Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina

Prepared by

NC Geographic Information Coordinating Council
and
NC Department of Environment and Natural Resources

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EXECUTIVE SUMMARY

Why was this study performed?

In recent years, the State of North Carolina and its citizens have placed added emphasis on issues concerning water quality, resource viability, and potential impaired conditions of streams, rivers, and lakes. As a result, legislation, administrative rules and other legal mechanisms for stream corridor protection have been implemented to maintain a high quality of living, natural resource stewardship, and positive economic climate. Some desired outcomes of these actions include improvement to water quality, better conservation of water resource supplies, improvements to wildlife and aquatic species, and mitigation of downstream effects from wetland impacts and stormwater.

The added focus on stream corridor protection and the associated rules have increased the demand and requirements for stream mapping, beyond a relied upon traditional resource. The popular statewide map series from the 20th century, "topographic maps" produced by the U.S. Geological Survey (USGS), show stream locations but the content no longer serves today's requirement for detail in the local landscape and in the upper reaches of the stream tributary network. *As an example, it is estimated that 50% of all points statewide where a perennial stream changes to an intermittent stream are not characterized by any type of stream feature on the USGS map.* Furthermore, USGS has suspended its maintenance of the traditional map product and unfortunately, no better map is available statewide.

Still, planners, transportation engineers, regulators, and natural resource representatives of government organizations and members of the private sector rely on the USGS map as the best available product statewide. Specific deficiencies, in the context of today's information requirements, are that the maps are outdated, inaccurate, incomplete, and lack uniformity across jurisdictions. Representatives of the USGS will be the first to point out that the mapping conducted by their bureau over the course of six decades was never intended to be utilized for regulatory purposes. Most counties in North Carolina now maintain digital mapping of streets, property boundaries, and aerial imagery at a mapping scale of 1:2,400, or 10 times more detailed than that of the USGS base map. The primary reasons that the state is considering a departure from the traditional USGS map series as a resource for stream mapping are listed in the following requirements:

- Increase the quality and content of mapping, especially in upper reaches of the watersheds so that all regulated streams and water bodies are mapped and available on the Internet (through NC OneMap)
- Provide uniform mapping across all jurisdictions in the state resulting in an extraordinary opportunity for better decision making, closer collaborations on cross-jurisdictional initiatives and better use of resources.
- Develop a resource that reflects current streams and lake locations in the landscape to enhance efforts to avoid wetlands in the planning of public-private facilities.
- Implement a plan to maintain and update the content as conditions change in the landscape thereby preserving North Carolina's investment.

- Utilize larger, more detailed mapping scale to complement the mapping systems managed by local governments (mapping scales of 1:1,200) for local planning efforts.
- Improve accuracy and uniformity of stream mapping by utilizing (leveraging) the State's recent investment in statewide elevation data (using LIDAR technology), and the aerial image resources of counties and the state.

The Stream Mapping Study has been performed in response to Senate Bill 1152, known as the "Studies Act of 2004". This Senate Bill was ratified by the North Carolina General Assembly in the summer of 2004. Part XXXIII of the Bill includes the following needs:

- **Section 33.1** – "The Geographic Information Coordinating Council and the Department of Environment and Natural Resources shall develop and recommend a plan to improve the mapping and digital representation of surface waters in North Carolina, including intermittent and perennial streams, lakes, and ponds, to the General Assembly and the Environmental Review Commission on January 15, 2005."

- **Section 33.2** – "The plan shall include at a minimum: mapping specifications and standards; estimated budget and schedule for statewide implementation; and entry of the data into NC OneMap."

- **Section 33.3** – "The Geographic Information Coordinating Council and the Department shall include at a minimum the Division of Emergency Management in the Department of Crime Control and Public Safety, the Department of Commerce, the Department of Transportation, and the US Geological Survey in the development of the plan."

- **Section 33 . 4** – "The General Assembly encourages municipalities and counties to share the mapping and digital representation of surface waters that they have developed with the Geographic Information Coordinating Council, NC OneMap, and the public."

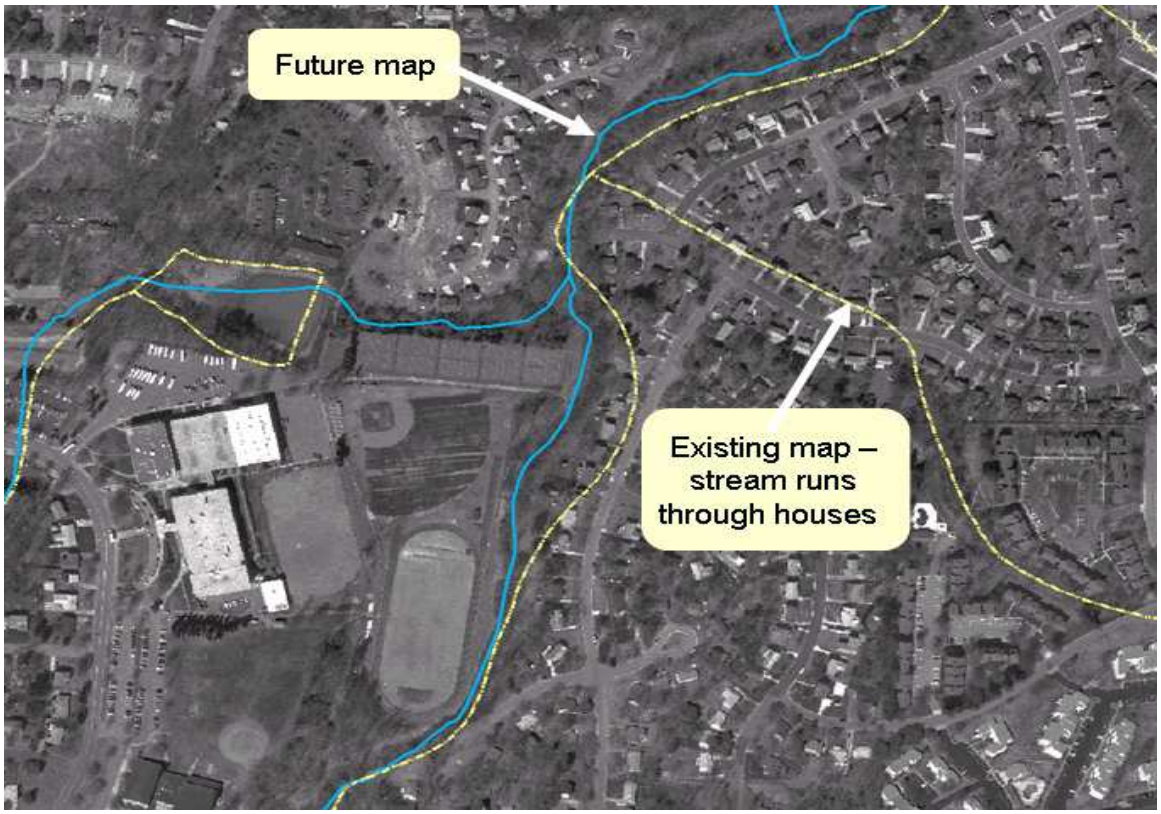
[Note: NC OneMap is the geographic data resource available over the Internet that allows the user to view city, county, regional, state, and federal geographic information such as orthophotography, roads, rivers and streams, and parcel boundaries seamlessly for decision making and other purposes. It is managed by the Center for Geographic Information and Analysis.]

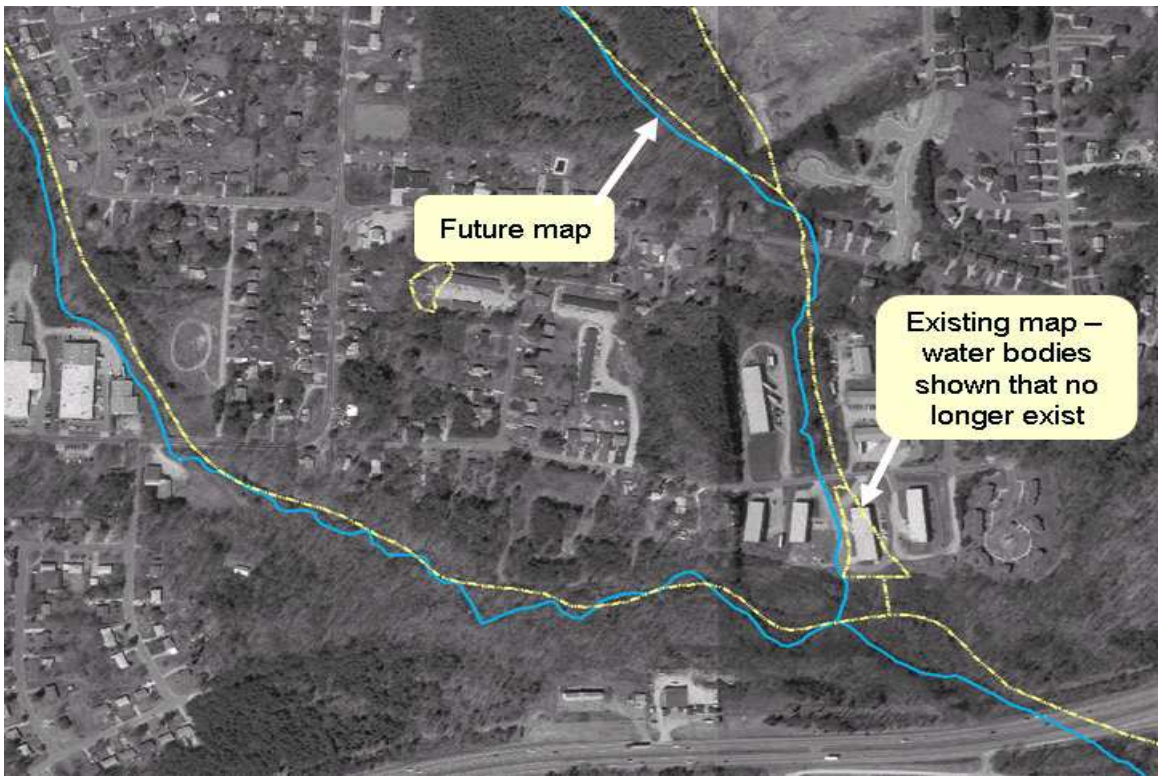
The purpose of the Stream Mapping Study is to develop an implementation plan to improve the mapping and digital representation of surface waters in North Carolina. This study is a collaborative effort of local, state, and federal agencies. Insights provided by these agencies have been combined into this document to create a strategy for the project.

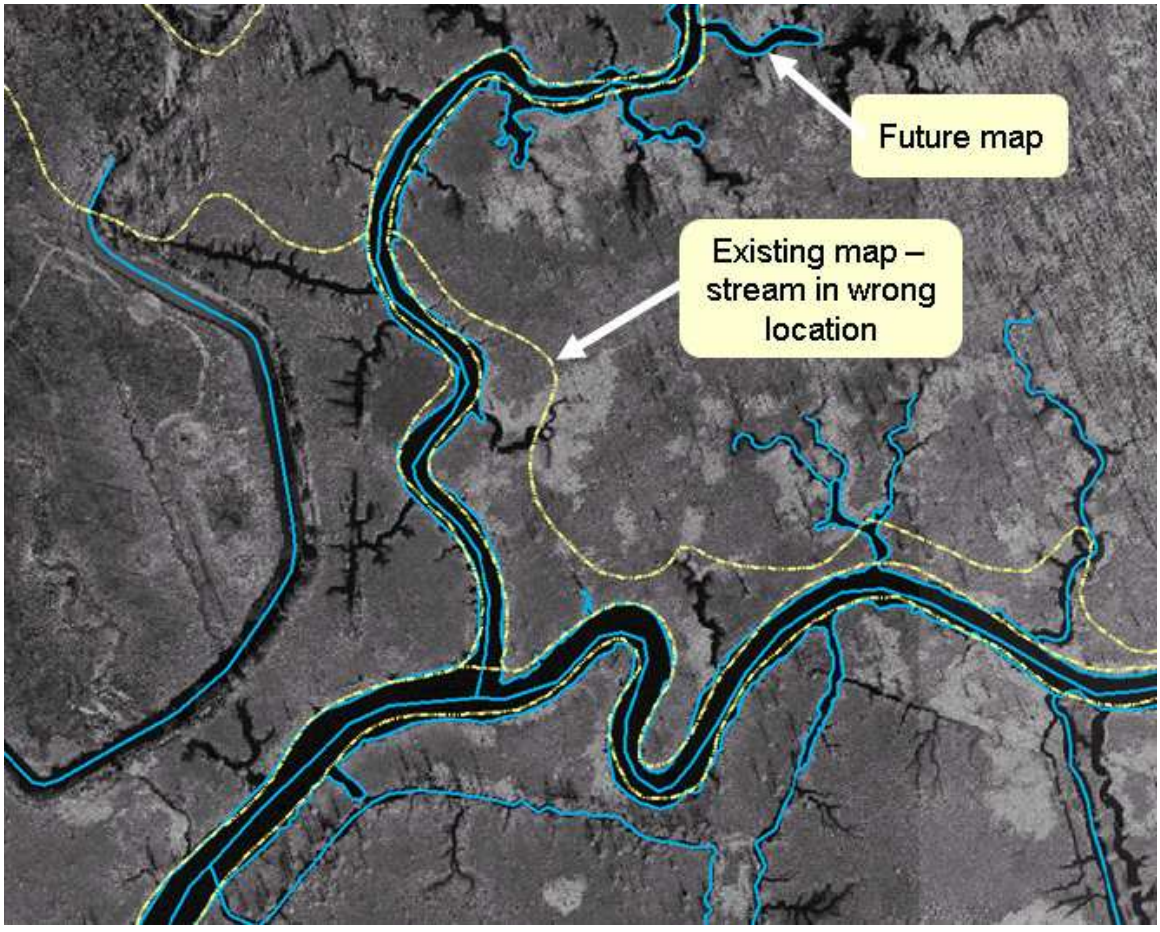
The General Assembly and the Environmental Review Commission will review the implementation plan and decide what action(s) should be taken to make the recommended improvements. **The potential end result for the Stream Mapping Study is a statewide project leading to a digital surface waters file that can be effectively used and maintained by federal, state and local government agencies as well as the public.**

What are the existing problems with the current data?

One of the most common problems with the existing mapping used is horizontal accuracy. Horizontal accuracy refers to the mapped location of a streamline as compared to the actual location of the stream on the Earth's surface. **The pictures below display horizontal accuracy problems with current data versus the stream data that would be used as a basis for the Stream Mapping Project.**




Future map
Existing map – water bodies shown that no longer exist


Future map
Existing map – stream in wrong location

Additional Problems:

- Much of the existing data is not maintained and is out of date
- Some of the existing maps do not contain water body features such as lakes and ponds
- Some of the existing maps do not contain coastlines and sounds
- Much of the existing data is not uniform or complete which requires agencies to expend significant resources in data validation before starting projects
- Multiple stream files are used by individual agencies
- Duplicate mapping efforts resulting in conflicting information and increased maintenance costs

What are the benefits of doing this project?

This initiative emphasizes the value of a new statewide digital surface waters file for partners as well as the general public. A shared vision supported by common goals ensures a product that will be beneficial to all parties. The creation of a new statewide digital surface waters file provides numerous financial and time saving benefits to individual agencies. **These benefits promote and enhance business practices as well as the quality of data produced by these agencies for analytical and regulatory purposes. This ultimately translates into better management of our natural and built environments supporting the continued economic health of North Carolina.**

The following list of quantified benefits represents examples of the savings that will result from investment in a new digital surface waters file.

Reason 1 –NC Department of Transportation (NCDOT), NC Ecosystem Enhancement Program (NCEEP), Wetlands Mitigation

Over the next three years, NCDOT anticipates needing approximately 1.5 million feet of stream mitigation for project impact. Currently the existing U.S. Geological Survey (USGS) 1:24,000-scale hydrology maps are considered the best available stream data for doing this analysis. **Since mitigation is costly (average cost is $205 per linear foot), and because mitigation is provided at a 2:1 mitigation to impact ratio, small changes in the impact projections (or accuracy of the stream data) will result in large changes in the amount of money committed to implementing mitigation.** Overestimates in mitigation projections may result in money being unnecessarily spent (because the mitigation credits would not actually be needed). Underestimates of mitigation projections could result in permitting delays or road construction delays (because insufficient mitigation credits were developed).

For example, if the current stream maps underestimate the actual linear footage of a stream by twenty percent, NCDOT could seriously underestimate projected impacts. **Considering that current mitigation estimates fall around 1.5 million feet for the next three years, a twenty**

percent underestimation would mean that an additional 300,000 linear feet of stream would need mitigation. That would be approximately 100,000 linear feet a year, or an additional $20 million worth of restoration each year. In this example, inaccurate mapping would result in the potential for unexpected expenses.

Better stream maps will not only allow NCDOT to provide NCEEP with better estimates for the type and quantity of mitigation needed, they will allow NCEEP to become more efficient in providing mitigation. Inaccuracies in the maps result in staff time spent correcting stream location, verifying stream type, or verifying that a stream even exists on a site. **If the new maps were to produce just a two percent increase in NCEEP staff efficiency during the next three years, NCEEP could provide approximately an additional 30,000 additional feet of stream mitigation credits to meet NCDOT's needs. The additional mitigation credits would be worth approximately $6,150,000.**

Reason 2 – City of Durham

Review and approval of site plans would take staff less time to complete. Currently City staff regulates Neuse Basin buffers according to streams shown on the USGS and Soil Survey maps. If the map is inaccurate the owner has to request that NC Division of Water Quality (NCDWQ) perform a field assessment, and then must provide the City with written documentation from the NCDWQ before plan approval can progress.

Additionally, with the forthcoming Cape Fear Watershed regulations, the City may be put in a position that will require increased staff to field verify stream conditions for each site plan submitted for review/approval. On average the City receives 800 to 1,000 site plans per year. It is estimated that it may take four hours per plan to conduct field verification. By applying a 20% multiplier to account for multiple streams per site, it can be forecast that up to 4,800 hours of additional work per year that would need to be performed by City staff at forecasted annual cost of $215,730. **The new statewide digital surface waters file would save the City of Durham $215,730 per year.**

Reason 3 – NC Wildlife Resources Commission (NCWRC)

Environmental permit review time spent by the Commission would be reduced. NCWRC staff currently spends 1,568 days to handle 2,746 permits. These numbers are based on 2003-2004 data provided by the NCWRC. Review time would be reduced by 15 minutes per permit. The total time savings is 686.5 hours. The review labor rate is $30 per hour. **The new digital surface waters file would save the NCWRC $20,595 per year.**

Reason 4 – U.S. Geological Survey (USGS)

The value of science and other partnership dollars to the State, or for joint Federal agency projects that will be of benefit to the State, could be significantly delayed or lost without supporting base data such as the 1:24,000-scale National Hydrography Dataset (NHD). The time to accomplish the work involved in calculating flood frequency statistics at an ungaged site on a stream could be cut from 16 hours of manual calculation to 15 minutes with statewide coverage

of the 1:24,000-scale NHD available for computer processing. **At a burdened $60.00 per hour for a hydrologic technician, that is a difference in dollars of $960.00 per manual calculation versus $15.00 per computer calculation.**

Reason 5 – NC Department of Environment and Natural Resources (NCDENR), Division of Water Quality (NCDWQ)

Considerable cost savings would be realized by the applicants and environmental consultants who prepare the applications and plans for NCDWQ reviews. Private consultants would no longer need to make approximately 2,000 site visits (out of the 5,000 estimated visits made by consultants) per year since they would be able to rely on the perennial and intermittent depiction of a stream provided by the new stream mapping. **At a rate of $75 per hour and assuming a three-hour site visit (including travel time), this leads to a possible savings of $450,000 to the development community if a new stream map was available.**

Reason 6 – NC Department of Commerce

The NC Department of Commerce depends heavily on geographic information system (GIS) data for strategic thinking and decision support. Even though the Department would not utilize the new digital surface waters file for the purpose of permitting, site review, or mitigation, the Department of Commerce would reap the benefits of its partners in economic development having the ability to accurately depict North Carolina's surface waters. The statewide digital surface waters mapping product would provide Commerce and its allies with the ability to make better and more accurate decisions when siting a building or making an important community development decision. It will also better protect the environment by allowing these decisions to be made prior to the commitment by the industry, thus avoiding unforeseen surface water impacts. It is critical for North Carolina to develop and maintain a new digital surface waters file.

The following list shows other agencies and organizations that will benefit from the Stream Mapping Project. Many of the State departments contain several subgroups that will benefit as well:

- League of Municipalities
- City of Charlotte
- NC Department of Crime Control and Public Safety
- NC Department of Transportation
- NC Floodplain Mapping Program
- NC Division of Coastal Management
- NC Center for Geographic Information and Analysis
- NC Geodetic Survey
- NC Geological Survey
- US Fish and Wildlife Service
- North Carolina State University

Additional Benefits Include:

- Better stream maps
- Fewer field visits
- Improved mitigation planning
- Public access through NC OneMap
- Enhanced modeling
- Improved permitting
- Improved capital improvement projects
- Better protection of wildlife habitats
- Building block for other data
- Preventing project delays
- More efficient resource allocation
- Similar projects not necessary
- Enhanced emergency response
- Better water quality monitoring
- More accurate stream buffer regulations
- Watershed boundary delineation
- Analysis and design of stormwater projects
- Stream restoration
- Improved wetland mapping
- Water supply planning

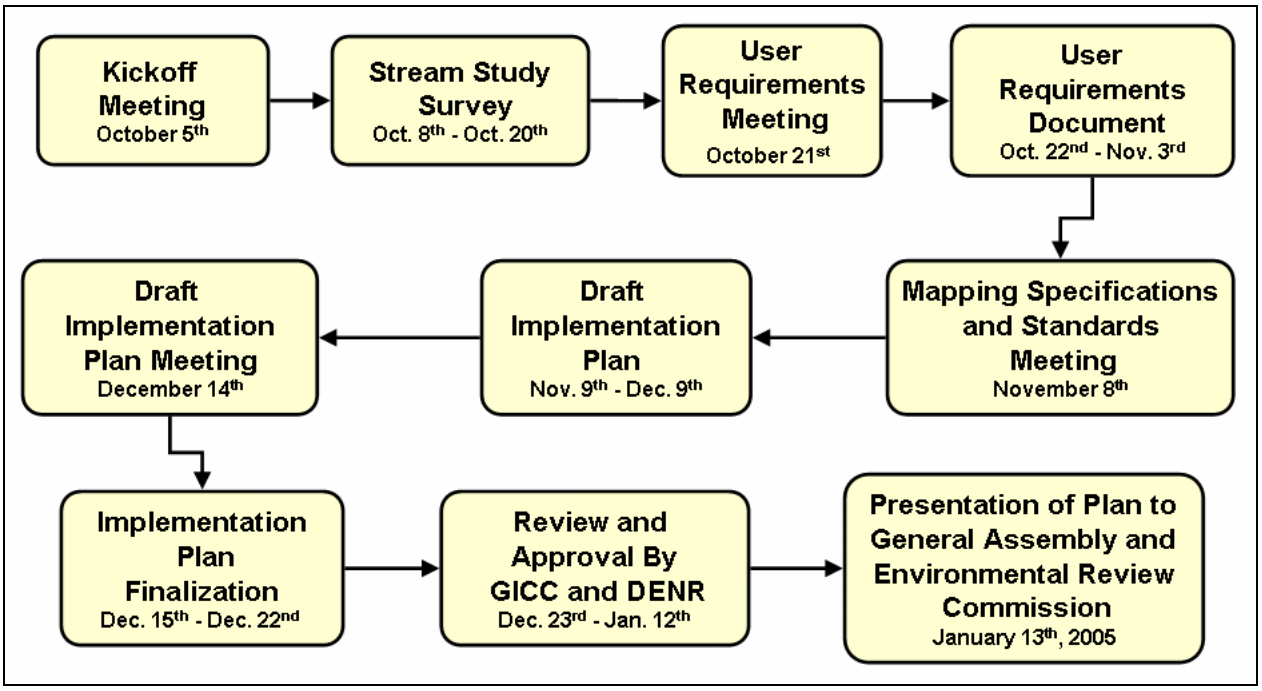
How was the plan developed?

To develop an effective implementation plan, the Geographic Information Coordinating Council (GICC) and the Department of Environment and Natural Resources established a Stream Mapping Working Group (Working Group). **This group was formed to help gather information and provide unique perspectives into the creation of the statewide digital surface waters file.**

A series of meetings to determine user requirements, mapping specifications, and implementation options was facilitated, supplemented by a formal survey to members of the Working Group. The survey included questions regarding current stream maps and digital stream files, uses of stream data, geographic information system related questions, data maintenance, funding, and general information about each agency. The surveys create the foundation for the user requirements analysis. The User Requirements Meeting gave members of the Stream Mapping Working Group an opportunity to discuss survey results and identify

critical user needs that should be considered into the design of the final statewide digital surface waters file. The Mapping Specifications and Standards Meeting focused on determining the design of the new statewide surface waters file to meet the requirements stated in the document. The Implementation Options Meeting focused on the individual agency benefits of the new digital surface waters file.

The process used to develop this entire report is shown in the following flow chart. **The following chart provides an overview of the process from inception of the Stream Mapping Study to the presentation of the implementation plan to the General Assembly and the Environmental Review Commission.**



A case example was selected for evaluating and validating certain costs for improved stream mapping. The City of Greensboro recently completed a study of intermittent and perennial streams. This study identified and mapped approximately 40 square miles of intermittent and perennial streams in water supply watersheds. Field visits were conducted to locate actual points on the ground (breakpoints) where streams changed from intermittent to perennial. This was a $400,000 to $450,000 effort that was finalized in July of 2003. The results of the study were provided to the Stream Mapping Working Group by the City of Greensboro for analysis. The results showed that using a drainage area requirement for mapping the headwaters of streams will capture a large majority of intermittent streams. This analysis represents a cost effective in-office method for mapping intermittent streams.

Who were the key stakeholders in the plan development?

The vision driving the study is one of interagency cooperation to facilitate data sharing and use. The key stakeholders are the members of the Stream Mapping Working Group. Included in the Working Group are members of the GICC, SMAC, and the Local Government Committee (LGC) of the GICC, as well as other agencies that consistently use stream maps and digital stream files in daily business practices. The stakeholders listed in Senate Bill 1152, as well as various local, state, and federal agencies, and other organizations have participated in the creation of the implementation plan. The insights provided by these agencies and other organizations have been crucial to making this study a success.

City of Charlotte
City of Durham
City of Greensboro
City of Raleigh
City of Wilson
Buncombe County
Haywood County
Henderson County
Rutherford County
Surry County
Wake County
Land-of-Sky Regional Council
NC Department of Agriculture
NC Department of Commerce
NC CCPS- Floodplain Mapping Program
NC DENR-Center for Geographic Information and Analysis
NC DENR-Coastal Management
NC DENR-Ecosystem Enhancement Program
NC DENR-Land Resources
NC DENR-Water Quality
NC DENR-Water Resources
NC Land Records Management Division
NC Department of Transportation
NC League of Municipalities
NC Wildlife Resources Commission
Clean Water Management Trust Fund
US Army Corps of Engineers
US Department of Agriculture-NRCS
US Environmental Protection Agency
US Fish and Wildlife Service
US Geological Survey
North Carolina State University
URS Corporation
Watershed Concepts, Inc

What is the recommended action plan?

The North Carolina Stream Mapping Project should be completed in five phases, with each phase adding a greater level of detail and utility to the map. The first two phases shall consist of the completion of the 1:24,000-scale NHD data for North Carolina and the incorporation of the North Carolina Floodplain Mapping Program stream data. Phases 3 through 5 consist of the development and implementation of the North Carolina Stream Mapping Project.

- Phase 1A – Completion of the ongoing 1:24,000-scale NHD data for the State of North Carolina.
- Phase 1B – Design and development of the geodatabase and software tools.

- Phase 1C – Continuing public outreach and education on the uses, purposes, and value of the new statewide digital surface waters file.
- Phase 2 – Incorporation of the North Carolina Floodplain Mapping Program stream data.
- Phase 3 – Extend the mapping created from Phase 2 upstream to the 20-acre drainage area requirement.
- Phase 4 – Extend the mapping created from upstream of Phase 3 to the 6-acre drainage area requirement.
- Phase 5 – Maintenance of the data beginning in the second year and beyond.

Phase 1A will complete a valuable interim product in the 1:24,000-scale NHD data. This was the viewpoint of the stakeholders on the Working Group. Phase 1B develops the database design and software that will support Phases 3 through 5 later in the Stream Mapping Project and is therefore a key step in the five-phase effort. Phase 1C, public outreach and education, is critical to the overall success of the Stream Mapping Project. As the NHD is finalized in Phase 1, users of this data will need to become aware of its utility and value in meeting their needs. This will be accomplished through an intensive public outreach effort. During the latter phases of the project, public outreach will also be important as a means of conveying the value and usefulness of the 20-acre and 6-acre mapping products, respectively, to the users and the public.

The Stream Mapping Working Group recommends using a 6-acre drainage area as the eventual, standard mapping product, which will meet the majority of the study's requirements in the most cost effective manner. This 6-acre drainage area will capture 95% of intermittent and perennial streams based on analysis of the City of Greensboro example cited earlier. To capture 100% of the intermittent and perennial streams, extensive field work to walk the length of every stream would need to occur. This cost has been estimated at over $500 million statewide and is therefore considered cost prohibitive.

The project team will evaluate the state-of-the-art with respect to stream mapping as the project moves through Phases 2 through 5. Current research into improved methods and techniques will be examined during these phases to potentially save cost and improve the overall product.

Cost Estimate

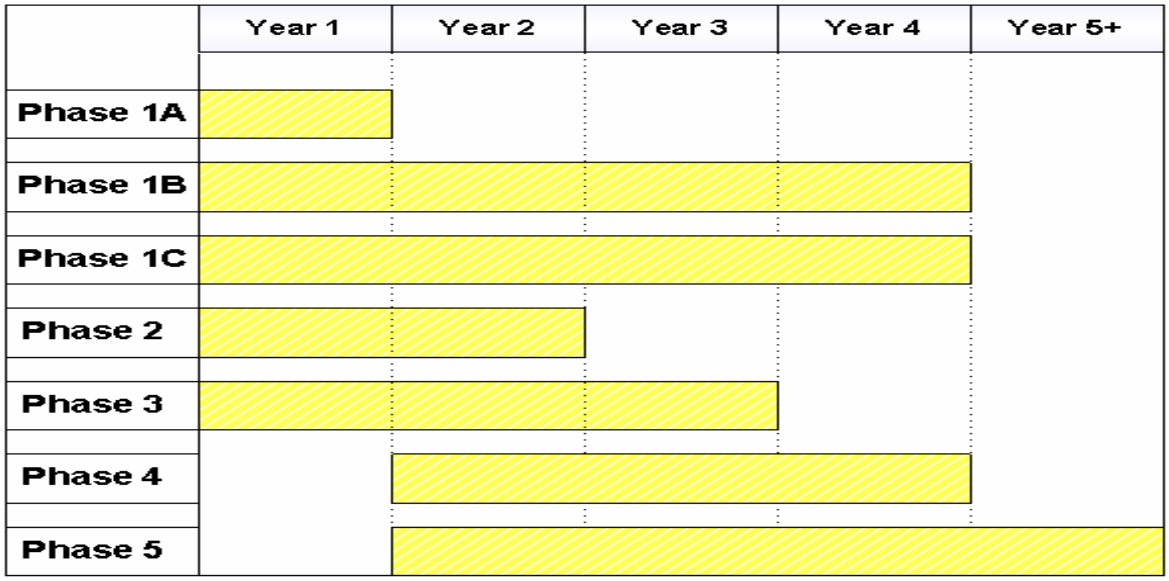
The total cost for the Stream Mapping Project is $16,236,500. It consists of $13,900,000 in development costs and $2,336,500 in maintenance cost over a five-year period. The cost estimate for the Stream Mapping Project has been computed according to the five project phases. The project will leverage significant investments that have been made in LIDAR (for defining detailed elevations for floodplain mapping) by the state and aerial imagery (or orthophotography) by local governments in developing improved stream mapping for North Carolina.

