A Business Plan for the National Hydrographic Dataset in West Virginia

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This document presents a proposed business plan for the National Hydrographic Dataset (NHD) in West Virginia. It addresses several major issues common with any large, complicated geospatial dataset including stewardship and maintenance, adoption, and long term plans for improvement. The plan is divided into four sections. The first section provides a background review of the development of NHD in West Virginia. The second section reports on recent efforts to develop Local Resolution (LR, 1:4,800 map scale) NHD for the state. Included is a discussion of lessons learned during that process as well as a summary of future plans. In the third section a plan for hastening the adoption and use of High Resolution (HR, 1:24,000 map scale) NHD in West Virginia, particularly within state agencies, is presented. The final major element of this document is a business plan for implementing a stewardship program for West Virginia NHD data.

Section 1. THE NHD IN WEST VIRGINIA

1.1 Introduction and history of NHD in West Virginia

The National Hydrography Dataset (NHD) is a comprehensive digital spatial dataset that maps and describes the nation's surface water features, including streams, rivers, lakes, swamps, and constructed waterways (USGS 2007). High resolution (HR, 1:24,000 map scale) NHD data are now available for the entire country, as well as the previously completed medium resolution (1:100,000 scale) datasets. The NHD data format was developed in order to combine previously existing USGS and EPA spatial datasets for surface water features, specifically the EPA River Reach files and the USGS Digital Line Graph (DLG) files. The common format of the NHD at various spatial scales is designed to encourage cooperation and exchange of data between users at the federal, state, and local levels. NHD data support a variety of applications, including map making, referencing existing datasets to locations within the NHD data, modeling water flow, and general hydrologic data maintenance.

The state of West Virginia includes a total of 32 USGS sub-basins (major watersheds, or USGS 8-digit hydrologic cataloging units) as shown in Figure 1. Medium resolution NHD was completed for all sub-basins by USGS. Following completion of the medium resolution NHD, USGS determined that in order to create the HR NHD at the 1:24,000 map scale, the existing medium resolution NHD information would be transferred or conflated to a 1:24,000 scale stream network based on mapped DLG hydrography features. The HR NHD conflation processing for WV was completed by sub-basin, with USGS contractors completing all sub-basins in the eastern portion of the state (Potomac drainage), and the Natural Resource Analysis Center at West Virginia University completing conflation for the remaining sub-basins. Funding support and cooperation for the completion of the HR NHD dataset was provided to NRAC by the USDA Forest Service, Monongahela National Forest, and the WVDEP. Technical support and training for the HR NHD conflation process was provided by the USGS Mid-Continent Geographic Science Center in Rolla, Missouri. By 2003, West Virginia became one of the first states in the nation to complete development of the more detailed high resolution NHD.

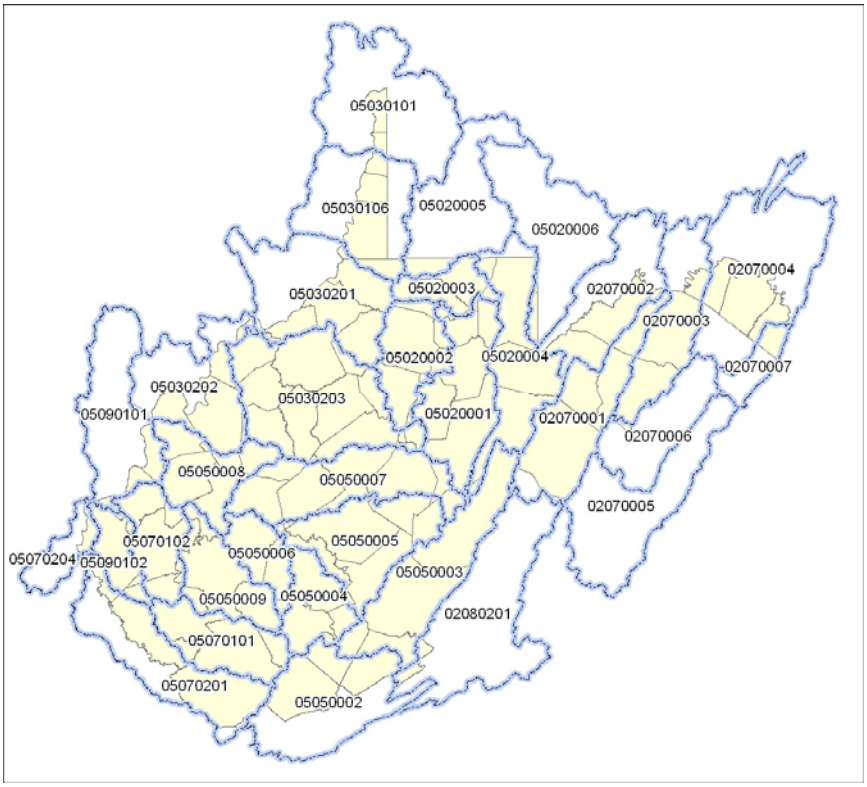

Figure 1. Eight-digit HUCs of West Virginia

Since completion of the HR NHD, a wide variety of individuals and institutions have accessed the NHD datasets for their own use. NHD data are available for download through the USGS NHD website (http://nhd.usgs.gov) in geodatabase format. In addition, the WV GIS Technical Center (WVGISTC) at West Virginia University has also made the WV NHD data available in a few alternative formats for the state of West Virginia, including merged statewide shapefiles. These formats have proven to be popular. Users of the WV high resolution NHD dataset include researchers, students, non-profit institutions, businesses, utilities, and federal, state, and local government agencies.

