issues heard from the stakeholders at that previous meeting. The exercise of identifying specific problem areas using large scale maps as reference points was continued to gain information from individuals who missed the first meeting. A listing of the data sources was handed out for the attendees to review. Additional studies were described by attendees and potential contact agencies given. The public survey was discussed with several attendees offering to distribute surveys to their respective organizations. Workshop participants prioritized particular streams that they would like to see studied in detail. Both hydrologic and hydraulic models were discussed as well as the pollutant loading and estuary modeling to be performed in Phase II. Workshop participants identified and then prioritized a list of pollutants of concern that would be potentially modeled later on in the project. Attendees also identified outfalls where they have observed pollution in the receiving stream.

For more detailed information on the workshop results please review the meeting minutes, associated maps, and the list of invited stakeholders in Appendix A.

Watershed Management Tool Workshop

In addition to the external stakeholder workshops, a two-day workshop for County staff members was held to define the GIS based Watershed Management Tool. This workshop focused on identifying the user groups, the tool's functional requirements, and the data needed to fulfill those requirements.

2.2 Survey Results

Objective

As determined in various meetings with the County, the most important use of the survey was to elicit specific information on the condition and problems residents saw with the tributaries and the River. It was hoped that this information would be utilized as reference during the field collection efforts of Phase II. Some possibilities of how this data may be used would be to prioritize those areas in terms of schedule or focus or to aid the field teams in locating particular problems during field walks.

Approach

Surveys were mailed to 2500 randomly selected watershed residents. Additional surveys were sent out to approximately 400 heads of organizations as well. These organizations comprised the stakeholder list determined in earlier public involvement efforts and a list of neighborhood associations in the area. It was presumed that many of these people would make copies and distribute the surveys throughout their organization. Unfortunately, it is not known how many surveys were distributed in addition to the 2900 original mailed surveys. Approximately 410 surveys were returned, for a maximum possible return rate of 14.1% (assuming that only 2900 surveys were distributed).

Watershed Survey Results

As stated earlier, the objective of the survey was to receive information regarding problems and resident concerns in the watershed. As a result, the information lends itself to being very anecdotal in nature. This information has been compiled and will be distributed to the field teams for use as reference in their field walks during Phase II. While the data will not change the amount of or preclude any streams covered during the stream walks nor will monitoring stations be chosen solely on the basis of the survey results, the data will direct field crews to areas of interest during their stream walks and will provide an additional layer of possible reasons to choose a particular site for a monitoring station. Also, this information may feed into the ranking criteria later developed in Phase II. In addition, some quantitative analysis was performed on particular questions that could aid in getting an overall picture of how the residents of Anne Arundel County perceive their watershed. Particulars on these questions are described below. Detailed pie charts and percent rankings, as well as compilation of some of the anecdotal information, are found in Appendix A.

Question 1 – resident's enjoyment of the County bodies of water

The majority of residents replied that their ability to enjoy the County bodies of water has increased or stayed the same over the past 5 years. Of those who responded that their enjoyment has decreased, the majority complained of too heavy boat traffic and pollution as being the main causes. Several responded with concerns of sedimentation of the streams. Overall, the main reason the respondents use the County bodies of water is for boating. These responses were to be expected. The Severn River Watershed has many recreational bodies of water that are highly utilized. In addition, the Severn River Watershed residents tend to be highly educated and motivated by environmental concerns. Therefore there is a contrast, with many responding that they use the waters for boating while at the same time many others see their enjoyment decreasing because of the increase boating and jet ski activities. Other activities that the County residents rated highly are fishing and swimming.

Question 2 – evidence of pollution

The majority (an overwhelming 73%) of respondents have found evidence of pollution in the County water bodies. The majority of those listed muddy water as the main evidence of pollution. Trash and litter were also frequently listed. Evidence of pollution was most frequently seen after rainfall events.

Question 3 – relative pollution of streams

Most of the people responding to this question answered "Don't Know". Clearly, respondents had difficulty making the relative comparison between streams intended by this question. There may be several reasons for this difficulty. Many respondents mentioned that streams within the watershed are bordered by private properties and are therefore inaccessible to most of the public. This may prevent people from developing a broader base of knowledge from which to make comparisons between streams. Individuals may be less likely to make relative comparisons unless they feel that they have specific data on the amount of pollution in particular streams. The response to this question in itself does not suggest a lack of awareness of environmental issues, rather a difficulty in making relative comparisons between water bodies. The stream that did receive the highest number of responses (other than "Don't know") was the Severn River. This is expected because of the high visibility of the river and all the activities that rely on it.

Question 4 – streams blocked by debris

In this question, residents were asked to give details on stream names and locations of where they had seen debris obstructions. Locations along Severn River and Severn Run were most frequently listed. The types of debris listed along the Severn River included trash, sandbar, beaver dam, fallen trees, crab pots, and construction fill. The types of debris listed along the Severn Run included trash, sandbar, and fallen trees. Trash was observed at almost every listed location along the Severn Run. Other streams listed multiple times included Clements Creek and Saltworks Creek.

Question 5 – flood prone areas

The majority of residents responded that they found roadways to be routinely flooded after a storm. A list of these areas will be used as reference in Phase II efforts and is included in Appendix A.

Question 6 – erosion and sediment transport

The results of this question showed an almost even split between County residents. That is, half of those responding had seen evidence of erosion or sediment transport within the watershed and half had not seen evidence. Residents were then asked to give details on stream names and locations of where they had seen evidence of erosion. Of the 93 people who responded to that question, 22.6% listed locations on Severn River and 21.5% listed locations on Severn Run. Other streams listed multiple times included Clements Creek, Forked Creek, Saltworks Creek, Spa Creek, Weems Creek, and Yantz Cove.

Free response question – overall degraded conditions

This question allowed the survey respondents to write any additional observations they had regarding degraded environmental conditions in the watershed. These responses were much too anecdotal for any type of quantitative analysis, but a compilation of the responses is included in Appendix A. A common theme in many of these responses was the concern over boat and jet ski traffic on the waterways. Concerns over development impacts on the environment were also echoed in several responses.

Preference question – preferred method of contact and information dissemination

Lastly, the respondents were asked to rate their preference of different methods for keeping informed about the study. This information will be invaluable as the Public Involvement effort enters Phase II. Five different ways of being kept informed were evaluated: Anne Arundel County Website, Periodic Mailings, Telephone Calls and County Staff, Public Meetings, and Announcements in Local Newspapers. Survey respondents were asked to rank these methods 1 through 5. Because many people ranked more than one category as "1", a pure percentage based comparison cannot be performed. However, the results have shown that the favored methods of information dissemination are periodic mailings, announcements in local newspapers, and the Anne Arundel County website.

Results of the Survey and Impacts to Future Outreach Efforts

The overall purpose of the survey was to elicit specific information on the current conditions and problems residents observe in the tributaries and the River. The survey met these objectives. It is risky to infer conclusions about public behavior beyond the specific objectives of the survey. For example, the survey did not try to capture data on the general environmental IQ of the watershed residents.

With these ground rules; however, some general observations can be made. The survey's return rate of 14.1%, was only slightly higher than average for this type of survey (approximately 10%). The project team had higher expectations for the return rate, due to the perceived high educational level and environmental interest of the watershed residents and to the targeting of additional surveys to stakeholder groups. From this low response we may conclude that broad, nearly random outreach efforts (like the survey) will be less effective for the Phase II public involvement program than more targeted communication to specific groups. We may also conclude, due to the difficulty people had in responding to the relative comparison in question 3, that impressions of stream and water quality are very localized. It may be difficult for area residents to evaluate watershed-wide programs and policies without understanding how a tool or management alternative will impact the water body with which they are most familiar.

2.3 Website (www.severn-river-watershed.com)

Purpose and Concept Development

Prior to developing the look and feel of the site, the website's audience and purpose were identified. The audience was defined as interested and affected community members, project participants, stakeholders, businesses, and individuals interested in watershed studies.

The ongoing purpose of the site throughout the phases of the study is to educate the audience about watershed studies in general, and the Severn River Watershed study in particular. Several components were identified that contribute to our purpose. Specifically, there are key environmental concepts to be explained in everyday language, and maps and data collection materials that would inform the community about environmental studies and planning. These components will be added in the next phase of the project.

The site also serves as a communication source for up-to-date project information and activities. Community members access the calendar of events for upcoming public meetings, workshops, and project status. In addition, users identify project participants and contact designated county representatives by email, phone, or mail for comment and/or question.

The site is set up for internal internet hosting by the consultants. This service provides web statistics about site visitors including number of users and time spent on the site.

Website Outline

The site has been developed with a navigational structure of seven major sections plus the homepage, or portal page, where users first arrive. Each of these sections can expand to accommodate growth and development of information throughout the watershed study. The seven sections are *overview*, *calendar*, *conditions*, *maps*, *contacts, community*, and *survey*. Each section is designed for further development during the next phase of the project. Details for the information developed for each section follows.

Homepage (Portal Page)

Using full color photography from the watershed, the homepage invites users to visit any of the seven sections of the site and provides a brief introduction to the project. In addition, timely events such as public meetings are linked directly from the homepage for easy access to critical information.

Overview

Users learn background about the Severn River Watershed study, including why the study is being conducted and the process for environmental evaluation. Users are educated on specific aspects of a watershed study including assessment, public involvement, analysis, and improvements.

Calendar

Users access information about project deadlines, as well as upcoming events such as public meetings and workshops.

Conditions
This section educates visitors about factors that contribute to the condition of their streams, wetlands and forests. The findings of the study are presented here and updated as they are collected and analyzed. Potential causes of impairment and resources needing protection further relate the environmental study to the unique characteristics of the Severn River. This section is designed for further development during the next phase of the study.

Maps
Detailed maps based on digital information are presented in an easy-to-read format. In the next phase of the project, a variety of maps such as a historical tour of the area, aerial photography, and overviews of the watershed study area may be included.

Contacts
Visitors to the site identify project participants including Anne Arundel County, and contributing consultants. Community members also find contact information here so they can email, call or send comments and questions to a designated public involvement representative.

The contact section also includes links to relevant sites of interest. These sites include the Anne Arundel County home page, state sites for the Maryland Department of the Environment (MDE) and Department of Natural Resources (DNR), federal sites for the U.S. Geological Survey (USGS) and Environmental Protection Agency (EPA), and other not-for-profit organizations of interest including the Center for Watershed Protection and Maryland Save Our Streams (SOS).

Community
Community members learn how they can be active in the watershed study. Information from public meetings as well as how to take responsibility for the environment in their neighborhoods can be further development in the next phase of the project.

Survey
The survey is an online version of the paper version distributed to citizens within the watershed. Citizens fill out the survey and submit their results, which are then emailed to the public involvement consultant for further action.

Site Graphic Design

Finally, the site was designed to incorporate detailed photography taken from throughout the watershed. Full color photographs were included as well as duotone images, or two-color images, which provide a header for each of the seven sections. Typography and color were carefully considered to invoke the classic presence of the Anne Arundel County residents and the importance of the Severn River.

Specifically, the traditional font, Garamond, was used for the title block and all section headers. The tan color of the site's background directly relates to color found in the photography. The cobalt blue/violet was used to create a strong contrast with the site's background.

Overall, the structure and look of the site combine to create a strong public involvement piece that meets the purpose of providing a communication tool to facilitate communication between Anne Arundel County and its community members.

2.4 Phase II Public Involvement Approach

Objective

While the Phase I public involvement program focused on supplementing the data collection and analysis, the focus of the Phase II program shifts to developing the necessary external support for the Watershed Management Plan to be accepted and the Watershed Management Tool to be implemented.

With this new focus, it is helpful to include groups who need to be aware of the project and eventually support its outcomes. These groups may include:

- Anne Arundel County Council
- Anne Arundel County Executive
- Department Heads
- County Staff
- Maryland Regulatory Agencies (MDE, MDNR, MDOP)
- Residential and Commercial development community
- Environmental interests such as the Severn River Commission
- Planning and Community Associations

Approaches for Building Awareness and Support

The overall intent of these approaches is to reach out to key stakeholders to build a well-developed understanding of the project and their potential role in its implementation. The potential interrelationship between the Severn River project and other state and county efforts, in terms of shared data and complementary objectives, will be explored with appropriate agency representatives.

These techniques, the frequency of their use, and their information may have to be revised based on input from the intended audiences.

1. State and County Agency Briefing

This briefing will include representatives of the Maryland Departments of Environment, Natural Resources, and Planning. The purpose is to determine where and how the Severn River Watershed Master Plan project augments similar efforts undertaken elsewhere in the state and to develop ongoing communication to facilitate exchanges of information, ideas, approaches, and policy related to watershed protection goals.

2. Develop a Briefing Package

The briefing package includes the project fact sheet and watershed map, a fact sheet describing the Watershed Management Tool, the flow charts illustrating the decision processes for Phase I and Phase II and a project schedule. Various Technical Memorandums from the project could be

provided upon request or on a customized basis for each recipient. Elected officials may be particularly interested in the Public Involvement Memorandum and information pertaining to the cost of the project.

3. Develop and Update a Project Powerpoint presentation

A powerpoint presentation could be used by the project team to present to various interest groups at their regular (monthly) meetings at important intervals during the project. The presentation would contain basic information on the history of development in the watershed, the problems to be addressed in the Watershed Management Plan, and recent information on the field collection efforts, modeling, problem identification, and management alternatives.

4. Conduct Briefings with the County Directors and the Office of County Executive:

The Office of County Executive Janet Owens bridges the Departments of Public Works, Planning and Zoning and Inspections and Permits. For these and other reasons, the Executive will have an interest in the functions developed for the Watershed Management Tool. In addition, the Executive or designee may wish to participate in the difficult tradeoffs involved in defining the standard of Maximum Extent Practicable (MEP) required in the County's storm water NPDES permit.

5. Conduct Briefings with County Council Members:

At least five of the seven Council members have a portion of the watershed within their councilmanic districts. Council members will be concerned about how this project may affect their constituents. Members with other watersheds within their districts will be watching to learn what happens with the Severn River project to determine how future watershed planning efforts may impact them. Council action will be required if the Watershed Management Plan requires any kind of zoning, land use or regulatory change. Support of the plan and successful action on implementation measures will require an ongoing knowledge about the project and the process for developing tools and recommendations.

6. Economic Development Outreach

Key organizations representing residential, commercial, industrial development interests can be pathways for communicating about the project. These organizations may include the Anne Arundel Commercial Industrial Association, Home Builders Association, Annapolis/AA County Chamber of Commerce and the Anne Arundel Chapter of Association of Builders and Contractors.

AAEDC, as a countywide organization representing the industrial and commercial economic development interests, will be kept informed throughout the entire project. AAEDC was represented throughout the Phase I public involvement effort. . As a non-profit organization they may also appreciate the role a healthy environment, particularly water quality, plays in attracting new employers and expanding businesses in the County.

7. Develop a Quarterly Newsletter

The newsletter would be one page (front and back) mailed to the attendees of the Phase I workshops and other stakeholders. The newsletter would also be posted on the project website. Its function would be to provide a quick summary of the project and periodic updates on the

progress of the field collection, modeling, problem area identification and development of management alternatives.

8. Conduct Stakeholder Workshop – Prioritizing Problem Areas

This evening workshop is a forum to present the results of the field surveys and modeling. Participants would provide "weights" ascribing the relative importance of one problem area to another. A facilitated Nominal Group Technique session would be used to achieve the collective weighting. Information on the range of management tools under consideration would also be provided including the functions, effectiveness, and practicality in implementation.

The results of this problem area weighting could be used to develop a GIS coverage of the severity and sensitivity of the problem areas for sub-basins and basins.

9. Conduct Management Alternatives Mini Workshop Series

This series of workshops is intended to demonstrate the functions of the Watershed Management Tool and develop a broad-based understanding of its role in land use decisions. The workshops may also be an opportunity to solicit feedback on the management alternatives.

The Watershed Management Tool will be taken to specific groups to accomplish these purposes. These include meetings of the Severn River Commission, groups representing the economic development community, the County Department Heads, the County Executive, and a meeting of the stakeholders participating in the problem weighting workshop.

3.0 Model Selection and Data Requirements for Watershed Modeling

This section of the report summarizes the pollutants of concern, model selection, and data requirements for watershed and receiving water models to be used in the Severn River Watershed Management Master Plan Study. In several meetings with County staff, it has been determined that a suite of models will be needed to analyze and forecast how land use decisions, additional BMPs, or other changes in the watershed affect the Severn River and its tributaries. The suite of models currently identified deal with the following watershed processes:

- Pollutant Loading
- Stream Assessment Scoring/Grading
- Hydrologic Models/Analysis
- Hydraulic Models/Analysis
- Soil Erosion Models/Analysis
- Estuary Models/Analysis
- Groundwater and Surface Water Interactions

As originally scoped, this study focused only on pollutant loading models, estuary models, and soil erosion models. However, in meetings with County staff, the need to address groundwater and surface water interactions was brought up as an evaluation criterion for different modeling options. Also, interest was shown in the ability to forecast stream condition from watershed changes. A model for this purpose is discussed briefly in this section and in more detail in Appendix B.