Completion of the project in phases allows for an interim product to be produced and utilized while a more detailed product is being created.

Phase	Description	Total Cost	Program Year				
			Year 1	Year 2	Year 3	Year 4	Year 5+
Phase 1A	Complete Ongoing 24K NHD Data Project	$900,000	$900,000	$0	$0	$0	$0
Phase 1B	Design and Development of Geodatabase and Software Tools	$860,000	$345,000	$415,000	$50,000	$50,000	$0
Phase 1C	Public Outreach and Education	$640,000	$160,000	$160,000	$160,000	$160,000	$0
Phase 2	Incorporate NC Floodplain Mapping Program Stream Data	$1,200,000	$720,000	$480,000	$0	$0	$0
Phase 3	Extend Dataset to 20-Acre Drainage Area	$5,600,000	$560,000	$2,800,000	$2,240,000	$0	$0
Phase 4	Extend Dataset to 6-Acre Drainage Area	$4,700,000	$0	$140,000	$1,760,000	$2,800,000	$0
TOTAL DATA GENERATION COST		$13,900,000	$2,685,000	$3,995,000	$4,210,000	$3,010,000	$0
Phase 5	Maintenance of the Data	$2,336,500	$0	$268,000	$364,500	$314,000	$1,390,000

Schedule

The total timeframe for completion of the project is four years, with maintenance of the data beginning in the second year and continuing through the fifth year and beyond.



Alternative Cost Estimate and Schedule

There is a lower cost alternative for completing the Stream Mapping Project. This alternative will improve the accuracy of the current stream mapping but stops short of capturing intermittent and perennial streams. It is less expensive but it will not meet the requirements that NCDWQ and NCDOT stated during the Stream Mapping Study.

The total data generation cost for this alternative is $4,166,000 spread over four years, although the effort could occur over three years. The maintenance cost is an additional $943,100 over four years.

The overall cost (mapping and maintenance) is $2,313,000 in the first year, $1,541,000 in the second year, $834,500 in the third year, and $420,600 in the fourth year for a total four-year expenditure of $5,109,100. This compares to the total cost of $16,236,500 for mapping that captures intermittent and perennial streams. The following table summaries the annual cost of this alternative.

Phase	Description	Total Cost	Program Year			
			Year 1	Year 2	Year 3	Year 4
Phase 1A	Complete Ongoing 24K NHD Project	$900,000	$900,000	$0	$0	$0
Phase 1B	Design and Development of Geodatabase and Software Tools	$646,000	$273,000	$273,000	$50,000	$50,000
Phase 1C	Public Outreach and Education	$420,000	$120,000	$120,000	$120,000	$60,000
Phase 2	Incorporate NC Floodplain Stream Data	$2,200,000	$1,020,000	$880,000	$300,000	$0
TOTAL DATA GENERATION COST		$4,166,000	$2,313,000	$1,273,000	$470,000	$110,000
Phase 3	Maintenance of the Data	$943,100	$0	$268,000	$364,500	$310,600

The Stream Mapping Study was performed in response to Senate Bill 1152, known as the "Studies Act of 2004". The purpose of the study was to develop an implementation plan to improve the mapping and digital representation of surface waters in North Carolina. Insights provided by the agencies that participated on the Stream Mapping Working Group have been combined into this document to create a strategy for the study and have been crucial to making this study a success. The creation of a new statewide digital surface waters file provides numerous financial and time saving benefits to individual agencies. These benefits promote and enhance business practices as well as the quality of data produced by these agencies for analytical and regulatory purposes.

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1 Introduction

1.1 Background Information

In recent years, the State of North Carolina and its citizens have placed added emphasis on issues concerning water quality, resource viability, and potential impaired conditions of streams, rivers, and lakes. As a result, legislation, administrative rules and other legal mechanisms for stream corridor protection have been implemented to maintain a high quality of living, natural resource stewardship, and positive economic climate. Some desired outcomes of these actions include improvement to water quality, better conservation of water resource supplies, improvements to wildlife and aquatic species, and mitigation of downstream effects from wetland impacts and stormwater.

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- Develop a resource that reflects current streams and lake locations in the landscape to enhance efforts to avoid wetlands in the planning of public-private facilities.
- Implement a plan to maintain and update the content as conditions change in the landscape thereby preserving North Carolina's investment.

- Utilize larger, more detailed mapping scale to complement the mapping systems managed by local governments (mapping scales of 1:1,200) for local planning efforts.
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- **Section 33.2** – "The plan shall include at a minimum: mapping specifications and standards; estimated budget and schedule for statewide implementation; and entry of the data into NC OneMap."

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- **Section 33 . 4** – "The General Assembly encourages municipalities and counties to share the mapping and digital representation of surface waters that they have developed with the Geographic Information Coordinating Council, NC OneMap, and the public."

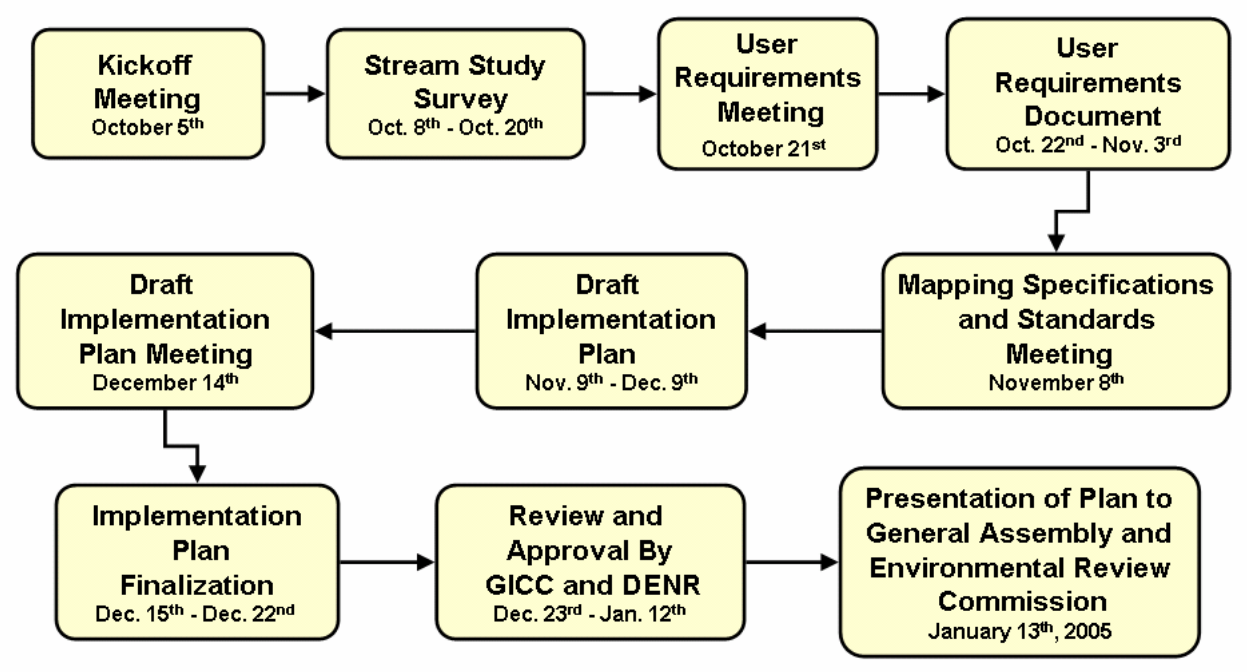
As discussed in Senate Bill 1152, the term "surface waters" encompasses all surface waters including perennial and intermittent streams, as well as lakes and ponds. In order to simplify the broad nature of the term surface waters, the term "stream" has been used in its place in portions of this document. The Stream Mapping Study survey described in Section 2.2 includes a caveat that the term stream has been used in place of surface waters. It was noted in the User Requirements Meeting described in Section 2.3 that the term stream would be used to describe the surface waters file for meeting purposes. The term "stream" has been used to identify existing maps and digital data that contain water bodies and coastlines as well as actual stream lines. Any references to the final statewide digital file will use the term surface waters.

In order to effectively assess and incorporate user requirements in the implementation plan, the Geographic Information Coordinating Council (GICC) and the Department of Environment and Natural Resources (DENR) has tasked the Statewide Mapping Advisory Committee (SMAC), with the creation of the Stream Mapping Working Group (Working Group). Included in the Working Group are members of the GICC, SMAC, and the Local Government Committee (LGC) of the GICC, as well as other agencies that consistently use stream maps and digital stream files. The purpose of this group is to help gather information for the North Carolina

Stream Mapping Study. This group of individuals has vast experience working with North Carolina stream and surface waters data for various regulatory and analytical purposes. The roster of the Stream Mapping Working Group members is included in Appendix A. The members of the GICC, SMAC, and LGC are denoted with asterisks in the roster.
As set forth by Senate Bill 1152, NC OneMap will be the distribution center for the digital data. According to NC OneMap's vision statement listed on www.nconemap.com, this site is a "comprehensive statewide geographic data resource." The digital data housed on this website "provide information to support the daily business processes of numerous organizations and their functions." Some examples of data currently found on NC OneMap are tax parcels, roads, municipal and county boundaries, orthophotography, and soil types.

The process used to develop this entire report is shown in the following flow chart. Figure 1-1 provides an overview of the process from inception of the Stream Mapping Study to the presentation of the implementation plan to the General Assembly and the Environmental Review Commission.

Figure 1-1
Review of Process for the Stream Mapping Study



1.2 Objectives

1.2.1 Purpose

The State of North Carolina Stream Mapping Study is an initiative whereby the end result will be an implementation plan for improving the mapping and digital representation of surface waters

in North Carolina. The General Assembly and the Environmental Review Commission will review the implementation plan and decide what action(s) should be taken to make the recommended improvements. The potential end result for the Stream Mapping Study is a statewide project leading to a digital surface waters file that can be effectively used and maintained by federal, state and local government agencies as well as the public. Watershed Concepts has been contracted by the North Carolina Department of Environment and Natural Resources (NCDENR) to assist in writing the implementation plan and to facilitate a series of meetings to determine user requirements, mapping specifications, and implementation options.

1.2.2 Scope

The task consists of the preparation of a plan to develop an enhanced statewide digital stream and water body coverage for the Geographic Information Coordinating Council and the NC Department of Environment and Natural Resources. The implementation plan will include but will not be limited to the following:

- Data needs determination
- Mapping specifications and standards
- Project phases
- Data maintenance
- Schedule of completion
- Cost estimate analysis

1.3 Acronyms and Definitions

Table 1-1
Acronym List

Acronym	Full Name
DEM	Digital Elevation Model
DLG	Digital Line Graph
DOQQ	Digital Orthophotography Quarter Quadrangle
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
GICC	Geographic Information Coordinating Council
GIS	Geographic Information System
GNIS	Geographic Names Information System
GUID	Globally Unique Identifier
HUC	Hydraulic Unit Code
IT	Information Technology
LGC	Local Government Committee
LIDAR	Light Detection and Ranging
NCCGIA	North Carolina Center for Geographic Information and Analysis
NCCWMTF	North Carolina Clean Water Management Trust Fund
NCDA	North Carolina Department of Agriculture
NCDCM	North Carolina Division of Coastal Management

Acronym	Full Name
NCDEM	North Carolina Division of Emergency Management
NCDENR	North Carolina Department of Environment and Natural Resources
NCDOT	North Carolina Department of Transportation
NCDWQ	North Carolina Division of Water Quality
NCDWR	North Carolina Division of Water Resources
NCEEP	North Carolina Ecosystem Enhancement Program
NCFMP	North Carolina Floodplain Mapping Program
NCGS	North Carolina Geological Survey
NCSU	North Carolina State University
NCLOM	North Carolina League of Municipalities
NCWRC	North Carolina Wildlife Resources Commission
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NHP	Natural Heritage Program
NRCS	Natural Resources Conservation Service
QA/QC	Quality Assurance / Quality Control
SMAC	Statewide Mapping Advisory Committee
TIGER	Topologically Integrated Geographic Encoding and Referencing
TIN	Triangular Irregular Network
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Definitions

Accuracy – measures how close an average of measurements lie to a true or accepted value. See Figure 1-2 for comparisons between accuracy and precision.

Breaklines – lines on the earth's surface having a known elevation and positional coordinates. Breaklines are used to indicate abrupt changes in elevation, and are used to adjust other data to account for distortions in terrain. Breaklines can be two or three dimensional.

Consistency – an agreement or logical coherence among things or parts. Consistency also refers to reliability or uniformity of successive results or events.

Digital Line Graph (DLG) – United States Geological Survey (USGS) defines DLGs as digital vector representations of cartographic information derived from USGS maps and related sources.

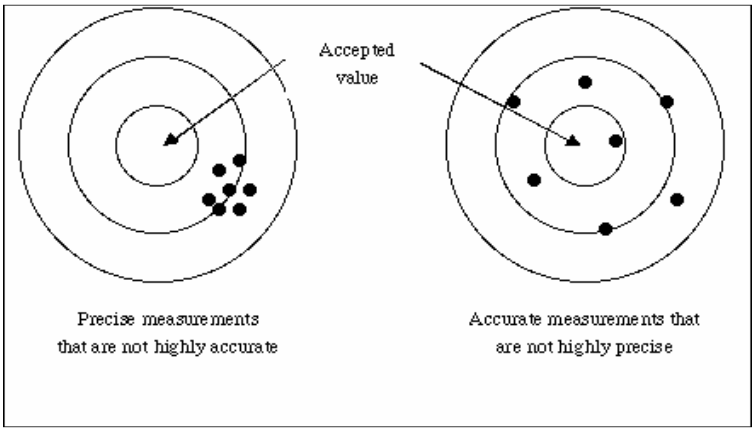
Light Detection and Ranging (LIDAR) – the technology of using pulses of laser light striking the surface of the earth and measuring the time of pulse return. LIDAR can collect terrain data of steep slopes and shadowed areas, and also has the ability to capture intensity reflectance data in

addition to x-y-z coordinates. LIDAR data is well-suited for making digital terrain models (DTM) and for topographic mapping.

Precision – how close all measurements are to one another, as opposed to the true or accepted value. Precision is a measurement of how closely the analytical results can be duplicated.

Resolution – refers to the sharpness and clarity of an image. Resolution is often classified as high, medium, or low. The amount of detail found in one pixel of the image. For example an image with one meter resolution means that each pixel in the image represents one square meter on the ground.

Figure 1-2
Difference between Precision and Accuracy of Measurements



1.4 References

The web pages listed below contain information pertaining to the Stream Mapping Study including study participants, the user requirements survey, data distribution, stream definitions, references for documents listed in the appendices, and references for graphics used.

http://www.cgia.state.nc.us/streammap

http://h2o.enr.state.nc.us/admin/rules/documents/rb080104.pdf

http://www.nconemap.com/

http://erg.usgs.gov/isb/pubs/factsheets/fs10699.html

http://nhd.usgs.gov/images/nia1_04c.pdf

http://www.epa.gov/waters/doc/techref.html

http://www.esri.com/news/arcnews/fall01articles/arceditor.html

http://www.esri.com/library/brochures/pdfs/arcsde-server.pdf

1.5 Content Overview

The major sections of the Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina are described below:

- **1 Introduction** – This section provides a brief overview of background information for the Stream Mapping Study. It also gives insight into the purpose and scope of the "Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina." Acronyms and definitions used within the document are provided as well as reference information for websites used in compiling the document.

- **2 User Requirements Analysis** – This section describes the outcome of a survey that was sent by email to members of the Stream Mapping Working Group as well as a User Requirements Meeting. The survey includes questions regarding current stream maps and digital stream files, uses of stream data, Geographic information system (GIS) related questions, data maintenance, funding, and general information about each agency. The surveys are the foundation for the user requirements analysis. The User Requirements Meeting gave members of the Stream Mapping Working Group an opportunity to discuss survey results and identify critical user needs that should be considered into the design of the final statewide digital surface waters file.

- **3 Development of Mapping Specifications and Standards** – This section describes the Mapping Specifications and Standards Meeting and the outcome of the topics that were discussed by the Stream Mapping Working Group.

- **4 Drainage Area Requirements –** This section explains the relationship between the drainage area used and the amount of stream miles mapped and includes graphics showing examples of this relationship.

- **5 Digital Surface Waters File Mapping Specifications and Standards** – This section discusses the detailed mapping specifications and data standards that will be applied to the final statewide digital surface waters file. Special case scenarios, data maintenance, distribution methods for public access and quality control measures are also discussed in this section.

- **6 Implementation Options** – This section describes the Implementation Options Meeting with the Stream Mapping Working Group. A portion of the meeting covered the topics of sequencing, schedule and cost of the new statewide surface waters file. Also included in this section are the individual agency benefits of the new digital surface waters file.

- **7 Project Implementation** – This section includes the five phases for the development of the final statewide digital surface waters file. It also provides the respective cost analysis and timeframe for each of the phases of the Stream Mapping Project.

- **8 Conclusion** – This section summarizes the findings of the Implementation Plan.

- **Appendix A** – Appendix A is a roster of Stream Mapping Working Group Members.

- **Appendix B** – Appendix B includes letters of support for the Stream Mapping Project as defined in this implementation plan.

- **Appendix C** – Appendix C is a document entitled "NHD Fact Sheet". This document provides general information about The National Hydrography Dataset (NHD).

- **Appendix D** – Appendix D is an excerpt from a document entitled "The U.S. EPA Reach File Version 3.0 Alpha Release (RF3-Alpha) Technical Reference." This document provides detailed information on United States Environmental Protection Agency (USEPA) Reach Codes and their uses.

User Requirements Analysis

2.1 Introduction

Members of the Working Group were asked to take part in a survey and a User Requirements Meeting to assess user needs for the final statewide digital surface waters file. The following sections include the questions and general responses given in the survey, as well as discussion topics from the User Requirements Meeting.

2.2 Stream Study Survey

A stream study survey was sent by email to Stream Mapping Working Group members on October 8th, 2004. The objective of this survey is to assess the surface waters mapping requirements of the Working Group. An analysis of user requirements is the most important facet of the Stream Mapping Study. Surveys were accepted through October 20, 2004. This survey was also made available on the Stream Mapping Working Group's webpage (http://www.cgia.state.nc.us/streammap).

A total of 34 people representing 24 unique agencies responded to the survey. In some instances, multiple departments of an agency filled out one survey. The answers were counted separately but were grouped under the same agency. Using the classification mentioned above, 28 completed surveys were received. In order to analyze the survey results, agencies were divided into three categories. These categories are:

- Federal: Federal agencies
- State/Regional: State of North Carolina agencies, North Carolina funding agencies, Councils of Government, and State Universities
- Local: Counties, Municipalities

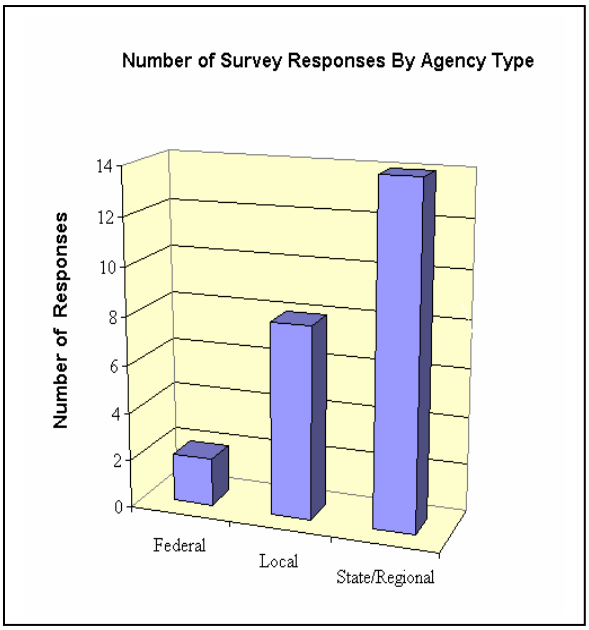
2.2.1 Participants

Table 2-1 on the next page displays the agencies participating in the survey and their organizational type. Figure 2-1 displays the number of agencies that participated in the survey separated by agency type.

Table 2-1
Survey Participants by Agency and Type

Agency	Type
Buncombe County	Local
Durham, City of	Local
Haywood County	Local
Henderson County	Local
Land-of-Sky Regional Council	State/Regional
NCCGIA	State/Regional
NCCWMTF	State/Regional
NCDA	State/Regional
NCDCM	State/Regional
NCDOT	State/Regional
NCDWQ	State/Regional
NCEEP	State/Regional
NCFMP	State/Regional
NCGS	State/Regional
NCSU	State/Regional
NCWRC	State/Regional
NC Geodetic Survey	State/Regional
NC Land Records Management Division	State/Regional
Rutherford County	Local
Surry County	Local
USACE	Federal
USGS	Federal
Wake County	Local
Wilson, City of	Local

Figure 2-1
Number of Survey Responses by Agency Type



2.2.2 Questions and Results

The survey provides significant amounts of information about various topics including current stream maps and data uses, update frequency, current and future needs, as well as GIS-oriented questions about current data formats and file attributes. Survey questions are grouped into the following six classifications for further analysis.

- General Agency Information (5 questions)
- Agency Needs/Benefits (3 questions)
- Agency's Use of Current Data (8 questions)
- GIS-Related (7 questions)
- Data Maintenance (2 questions)
- Funding (2 questions)

The 18 most critical user issues have been pulled from the survey for analysis. These issues include but are not limited to:

- Use of Stream Maps/Digital Stream Files
- Current Needs for a Statewide Digital Surface Waters File
- Future Needs for a Statewide Digital Surface Waters File
- Current Digital Stream File Formats
- Current Stream Map and/or Digital Stream File Attributes
- Water Features (Lakes, Wetlands, etc.) Without Outfalls
- Investment of Funds Into New Statewide Digital Surface Waters File Creation
- Frequency and Method of Data Updates
- Benefits of the Final Statewide Digital Surface Waters File

The following are survey questions and results that pertain to these critical issues.

1) How will the resulting stream file be of use and /or benefit to your agency?

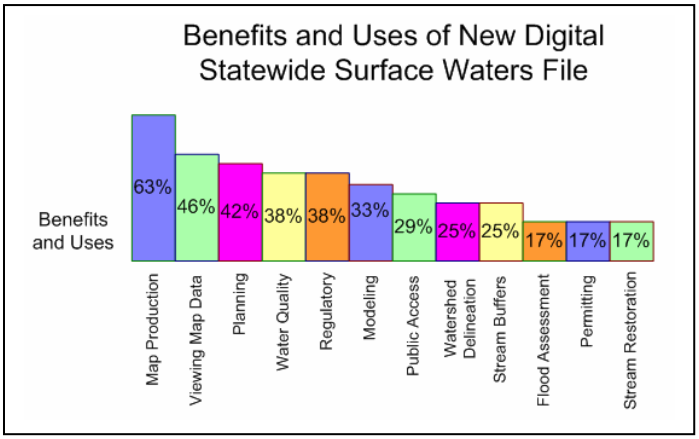
Responses

A broad range of responses are given in regard to uses and benefits of a new statewide digital surface waters file. These various uses and benefits are summarized in Table 2-2. Stream maps and digital stream files are used most by the Working Group for Mapping/Map Production and Viewing/Locating Data. Planning, Water Quality, Modeling, and Regulatory uses are the next most popular uses of stream maps and digital stream files. Working Group members (federal, state/regional, and local) use stream data for the purposes listed in Figure 2-2 in some capacity.

Table 2-2
Benefits and Uses of Stream File by Percentage and Total

Function	Percent	Total
Mapping/Map Production	63%	15
Viewing/Locating Data on Maps	46%	11
Planning	42%	10
Water Quality	38%	9
Regulatory	38%	9
Modeling	33%	8
Public Access	29%	7
Watershed Delineation	25%	6
Stream Buffers	25%	6
Flood Assessments	17%	4
Permitting	17%	4
Stream Restoration	17%	4
Emergency Management	13%	3
Data Creation	13%	3

Figure 2-2
Benefits and Uses of Stream File by Percentage



Notes

For analytical purposes, the various uses of stream data have been condensed in the following manner.

- The Planning function includes mitigation, stormwater management, proposal review, funding decisions, and plan review.
- Water Quality includes Total Maximum Daily Load (TMDLs), illicit discharge, wildlife and fish habitats, cumulative impact analyses, and water quality activities.
- Viewing and Locating Data includes wetlands, stormwater infrastructure, bridge locations, and field visits.
- Public Access includes accessing the data through NC OneMap.

Important Considerations

The digital surface waters file will need to enable links to unique information that may only be applicable to a particular agency. It should be noted that agencies who filled out the survey found multiple benefits from creation of a new statewide surface waters file.

2) What are your agency's current and future needs for a digital stream file?

Similar to the above question about agency uses/benefits of a new statewide digital surface waters file, a broad range of responses are given in regard to current and future agency needs for the file. These various current and future needs are summarized in Table 2-3. The three major needs for survey participants are:

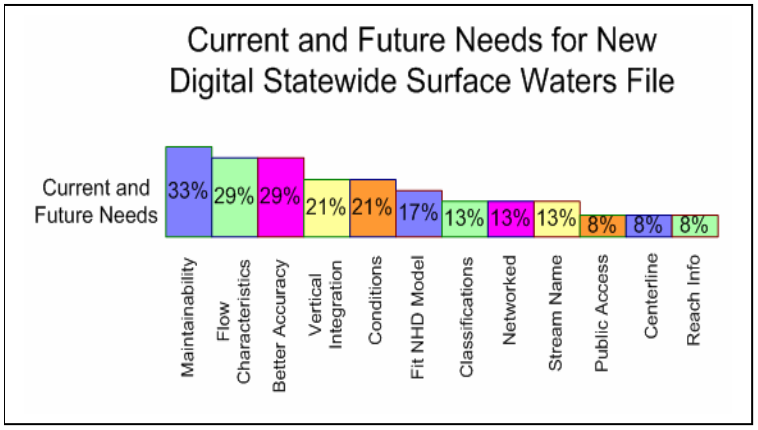
- a file that can be updated frequently as changes occur
- information such as the flow characteristics of the stream (including perennial versus intermittent)
- horizontal accuracy that is better than existing stream maps in use by each agency

Vertical integration (e.g., matching to orthophotos) of the new file with existing data is a major concern. Some agencies need a high-resolution networked surface waters file that will fit with the existing NHD model, while others require stream names, classifications, and stream conditions to be added to the new statewide file. Some need to have stream centerlines added for double-line stream files. Public access to the new data is also a concern for many agencies. Ponds/Lakes are lower on this table of survey results, but are listed in Senate Bill 1152 as a requirement. EPA reach codes, metadata, and watershed delineation are also listed as needs but in the minority.

Table 2-3
Agencies Current and Future Stream File Needs
by Percentage and Total

Function	Percent	Total
Maintainability	33%	8
Flow Characteristics	29%	7
Better Accuracy	29%	7
Vertical Integration	21%	5
Conditions	21%	5
Fit NHD Model	17%	4
Classifications	13%	3
Networked	13%	3
Stream Name	13%	3
Public Access	8%	2
High-Resolution	8%	2
Centerline	8%	2
Reach Info	8%	2
Ponds/Lakes	4%	1
Wetlands	4%	1
Watershed Delineation	4%	1
Metadata	4%	1

Figure 2-3
Current and Future Needs of Stream File
by Percentage



Notes

As with agency uses/benefits, current and future agency needs are condensed as well. Update changes were added to Maintainability. Intermittent versus perennial, and flow direction were added to Flow Characteristics. Connectivity was integrated into Networked. Water quality information, riparian conditions, impoundments, and impairment were included in Condition.

Important Considerations

The vast number and the lengthy responses that were received is an indicator of the great need for this Stream Mapping Study. Section 2.3 of this document is dedicated solely to user requirements as determined by the Stream Mapping Working Group.

3) How often does your agency use stream maps or digital stream files?

Responses

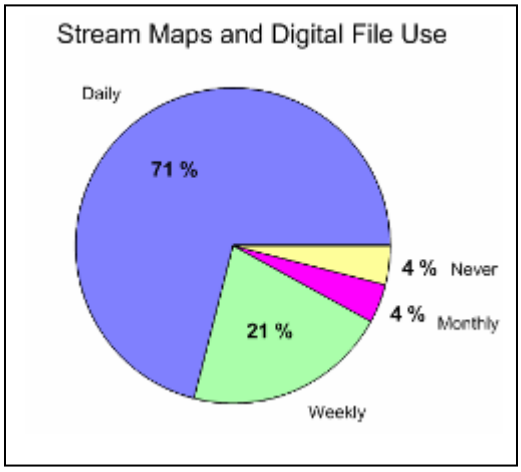
A large majority (71%) of the surveyed agencies use stream maps and/or digital stream files on a daily basis. The uses of the data include: planning and mitigation activities, monitoring, regulatory activities, delineation of watersheds, modeling, delineation of stream buffers, and for map production and viewing of the data in combination with other data.

Twenty-one percent of these remaining agencies use stream data on a weekly basis. Only 8% of the participating agencies rarely or never use stream maps or digital stream files.

Table 2-4
Frequency of Stream Map and Digital File Use by Agency

Agency	Daily	Weekly	Monthly	Never
Buncombe County	X			
Durham, City of	X			
Haywood County		X		
Henderson County		X		
Land-of-Sky Regional Council		X		
NCCGIA	X			
NCCWMTF	X			
NCDA		X		
NCDCM	X			
NCDOT	X			
NCDWQ	X			
NCEEP	X			
NCFMP	X			
NCGS	X			
NCSU	X			
NCWRC	X			
NC Geodetic Survey			X	
NC Land Records Management Division				X
Rutherford County		X		
Surry County	X			
USACE	X			
USGS	X			
Wake County	X			
Wilson, City of	X			

Figure 2-4
Frequency of Stream Map and Digital File Use by Percentage



Notes

This large number of daily users also displays the benefits of a new statewide surface waters file.

4) Do you currently have any statewide or countywide stream maps or digital stream files?

Responses

Half (50%) of the surveyed agencies use the 1:24,000-scale DLGs (or digital line graphs) as a base existing statewide digital stream file. Thirty-eight percent of the remaining agencies use in-house data. Sixteen percent of the participating agencies use NHD and/or USGS files, while 4%

use Topologically Integrated Geographic Encoding and Referencing (TIGER) data, and 13% of agencies stated that the question was not applicable to them.