In 2005, a pilot project to explore development of a local scale (1:4,800) NHD product in West Virginia was begun following an initial informational meeting of interested parties. Section 2 of this report describes the LR NHD efforts in WV in more detail.

1.2 Enhancing the high resolution NHD in WV

Several related mapping and modeling efforts have been initiated to enhance the utility of the high resolution NHD for WV, including application of a statewide stream coding system, development of stream segment-level watersheds, and development of related stream modeling capabilities in applied project work. These additional efforts take advantage of the built-in modeling and stream networking capabilities of the NHD, and make the data more useful to particular user groups in WV.

The first enhancement to the high resolution NHD was the application of the previously existing statewide WV stream coding system. The WVDEP's Division of Water and Waste Management (as well as other state agencies) use an alternate, alphanumeric stream coding system to uniquely identify all streams in state records and databases. Several points differentiate these stream codes from the system already in place within the NHD data structure (for details on the NHD data structure, please refer to USGS 2007). These codes offer a unique reference ID for each stream as a whole, as opposed to the NHD stream coding which may or may not uniquely identify a stream as a whole. The system also applies a stream name to every stream (even where NHD gives no name), and locates unnamed streams

along mainstem named streams using a river mile based reference system. The coding system enables WVDEP to maintain a link between legacy datasets using the stream coding system and the spatial representation of each stream in the NHD. WV state stream codes were also applied to braided segments of larger rivers and streams, while the NHD does not attach names to these features.

An additional enhancement related to the high resolution NHD was the completion of stream segment-level watersheds. Segment-level watersheds are defined as drainage areas delineated for individual stream segments (portions of linework between stream confluences or junctions). Segment-level watersheds are attributed with a unique reference code linking the watershed area with a particular stream segment. A similar product (NHDPlus) has also since been made available at the 1:100,000 map scale (corresponding to medium resolution NHD) and is available from a USGS contractor (Horizon Systems 2007).

Additional modeling capabilities have been developed to use the segment-level watersheds and the associated high resolution NHD in various modeling efforts designed to examine the influence of landscape factors on instream water quality and biota. These capabilities include calculations (by segment-level watershed) of cumulative watershed statistics and stream network distances. These modeling capabilities have been used in a number of applied research projects by the Division of Forestry and Natural Resources at WVU, the WV Cooperative Fish and Wildlife Research Unit at WVU, and the WV Water Research Institute.

Enhanced datasets related to the HR NHD in WV (WV state stream codes, stream segment-level watersheds) have not been specifically incorporated into the national NHD data repository. Instead, copies of these datasets are currently available by contacting either the Natural Resource Analysis Center (Jackie Strager: jmstrager@mail.wvu.edu) or the WVDEP (Chris Daugherty).

Section 2. DEVELOPMENT OF LOCAL RESOULUTION NHD FOR WEST VIRGINIA

2.1 Introduction

An informational meeting on the possibility of developing even higher resolution NHD datasets within WV was held in November 2005 with several interested parties. The meeting was followed by a survey of water resources data users. Comments received at the meeting and from the survey highlighted the needs of these data users for more up-to-date and more spatially detailed surface water datasets for the state. Following the meeting and survey, the WVGIS TC and NRAC began to investigate the work required to complete Local Resolution NHD (LR NHD) datasets for portions of the state, at a map scale of 1:4800. A pilot project to complete LR NHD datasets for two watersheds, the Gauley River and the Upper Guyandotte River, was begun the following spring. The pilot watersheds were selected due to their location completely within the state's borders, and the fact that these watersheds are among those influenced by stream alterations due to mining activities.

2.2 Source Data and Initial Steps

The source data for stream and waterbody geometry for the LR NHD were aerial photographs taken in spring 2003 for the WV Statewide Addressing and Mapping Board (WV SAMB). Contractors for the WV SAMB collected planimetric data from the aerial photographs, including streets, streams, and waterbody polygons (wide streams, lakes, ponds, swamps, etc.). Appendix D lists specific criteria used by the contractors to produce planimetric stream data. The original WV SAMB surface water datasets were corrected and updated by the WVGISTC, statewide. Corrections and updates included addition of many streams originally present in the 1:24,000 NHD but not included in the SAMB streams, as well as occasional updates to correct closed polygons in the stream network and other anomalies. WVGISTC also divided the 1:4,800 scale lines into their respective 8-digit HUCs and performed edge matching between them. All updated SAMB stream / waterbody datasets are available for download by river basin from the WVGIS TC website.