3.1 Pollutants of Concern

The starting point for identifying pollutants to be modeled was the State of Maryland's 303(d) list for the Severn River, which shows nutrients, sediments and bacteria are the pollutants for concern in the estuary. At the May 17th workshop, stakeholders prioritized a list which included more detail: total suspended solids (TSS), nitrogen, fecal coliform, metals, phosphorus, TPH and grease. Subsequent discussions identified specific forms of these pollutants, as follows.

Nutrients	Total Kjedahl Nitrogen
	Nitrate + Nitrite
	Ammonia
	Total Phosphorus
Metals	Copper
	Cadmium
	Lead
	Zinc
Other	Fecal Coliform
	Total Petroleum Hydrocarbons
	Oil and Grease
	Total Suspended Solids

3.2 Modeling Objectives

The Severn River watershed includes tidal and non-tidal surface water. The tidal Severn River begins within Anne Arundel County and flows southeast until joining the Chesapeake Bay to the east of Annapolis. The pollutants entering the Severn River and its tributaries will impact the biota in the River as well as those in the Bay. The estuarine part of the River is currently on the 303(d) list for nutrients, sediment and bacteria.

Severn River watershed has been under pressure from continued development due to growth within the watershed and in the surrounding urban areas. Urbanization may change the hydrologic regime, increase pollution and decrease habitat quality in the water bodies. Impact of urbanization and pollution from existing sources need to be reduced and managed properly to preserve/improve habitat quality, reduce flooding and improve water quality. Modeling provides necessary tools for analyzing various alternatives for sustainable development without compromising environmental quality.

To address the diverse issues and problems we need to understand several components of modeling. Due to the complexity of the system and problems no single model can be used successfully to simulate the pollutant loads from various point and nonpoint sources, fate and transport of all the pollutants on land and in water body, and the impact on habitat quality. Also time and spatial scale play an important role in selecting an appropriate model(s). We reviewed different models for watershed and receiving water quality modeling with a primary objective that the County personnel can maintain and operate the model efficiently. The review of different watershed models describes our basis for model selection. We also reviewed modeling efforts by other agencies/organizations to avoid duplication of the modeling exercise, identify potential sources of information and maintain consistency in modeling approach. Our model selection can be summarized as follows:

- Two watershed models are recommended to simulate runoff quality (PLOAD and GWLF)
- An estuary model is recommended to simulate the fate and transport of pollutants in the tidal Severn River (MIKE 21)
- A model to simulate soil erosion from the land surface can be obtained from the two watershed models previously mentioned (both PLOAD and GWLF can be used, but GWLF applies a more deterministic approach based on the Universal Soil Loss Equation - USLE)
- Hydrologic (TR-20) and hydraulic modeling tools (HEC-RAS) are recommended to address flooding and changes in flow regime
- A model to examine the ground water and surface water interactions and overall watershed water budget can be obtained using one of the recommended watershed models (GWLF)
- A regression model can be used to link stressors to habitat quality (WISE)

3.3 Model Selection

Numerous watershed and receiving water quality models are available from government agencies and private vendors. An initial screening eliminated many models from consideration and, therefore, narrowed the focus to a limited number of models for a thorough comparison. The criteria used for initial screening are listed below.

- Models that do not possess a proven track record (i.e. peer reviewed and widely accepted by the modeling and regulatory communities) were not selected for further review. Models with proven track records tend to receive continued support for improvements and enhancements. The scientific basis of the selected models were not compromised by selecting models well accepted by regulatory agencies and modeling community.

- Proprietary models that can be purchased off-the-shelf or public domain models are generally a better choice due to low or no upgrade and maintenance cost. Continued support for customized models may not be available or may by prohibitively expensive.

- Availability of technical support and training opportunities are also key considerations in selection of models for use by the County personnel.

- Some proprietary models (e.g. WMS, MIKE21) have better preprocessing and post-processing capabilities than other models. These additional capabilities may reduce the level of effort needed when setting up the model and interpreting the results, and offset the price of the software. Although ease of importing and exporting data into and out of the model is a related important issue, a model which is "un-user friendly" in this area may be modified by the programmers of the Watershed Management Tool to be more user friendly.

In many cases models are continually refined after initial development as more data become available. We will set up the recommended models in Phase II using available data. County personnel will be able to improve the model as more data become available or upgrade the model when a newer version becomes available.

3.4 Water Quality Modeling – Pollutant Loading

Table 1 compares various features of a few watershed models and lists different pollutant categories that can be simulated by various models. Many watershed models do not simulate metals. Input data requirements are a key consideration in selecting models. Model selection should take availability of data into consideration so that there are adequate data for setting up and calibrating the model. PLOAD requires the least data for modeling while complex dynamic models (e.g. HSPF and SWMM) require the most data.

Models differ in their time scales, as well. PLOAD simulates annual/seasonal pollutant loads while GWLF simulates pollutant loads at a daily interval. HSPF and SWMM can simulate pollutant loads/concentrations at a much smaller time step (e.g. 1 minute).

There are other considerations. HSPF, SWMM and GWLF have simple ground water and surface water interactions. However, none of these watershed models are capable of comprehensive groundwater modeling. PLOAD simulates pollutant loads based on a statistical

approach while other models listed in Table 1 use a deterministic/empirical approach. PLOAD does not model soil erosion and sediment transport. GWLF does not consider BMPs, though custom applications of GWLF have been developed by consultants that include BMP modules. GWLF model support is available from EPA and USDA. Finally, complex models require very skilled users to set up the model and interpret the results while simple models (e.g. PLOAD) can be used by novice users.

PLOAD and GWLF were selected for watershed modeling. The primary reason HSPF and SWMM were rejected was for their complexity. Data requirements are high and the skill level to run these models is much higher.

Pollutant Loading Model (PLOAD)

PLOAD is a simplified, GIS-based model to calculate pollutant loads for watersheds. PLOAD estimates nonpoint sources (NPS) of pollution on an annual average basis, for any user-specified pollutant. The user may calculate the NPS loads using either the export coefficient or the EPA's Simple Method approach. Optionally, best management practices (BMPs) and point source loads may also be included in computing total watershed loads. PLOAD includes several alternatives that may be specified to show the NPS pollution results as maps and tabular lists, and to compare multiple sessions. This model can be applied successfully to assess the impact of different development plans including land use changes and implementation of BMPs on water quality. The ArcView GIS based graphical user interface (GUI) allows users to link GIS data and visualize model output within the ArcView software.

Input data required by PLOAD

1. Watershed/sub-watershed boundaries
2. Land use and land cover
3. Annual/seasonal precipitation
4. Land use specific event mean concentrations for each pollutant of concern
5. Location of point sources, pollutant load data
6. Best management practices (BMP) -- location, acres of various land uses served, type of BMP

TABLE 1: COMPARISON MATRIX FOR WATER QUALITY AND POLLUTANT LOAD MODELING

Model	Pollutant modeling capability				Model Input Data Require-ment	Model Calibra-tion	Event/ Contin-uous	Ease of use/skill level	GW/SW interface	Deterministic vs statistical	Erosion
	Nutrients	Bacteria	Sediment	Metals							
Watershed Models											
PLOAD	Yes	Yes	Yes	Yes	Low	None	NA (Annual/ seasonal)	Simple	None	Statistical	No
GWLF	Yes	No	Yes	Limited (Total metals)	Medium	Supported	Continuous	Medium	Limited	Deterministic/ empirical	Yes
AGNPS	Yes	No	Yes	No	Medium	None	Event	Medium	None	Deterministic/ empirical	Yes
HSPF	Yes	Yes	Yes	Yes	High	Yes	Continuous	Complex	Limited	Deterministic/ empirical	Yes
SWMM	Yes	Yes	Yes	Yes	High	Yes	Continuous	Complex	Limited	Deterministic/ empirical	Yes

TABLE 1 COMPARISON MATRIX FOR WATER QUALITY AND POLLUTANT LOAD MODELING (CONTINUED)

Model	BMP	Model support	Software Cost	Model Development Cost
Watershed Models				
PLOAD	Yes	Limited (EPA)	Public Domain	Low
GWLF	None	No	Approx. $10,000	Medium
AGNPS	Ag BMPs	USDA	Public Domain	Medium
HSPF	Yes	EPA/USGS	Public Domain	High
SWMM	Yes	EPA	Public Domain	Hlgh

3.5 Generalized Watershed Loading Functions (GWLF)

The GWLF model was originally developed by the Department of Agricultural and Biological Engineering at Cornell University. The model is based on simple runoff, sediment, and groundwater relationships combined with empirical chemical parameters. GWLF simulates streamflow (runoff, evaporation, infiltration, and baseflow), nutrients, soil erosion, and sediment yield values for daily time intervals. Runoff is calculated using the SCS curve number equation and soil erosion is calculated using the Universal Soil Loss Equation (USLE). Urban nutrient loads are computed by exponential accumulation and wash-off functions. Nutrient loads from septic systems are calculated by estimating the per capita daily load from septic systems and the population served by septic systems Using GWLF in addition to PLOAD is recommended to model soil erosion and sediment loads, and the impact of septic system failure on water quality more accurately.

Input data required by GWLF

1. Watershed/sub-watershed boundaries
2. Land use and land cover
3. Soils data to derive SCS curve numbers by source area, USLE factors and soil water.
4. Digital Elevation Model (DEM) data
5. Weather data: daily precipitation, temperature and evaporation
6. Land use specific event mean concentrations for each pollutant of concern
7. Location of the point sources, pollutant load data
8. Erosivity coefficients, generally derived from physiography map
9. N and P point source loads
10. Background N/P concentrations in GW
11. Background P concentrations in soil
12. Background N concentrations in soil
13. Months of manure spreading on agricultural land
14. Population on septic systems

HSPF, BASINS, and IWAMS

We reviewed the watershed models developed by the Chesapeake Bay Program Office's (CBPO) and watershed tool used by the Maryland Department of Natural Resources (DNR), Integrated Watershed Analysis and Management System (IWAMS), and their applicability in Anne Arundel County for watershed management. The Chesapeake Bay Program used the HSPF model to simulate runoff from various watersheds. Sizes of the watershed in the CBPO's model are very large compared to the County's needs for watershed management and only nutrients are simulated by the CBPO's model. HSPF is a good watershed model, but input data, user expertise and level of effort necessary to use the model on a regular basis would be very expensive. IWAMS is a customized version of EPA's BASINS software supported by Maryland DNR. IWAMS does not include the latest tools and models included in the latest version (version 3) of EPA's BASINS software. PLOAD is included in BASINS version 3.

3.6 Receiving Water Quality Modeling - Estuary Model

We reviewed several hydrodynamic and water quality models and focused on EPA's WASP5 and Danish Hydraulic Institute's (DHI) MIKE 21 models.

WASP5

WASP5 includes three modules -- DYNHYD, EUTRO5 and TOXI5 to simulate hydrodynamics, conventional pollutants and eutrophication, and toxic substances, respectively. DYNHYD is a one-dimensional hydrodynamic model suitable for narrow tidal estuaries. For the wide Round Bay area in the Severn River a lateral two-dimensional model will be needed for accurate simulation. DYNHYD can be extended to a pseudo-two-dimensional model to represent Round Bay and simulate the circulation pattern. EUTRO5 can be used for up to three-dimensional modeling of fate and transport of conventional pollutants and eutrophication. WASP5 is a DOS based model that requires significant effort in setting up the model correctly and post-processing model results. EPA has released a new Windows version of WASP (WASP6) which includes a GUI. However, the full implementation of WASP is not yet available in WASP6 and some pollutants (e.g. bacteria) cannot be simulated using WASP6.

MIKE 21

MIKE 21 is a comprehensive modeling system for simulating two-dimensional hydrodynamic and water quality processes in estuaries, bays, and coastal areas where stratification can be neglected. The model includes several modules (e.g. advection-dispersion, water quality) to simulate water quality. Seamless integration of hydrodynamic and water quality modeling capabilities make MIKE 21 a better choice for Severn River estuarine modeling application. The water quality module can simulate the fate and transport of bacteria, suspended solids, BOD, nutrients and dissolved oxygen. It includes a Windows based GUI to facilitate the application of the system. A wide range of support software for use in data preparation, analysis of simulation results and graphical presentation are also included. Because of the many user-friendly features, compatibility with latest operating system and availability of support we recommend MIKE 21 for Severn River estuary modeling. The disadvantage of MIKE 21 is that the software is proprietary and is relatively expensive.

Input data required by the estuary model (regardless of which model software chosen)

1. Bathymetry data
2. Tributary flow and pollutant loads (will be modeled using a watershed model)
3. Seaward boundary data (tide information)
4. Weather data (hourly wind speed and direction, precipitation, evaporation data)
5. Salinity at different locations
6. Sediment and water quality data for desired pollutants in the estuary. Also water quality data at the downstream boundary
7. Point source discharge data

Items 2 though 7 are time series data.

3.7 Hydrologic Modeling

TR-20 was developed in the 1970s by the U. S. Department of Agriculture, Natural Resources Conservation Service and has been applied widely across the United States. It is one of the methods approved for H/H modeling by MDE, and most water resources engineers in Maryland are familiar with its use. TR-20 is a single-event model that provides peak discharges and runoff volumes. It is used to find runoff hydrographs, perform reservoir and reach routing, and combine flows from different subwatersheds. Hydrograph generation is based on Curve Numbers (CN) which combine land use and soil parameters, and the time of concentration (Tc), which is determined by the longest flow path in the watershed. Input data are conceptually fairly simple and reasonably available. TR-20 has no water quality modeling capability and does not model groundwater interactions. Rainfall that is infiltrated is lost from the model.

Input data required by TR-20

GIS Data

1. Watershed/sub-watershed boundaries
2. Land use and land cover
3. Soils
4. Topography or DEM
5. Location of streams and drainage network
6. Location of BMPs

Other Data

1. CN by land use and soil classification
2. Rainfall Intensity-Duration-Frequency relationships
3. BMP storage capacity

3.8 Hydraulic Modeling

HEC-RAS, developed by the US Army Corps of Engineers, is the model most commonly used by FEMA for floodplain delineation and mapping. It is a one-dimensional single-event model for steady, gradually-varied open channel flow. Channels are modeled as reaches with unchanging cross-sections, the number and spacing of cross-sections is chosen by the modeler based on the resolution of the output desired. Subroutines are included for modeling the effects of bridges, culverts, and other structures or obstructions. Output from the model includes water surface elevations, flow, and velocity at each discrete channel section.

Input data required by HEC-RAS

GIS Data

1. Topography or DEM
2. Location of streams and drainage network
3. Floodplain boundaries
4. Location of culverts and bridges

Other Data

1. Channel cross-sections
2. Culvert dimensions and invert elevations
3. Bridge dimensions and elevations
4. Stream gage data (for calibration)

3.9 Soil Erosion Modeling

Susceptibility of each basin and subbasin to soil erosion is a factor of the sediment load delivered to streams and the estuary in the Severn River watershed. Soil erosion from the land surface is frequently estimated with the Universal Soil Loss Equation (USLE), an empirical approach derived from statistical analyses of soil loss data by the USDA. GWLF simulates soil erosion by using USLE. This model is explained in more detail in the section titled Water Quality Modeling – Pollutant Loading. The input data required is also detailed in that section. GWLF is recommended to be included in the suite of models.

3.10 Stream Assessment

The field data collection efforts slated for Phase II of this project will assess the current condition of the Severn River Watershed. Based on the field data, various bioassessment indices will be applied and a score or grade given to that particular reach of the stream. The next conceptual step in the planning process would be to determine what those scores would be in the future based on land use changes and future development. There are some options to predict the future stream assessment conditions. One such option is the Watershed Improvements through Statistical Evaluation (WISE) model. It is based on regression and correlation analyses which can evaluate the cause-and-effect relationships between potential habitat stressors and stream degradation. A more detailed description of the WISE Model can be found in the narrative in Appendix B.

4.0 Watershed Management Tool Outline

4.1 Introduction and Purpose

This section of the report outlines the high-level functional requirements for a Watershed Management Tool to support Anne Arundel County's watershed management and related planning activities. The Severn River Watershed Management Master Plan Study, Phase I scope called for the specification of a GIS tool to support the program. However, based on several meetings with County staff it was decided that this section should address an overall Watershed Management Tool that includes:

- Databases
- GIS tools
- Engineering models
- Software interfaces between the databases, GIS tools, and models
- Procedures and business processes to use these tools and to implement the overall Watershed Management Tool.

This section therefore addresses GIS- and mapping-related components of the Anne Arundel County Watershed Management Tool at a high level, and addresses other elements of the Watershed Management Tool as necessary. Other section of this report address the data needs and modeling recommendations for this system in more detail.