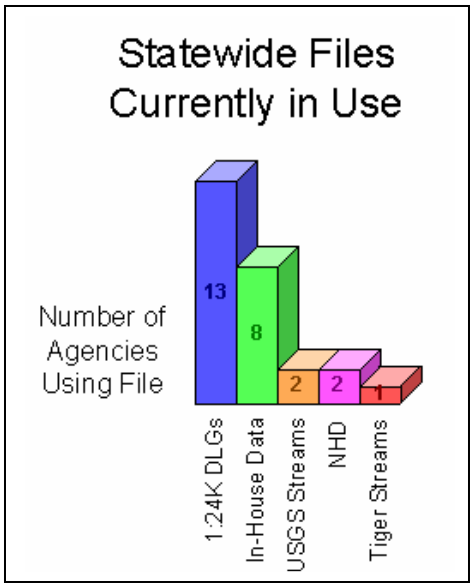
Table 2-5
Type of Stream Map and File Use by Agency

Agency	1:24K DLGs	NHD	USGS File	In-House Dataset	TIGER Data	N/A
Buncombe County	X					
Durham, City of	X			X		
Haywood County				X		
Henderson County	X					
Land-of-Sky Regional Council	X					
NCCGIA	X					
NCCWMTF	X					
NCDA	X					
NCDCM			X			
NCDOT	X					
NCDWQ	X					
NCEEP	X					
NCFMP				X		
NCGS						X
NCSU				X		
NCWRC	X					
NC Geodetic Survey						X
NC Land Records Management Division						X
Rutherford County					X	
Surry County				X		
USACE	X	X		X		
USGS		X	X			
Wake County				X		
Wilson, City of	X			X		

Notes

Some agencies have more than one statewide digital stream file.

Figure 2-5
Number of Agencies Using Statewide Digital Stream Files



Important Considerations

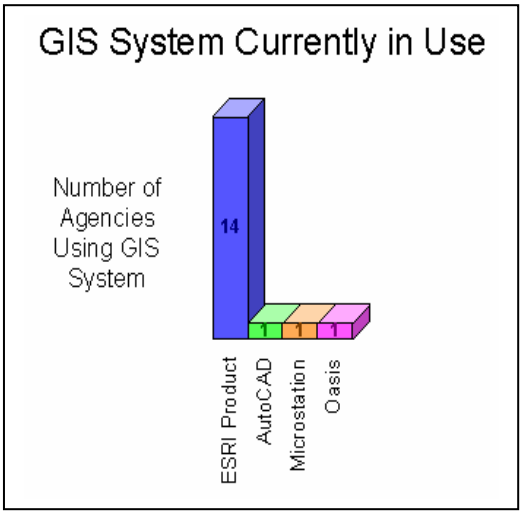
The majority of agencies surveyed currently use digital statewide stream files in some aspect of their work. Almost all use the most accurate streamline coverage that is currently available, 1:24,000-scale DLGs.

5) What GIS system are you currently using?

Responses

A large majority (88%) of the surveyed agencies use Environmental Systems Research Institute, Inc. (ESRI®) products for viewing and manipulating their digital stream files. Six percent of the agencies use MapInfo®, 6% use AutoCAD® and Microstation® software, and 6% of the participating agencies use Oasis® software.

Figure 2-6
Number of Agencies Using GIS Systems



Notes

Included in ESRI Products are ArcGIS®, ArcView® (3.x), ArcSDE®, ArcINFO® Workstation, ArcIMS®, ArcReader®, and ArcPad®. Some agencies use multiple software programs.

Important Considerations

Due to the large number of agencies using ESRI products, it is important that the new statewide digital surface waters file be compatible with the ESRI product line.

Table 2-6
GIS System Use by Agency

Agency	ESRI Product	MapInfo	AutoCAD	Microstation	Oasis
Buncombe County	X				
Durham, City of	X				
Haywood County					X
Henderson County	X				
Land-of-Sky Regional Council	X				
NCCGIA	X				
NCCWMTF	X				
NCDA	X				
NCDCM	X				
NCDOT	X			X	
NCDWQ	X				
NCEEP	X				
NCFMP	X				
NCGS	X	X			
NCSU	X				
NCWRC	X				
NC Geodetic			X		
NC Land Records Management Division	X				
Rutherford County	X				
Surry County	X				
USACE	X				
USGS	X				
Wake County	X				
Wilson, City of	X				

6) What is the type (line versus polygon) and format (.shp, .dgn, .dxf) for each stream file you currently have?

Responses

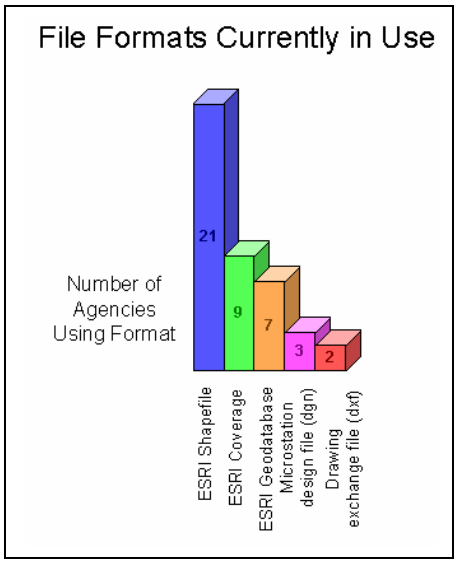
Most of the participating agencies use digital stream files that contain both lines and polygons (54%). The line work denotes stream segments and the polygons denote water bodies (lakes, ponds, etc.). Twenty-nine percent of the agencies use files that only contain lines. Thirteen percent of the agencies responded that this question is not applicable.

A large majority (88%) of the surveyed agencies use ESRI products file formats for viewing and manipulating their digital stream files. Twelve percent of the agencies use AutoCAD and Microstation file formats, and 4% of the participating agencies use Oasis Software file formats. Twenty-nine percent of the agencies use ArcSDE personal geodatabases as a file format.

Table 2-7
File Type and Format Use by Agency

Type	Percent	Total
Line	83%	20
Polygon	54%	13
ESRI shapefile (.shp)	88%	21
ESRI coverage (cov)	38%	9
ESRI geodatabase (gdb)	29%	7
Microstation design file	13%	3
Drawing exchange file (.dxf)	8%	2
AutoCAD drawing file (.dwg)	4%	1
Oasis Format (.gst, .gch, .gpt)	4%	1

Figure 2-7
Number of Agencies Using Each File Format



Notes

Some agencies use multiple file formats which coordinate with the use of multiple software programs. ArcGIS generates both coverages and shapefiles, and can also convert design files, and drawing exchange files into workable formats. Microstation can import drawing exchange files. Geodatabases are only associated with the ArcSDE program.

Important Considerations

As survey results show, the new statewide digital surface waters file needs to include both lines and polygons. Again, due to the large number of agencies using ESRI products, it is important that the new statewide digital surface waters file be compatible with the ESRI file format.

7) What is the map scale for each stream map and digital stream file that you currently have?

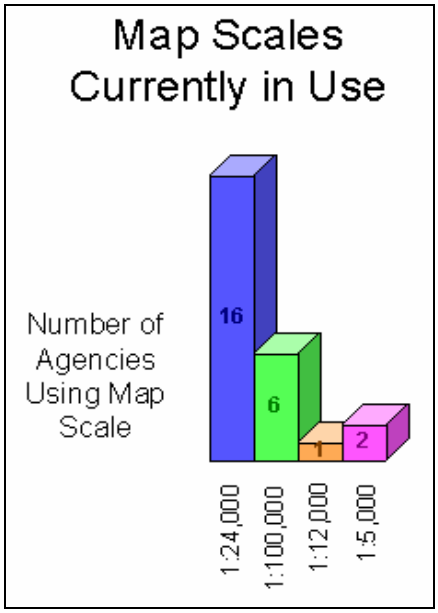
Responses

A majority (67%) of the surveyed agencies use the 1:24,000-scale (1:24K) digital stream lines. Twenty-five percent of the agencies use 1:100,000-scale (1:100K) digital stream files, some in addition to other files. For 17% of the participants this question is not applicable.

Table 2-8
Map Scale Use by Agency

Agency	1:24K	1:100K	1:12K	1:5K	Unknown	N/A
Buncombe County	X					
Durham, City of	X					
Haywood County					X	
Henderson County	X					
Land-of-Sky Regional Council	X					
NCCGIA	X					
NCCWMTF	X					
NCDA	X					
NCDCM	X					
NCDOT	X					
NCDWQ	X					
NCEEP	X	X				
NCFMP	X		X	X		
NCGS						X
NCSU	X					
NCWRC		X				
NC Geodetic Survey						X
NC Land Records Management Division						X
Rutherford County					X	
Surry County		X				
USACE	X	X				
USGS	X	X				
Wake County				X		
Wilson, City of	X					

Figure 2-8
Number of Agencies Using Each Map Scale



Notes

The denotation 1:5K is actually 1:4,800-scale. Most of the 1:24K answers are due to use of the 1:24,000-scale DLGs.

Important Considerations

Most of the surveyed agencies use the most accurate statewide digital stream file available, which happens to be the 1:24,000-scale DLGs.

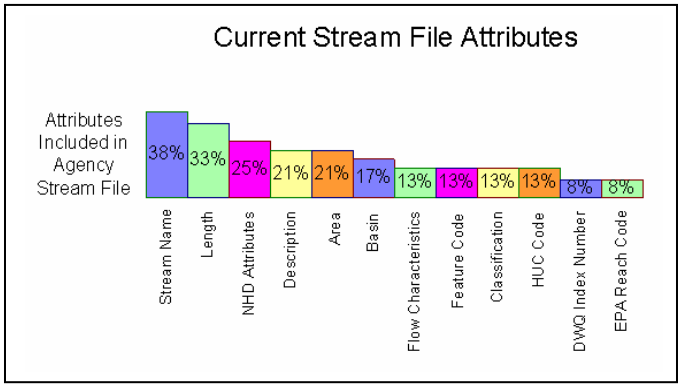
8) List the attributes that are included in each stream map or digital stream file.

As with agency uses/benefits and current and future agency needs, a vast range of attributes are listed in existing statewide digital stream files. These various file attributes are summarized in Table 2-9. According to survey results, the three most common attributes are stream name, stream/segment length, and the attributes from the NHD model. Descriptions (lake, stream, etc.), areas for polygon features, basin names, flow characteristics, feature codes, stream classification, and NHD hydrologic unit codes (HUC) are also common attributes.

Table 2-9
Attributes Included in Agency Stream Files

Function	Percent	Total
Stream Name	38%	9
Length	33%	8
NHD Attributes	25%	6
Description	21%	5
Area	21%	5
Not Applicable	21%	5
Basin	17%	4
Flow Characteristics	13%	3
Feature Code	13%	3
Classification	13%	3
HUC Codes	13%	3
DWQ Index #	8%	2
Quad Name	8%	2
EPA Reach Code	8%	2
Stream Order	4%	1
AU Number	4%	1
Elevation	4%	1
Fishing Regulations	4%	1
Origin	4%	1

Figure 2-9
Percentage of Agency Stream Files that Include Each Attribute



Notes

As with agency uses/benefits, and current and future needs some attributes were condensed as well. Table 2-9 again displays the large array of agency uses of digital stream files.

Important Considerations

Given the number of existing attributes in each digital stream file, it will be a challenge to incorporate all of the characteristics in the new digital statewide surface waters file. Many agencies have adopted the existing digital stream files and adapted the characteristics of the file to meet agency needs. The new statewide digital surface waters file will need to have a common link to agency data.

9) Is your stream data in the private domain or is it all in the public domain? Are any of the data attributes confidential?

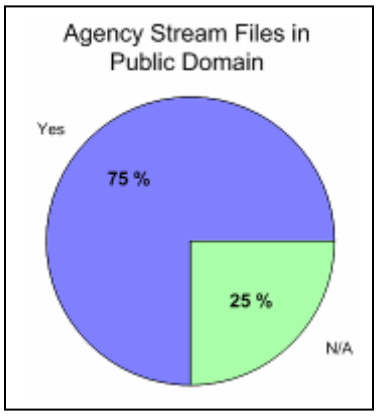
Responses

All of the agencies responded that their data is in the public domain, which means that the data can be used by anyone. One agency has certain attributes that are confidential. This question was not applicable for six agencies.

Table 2-10
Public and Private Stream Data by Agency

Agency	Public	Private	Confidential	N/A
Buncombe County	X			
Durham, City of	X			
Haywood County	X			
Henderson County	X			
Land-of-Sky Regional Council	X			
CGIA	X			
CWMTF				X
NCDA				X
NCDCM	X			
NCDOT	X			
NCDWQ				X
NCEEP				X
NCFMP	X			
NCGS				X
NCSU	X			
NCWRC	X		X	
NC Geodetic Survey	X			
NC Land Records Management Division				X
Rutherford County	X			
Surry County	X			
USACE	X			
USGS	X			
Wake County	X			
Wilson, City of	X			

Figure 2-10
Agency Stream Files in Public Domain



Notes

Most of the "not applicable" responses are due to the fact that many agencies are data users, not data creators.

Important Considerations

Most agencies surveyed make data available to the public. Because of its inclusion on NC OneMap, all of the data from the new digital surface waters file will be in the public domain. It may be necessary for restrictions to be applied for some of the data characteristics. Actions will be taken to accommodate these restrictions if the need arises.

10) Do you have any double-line streams? If so, do they have a centerline?

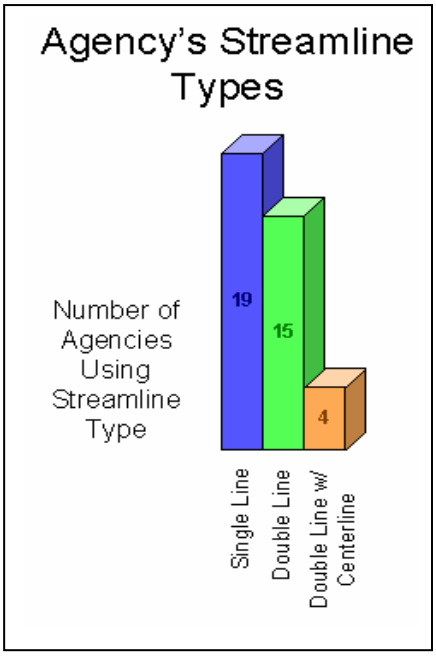
Responses

A majority (79%) of the surveyed agencies have digital stream files with at least a single line to denote stream lines, 17% have only single lines. Sixty-three percent of the agencies have double lines to denote wide streams. Agencies use differing standards to indicate which stream lines would require a double line for display. For example, the North Carolina Floodplain Mapping Program (NCFMP) uses a 40 foot standard. Only 17% of the agencies have double-line streams which also include centerlines. For 21% of the agencies this question is not applicable.

Table 2-11
Stream File Denotation by Agency

Agency	Single	Double	Double w/ Centerline	N/A
Buncombe County	X	X		
Durham, City of	X	X		
Haywood County	X	X		
Henderson County	X	X		
Land-of-Sky Regional Council	X	X		
CGIA	X	X	X	
CWMTF				X
NCDA				X
NCDCM	X	X		
NCDOT	X	X		
NCDWQ	X	X		
NCEEP	X	X		
NCFMP	X	X	X	
NCGS				X
NCSU	X			
NCWRC	X			
NC Geodetic Survey				X
NC Land Records Management Division				
Rutherford County	X			
Surry County	X			
USACE	X	X	X	
USGS	X	X	X	
Wake County	X	X		
Wilson, City of	X	X		

Figure 2-11
Number of Agencies Using Each Stream File Line Type



Notes

Although many agencies do not currently possess digital stream files that contain centerlines for double-line streams, many answered that this is a feature that they would like to be included in the new statewide digital surface waters file.

Important Considerations

Many agencies have adopted a blend of different standards for their digital stream files. The new statewide digital surface waters file must incorporate a standard that could be used by most, if not all of the cooperating agencies.

11) Do your stream maps or digital stream files have lakes, dams, swamps, or any other water feature which may not have an outfall?

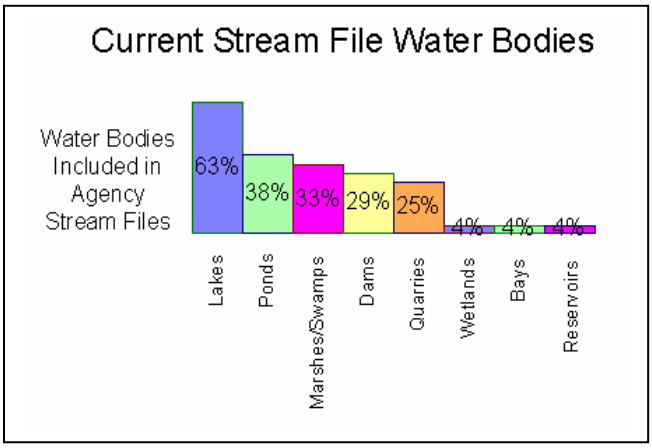
Responses

A majority (63%) of the surveyed agencies has digital stream files that contain lakes, and 38% have digital stream files that contain ponds. Thirty-three percent of the agencies have marshes and swamps included in their files, and 29% contain dams. Seventeen percent of the agencies do not possess a digital stream file that contains any features without outfalls, and for 13% of the agencies this question is not applicable.

Table 2-12
Water Body Types Included in Digital Files

Function	Percent	Total
Lakes	63%	15
Ponds	38%	9
Marshes/Swamps	33%	8
Dams	29%	7
Quarries	25%	6
No	17%	4
N/A	13%	3
Wetlands	4%	1
Bays	4%	1
Reservoirs	4%	1

Figure 2-12
Water Body Types Included in Stream File



Notes

Many agencies use the 1:24,000-scale DLGs and NHD data. Both of these files depict features without outfalls.

Important Considerations

Water features need to be identified in the new statewide digital surface waters file.

12) Do any of your stream maps or digital stream files depict the coastline?

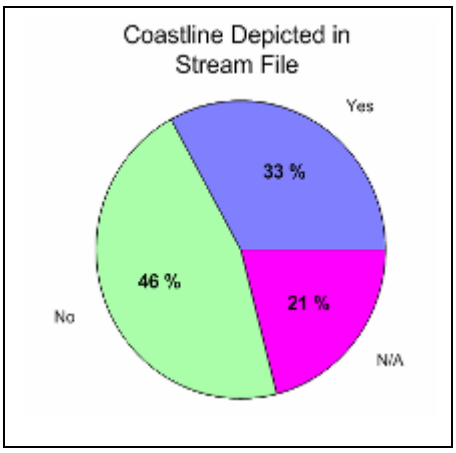
Responses

Of the 24 surveyed agencies, 11 agencies do not have digital stream files that depict the coastline. Eight of the agencies do use files that contain the coastline. Five agencies responded that this question is not applicable. Percentages are displayed in Figure 2-13 below.

Table 2-13
Coastline Depiction in Stream File by Agency

Agency	Yes	No	N/A
Buncombe County		X	
Durham, City of		X	
Haywood County		X	
Henderson County		X	
Land-of-Sky Regional Council		X	
NCCGIA	X		
NCCWMTF			X
NCDA			X
NCDCM	X		
NCDOT	X		
NCDWQ	X		
NCEEP	X		
NCFMP	X		
NCGS			X
NCSU		X	
NCWRC		X	
NC Geodetic Survey			X
NC Land Records Management Division			X
Rutherford County		X	
Surry County		X	
USACE	X		
USGS	X		
Wake County		X	
Wilson, City of		X	

Figure 2-13
Coastline Depiction in Stream File by Percentage



Notes

All of the federal agencies have data that contain the coast, while some of the state/regional have data for the coast.

Important Considerations

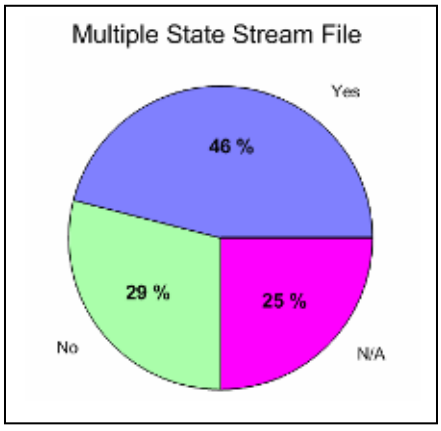
A decision will need to be made on whether to include the coastline in the statewide surface waters file and if so, whether any of the existing data sources will be useful in mapping the coastline.

13) Do any of your digital stream data include entering or exiting to another state or county? If so, is the data horizontally integrated?

Responses

Less than half (46%) of the surveyed agencies has digital stream files that cross state or county boundaries. Of the agencies that have files that cross borders, 29% of the agencies have files that are horizontally integrated. Horizontal integration involves edge matching of different data sources at jurisdictional boundaries to create a seamless coverage. Twenty-nine percent of the agencies have files that do not cross boundaries or are clipped to the state or county boundary. For 25% of the agencies this question is not applicable.

Figure 2-14
Agencies with Stream Files
Crossing North Carolina Borders
by Percentage



Notes

Many agencies use the 1:24,000-scale DLGs and NHD data. Both of these files cross the North Carolina state boundary and are horizontally integrated at the border.

Important Considerations

The new digital surface waters file will need to be a statewide coverage for use by all agencies. If the coverage also extends past the state's borders, it should be integrated with surface waters across the state's borders at those points.

Table 2-14
Stream File Crossing State Border by Agency

Agency	Yes	No	Horizontally Integrated	N/A
Buncombe County		X		
Durham, City of		X		
Haywood County	X		X	
Henderson County	X		X	
Land-of-Sky Regional Council	X			
NCCGIA	X		X	
NCCWMTF				X
NCDA				X
NCDCM		X		
NCDOT	X		X	
NCDWQ		X		
NCEEP		X		
NCFMP	X		X	
NCGS				X
NCSU	X			
NCWRC				X
NC Geodetic Survey				X
NC Land Records Management Division				X
Rutherford County	X			
Surry County	X			
USACE	X		X	
USGS	X		X	
Wake County		X		
Wilson, City of		X		

14) Do you vertically integrate your digital stream files with other categories or layers of data? If so, list them.

Responses

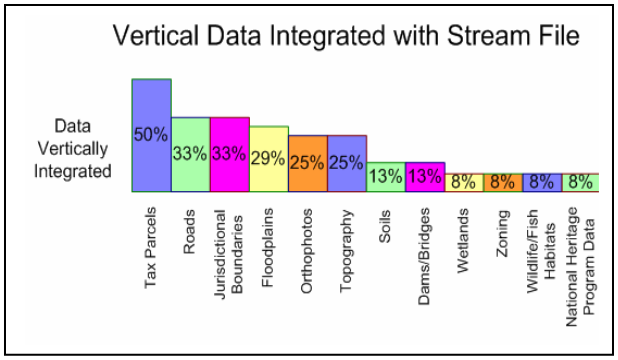
An array of differing files was given for this question. The various files that agencies vertically integrate with digital stream files have been summarized in Table 2-15. Vertical integration

involves correlation among and between layers of data. For example, when a stream line moves a tax parcel boundary may now be affected. According to the survey results, the three most common vertically integrated files are tax parcels, roads, and jurisdictional boundaries. Floodplains, orthophotos, and topography codes are also common files that are vertically integrated with digital stream files. For 13% of the surveyed agencies this question is not applicable.

Table 2-15
Data Commonly Vertically Integrated with Stream File

Function	Percent	Total
Tax Parcels	50%	12
Roads	33%	8
Jurisdictional Boundaries	33%	8
Floodplains	29%	7
Orthophotos	25%	6
Topography	25%	6
Soils	13%	3
Dams/Bridges	13%	3
N/A	13%	3
Wetlands	8%	2
Zoning	8%	2
Wildlife/Fish Habitats	8%	2
Natural Heritage Program Data	8%	2
Acquisition Boundaries	4%	1
Monitoring Data	4%	1
Buffer Zones	4%	1
Stormwater Inventory	4%	1

Figure 2-15
Data Vertically Integrated with Stream File by Percentage



Notes

Most of the surveyed agencies vertically integrate more than one data layer with their digital stream files.

Important Considerations

The new statewide digital surface waters file will need to be at least as accurate as other vertically integrated data layers or anomalies will show. This will mean that the horizontal accuracy of the 1:24,000-scale DLGs will not be sufficient for a statewide surface waters coverage that will meet the needs of the users.

15) How frequently is your data updated? How do you post updates?

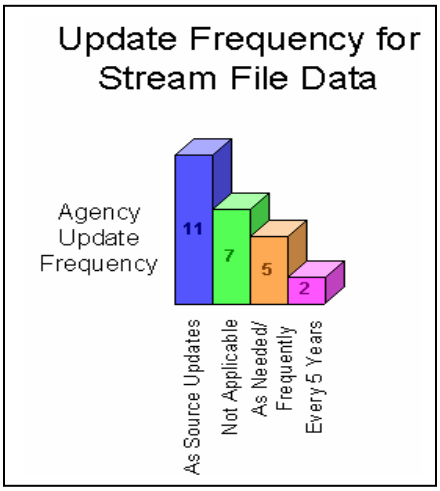
Responses

A minority (21%) of the surveyed agencies creates and updates their own digital stream files. Forty-two percent of the agencies use digital stream files that are created by another agency, and are not directly related to updates of the data. For 29% of the agencies this question is not applicable.

Table 2-16
Frequency of Data Updates by Agency

Agency	As Needed	As Source Updates	Every 5 Years	N/A
Buncombe County		X		
Durham, City of		X		
Haywood County				X
Henderson County				X
Land-of-Sky Regional Council		X		
NCCGIA	X			
NCCWMTF		X		
NCDA		X		
NCDCM				X
NCDOT		X		
NCDWQ		X	X	
NCEEP		X		
NCFMP			X	
NCGS				X
NCSU	X			
NCWRC		X		
NC Geodetic Survey				X
NC Land Records Management Division				X
Rutherford County		X		
Surry County	X			
USACE	X			
USGS	X			
Wake County				X
Wilson, City of		X		

Figure 2-16
Update Frequency for Stream File Data



Notes

This question may not apply to some of the agencies because they are using in-house data that are not maintained or they are using paper maps. Many agencies are data users versus data creators.

Important Considerations

The agencies who currently maintain their data will need the ability to post updates to the new digital surface waters file as well.

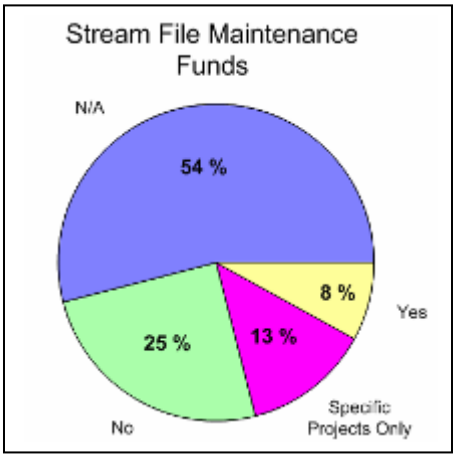
16) Does your agency have funds available for data maintenance?

Of the 24 surveyed agencies, only two agencies have funds available for data maintenance, while another six do not have funds available currently. Three agencies fund their maintenance on a project-by-project basis. For 13 of the agencies, this question is not applicable. Percentages are shown in Figure 2-17.

Table 2-17
Availability of Data Maintenance Funds by Agency

Agency	Project Oriented	Yes	No	N/A
Buncombe County				X
Durham, City of			X	
Haywood County				X
Henderson County				X
Land-of-Sky Regional Council				X
NCCGIA	X			
NCCWMTF				X
NCDA			X	
NCDCM			X	
NCDOT		X		
NCDWQ				X
NCEEP				X
NCFMP	X			
NCGS				X
NCSU	X			
NCWRC				X
NC Geodetic Survey				X
NC Land Records Management Division				X
Rutherford County			X	
Surry County			X	
USACE			X	
USGS		X		
Wake County				X
Wilson, City of				X

Figure 2-17
Stream File Maintenance Funds by Percentage



Notes

The reason that this question may not apply to some of the agencies is that they are using in-house data that are not maintained or they are using paper maps. Many agencies are data users versus data creators.

Important Considerations

Many of the agencies do not currently set aside funds specifically for data maintenance.

17) Does your agency invest annually in stream mapping and/or digital stream file creation?

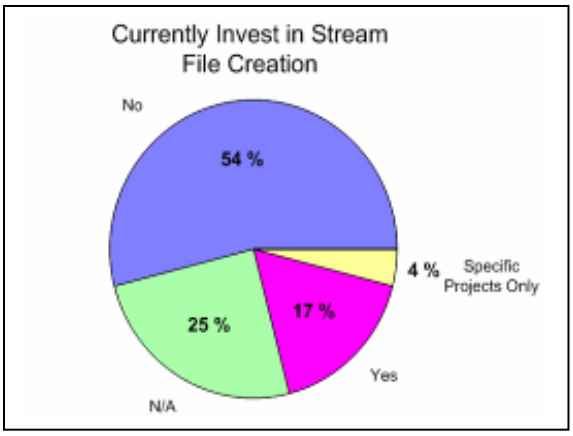
Responses

Of the 24 surveyed agencies only four invest annually in stream mapping and/or digital stream file creation, while 13 agencies do not invest at all. One agency invests in stream mapping and/or digital stream file creation on a project-by-project basis. For six of the agencies this question is not applicable. Percentages are shown in Figure 2-18 below.

Table 2-18
Investment in Stream File Creation by Agency

Agency	Yes	No	Project Oriented	N/A
Buncombe County				X
Durham, City of		X		
Haywood County				X
Henderson County				X
Land-of-Sky Regional Council		X		
NCCGIA			X	
NCCWMTF				X
NCDA		X		
NCDCM		X		
NCDOT		X		
NCDWQ		X		
NCEEP	X			
NCFMP				X
NCGS		X		
NCSU	X			
NCWRC	X			
NC Geodetic Survey		X		
NC Land Records Management Division		X		
Rutherford County		X		
Surry County		X		
USACE		X		
USGS	X			
Wake County				X
Wilson, City of		X		

Figure 2-18
Current Investment in Stream File Creation by Percentage



Notes

The reason that this question may not apply to some of the agencies is that they are using in-house data that are not maintained or they are using paper maps. Many agencies are data users versus data creators.

Important Considerations

Many agencies use existing data that were created by other organizations.

18) Is your agency willing to invest funds into the creation of a new statewide digital surface waters file?

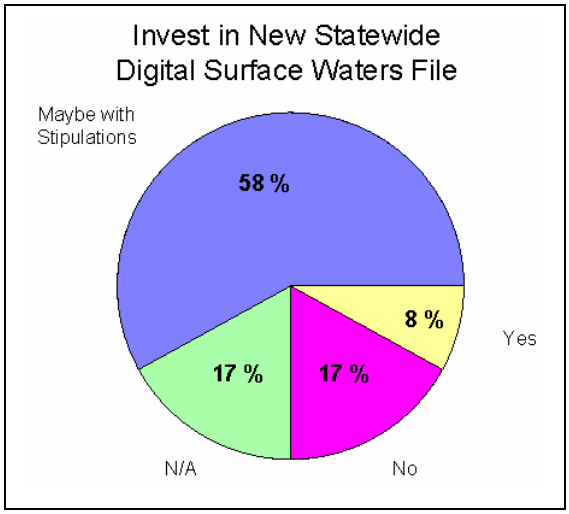
Responses

Of the 24 surveyed agencies, 15 agencies may be willing to invest in a new statewide digital surface waters file if certain stipulations are met, and two agencies are currently willing to invest if funds are available. Five agencies do not currently have funds available to invest in a new statewide digital surface waters file, and for three of the agencies this question is not applicable. Percentages are shown in Figure 2-19 below.