2.3 Pre-conflation and Conflation: Creating the LR NHD

The LR NHD creation process uses routines and procedures developed by the USGS Mid-Continent Mapping Center for the ArcGIS software environment. Most of the procedures are run using ArcGIS and the NHD GeoConflation Toolbox (NHDGCT), although some of the steps must be run from command line ARC/INFO. The basic steps consist of data preparation (pre-conflation), and conflation of the existing NHD information from the source dataset (HR NHD) to the target dataset (new LR NHD).

Once the SAMB stream datasets had undergone an initial revision, the SAMB stream datasets for the two pilot watersheds were converted to proper input format for conflation. This pre-conflation process included use of the USGS NHDCreate process to assemble datasets for the sub-basin, ensure stream connectivity and flow direction, establish artificial paths, and attach NHD feature codes.

Conflation steps are largely automated using the NHDGCT provided by USGS. The USGS also offered technical support in using the NHDGCT tools. Conflation steps ensure that existing reach code, GNIS Name, and GNIS ID attributes from the 1:24,000 HR NHD were transferred to the corresponding stream lines in the new 1:4,800 LR NHD where possible. Where stream reach codes did not transfer cleanly, or where new reach codes were needed, the NHDGCT produced reach cross reference documentation that will allow users to track reach code changes or anomalies.

Conflation proved to be an extremely time-consuming and painstaking process, with many steps requiring detailed, iterative updates to the target databases and stream features. ArcGIS software expertise and a high degree of familiarity with the NHD data model are both required for successful use

of the NHDGCT tools. At the time this report was prepared, automated conflation tools related to quality assurance/quality control had not yet been completed within the NHDGCT.

2.4 LR NHD Conflation Results

A summary of the LR NHD features included for one of the pilot watersheds (Gauley River) is provided in the table below. The table illustrates the sheer increase in number and extent of mapped surface water features from the 1:24,000 scale HR NHD to the 1:4,800 scale LR NHD. The number of mapped stream segments more than doubled, while the percentage of streams with an attributed stream name dropped significantly, as might be expected. The number of mapped waterbodies also increased.

Mapped features (Gauley River watershed)	**HR NHD (1:24,000)**	**LR NHD (1:4,800)**
Number of unique stream segments (COMIDs)	7,357	18,459
Total length of mapped streams, km (flowlines)	4,932	6,636
Number of named stream segments (GNISNAME)	3,570	5,430
Percentage of stream segments with name	48.5%	29.4%
Number of mapped waterbodies	1,656	3,060

Table 1. Summary of mapped NHD features for the Gauley River watershed, at the 1:24,000 and 1:4,800 scales.

2.5 Summary of LR NHD Recommendations

Based on current experience with LR NHD data development for the Gauley and Upper Guyandotte, several main limitations of this dataset (particularly the source data) are apparent and further development for other watersheds in the state is not recommended at this time. This may change in the future, but for now, the state's primary hydrological dataset should be the 1:24,000 scale HR NHD. For reasons outlined below, all NHD stewardship, maintenance, and update efforts will be concentrated on the HR NHD dataset at this time. LR NHD dataset development for various watersheds will be continued as funding or data needs permit. At this time however, updating the existing, completed HR NHD will be more beneficial to the state as a whole.

The LR NHD pilot study revealed that conflation, data integrity, and generalization issues are obstacles in attaining 1:4800-scale local resolution NHD. It was hoped that the pilot would create a more useful local resolution NHD framework, by conflating existing 1:24k NHD attributes to the more spatially accurate and current 1:4800-scale stream data. However, the pilot revealed a combination of limiting factors.

First, the 1:24,000 to 1;4800-scale conflation is more difficult and time-consuming than the initial 1:24,000-scale conflation from Digital Line Graph format source data. The local resolution conflation requires knowledge of several GIS software products (ARC/INFO Workstation and ArcGIS) as well as detailed knowledge of the NHD data structure and rules.

Second, the local resolution hydrographic source data was collected in a non-uniform manner and is inconsistent across watersheds. Some of the stream line features were actually connected, forming closed loops which would be practically impossible in the real world. Extensive checks of the data using the 3 meter Digital Elevation Models and other ancillary data are required to make sure that all streams "flow" downhill. Closed loops cause a variety of problems in the NHDGCT conflation routines. Additionally, there are several instances even within the same watershed (or even the same USGS quadrangle) where stream linework was digitized at varying levels of detail, which leads to lower confidence in these lines as a valid map product for a particular map scale (Figure 2).