The recommendations in this section are based on the results of a two-day workshop with over fifty County staff and administrators, meetings with Severn River Watershed stakeholders, and several meetings with the County's Master Plan project management team. Recommendations are also based on the consultants' prior experience developing similar systems for other municipalities.

The Severn River Watershed Master Plan will provide a blueprint and tools to facilitate land use and infrastructure decisions by County staff and stakeholders to protect the resources of the Severn River. The Tool, while developed for the Severn River Master Plan, will be designed for future use across all watersheds Countywide.

This document provides a high-level outline of the Watershed Management Tool, including identifying users, tool functions, software, hardware, and training requirements. A more detailed analysis of current County resources and work flow (business processes) is necessary to complete the identification of detailed requirements and system design as described in the following section.

4.2 Additional Software Development and Design Steps

A more detailed specification for the GIS tools, interfaces to databases and models, and procedures and business processes for the Watershed Management Tool will be provided in Task

8.2 (Software Design and Specifications) of the Study, which has been scoped for an intermediate phase of the project, Phase IA. The following flowchart illustrates the recommended development process for large enterprise information management systems such as the Anne Arundel County watershed management system. This section addresses the first two very important steps of the entire system development process – Program Strategy and Project Definition. Task 8.2 will address the Business Process Analysis, Requirements and Specifications, and Design stages of system development:

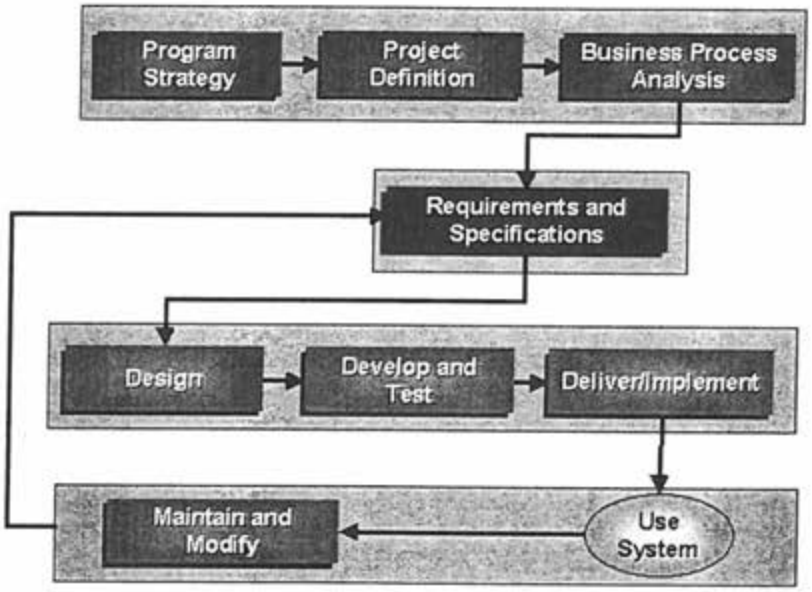

FIGURE 1: INDUSTRY-STANDARD DEVELOPMENT METHODOLOGY FOR INFORMATION MANAGEMENT SYSTEMS

4.3 Watershed Management GIS Tool Definition

The GIS components of the Anne Arundel County Watershed Management Tool can be defined as

> *A collection of GIS software, applications, and hardware, GIS data, data collection and maintenance procedures, analysis and modeling tools, staff, and procedures to facilitate watershed management decision-making and planning activities. The GIS tool will leverage existing Anne Arundel County GIS programs such as CountyView and MapOptix, modeling programs, data, procedures, and staff where available and will enhance these existing resources with new components where necessary. This report refers to the GIS components of the Watershed Management Tool as the "GIS Tools" or alternately as the "watershed management GIS Tools".*

The Watershed Management Tool can be conceptualized as having several major components as illustrated in Figure 2 below:

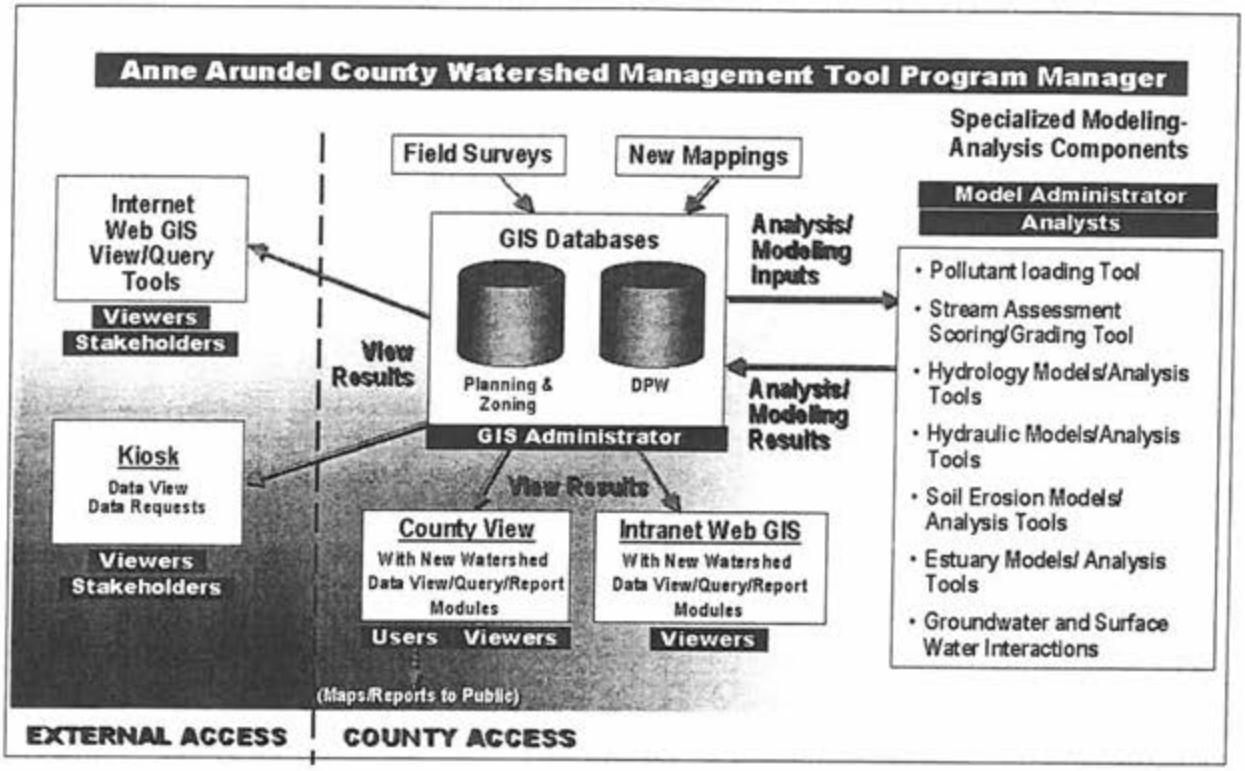

FIGURE 2: ANNE ARUNDEL COUNTY WATERSHED MANAGEMENT TOOL

As seen in the illustration above, the Watershed Management Tool is not a single software program or application. Rather, it is a collection of GIS software, engineering modeling tools, databases, interfaces to move information between these databases and software, and standard business processes that when used together facilitate watershed management decision-making activities.

The high-level functional requirements of each component, interaction between components, and required hardware, software, data, staffing, and training are described in this section. Each of the components are described in greater detail in Section 4.4.

GIS Tool Advantages

Advantages of the GIS Tool to Anne Arundel County include:

- Better access and use of existing map and related data
- Ability to make more informed decisions via efficient presentation and analysis of existing and future data
- More consistent review and analysis

- Supports existing business practices (such as development review and master planning) and enhances those processes where appropriate
- Leverages existing County investment in GIS (CountyView and MapOptix) and information technology (network, servers)
- Provides a holistic, systematic watershed perspective to planning and plan review activities
- Is a dynamic tool which can be extended to include additional map data and modeling/analysis components at any time

Watershed Management Tool Objectives

Overall objectives of the Watershed Management Tool include:

- **Watershed-based land management and land use planning** – The system will allow County staff to estimate and visualize impacts of development on stormwater runoff, erosion, non-point source pollution, stream water quality, habitat, and other impacts on existing natural resources. The system will also facilitate understanding the impacts of land use decisions and will allow the County to reassess current land use regulations.

- **Development review** – The Watershed Management Tool will also facilitate development plan review. While the system is primarily suited to watershed-level planning activities, if data of an appropriately detailed scale are available for specific sub-watersheds, subdivisions, or sites, the system can be used to visualize local impacts of specific development efforts.

- **Capital improvements planning** – As the watershed management database can store past, existing, and future conditions data, the system can be used to track capital improvement projects (such as best management practice facility construction, stream restoration, and the like) – including project location and status – and can also track the known environmental conditions before, during, and after project completion, thereby allowing the County to visualize improvements to the watershed through time.

- **Support NPDES permitting and compliance** – The system can be used to support the County's NPDES permitting analysis and decision-making process by integrating long-range development impacts with potential BMP retrofits to estimate changes in water quality. The system will allow County staff to estimate reductions in pollutant loads from "handbook" estimates and compare those modeled reductions against monitoring data.

GIS Tool Functions

Overall functions of the GIS components of the Watershed Management Tool will include:

- **Data Visualization** – The Watershed Management Tool GIS visualization components will allow users to view any combinations of GIS map layers to facilitate the decision-making process. Users will be able to view any or all existing GIS map layers, any future map layers to support watershed management, and any analytical model results via the GIS tools. CountyView will act as the primary mechanism by which watershed management program data can be visualized.

One or more new modules can be added to CountyView to support the Watershed Management Tool. In the illustration below, icons along the left-hand side of the CountyView window represent functional modules such as Water and Sewer, Storm Drain Inventory (currently being developed by GeoNorth LLC), Parcel Management and others. This list of icons would be modified to include a "Watershed Management Icon" and similar data management and query forms such as that shown here for storm drains could be developed:

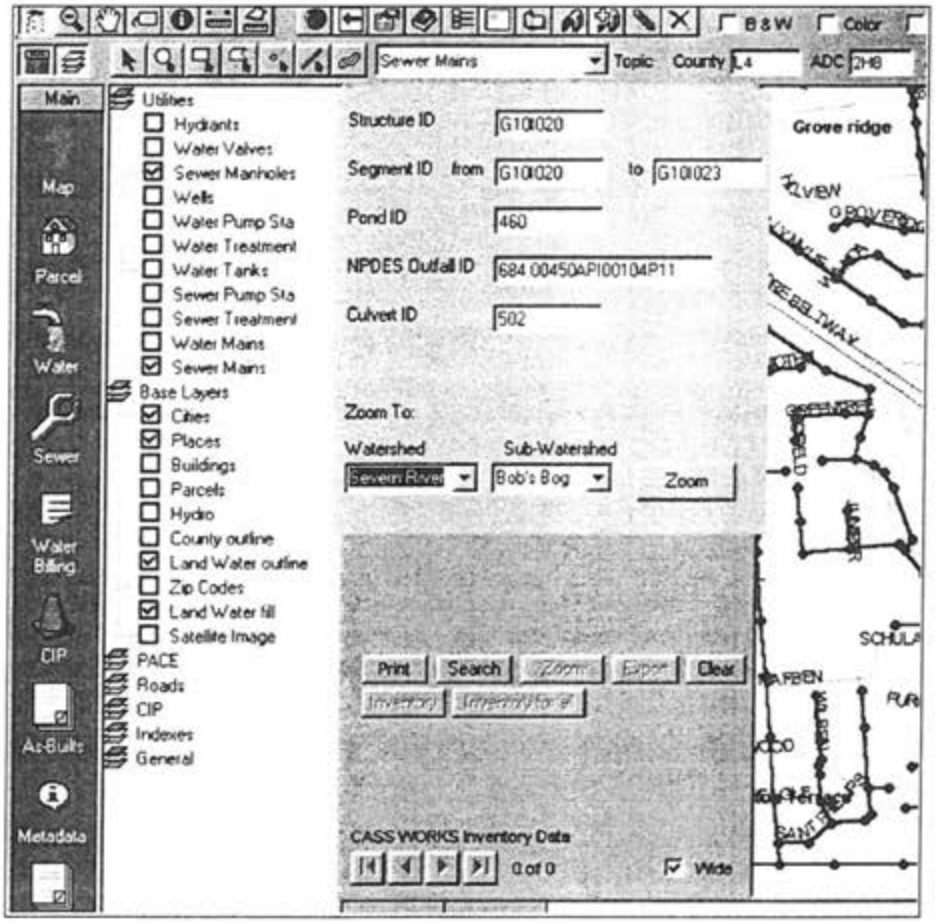

FIGURE 3: USE OF COUNTYVIEW TO FACILITATE DATA VISUALIZATION

- **Data Query** – Users will be able to query any GIS database in one of the following fashions:

  1. **Ad-hoc attribute query** – Users will be able to perform searches ("queries") on GIS maps and related information. For example, County staff could query the best management practice (BMP) inventory in the GIS to find all retention ponds that are of a certain size or capacity.

  2. **Ad-hoc spatial (locational) query** – Users will be able to search GIS data based on spatial or locational properties. For example, County staff could search the watershed management GIS layers to determine if there are any steep slopes (potential erosion areas) in close proximity to a proposed development).

3. **Pre-defined custom queries** – The Watershed Management Tool GIS visualization components could be customized to provide pre-defined, single-button-click queries. For example, staff could click an icon in a future CountyView Watershed Management module and have all watersheds classified with "poor" water quality (based on analytical modeling tools and procedures) automatically highlighted on the map.

- **Generate Maps and Reports** – Users will be able to generate printable maps and generate reports for presentations to developers, regulatory agencies, stakeholders, and the general public, for inclusion in reports, and to support internal decision-making business processes. The following illustrates an example of a pre-formatted map available by clicking a button in a stream assessment GIS tool for another local municipality:

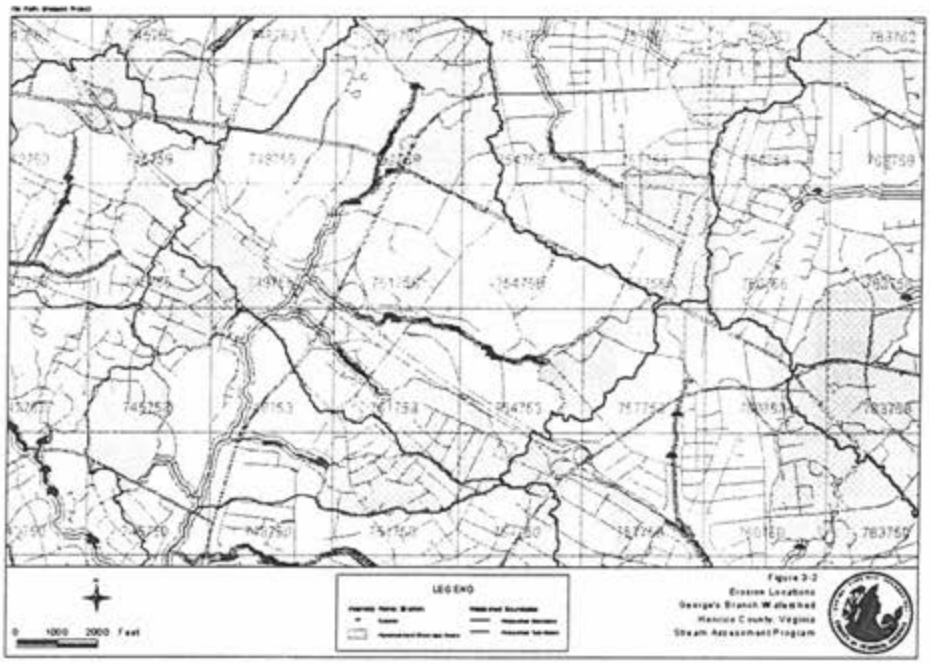

FIGURE 4: GENERATION OF MAPS AND REPORTS

- **Support Modeling and Analysis** – The GIS tools and related watershed management data will directly support – and will be used to display results of – analytical models including non-point source pollutant loading models, hydrology and hydraulic models, erosion models, etc. GIS data will be used as inputs to the analytical modeling tools and will also be used to display, query, analyze, and report model results.

Some of the analytical modeling tools identified in Section 4.4 provide capabilities to import GIS data and save model results in GIS format (for example HEC-RAS for hydraulic modeling, GWLF for groundwater/surface water interaction, and others). Other analytical modeling tools – such as PLOAD for non-point source pollutant load estimation – run directly in GIS software

and directly access GIS databases. Specific details on each analytical modeling component can be found in Section 3.0 of this report.