Table 2-19
Investment in New Digital Surface Waters File by Agency

Agency	Yes	No	Maybe w/ Stipulations	N/A
Buncombe County			X	
Durham, City of			X	
Haywood County			X	
Henderson County			X	
Land-of-Sky Regional Council		X		
NCCGIA				X
NCCWMTF			X	
NCDA				X
NCDCM			X	
NCDOT	X			
NCDWQ			X	
NCEEP			X	
NCFMP				X
NCGS				X
NCSU	X			
NCWRC			X	
NC Geodetic Survey		X		
NC Land Records Management Division		X		
Rutherford County		X		
Surry County			X	
USACE			X	
USGS			X	
Wake County			X	
Wilson, City of			X	

Figure 2-19
Percentage of Agencies Willing to Invest in New Digital Surface Waters File



Notes

Stipulations involved with funding for the new statewide digital surface waters file include:

- Investment must include completion of 1:24,000-scale NHD for the entire state
- Data must be recognized for regulatory purposes
- Equitable payments between partners with a clear definition of the final product
- Business must benefit and the new file would need to help with funding decisions
- Data must meets local standards and the needs of the community
- Must enhance the ability to conduct watershed planning and restoration identification, planning, and assessment
- Commissioners must allocate funds
- Cost must justify benefit

Important Considerations

Members of the Working Group will need a statewide digital surface waters file that they can use on a daily basis for business purposes. If this data can be tailored to meet each agency's needs, to a sufficient degree, then there will be an increased likelihood of increasing the funding for this project.

The findings of the surveys submitted by participating agencies are further discussed in the next section. The survey findings give insight into the broad range of needs incorporated within the Stream Mapping Working Group. These necessities were narrowed down into minimum and optional requirements for the new statewide digital surface waters file at the User Requirements Meeting.

2.3 User Requirements Meeting

Watershed Concepts facilitated a User Requirements Meeting with the Stream Mapping Working Group on October 21, 2004 at the USGS facilities in Raleigh, North Carolina. This day-long meeting provided an overview of the Stream Study Survey results and gave the Working Group a chance to discuss their needs relating to a new statewide surface waters file. The focus of the User Requirements Meeting was on developing the initial standards for a statewide digital surface waters file and ensuring that each agency's minimum requirements could be met. In addition to the survey and the User Requirements Meeting, comment forms were provided to Working Group members to ensure that each agency was given additional outlets to express their needs and concerns. Information from the comment forms has been incorporated throughout the relevant subsections of Section 2.3.

During the User Requirements Meeting, members of the group were given an opportunity to briefly explain their agency's most critical user requirements. Votes were cast to determine the most critical user requirements from all of the answers given. A total of 15-20 minutes of meeting time was dedicated for each specific item that received a majority of attendee votes. Following is a list of those critical user requirements as defined by the members of the Working

Group. Also included below are detailed discussions of the user needs and the outcomes that were formulated during this meeting.

- Stream Definition
- Source Data (USGS, NHD, NCFMP breaklines)
- Modeling
- Coverage Area (statewide and cross-state)
- Accuracy (horizontal and vertical)
- Uniform Standards (completeness)
- Formats
- Attributes (flow characteristics)
- Maintenance
- Metadata
- Public Access

Below is Table 2-20, which depicts the Stream Mapping Working Group members who attended the User Requirements Meeting held on October 21, 2004.

Table 2-20
Attendees and Agencies Represented at the User Requirements Meeting

Will Aycock - City of Wilson	Cam McNutt - NCDWQ
Jim Borawa - NC Wildlife Res. Comm.	Rex Minneman - NC Land Record Mgmt. Div.
Hubo Cai - URS Corp.	Gray Minton - Watershed Concepts
Tom Calhoun - City of Charlotte	Chris Moore - Haywood County
Melissa Carle - NCDCM	Zsolt Nagy - NCCGIA
John Correllus - NC Dept. of Commerce	Doug Newcomb - US Fish and Wildlife Service
John Cox - City of Durham	Susan Phelps - Watershed Concepts
Scott Edelman - Watershed Concepts	Elizabeth Porter- USACE
Melani Harrell - City of Charlotte	Jeff Reid - NC Geological Survey
Bill Holman - CWMTF	Linda Rimer - USEPA
Tim Johnson - NCCGIA	Mark Senior - City of Raleigh
Chris Kannan - USGS	L. C. Smith - NCDOT
Steve Kroeger - NCDWQ	Jim Stanfill - Ecosystem Enhancement Program
Wright Lowery - Wake County	Steve Strader - USGS
Dan Madding - NC Dept. of Agriculture	Silvia Terziotti - USGS
Andy McDaniel - NCDOT	Gary Thompson - NC Geodetic Survey
Sean McGuire - NCDCM	Tom Walker - USACE
Terri McLean - Watershed Concepts	Sarah Wray - NCFMP

2.3.1 User Groups

As a result of the surveys and the meeting, two different groups emerged within the Stream Mapping Working Group. These groups are the data users and the creators/maintainers of the data.

- The data users will access this statewide digital surface waters file for viewing, mapmaking or analytical purposes.
- The data creators and maintainers will download the surface waters file for maintenance purposes such as adding, editing or deleting data.

An analysis of the groups shows virtually an equal number of map/data users and creators. Approximately 48% of the Working Group members consider themselves data users and the other 52% are data creators. Although, it should be noted that many of the data users would likely utilize this statewide digital surface waters file for creation of data if their user requirements are met.

2.3.2 Surface Waters Definitions

The members of the Working Group determined that the first priority of the User Requirements Meeting would be to adopt definitions for streams and water bodies. Many agencies have different descriptions of surface waters, which can lead to various interpretations of the scope of work. Various agency definitions of streams were shared during the meeting to assess whether they could be used for the project. The Stream Mapping Working Group determined that the NC DENR-Division of Water Quality's (NCDWQ) surface water definitions provided a solid foundation for the statewide digital surface waters file. NCDWQ's surface water definitions (http://h2o.enr.state.nc.us/admin/rules/documents/rb080104.pdf), as well as relevant terms and definitions from the National Oceanic and Atmospheric Administration (NOAA) and USGS, are listed in Table 2-21 below.

Table 2-21
Stream and Surface Water Definitions

Term	Definition
Channel	A natural, water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water.
Ditch or Canal	A man-made channel other than a modified natural stream constructed for drainage purposes that is typically dug through inter-stream divide areas. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent streams.
Ephemeral (Stormwater) Stream	A feature that carries only stormwater in direct response to precipitation with water flowing only during and shortly after large precipitation events. An ephemeral stream may or may not have a well-defined channel, the aquatic bed is always above the water table, and stormwater runoff is the primary source of water. An ephemeral stream typically lacks the biological, hydrological, and physical characteristics commonly associated with the continuous or intermittent conveyance of water.

Intermittent Stream	A well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological and hydrological characteristics commonly associated with the conveyance of water.
Mean High Water	The average elevation of all high waters recorded at a particular point or station over a considerable period of time, usually 19 years. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal (daily). (NOAA Coastal Services Center definition).
Modified Natural Stream	An on-site channelization or relocation of a stream channel and subsequent relocation of the intermittent or perennial flow as evidenced by topographic alterations in the immediate watershed. A modified natural stream must have the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.
Perennial Stream	A well-defined channel that contains water year round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.
Perennial Waterbody	A natural or man-made basin that stores surface water permanently at depths sufficient to preclude growth of rooted plants, including lakes, ponds, sounds, non-stream estuaries and ocean. For the purpose of the State's riparian buffer protection program, the waterbody must be part of a natural drainageway (i.e., connected by surface flow to a stream).
Stream	A body of concentrated flowing water in a natural low area or natural channel on the land surface.
Surface Water	All waters of the state as defined in G.S. 143-212 except underground waters.
Waters (Defined in G.S 143-212)	Any stream, river, brook, swamp, lake, sound, tidal estuary, bay, creek, reservoir, waterway, or other body or accumulation of water whether surface or underground, public or private, or natural or artificial, that is contained in, flows through, or borders upon any portion of this State, including any portion of the Atlantic Ocean over which the State has jurisdiction.

Consensus: Members of the Stream Mapping Working Group discussed various terms and definitions that are currently used for surface waters and streams. The consensus of the local, state, and federal government officials was to use NCDWQ's definitions for the classification of streams as well as surface waters. Guidelines will need to be set on how to characterize streams as well as other bodies of water.

2.3.3 Source Data

There are many stream maps for North Carolina in existence that could be used as a basis for the North Carolina Stream Mapping Project. Most of the agencies involved in the User Requirements Meeting indicated that they currently use one or more of the following stream files: the 1:24,000-scale DLGs, the 1:24,000-scale NHD data model or the North Carolina

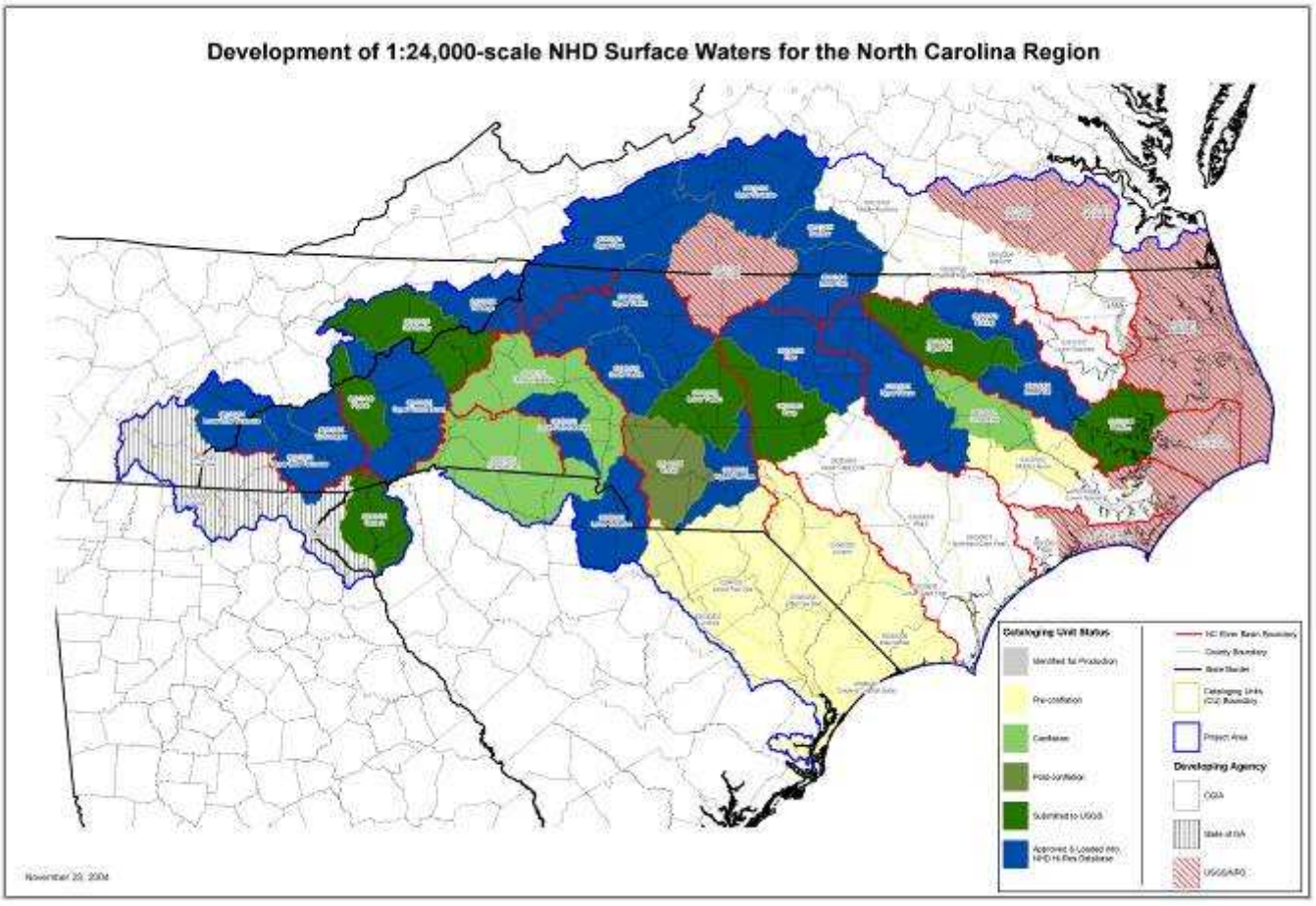
Floodplain Mapping Program breaklines. The following is a brief analysis of existing stream data sets discussed by the Working Group in meetings and in surveys.

- USGS Blue Lines/1:24,000-scale DLGs—streams are depicted as blue lines on 1:24,000-scale paper topographic maps and the DLGs are the digital representation of the USGS blue lines. Data is complete for the entire state of North Carolina as well as surrounding states. However, there is a lack of consistency of detail between adjacent map sheets (or quadrangles) that make up a geographic area. For instance, two different contractors may have mapped two adjacent USGS quadrangles so that the quality may differ. Also, these lines do not have any associated stream classifications.

- 1:24,000-scale NHD Data - this data contains basic information about surface water features such as streams, rivers, lakes, ponds, springs and wells. The creation of this NHD model began at 1:100,000-scale and has migrated to 1:24,000-scale, and is based on the existing 1:24,000-scale DLGs. The NHD data does not currently include value added information from partnering agencies.

  The NHD is not yet complete for the entire state, but progress is moving west to east across the state. Figure 2-20 indicates the status of the progress of the NHD data. Areas in blue are complete and have been loaded into the NHD high-resolution database. Areas in green are currently in progress. The 1:24,000-scale NHD project is scheduled for completion during the 2005-2006 fiscal year, with the stipulation that the funding needs will be met.

Figure 2-20
1:24,000-Scale NHD Surface Waters File Status



- FMP streamlines—these streamlines are 3-D breaklines created from LIDAR bare earth mass points along with the best quality orthophotos available for the area. These represent centerlines of the stream when the stream width is less than 40 feet wide, and the edge of water for streams that are more than 40 feet wide. Generally, in rural areas these streamlines extend downstream from the one square mile drainage point and in urban areas from the ½ square mile drainage point. Elevations are added to each vertex on the streamline. Vertical elevation noted on the vertex represents near top of water elevation when the LIDAR was flown.

Figure 2-21
Hillshade Derived from NC FMP LIDAR Data

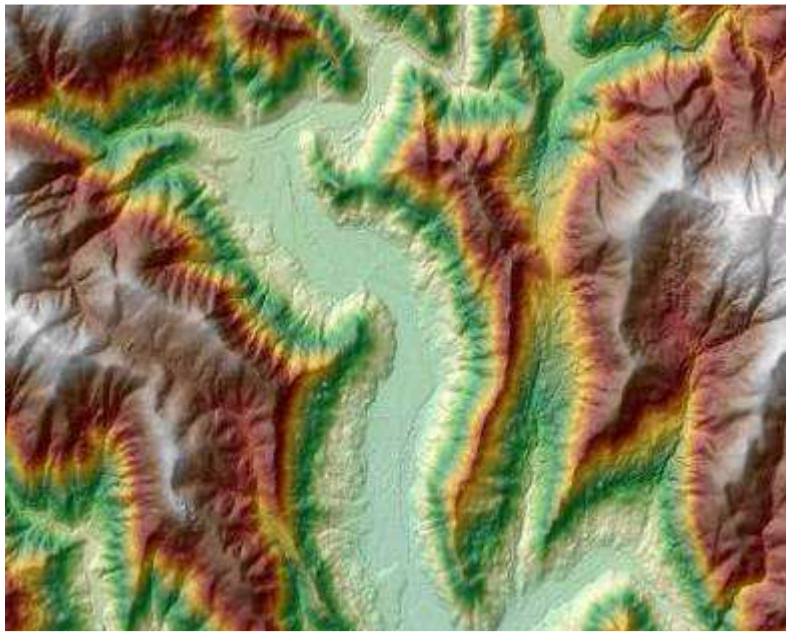
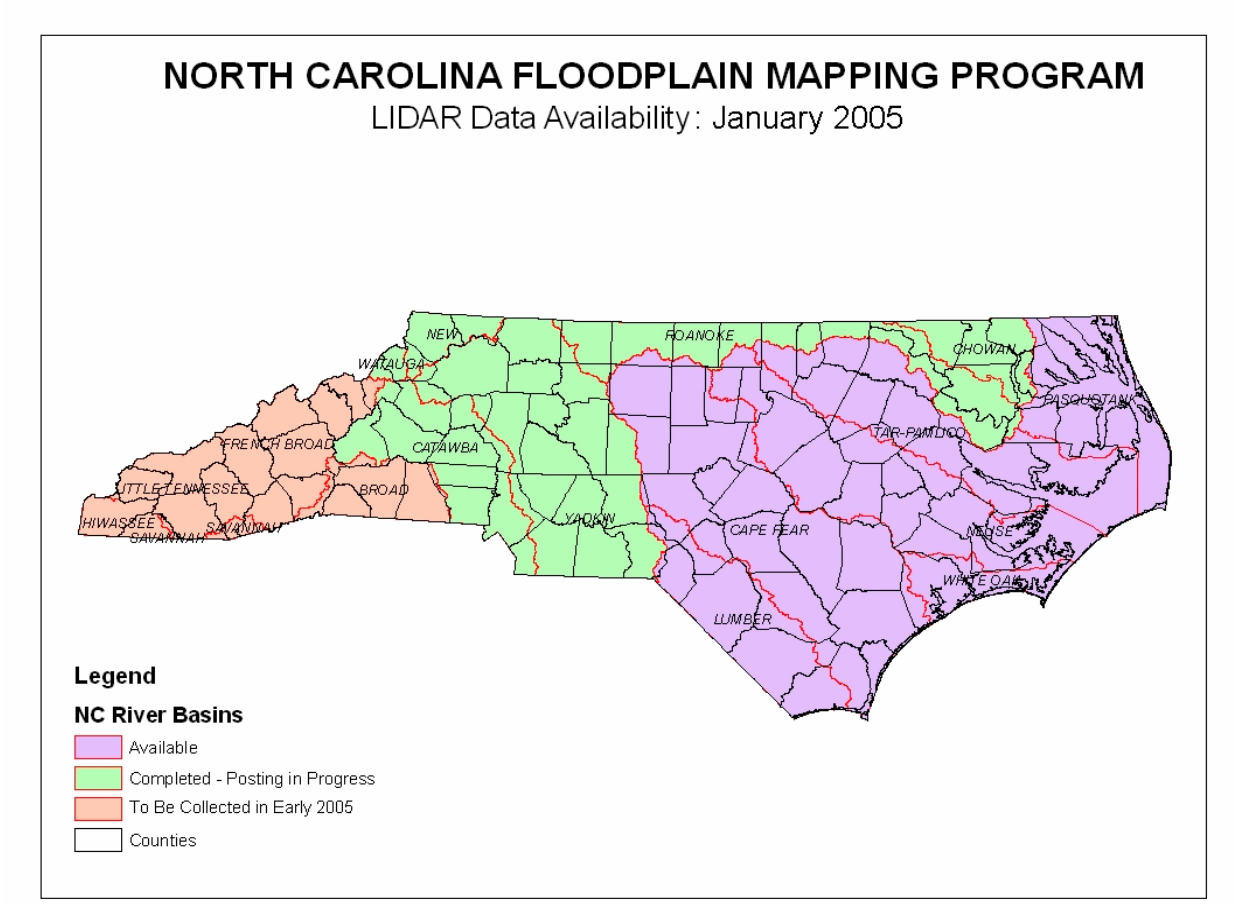


Figure 2-21 shows an example of a hillshade that was derived from LIDAR for the North Carolina Floodplain Mapping Project. There is considerably higher accuracy when a source such as LIDAR is used for stream mapping. With LIDAR technology, billions of digital bare earth points are collected which are made into a three-dimensional, high resolution model of the Earth's terrain.

In addition to the LIDAR data, newly created Digital Orthophotography Quarter Quadrangle's (DOQQ's) or more recent local orthophotography were also used to develop the breaklines. The DOQQ's are at 1 meter resolution. Breaklines have been created for Phases I and II of the North Carolina Floodplain Mapping Project. Phases I and II of the project cover the eastern and central portion of the state. Phase III covers the western portion of the state, and is not yet complete.

Figure 2-22 is a status map for the North Carolina Floodplain Mapping Program. This map illustrates the availability of LIDAR data across North Carolina. River basins in the east (purple) have completed LIDAR data that has been loaded on the NC Flood Maps website (http://www.ncfloodmaps.com/default_swf.asp). The central (green) areas are the river basins where LIDAR data has been submitted and is currently being reviewed. All basins in the west (orange) have had some preliminary work performed.

Figure 2-22
North Carolina Floodplain Mapping Program LIDAR Availability



Consensus: The Working Group will examine the above-mentioned data in greater detail to determine whether or not any of these current stream files meet the requirements of this project. Factors that will be evaluated in each of these existing stream files include modeling capabilities, coverage area, accuracy, uniformity, and attributes. It was noted that using the most current data will be imperative for this study. The streamlines developed through the Floodplain Mapping Program, with improved horizontal accuracy, and the 1:24,000-scale NHD data model, with extensive description of the data, both meet the criteria.

2.3.4 Modeling

The Working Group expressed the need for modeling capabilities with the new digital surface waters file. At the User Requirements Meeting, discussions included a desire for networked (connected) streamlines, and the need for centerlines. Members of the Working Group explained that the digital surface waters file needs to have a continuous stream network for modeling to be effective. Centerlines are also a necessity in areas where the stream may be displayed as double line features.

The use of existing NHD data to perform modeling was also mentioned at the User Requirements Meeting. Many agencies currently use the 1:24,000-scale NHD data model for this task. Members of the Working Group indicated that they would like to use the new digital surface waters file for hydraulic and hydrologic modeling purposes as well. One suggestion from the User Requirements Meeting is to provide unique reach codes for the purpose of linking the two data files. Another idea is to create an application for the purpose of joining the data files. Research will be needed to examine the implications of how the two types of data can be used in conjunction with one another. Another consideration with the NHD data will be how scaleable the data is on a local level. Additional information about the NHD model can be found in Appendix C of the report and more data about EPA Reach Codes can be found in Appendix D.

Consensus: No matter which data source is used for the Stream Mapping Project, functionality in hydraulic and hydrologic modeling will be an important consideration in developing the new digital surface waters file. A process must be established whereby the existing 1:24,000-scale NHD model can be linked to the final digital surface waters file or the information placed directly in the file.

2.3.5 Coverage Area

Another factor discussed at the User Requirements Meeting was whether the final digital surface waters file will need to extend beyond the borders of North Carolina into surrounding states. If the new streamline crosses the state border, it will need to be horizontally integrated with data from adjoining states and collaboration with state and federal agencies in these adjoining states will be necessary. Another stipulation will be that EPA reach code commonality will need to be applied to the integrated data.

The existing digital stream files used by the Working Group have differing coverage areas and levels of completeness. Table 2-22 lists the three commonly-used stream data sources and their coverage areas.

Table 2-22
State Coverage Area of Existing Stream Files

Data Source	Statewide Coverage	Cross State Borders	Horizontally Integrated
USGS Blue Lines/ 1:24,000-scale DLGs	X	X	X
1:24,000-scale NHD Data Model	in progress	X	X
FMP streamlines	in progress	only extends short distance over state boundary	X

Consensus: The digital surface waters file produced by the Stream Mapping Project will be a North Carolina statewide coverage. The work may need to be performed in phases or by regions. Additional consideration will need to be given to determine if the file will extend past the state

boundaries. Members of the Working Group will also need to determine where the state territory ends along the coastline and how far beyond the outer banks the data will be mapped.

2.3.6 Accuracy

Horizontal accuracy is a critical user requirement of the Working Group in regards to the new digital surface waters file. Horizontal accuracy refers to the mapped location of the stream line in regards to the actual location on the Earth's surface and can be expressed as the difference in coordinates between the probable "correct" position of a streamline and its database coordinates. When a streamline is said to have "plus or minus 40 feet" horizontal accuracy, the user assumes that the streamline is somewhere inside an 80-foot square, having the stream's "correct" position at its center. Because of this variance, it is important that the mapped location of the streamline be as accurate as possible.

Existing stream files used by the group have differing levels of horizontal accuracy. The following is a list of existing data with their applicable horizontal accuracy levels.

- USGS Blue Lines/1:24,000-scale DLGs —blue lines on the paper topographic maps and the DLGs in the stream file have a horizontal accuracy of ± 40 feet. 1:24,000-scale NHD data model—has a horizontal accuracy of ± 40 feet and uses DLGs as a base data file.
- LIDAR-derived breaklines—has a horizontal accuracy of ± 1 meter. The use of LIDAR as a source in the creation of the breaklines greatly increases horizontal accuracy.

Figure 2-23 displays the difference in horizontal accuracy between the 1:24,000-scale DLGs (red streams) and the North Carolina Floodplain Mapping Program breaklines (blue streams).

Figure 2-23
Accuracy Differences Between 1:24,000-Scale DLGs and NCFMP Breaklines

Vertical accuracy was also addressed at the User Requirements Meeting but it was not evaluated in as great of detail as was horizontal accuracy. It will be an important factor for integration with other data. Some of the files that are frequently vertically integrated with streamlines include roads, orthophotography, tax parcels, jurisdictional boundaries, and buffer zones.

Consensus: The consensus of the Working Group is that horizontal accuracy for the final digital surface waters file should be ± 1 meter. Many local agencies will require this standard of accuracy for permitting purposes. It was noted that the budget and costs associated with this project will be a direct reflection on the accuracy level decided upon.

2.3.7 Uniform Standards

Another topic of discussion at the User Requirements Meeting was the need for uniform standards for certain aspects of the new statewide digital surface waters file. Included in those standards is completeness of the data, and the capacity to link this surface waters file to other data models and files. It is important that data collection and attribution remain consistent throughout the phases of collection and regions of the State. The statewide digital surface waters file should cover the same drainage areas for designated regions. For example, the North Carolina Floodplain Mapping Program uses a standard of ½ square mile drainage area in urban areas and 1 square mile drainage area in rural areas for data collection.

Figure 2-24
Consistency Differences in 1:24,000-Scale Maps

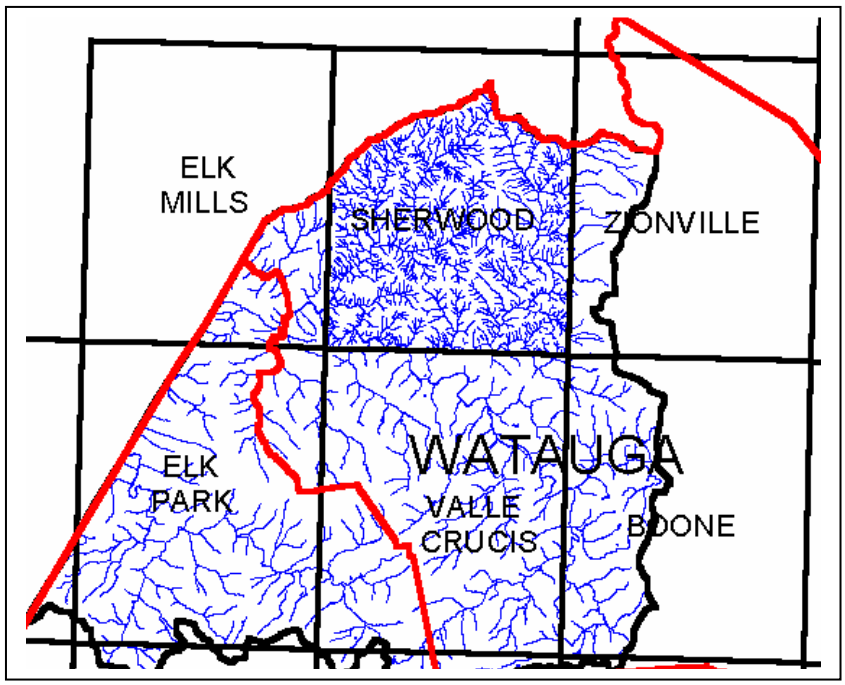


Figure 2-24 displays the difference in the 1:24,000-scale USGS quadrangle in the western region of North Carolina. This image was provided by the NC Division of Water Quality and the NC Division of Water Resources. This graphic is from a handout titled "Stream Mapping in North Carolina" that can be found on the Stream Mapping Working Group Website (http://cgia.cgia.state.nc.us/streammap).

The second uniform standard that will be required of this project is the ability to link other models and data with this statewide surface waters file. This will be important for modeling purposes as well as infusing local information with this core data. A quality assurance/quality control (QA/QC) process will be needed to ensure that the updated local files meet or exceed the standards put into place for this project.

Consensus: Uniform as well as minimum standards must be set forth for the scope and quality of this project. A method of quality assurance and control will be developed and implemented throughout the phases of the project.

2.3.8 Formats

A variety of file formats are in existence for GIS-related data so it will be imperative that the statewide digital surface waters file can be formatted into different file types. Some of the common formats used by the Stream Mapping Working Group include ESRI formats such as shapefiles, coverages, and geodatabases. Microstation and AutoCAD software file formats are also used by the Working Group. The majority of the members use similar or compatible formats with their existing data.

Formats can also include criteria such as lines versus polygon features. Polygons will be used to map the area of water bodies. Lines will be used to display the centerlines of the streams as well

as the centerlines of water bodies. Double-lines will be used to map streams wider than 40 feet. The actual point at which a stream becomes a double line will be discussed in Section 5. A policy will be required on how to handle the intersection between the coastal and riverine areas.

Consensus: In the User Requirements Meeting, the geodatabase format was recognized as an ideal format of the digital surface waters file and its attributes. With regard to lines and polygon features, the decision was made by the Working Group to include both file types.

2.3.9 Attributes

The Stream Mapping Working Group included attributes (or information that further describes a stream) as one of the top user requirement topics. Examples of attributes are the name of a stream and its flow direction. There are numerous federal, state and local agencies collaborating on the implementation plan for a new statewide digital surface waters file. Many of these agencies will have differing attribute databases that may be difficult to incorporate in the file. A core set of attributes will be used in the statewide file. Once the final surface waters file has been uploaded to NC OneMap, the objective is for agencies to download the data and conform it to their needs. Using a unique identifier field in the database as a link, agencies will be able to join the new data to existing files. This link will provide each agency with a database that can be used in standard business practices. In addition to downloading the data, users will also be able to utilize this data for Internet applications.

Some of the attributes that will be included in this study involve stream flow characteristics. Below is Table 2-23, which lists some of the flow characteristics that were discussed in the User Requirements Meeting.
Other attributes that may be incorporated into the statewide digital surface waters file include:

- Stream Name (An official stream name as well as any local stream names)
- EPA Reach Codes for linking stream segments to other databases (may need to be expanded with Globally Unique Identifiers (GUID) as a unique identifier for instances where the reach codes are not detailed enough)
- Feature types such as pond, island and right bank shoreline
- Flow direction
- Source or maintenance dates
- Metadata link

Table 2-23
List of Flow Characteristics

Flow Characteristics
Average Annual Flow
Braided Networks
Channelized
Coastal
Ditches
Impoundments
Intermittent
Isolated Networks
Navigable
Normal Pool Elev. For Reservoirs
Perennial
Regulated Flow

Consensus: The Working Group agreed that the minimum attributes for inclusion in the statewide digital surface waters file are the stream name, the feature type and a unique identifier, such as the EPA reach codes. NCDWQ's definitions listed in Section 2.3.2 will be used to attribute water features in the data file.