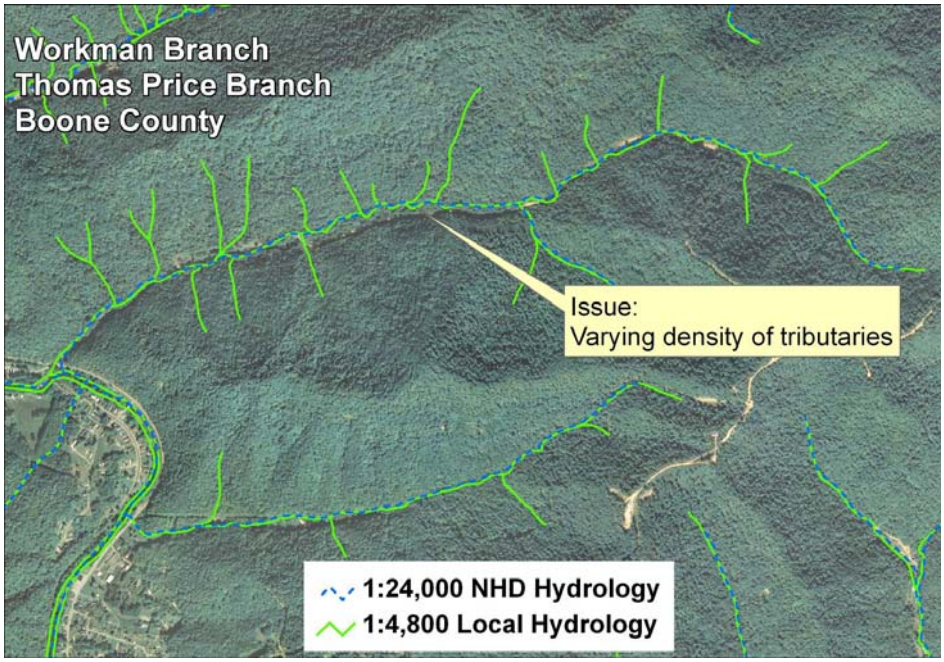

Figure 2. Varying levels of detail in 1:4800 mapped hydrology.

Third, the local resolution stream dataset is so highly detailed that it includes features (e.g., culverts, ditches, small intermittent streams) which require field validation to determine if they are actual permanent streams. Finally, the local resolution data is too dense for certain cartographic and modeling applications and thus requires a reliable methodology for generalizing the local resolution streams to smaller map scales. While the USGS is actively working to address this issue, at present, the concern is such that among NHD stakeholders, support for the continued development of LR NHD is tentative.

Section 3. ADOPTION OF THE HR NHD

This section reviews the current state of NHD usage in West Virginia. This information is derived from experience on the part of the authors as well as from the results of a survey administered to the NHD user community in mid to late 2008 (See Appendix E for full results). This section also outlines a general plan to encourage the implementation of HR NHD into the workflow of West Virginia's GIS users.

3.1 The Current State of NHD Use in West Virginia

While the HR NHD dataset is certainly the most complete and technically powerful GIS dataset for streams available in West Virginia, most agencies seem to depend on a myriad of stream datasets within their workflow, depending on the task at hand. Based on survey responses (See Appendix E for survey responses), the most frequently utilized hydrographic datasets in West Virginia are the HR NHD (67% "frequently use") and 1:4,800 scale lines (56% "frequently use"). While the 1:4,800 scale lines are the principal data source in the local resolution NHD pilot project, the dataset contains no unique attributes and is more or less entirely graphic in nature. Medium Resolution NHD rounds out the top three most utilized hydrographic datasets but is cited as "sometimes used." Only one respondent cited using another available dataset – NHD Plus (an enhanced version of the medium resolution NHD). Hydrographic data users in West Virginia look chiefly to free and public data sources.

Users seem generally aware of the more advanced features of the NHD dataset (linear referencing, flow modeling, etc.), and approximately two-thirds of users actually utilize them, though most users classify that use as "sometimes." Most respondents principally utilize the NHD as a cartographic element in map making (78% of respondents "frequently use" NHD data for cartography/map making). Survey comments indicate that users who do not currently exploit advanced features of the NHD are interested in those features.

Some users edit the NHD to suit their needs and to reflect changes on the ground, effectively taking ownership of the data. Twelve of 18 respondents have edited the HR NHD. Perhaps more importantly, nine respondents "inventory and/or collect new or updated stream geometry (e.g., higher resolution stream lines, new drainage from physically altered landscapes such as mines) or attributes (e.g. alternative names)." These people represent a potentially important demographic as the NHD stewardship program is developed. This is discussed further in section 4.5.2.

3.2 High Resolution NHD and West Virginia's GIS Community

The results of the survey are encouraging in that they make it clear that within West Virginia resides an educated and enthusiastic NHD user community. Users are not, however, in the practice of depending on a single dataset for all of their hydrographic data needs. This is not a problem, per se, as individual users have unique requirements that may not be met by a single dataset. Nonetheless, a key goal of West Virginia's stewardship effort will be to attempt and answer many of these shortcomings and, where possible, encourage users to implement the HR NHD into their workflow as their primary hydrographic data source.

Thanks to the continued development of NHD tools by the USGS, achieving this goal is less daunting than it once was. USGS provides software tools, training and technical references, all designed to aid users in the implementation of NHD into their day to day business. While survey results indicate that users are aware of the advanced functionality of the NHD, the lack of regular use of these features indicates an opportunity to educate and train interested NHD users in these features.

This will be accomplished in the short term by improving links between current, state-level NHD data distribution and supporting materials such as those available from USGS through the NHD FTP site. Where possible, these documents will be supplemented with local examples. In the long term, the Natural Resource Analysis Center, West Virginia GIS Technical Center and their partners will work to develop

NHD training courses tailored towards the overall goal of increasing NHD use in West Virginia. Lastly, as the principal source of GIS data in WV, the WVGISTC will encourage the sharing of data in formats that capitalize on the advanced capabilities of NHD, such as reach registered information.