Figure 5 below illustrates PLOAD, a GIS-based non-point source pollutant loading model that uses GIS maps (land use, BMP locations, watershed boundaries) as model inputs and displays model results (pollutants on a watershed-by-watershed basis) via GIS map displays:

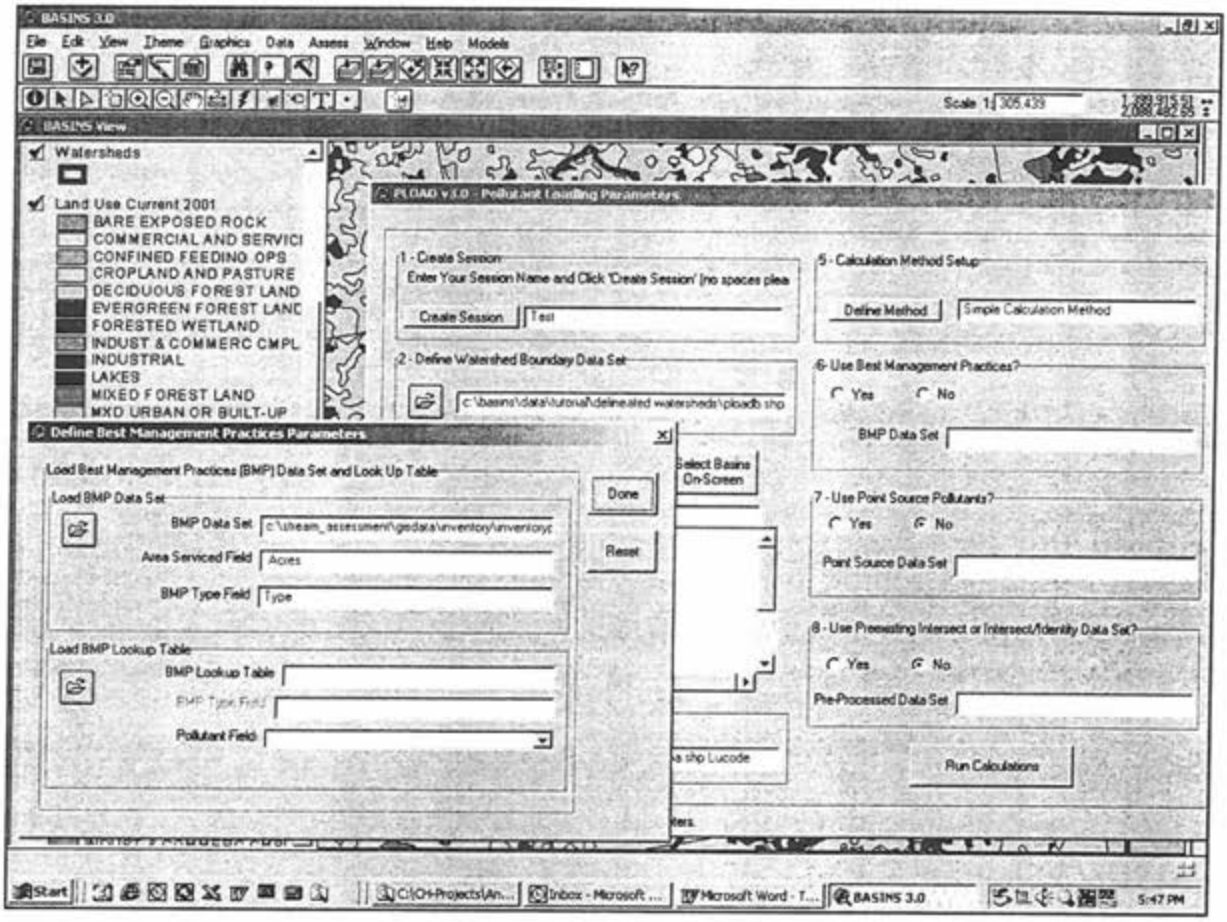

FIGURE 5: EXAMPLE OF ANALYTICAL MODEL INPUTS AND VISUALIZATION OF MODEL RESULTS

Visualizing Existing, Proposed, and Future Conditions

The Watershed Management Tool must be able to support modeling and analysis of both current and future conditions to support planning decision-making activities. Therefore the system must allow for easy development and tracking of "what-if" scenarios. Using the "what-if" scenario capability County staff will be able to analyze numerous development or planning alternatives, review the modeled (estimated) impacts via the visualization components of the GIS tool, and then remove or save any alternatives as necessary.

To facilitate efficient and orderly management of alternatives:

- Standard directory structures should be established to segregate master data bases (representing current conditions) from "what-if" data sources. For example, the current

zoning map should be stored in a location separate from copies of the current zoning map that have been modified to support what-if modeling activities (e.g., "what happens if I change this area from agricultural to low density residential?").

- Standard procedures should be established to guide storage of "what-if" scenario data and documentation (electronic or paper) for reference by other staff.

- Electronic metadata (data about data) that should be included with each "what-if" set of data should include:

  - ❖ Timestamp (when the copy of the data was created)
  - ❖ Author (person(s) creating the what-if data set)
  - ❖ Purpose of the what-if data set
  - ❖ Parent data (identify the data from which this copy was generated – either the master database or other what-if scenarios)
  - ❖ How the data in the "what-if" scenario differs from the parent data
  - ❖ Other Federal Geographic Data Committee (FGDC) spatial metadata as necessary.

Managing Metadata

FGDC and other metadata can be captured using metadata management tools from ESRI (the Anne Arundel County GIS vendor) or using other available public-domain metadata tools that run independent of the ESRI GIS software:

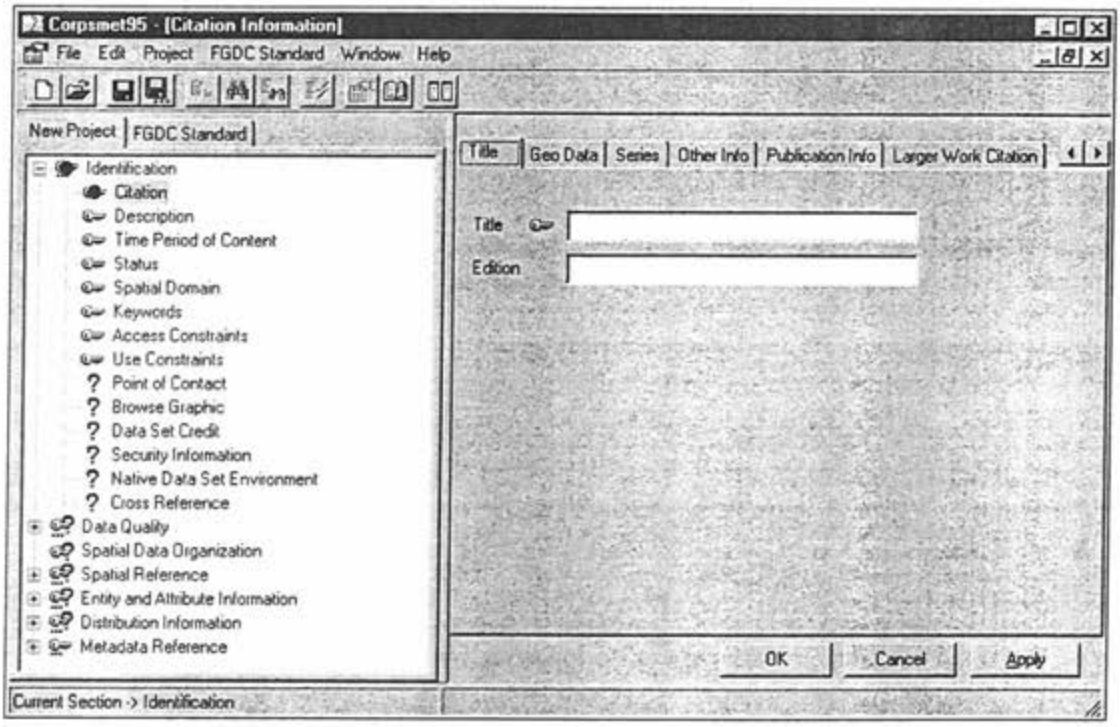

FIGURE 6: METADATA FORM TO DESCRIBE WATERSHED MANAGEMENT GIS DATA FILES

While management of data (utilizing standard directory structures, documenting data sets, building metadata, etc.) associated with what-if scenarios may require additional time from County staff, the benefit far outweighs the cost as the County will quickly generate numerous alternative data sets that must be tracked for proper interpretation, archiving, and retrieval purposes.

4.4 System Users and Roles

Organizational Requirements

To facilitate the use and maintenance of the Watershed Management Tool, the formation of a formal Watershed Program Management functional group is recommended. This group would be cross-functional, providing services for both the Department of Public Works and the Office of Planning & Zoning. This group's position in the County organization bears no influence on its role related to the WMT. However, internal County policies and procedures, human resource needs, and existing skill sets in the departments may predetermine which department is the best fit. The group would include a Program Manager, Administrators, and Analysts as described in the subsequent sections. Staff for this group may be drawn from existing staff or may be new hires. This Watershed Program Management group would provide the following overall functions:

- Interaction with internal and external agencies,
- WMT administration (including coordination and collaboration with existing County technical support staff, such as DPW Technical Services and P&Z Planning Services),
- WMT analytical services (performing analytical model runs),
- Training and technical support, and
- Management of data maintenance efforts.

Users and viewers of WMT information are not included as part of this Watershed Program Management Group. Personnel falling into the User/Viewer category will include any and all staff from the DPW, I&P, and P&Z Departments who wish to use the WMT for visualization or wish to receive model results. Overall, the WMT will provide efficiency to many of the County's existing business processes. However, given the nature of reviewers now wanting better information and wanting to see different model results, there will be an added workload at the startup of this program.

For the purposes of defining the Watershed Management GIS Tool system, five user types are defined:

- Program Manager
- Administrators
- Analyst
- User
- Public and stakeholders

Program Manager

Given the broad cross-departmental and cross-functional nature of the WMT, it is recommended that a dedicated program manager position be filled to administer the system. This individual

would fulfill a planning administrator role and should have cursory GIS and IS technical expertise. Primary roles of the system administrator would include:

- Overseeing the Watershed management program, decision making, strategic direction, and administrative support (staff, data, hardware, software resource management acquisition and sustainment),
- Guiding WMT priorities and addressing future requirements ,
- Providing policy guidance and program introductory training,
- Acting as liaison to Anne Arundel County department directors, County Council, County IS Department, and external stakeholders (Severn River Commission, etc.),
- Providing technical leadership,
- Managing the overall WMT database
- Coordination and involvement with the smaller watershed studies being conducted in the County that are referenced in Bill No. 53-01,
- Coordination and involvement with the larger watershed studies being conducted both statewide and baywide, and
- Coordination with managers of MapOptix.

This individual should have:

- Strong conceptual knowledge of all functional areas addressed by the WMT (e.g., development plan review and approval process, hydrology and hydraulics, non–point source pollution management, etc.),
- At least cursory technical expertise in database management, GIS and relational database technology, and engineering models,
- Experience in managing large municipal technology programs, and
- An understanding of the Anne Arundel County organization and political structure

FTE Equivalent for Program Manager

This position will require one FTE and can be filled by promoting qualified County staff or by hiring outside the organization.

System Administrators

Several functionally specific administrators are recommended to administer different components of the WMT. At least two administrators are recommended:

GIS Administrator

A GIS coordinator and database administrator would manage the databases and software required by the WMT GIS tools. Responsibilities would include:

- Interfacing with the WMT Program Manager and the Model Administrator,
- Coordinating with the County IS Department (and with DPW MIS staff),
- Installing, maintaining, and supporting all GIS tool software components,
- Sharing oversight of data collection and maintenance efforts,
- Coordinating with analysts to incorporate their changes into the master system database,

- Overseeing development and deployment of the GIS tool mapping components, and
- Coordinating with modeling and analysis staff.

The GIS administrator should have:

- In-depth understanding of all components of the WMT (software and database),
- Strong hands-on technical ability with ESRI GIS and relational database management systems, and
- Ability to manage staff resources and projects.

Note: the GIS administrator would not be responsible for maintenance of CountyView or MapOptix. These would be continued to be administered through current mechanisms.

Model Administrator

A model administrator would manage engineering models and analysis components of the WMT, and would support the GIS administrator in managing the WMT databases. Responsibilities would include:

- Interfacing with the WMT Program Manager and the GIS Administrator,
- Installing, maintaining, and supporting all modeling-analysis tool software components,
- Coordinating with County IS Department (and with DPW IS staff),
- Sharing oversight of data collection and maintenance efforts,
- Establishing and maintaining standard business processes and work flows to use modeling and analysis tools to support County mission and goals, and
- Coordinating with modeling, mapping, and analysis staff.

The model administrator should have:

- In-depth understanding of all components of the WMT (software and database),
- Civil or environmental engineering and planning background,
- Strong hands-on technical ability with several or all of the WMT modeling and analysis tools, and
- Ability to manage staff resources and projects.

FTE Equivalents for GIS and Model Administrators

The GIS Administrator and Model Administrator roles would each require approximately two thirds FTE. Given current staff utilization and work loads, the GIS and model administrator roles should be filled by either:

- Hiring new staff to fill those roles or
- Promote existing staff into these roles (however, this option would require that new individuals be hired to fill positions and responsibilities vacated by promoted staff).

Analysts

Analysts are defined as County staff qualified to:

- Create and modify map layers in the GIS,

- Create and modify data to support modeling and analysis components of the system, and
- Perform modeling analysis using GIS data and linking model results to the GIS layers for viewing using GIS tool components.

GIS Analysts

GIS analysts would perform map data edits (graphics and attribute edits) using ArcInfo, ArcView, or other GIS software retained and used within Anne Arundel County and would also use the WMT standard work flow procedures to prepare data for use in the modeling and analysis components of the system. GIS analysts would also use the GIS tools to generate custom map products and perform as-needed data analysis using either ArcInfo, ArcView, or MapOptix.

Modeling Analysts

Other analysts would be responsible for running engineering models (pollutant loading, hydrology, hydraulics, soil erosion, groundwater/surface water interaction models, etc.) and would (a) use GIS data as inputs and (b) map model results on GIS map layers. These engineers may require GIS training to support and maximize their use of GIS data in the modeling process.

FTE Equivalents for GIS and Modeling Analysts

GIS and modeling analysts could be comprised primarily of existing County staff in the Planning and Zoning and Public Works Departments. The GIS staff currently contains individuals with many of the correct skill sets. Additional staff could be trained properly to fulfill roles as modeling analysts. However, during the business process interviews, the Project Team learned that many departments were already at maximum work load capacity. It is assumed that one FTE is needed for each of these roles. Also, additional GIS support staff may be necessary to support external (publicly accessible) visualization components of the WMT. Note that some individuals may fill both the role of GIS and modeling analyst, depending on work responsibilities, skill levels, and personal interest.

Users / Viewers

GIS users are defined as existing and future County staff (administrators, department heads, and staff) who access maps and reports generated by the WMT in order to make decisions and to support their mission, objectives, and business processes. Users will be accessing these products in a "read-only" fashion; any changes to map layers and related data – or performing model analysis – would be performed by "Analysts," as defined above.

System users would access maps and data generated by the GIS tools via a modified Version of the existing CountyView system and/or via a modified version of the MapOptix intranet web-based mapping tool. System users would not normally use any of the modeling or analysis components of the WMT.

Communication

Standard work flow and business processes must be defined to formalize communication between users, analysts, administrators and management. The proposed WMT would include a Management Component to integrate data, initiate modeling requests, and monitor projects and resource usage. For example, should a user or users wish to evaluate a given set of alternatives

to support a planning, design, or management decision, a standard mechanism (automated on-line forms, standard lines of communication) must be in place to allow users to make requests of analysts in a formal, efficient, user-friendly, and consistent fashion.

At the upper management level, the WMT administrators and program manager also need to be involved in watershed related business process. They should attend meetings held by other divisions, such as P&Z Development Review and Small Area Planning, to understand upcoming projects and outstanding issues regarding using the WMT.

The WMT group internally should have monthly meeting to discuss workloads coordination, issues and challenges, and potential opportunities. WMT is a set of databases and systems that work together to achieve a defined set of goals. It will require different expertise to interact with each other. The WMT group can exchange information and experience through their monthly meetings to learn and grow.

FTE Equivalents for System Users / Viewers

GIS users would be comprised of existing County staff and managers. No new FTEs are required to support use or maintenance of the WMT.

Overall Staffing Requirements

Table 2 below summarizes additional staffing recommendations to directly support the WMT administration and use:

TABLE 2: WATERSHED MANAGEMENT TOOL STAFFING REQUIREMENTS

WMT User/Role	FTEs	Comments
Program Manager	1	Oversight of the watershed management program and WMT management
GIS Administrator	0.66	Administer WMT-specific GIS databases and GIS applications
Model Administrator	0.66	Administer WMT modeling data and applications
GIS Analyst*	1	Maintain and analyze WMT-specific GIS databases, develop map products for watershed management program
Modeling Analyst	1	Execute WMT analytical modeling tools, analyze results, and coordinate with GIS analyst to present results via WMT viewing components
WMT Users / Viewers	Varies	Existing and future staff who use the WMT.