2.3.10 Maintenance

The statewide digital surface waters file must be maintained to ensure that the data remains valid to all users. Education and training on the state and local level may assist with setting standards for maintainability.

Spatial characteristics as well as attributes of the digital statewide surface waters file will need to be maintained. Maintenance includes additions, deletions and modifications to the core data. Considerations include how often updates will be performed, who will perform them, and where the final data will be housed. A quality assurance/quality control (QA/QC) process must be established to ensure that the modifications are necessary and correct.

Some maintenance suggestions were given at the User Requirements Meeting from the Working Group. These ideas included an update cycle based on the probability of change in an area or updates based on river basins. For many local agencies, this would be a biennial process.

Another idea for performing maintenance on the surface waters file was to designate one group to maintain the spatial data and designate another to maintain the attributes. At the meeting, it was not decided where the data will be housed. Members of the Working Group will be able to provide experience and guidance on setting up a model for data maintenance. The agencies responsible for maintenance will need to be experienced and knowledgeable with local and statewide regulations.

The QA/QC process is an important asset in providing data maintenance to the digital surface waters file. Any information added to the core data needs to pass predetermined uniform standards and procedures. Standards for scale, resolution and accuracy should be provided. The horizontal accuracy and consistency of the additional data must meet or exceed the standards set forth in the original statewide digital file. These standards may be included in the form of metadata.

Another factor that must be examined is whether the new data can be linked to existing data. Updated data may need to be provided in certain formats and with specific attributes to ensure a smooth transition in the maintenance process. Other considerations with data maintenance include linked tables and metadata. Both of these items will have to be updated in conjunction with the original file when maintenance is performed. An important question with maintenance of the data is whether the digital surface waters file can be used for regulatory purposes. Many local agencies need assurance that any updates to the core data will be recognized by regulatory agencies.

Consensus: Various factors are included in data maintenance, many of which have been discussed in detail at the User Requirements Meeting. Additional consideration should be given to how the statewide digital surface waters file can be improved upon by contributions from local government agencies. However, it has not been determined where the final data will be housed, who will perform the QA/QC and updates to the data, and how frequently the data will be updated.

2.3.11 Metadata

Members of the Working Group recognize the necessity of including metadata (i.e., data about the data) as a part of this project. Using metadata is the best way to provide reassurance in the information contained within the digital surface waters file. Some suggestions were given on how best to display metadata along with the data. One of the ideas was to use a metamap, a user-friendly version of metadata that is shown in map format. Another thought was to include metadata for each attribute. If that proposal is used, a link would be provided in the attributes to the metadata.

It was indicated that metadata needs to be provided on the core statewide data at a minimum and that it should be compliant with Federal Geographic Data Committee (FGDC) regulations. Additional metadata may be available for each feature or any updates to the master surface waters file. The agencies making modifications to the data may additionally be responsible for the metadata. However it is used in conjunction with the digital file, a process needs to be developed as to how metadata can be modified to reflect changes during the maintenance process.

Consensus: The final opinion from the User Requirements Meeting was that metadata must be provided with the digital surface waters file and it must be user-friendly. It should be in a form that is FGDC compliant. In addition, some form of sub-metadata needs to be provided for each surface waters feature (e.g., lake, pond, stream).

2.3.12 Public Access

At the User Requirements Meeting, Working Group members agreed that public access to this statewide digital surface waters file will be crucial to this project. Some of the considerations with public access to the data include distribution through NC OneMap, open standards for downloading files, browser capabilities, and download capabilities.

It is imperative that the user has assurance in any data found online. NC OneMap has gained a reputation for providing the best available data over the internet. Millions of maps are produced from the site each month. This fact is due to the ease with which the general public can view and download data. NC OneMap is available to all statewide GIS data users and includes data collected from a variety of sources. There are currently 48 participating local government organizations and 4 regional councils of government that provide data to NC OneMap. NC OneMap compliments the nationwide efforts of The National Map and the Geospatial One-Stop programs. Figure 2-25 is a snapshot from the NC OneMap Viewer that depicts orthophotography for the Manteo, NC coastal area. (http://www.nconemap.com/).

Figure 2-25
Sample Map from NC OneMap Website

There will be various users of the new statewide digital surface waters file, and open standards will be of utmost importance. These standards ensure that the user-downloaded files can be manipulated regardless of original formatting. Open standards eliminated the need for file-conversion software applications that would have been necessary in the past. Along with the actual vector data, any related tables that are linked to the digital surface waters file must have open standards as well.

When a variety of users are searching a website for GIS-related data, it is important that the site have browser capabilities. Many people accessing NC OneMap will use the data for simple viewing or to print a map of a specific area. A user-friendly interface will make the browsing processes less confusing to the general user. The purpose of having data accessible on the internet is to easily distribute it to as many people as possible.

For the user interested in downloading data, the process should remain as seamless as possible. The option of using open standards for data formats provides assurance that data will be accessible once it is downloaded. Another option would be to let the user choose from a variety of file formats. An additional consideration is whether straight downloads from ftp sites should be allowed. There are security issues that would need further examination with that option. The new statewide digital surface waters file will most likely be large in size. Providing the new surface waters file clipped to county or other state boundary would make the data more readily accessible to users.

Some potential users of the North Carolina digital surface waters file who may need public access to NC OneMap include: federal agencies, state government agencies, regional

governments, local governments, non-profit organizations, universities, schools, private sector organizations, and individual citizens.

Consensus: NC OneMap will be the distribution center for the digital surface waters file, as set forth by Senate Bill 1152. NC OneMap needs to include browser and download capabilities for all users.

The necessities of the Stream Mapping Working Group were narrowed down to minimum and optional requirements for the new statewide digital surface waters file at the User Requirements Meeting. The main points emphasized in both the surveys and at the meeting are listed in the next section.

2.4 Summary of Findings

2.4.1 Stream Study Surveys

The results of the surveys from Section 2.2 of this document are briefly summarized below.

- The digital surface waters file will need to be beneficial and flexible to all the members of the Stream Mapping Working Group as well as to other potential users of the data. The number of survey responses received is an indicator of the great need for the Stream Mapping Study.
- Stream maps and/or digital stream files are used on a daily basis in many agencies. Having a new statewide digital surface waters file available is important for their business practices.
- Due to high demand, the new statewide digital surface waters file should be compatible with the ESRI product line. Agencies desire to have streamlines defined as both double lines as well as with centerlines. The new statewide digital surface waters file also needs to include both lines and polygons.
- Data from the new digital surface waters file will be in the public domain because of its inclusion on NC OneMap.
- Water body features will need to be defined and identified in the new surface waters file.
- Inclusion of the coastline in the statewide file will be beneficial to some agencies.
- The new statewide digital surface waters file should be as accurate as other vertically integrated data layers or anomalies will show.
- The new statewide digital surface waters file will need to have a common link to agency data.
- Agencies who currently maintain their data will need the ability to post updates to the new digital surface waters file as well.
- It will be important to factor data maintenance into the budget for this project.

- Dataset should be tailored to meet agencies' needs to the highest degree possible. This will likely increase funding for this project.

2.4.2 User Requirements Meeting

The following is a summary of the outstanding issues and conclusions made by the Stream Mapping Working Group during the User Requirements Meeting. It is a brief overview of the findings from Section 2.3 of this document.

Surface Waters Definition

- Mandatory
  - use the NCDWQ's definitions for surface waters
  - set guidelines for what is included in surface waters

Source Data

- Mandatory
  - use the most current and up-to-date information for this study
- Optional
  - use the Floodplain Mapping Streamlines
  - use the 1:24,000-scale NHD data model

Modeling

- Mandatory
  - surface waters file must have modeling capabilities
  - single lines and double lines will be included
- Optional
  - establish a process to link the existing 1:24,000-scale NHD model to the new digital surface waters file or include the NHD information as part of the new file
  - if included, investigate how scaleable the NHD data is on a local level

Coverage Area

- Mandatory
  - digital surface waters file produced will be a North Carolina statewide coverage
- Optional
  - determine if the coverage will extend past the state boundaries
  - work may need to be performed in phases or by regions

Accuracy

- Mandatory
  - horizontal accuracy for the new surface waters file will be ± 1 meter
- Optional
  - use FMP breaklines that meet this requirement

Uniform Standards

- Mandatory
  - uniform and minimum standards must be set forth for the scope and quality
  - local information added to core data must meet or exceed standards
  - QA/QC method developed and implemented throughout the phases of the project

Formats

- Mandatory
  - determine final digital surface waters file format
  - include both line and polygon features in the digital file
- Optional
  - use geodatabase for format of the digital file and its attributes

Attributes

- Mandatory
  - minimum attributes in the digital surface waters file will be the stream name, the feature type and a unique identifier
  - NCDWQ's definitions for surface waters will be used to attribute water feature types in the data
- Optional
  - additional attributes may be added to core data

Maintenance

- Mandatory
  - the final data should be housed by one agency
  - quality control of the data updates needs to be performed
  - update frequency needs to be established

Metadata

- Mandatory
  - metadata must be provided with the digital surface waters file
  - must be user-friendly
  - format that is FDGC compliant for at least the core data
  - feature level attributes need a minimum amount of "sub-metadata"
- Optional
  - use metamap to view metadata
  - provide link to metadata in attribute table

Public Access

- Mandatory
  - NC OneMap will be the distribution center for the digital surface waters file

  - browser capabilities
  - download capabilities
- Optional
  - download different formats
  - clip data for download

3 Development of Mapping Specifications and Standards

A Mapping Specifications and Standards Meeting with the Stream Mapping Working Group was held on November 8th, 2004 at the USGS facilities in Raleigh, North Carolina. This meeting provided an overview of the user requirements analysis section of this document, and gave Working Group members a chance to confirm that the requirements included in the analysis were accurately stated. The remainder of the meeting focused on determining the design of the new statewide surface waters file to meet the requirements stated in the document.

The user requirements analysis was sent to members of the Working Group prior to the meeting for review. Working Group members were given until the close of business the day of the meeting to make comments on the document. In addition, comment forms were provided to Working Group members at the meeting, which ensured that each agency was given additional outlets to express their needs and concerns. All comments have been incorporated into this document.

3.1 Mapping Concerns

The following is a summary of concerns that were discussed by the Working Group during the Mapping Specifications and Standards Meeting.

- Stream reach determinations must be kept simple for the contractor performing the Stream Mapping Project. Walking every stream is not a cost effective option for this project. The estimated cost for completing such an effort statewide is over $500 million. Therefore, the easiest way to handle the determination of stream reaches would be to have a drainage area requirement, which could vary for regions of the state. The project cost will be proportional to how far up streams will be mapped. It was also mentioned that this item could be phased (e.g., scope 40 acres first, then down to 20 acres later), or that areas in need could be completed at a 20-acre minimum in conjunction with local government data.

- The Floodplain Mapping Program uses 40 feet as the criteria to determine whether streams should be denoted with double lines. The 40-foot standard was derived from map scale (1:500). It was noted that this width might not be suitable for determination of riparian buffers, which are measured from top of bank, or for local government purposes. Local data, which may use a 20-foot minimum, will be incorporated into the final digital file. Determinations will need to be made as to how the differing line widths will be joined.

- The National Hydrography Dataset (NHD) model's (Figure 5-1) general rule for centerlines is that they generally flow in the center of the stream banks, but the actual criteria is that the centerline lie somewhere between the double lines. It was decided that the NHD criteria would be suitable for the needs of the Working Group.

- Individual agencies can conduct field visits for increased horizontal accuracy. It was noted that DOQQs are complete and LIDAR is two-thirds complete for the State, and that any additional forms of data collection are tied to cost.

4 Drainage Area Requirements

4.1 Drainage Area to Stream Mapping Relationship

A relationship exists between the length of stream miles within a certain area and the upstream minimum drainage area. A 6,762 square mile section of the Floodplain Mapping Program breakline data was analyzed to determine the relationship. Figure 4-1 displays the miles of stream per drainage area in acres. The larger the drainage area requirement, the fewer the number of stream miles that will need to be mapped.

Figure 4-1
Relationship of Drainage Area and the Number of Stream Miles Mapped

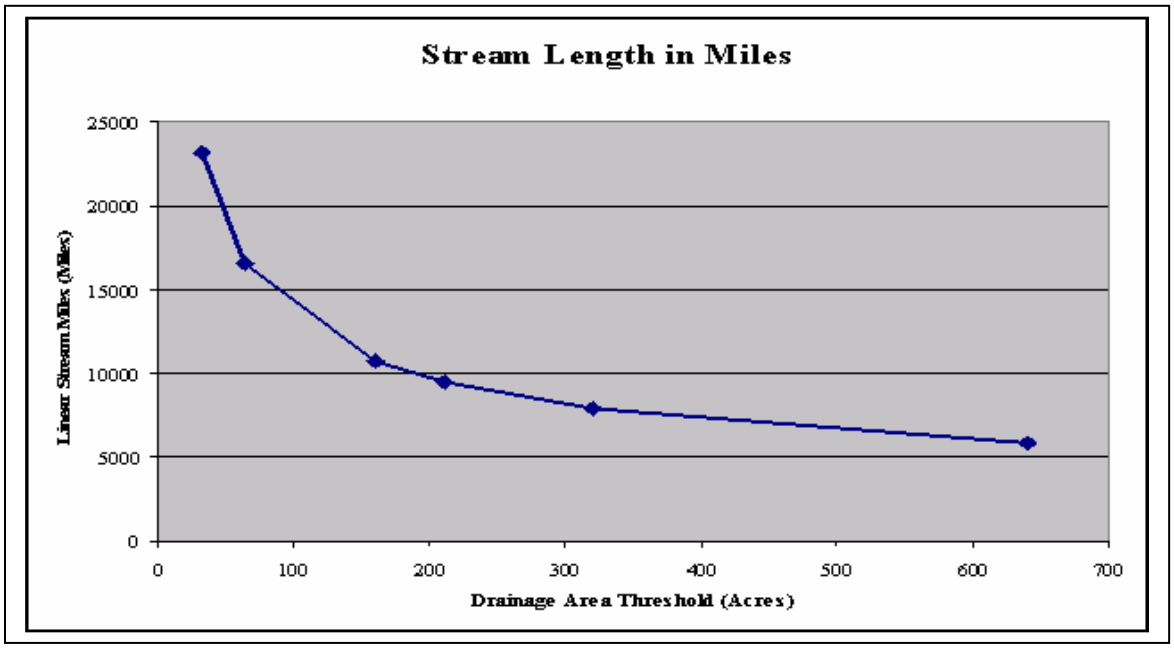
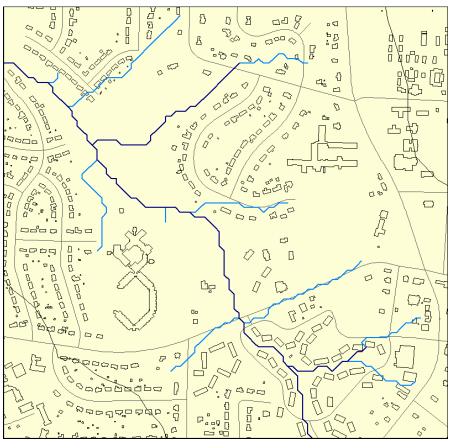


Figure 4-2 shows the difference in stream reaches mapped between a 20-acre drainage area (light blue) and a 40-acre drainage area (dark blue). A smaller drainage area will map more streams but will increase the project cost.

Figure 4-2
Difference in Stream Reach Limits Between 20 and 40 Acre Drainage Areas



4.2 Intermittent and Perennial Stream Depiction

In the summer of 2000, the City of Greensboro initiated a study of intermittent and perennial streams. This study identified and mapped approximately 40 square miles of intermittent and perennial streams in water supply watersheds. Using information obtained from a previous citywide stormwater infrastructure inventory, open channels were identified for field study. Field visits were conducted to locate actual points on the ground (breakpoints) where streams changed from intermittent to perennial. These breakpoints were identified and located with sub-meter GPS units. Ground points where streams changed to ephemeral (stormwater open channels) stream were also defined. Methodologies were determined to classify each point as intermittent, perennial, or ephemeral. This was a $400,000 to $450,000 effort that was finalized in July of 2003. The results of the study were provided by the City of Greensboro for analysis.

The table below displays the cost of applying the study performed by the City of Greensboro to a statewide project. If each stream in the state was visited by a field crew to determine the intermittent and perennial breakpoints, then the total cost would be over half a billion dollars. This cost is unreasonable given the scope of the Surface Waters Mapping Project.

Table 4-1
Cost of Field Determination of Intermittent/Perennial Breakpoints in North Carolina

City of Greensboro Study Area	Cost of Greensboro Study	Cost Per Square Mile	Area of NC (Square Miles)	Cost of NC Intermittent / Perennial Study
38.35 Square Miles	$425,000	$11,082	49,355	$546,958,931

The table below displays the relationship of drainage area to the number of intermittent, perennial, and ephemeral breakpoints captured. Using the City of Greensboro stream study data, as the drainage area for mapping the headwaters of streams decreases, the number of breakpoints captured increases. At a 20-acre drainage area requirement, 53% of the intermittent / perennial breakpoints are captured, and at a 6-acre drainage requirement the percentage of points captured increases to 95%. The results displayed in this table indicate that using a drainage area requirement for mapping the headwaters of streams will capture intermittent as well as perennial streams. This analysis represents a cost effective in-office method for mapping intermittent streams.

Table 4-2
Relationship of Drainage Area to Intermittent/Perennial Breakpoints Captured

Point Type	6 acres (# of points captured)	6 acres (% captured)	20 acres (# of points captured)	20 acres (% captured)	40 acres (# of points captured)	40 acres (% captured)
Intermittent/Perennial (123 total points in study)	120	95%	65	53%	20	16%
Ephemeral/Perennial (94 total points in study)	72	77%	41	44%	18	19%
Ephemeral/Intermittent (230 total points in study)	176	77%	61	27%	13	6%

5 Digital Surface Waters File Mapping Specifications and Standards

5.1 Introduction

The following mapping specifications and standards have been identified by the Stream Mapping Working Group as important considerations in the new statewide digital surface waters file. The specifications and standards set forth by the Working Group establish the guidelines for the creation of the surface waters data. Each item is discussed in detail in Section 5.4 of this document.

- Surface Waters Definition (using NCDWQ's definitions)
- Determination of Stream Reach Limits
- Centerlines for Streams, Coastlines, and Sounds
- Double Lines for Streams
- Accuracy Requirements (Determination of Stream Lines When Obscured on LIDAR)
- Surface Waters Attributes
- Optional Stormwater Attributes
- Display of Channels Around Islands
- Display of Braided Streams
- Display of Open Channels Between Stormwater Systems
- Display of Water Bodies (includes wetlands)
- Flow Directions for Interconnected Basins
- Other Special Case Situations
- Data Maintenance

5.2 Background

The specifications are constructed around one existing standard and one existing data set. The existing standard that has been adopted for this project is the NHD and the common data set used to define the minimum standards of the product is the North Carolina Floodplain Mapping Program three-dimensional breaklines. These two items form the foundation of the specifications.

5.2.1 The National Hydrography Dataset (NHD)

The NHD is an effort to build a consistent level of hydrography data for the nation. It is a cooperative effort between the USEPA, the USGS, and many other partners.
The data contains basic digital information about surface water features. Included are features such as streams, rivers, lakes, ponds, springs and wells. There are over 100 feature types included in the NHD. In addition to this basic information, the NHD provides:

- a standard unique identifier (EPA reach code) for each stream segment,
- tabular routing for upstream and downstream navigation,
- indexing for outside data sources to streams, including monitoring sites, outfalls, Natural Heritage Program (NHP) sites, etc.,
- a networked stream system with network junctions and flowline attributes,
- a complex data model suitable for hydrography applications such as mapping, referencing, and modeling/analysis, and
- a feature-based metadata model.

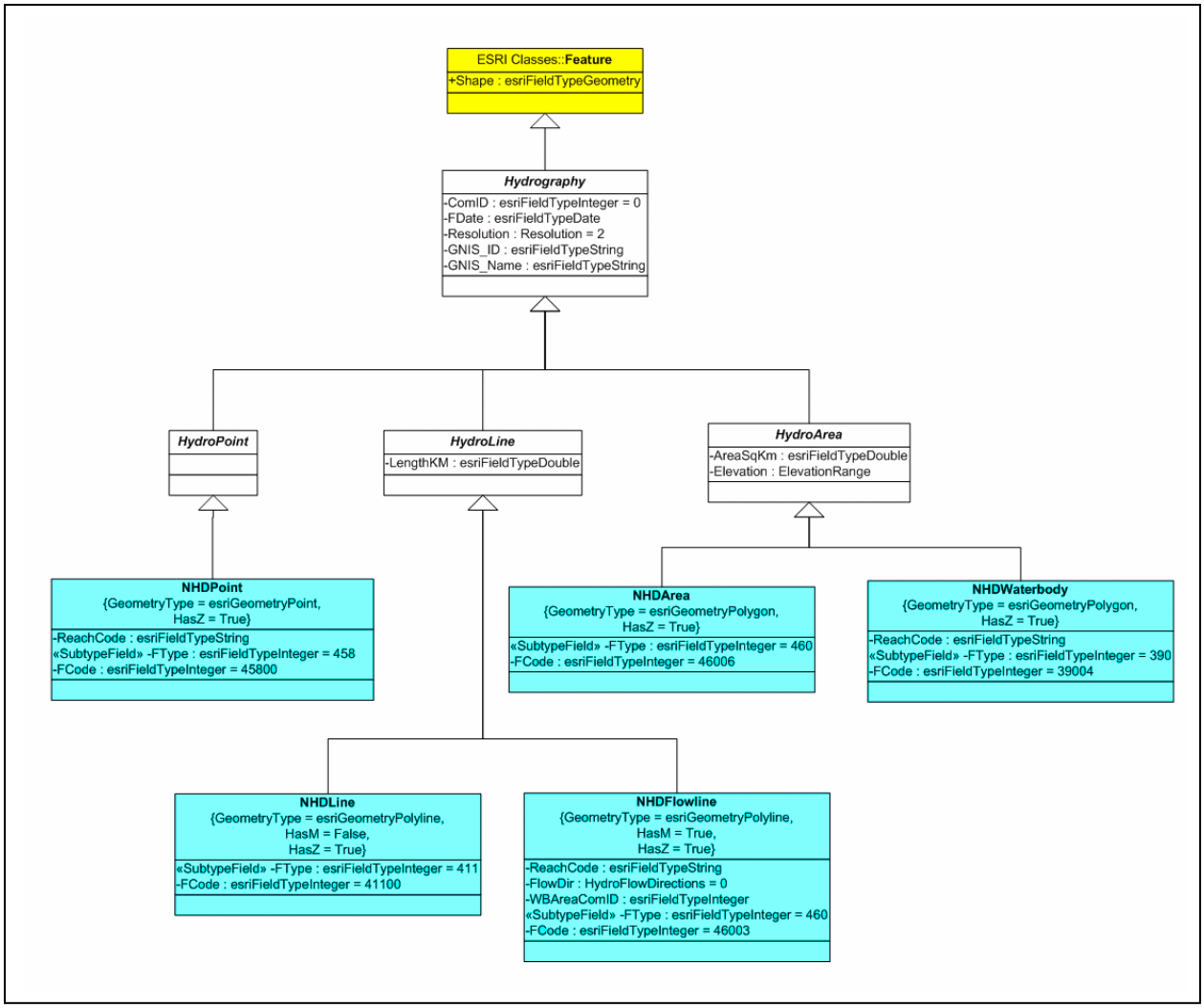
The NHD for North Carolina currently involves 17 river basins, adjacent states, and intergovernmental cooperation. The NHD completion progress is moving west to east across the state. The NHD is available in both ESRI shapefile and ESRI geodatabase formats (the geodatabase includes event tables) and is compatible with the ESRI ArcHydro data model.

The NHD incorporates a nationally accepted standard that allows the distribution of the data through the National web-site. NHD data for entire states can be downloaded at one time. The NHD has been successfully scaled from 1:100,000-scale to 1:24,000-scale, and is now being scaled to the local level (1:5,000-scale).

Point, line, and polygon features compose the hydrography of the data model. Figure 5-1 displays the model schematic.

- The primary distinction within the polygon feature classes is that water bodies may have a reach code attribute for linking associated data.
- The primary distinction within the line feature classes is that flowline features may have a reach code attribute for linking associated data and have topologically connected flow networks. Artificial paths, which are arbitrary streamlines drawn as centerlines through double-line streams or water bodies, may also have a link to an associated water body.
- Distinctions are not made within point feature classes.

Figure 5-1
NHD Data Model Schematic



5.2.2 North Carolina Floodplain Mapping Program 3-D Breaklines

Breaklines are lines on the earth's surface having known elevations and positional coordinates. They are used to indicate abrupt changes in elevation, and are used to adjust other data to account for distortions in terrain. Breaklines may be two-dimensional (no recorded elevations) or three-dimensional (elevations are recorded at each stream vertex).

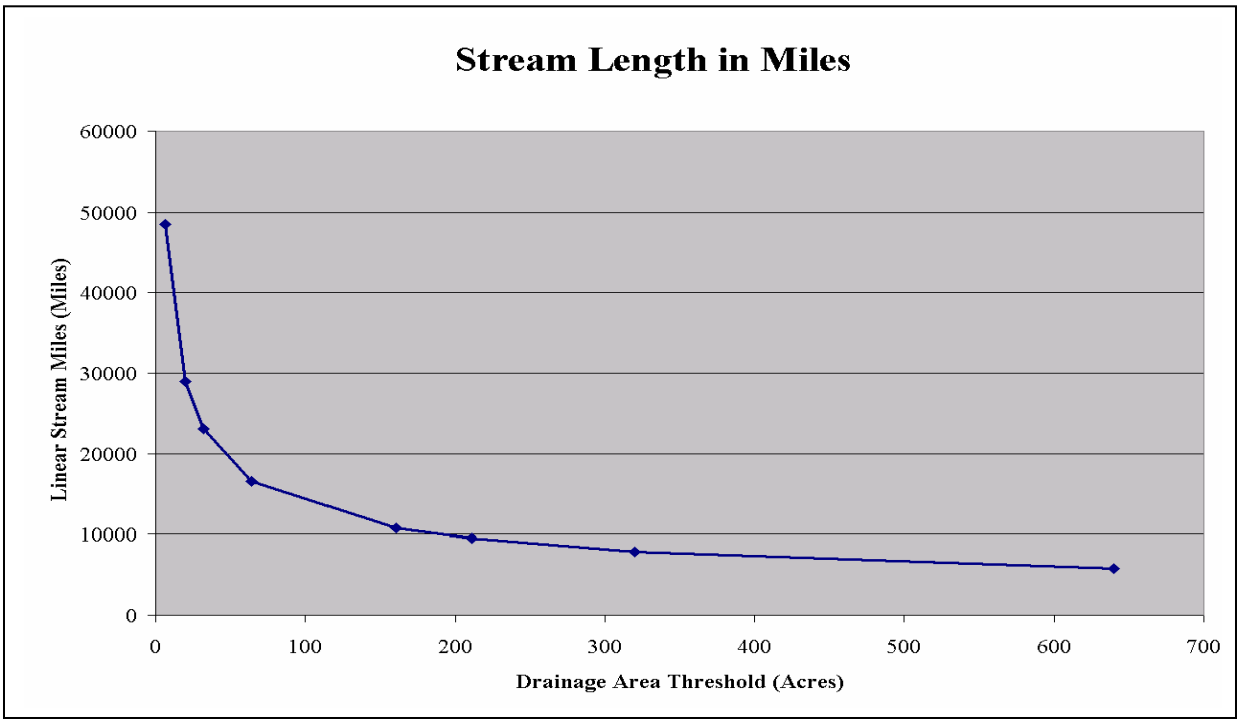
Figure 5-2
Example of FMP 3-D Breaklines

The horizontal alignment of the breaklines used for the North Carolina Floodplain Mapping Program is verified by orthophotos and LIDAR. As a general rule, the upper stream reach limits for the program are the USGS blue line streams. In general, the breaklines do not completely cover the upper reach limits of the USGS blue line streams in the eastern region of the state. Upper reach limits are matched in the central region, and are exceeded in the western region of the state.

The breaklines and the LIDAR data are used in the generation of the Triangular Irregular Network (TIN). Both 20-foot and 50-foot Digital Elevation Models (DEMs) are created from the TINs. The Floodplain Mapping Program uses 3-D breaklines that are burned (fused) into 50-foot DEMs. Manual tools and a software application are used to hydro-correct the DEMs. These hydro-corrected breaklines are the streamlines used for the North Carolina Floodplain Mapping Program.

Figure 5-3 displays drainage areas in acres and the miles of stream that would be mapped at those specific drainage area requirements. The information is based on calculations for the entire State of North Carolina. Similar to the results displayed in Figure 4-1, the larger the drainage area requirement, the fewer the number of stream miles that will need to be mapped.

Figure 5-3
Drainage Area Versus Stream Miles Mapped for the State of North Carolina



5.3 Project Phasing

The Stream Mapping Project shall be completed in five phases. The first two phases shall consist of the completion of the 1:24,000-scale NHD data for North Carolina and the incorporation of the North Carolina Floodplain Mapping Program streamline data. These early phases will provide initial products that will serve as a bridge for development of the latter phases of the project. Phases 3-5 consist of the development, implementation, and maintenance of new, statewide surface waters mapping.

Phase 1A

Phase 1A will complete a valuable interim product in the 1:24,000-scale NHD data. This was the consensus of the stakeholders on the Working Group. This effort will be completed in the first year of the five-year plan.

Phase 1B

Phase 1B develops the geodatabase design and software that will support Phases 3 through 5 in the Stream Mapping Project and is a key step in theoverall effort. The products that will be developed include:

a. Schema for the attributes of North Carolina Statewide Digital Surface Waters File
b. Design of the geodatabase
c. Submittal of a data maintenance plan
d. Submittal of a quality assurance plan
e. Recommended modifications of standards and various plans
f. Development of tools necessary for automated QA/QC
g. Development of tools necessary for maintenance
h. Development of tools to allow partners to contribute modifications to the database

Phase 1C

Phase 1C, public outreach and education, is critical to the overall success of the Stream Mapping Project. This effort will focus on conveying the uses and purposes of the new statewide digital surface water file to the broad user community. This will involve stakeholders including both users and creators of surface waters data. In the early phases, outreach will be focused on the value of the NHD data to the users. As the 20-acre and 6-acre products are defined and developed, outreach will shift to educating the users and the public on the usefulness of these products.

Phase 2

Phase 2 incorporates the North Carolina Floodplain Mapping Program streamline data for a more accurate depiction of streams using the LIDAR data as a base.