3.3 High Resolution NHD and the Department of Environmental Protection

The WVDEP is one of the major users of NHD datasets within the state, and has also been identified as the likely data steward for the high resolution NHD dataset. Within DEP, the Division of Water and Waste Management has responsibilities related to permitted municipal and industrial discharges, water quality standards, and watershed assessment, all of which require accurate, up-to-date, and detailed surface water GIS datasets. In addition, several other divisions of DEP also make use of mapped streams, including the Division of Mining and Reclamation and the Technical Applications and Geographic Information Systems unit (TAGIS). WVDEP is moving towards the use of centralized data repositories for GIS datasets, which would include the HR NHD as the main, statewide GIS surface water dataset, rather than maintaining multiple copies of the state stream datasets within individual programs and offices. WVDEP has also been one of the main drivers in recognizing the need for NHD updates, corrections, and ongoing stewardship, as described in Section 4.2 of this report. Implementing the HR NHD into the daily workflow of the WVDEP is an important first step towards the long term goal of statewide use of that dataset.

Section 4. NHD STEWARDSHIP IN WEST VIRGINIA

The High Resolution National Hydrographic Dataset (HR NHD) for West Virginia (1:24,000 map scale) was completed in 2002 and has since become a centerpiece of the state's spatial data infrastructure. Since the completion of the dataset, it has become apparent that water features on the ground are in a state of flux due to mining activity, road construction and other processes. Additionally, the HR NHD was recognized to be imperfect and contained a number of errors. Because of these issues, and due to the mass use and popularity of the NHD in West Virginia it is imperative that this dataset finds a permanent home and a formal steward. This section of the NHD Business Plan for West Virginia will review the impetus for developing an NHD stewardship program and propose a structure for that program.

4.1 Introduction

Nationally, development of the NHD was driven primarily by three Federal agencies: the USGS, the EPA and the USDA Forest Service. During the data development process a great number of state and local partners were brought on board and these partnerships remain today in the form of a diverse user community. The data model and production process was crafted by many contributors, but in the end, was guided and managed by the USGS. Today the USGS continues to be the final source of NHD data and standards.

There have been changes, however. As the NHD has evolved and become more widely used and the USGS has shifted away from a strict top-down data management focus, it has become increasingly apparent that there exists a need for local stewardship of NHD data. Essentially, USGS has come to recognize that intermediary data stewards will play a crucial role in temporally maintaining the NHD's geographic and attribute accuracy. To that end, the USGS has developed a data editing tool and data model for use by the NHD data steward. They have also developed a very general outline of the editing and maintenance process.

West Virginia is, perhaps, somewhat unique in terms of the pace of change to hydrographic features. Surface mining, road construction and other economic development all contribute to changes in streams on the ground, none of which is reflected in the static HR NHD. The HR NHD is derived from the "blue lines" on 1:24,000 scale 7.5 minute topographic maps created 20 or more years ago. Additionally, attentive data users have identified some minor errors that occurred during the processing of the HR NHD dataset. All of this has resulted in an NHD dataset that is inaccurate due to temporal and technical issues.

That being said, the NHD data model and the overall high quality of the dataset has resulted in widespread use within the West Virginia GIS community. Many users, in fact, have taken note of observed problems and areas that require updates and have shown an interest in participating in a stewardship process. In order to avoid the problem of multiple versions of NHD data for West Virginia, it is necessary to identify a central data steward and establish an editing and stewardship process.

4.2 Need for Data Stewardship: Updates and Corrections

Since the completion of the HR NHD for West Virginia in 2002, data users and others familiar with the hydrology of West Virginia have noted the need for updates and modifications to this dataset. Some of the issues with the current HR NHD data have been noted through a systematic statewide review of the data by WVDEP (particularly focused on stream names), while others have been noted anecdotally by other data users. Specific errors and issues that NHD data stewardship updates will address include: alignment errors, attributing errors, connectivity problems, flow direction errors, reach coding/conflation errors, missing features, and GNIS name problems, among others. A summary of the number of errors found during the statewide review by WVDEP is provided below in Table 2 in order to provide a general idea of the amount and extent of the problems.

In general, the most commonly occurring problem noted in this review is an error or suspected error in the stream name attribute (GNISNAME). Geometry errors include missing segments, mis-aligned stream centerlines, and so on.

Type of problem	Number of Segments	% of Segments	Total Length (mi)
Possible geometry error	614	0.28	254
NHD attribute error (FCODE)	6	0	3
NHD format error (reaches)	6	0	n/a
Name issues (possible)	204	0.09	89
Name issues	1,337	0.62	657
TOTAL	216,579		94,796

Table 2. Quantification of specific problems observed in HR NHD by statewide review.