* Staffing levels for GIS Analyst do not include effort needed to maintain the land use layer, as referred to in Section 1.4. Perhaps as much as 2.5 FTEs will be needed to maintain the land use layer.

NOTE: All WMT FTEs *except* for users would require new positions. These may be filled by promotion of qualified individuals or by hiring new staff.

The above recommendations address the Watershed Management Tool as a whole, covering the entire County. As the County starts to use the WMT with the Severn River Watershed, it is presumed that the GIS and Model staff will not have to devote all the time described in Table 2. Once the WMT is deployed for the entire County and all watersheds, the required level of effort to administer and maintain the WMT will approximate the recommendations in Table 2.

Public and Stakeholders

The general public and stakeholders could access maps and reports from the Watershed Management Tool in one of two fashions:

- **Direct access via internet web tools or kiosks at County offices** – Anne Arundel County could develop pre-defined maps and reports that contain content appropriate for public consumption. The general public could access and download or print these maps from an internet site or from a computer terminal ("kiosk") available at County offices. More information on these options can be found in the discussion of External Visualization components.

- **Requests to County staff** – In cases where the public – or stakeholders identified in phase I of this project – require custom map or report products, requests could be made directly to the Program Manager to prepare those products using the GIS Tool. A mechanism should be established by Anne Arundel County to allow requests to be made and to allow the requesting party to follow-up to determine progress of County responses to the request.

4.5 Watershed Management Tool Components

While the watershed management Tool is comprised of several different GIS programs and modeling analysis tools, there are essentially five overall components of the system:

- Modeling and Analysis Tool Component
- Central Database Component
- External Visualization (GIS) Component
- County Visualization (GIS) Component
- Interface and Standard Workflow Management Component (shown as arrows between other components in Figure 7 below)

Modeling and Analysis Components

The modeling and analysis components are the most important element of the Watershed Management Tool. Results from the analytical modeling components will be interpreted by County staff and, in some cases, external stakeholders to make planning, development, and conservation decisions. Functionality provided by each analytical model will dictate the level of customization to meet County needs, and data required by each model will dictate County data collection efforts.

Functional Overview

Based on several meetings with County staff and external stakeholders, the following high-priority analytical modeling components were identified for inclusion in the Watershed Management Tool:

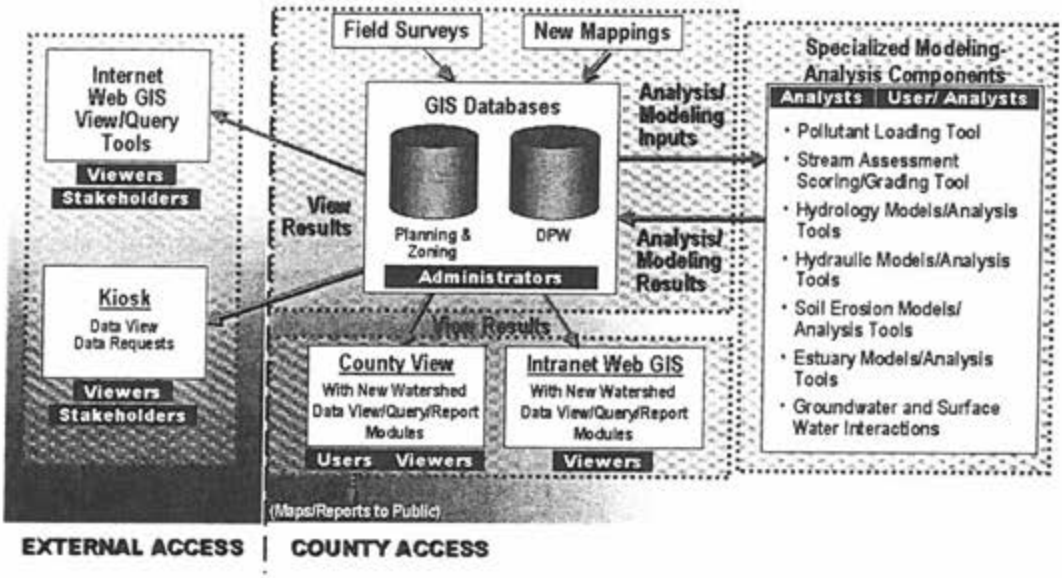

FIGURE 7: MAJOR COMPONENTS OF THE WATERSHED MANAGEMENT TOOL

- Pollutant loading (point source and non-point source) estimation model
- Stream assessment and stream health quantification tool
- Hydrology (rainfall-runoff) model
- Hydraulic (open channel flow) model
- Estuary (tidal) model
- Groundwater and surface water interaction model
- Soil erosion model

Section 3.0 of this report further describes specific functional requirements associated with each modeling component, recommended model alternatives (available software packages) for each modeling component, and general cost vs. functionality overview.

Model Inputs

All of the above-listed models will use GIS and related tabular data stored in the central database described in below. In most cases these data will need to be pre-processed to prepare the data in a format acceptable to each analytical model. Data pre-processing and modeling would be performed by system analysts.

Model Results

Data and information generated by each model should be posted back to standard directory locations in the central database. System users would then use GIS visualization and reporting tools to view and analyze these results.

Some available modeling software include GIS or other graphical software interfaces for interpreting data (e.g., PLOAD for pollutant loading, MIKE-21 for estuary modeling, HEC-RAS for hydraulic models). In these cases the model visualization tools should be provided to system users where costs are minimal. In cases where distribution of the tools is expensive or no visualization tools are available, CountyView and/or MapOptix should be customized to enable visualization of those model results.

Software Requirements

Varies based on the exact models chosen. Refer to Section 3.0 of this report for more information.

Application Development Recommendations

Varies based on the exact models chosen. Refer to Section 3.0 of this report for more information.

Central Database Component

Functional Overview

A centrally stored database or databases is recommended to store all data associated with the Watershed Management Tool. The database(s) will store master data representing current conditions, files representing past conditions as necessary, and files representing estimated or known future conditions.

The databases would store the following:

- GIS maps and related imagery, in several GIS formats (ESRI coverages, shapefiles, geodatabases, etc.)
- Field inventory and monitoring data, in several formats (e.g., Excel, Access, Lotus, other tabular formats)
- Model input files in formats dictated by individual modeling software packages.
- Model result files in formats generated by the modeling software packages.

Standard directory structures should be established to segregate data representing existing conditions from data representing "what-if" scenarios as described above. Each folder in each standard directory structure should also include the metadata described above.

Existing data repositories already in place in Anne Arundel County can serve as "central databases" within the Watershed Management Tool. There is no need to replicate or copy existing data into new directory structures entirely dedicated to the Watershed Management Tool.

Software Requirements

The Watershed Management Tool databases should provide the following:

- Use of widely-available and widely-used relational database management systems (RDBMS) such as Oracle or SQL Server.
- Ability to store and rapidly retrieve large amounts of spatial and tabular data.
- Support multi-user edits (as several analysts may be editing the same data sets simultaneously at some future point in time).
- Be open in nature to support access from analytical modeling software, CountyView, MapOptix, and other future GIS visualization tools.

Specific software recommendations are deferred until completion of the efforts under Task 8.2 to follow.

Application Development Recommendations

Specific application development recommendations are deferred until completion of the efforts under Task 8.2 to follow.

County Visualization Components

Functional Overview

The visualization tool components of the Watershed Management Tool will allow County staff (users, analysts, and administrators) to view, query, report, and analyze modeling results and raw data.

Some of the analytical models provide their own model output visualization tools (e.g., PLOAD for pollutant loading uses custom ArcView programs to facilitate display of model results, MIKE-21 uses proprietary software to display model results). In these cases, the model output visualization tools will be the primary tool to be used by County staff to review model results. However, where distribution of the model tools is cost-prohibitive (such as with MIKE-21), custom GIS programs or tools within existing programs (CountyView, MapOptix) should be prepared to distribute model output data.

- Model result viewing tools should provide the following functionality:
- Display model results in GIS (map) and, where appropriate, tabular format.
- Allow for user customization to the model output map display (custom colors, classification ranges, etc.).
- Browse and sort numeric results in tabular format.

- Query numeric results from the associated GIS maps using both ad-hoc (user-defined) and pre-defined queries.
- Generate maps for printing and inclusion in reports and presentations.
- Generate user-defined and pre-defined reports on all model outputs and on user-selected subsets of the model output database.
- Allow users to save their customizations (file configurations) to local hard drives for opening at a later time.

These functional requirements were further defined in Section 4.2. Specific functionality within each visualization module will be provided in the more detailed Task 8.2 technical memorandum in Phase IA.

Software Platforms for Visualization Tools

Where possible the following software packages should be used to facilitate visualization of model results by County staff:

- **ArcView** – Users and analysts may access model results using custom tools and functions within ArcView from ESRI. Analysts may also access model results using native-mode (un-customized) versions of ArcView GIS from ESRI. Where possible tools should be developed using the new ArcView GIS 8.1. Alternately existing tools compliant with ArcView 3.x (e.g. PLOAD, Stream Assessment Tools) can be used by County staff.

- **CountyView** – CountyView from GeoNorth LLC should be customized to include a Watershed Management module. The general look and feel of the Watershed Management module should closely emulate the look and feel of existing modules such as the Water and Sewer modules. When users click on the "Watershed Management" button from the active list bar, they will be presented with a panel that provides access to Watershed Management Tool model result GIS layers and associated data.

- **MapOptix** – Result data from analytical models should also be made available to County staff via the MapOptix web-based GIS browser from GeoNorth LLC. Users, analysts, and administrators could use this tool for high-level browsing and review of model result data.

Software Requirements

Additional licenses of ArcView may need to be purchased for Watershed Management Tool users and analysts.

Additional copies of CountyView and MapOptix may need to be installed for Watershed Management Tool users and analysts.

Application Development Recommendations

Custom applications would be developed for ArcView, and CountyView will be customized to enable a Watershed Management Tool module. The exact customization recommendations will be provided in the Task 8.2 technical memorandum to follow.

External Visualization Components

Functional Overview

Individuals and organizations external to Anne Arundel County should also have limited access to Watershed Management Tool data and model results. A web-based application deployed on the internet and at kiosks (walkup terminals) located in County offices would allow for stakeholders and the general public to access watershed management GIS layers and, where appropriate as determined by County staff, model results.

These results should be provided both as:

- "Live" data the external user can zoom, pan, and query.
- Pre-defined maps generated by County staff and served on the external visualization component as downloadable and printable images.

Functionality should include the ability to:

- Zoom and pan around the map.
- Zoom to address, intersection, or street.
- Turn map layers on and off.
- Point-and-click query of map features (watershed catch basins, zoning areas, streams, etc.).
- Browse available pre-defined (pre-prepared) maps and download or print those maps as desired.

A mechanism should be provided on the external visualization system to allow external users to:

- Provide feedback on the information presented on the external application. These would be sent via EMAIL to the Watershed Management Tool program manager. That individual would then act on or delegate action to other staff as necessary.
- Request additional information either in electronic or paper (hardcopy) format. These requests would go to the Watershed Management Tool Program Manager and action would be delegated as necessary.

The WMT Program Manager in agreement with the Directors would retain full control over what data and information will be provided on the external visualization component. It is important to limit available model results to those that are easily interpreted and to maps that adequately portray more complex model results.

Deployment Considerations

External visualization components should not be provided until all other components of the Watershed Management Tool are installed and in use by County staff. Given additional resource requirements necessary to prepare and manage data for external consumption and to respond to user requests and questions, external functions should not be made available until additional GIS support staff are hired by the County.

Software Requirements

An internet map server (ArcIMS) may be necessary to serve maps and applications to stakeholders and the general public. This map service would access model results and other data stored in the central database component of the Watershed Management Tool and would serve those data and other map products directly to the web. Alternately, for security concerns a subset of data from the central data can be posted (copied) to the web server and served off-line from the central database.

Application Development Recommendations

A web-based application would be developed to enable functionality described in Section 3.4.1. The exact customization recommendations will be provided in the Task 8.2 Software Design and Specification technical memorandum in project Phase IA.

Interface and Standard Workflow Management

A critical component of the Watershed Management Tool is the interface between the other components; how will information and data move from the central database to the modeling tools, results from the modeling tools back to the central database, and then distribution to the visualization tools.

Two major issues must be addressed:

- **Automated data management and integration** – Productivity tools should be developed to automate pre-processing of data where appropriate and automated posting of those data to pre-defined locations for use by analytical modeling tools (HEC-RAS, MIKE-21, WISE, etc.) and for access and use by visualization tools (CountyView, MapOptix, etc.). These tools should be written using standard programming languages (Visual Basic, other) to be determined in the Task 8.2 Software Design and Specifications report.

- **Standardized, yet manual, work flow management** – The other, and perhaps more significant, component is standardizing work flows and County business processes to facilitate collaborative, coordinated, and efficient use of the Watershed Management Tool. Standard work flows and business processes should be developed to facilitate:

  - **User / New Project Requests** – User requests for development of model alternatives (e.g., a user could request that a new pollutant modeling analysis be performed given a

potential change in zoning in a given area). These requests would then be received and performed by analysts.

- **Project Fulfillment** – Capability should be provided for analysts to document (a) what data were used on a given project, (b) what new data (model results) were generated on a project, and (c) where these data have been placed in the central database. This tool will facilitate sharing of project information with all County staff (other analysts, users).

- **Project Tracking and Costing** – Capability should be provided allowing the County to log who works on a request and the amount of labor and equipment time taken to fulfill the request. This information will enable the WMT Program Manager to track staff utilization, labor costs, and other metrics to support detailed accounting and to support cost-benefit and return on investment analysis for annual budgeting and continuous improvement.

This system could be enabled via a web-based project management system. This web-based system would include:

- Forms to facilitate the above-listed functionality (new project requests, project status and fulfillment, job costing and accounting).
- A calendar for collaborative scheduling of watershed management activities.
- A library allowing related documents to be uploaded, searched based on a keyword indexing system, and downloaded for review.
- Access to all project metadata (see Sections 1.5 and 1.5.1).

Figure 8 below illustrates an example of a project management web site with collaborative tools for scheduling and requesting project activities:

4.6 Data Requirements

A significant amount of data are required to support the modeling and analysis components identified above. Additional data may be required to support future site-level analysis. The reader is referred to Table 3 in the Section 5 of this report for specific data needs to support each model, availability of existing data, and recommendations for additional data collection.

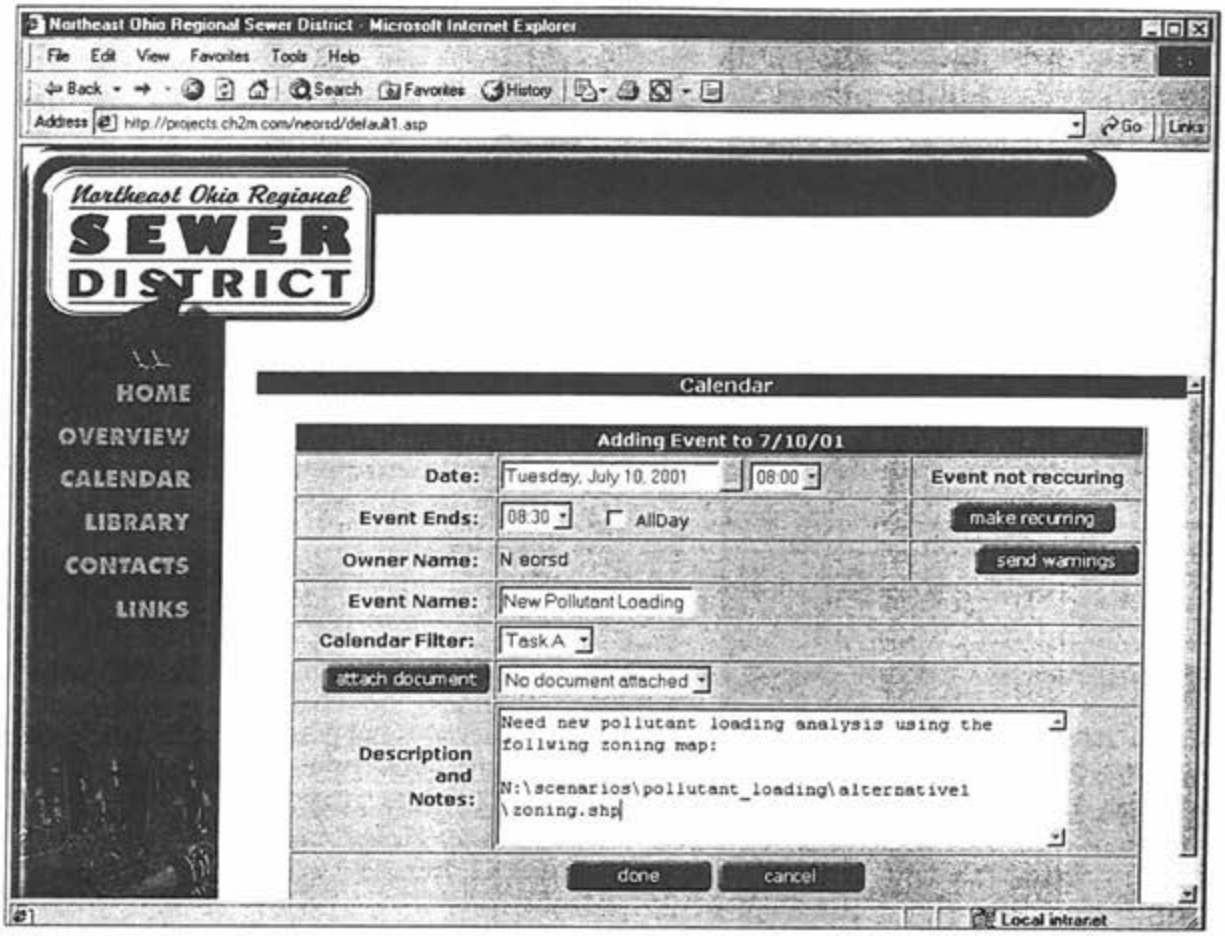

FIGURE 8: MANAGEMENT WEB SITE FOR PROJECT TRACKING AND COLLABORATION

4.7 Staffing and Training Recommendations

Training Recommendations

Training will be necessary for both existing and future staff to support use and maintenance of the Watershed Management GIS Tool and systems. This section outlines the types of training that will be necessary; specific numbers of staff to be trained will be estimated during future project phases.