Phase 3

Phase 3 of the project extends the mapping created from Phase 2 upstream to the 20-acre drainage area requirement. The size of this drainage area for mapping was reached through

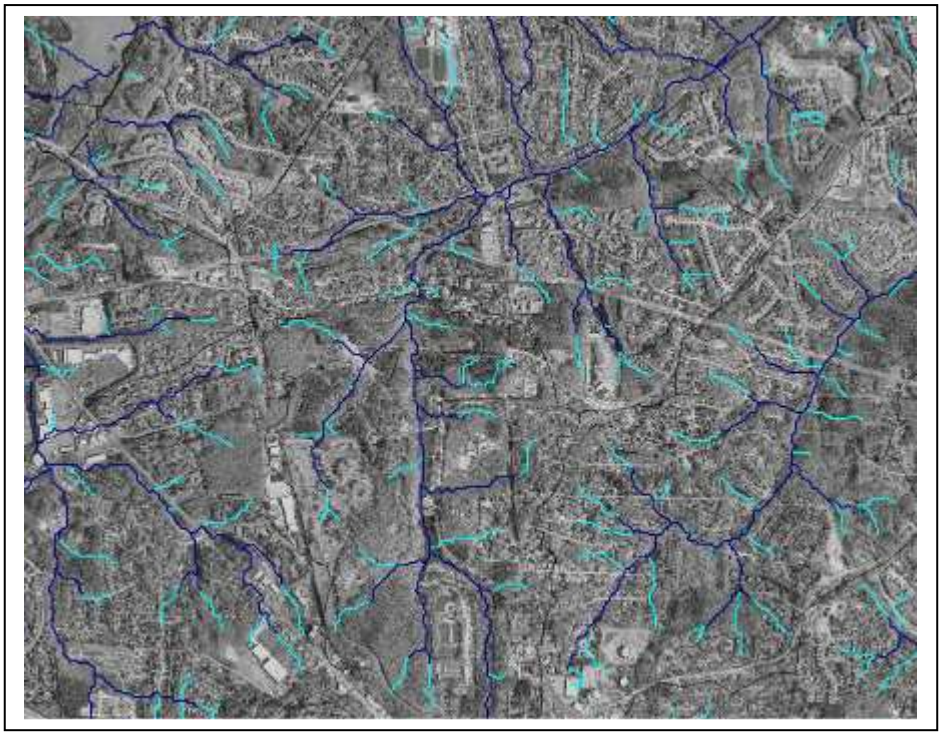
consensus of the Working Group. Attribution of the streamlines with core surface waters attributes outlined in Section 5.4.6 will also be completed in this phase.

Phase 4

Phase 4 extends the mapping created from upstream of the Phase 3 delineation to the 6-acre drainage area requirement. Watersheds containing urban areas will be the first priority for mapping from the 20-acre to the 6-acre requirement. This will assist with meeting Phase II NPDES regulations in the urban areas of North Carolina.

Figure 5-4 displays the difference between streams mapped at the 20-acre drainage area (dark blue) and those mapped at the 6-acre drainage area (light blue).

Figure 5-4
Streams Mapped at 20 and 6 Acres



Phase 5

Phase 5 of the project is the maintenance phase which will actually start in the second year of the project and continue as needed.

Phases 2 through 5 incorporate an ongoing evaluation of state-of-the-art processes and technologies. One of these technologies is the intermittent/perennial stream research study conducted by North Carolina State University in cooperation with NCDWQ and NCDOT.

Sections 5.4 through 5.6 of this document cover the design and development of the geodatabase as well as the software tools to support the project. Section 6 of this document details the implementation of all the phases.

5.4 Mapping Specifications

5.4.1 Surface Waters Definitions

The NCDWQ's definitions along with the NOAA definition for mean high water shall be used as a basis for the Stream Mapping Project. Listed below are definitions used by NCDWQ for surface waters.

- *Channel* -- A natural, water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water.
- *Ditch or Canal* -- A man-made channel other than a modified natural stream constructed for drainage purposes that is typically dug through inter-stream divide areas. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent streams.
- *Ephemeral (Stormwater) Stream* -- A feature that carries only stormwater in direct response to precipitation with water flowing only during and shortly after large precipitation events. An ephemeral stream may or may not have a well-defined channel, the aquatic bed is always above the water table, and stormwater runoff is the primary source of water. An ephemeral stream typically lacks the biological, hydrological, and physical characteristics commonly associated with the continuous or intermittent conveyance of water.
- *Intermittent Stream* -- A well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological and hydrological characteristics commonly associated with the conveyance of water.
- *Mean High Water* -- The average elevation of all high waters recorded at a particular point or station over a considerable period of time, usually 19 years. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal (daily). (NOAA Coastal Services Center definition).
- *Modified Natural Stream* -- An on-site channelization or relocation of a stream channel and subsequent relocation of the intermittent or perennial flow as evidenced by topographic alterations in the immediate watershed. A modified natural stream must have the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.
- *Perennial Stream* -- A well-defined channel that contains water year round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.
- *Stream* -- A body of concentrated flowing water in a natural low area or natural channel on the land surface.

- *Surface Waters* -- All waters of the state as defined in G.S. 143-212 except underground waters.
- *Waters (Defined in G.S 143-212)* -- Any stream, river, brook, swamp, lake, sound, tidal estuary, bay, creek, reservoir, waterway, or other body or accumulation of water whether surface or underground, public or private, or natural or artificial, that is contained in, flows through, or borders upon any portion of this State, including any portion of the Atlantic Ocean over which the State has jurisdiction.

5.4.2 Determination of Stream Reach Limits

All surface waters shall be identified for drainage areas greater than 20 acres, and mapped based on the North Carolina Floodplain Mapping Program LIDAR data. Table 5-1 below illustrates the relationship between land area and the miles of stream mapped at the 20-acre drainage requirement. The table displays this relationship by North Carolina river basin.

Table 5-1
Land Area and Miles of Stream for NC River Basins

River Basin	Area (Square Miles)	Stream Length (Miles)
Broad	1,513	6,492
Cape Fear	9,271	39,774
Catawba	3,285	14,092
Chowan	1,309	5,616
French Broad	2,829	12,137
Hiwassee	644	2,762
Little Tennessee	1,796	7,706
Lumber	3,328	14,275
Neuse	5,658	24,271
New	753	3,231
Pasquotank	2,201	9,441
Roanoke	3,499	15,013
Savannah	171	735
Tar-Pamlico	4,625	19,840
Watauga	205	878
White Oak	1,047	4,493
Yadkin	7,221	30,979
TOTAL	**49,355**	**211,734**

5.4.3 Centerlines for Streams, Coastlines, and Sounds

All streams, coastlines, and sounds shall have centerlines in the new statewide digital stream file. The following items represent how the centerlines shall be located.

1. The NC Floodplain Mapping Program's LIDAR information shall be used to map the stream centerlines, in conjunction with the most recent orthophotography (DOQQs or local imagery).
2. For most stream centerlines, the location of the centerline streamline shall be within the stream banks when the stream banks are provided. These lines should generally be located in the apparent centerline of the stream.
3. For sounds using bathymetry (underwater ridgelines), the Natural Resources Conservation Service (NRCS) centerlines shall be used, if available. If the bathymetry data is not available, a centerline shall be mapped down the visual center of the sound.
4. For coastlines, centerlines shall represent the line of mean high water.

5.4.4 Double Lines for Streams

Double-line streams shall be:

1. Measured from the edge of water when the orthophotos were flown.
2. Used in areas where stream width is 40 feet or greater.

5.4.5 Horizontal Accuracy Requirements

When a streamline is visible in the orthophoto and the terrain data shows the location of the stream, the horizontal accuracy shall be ± 1 meter. The accuracy of each stream segment shall be reflected in the metadata attribute.

Stream placement cannot be guaranteed in areas where the streamline is obscured by heavy vegetation. The accuracy for these areas shall be reflected in the metadata attribute.

Figure 5-5
Stream Line Displayed on a DOQQ

The new statewide digital surface waters file shall be submitted in North American Datum (NAD) 1983 State Plane Feet.

5.4.6 Surface Waters Attributes

The State of North Carolina has provided a list and description of attributes to be collected. Using this list, the contractor shall submit a proposed schema and domain tables to the State for approval. The attributes include:

1. EPA Reach Code
    a. The contractor shall establish the same stream segmentation as the NHD data. The EPA reach codes provided in the NHD shall be used for these stream segments. A stream segment is defined as the area separated by any two incoming tributaries.

b. If a stream segment is split for modifications, then same reach code shall be assigned to both sections. If a stream segment is added, then new reach shall be assigned a -9999 denotation.

c. If a stream segment is deleted, then the associated reach code shall be permanently retired.

d. The segment metadata shall also reflect all attribute changes.

2. Com_id

a. Each stream segment shall also contain the NHD unique identifier Com_id in addition to the reach code. The Com_id is the reach code + % of stream length.
b. If a stream segment is added, then the Com_id shall be assigned a value of zero.

3. North Carolina Globally Unique Identifier (GUID)

a. The contractor shall assign a GUID for each stream segment within the statewide digital surface waters file. This number shall be unique between tributaries.

b. If a stream segment is split, then the contractor shall assign a new GUID to each section.

c. If a stream segment is added, then a new GUID shall be assigned to the new segment.

4. Official Stream Name

a. The contractor shall populate the official stream name using the NHD data and the Geographic Names Information System (GNIS) for additional information.

b. If an official stream name cannot be determined or does not exist, then the field name shall be populated with “unnamed”.

5. Local Stream Name

a. The contractor shall populate the local stream name using local agency data if available.

b. If the local name is the same as the official name, then the local name shall be populated with the official name.

c. If a local stream name cannot be determined or does not exist, then the field name shall be populated with “unnamed”.

6. Feature Type

a. The contractor shall populate the feature type with the NHD feature types.

b. If a feature type cannot be determined, then the feature type field shall be populated with “uninitialized”.

Figure 5-6
Examples of NHD Feature Types

OBJECTID*	FCode	Description
1	43625	Reservoir: Reservoir Type = Disposal; Construction Material = Earthen
2	43626	Reservoir: Reservoir Type = Disposal; Construction Material = Nonearthen
3	56600	Coastline
4	30700	Area to be Submerged
5	31200	Bay/Inlet
6	31800	Bridge
7	33400	Connector
8	33600	Canal/Ditch
9	33601	Canal/Ditch: Canal/Ditch Type = Aqueduct
10	34300	Dam/Weir
11	34305	Dam/Weir: Construction Material = Earthen
12	34306	Dam/Weir: Construction Material = Nonearthen
13	36100	Playa
14	36200	Flume
15	36400	Foreshore
16	36700	Gaging Station
17	36900	Gate
18	37300	Hazard Zone
19	37800	Ice Mass
20	39000	Lake/Pond
21	39001	Lake/Pond: Hydrographic Category = Intermittent
22	39004	Lake/Pond: Hydrographic Category = Perennial
23	39005	Lake/Pond: Hydrographic Category = Intermittent; Stage = High Water Elevation
24	39006	Lake/Pond: Hydrographic Category = Intermittent; Stage = Date of Photography

7. Segment Length

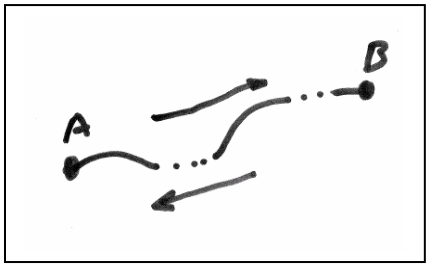
   a. The contractor shall populate the segment length with the length of the centerline from the upstream to downstream point for single line streams.

   b. The contractor shall populate the segment length with the centerline distance for double-line streams.

8. Flow Direction

Figure 5-7 below assumes that the stream line segment was drawn from A to B. In general, A is the upstream limit of the stream reach, and B is the downstream limit of the stream reach.

Figure 5-7
Flow Direction Between A & B



a. If the stream flows from A to B, then the flow direction shall be populated with the number 1.

b. If the stream flows from B to A, then the flow direction shall be populated with the number -1.

c. If stream flow direction cannot be determined, then the flow direction shall be populated with a zero.

9. Upstream Reach Limit (A) Drainage Area

   a. The contractor shall populate this item with the drainage area of A.

10. Downstream Reach Limit (B) Drainage Area

   a. The contractor shall populate this item with the drainage area of B.

11. Upstream Reach Limit (A) X coordinate

   a. The contractor shall populate this item with the easting of A.

12. Upstream Reach Limit (A)Y coordinate

   a. The contractor shall populate this item with the northing of A.

13. Downstream Reach Limit (B) X coordinate

   a. The contractor shall populate this item with the easting of B.

14. Downstream Reach Limit (B) Y coordinate

   a. The contractor shall populate this item with the northing of B.

15. Metadata GUID

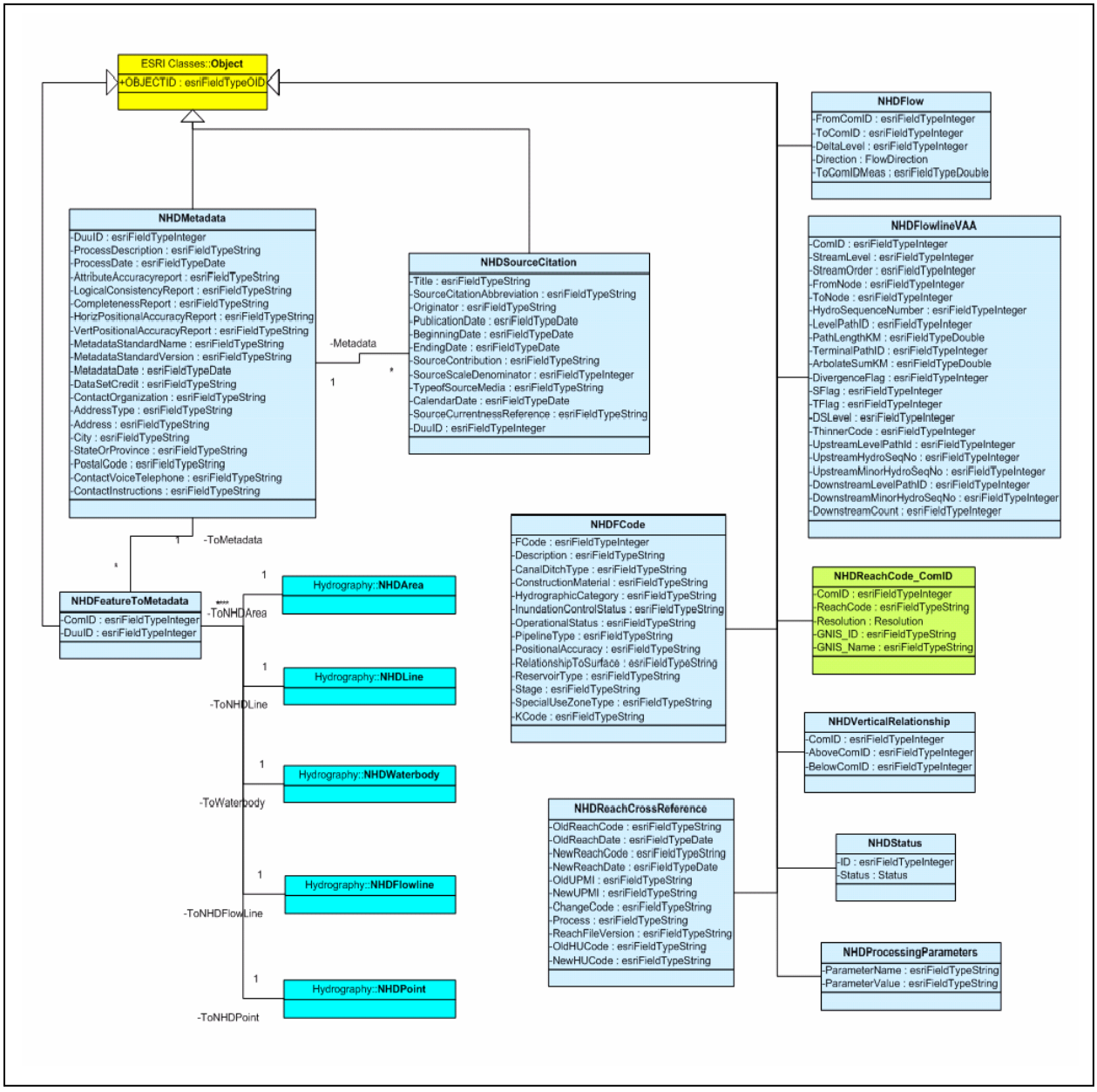
   a. The contractor shall populate this field with a metadata GUID for each stream segment in the digital surface waters file.

   b. The metadata for the initial statewide digital surface waters file shall be FGDC compliant.

Figure 5-8 displays the breakdown of the NHD metadata model, which provides a good example of a model that could be used for the Stream Mapping Project.

- The ReachCode_ComID is available in the central database, but is not included in the personal geodatabase distribution. The ReachCode_ComID allows for backward compatibility with other feature based databases (e.g., individual agency data).
- The NHDStatus field is only used to track data changes for data changes in the central database.

Figure 5-8
NHD Metadata Model Schematic



16. Attribute Metadata

    a. The contractor shall create a sub metadata GUID attribute field for each of the core attributes listed in Section 5.4.6.

    b. Sub-metadata shall at a minimum include: link field, agency making the change, when the change was made, why the change was made, field changed, old value, new value, and horizontal accuracy.

    c. The sub-metadata domain attribute table shall be blank when the statewide digital surface waters file is first submitted, and shall only change when modifications occur.

Table 5-2
Example Sub-Metadata Attribute Table

ATTRIBUTE TABLE	
Field Name	**Sub Metadata Field Name**
EPA Reach Code	SMD EPA Reach Code
Com_ID	SMD Com_ID
NC GUID	SMD NC GUID
Official Stream Name	SMD Official Stream Name
Local Stream Name	SMD Local Stream Name
Feature Type	SMD Feature Type
Segment Length	SMD Segment Length
Flow Direction	SMD Flow Direction
Point A Drainage Area	SMD Point A Drainage Area
Point B Drainage Area	SMD Point B Drainage Area
Point A X Coordinate	SMD Point A X Coordinate
Point A Y Coordinate	SMD Point A Y Coordinate
Point B X Coordinate	SMD Point B X Coordinate
Point B Y Coordinate	SMD Point B Y Coordinate
Metadata GUID	SMD Metadata GUID

[Note: SMD = sub-metadata]

17. Maintenance Date

    a. The contractor shall populate the maintenance date with the most recent date that any modifications were made to each stream segment.

18. Status

    a. The status shall be populated with addition, deletion, or modification.

5.4.7 Optional Surface Waters Attributes

1. Flow characteristics
   a. If included as part of the scope of work determined by the State of North Carolina, the contractor shall populate this attribute with perennial, intermittent, or ephemeral.
   b. If water is visible in the orthophoto, then the attribute shall be populated with perennial. If water is not visible in the orthophoto, then the attribute shall be populated with "uninitialized", unless field verified.

2. Stormwater attributes

If included as part of the scope of work determined by the State of North Carolina, the contractor shall include stormwater attributes. All stormwater features that have been previously inventoried shall be identified and submitted as point and line features. These features shall be linked to the core surface waters attributes using a unique identifier and the following attributes.

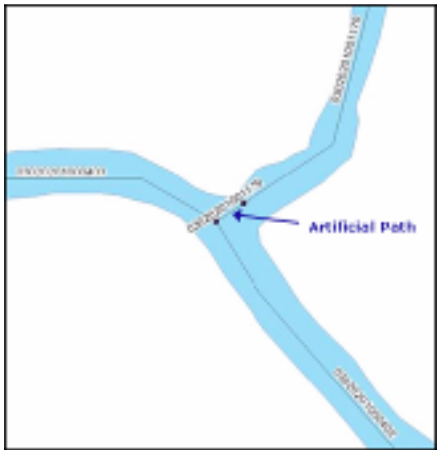
a. Nodes (points) – Structure type (catch basin, curb inlet, drop inlet, slab inlet, manhole, end section, channel junction, pipe junction, junction box, other), survey date, survey time, location, node id, structure shape, width, length, depth, invert, grate type, grate length, grate width, throat length, throat height, throat rod, throat invert, material, condition, obstruction, flow
b. Pipes (lines) – survey date, survey time, upstream node id, downstream node id, pipe shape, diameter, material, depth, inverts, condition, slope, obstruction, flow direction

5.4.8 Special Cases

5.4.8.1 Double Lines Connecting into Double-Line Streams

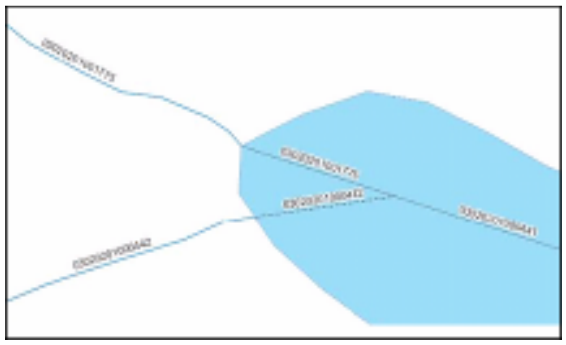
When a double-line stream connects to a double-line stream, intersection (junction) points of the lines shall not be denoted for this study. An artificial path shall connect the stream centerlines and the same reach code as the incoming stream shall be assigned to the new segment.

Figure 5-9
Artificial Path of Added Double-Line Stream



5.4.8.2 Single Lines Connecting into Double-Line Streams

Figure 5-10
Artificial Paths of Added Single Line Stream



When a single line stream connects into a double-line stream, the junction of the two streams shall be placed within 50 feet of where the stream lines become 40 feet wide or wider. The actual junction points shall not be denoted for this study. An artificial path shall connect the stream lines and the same reach code as the incoming stream shall be assigned to the new segment.
The exception to this rule is for a single line stream connecting to a double-line stream that is a lake or a pond. In this situation, the artificial path connecting the incoming stream shall be assigned a new reach code.

5.4.8.3 Display of Braided Streams

The NHD definition of braided streams shall be used for the Stream Mapping Project. A polygon shall be drawn around the area and the polygon feature type shall be coded as a braided stream. One channel is given the flow characteristics of the network. If the fingers of the braided stream measured 40 feet or greater, then the channels shall be displayed with double lines.

The NHD definition of a braided stream identifies naturally flowing water in predominantly arid or semiarid region; the stream has frequently changing braided sub-channels that expose island-like sand or gravel bars during its prevailing stage, rather than covering its bed entirely.

5.4.8.4 Display of Channels Around Islands

Islands shall be labeled with a feature type of island in the polygon coverage. Islands shall be treated the same way as the NHD data, which usually displays one flow path.

Figure 5-11 shows how islands are handled at the confluence of the Brunswick River and Cape Fear River in Wilmington. The blue stream line is the NHD channel delineation.

Figure 5-11
NHD Display of a Channel Flowing Around an Island

5.4.8.5 Display of Water Bodies

Water bodies shall be delineated with a polygon, and tagged with a feature type (e.g., stream, lake, pond, wetland, etc.). All water bodies shall contain a centerline.

The NHD definition of wetland (swamp/marsh) shall be used for wetland delineation. The NHD definition of a wetland (swamp/marsh) is a non-cultivated, vegetated area that is inundated or saturated for a significant part of the year. The vegetation is adapted for life in saturated soil conditions.

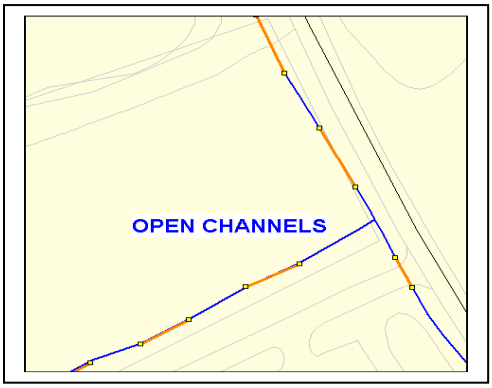
The final statewide digital surface waters file may actually contain two shapefiles for water bodies: one for lines and one for polygons. The NHD currently displays water bodies in polygon format, yet some agencies have need for the features to be displayed in line format.

5.4.8.6 Display of Channels Between Stormwater Systems

Junction points between intermittent and perennial streams as well as stormwater systems with intermittent and perennial streams shall be marked with nodes. For the nodes connecting to stormwater systems, the end point shall be attributed as an artificial end and shall contain a link to the stormwater inventory data of specific agencies.

Subsurface (piped) streams shall be attributed as connectors. The scope for this subsurface determination shall be to stop the stream where daylight ends. If there is a non-sufficient number of reach codes in the area, then the stream address shall be used for the channels along with a GUID.

Figure 5-12
Open Stormwater Channels

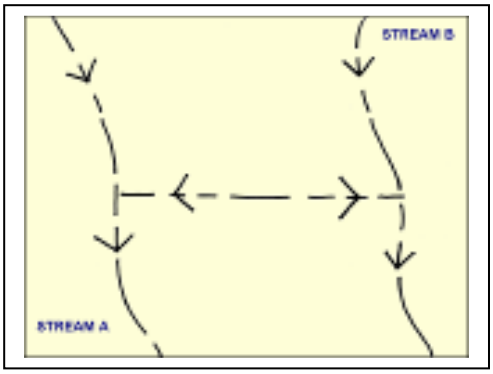


5.4.8.7 Flow Directions for Interconnected Basins

Flow directions shall not be indicated for interconnected basins because flow can go either way, depending on which stream has higher flow.

Figure 5-13 shows Stream A may flow into Stream B or vice versa with heavy rainfall.

Figure 5-13
Example of Interconnected Basins



The figures below are examples of a farm field in the eastern region of North Carolina where an interconnected basin situation may occur. The graphic on the left is an orthophoto, and the graphic on the right is the same area on LIDAR.

Figure 5-14
Interconnected Basins on a DOQQ

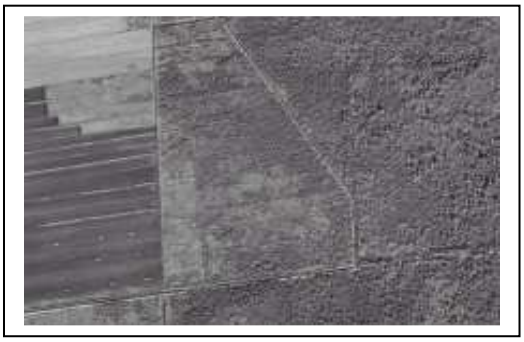
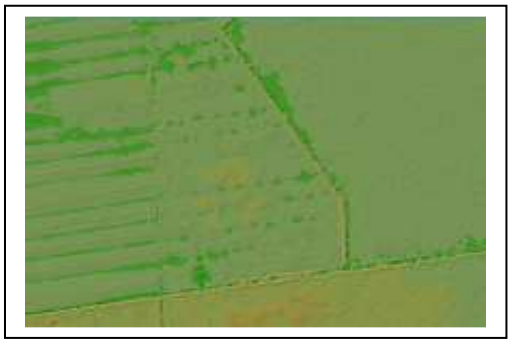


Figure 5-15
Interconnected Basins on LIDAR



5.4.8.8 Other Special Cases

For any other unusual situations not listed in the special case section, a special problem report shall be submitted to the State. This report shall list the problem and propose possible solutions. This report shall be approved by the State before being added to the mapping specifications for the Stream Mapping Project.

5.5 Geodatabase Design

The contractor shall design a geodatabase for the core data of the Stream Mapping Project. Shapefiles connected with .dbf files shall be exported from the geodatabase. Both the geodatabase and the shapefiles shall be available to the public.

5.6 Data Maintenance

The State of North Carolina has the following requirements for maintenance of the statewide digital surface waters file.

5.6.1 Data Maintenance Plan

The contractor shall provide a detailed maintenance plan for the data within 90 days of the project award. At a minimum, the plan shall include an outline on the process of submitting data changes to the State.

5.6.2 Additions, Deletions and Modifications

The statewide digital surface waters file shall be maintained by the North Carolina Center for Geographic Information and Analysis (NCCGIA). Any revisions to the data, including additions, deletions and modifications, shall be submitted to NCCGIA for approval and inclusion into the core surface waters file.

1. Additions to the statewide digital surface waters file shall have a new reach code added.
2. Deletions to the statewide digital surface waters file shall have their reach code deleted. This reach code shall be retired.
3. Modifications to the statewide digital surface waters file shall maintain the original reach code for each modified stream segment.
4. With any of the above three cases, the "Status" attribute shall be populated with either "Addition", "Deletion", or "Revision".

5.6.3 Housing the Data

The new digital surface waters file shall be available to the public on NC OneMap (http://www.nconemap.com), and have browser and download capabilities. NCCGIA shall be the interface between NC OneMap and the public. USGS shall be a dual host for the digital surfaces waters file for use with the National Map.

5.6.4 QA/QC and Approval Process

The contractor shall submit a detailed QA/QC plan for the data within 90 days of the project award. At a minimum, the plan shall include the following items:

1. A procedure for coordination between NCCGIA and participating partners
2. A method for submitting the revised data to NCCGIA
3. A QA/QC approval process

Although NCCGIA shall house, approve, and maintain the final data, primary maintenance shall be the responsibility of the partners. To become a partner in the Stream Mapping Project, each participating agency shall designate a point of contact. The contact person shall fill out a roll-on form to be added as a participating partner and submit the form to NCCGIA. Participating partners shall be responsible for submitting data revisions and additions to NCCGIA.

1. Any data submitted by partners shall meet or exceed the standards used in the core data. If local data is more accurate than the original file, then the local data shall be merged into the master file.
2. A tolerance shall be developed and applied as a QA/QC measure for horizontal accuracy. An accuracy attribute is also a required metadata attribute for the digital surface waters file.

3. A table of changes to the data shall be available to the public. This table shall be a snapshot of time and have a search/archive option to search by date. File sizes shall be examined to see if all the data shall be retained or just the modifications.

5.6.5 Update Tools

Individual agencies shall assist in keeping the data up to date. Tools will be required for implementation of the Stream Mapping Project. Tools shall be developed for data maintenance and QA/QC, as well as for individual agencies to be able to handle linking the digital surface waters file data to their own data.

NCCGIA uses ESRI products, so that updates shall be completed using ESRI software. However, data shall be available in multiple formats for non-ESRI users, which shall require additional tools.

5.7 Data Submission Requirements

The contractor shall make submissions that include the following criteria:

1. Metadata shall be submitted for the core data and any modifications to the data.
2. Data shall be submitted to NCCGIA.
3. The contractor shall submit a recommendation for file submittal based on work order determination.

5.8 Reporting Requirements

The contractor shall submit monthly status reports to NCCGIA and shall attend monthly coordination meetings to discuss the project.

6 Implementation Options

An Implementation Options Meeting with the Stream Mapping Working Group was held on December 14th, 2004 at the USGS facilities in Raleigh, North Carolina. This meeting provided an overview of the mapping specifications and standards section of this document, and gave Working Group members a chance to confirm that the specifications derived from the previous meeting were accurately stated. A portion of the meeting covered the topics of sequencing, schedule and cost of the new statewide surface waters file. The remainder of the meeting focused on the individual agency benefits of the new digital surface waters file.

The mapping specifications and standards and implementation portions of the "Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina" was sent to members of the Working Group prior to the meeting for review. Working Group members were given until the close of business the day following the meeting to make comments on the document. In addition, comment forms were provided to Working Group members at the meeting, which ensured that each agency was given additional outlets to express their needs and concerns. All comments have been incorporated into this document.