In addition to the statewide review of the NHD by WVDEP, the NRAC at WVU has also conducted a small study in the Coal River sub-basin (05050009) to determine the location and amount of potential stream linework changes due to recent mining activities. The Coal may be considered a representative watershed for the southern coalfields region of the state. The HR NHD stream linework in this region will need extensive updating, due to alterations in surface drainage as a result of various surface mining practices including mountaintop removal/valley fill mining. For the 570,000 acre Coal River watershed, a total of 94 miles of streams currently mapped in the HR NHD were directly impacted by mining activities, and were no longer visible on recent aerial photographs (dated 2007). Of these 94 miles, 33 miles (or 35 percent) were known to be impacted between 2003 and 2007, indicating the need for frequent temporal updates to the NHD in this region. WVDEP has also conducted a similar internal review for portions of the Coal and Guyandotte watersheds, based on mapped streams and mining visible on remotely sensed images captured in 1990, 1994, and 1998 (M. Shank, TAGIS internal report).

In addition, a similar review of the LR NHD data for the Coal indicated that even though the LR NHD was based on much newer aerial imagery collected in 2003, mining activity since 2003 has caused additional alterations to stream geometry. Ultimiately, these examples illustrate that stream geometry is constantly changing, and users of stream datasets need to be aware of this limitation. Stream data stewardship may help address some of these stream change issues.

4.3 Stewardship Requirements

The USGS has developed a conceptual framework for NHD Stewardship at the state and local levels. They envision an arrangement whereby an intermediary agent (between the community at large and USGS), referred to as a data steward, will collect information from users and execute edits in the NHD dataset. These edits will then be submitted to the USGS and they will be implemented into the national database. The process of editing the data is well defined and USGS has developed a robust toolset that the data steward will be trained to utilize. Though it is not an exhaustive list, the USGS defines the following responsibilities to the data steward:

- Guarantee that updated NHD data pass all validation tests.
- Assure that the core content (features, attributes and relationships identified in the NHD standards) is included.
- Keep the data current.
- Consider any change submitted and decide authoritatively if it will be accepted or not. (Some changes can have significant impacts, and it is essential that any changes made to the NHD are valid.)
- Report the decision publicly.
- Respond to proposed changes within some agreed upon reasonable time.
- Provide publicly available information on status of data development and updating.
- Maintain awareness of activities by other agencies and groups.

The data steward for West Virginia must be an agency with strong technical GIS skills and experience with NHD data. In addition, if the data steward is not aware of the composition of the NHD user community in West Virginia, steps should be made to organize that community with the data steward playing a central role. This document includes a general overview of the methods by which other states have collected proposed edits from the user community, but organizing data stewards will be a crucial element of that effort.

4.4 Establishing a Stewardship Program

Once a data steward has been identified for West Virginia, the process of establishing a stewardship program is fairly straightforward. In order to make a stewardship program official, a Memorandum of Understanding (MOU) must be drafted and agreed upon by both the data steward and the USGS. This document describes all elements of the stewardship process, including a background of the stewardship effort, who the data steward is and why they have been chosen, the responsibilities of all parties, a description of the process by which updates will be made, where updates will come from and how the data steward will collect and manage those updates, and a description of any necessary arrangements between third parties such as the US Forest Service. Presently, 24 states have signed agreements and established stewardship programs, as can be seen in Figure 3, taken from the NHD stewardship website (http://webhosts.cr.usgs.gov/steward/):

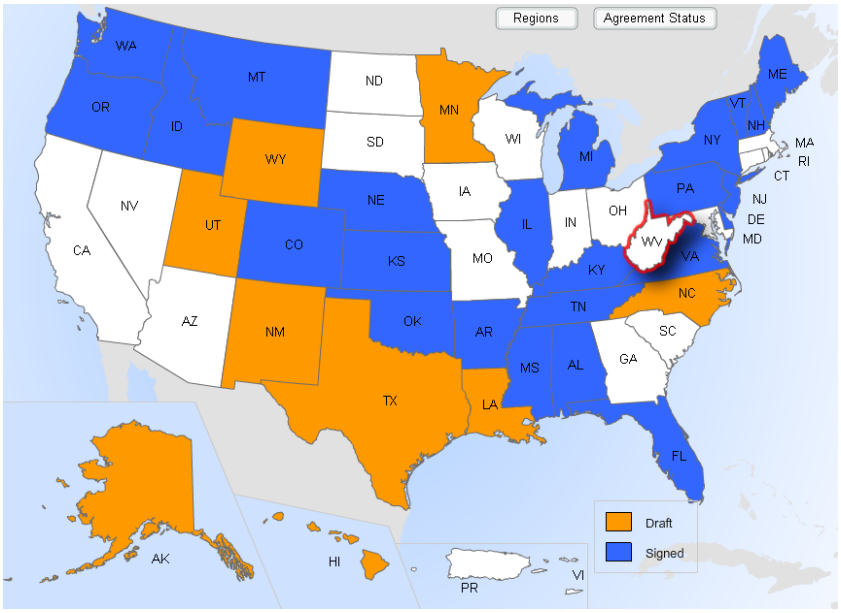

Figure 3. NHD stewardship program status.

Much of the content of an MOU document is already established. The principal responsibilities of the data steward, for instance, are fairly constant from state to state. How those duties are managed and executed, however, are subject to the interests of the data steward themselves. It is these elements that will require planning and coordination among West Virginia stakeholders. Fortunately, the WV community is not alone in these experiences. The national NHD community is active, well organized, and experienced. This community will prove to be a valuable resource as the West Virginia NHD Stewardship program is developed. A list of states that have established (or begun to establish) NHD stewardship programs can be found in Appendix A.