Two types of training are recommended:

- **General watershed management program overview** – A 2-day seminar should be developed to introduce staff, administrators, and, where appropriate, external stakeholders to the Watershed Management GIS Tool and related data management procedures. The seminar would provide an overview of the Anne Arundel County watershed management program, an overview and orientation (hands-on demonstration) of the GIS Tool, description of GIS Tool components, and a description of staff responsibilities, maintenance procedures, and contact points. The course should be offered on a recurring, as-needed basis.

- **Specific training on GIS Tool software and components** – Specific training for individual watershed management program components (CountyView, MapOptix, ArcInfo, ArcView, modeling and analysis tools such as HEC-RAS, etc.) should be provided to appropriate staff. The remainder of this section describes specific training needs based on GIS Tool user types.

The following training are recommended for the different user types identified in Section 2:

- **Public and Stakeholders** – No training will be required for the general public and external stakeholders. However, it is important that the external visualization tools be designed in an intuitive, easy-to-use fashion to facilitate use by non-technical, untrained individuals. Select external stakeholders may be identified to attend the 2-day seminar describing the County's watershed management program.

- **Users / Viewers** – All users / viewers should attend the 2-day seminar describing the County's watershed management program. Users / viewers should receive formal training in MapOptix.

- **Analysts** – Analysts should receive the following training where necessary:

  1. **GIS Analysts** – County staff responsible for creating and maintaining watershed management program GIS layers should attend the 2-day watershed management program overview seminar, receive training in CountyView and MapOptix, and should also receive training from the GIS software vendor (ESRI) in ArcInfo, ArcView, and related products. A broad range of training courses are available from the software vendor, including introductions to ArcInfo and ArcView, programming, data maintenance, etc.

  2. **Modeling and Analysis Staff** – Staff responsible for performing engineering analysis models (pollutant loading, hydrology, hydraulics, etc.) should not only be trained in the use of those models, they should also receive training in the use of CountyView and MapOptix and ArcView training from ESRI, the ArcView vendor. Appropriate ArcView training will enable modeling/analysis staff utilize GIS data as inputs to specific models and to link model results back to GIS map layers for access by GIS users via the GIS Tool viewing components.

- **Administrators** – Administrators are responsible for long-term maintenance and enhancements to the watershed management GIS Tool and system. These staff should therefore attend the 2-day watershed management program overview seminar, be trained in the use and maintenance of CountyView and MapOptix, and should receive specialized training from ESRI, the County's GIS software vendor. County administrators should attend GIS system administration, database design and tuning, and application development training from ESRI. System administrators should also attend training offered to County Information Technology (IT) staff to ensure proper synergy between the GIS and County IT system administrators.

While it is not necessary for GIS Tool administrators to receive training in the use of the specific modeling and analysis components, administrators should be conceptually familiar with the function of each modeling and analysis tool and – most importantly – be aware of the input data requirements and resulting outputs such that the GIS system can be designed to accommodate those data.

Staffing Recommendations

While additional staff may be likely be necessary to utilize, support, and maintain the watershed management GIS Tool, specific recommendations cannot be provided at this time.

It is recommended that a Watershed Management Tool Program Manager, GIS Administrator, and Model Administrator be hired. 2 to 3 FTEs are estimated for management and administration. Refer to Section 2 System Users and Roles for more information.

A more thorough understanding of current staffing resources and responsibilities is necessary to make recommendations for additional system analysts. Recommendations for additional staff can be made after a formal business process analysis is performed during Task 8.2.

4.8 Conclusion: Implementation and Management Considerations

In summary, Anne Arundel County should consider the following when developing and maintaining the Watershed Management Tool:

- **County-wide application** – While the system is being developed as part of the Severn River Watershed Master Plan study, the system should be designed in such a way that the system can be extended to all watersheds Countywide simply by adding those data to the Watershed Management Tool database.

- **Initial Implementation Testing on Single Watersheds** – It is recommended by County staff that development testing of the system utilize data from two critical high-priority sub-watersheds. Jabez Branch was identified as the first and the second watershed has yet to be chosen. Initial roll-out of the Watershed Management Tool will include data and applications for the entire Severn River watershed.

- **A more detailed specification and design effort is necessary prior to commencing system development** – The Watershed Management Tool will be fairly broad-reaching and complex; it will be used on a frequent and regular basis by the majority of staff within the County Department of Public Works and Planning and Zoning Department. The system will address numerous County functions and will require a broad range of data to support decision making.

  It is therefore recommended that a more formalized evaluation of existing staff resources, existing business processes, information management resources and work flow be performed to support detailed system design. That effort is proposed as Task 8.2.

- **Leveraging existing systems** – Existing applications including CountyView and MapOptix will play an integral role in the Watershed Management Tool. Additionally, existing data

will provide a solid foundation for the system. However, both CountyView and MapOptix may need to be modified to support watershed management and additional data will need to be collected to support the system.

- **Functional Scale of System** – The system would initially be designed to support planning-level assessments for long-range planning and to reassess and evaluate "big picture" decisions such as zoning. The Development Division will not have as great immediate benefit from the system in its initial versions as site-level analysis (and data required for site-level analysis) will not be available in the near-term. It is important to keep in mind, however, that the model analysis results utilizing the more detailed data may not show a large difference. Because the proposed models are lumped models, direct benefits from having site level data will not be seen in the results. The new data will allow more precision in the analysis only. More detailed data in the future will allow better visualization and comparison of inventory, field, and GIS data.

- **Dedicated system administrators** – Management and administration of the system will necessitate full-time administrators including a dedicated program manager and day-to-day GIS, database, and modeling system administrators. 2-3 FTEs are recommended to support management of the system.

- **Staff and workload requirements** – There are significant concerns amongst County staff regarding staff resources. It is believed that additional staff will be necessary to support management and daily use of the system. However, the majority of system users will be drawn from existing staff. Further study is necessary to prepare detailed justification and cost-benefit analysis for new staff to use the system.

- **Public (non-County) access to the system** – Public access and provision of the Watershed Management Tool to the public should not be attempted until it is well understood and regularly used by County staff. An interim solution might include provision of summary data, maps, and reports (prepared in advance by County staff) to the public via the web or via kiosks in County offices.

5.0 Data Collection and Analysis

5.1 Data Collection

Environmental Data

Existing environmental and watershed literature and data for the Severn River watershed has been compiled. Research included, but was not limited to, estuary hydrodynamics, toxicology, biological condition, water quality, pollutant loading, flow and gauge data and land use. The following briefly describes the source of data, types of data collected and the manner in which is it presented.

Sources of Data

Sources researched for potential data related to the Severn River watershed were many and varied. Federal, state, county and local agencies and organizations were researched including the United States Geological Survey and its associated agencies, the U.S. Environmental Protection Agency, Anne Arundel County Office of Planning and Zoning and Maryland Department of Natural Resources. Many community organizations were also beneficial including the Severn River Association, the Severn River Commission and the Alliance for the Chesapeake Bay.

Types of Data

In general the most abundant types of literature found for the Severn River watershed were planning documents, small and large scale data collection and assessment reports, general summary documents and raw data.

Planning related documents include the Anne Arundel County General Development Plan and many Small Area Plans for the communities within the watershed. These documents provide less data but more mapping and land use information. Data collection and assessment documents include both focused research such as that conducted for Picture Spring Branch as well as more broadly based studies researching toxics in the Chesapeake Bay. Many of the documents collected gave very general assessments of the watershed, streams, wetlands and the land use factors affecting them. Chronologies of trout populations in Jabez Branch and histories of management in the watershed are examples. Sources with complete datasets for parameters such as toxics, physical stream characteristics, stream flow and tidal gauge data were not common.

Metadata Presentation

Included are the document list, which assigns a document code to each source and the appropriate citation, which identifies the author and owner of the data or document. The document code is used to cross reference the document list with the metadata database. The database is divided into four tables with each document listed. The tables include,

1. General Characterization
2. Regulatory Criteria
3. Living Resources/Habitat
4. Biological Community Measures

Each parameter within the four tables is marked for each document to indicate that the document deals with that particular parameter. Notes are added where further description is necessary to describe the contents. The document list and metadata set are by no means complete. Further research has been identified and requested from agencies and journals and will be added in future submittals.

GIS Data

Sources of Data

The approach to the mapping for this project was to use available County GIS data as much as is possible. The consultant's staff reviewed the GIS data available from the Departments of Planning and Zoning and Public Works and discussed the data during the meeting on March 1st. With the help of County staff, we selected the coverages which appear to be most useful for this study and received them on CD at the same meeting.

The primary source of external data will be the USDA for digital soils data. As discussed earlier, it appears likely that the USDA digital soil survey may be complete in time to support this study.

Types of Data

County GIS data was supplied as shapefiles or ARC/INFO export coverages.

Metadata Presentation

Metadata is included in an Excel spreadsheet (GISMetadata.xls). It was created using the P&Z listing of available data layers as a base, and adding fields for the information needed about each GIS layer.

Source Scale – The scale of the original source document used to create the data.

Last Update – Most recent date that the layer was changed.

Feature Type – Point, line, or polygon

Process Description –Short description of how the GIS data was created, which would include methods of conversion from other files or digitizing that was undertaken.

Estimated Accuracy – An estimate of the scale the data was created at or of the ground accuracy of the features.

County staff supplied some of the metadata shown. Revisions and additions to the database are anticipated during the remainder of the project as the need to update existing coverages and digitize new coverages is assessed.

5.2 Data Needs, Gaps, and Updates

This report presents a draft analysis of the environmental and GIS data collected. It has been compared with the data needs for the models and GIS Tool functions, and the need for additional data has been determined. Table 3 shows a summary of the data needed for each model, along with its availability and a brief description of the work required.

Existing studies and sources of information on the Severn River watershed are presented in Appendix C. Sources with current usable data sets are described in more detail in Appendix D and in the text below with listing of the source of the information, geographical location such as stream name, the type of data collected and the time period when the data was collected. Appendix E shows locations of where the data was collected in a series of maps of the watershed.

The following summarizes the data requirements of the Severn River Watershed Study, broken down into categories shown in Table 3, including Stream Assessment, Flow and Weather Data, Water Quality Data, and Estuary Data. Existing environmental data deemed useful for input and calibration of the models is presented. Existing studies were categorized and metadata concerning type and dates of data collection were assembled. From the data requirements and existing data a gap analysis was conducted to determine what existing data needs to be recollected and what additional data needs to be generated. Both spatial and temporal variables were considered.

In addition to the data discussed below, there are portions of the outstanding data still to be collected through continued research and cooperation with agencies, the County and stakeholders. Additional information is required for the following environmental areas:

- Septic Systems
- Groundwater/geology
- Flooding data, reports of flooding at bridges and culverts
- Point Source discharge data

TABLE 3: SUMMARY OF DATA REQUIREMENTS

Data Type	PLOAD	TR-20	HEC	GWLF	WISE	MIKE21	Availability	Work Required
Stream Assessment Data								
MBSS benthic IBI					x		Partial	Collect during stream assessment
MBSS physical habitat index					x		Partial	Collect during stream assessment
Flow and Weather Data								
Stream gage data			x			x	No	Limited flow metering
Annual rainfall	x	x			x		Yes	Obtain from Nat'l Climatic Data Center
Seasonal rainfall	x	x			x		Yes	Obtain from Nat'l Climatic Data Center
Daily weather data				x			Yes	Obtain from Nat'l Climatic Data Center
Hourly wind and precip						x	Yes	BWI only
Water Quality Data								
EMCs by LU	x			x	x		Partial	Conduct limited wet weather sampling
Point source loads	x			x	x	x	Yes	None
N/P in groundwater				x			No	Dry weather baseflow sampling
N/P in soils				x			Yes	Develop from data in soils map
Instream WQ data					x		Partial	Collect during stream assessment
Estuary Data								
Tide gage data						x	Yes	None
Salinity						x	Yes	None
WQ data at Bay interface						x	Yes	None
GIS Data								
Watershed Boundary	x	x		x	x		Yes	Adjust at Annapolis
Subwatershed Boundaries	x	x		x	x		Partial	Subdivide larger subwatersheds
Catchment Boundaries	x	x		x	x		No	Delineate and digitize
LU/LC Current	x	x		x	x		Partial	Digitize with current orthophotography
LU/LC Approved	x	x		x	x		No	Revise new LU/LC
LU/LC Future	x	x		x	x		Partial	Create from Zoning/Land Use Plan
Soils and attributes		x		x			Yes	To be delivered from USDA
DEM			x	x			Yes	None
Sewered / unsewered areas				x			No	Add attributes to LU coverage
Stream network		x	x	x			Partial	Fill in gaps
Storm drain network		x	x	x			Partial	None
SWM location, type, size	x	x			x		Partial	Cross-reference and digitize
SWM drainage areas and LU	x	x			x		Partial	Collect data
Floodplain boundaries			x				Partial	None
Culvert and bridge location			x				Partial	Ground truth and digitzie
Culvert and bridge data			x				Partial	Collect data as needed
Channel cross-sections			x				No	Collect data as needed
Bathymetry						x	Yes	Obtain from USGS/NOAA
Lookup Tables								
LU/Soils/CN		x					Partial	Develop from GIS coverages
LU/Imperviousness	x			x			No	Develop from GIS coverages

Stream Assessment Data

Data Requirements

To effectively characterize the biological condition of the streams in the Severn River watershed, stream assessment data from selected sites are required. Stream assessment data includes water quality, benthic macroinvertebrates and physical/habitat assessments. Ancillary data concerning fish abundance, blockages, herpetofauna, SAV is also useful to supplement habitat assessments and indicate overall health of the biological community.

Water quality information is needed to assess, on a very basic level, the health of streams and wetlands both in freshwater and in tidally influenced estuarine regions of the watershed. Required water quality data includes basic physical parameters such as dissolved oxygen, pH, temperature, conductivity, TSS and turbidity. Chemical parameters would include nitrates, nitrites, ammonia, and total phosphorus. Data for pollutants of concern, which may include nitrogen, sediments, bacteria (fecal coliform), PAH's and metals (copper, zinc) are also required. The Severn River is listed on the EPA's 303 (d) list and MDE's list of Water Quality Limited Basin Segments for nutrients, fecal coliforms and suspended sediments. Although their priority is considered low for TMDL development these parameters need to be addressed. Water quality data from each subwatershed and major tributaries to the Severn is basic baseline information that is essential to characterizing aquatic health.

Data is also required for benthic macroinvertebrate communities within the subwatersheds. Such biological data is an important supplement to the water quality data and will allow for efficient characterization of the biological health of the waters. Benthic macroinvertebrates are chosen as they have limited migration patterns and thus are good indicators of localized conditions. Communities offer a broad range of tolerances and inspection can reveal degradation and impacts of short term variation to the water quality or habitat. Data should be recent and be conducted using either EPA's Rapid Bioassessment Protocol (RBP) or Maryland Biological Stream Survey (MBSS).

Biological health is heavily dependent on the habitat and physical condition of the watershed, riparian zone and channel. Both qualitative and quantitative assessments of the habitat provide information to supplement the water quality and biological data. Visual and GIS assessment of the local land use including sources of runoff, point and non-point source pollution and impervious surfaces are needed. Assessment of the immediate surrounding habitat is also required and should include description of the riparian vegetation structure and its completeness. Qualitative assessment of instream characteristics such as variety and quality of substrate, bank stability and embeddedness are required in addition to quantitative assessment of slope, sinuosity, depth and discharge.