6.1 Project Benefits to Stream Mapping Working Group Members

The following is a summary of project benefits to each individual agency that were given by Working Group members during the Implementation Options Meeting.

- *NC Wildlife Resources Commission*
  - Protection of Habitats
  - Hunting and Fishing Recreation for NC residents and Tourists
  - Fewer Field Visits (Less Money Spent)
  - Wildlife Commission Support

- *NC Floodplain Mapping Program / Division of Emergency Management*
  - Improved Mitigation Planning
  - Emergency Response and Disaster Planning (Less Time Reviewing Damage Claims)
  - Improved Future Hazards Analysis (Spill Response)
  - 6-8 Months Saved on Planning and Scoping (Finding Stream Centerlines)
  - Phasing Based on Population (Meets FEMA Specifications)
  - Floodplain Map Cataloguing and Maintenance Costs Reduced

- *US Geological Survey*
  - Accurately Indexed Stream Mileage
  - Basis for Funding Other Projects
  - Stream Stats Project Viewer Won't Be Funded w/out this Dataset
  - Infrastructure File (Building Block)
  - Improved Quality of Life
  - Stream Elevations Included (Save Time Comparing w/ Other Datasets)

- *NC Division of Water Quality*
  - Water Quality Monitoring and Modeling
  - Assist with NPDES Phase II Stormwater Regulations
  - Stream Restoration

- *NC Ecosystem Enhancement Program*
  - Assist in Providing Exact Impacts for Mitigation
  - Prevent Project Delays and Time Wasted from Over or Underestimation of Impacts
  - Potential for $75 Million in Savings if 25% of Mitigation Estimates are Incorrect

- *NC State University*
  - Municipalities Save Money By Not Performing Individual Projects (Walking Streams with GPS)
  - Accurate Streams Contribute to Forest BMP's
  - Approximate Horizontal Locations for Intermittent/Perennial Breakpoints Could Be Determined Using NCSU Study Methodologies

- *NC Geological Survey*
  - Public Outreach and Education to Increase Number of Users
  - Increased Review Efficiency and Effective Resource Allocation
  - Assist with Health and Disease Issues

- *League of Municipalities*
  - Substantial Savings to Flood Early Warning Programs
  - Assist with Water Supply Planning (Early Drought Warning)
  - Funding for Grants
  - Assist Floodplain Managers

- *City of Durham*
  - Site Planning Not Necessary on Permit to Permit Basis
  - Use with Watershed Plans
  - Resource for Planning by Developers

- *NC Department of Commerce*
  - Attract Industries (Better Decision-Making for Sites)
  - Strategic Planning

- *City of Charlotte*
  - Same Dataset Used for Multiple Maintenance Projects (Over 300 Performed in Charlotte Area Alone)
  - Improved Identification of Annexation Areas Across Watersheds
  - Commonality Between Reach Codes

- *NC Department of Transportation*
  - Time Saved on Environmental Analysis and Design
  - Enhance Merger of One Process
  - Expedite Permitting for DOT processes
  - Select Least Environmentally Damaging Practical Alternative
  - Improved Efficiency of Hydraulic Design
  - Management of Drainage Districts

- *NC Geodetic Survey*
  - Improved County Line Surveys

- *Clean Water Management Trust Fund*
  - Assist with Acquisition Projects
  - Linear Feet of Stream Determination for Buffer Protection

- *Wake County*
  - $100,000 Spent on Orthophotos and Contours
  - Groundwater Study for Base Flow of Streams

- *US Fish and Wildlife Service*
  - Screen Projects for Stream Restoration on Private Land

- *NC Division of Coastal Management*
  - CAMA Review and Impacts
  - Improved Wetland Mapping
  - Less Time Evaluating Inaccuracies in Agency's Data (Use Statewide File)

- *NC Center For Geographic Information and Analysis*
  - Better Depiction of Streams for Clients
  - Consistent, Statewide High-Quality Data for NC OneMap

7 Project Implementation

7.1 Implementation Process

The North Carolina Stream Mapping Project is composed of five phases for implementation. The first two phases involve the completion and incorporation of existing data into the project. These data files include are the NHD data for North Carolina and the Floodplain Mapping Program streamlines. The third phase builds off the first two phases, extends the created FMP data to the 20-acre drainage requirement, and attributes it using the NHD data. The fourth phase involves incorporating a 6-acre drainage requirement for urban and rural counties. The fifth phase involves ongoing maintenance of the statewide digital surface waters file over time. These five phases are discussed in more detail below.

7.1.1 Phase 1A – Completion of North Carolina NHD Data

In conjunction with the Stream Mapping Project, the 1:24,000-scale NHD data will be completed for the State of North Carolina. The information contained within the NHD model will be used for the statewide digital surface file. The new surface waters file will have a link (the Com_id attribute) to the NHD data so that individual agencies and the public can use the NHD for modeling purposes. Many agencies use the NHD in standard business practices. The new statewide digital surface waters file will use the NHD feature types and reach codes.

7.1.2 Phase 1B – Design and Development of Geodatabase and Software Tools

In addition to the completion of the North Carolina NHD data, Phase 1 includes eight associated tasks that deal with managing the data in a GIS database. The following is a list of responsibilities of the contractor:

- Design of the Streamline Schema – This task involves the design and creation of the core attribute table for the digital surface waters file as well as the associated event (lookup) tables.
- Design of the Geodatabase – This task involves the design and creation of the geodatabase that will house the core data, as well as a system to export shapefiles and associated .dbf tables for public use.
- Submittal of a Data Maintenance Plan – This task involves the development of a long-term maintenance plan for the digital surface waters file. This plan should include measures for individual agencies to submit changes to the file.
- Submittal of a Quality Assurance Plan – This task involves the development of a quality assurance / quality control plan for the digital surface waters file. This plan should include measures for QA/QC of the core data as well as for updates to the file. The contractor will work to establish acceptable tolerances for data updates.

- Recommended Modifications of Standards and Various Plans – This task involves contractor recommendation for revisions and updates of stream data standards.

- Development of Tools Necessary for Automated QA/QC – This task involves the design and creation of QA/QC software tools to enable the State to perform internal quality assurance data checks.

- Development of Tools Necessary for Maintenance – This task involves the design and creation of software tools necessary for long-term data maintenance.

- Development of Tools to Allow Partners to Contribute Modifications – This task involves the design and creation of software tools necessary for individual agencies to submit updates to the statewide digital stream file.

7.1.3 Phase 1C – Public Outreach and Education

Continuing public outreach and education on the uses, purposes and value of the new statewide digital surface water file will be a necessary tool for public and private agencies, as well as individuals. Training and public outreach will be imperative to make this project successful. Explanations of how and for what purposes the data should be utilized will increase user efficiency and effectiveness. Public and private agencies will be encouraged to use the new data as it becomes available through the Stream Mapping Project. The budget for the statewide digital surface waters project will include funds for educational assistance.

7.1.4 Phase 2 – Incorporation of the NC Floodplain Mapping Program Stream Data

In conjunction with the Stream Mapping Project, the North Carolina Floodplain Mapping Program stream data will be completed. This task involves the remainder of the LIDAR collection for the western portion of the state. LIDAR data will be used in combination with 50-foot hydro-corrected DEMs and orthophotos to verify the horizontal alignment of streamlines. Also included in Phase 2 is the attribution of the streamlines with the core attributes and associated event tables. An independent QA/QC will also be performed on the FMP streams.

7.1.5 Phase 3 – Extension of Phase 2 Streams to 20-Acre Drainage Area

Phase 3 involves extending the upper stream reach limits of the stream file created in Phase 2 to a 20-acre drainage area requirement. The horizontal locations of the new reaches will include the same accuracy tolerance that was established in Phase 1, and an independent QA/QC will be performed on the new reaches. The new stream reaches will also be attributed with the core attributes. All updates will be approved by the State before changes are officially incorporated into the statewide digital surface waters file.

7.1.6 Phase 4 – Extension of Phase 3 Streams to 6-Acre Drainage Area

Phase 4 involves extending the upper stream reach limits of the stream file created in Phase 3 to a 6 acre drainage area requirement. For workflow purposes, urban area watersheds will be the first priority for mapping from the 20-acre to the 6-acre requirement. The horizontal locations of

the new reaches will include the same accuracy tolerance that was established in Phase 1, and an independent QA/QC will be performed on the new reaches. The new stream reaches will also be attributed with the core attributes. All updates will be approved by the State before changes are officially incorporated into the statewide digital surface waters file.

7.1.7 Phase 5 – Maintenance of Statewide Digital Surface Waters File

Phase 5 involves long-term maintenance of the statewide digital surface waters file. Maintenance includes additions, deletions, and modifications to the data from participating agencies. These modifications will be submitted to the State for QA/QC and approval. The data will be maintained on NC OneMap for public availability. Maintenance will be performed at least on an annual basis.

Phases 2 through 5 incorporate an ongoing evaluation of state-of-the-art processes and technologies. One of these technologies is the intermittent / perennial stream research study conducted by North Carolina State University in cooperation with NCDWQ and NCDOT. The purpose of the research is to develop the protocols for LIDAR/GIS-based methods of mapping the upper limits of streams in North Carolina. Processes to thoroughly test the accuracy of mapping methods with extensive ground truth data will be determined.

7.2 Work Order Determination

The contractor shall propose a sequencing order to complete each phase. This sequencing plan shall be approved by the State prior to commencement of work. There are several options for establishing work order. Some of these options are as follows:

- River basin
- NHD cataloging unit
- Urban versus Rural
- Counties experiencing the most population growth in the past 10 years
- East to west across the state

7.3 Cost Estimate

The cost estimate for the Stream Mapping Project has been computed according to the five project phases. Completion of the project in phases allows for an interim product to be produced and utilized while a more detailed product is being created.

A 20-acre drainage area requirement was decided by the Working Group as the upper stream reach limit for Phase 3 of the Stream Mapping Project. The drainage area requirement will be reduced to 6 acres in Phase 4. The 6-acre requirement will ensure that the final statewide digital surface waters file will be useful to local government agencies, and for regulatory purposes.

Included in Phases 2 through 4 are the recurring costs of contractor management, independent QA/QC, State management cost, and the average hourly production rate. The assumptions are listed below.

Table 7-1
Cost Estimate Assumptions

Attribute	0.20	hrs per mile of stream
Contractor Management	10%	of effort
Independent QA/QC	10%	of effort
State Management Cost	10%	of effort
Average Hourly Rate	$60	per hr

During the incorporation of the NC Floodplain Mapping Program stream data in Phase 2, the cost assumption listed below was used.

- 0.07 hours to map the horizontal location for 1 mile of a stream

For Phases 3 and 4, a different set of cost assumptions were used.

- 0.13 hours to map the horizontal location for 1 mile of a stream

Table 7-2 displays the costs associated with the development of software tools for the Stream Mapping Project.

Table 7-2
Cost Breakdown for Design and Development of Geodatabase and Software Tools

Task	Estimated Cost
Design of the Streamline Schema	$40,000
Design of the Geodatabase	$35,000
Development of the Maintenance Plan	$50,000
Development of the Quality Assurance Plan	$45,000
Revision and Update of Streamline Standards	$60,000
Development of QA/QC Software Tools	$230,000
Development of Maintenance Tools	$300,000
Updates	$100,000
TOTAL	**$860,000**

Table 7-3 below is the total data generation cost estimate breakdown for each phase of the Stream Mapping Project. The project will be a $16 to $17 million effort in total, divided into $2.5 to $4.5 million increments per year.

Table 7-3
North Carolina Stream Mapping Project Cost Estimate

Phase	Description	Total Cost	Program Year				
			Year 1	Year 2	Year 3	Year 4	Year 5+
Phase 1A	**Complete Ongoing 24K NHD Data Project**	**$900,000**	**$900,000**	**$0**	**$0**	**$0**	**$0**
Phase 1B	**Design and Development of Geodatabase and Software Tools**	**$860,000**	**$345,000**	**$415,000**	**$50,000**	**$50,000**	**$0**
Phase 1C	**Public Outreach and Education**	**$640,000**	**$160,000**	**$160,000**	**$160,000**	**$160,000**	**$0**
Phase 2	**Incorporate NC Floodplain Mapping Program Stream Data**	**$1,200,000**	**$720,000**	**$480,000**	**$0**	**$0**	**$0**
Phase 3	**Extend Dataset to 20-Acre Drainage Area**	**$5,600,000**	**$560,000**	**$2,800,000**	**$2,240,000**	**$0**	**$0**
Phase 4	**Extend Dataset to 6-Acre Drainage Area**	**$4,700,000**	**$0**	**$140,000**	**$1,760,000**	**$2,800,000**	**$0**
TOTAL DATA GENERATION COST		**$13,900,000**	**$2,685,000**	**$3,995,000**	**$4,210,000**	**$3,010,000**	**$0**
Phase 5	**Maintenance of the Data**	**$2,336,500**	**$0**	**$268,000**	**$364,500**	**$314,000**	**$1,390,000**

7.4 Schedule

The total timeframe for completion of the project is four years, with maintenance of the data beginning in the 2nd year and continuing.

Table 7-4 outlines the project completion dates divided by phase and year.

Table 7-4
Estimated Project Completion Timeframe

Phase	Description	Program Year				
		Year 1	Year 2	Year 3	Year 4	Year 5+
Phase 1A	Complete Ongoing 24K NHD Data Project	X				
Phase 1B	Design and Development of Geodatabase and Software Tools	X	X	X	X	
Phase 1C	Public Outreach and Education	X	X	X	X	
Phase 2	Incorporate NC Floodplain Mapping Program Stream Data	X	X			
Phase 3	Extend Dataset to 20-Acre Drainage Area	X	X	X		
Phase 4	Extend Dataset to 6-Acre Drainage Area		X	X	X	

Alternative Cost Estimate and Schedule

There is a lower cost alternative for completing the Stream Mapping Project. This alternative will improve the accuracy of the current stream mapping but stops short of capturing intermittent and perennial streams. It is less expensive but it will not meet the requirements that NCDWQ and NCDOT stated during the Stream Mapping Study.

The total cost for this alternative is $4,166,000 spread over four years, although the effort could occur over three years. The maintenance cost is $943,100 over four years.

The overall cost (mapping and maintenance) is $2,313,000 in the first year, $1,541,000 in the second year, $834,500 in the third year, and $420,600 in the fourth year for a total four-year expenditure of $5,109,100. This compares to the total cost of $16,236,500 for mapping that captures intermittent and perennial streams. The following table summaries the annual cost of this alternative.

Table 7-5
Alternative Cost Estimate for Stream Mapping Project

Phase	Description	Total Cost	Program Year			
			Year 1	Year 2	Year 3	Year 4
Phase 1A	Complete Ongoing 24K NHD Data Project	$900,000	$900,000	$0	$0	$0
Phase 1B	Design and Development of Geodatabase and Software Tools	$646,000	$273,000	$273,000	$50,000	$50,000
Phase 1C	Public Outreach and Education	$420,000	$120,000	$120,000	$120,000	$60,000
Phase 2	Incorporate NC Floodplain Stream Data	$1,200,000	$720,000	$880,000	$300,000	$0
TOTAL DATA GENERATION COST		$4,166,000	$2,313,000	$1,273,000	$470,000	$110,000
Phase 3	Maintenance of the Data	$943,100	$0	$268,000	$364,500	$310,600

8 Conclusion

The Stream Mapping Study was performed in response to Senate Bill 1152, known as the "Studies Act of 2004". The purpose of the study was to develop an implementation plan to improve the mapping and digital representation of surface waters in North Carolina. In order to develop an effective implementation plan, the Geographic Information Coordinating Council (GICC) and the Department of Environment and Natural Resources tasked the Statewide Mapping Advisory Committee (SMAC), with the creation of the Stream Mapping Working Group (Working Group). This study is a collaborative effort of the Stream Mapping Working Group, which is comprised of local, state, and federal agencies. The Working Group was formed to help gather information and provide unique perspectives into the creation of the statewide digital surface waters file. Insights provided by these agencies have been combined into this document to create a strategy for the study and have been crucial to making this study a success.

One of the focal points of the Stream Mapping Study has been to assess the requirements of potential users of the data. This evaluation occurred through a series of meetings to determine user requirements, mapping specifications, and implementation options. In addition to the meetings, a survey was emailed to members of the Stream Mapping Working Group. The end result for the Stream Mapping Project will be a comprehensive statewide digital surface waters file that can be effectively used and maintained by federal, state and local government agencies as well as the public.

The creation of a new statewide digital surface waters file provides numerous financial and time saving benefits to individual agencies. These benefits promote and enhance business practices as well as the quality of data produced by these agencies for analytical and regulatory purposes.

The Stream Mapping Project shall be completed in five phases. The first two phases involve the completion and incorporation of existing data into the project. These data are the NHD data for North Carolina and the Floodplain Mapping Program streamlines. The third phase builds from the first two phases, extends the created Floodplain Mapping Program data to the 20-acre drainage requirement, and adds attributes to further describe it using the NHD data. The fourth phase involves incorporating a 6-acre drainage requirement for urban and rural counties. The fifth phase involves ongoing maintenance of the statewide digital surface waters file over time. As with any project of this size, other state-of the art technologies will need to be explored. Phases 2 through 5 will incorporate an evaluation of these technologies, including the research of intermittent and perennial streams by North Carolina State University and other sources.

The cost estimate for the Stream Mapping Project has been computed according to the five project phases. Completion of the project in phases allows for an interim product to be produced and utilized while a more detailed product is being created. The project will be a $16.2 million effort in total, with proposed expenditures of between $2.6 and $4.6 million per year. The total timeframe for completion of the project is four years, with maintenance of the data beginning in the second year and continuing.

The vision driving the study is one of interagency cooperation to facilitate data sharing and use. This initiative emphasizes the benefits and value of a statewide digital surface waters file for

partners as well as the general public. A shared vision supported by common goals ensures a product that will be beneficial to all parties.

APPENDIX A

Stream Mapping Working Group Members

Will Aycock - City of Wilson
Chris Beachum - NC Dept. of Commerce
Jon Beck - Land-Of-Sky Regional Council
Dempsey Benton - GICC / DENR *
Sherman Biggerstaff - USDA / NRCS
Jim Borawa - NC Wildlife Resources Commission
Jeff Brown - NCCGIA
Jeff Bruton - NCDWR
Scott Bryant - City of Greensboro
Hubo Cai - URS
Tom Calhoun - City of Charlotte
Melissa Carle - NCDCM
John Correllus - NC Dept. of Commerce
John Cox - City of Durham
John Dorman - NCFMP
John Dorney - NCDWQ
Scott Edelman - Watershed Concepts
Jocelyn Elliott - NCD
Una Freeman - Surry County
Jim Gregory - NCSU
Nancy Guthrie - NCCWMTF
Melani Harrell - City of Charlotte
Bill Holman – NCCWMTF *, **
Steve Jadlocki - City of Charlotte
Tim Johnson – NCCGIA **
Chris Kannan - USGS
Colleen Kiley - NCEEP
Suzanne Klimek - NCDWQ
Steve Kroeger – NCDWQ
Kelly Laughton - Henderson County *, ***
Janet Lowe - Buncombe County, **
Wright Lowery - Wake County
Dan Madding - NC Dept. of Agriculture
Andy McDaniel - NCDOT
Sean McGuire – NCDCM **
Terri McLean - Watershed Concepts
Scott McLendon - USACE
Cam McNutt – NCDWQ
Rex Minneman – NC Land Records Management Division **
Marie Monteith - Rutherford County
Chris Moore - Haywood County ***

John Morris - NCDWR
Zsolt Nagy - NCCGIA
Stacy Nelson – NCSU
Doug Newcomb - US Fish and Wildlife Service
Susan Phelps - Watershed Concepts
Elizabeth Porter – USACE
Jeff Reid - NC Geological Survey
Linda Rimer - USEPA
Forrest Robson – NCDOT **
Gerald Ryan – USGS *, **
Edward Schwartzman - NCDWQ
Mark Senior - City of Raleigh
Jim Simons – NC Division of Land Resources **
Ron Small - City of Greensboro
L C Smith - NCDOT
Christy Sokol – City of Durham
John Spurrell - NC League of Municipalities **
Jim Stanfill – NCEEP
Steve Strader - USGS
Ken Taylor - NC Emergency Mgmt.
Silvia Terziotti - USGS
Gary Thompson - NC Geodetic Survey **
Steve Underwood – NCDCM
Chad Wagner - USGS
Tom Walker – USACE
David Wray - NC Dept. of Agriculture
Sarah Wray – NCFMP

* Denotes Geographic Information Coordinating Council (GICC) member
** Denotes Statewide Mapping Advisory Committee member
*** Denotes Representative of Local Government Committee

APPENDIX B

Letters of Support for Stream Mapping Project

Ecosystem Enhancement PROGRAM

January 21, 2005

Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Deputy Secretary Benton:

The North Carolina Ecosystem Enhancement Program has been following the progress of the NC Stream Mapping Work Group with great interest. Accurate, standardized, state-wide stream maps would prove to be an invaluable tool for EEP's daily activities. I would like to express my support for the current initiative to improve and standardize the State's stream mapping.

Over the next three years, EEP is anticipating to provide approximately 1.5 million feet of stream mitigation for DOT. This mitigation projection was calculated by estimating the future stream impacts of the Transportation Improvement Program (TIP). The process uses GIS methods and the 1:24 K USGS hydrology data set. Currently the 1:24 K hydrology is considered the best available stream data for doing this analysis. In our agreement with NCDOT, DENR regulatory agencies, and US Army Corps of Engineers, EEP must complete the construction of this mitigation by July 2008. In order for this to happen, most of this work must be started years in advance of 2008. Thus, the accuracy of the stream layer is critical to identifying where and how much mitigation must be procured by EEP.

Small inaccuracies in the stream layer can result in large inaccuracies in the mitigation projections, because the amount of mitigation EEP must provide is based on the actual impact, not the impacts estimated from the stream layer. Also, since mitigation is costly (average cost is $205/lf), and because mitigation is provided at a 2:1 mitigation to impact ratio, small changes in the impact projections (or accuracy of the stream data) will result in large changes in the amount of money committed to implementing mitigation. Overestimates in mitigation projections will result in money being spent prematurely (because the mitigation credits were not actually needed). Underestimates of mitigation projections could result in permitting delays or road construction delays (because insufficient mitigation credits were developed). Inaccuracies in stream location can have both effects. In some cases, mitigation credits will be built in the wrong location or not built at all because the stream data was incorrect.

Ecosystem Enhancement PROGRAM

Better stream maps will not only allow DOT to provide EEP with better estimates for the type and quantity of mitigation needed, they will allow EEP to become more efficient in providing mitigation. EEP planners, implementation, and monitoring staff use the current stream maps daily. Inaccuracies in the maps result in staff time spent correcting stream location, verifying stream type, or verifying that a stream even exists on a site. If the new maps were to produce just a two percent increase in EEP staff efficiency during the next three years, EEP could provide approximately an additional 30,000 additional feet of stream mitigation credits to meet DOT's needs. The additional mitigation credits would be worth approximately $6,150,000. In order to meet the requirements of the MOA, EEP must plan as far in advance as possible to meet mitigation needs. Increases in efficiency as described in the example would help EEP ensure that it's mitigation targets are met.

In conclusion, better stream maps will result in increased efficiency, better planning, and enhanced ability to plan for and implement appropriate mitigation. Cost savings would be realized in reduction of wasteful spending and increases in mitigation production.

Because EEP relies so heavily on statewide stream maps, it is important to ensure that the state realizes the importance of these maps as tools for the conservation of some of the State's most valuable natural resources. Improvements in state stream mapping benefit not only my agency, but all agencies, municipalities, and organizations that use these maps. I urge the State to devote the resources necessary to improve and standardize the state-wide stream mapping.

Sincerely,

William D. Gilmore

William D. Gilmore, P.E.
Director, NC Ecosystem Enhancement Program

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

1501 MAIL SERVICE CENTER, RALEIGH, N.C. 27699-1501

LYNDO TIPPETT
SECRETARY

January 14, 2005

Mr. Dempsey Benton
The Geographic Information Coordinating Council
20322 MSC
Raleigh, North Carolina 27699-0322

Dear Mr. Benton:

SUBJECT: North Carolina Stream Mapping Study Implementation Plan

The North Carolina Department of Transportation (NCDOT) is committed to providing the very best transportation system for the citizens of North Carolina. The department also constantly strives to maintain the delicate balance between necessary transportation facility development and preservation of the state's valuable natural resources.

The NCDOT Transportation Improvement Plan outlines the nearly 2800 projects, totaling approximately $10.2 billion that have been scheduled over the next seven years. An extensive analysis is conducted of the impact that each of the projects would potentially have on the environment. The NCDOT maintains a professional staff of transportation engineers and planners to assure that the proper analysis is undertaken in a conscientious manner. The NCDOT also coordinates with other state, federal, and local agencies, and with communities during the assessments.

In order to perform the proper analysis the staff must have the proper tools. Accurate mapping of the natural and human resources within the area through which a project is proposed, is an essential tool for this analysis.

The NCDOT was proud to partner with the Geographic Information Coordinating Council, the Department of Environment and Natural Resources, and other state, federal, and local agencies in the State Mapping Study to formulate a plan . . ."to improve the mapping and digital representation of surface waters in North Carolina…".

PHONE 919-733-2520 FAX 919-733-9150

We feel that the North Carolina Stream Mapping Study Implementation Plan is a sound plan to enhance the surface water mapping available to public agencies and the citizens of North Carolina. The state's natural and human resources would benefit from the objectives of the plan.

Sincerely,

Roger E. Sheats, Jr.
Deputy Secretary for Environment,
Planning and Local Government

RES/fr

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1869
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DEPARTMENT OF PUBLIC WORKS
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January 24, 2005

Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Re: Support for Stream Mapping Project

Dear Mr. Benton:

As an active participant in the development of the Stream Mapping Implementation Plan, Durham Stormwater Services supports this effort.

Having accurate streamline mapping would provide the City with a reliable resource for use when identifying and regulating streams. Also, having up to date stream maps would greatly reduce the amount of time and costs associated with field verification of streams that currently are incurred by land developers and City staff who are involved with site plan development and approvals. In addition, having an up to date and comprehensive geodatabase of stream attributes would assist the City with the timely and cost effective completion of stormwater related projects such as watershed planning, capital improvement projects, and flood studies.

Support of this program by the State legislature would show North Carolina's commitment to establishing and maintaining a top notch stream geographic information system and demonstrate the State's dedication to protecting our water ways.

Sincerely,

Douglas D. Vaughn, P.E.
Manager, Stormwater Services Division

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

In Reply Refer To:
Mail Stop 170

25 January 2005

Mr. Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Dear Mr. Benton:

The U.S. Geological Survey (USGS) supports the efforts of North Carolina to develop and fund the surface water mapping plan, titled "Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina", to collect, archive, maintain and provide access to geospatial data of surface waters for the state. The completion of the 1:24,000-scale National Hydrographic Dataset (NHD) in North Carolina, step one in the plan, is vital to completing the national coverage of surface waters at a consistent scale for *The National Map*. We support efforts in the plan to refine these data to reflect higher resolution surface water data in the future and the implementation and funding of a maintenance capability so the data at all levels of complexity can be kept current.

The USGS, through the National Geospatial Program Office, is supporting the efforts of the National Spatial Data Infrastructure to promote the sharing of geospatial data throughout all levels of government, the private and non-profit sectors. This data, which will be accessible through NC OneMap and *The National Map*, will provide geospatial information to support science, decision making and the business community. The North Carolina surface water mapping plan will help both of these programs move closer to their common goal of making geospatial data available for the needs of federal, state, and local governments, academia, private business, and the general public.

Sincerely,

Pamela Malam
Regional Geographer
Eastern Region Geography
US Geological Survey

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
3916 Sunset Ridge Road
Raleigh, North Carolina 27607

January 25, 2005

Mr. Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Dear Mr. Benton:

The U.S. Geological Survey (USGS) supports the efforts of North Carolina to develop and fund the surface-water mapping plan, "Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina," to collect, archive, maintain, and provide access to surface-water data for the State.

The completion of the 1:24,000-scale National Hydrographic Dataset (NHD) in North Carolina, step one in the plan, is important in providing consistent base data from which to develop cooperative plans and programs in support of water-resources initiatives throughout the State. Using the NHD data model will take advantage of methods and tools that have been developed over a number of years. The NHD also will build upon a unique method for reporting incidences on streams, which many Federal and State agencies recognize and require.

The plan's goals to refine the 1:24,000-scale data to drainage areas of 20 and 6 acres will add to the accuracy and completeness of cooperative projects the USGS undertakes. In many cases, without the base data, projects either would be impossible or more expensive and time consuming because the data would have to be created for the project. Also key to the plan is the proposed implementation and funding of a maintenance component so the data can be kept current.

The USGS believes the adoption and funding of this plan will provide substantial return to the State and the USGS by creating a common data base for water-resources projects, and we support its implementation.

Sincerely,

Gerald L. Ryan
District Chief

(919) 571-4000 • FAX (919) 571-4041

Memorandum

To: Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

From: Tim Richards
Director
City of Charlotte Storm Water Services

Date: 1/24/2005

Re: Stream Mapping Study

From the time of its inception, Charlotte Storm Water Services has been using geographic information system (GIS) data. Initially GIS was an administrative tool used chiefly for mapping and tracking impervious surfaces in the Charlotte area on a case-by-case basis. Today GIS and the related datasets are utilized extensively by Maintenance, Engineering, Water Quality, and Administrative staff.

Whether responding to a request for service, checking the drainage of a capital improvement project area, or designing a stream restoration project, GIS provides a conduit for the warehouse of data constructed by Charlotte and Mecklenburg County about this area.

GIS infrastructure data, including streams, is critical to the nature of our work. As we move towards a more regional approach it becomes more important that our network of GIS databases also interconnects with the counties that touch our borders. The North Carolina Stream Mapping project goes a long way towards achieving this goal by setting the standards for the creation and maintenance of this data. This ensures that everyone is using the same standards for data and forms the foundation for creating a true statewide standard for GIS stream data.

Michael F. Easley, Governor
William G. Ross, Jr., Secretary
North Carolina Department of Environment and Natural Resources

Alan W. Klimek, P.E. Director
Division of Water Quality

January 24, 2005

Mr. Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Dear Mr. Benton:

The North Carolina Division of Water Quality (DWQ) strongly supports the *Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina*, prepared by the NC Geographic Information Coordinating Council and the NC Department of Environment and Natural Resources. The plan reflects the needs of federal, state and local governments and once implemented, the plan would provide substantial benefits to the DWQ. It is noteworthy that the plan was developed by a group representing federal, state and local agencies familiar with the problems with existing maps, and the technical and applied expertise to be able to produce much-improved maps of surface waters in a digital format.

The NC Division of Water Quality would benefit greatly from the development of digital maps of surface waters. These maps would be used daily in almost all permitting, planning and monitoring programs in the Division, and would more accurately reflect the extent and boundaries of surface waters subject to federal and state regulations. The new maps would:

- provide a more accurate depiction of waters subject to regulations, for both staff and the public, than currently available mapping products;
- assist in minimizing the spread of materials and contamination from emergency spills; and
- allow DWQ to efficiently process, analyze and share spatial data in a digital format.