4.5 Elements of a Successful Stewardship Program

Successful stewardship programs have several common elements. This section describes those elements and provides some basic guidelines as to how the various roles are best filled. This section outlines the following: the principal steward, sub-stewards, the NHD User Community and NHD Tools. Much of the content in this section is based on information provided by the USGS and the NHD User Community at the 2009 NHD/WBD Stewardship Conference.

4.5.1 The Principal Steward (PS)

The principal steward of the NHD in a state is that entity which signs a memorandum of understanding with the USGS, committing themselves to leading the stewardship process in their state. The content and makeup of the MOU can vary from state to state, but generally speaking, the USGS commits to a certain amount of technical support and the steward agrees to coordinate and supervise stewardship in their region of interest. As such, the principal steward has several important **jobs**:

1. The principal steward acts as a leader and coordinator. Most states operate in a steward/sub-steward (see below) system. The PS must work to ensure that all sub-stewards follow protocol and work in a way that ensures the highest quality edits are made to the NHD. The PS must also recognize who is best qualified to make what edits (based on jurisdiction, for instance). The PS works to ensure the coordination of work and to minimize the repetition of effort. The PS also receives and approves edits made by sub-stewards before submitting them to the USGS.
2. The principal steward edits and maintains the NHD. In most cases, the entity that fills the PS role is within some regulatory agency that has firsthand knowledge of on the ground changes to streams. This knowledge, in turn, is utilized to maintain the NHD. In addition, the PS is generally a power user of the NHD and, through that experience, is aware of existing problems in the NHD that need to be repaired.
3. The principal steward interfaces with the water boundary dataset (WBD) steward. One of the major upcoming changes to the NHD in the upcoming years will be the inclusion of the WBD into the NHD. In most states, the WBD steward and NHD steward are not the same person. For this reason, the two stewards must work closely with one another to ensure the integrity of the two elements. West Virginia's WBD steward is Debbie Chase of the US Natural Resources Conservation Service.
4. The principal steward is an advocate of the NHD. The National Hydrographic Dataset is a powerful tool for hydrologic modeling. The dataset's existence is the result of substantial cross-agency coordination and for development and evolution to occur, it is not only important that the PS ensure stewardship of the dataset, but also use of the dataset. The PS must advocate among key hydrographic stakeholders for the utilization of the dataset.

There are also several **pre-requisites** the PS should meet in order to help ensure the success of a stewardship program:

1. The principal steward must be familiar with the NHD data model. The NHD data model is complicated, though not impossibly so. An understanding of the model design, as well as its strengths, weaknesses and capabilities is a must for the PS.
2. The principal steward should have a strong knowledge of the NHD user community. Due to the volume of potential work facing the NHD steward, it is important the PS have a fairly substantial awareness of who the principal users of the data are. This will allow for coordination and prioritization of efforts.
3. The principal steward "agency" should be able to commit at least 1 FTE employee in the first year of stewardship and ½ FTE or greater in the following years. Start up funding is available from the USGS to help facilitate this.

The authors of this business plan believe that the best candidates for the role of Principal Steward are, in no particular order, the Division of Water and Waste Management within the West Virginia Department of Environmental Protection, the Technical Applications and Geographic Information Systems Unit (WVDEP), the West Virginia GIS Technical Center (WVU), and the Natural Resource Analysis Center (WVU). Given the regulatory and data collection role of the WVDEP, many of the changes to stream geometry on the ground will be already tracked at that agency, making it easier for those changes to be reflected in the NHD as edits.

4.5.2 The Sub-Steward(s)

Most state employ stewardship arrangements whereby several entities edit the NHD, all under the coordination of the PS. The PS agency is often one of many agencies that have knowledge about the NHD data in the region of interest and as a result, a coordinated, cross agency editing effort is the most efficient way to maintain the NHD. Given the land ownership/management puzzle, it is only natural that the coordination of several key entities will be crucial if all of the knowledge gaps are to be filled.

Arrangements wherein Sub-Stewards complete edits of the NHD which are checked and turned in by the PS are common. Coordination of the sub-stewards by the PS is not generally direct, but rather involves coordination to minimize or eliminate repetition of effort. The PS is able to, along with the USGS, determine who can and cannot edit sub-basins within their state boundary.

Potential sub-steward candidates in West Virginia include the West Virginia GIS Technical Center, the Natural Resource Analysis Center, the Monongahela National Forest and the West Virginia Division of Natural Resources. These entities can offer technical expertise, knowledge of conditions on the ground, or both. One of the most important contributions sub-stewards may be able to make is to lighten the initial load of edits that the HR-NHD in West Virginia needs.

4.5.3 The NHD User Community (UC)

For this stewardship program to be successful, it is vital that the community of NHD users in West Virginia be organized and kept informed. Many edits will source from the myriad of NHD users in the state. It is an impossible task, after all, for one person or agency to be familiar with all of the hydrologic features in the state. Based on survey responses (see Appendix E), there is a small but active community of NHD users that edit the NHD. These edits are mission driven – i.e., the nature and purpose of the edits is directly informed by the stated mission of the editor. It is unclear at this time if these edits will directly inform the stewardship process.