Presently Available Data

Baseflow water quality and pollutant information is currently available for approximately 60 sites throughout the watershed. Most information includes typical physical parameters such as

pH, DO, temperature, conductivity and TSS. Typical chemical parameters include nitrates, sulfates, total nitrogen and total phosphorous. Streams with water quality data from non-tidal portions include Severn Run, Weems Creek, Picture Spring Branch, Jabez Branch, Gumbottom Branch, Mill Creek and Saltworks Creek. Fewer complete datasets are available from the tidal portions of the watershed.

Biological data is available for approximately 50 sites within the watershed. These generally include fish and benthic macroinvertebrate data with the majority being benthic macroinvertebrates. Data is near complete for at least four subwatersheds with multiple monitoring stations and benthic collections within the last seven years including Severn Run and its tributaries, Picture Spring Branch, Saltworks Creek and Cowhide Branch. An additional five subwatersheds have existing data that may need to be supplemented by future collection as they have only one monitoring station. These include Mill Creek, Severn Run, Schultz Run, Jabez Branch and Weems Creek.

Habitat and physical data has been collected for all of the streams listed in Table 4 and includes a mixture of MBSS, RBP, Rosgen and Pfankuch habitat and physical assessment techniques.

TABLE 4: STREAM ASSESSMENT STUDIES AND METADATA

Source	Location	Type	Dates
MD-DNR 1997A (digital)	Mill Creek (1) Severn Run (11) Schultz Run (1) Un-named Trib to Deep Ditch Branch (1) Jabez Branch (1)	water quality, fish, SAV, benthic macroinvertebrate, habitat, herpetofauna, landuse, physical	1997
MD-DNR 1994 (digital)	Severn Run (6) Un-named Trib to Severn Run (2) Un-named Trib to Severn Run2 (4)	water quality, fish, SAV, benthic macroinvertebrate, habitat, herpetofauna, landuse, physical	1994
TT 2000A Tetra Tech for AA County	Picture Spring Branch (10)	water quality, physical and habitat assessment, benthic macroinvertebrate, Rosgen Level III, Pfankuch	2000
AACo 1998 Tetra Tech for AA County	Saltworks Creek Weems Creek Cowhide Branch Church Creek (South River) Broad Creek (South River) Gingerville Creek (South River)	benthic macroinvertebrates, water quality, physical and habitat assessment, Rosgen, Pfankuch	1997

Additionally Required Data

Additional water quality, benthic macroinvertebrate and physical habitat data are required for the remaining subwatersheds in the Severn River watershed study area.

Locations and numbers of stream assessment monitoring stations will be determined by a priority ranking and through the watershed walk thru to be conducted early in Phase II of the study. It is recommended that at the very least one station be established in each subwatershed and that two or more be established in priority areas such as Jabez Branch. Density and location of monitoring stations will be based on a number of factors including the level of development and

corresponding problem areas. Basins and stream reaches targeted for sampling will be stratified based upon a number of factors such as: drainage area, stream length, stream system type, topography, land use and percent impervious. Measurements or sampling at distinct geomorphic breaks or changes will reduce the number of sampling stations yet still provide valid information.

It is recommended that reference stations within each sub-basin and a reference sub-basin be selected based upon limited development and percent impervious. It is possible that existing data from Severn Run and Jabez Branch from MD-DNR's 1997 sampling may be usable for reference values.

The original scope of work estimated that 400 stations in 115 miles of stream would be required to adequately characterize the overall biological health of the non-tidal tributaries to the Severn River. Review of existing mapping and prior studies indicates that approximately 200 cross-sections would have to be sampled for a thorough characterization of aquatic habitat and physical condition of all the streams in the watershed, based on sampling points on 1st and 2nd order streams and an average drainage area of 250 acres. Rosgen Level II geomorphological assessment would be carried out on about 100 of these stations.

Monitoring at each station will include

Water Quality - pH, DO, turbidity, temperature, Conductivity, Total Dissolved Solids, nutrients (nitrogen, phosphorous), and fecal coliform. Additional parameters may be added as current information and priorities are evaluated.

Benthic Macroinvertebrates - collection and analysis following the MD-DNR's MBSS sampling protocol is recommended. This will allow comparison to past and future MBSS data.

Habitat Assessment - the MD-DNR's Physical Habitat Index (PHI)or Spring Habitat Assessments may be used. The PHI will allow comparison to reference reaches and was calibrated using MD-DNR benthic and fish data. Additionally the EPA's RBP may be used.

Physical Assessment - geomorphologic and stream stability analyses will be performed using fluvial geomorphologic assessment methods developed by Rosgen. This system of classification will be done at Level I for the entire watershed and Level II at selected stream reaches. The level of intensity and continued assessment will be determined largely by the watershed walk through and determination of priority areas. Field surveys of cross-sections and slope will be surveyed at the appropriate locations and distances in selected watersheds.

Flow and Weather Data

Data Requirements

Models will include TR-20 and HEC-RAS. These are key models for the study, because they will be used for erosion and scour analysis, floodplain delineation, roadway flooding studies, and analyzing the need for additional SWM facilities to meet requirements.

Minimum data required to run the TR-20 and HEC-RAS models include rainfall and streamflow data from similar areas within the watershed. Specifically data from storm event hydrographs and the associated rise in stream flow discharge is required. Additionally, information on stream length and path, bridge and culvert location and sizing and surveyed cross sections along the system in question are necessary. Cross sections every 200 feet will be needed. Reports and records of flooding events are also needed.

Annual and daily weather data are used as input to the PLOAD and GWLF models, and hourly weather data are one of the inputs for the estuary model.

Presently Available Data

Streamflow data in the form of Daily Mean Discharge Data is available from USGS at one station in the Severn River Watershed. Station 01589795 Sf Jabez Branch B at Millersville, MD, from 6/19/1997 to 9/30/1999. This data may be useful for model calibration and is available in digital format. Additional data for Picture Spring branch may also be useful.

TABLE 5: FLOW, WEATHER DATA STUDIES, AND METADATA

Source	Location	Type	Dates
USGS 2001 (digital)	Sf Jabez Branch at Millersville	Daily stream discharge (cfs)	1997-99
TT 2000 Tetra Tech for AA County	Picture Spring Branch	Storm Event monitoring temperature, pH, flow hydrographs, rainfall, rating curve	1999
NWS 2001 National Weather Service (digital)	BWI Airport	Daily records of precipitation, wind speed and direction, temperature, sea level pressure	1997-2001

Additionally Required Data

Additional streamflow data will be required to model various subwatersheds within the Severn River watershed. Streamflow and rainfall data for the selected subwatersheds will be best collected using instream water level data loggers. Collection of baseflow discharge, storm event discharge and rainfall data will be completed by these data loggers. Data loggers should be in place for at least six months to assure sufficient storm events have been captured.

The data will be collected and coupled with cross section and profile surveys to generate the hydrographs and discharge data required to calibrate the models. Cross section and profile surveys are not complete for any subwatershed within the study area and will need to be surveyed. Additional measurements of bridge and culvert locations and sizing are also needed.

Water Quality Data

Data Requirements

Pollutant loading and load reductions from each sub-basin will be found using the Simple Method developed by MWCOG (Schueler 1987). CH2M HILL has developed PLOAD, a GIS

tool that calculates pollutant loads using the Simple Method. Pollutant loads are found using the Event Mean Concentrations (EMC). This is an uncalibrated model, which relies on local EMC values to achieve the most accuracy possible. Key geographic information for the Simple Method is the continuing drainage area of the sub-basin and the imperviousness. The EMC development requires water quality, discharge data and hydrographs from storm events. Water quality records at stormwater management ponds allow for analysis of their effectiveness in meeting their design requirements for flow, temperature and nutrient/pollution removal.

Data required by PLOAD includes watershed/sub-watershed boundaries, land use and land cover, annual or seasonal precipitation, land use specific EMC's for each pollutant of concern, location of point sources, pollutant load data and location, landuse served and type of BMPs.

Presently Available Data

Presently there is very little water quality and discharge data available from storm events in the Severn River Watershed. Current water quality is largely from MD-DNR and consultants, focuses on dry weather sampling and does not target storm event monitoring. Some rainfall and discharge data is available for Picture Spring Branch in 1999. Data from County NPDES sampling is available for the South River Watershed, at the Parole Plaza and Church Creek with additional monitoring on Gingerville Creek and Broad Creek. Hydrographs and EMCs for many water quality parameters were developed for storms occurring in 1999 and 2000. Additionally, pollutant loading estimates have been developed using the Simple Method for various outfalls in the Severn River watershed, their location and estimates are available digitally.

TABLE 6: WATER QUALITY, POLLUTANT LOADING STUDIES, AND METADATA

Source	Location	Type	Dates
TT 2000 Tetra Tech for AA County	Picture Spring Branch	Storm Event monitoring temperature, pH, hydrographs, rainfall, rating curve	1999
PBS&J 1999A	County Wide	locations and assessment of existing outfalls, pollutant loadings, analysis of retrofit potential	1999
MCI 2000 (partially digital)	Parole Plaza (South River) Church Creek (South River) Severn River County Wide and Statewide	Parole Plaza and Church Creek event mean concentrations (EMC), storm hydrographs, storm water quality data, temperature, pH, BOD, TKN, NO2, NO3, P, TSS, cadmium, copper, zinc, TPH, phenols, oils and grease, fecal coliform; Severn outfall pollutant loadings and Countywide and Statewide EMC's	1999-2000
PBS&J 1998	Parole Town Center (South River) Church Creek (South River) Un-named Trib to Church Creek (South River) Gingerville Creek (South River) Broad Creek Un-named Trib to Broad Creek (South River)	assessment of stormwater basins, visual habitat assessments, water quality, temperature, DO, pH, conductivity, NO2, NO3, TKN, TP, TSS, metals and toxics, hydrographs	1997-1998

Source	Location	Type	Dates
NWS 2001 National Weather Service (digital)	BWI Airport	Daily records of precipitation, wind speed and direction, temperature, sea level pressure	1997-2001
NADP 2001 National Atmospheric Deposition Program (digital)	Wye River	Weekly and annual deposition, concentration and weighted mean-concentrations of Ca, Mg, K, Na, NH4, NO3, Cl, SO4, pH	1983-present

Additionally Required Data

The EMC and pollutant loading data from the County's NPDES reports, and outfall samples from nearby South River are useful for pollutant load modeling. Additional wet weather samples should be taken to develop input data for the water quality models. If currently available data is deemed incomplete the additional data required will be water quality and discharge data from storm events for different land uses. Areas and land use that need additional pollutant loading and EMC data will require storm sampling and laboratory analysis. Analysis for pollutants of concern should include those listed earlier in section 3.1.

Estuary Data

Data Requirements

The Hydrodynamic/Estuary model will generally require data concerning weather, bathymetry, hydrodynamics and pollutant loading. Tributary flow and pollutant loads will be modeled using the watershed model and will be a component of the Estuary model. Tide data from the seaward boundary as well as hourly wind speed and direction, precipitation and evaporation are required. Salinity values at locations throughout the estuary portion of the watershed are needed. Sediment and water quality data for desired pollutants in the estuary with particular attention to water quality at the downstream boundary are required. Point source discharge data from various points in the watershed are also needed.

Presently Available Data

Tide data near the seaward boundary is available at six minute intervals from the NOAA gauge at the U.S. Naval Academy. Weather data, including daily records of precipitation, wind speed and direction, temperature and sea level pressure are available though the NWS at nearby BWI airport. Flow data is available for Jabez Branch, but only for a small two year period from 1997-99. Other flow information, particularly from storm events are available for Picture Spring Branch as listed in Table 6. This information however is also limited in its scope.

Water quality data sources from both non-tidal tributaries and the estuarine portions of the watershed are listed below in Table 7. The parameters measured, locations and time periods of sampling are varied but generally are more abundant in the tributary streams and at the seaward boundary. The upper portions of the estuarine area have less information available. Specific parameters that have more complete datasets are fecal coliform, and to a lesser degree nutrients such as nitrate and nitrite.

TABLE 7: WATER QUALITY, TIDE DATA, AND METADATA

Source	Location	Type	Dates
NOAA 2001 (digital)	Santee Pier at US Naval Academy, Annapolis	Tidal Gauge, six minute, hourly, high and low waters, 18 year tidal datums (MHHW, MHW, MTL, MLW, MLLW)	1928-2000
USGS 2001 (digital)	Sf Jabez Branch at Millersville	Daily stream discharge (cfs)	1997-99
NWS 2001 National Weather Service (digital)	BWI Airport	Daily records of precipitation, wind speed and direction, temperature, sea level pressure	1997-2001
NADP 2001 National Atmospheric Deposition Program (digital)	Wye River	Weekly and annual deposition, concentration and weighted mean-concentrations of Ca, Mg, K, Na, NH4, NO3, Cl, SO4, pH	1983-present
MD-DNR 2001 (digital)	Upstream of Rt 50 bridge	Monthly samples at various depths of dissolved oxygen, pH salinity, temperature, secchi	1985-2000
AACC 2000 Anne Arundel Community College	Estuarine Portions of Watershed	Fecal coliform	1989-2000
MD-DNR 1997A (digital)	Mill Creek (1) Severn Run (11) Schultz Run (1) Un-named Trib to Deep Ditch Branch (1) Jabez Branch (1)	conductivity, pH, NO3, ANC, SO4, DOC	1997
MD-DNR 1994 (digital)	Severn Run (6) Un-named Trib to Severn Run (2) Un-named Trib to Severn Run2 (4)	temperature, conductivity, pH, NO3, ANC, SO4, DO, DOC	1994
GI 1992 Greiner Inc. for MD State Highway Admin	Above and below Rt 50 bridge on Severn River	alkalinity, NH4, metals, DO, salinity, temperature, pH, BOD, NO3, NO2, total P, turbidity, TOC, TSS, TKN	1992
MD-DNR 1991	Jabez Branch	Storm event temperature, pH, DO, conductivity, flow	1991
CEES 1992 Center for Environmental and Estuarine and Studies	Manderes Creek Hopkins Creek Severn River	Chlorophyll A, TSS, light attenutation, dissolved organic N, dissolved organic P	1991
AACC 1987 Anne Arundel Community College	Weems Creek	temperature, DO, turbidity, TDS, TSS, conductivity	1987
EPA 2001 STORET (digital)	Severn River 200 yds upstream of Rt 50	temperature, secchi, DO pH conductivity, salinity, residue, N, susp N, diss N, NO2, NO3, P, carbon, silica, Chlorophyll A, B and C, pheophtn A	1984-94
EPA 2001 STORET (digital)	Upstream of Rt 50 Bridge	temperature, turbidity, secchi, conductivity, DO, pH, salinity, residue, NH3, NH4, NO2, NO3, TKN, total P, total org C, total coliform, toxics, metals	1974-78
EPA 2001 STORET (digital)	Chesapeake Bay off Tolly Point	temperature, turbidity, N, DO NO2, conductivity, secchi, DO, salinity,NH3, carbon	1979

Source	Location	Type	Dates
		phosphorous,	
EPA 2001 STORET (digital)	Drawspan at Old Severn River Bridge	temperature, turbidity, secchi, conductivity, DO, pH, N, P, salinity, carbon, total coliform, fecal coliform, residue	1974-78

Additionally Required Data

Additional tide data for other points in the watershed may be necessary in addition to the one currently available station. The need for more complete tributary flow and pollutant loads will be determined under the watershed modeling. Salinity data at the downstream boundary was collected one day each month at various depths from 1985-2000 at a point near the Rt 50/301 bridge. Additional salinity data will need to be collected at other points in the estuarine portions of the watershed. Water quality at the upstream portions of the estuary are lacking and will need to be collected. Point source information is also lacking and will need to be researched or sampled in the field.

Additional data is hoped to be collected through continued research, specifically weather and point source discharge information. If these types of data are unavailable, field collection may be required. It is likely that additional water quality information including salinity and sediment will need to be field collected, particularly in the upper portions of the estuary.

GIS Data

Data Requirements, Presently Available Data and Additionally Required Data

As shown in Table 3, a great deal of GIS data is required to support model input. The two most important types of coverages used in most of the models are the drainage area boundaries and land use / land cover. The stream network and SWM facilities are the next most critical coverages.

Watershed and sub-basin boundaries – These coverages will be used to summarize and visualize watershed conditions in the Watershed Management Tool. They provide the first level of discretization of the watershed. The current coverage was digitized in 1995 by County staff. They are not currently digitized to the level of detail needed for this study.

Catchment boundaries – will be used as the lowest level drainage area for model input. There is no existing coverage.