It is difficult to quantify the financial benefits of new stream maps. Much of the savings would reflect efficiencies from using a digital product instead of paper maps, AND improved communication between DWQ and the public when water quality regulations apply to surface water features. I am convinced, however, that the cost savings would be considerable.

Other major benefits in the Implementation Plan include a provision to update maps as new information is acquired and making the maps publicly accessible through NC OneMap. Appropriate staff from this Division are available and prepared to assist in this endeavor in any manner you deem necessary.

Sincerely,

Alan Klimek

Alan Klimek, P.E.

AK/srk

WAKE COUNTY
NORTH CAROLINA

Office of the County Manager
Post Office Box 550 • Raleigh, North Carolina 27602

TEL 919 856 6160
FAX 919 856 6168

January 26, 2005

Mr. Dempsey Benton
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699 – 0322

Dear Mr. Benton:

Wake County would like to thank the Geographic Information Coordinating Council and the North Carolina Stream Mapping Working Group for their efforts in developing the North Carolina Stream Mapping Implementation Plan. Wake County is fully supportive of this project, as its benefits will greatly enhance County operations and services to our citizens.

As one of the fastest developing areas in the state, access to a universally accepted database of surface water locations will shorten delays in stream and riparian buffer assessments. Builders and homeowners will experience shorter review periods and will, therefore, be able to more quickly continue with the business process.

The improved accuracy of the surface water locations will also benefit local planning and conservation efforts. Wake County has a number of environmental programs including the Wake Watershed Management Plan, the Groundwater Information Management System, and the Consolidated Open Space Plan. Protection of natural resources, especially in water supply watersheds, is crucial to the quality of life for Wake County citizens. Many of our environmental projects extend beyond political boundaries. A statewide, periodically updated database will allow us to work more effectively with other local governments in the region on projects that are important to citizens throughout the Triangle area.

Once again, thank you for your efforts on this important plan.

Sincerely,

Joseph K. Durham
Deputy Wake County Manager

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

January 24, 2005

Mr. Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, North Carolina 27699-0322

Dear Mr. Benton:

As the Director of the Water Management Division of the United States Environmental Protection Agency Region 4 Office in Atlanta, I want to commend the State of North Carolina for the leadership you are demonstrating in water quality protection and watershed management.

I am specifically referring to the work of the North Carolina Stream Mapping Working Group in developing the Implementation Plan to Improve the Mapping and Digital Representation of Surface Waters in North Carolina.

The benefits of a new statewide digital surface waters file are wide ranging and varied. Although in North Carolina, EPA has delegated Clean Water Act authority to the Department of Environment and Natural Resources, we remain accountable to the US Congress for the implementation and enforcement of this major federal law. These new maps will enhance the ability of the state to monitor water quality, and assist in evaluation of progress being made to restore and protect watersheds in North Carolina.

EPA is also an active partner in the state's Ecosystem Enhancement Program (EEP). We are currently participating on a state and federal EEP workgroup to develop a GIS based stream functional assessment methodology to be used for planning purposes to estimate both projected project stream impacts and mitigation opportunities. The success of this EEP planning effort is dependent on having accurate digital stream mapping data.

In addition to our role in the regulatory program, EPA is also an active partner in water-related research and restoration. Our Office of Research and Development has been involved in major ecosystem research in North Carolina, particularly in the Neuse River basin. We are also involved with both the White Oak and Cape Fear River basins with significant financial investments to provide for effective watershed management and restoration. Having updated and accurate stream maps available that are uniform across jurisdictions will be most beneficial to these ongoing efforts.

If we can be of assistance as the state moves forward with the creation of this statewide file, please let us know. We would also be interested in opportunities to share some of the information you are collecting. You can contact me directly or Bill Cox, Director of our Watershed Management Office, at 404-562-9351.

Sincerely,

for James D. Giattina, Director
Water Management Division

North Carolina
Department of Commerce

Michael F. Easley, Governor **James T. Fain III, Secretary**

January 24, 2005

Dempsey Benton, Chair
Geographic Information Coordinating Council
20322 Mail Service Center
Raleigh, NC 27699-0322

Dear Dempsey Benton, Chair:

I am writing to give my and the Department of Commerce's full support for the Stream Mapping Project. We applaud the coordinated effort of the working group, which is reflected in the Stream Mapping Implementation Plan document. We appreciate the opportunity we were given to participate in the process.

The Stream Mapping Project Implementation Plan is an excellent example of interagency planning and involvement at all levels of government. It will provide North Carolina with accurate data that will support more informed decisions.

The NC Department of Commerce depends heavily on GIS data for strategic thinking and decision support. Even though Commerce would not utilize the new digital surface waters file for the purpose of permitting, site review, or mitigation, Commerce would reap the benefits of its partners in economic development having the ability to accurately depict North Carolina's surface waters. The statewide digital surface waters product would provide Commerce and it's Allies the ability to make better and more accurate decisions when siting a building or making an important community development decision. It will also better protect the environment by allowing these decisions to be made prior to the commitment by the industry, thus avoiding unforeseen surface water impacts.

We look forward to the development of the Stream Mapping Project. Commerce recognizes the need for North Carolina to build and maintain a new digital surface waters file and fully supports the Stream Mapping Project.

Sincerely,

Jim Fain

301 North Wilmington Street•4301 Mail Service Center•Raleigh, North Carolina 27699-4301
Tel: (919) 733-4151•Fax: (919) 733-8356

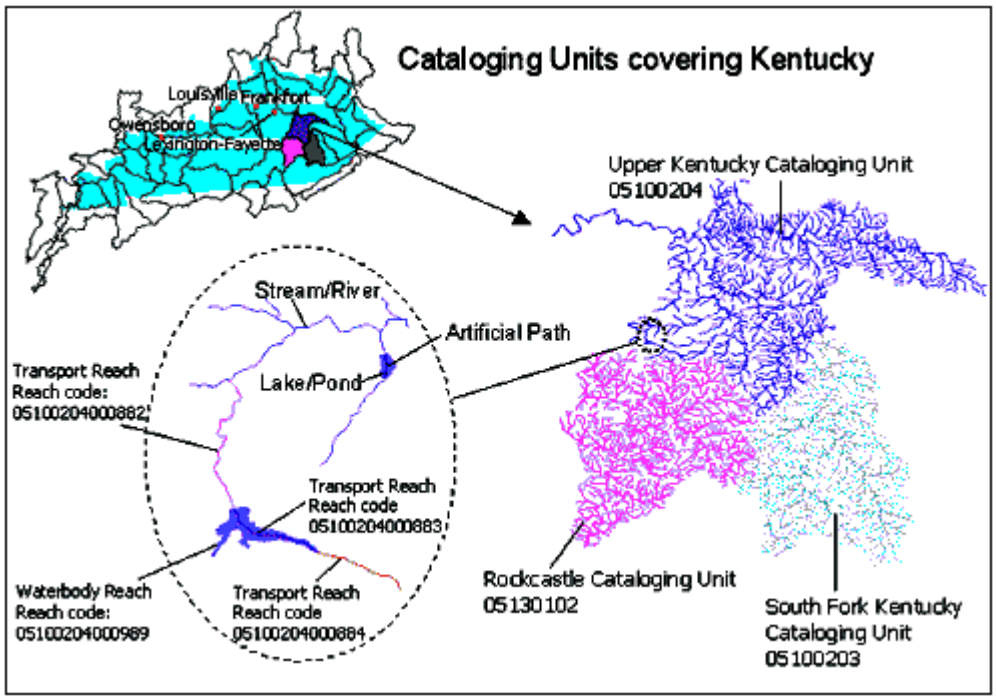
APPENDIX C

The National Hydrography Dataset Fact Sheet

The National Hydrography Dataset

Fact Sheet 106-99 (April 1999)

|| Characteristics of the National Hydrography Dataset || Maintaining the NHD ||
|| Obtaining Data from the NHD || Information ||



In the upper left, the irregular shapes on and around the shaded image of Kentucky are the hydrologic cataloging units that are in the State of Kentucky. On the right is a closer high- level view of three cataloging units, showing their hydrographic features and labeled with the names and numbers of the units. In the oval, a small area is enlarged to show examples of individual features with their reach codes. Note that the reach codes incorporate the eight-digit number of the cataloging unit in which they lie.

The National Hydrography Dataset (NHD) is a newly combined dataset that provides hydrographic data for the United States. The NHD is the culmination of recent cooperative efforts of the U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). It combines elements of USGS digital line graph (DLG) hydrography files and the USEPA Reach File (RF3). The NHD supersedes RF3

and DLG files by incorporating them, not by replacing them. Users of RF3 or DLG files will find the same data in a new, more flexible format. They will find that the NHD is familiar but greatly expanded and refined.

The DLG files contribute a national coverage of millions of features, including water bodies such as lakes and ponds, linear water features such as streams and rivers, and also point features such as springs and wells. These files provide standardized feature types, delineation, and spatial accuracy. From RF3, the NHD acquires hydrographic sequencing, upstream and downstream navigation for modeling applications, and reach codes. The reach codes provide a way to integrate data from organizations at all levels by linking the data to this nationally consistent hydrographic network. The feature names are from the Geographic Names Information System (GNIS).

The NHD provides comprehensive coverage of hydrographic data for the United States. Some of the anticipated end-user applications of the NHD are multiuse hydrographic modeling and water-quality studies of fish habitats. Although based on 1:100,000-scale data, the NHD is planned so that it can incorporate and encourage the development of the higher resolution data that many users require. The NHD can be used to promote the exchange of data between users at the national, State, and local levels. Many users will benefit from the NHD and will want to contribute to the dataset as well.

Characteristics of the National Hydrography Dataset

- It is a feature-based dataset that interconnects and uniquely identifies the stream segments or "reaches" that make up the Nation's surface water drainage system.
- Unique reach codes (originally developed by the USEPA) are provided for networked features and isolated water bodies
- The reach code structure is designed to accommodate higher resolution data.
- Common identifiers uniquely identify every occurrence of a feature.
- It is currently based on the content of the USGS 1:100,000-scale data, giving it accuracy consistent with those data.
- Data are in decimal degrees on the North American Datum of 1983.
- Names with GNIS identification numbers are included for lakes, other water bodies, and many stream courses.
- It provides flow direction and centerline representations through surface water bodies.

Maintaining the NHD

The NHD is designed to accommodate both the higher resolution data that many users need and the 1:100,000 scale data. The higher resolution data will be incorporated into the NHD through the participation of users at the national, State, and local levels. The common identifiers for the features are the basis for tracking and sharing deletions, additions, and modifications of features during maintenance. They are used to communicate and share corrections among organizations. The NHD will improve the integration of hydrographically related data in support of the varied applications of a growing national user community, and it will also enable shared maintenance and enhancement.

Obtaining Data from the NHD

The data are now available for downloading by cataloging unit from the USGS at nhd.usgs.gov. The cataloging unit is a geographic area that subdivides the accounting units within hydrologic units. Most of the more than 2,100 cataloging units for the Nation are larger than 700 square miles (1,813 square kilometers).

The data are available in two formats: ARC/INFO workspace and Spatial Data Transfer Standard. Each format is delivered as tarred and compressed files. Data on compact disc-readable is available for order through the USGS Global Land Information System.

Information

More information about the NHD can be found at nhd.usgs.gov.

For information on other USGS products and services, call 1-888-ASK-USGS, or visit the general interest publications Web site on mapping, geography, and related topics at erg.usgs.gov/isb/pubs/pubslists/.

For additional information, visit the ask.usgs.gov Web site or the USGS home page at http://www.usgs.gov/.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government. This document has undergone official review and approval for publications established by the National Mapping Division, U.S. Geological Survey. Some figures have been modified or added to improve the scientific visualization of information.

U.S. Department of the Interior — U.S. Geological Survey — 509 National Center, Reston, VA 20192, USA
URL: *http:// erg.usgs.gov /isb/pubs/factsheets/fs10699.html* — **Contact:** http://erg.usgs.gov/feedback.html
Page Maintainer: USGS Eastern Region Geography
Last modified: 07:04:47 Fri 20 Feb 2004 — USGS Privacy Policy and Disclaimers — Accessibility

APPENDIX D

The US EPA Reach File Version 3.0 Alpha Release (RF3-Alpha) Technical Reference

The U.S. EPA Reach File Version 3.0 Alpha Release (RF3-Alpha) Technical Reference

First Edition December 1994

Acknowledgments

A special thanks to those who contributed their valuable time and ideas to the development of this document: consultants Lucinda D. McKay, Sue A. Hanson, Robert C. Horn, Richard A. Dulaney, and Alan W. Cahoon, Mark V. Olsen of the Office of Research and Development's Environmental Monitoring Systems Laboratory in Las Vegas, NV (EMSL-LV), and Thomas G. Dewald of the Office of Wetlands, Oceans, and Watersheds (OWOW).

This document was prepared by Horizon Systems Corporation under sub-contract to Tetra Tech, Inc. as part of EPA contract number 68-C3-0303.

Introduction

The U.S. Environmental Protection Agency's (EPA) Reach Files are a series of hydrographic databases of the surface waters of the continental United States and Hawaii. The structure and content of the Reach File databases were created expressly to establish hydrologic ordering, to perform hydrologic navigation for modeling applications, and to provide a unique identifier for each surface water feature, i.e., reach codes.

A key characteristic of the Reach Files are their attributes which define the connected stream network. These attributes provide connectivity regardless of the presence or absence of topologic continuity in the digital linework. Flow direction is inherent in the connectivity attributes. This attribute-level connectivity enables the Reach Files to provide hydrologic ordering of stream locations using reach codes (what is upstream and downstream of a given point in the stream network) as well as network navigation proceeding in either the upstream or downstream direction.

Data Entities

RF3-Alpha is comprised of two entities -- a reach and a coordinate. A reach is a surface water feature as defined in the previous section. Belonging to each reach are one or more coordinates. If the reach is a point feature (i.e. a zero-length reach) then it has one and only one coordinate pair, otherwise a reach has a set of two or more coordinate pairs that define a line. If the reach is an isolated open body of water such as a lake with no inlets or outlets, the reach represents the entire shoreline of the waterbody and the first and last coordinates of its line are identical forming a closed polygon.

Attributes

Reach Entity Attributes

The most important attributes of a reach are the Reach Code and the navigation attributes. The Reach Code provides each reach with a unique identifier which supports the linking of significant hydrologic data files to the Reach File and thus to each other. The reach navigation attributes provide the basis for hydrologic ordering and modeling by specifying the connectivity between reaches and the flow direction. Using the navigation attributes, it is possible to traverse the surface water network from upstream to downstream or downstream to upstream.

The Reach Code consists of three parts as follows:

Catalog Unit - an eight digit code uniquely assigned to a watershed and defined as a Federal Information Processing Standard (FIPS) maintained by the USGS. There are 2123 Catalog Units in the continental US plus Hawaii, Puerto Rico, the Panama Canal, and the US Virgin Islands. The data field name for the catalog unit is CU.

Segment - The segment number is a unique four digit number assigned to each new surface water feature within a given catalog unit. Segment numbers are assigned serially, starting at 0001, without regard for the hydrologic order of the segments. The data field name for the segment is SEG.

Marker Index - When a segment, that exists in the Reach File, is subsequently divided by a new tributary, the two pieces of the segment are assigned a marker index. Their segment numbers remain the same, thus identifying them as once being a single reach. The new downstream piece receives a marker index of zero. The new upstream piece receives a marker index which is defined as the proration or ratio of the distance from the base of the reach segment to the point of sub-division to the total length of the reach segment. Note that some Marker Indexes were assigned in RF2 when the spatial length of the reach was based on the sparse geometry from GNIS. **DO NOT USE THE MARKER INDEX AS AN INDICATOR OF ACTUAL REACH LENGTH**. The only valid use of the Marker Indicator is as a coding approach that enables the pieces within one Segment to be hydrologically ordered. The data field name for the marker index is MI.

Reaches are "connected" to each other via the navigation attributes that are attached to each reach. If a given reach is designated as the "instant" reach, its navigation attributes (with their data field names in parentheses) are as follows:

Upstream Left Reach	(ULCU, ULSEG, ULMI)
Upstream Right Reach	(URCU, URSEG, URMI)
Downstream Reach	(DSCU, DSSEG, DSMI)
Divergent Reach	(DIVCU, DIVSEG, DIVMI)
Complement Reach	(CCU, CSEG, CMI)

Figure 1 illustrates the navigation attributes for the instant reach. The arrows in Figure 3 indicate direction of flow.

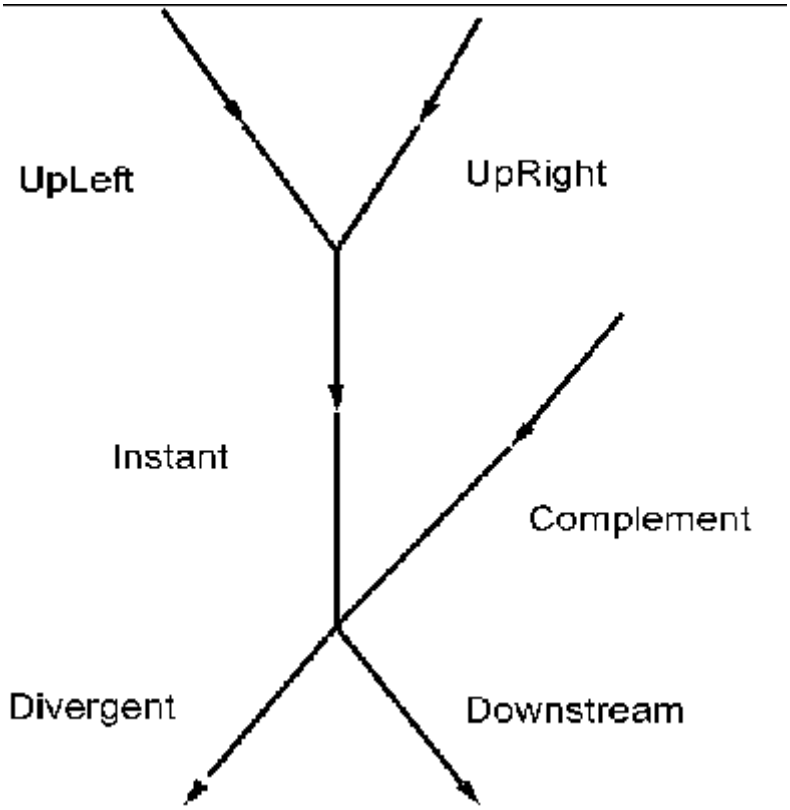


Figure 1

The navigation attributes permit only two reaches to converge upstream of a given reach. At certain scales (1:100,000 as an example), there are often three or more reaches converging at the same apparent point. When this happens, one or more zero-length reaches will appear in the reach file at the point of confluence to accommodate the binary upstream structure of the navigation attributes. Specifically, one zero-length reach is added for each reach, beyond the first two, which enters a confluence. For example, if, as in Figure 4, four reaches A, B, C, and D form a confluence and discharge into reach E, two zero-length reaches Z1 and Z2 will be added. A and B will discharge into Z1. C and Z1 will discharge into Z2. D and Z2 will discharge into E.

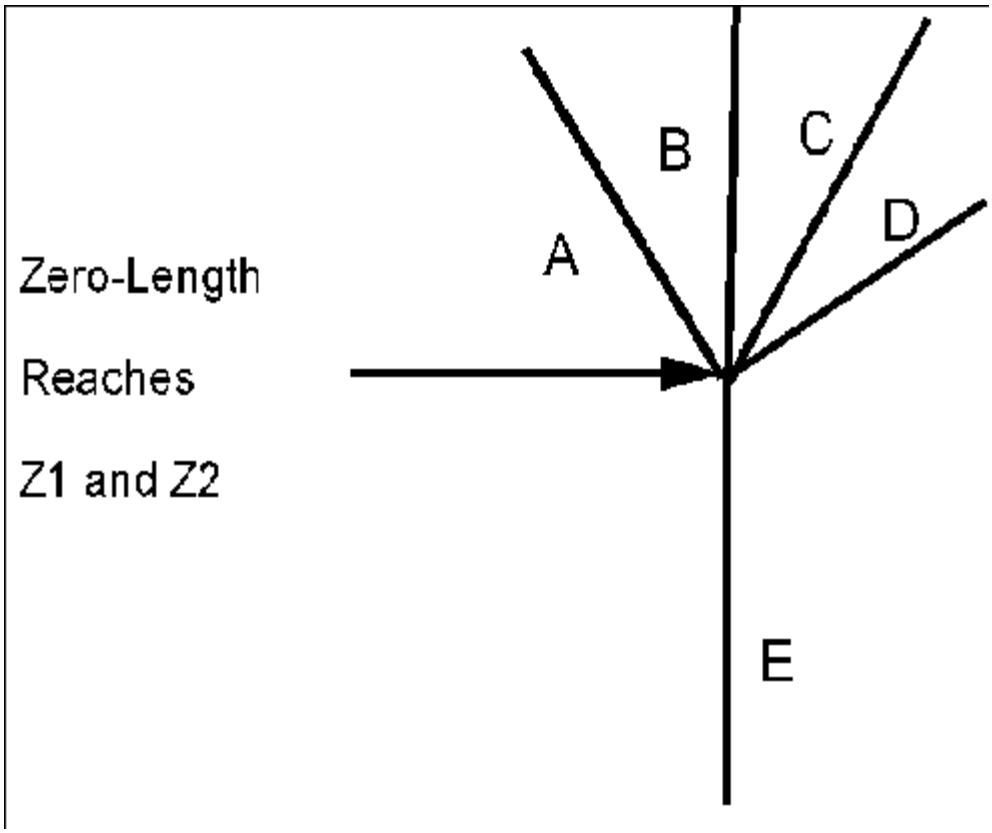


Figure 2

RF3-Alpha Attribute Descriptions

Reach codes - The Unique Feature Identifier

Reach codes are the unique identifiers of all reaches; they consist of 17 digits. As shown below, each number is constructed to include the USGS eight-digit catalog unit code, a four-digit segment number, and a five-place fixed decimal number referred to as the marker index.

Catalog Unit - an eight digit code uniquely assigned to a watershed and defined as a Federal Information Processing Standard (FIPS) maintained by the USGS. There are 2123 Catalog Units in the continental US plus Hawaii, Puerto Rico, the Panama Canal, and the US Virgin Islands. The data field name for the catalog unit is CU.

Segment - The segment number is a unique four digit number assigned to each new surface water feature within a given catalog unit. Segment numbers are assigned serially, starting at 0001, without regard for the hydrologic order of the segments. The data field name for the segment is SEG.

Marker Index - When a segment, that exists in the Reach File, is subsequently divided by a new tributary, the two pieces of the segment are assigned a marker index. Their segment numbers remain the same, thus identifying them as once being a single reach. The new downstream piece receives a marker index of zero. The new upstream piece receives a marker index which is defined as the proration or ratio of the distance from the base of the reach segment to the point of sub-division to the total length of the reach segment. Note that some Marker Indexes were assigned in RF2 when the spatial length of the reach was based on the sparse geometry from GNIS. DO NOT USE THE MARKER INDEX AS AN INDICATOR OF ACTUAL REACH LENGTH. The only valid use of the Marker Indicator is as a coding approach that enables the pieces within one Segment to be hydrologically ordered. The data field name for the marker index is MI.

In order to facilitate easy handling of updates, a fourth variable is used to identify the upstream point of the reach.

Upstream Marker Index - This number is the marker index associated with the most upstream end of the reach. The basis of this number is (in general) the distance measured from the start of the segment to the upstream end of the instant reach. For reaches derived from RF1 and RF2, this marker index is proportionally related to the reach lengths in the RF1 and RF2 spatial representations, respectively. The data field name for the upstream marker index is UPMI.

Data Source

RFORGFLAG records the version of the Reach File in which a given reach first occurred. A "1" denotes that the reach was first included in the RF1 version of the file. A "2" identifies those reaches added when the RF2 version was created and a "3" indicates this reach was added during the RF3 compilation.

Navigation Between Reaches

The navigation attributes in RF3-Alpha support two reaches converging and two reaches diverging, as illustrated in Figure A-1. The navigation attributes are associated with the "instant" reach. Points of convergence connect two input reaches with one output reach, points of divergence connect one or two input reaches with two output reaches, and points of simple connection connect one input reach to one output reach.

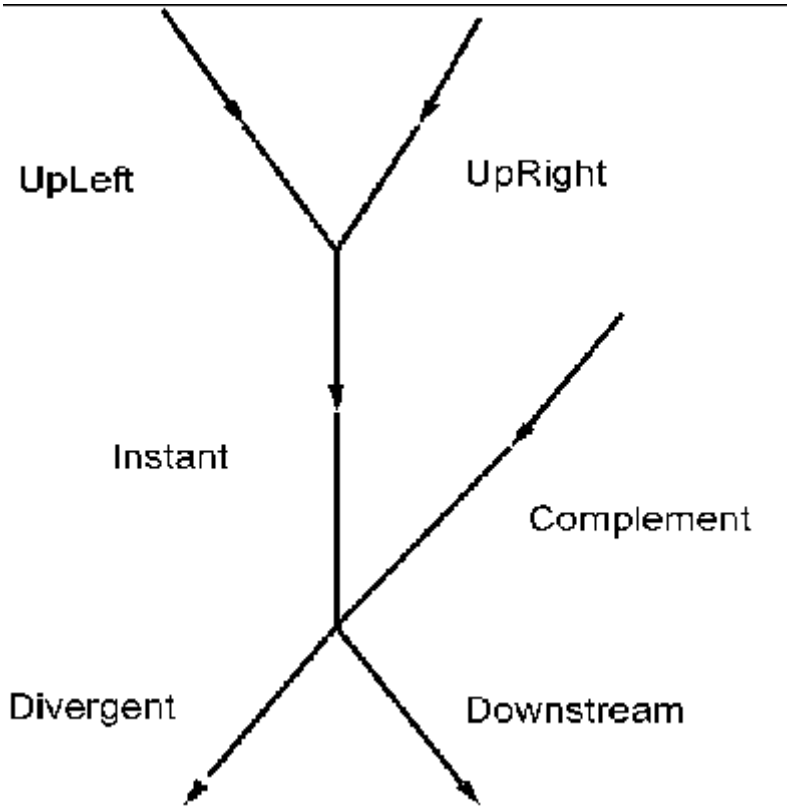


Figure A-1

Stream Levels

Each reach is assigned a stream level which defines the hierarchical relationship between streams and tributaries in a given drainage network. A tributary to a given stream is always one level higher than the stream into which it flows. For instance, the Mississippi River is a level-one stream, the Ohio River is a level-two stream, and the Tennessee River is a level-three stream. Stream levels are useful in retrieval algorithms. A "level path" can be followed to identify all mainstem reaches for a given river. For instance, the mainstem of the Mississippi River can be readily identified by retrieving all level-one reaches upstream of the Mississippi River terminus.

Reach Types

The term "reach type" refers to a one-character code which has been assigned to each reach. These type codes were generated, in part, from the DLG3 area and line attribute codes. Where DLG attribute codes appeared to be incorrectly assigned, temporary code changes were used to allow correct reach typing and to permit networking to be completed. For example, some lake shorelines had the DLG3 attribute code indicating that they were single line streams and, during compilation, the code would be temporarily

changed to correctly indicate a lake shoreline. The original codes are stored in the DLG-3 code attributes.

The valid reach type codes are as follows:

A Artificial Lake (RF1/RF2) Reach
C Continental Coastline Reach
Refers to a reach which represents a coastline on the Atlantic, Pacific or Gulf coasts.
F Falls Reach
A reach which is either a waterfall, drop spillway, or a reach of rapids.
G Great Lakes Shoreline Reach
Refers to a reach which represents a coastline in the Great Lakes.
H Headwater Lake Reach
A headwater reach, identified as a lake, which has no reaches above it in the reach file. This type of reach has either one or two reaches connected to its downstream end.
I Island Shoreline Reach
Identifies a reach whose DLG3 attributes identified it as an island shoreline.
J Braided Stream Envelope
Stream reaches which are around the perimeter of an unnetworked braided stream system.
L Lake Shoreline Reach
A reach which follows the shoreline of a lake other than the Great Lakes.
N Isolated Stream Reach
A stream reach not having navigation links in to other reaches.
O Apparent Limit Reach
A non-transport reach, usually designated by the DLG attributes as a marsh or wetlands.
P Indefinite or Intermittent Shoreline Reach
A non-transport reach, usually designated by the DLG attributes as a shoreline without definite boundaries.
Q Questionable Shoreline Reach
A reach which could be either an island or another closed area.
R Regular Reach
A reach which has upstream and downstream reaches connected to it and which is not classified as another type of reach.
S Start Reach
A headwater reach which has no reaches above it in the reach file. This type of reach has either one or two reaches connected to its downstream end.
T Terminal Reach
A reach downstream of which there is no other reach (for example, a reach which terminates into an ocean, a land-locked lake, or the ground). This type of reach has either one or two reaches connected to its upstream end.
U Unknown Reach
Reach cannot be classified.
V Open Water Terminal Reach
A reach which is both a terminal reach and an artificial open water reach.
W Wide-River Shoreline Reach
A reach which identifies either the Right or Left bank of a wide river.
X Terminal Start Reach
A reach which is both a terminal reach and a start reach.
Z Terminal Entry Reach
A reach which is both a terminal reach and an entry reach.

Names and Name Codes

The name, or names, associated with a given reach may have a maximum length of thirty (30) characters. Pseudo-names are included where reach names could not be identified when data was being compiled for RF1 and RF2. Pseudo-names in all cases consist of an asterisk followed by a single letter, e.g. "*A". Each reach name has an eleven (11) digit name code associated with it in order to uniquely identify the surface water represented by the reach.

Names that were assigned to the original RF1 reaches are stored in upper case letters. These names were developed manually from the source maps used to compile RF1. Names that were assigned to reaches that originated in RF2 and RF3-Alpha are stored in upper and lower case letters. These names came from a blind conflation of the 1988-version of the Geographic Names Information System (GNIS) data onto the RF3-Alpha data.

Up to three different names and name codes may be associated with a given reach:

PNAME, PNMCD:
These attributes are the primary name and name code, respectively, associated with the reach. For connected reaches, including open water reaches, this is a stream name. Each connected shoreline reach around an open waterbody will bear the name of the stream which feeds that open waterbody. All reaches of a given stream have been assigned the same name and the same primary name code. Other streams having that same name will have different primary name codes. For example, a Back Creek in Virginia would have a different PNMCD from any other Back Creek in Virginia or any other state.
CNAME, CNMCD:
These attributes are the common name and name code, respectively, which are reserved for the storage of alternate names.
OWNAME, OWNMCD:
These attributes are the open water name and name code respectively. For open water reaches (OWFLAG =1), this is the name of the lake or wide river in which the reach resides.

TERMID: Terminal Stream System Identifier

Each reach within a given terminal stream system is assigned a 5-digit code, unique to that terminal system. This code can be used to readily identify all reaches in a given stream system.

Currently, TERMID is not valued.

Latitude/Longitude Coordinates

There are numerous attributes in the Structure File that contain latitude/longitude coordinates. These attributes can be used for certain types of geographically-based retrieval and analysis, without the need to access the Coordinate ("LL") File. All latitude/longitude data are given in decimal degrees to the nearest 0.0001 degree.

Large-scale areal retrievals can be performed using the minimum and maximum latitude/longitude pairs. These coordinates define the smallest north-south/east-west rectangle containing the reach.