Existing land use, land cover – This coverage is a key input to calculations of imperviousness, determination of runoff flows, and estimates of non-point source runoff quality. The most recent coverage was digitized by County staff (file al01204 - updated 1994). Digitizing and attribute coding were somewhat inconsistent, and not always useful for hydrologic calculations. To determine the quality of the existing data, one subwatershed (Picture Spring Branch) was updated. Changes to the boundaries will need to be made and land use will be recoded as necessary in up to 14 different categories to support hydrologic and water quality modeling.

Approved Land Use / Land Cover This coverage shows the land use changes that have been approved by County agencies but have not yet been built. It is used for modeling scenarios which help determine the cumulative effects of development in a particular area. The coverage does not currently exist and will need to be developed from the other land use coverages.

Future Land Use / Land Cover This coverage shows the land use projected at build-out, and is used for modeling scenarios which help determine the ultimate effects of development in a particular area . It does not currently exist and will need to be developed from land use, zoning, and land use plan coverages.

Soils – are needed for hydrologic modeling, to determine runoff curve numbers. No digital soils coverage has been provided, but they are in production by NRCS in digital format and delivery is anticipated in the Fall of 2001.

Sewered/unsewered Areas – This coverage will be used as an indicator of on-site sewage disposal systems that have a potential to affect groundwater and baseflow water quality. Within the Severn River watershed, the sewers file provided by Department of Public Works (sewer - updated 2001) appears to match well with the most heavily populated areas (using planimetric coverage of buildings, provided by DPW - updated 1995). However, there are large developed areas (primarily residential) for which there are no sewer lines shown.

Stream Network – The stream network is a key coverage for visualization of watershed problems and stream condition and identification of discharge points for runoff modeling. The provided stream layers (ai00912f - streams from 1995 planimetrics and ai00909f - hydrography layer from 1995 planimetrics) closely match the provided aerial images. However, the streams are broken in places when viewing either coverage separately. Combining the hydrography layer with the stream layer, provides a more complete coverage of streams. It is anticipated that some amount of digitizing will be needed to develop a connected coverage.

Storm Drain Network Storm drains will be used for determination of flow paths and calculations of Time of Concentration for hydrologic modeling. The County has scanned drawings of a portion of its storm drain networks, some of which have been digitized in vector format. This information should be sufficient for the needs of the study and no additional work is anticipated.

SWM Facilities SWM facility information is needed for detention and hydrograph attenuation for hydraulic modeling, and for pollutant load reduction for water quality modeling. SWM databases are maintained by DPW and Inspections and Permits. All County-owned ponds are digitized with approximate locations, and in some cases a more detailed Arc/INFO coverage showing locations of pond boundaries, inlets, and outlet structures is now underway. Records for privately-owned ponds are not as complete. The I&P database lists all known ponds and SWM facilities which are to be inspected by County staff. To complete the SWM coverage, facilities in the database must be georeferenced, and attribute data must be added where it does not exist.

Floodplains Floodplains are used as an indicator of potential flooding. The FEMA floodplain coverage (ai00910 - updated 1985?) and the 100-year nontidal floodplain coverages were examined for the Severn River area. The stream layer and the hydrography layer, both from the 1995 planimetrics, were overlaid on the floodplain coverages. There were several areas within the Severn River watershed where the stream appears outside of the floodplain (see attached example). In some areas, the stream and the floodplain are approximately 200 feet apart. If this coverage were to be used for analysis, this error would need to be corrected.

Culverts and Major Bridge Crossings – Culvert databases have been developed by the County for County-owned culverts. State-owned culverts are available from SHA. These coverages will be used as for data visualization and as a basis for hydraulic modeling. Field verification and updates will be required in some cases. Major bridge crossings will be identified in the field and digitized using the planimetric coverage as a base.

Wetland Areas There are three wetland coverages provided (bb02818f -updated 1996 , bb02824f - updated 1995, and bb02826f - updated 1994). The most complete coverage (bb02826f) has areas which do not match well with streams in some areas (see attached example). This coverage should be updated. Once updated, this should be used to recreate necessary buffers. The NWI wetland buffer provided (bb02815 - updated 1996) appears to be a stream buffer rather than a wetland buffer.

The most recent Odenton town center wetland coverage appears to be accurate and useable (bg03476 - updated 2001). Wetlands for this area will not need to be updated, however a buffer may need to be created using the most recent wetland coverage.

Data Updates Required

Watershed and sub-basin boundaries Approximately 80 subwatersheds have been identified using earlier studies as guidance. They are based on tributaries to the Severn, and in the case of Severn Run, on major branches. Boundaries will be delineated using the County's 1995 topography and subsequently digitized.

Catchment boundaries will be delineated and digitized. To support the detail needed for modeling and analysis, catchments will average 50 acres in size, for a total of approximately 875 catchments. They will be based on drainage areas to the headwaters of first order streams and on confluences with larger order streams.

Existing land use, land cover – The 1995 land use coverage created by the County will be used as a basis for updates. It will be overlaid on the most current orthophotography, boundaries will be changed and land use will be recoded as necessary in up to 14 different categories to support hydrologic and water quality modeling. The categories proposed are shown below. Large parcels, particularly those owned by the Federal government, will be subdivided to delineate commercial/field/forested areas.

TABLE 8: LAND USE CODE RECLASSIFICATION MATRIX

	Future Category													
Current Category	Water	Agriculture	Forest	Field	SFR Low	SFR Med	SFR High	Townhome	Multi-Family	Commercial	Industrial	Transportation	Gas/Electric	School
Agriculture		x												
Water	x													
Open Space		x	x	x										
Single Family Dwelling					x	x	x							
Townhomes								x						
Multi-Family Dwelling									x					
Retail										x				
Office										x				
Industrial											x			
Utility				x								x	x	
School														x
Recreation				x										
Vacant		x	x	x										
City										x				

Approved land use / land cover This coverage does not currently exist. It will be created by identifying approved development and adjusting polygon boundaries on the map of existing land use, if developments are sufficiently large. Otherwise, model input parameters will be revised.

Future land use / land It is proposed to use either the Zoning or Land Use Plan coverage to develop this layer by adding or changing attributes to match the land use codes in Table 8 above and making minor changes in the spatial data.

Soils are in production by NRCS in digital format. The coverage has been through several series of edits, and delivery to the County is projected for late September, 2001. They will be delivered with annotation and tables and no update work is currently proposed. No work on this coverage is proposed.

Sewered / unsewered areas are not available as a coverage. The Team will provide updated land use coverage to the County for markup of sewered areas. The Team will recode the coverage with attributes for sewered/unsewered areas. New boundaries will not be delineated.

Stream networks have been updated recently by County staff. These coverages will be checked and updated. In order to produce a continuous network where free-flowing stream segments are connected by lakes, ponds, wetlands, or bogs, these will be added based on ground truthing during the stream walk and indicated with an attribute. No mapping or ground truthing will be

done on streams other than perennial. It is assumed that an additional 5% of the 134 mile stream network will have to be digitized, or approximately 6.5 miles.

Major storm drain outfalls have been mapped by County field crews, located with GPS, and digitized. No additional work is proposed by the Team.

SWM Facilities The available information will be compiled to identify all County-owned and privately-owned ponds in the Severn River watershed which can be located in existing in County records. The location for those in the Inspections Database which have not been digitized will be researched using subdivision names and street addresses, then located in the field and mapped with GPS. Only SWM facilities with a drainage area of 10 acres or more will be mapped in the field. No office or field research will be undertaken to find facilities whose existence may not be known by the County.

Floodplains have been acquired by the County, digitized from FEMA maps. These will be overlaid on final stream coverage for visualization purposes. No changes will be made to the floodplain boundaries. Revisions to floodplain mapping are not part of the scope of this project.

Culvert databases have been developed by the County for County-owned culverts. State-owned culverts are available from SHA. The Team will obtain these coverages and ground truth them during the stream walk.

Major bridge crossings will be identified in the field during the stream walk and digitized using the planimetric coverage as a base.

Riparian buffers – The critical area zones (RCA, LCA, IDA) are available digitally. No changes will be made to these coverages. A new buffer coverage will be created in GIS at a width to be determined with County staff. This coverage will be used for riparian buffer assessments and improvements.

Shorelines are available from the County digitally. Mapping and ground truthing shorelines is not part of the scope of this project, and shoreline characteristic (bulkheads, erosion, etc.) will not be inventoried.

Wetland coverage has been acquired by the County, digitized from NWI maps. This will be overlaid on final stream coverage for visualization purposes. No changes will be made to the boundaries, since wetland delineation is not part of the scope of this project.

Imperviousness – The Team will derive a lookup table between land use and imperviousness based on sampling representative areas in each land use category. For each category, a sample area of impervious features will be digitized from the planimetric coverage and the orthophotography, then polygonized and the area calculated.

CN Values using imperviousness calculations from the previous derivation, the Team will derive a lookup table between land cover, imperviousness, and hydrologic soil group based on TR55 values.

6.0 Conclusion

6.1 Summary of Phase I

Through a collaborative effort among County staff, stakeholders, and the consultants, the Severn River Watershed Management Master Plan began to take shape in Phase I. The Public Involvement Program was begun, with two stakeholder meetings and outreach to residents through a randomly mailed public survey and fact sheet. The Watershed Management Tool was outlined in some detail, and its uses and functions were identified. The computer models needed to make decisions about the watershed were identified, including two new models not in the original scope of the study. Finally, existing data about the watershed was analyzed, compared to what is required to drive the model and the Watershed Management Tool, and a plan for data collection and updates was begun.

The Project Vision has been stated as follows:

The Watershed Master Plan will provide a blueprint and tools to facilitate land use and infrastructure decisions by County Staff and Stakeholders to protect the resources of the Severn River.

The benefits of the project have been agreed upon:

- Analyze the land and watershed environments together
- Identify and protect environmentally sensitive areas
- Balance healthy economy and environment
- Maintain Anne Arundel County's quality of life

Public Involvement

The Phase I public involvement activities focused on enhancing the data collection process. There were three elements in this phase: identifying and involving stakeholders, conducting a public survey by mail, and putting up a website. Stakeholders were introduced to the Severn River Watershed project and asked to identify environmental concerns and problems within the watershed, identify data sources that can help with various elements of the Phase II analysis, and identify additional stakeholders to participate in the project. The survey was designed to elicit information on problems in the watershed, and the website gave basic information on the study.

Participation in the stakeholder workshops was lower than anticipated, partly as a result of the meeting times on summer evenings. Results of one of the survey questions on methods of information dissemination indicated that public meetings were one of the least preferred methods. Respondents indicated that they prefer mailings, announcements in local newspapers, or the County website to receive project information. These and other outreach approaches will be incorporated into the public involvement portion of Phase II.

1.

Watershed Management Tool

The Watershed Management Tool consists of more than a software system. The elements listed below will work together to facilitate watershed management decision-making and planning activities. The GIS tool will leverage existing Anne Arundel County GIS programs such as CountyView and MapOptix, modeling programs, data, procedures, and staff where available and will enhance these existing resources with new components where necessary.

- GIS software, applications, and hardware
- GIS data
- data collection and maintenance procedures
- analysis and modeling tools
- staff

Software components of the Watershed Management Tool will consist of a comprehensive watershed database of GIS layers, field inventory data, and monitoring data; a visualization tool to graphically show the watershed database elements, and a modeling tool to allow for qualitative and quantitative analysis and "what-if" scenarios.

Once developed, the Watershed Management Tool will allow County staff to have better access to watershed data and make better use of it. This will give the County the ability to make more informed decisions and provide more consistent review and analysis among different agencies and staff. It will provide an overall watershed perspective to the plan review process which is currently not feasible. For land use planning, it will allow analysts to estimate impacts of development, understnd the impacts of land use decisions, and reassess current land use regulations and ordinances. Development reviewers will be able to use it as a desktop indicator of conditions in the vicinity of proposed development, particularly to identify problems in streams downstream of the development site. It will also allow analysis of capital improvements such as regional BMPs or stream restoration projects, and can be used to test the effects of non-structural measures to reduce runoff pollution.

Models

The wide range of analyses needed to assess a large and diverse watershed such as the Severn River calls for several categories of models. **Water quality models** will be used to estimate polluants in runoff, provide pollutant loads to other models, and estimate the benefits of BMPs. PLOAD and GWLF were the models chosen for this task. The **estuary model** simulates the fate and transport of pollutants in the tidal portion of the River. MIKE21, a proprietary model from the Danish Hydraulic Institute, was selected. **Hydrologic and hydraulic modeling** will be performed using TR-20 and HEC-RAS to assess the potential for flooding at major bridge crossings and changes in flow regime in the free-flowing tributaries. **Soil erosion** from the land surface is modeled using the Universal Soil Loss Equation, which is a component of GWLF. This model will also allow analysis of **groundwater / surface water interactions**. Finally, to

model changes in **stream condition and habitat quality** that result from changes in the watershed, a model baseed on regression analysis (WISE) will be used.

Criteria for selecting models included whether the software was proprietary, or off-the-shelf. Support by a public agency such as EPA or the Corps of Engineers was also a consideration. Models were also rated highly if they included a linkage to GIS, which simplifies incorporating them into the Watershed Management Tool. Complexity, data needs, ease of use, and skills required by the user all factored into the choice.

Watershed Data

Data needed to drive the models falls into five categories. **Stream assessment data** consist of haitat indices such as the benthic macroinvetebrate IBI or the MBSS physical habitat index, along with the raw data used to derive the indices. **Flow and weather data** include stream gage readings, annual, seasonal, and daily precipitation, and hourly data on precipitation, wind, and temperature. **Water quality data** are field and laboratory measurements of pollutants in storm water, baseflow, groundwater, and soils, and also include monitoring data from point sources such as wastewater plants and factories. **Estuary data** is needed to analyze conditions in the tidal watershed, and includes tide gage data, salinity, and water quality measurements at the interface with the Chesapeake Bay. The largest category of data is **GIS data**, which will be used as input for all of the models and for visualization of watershed conditions.

Data were obtained from Anne Arundel County, outside sources such as the USGS, and stakeholders. Other information was obtained from the public survey.

6.2 Phase II

Phase II will consist of completing development and testing of the Watershed Management Tool, and providing the data and scenarios needed to analyze alternatives for the Severn River watershed and develop a Watershed Management Master Plan. The scope and budget of this phase are still being refined. There are, however, several tasks and assumptions which have been determined and are included in this report:

- The Public Involvement Plan is discussed in Section 2.4
- An outline of the development process for the Watershed Management Tool is given in Section 4.2
- All of Section 4.0 discusses activities needed for development of the Tool
- Additional data collection and GIS data updates are summarized in Section 5.3.

Key assumptions for Phase II include the following:

- Approximately 80 subwatersheds will be delineated and used for summarizing watershed conditions and forecasts. These consist of tributaries, and in the case of Severn Run, subdivisions by major branches.

- Approximately 875 catchments will be delineated for modeling and detailed reporting. The number was derived by using an average size of 50 acres, which will allow flows and pollutant loads to all first order streams to be modeled.
- An initial field walk will be made on all the perennial streams. 134 miles of streams were measured using the planimetric coverage, and it is assumed that missing sections will bring the total to 140 miles.
- Stream assessments using MBSS will be conducted at approximately 200 stations in the whole watershed, to be identified during the stream walk. Physical assessment will be done with Rosgen Level II methods. A subset of 15 stations in Jabez Branch and two others will be done first, to provide data needed to develop the habitat assessment model (WISE) and to assist in development of the Watershed Management Tool.
- Estuary modeling (MIKE21) will be conducted using no more than 200 segments. Bathymetry will be taken from existing NOAA or USGS data.
- Wet weather sampling has been proposed, to increase the data available for modeling water quality (PLOAD) and habitat assessment (WISE). Five events at 3 sites will be collected, using one crew to collect grab samples and automated samplers for composites.
- HECRAS modeling will be done for a 25-mile subset of the streams in the watershed. This subset will cover Jabez Branch, two other subwatersheds, and the major bridge crossings in the remainder of the Severn watershed. Cross sections will be taken from topography and bridge openings will be measured in the field, but no field-run survey is being proposed other than what is already proposed to support other applications.
- A total of 10 modeling scenarios proposed for each subwatershed. These consist of different mixes of land use and BMPs, done during two different tasks. In Task 4, when models are developed, the land use scenarios with existing BMPs will be run. In Task 7, several scenarios of different BMPS will be run to investigate management alternatives. The table below summarizes the scenarios, showing which scenarios will be done in each task.

	Land Use Scenarios	
BMPs	**Existing**	**Future**
Existing	4	4
All Structural	7	7
All Land Use	7	7
All Non-Structural	7	7
Best Mix	7	7

For these scenarios, structural BMPs include ponds, stream restoration, rain gardens, and other devices which are constructed and maintained. Land use BMPS are those which involve changes in how development occurs, such as rezoning or cluster development. Non-structural BMPs include activities such as public education, street sweeping, or buffer creation.

All scenarios would be run for all the models except the estuary model. Only the two scenarios with existing BMPs done in Task 4 are planned.