What is clear, however, is the need to formally organize the NHD users (and hydrographic data users) of West Virginia. A semi-annual meeting of hydrographic data users organized by the WV Office of GIS Coordination would be a valuable first step towards the long term goal of mobilizing the

hydrographic data users into a cohesive group where each member has the opportunity to submit edits and comments to the NHD steward when desired. We envision two major roles for the UC:

1. The UC can aid the PS and sub-stewards in the resolution of stewardship policy issues. In West Virginia, for instance, one of the principal causes of change on the ground is surface mining. At present, there is no policy as to how to account for these changes in the dataset. At what point in the timeline of a surface mine's existence should the NHD be "corrected" to account for the changes?
2. The UC, given their knowledge, will be an integral part of identifying possible edits in the NHD. A few states have deployed (and many more are planning to deploy) web based applications to facilitate the collection of potential edits in the NHD. These edits are, of course, sourced primarily from the UC and other stakeholders. Given the variation of technical ability among the UC and other stakeholders, it is necessary that these web based applications are both easy to use, and useful. A brief directory of those tools can be found in Appendix F.

4.5.4 Stewardship Tools and Data

USGS has developed a toolset specifically geared towards the maintenance of the NHD dataset – NHDGeoEdit. West Virginia's principal data steward will be trained to use these tools. It may be useful for other high level users of the NHD to be trained to use these tools as well, particularly those users whose areas of study, authority or interest cover large parts of the state – the USFS, for instance. These tools were designed to be utilized by a GIS power user to modify all elements of the NHD, be they attribute edits or changes to the underlying stream geometry. Along with the toolset, USGS has developed documentation and, more importantly, training programs. USGS provides on-site training in the use of the NHDGeoEdit tool and, following that, long-term technical support.

In addition, we believe that West Virginia should follow the lead of other states, such as Nebraska and Vermont, and develop a web based interface for reporting of NHD errors and changes. The principal purpose of this tool will be to engage the NHD user community in the stewardship process. As outlined in Section 3, we expect that in the next several years, several new entities will become power users of the NHD and, as such, will be able to contribute to the NHD. Several states in the US have developed or are actively developing web based reporting and/or editing tools to aid in NHD stewardship. These web applications are all open source and available for adaptation in West Virginia. There is a large group of active developers within the national NHD community. A brief directory of those tools can be found in Appendix F.

Also, as briefly reviewed in Section 2, a local resolution dataset of stream lines and water feature polygons is available for West Virginia. While the overall quality of this data is unclear, we recommend using this spatial dataset as a primary source of geographic edits in the HR NHD. These lines were collected from 2003 aerial photography and, despite collection inconsistencies, provide the most current source of stream geometry. All edits made with this geometry as the principal source should be, of course, reviewed on a case by case basis.

4.6 Recommendations and Next Steps

This section of the document contains recommendations for the development of an NHD stewardship program in WV. They are arranged in order of suggested occurrence and priority.

1. Identification of the principal steward of NHD in West Virginia is a top priority. This entity should understand the role as outlined in this document and be willing to act as a leader, coordinator and advocate for NHD in West Virginia.
2. Identification of a core group of sub-stewards who are willing to make edits to the NHD must

also take place as soon as possible. NHD stewardship in West Virginia will be a big job, particularly at the outset. The front loading of needed edits necessitates a coordinated effort. There are several candidate agencies that could assist the PS by performing some of the already identified routine edits.

3. Once the PS and sub-stewards are identified, those parties must work with both the NSDI liaison for West Virginia and the regional point of contact for the NHD, Craig Neidig and George Heleine, respectively, to secure a multi-agency cost sharing arrangement for the establishment of a stewardship program in West Virginia.
4. Once these key parties are identified and general coordination takes place, scheduling of an onsite NHD Geo Edit training session should occur. It is also vital that editors begin utilizing the tool as soon as they have been trained.
5. Convene a hydrographic data users group, probably as a subset of the West Virginia Association of Geospatial Professionals. This group should definitely include current users of the NHD, including more "traditional" hydro scientists may help accelerate the adoption and use of the NHD. Suggested tasks for the users group:
    - Develop a "best practices" document for NHD data use within agencies.
    - Explore the many applications of NHD as well as the software that exists to support those applications, such as the Hydro Event Management (HEM) tool.
    - Identify potential policy issues with NHD stewardship and discuss them.
    - Formalize a link between the users group and the PS.
6. Continue the compilation of known errors to the NHD. NRAC and WVDEP have already begun this process, including the categorization of errors by type. This process is vital and should continue.

5.0 CONCLUSIONS

This document has described the need to establish a permanent NHD steward for the State of West Virginia and offered an initial proposal to reach that objective. A significant opportunity exists to align the NHD program with the new statewide GIS strategic plan and include NHD stewardship as one of the primary GIS business plans. The need for an accurate, current, and information rich NHD dataset has been identified for West Virginia state agencies, as well as for the state's Federal and local partners.

Survey results indicate that the GIS community in West Virginia is actively using NHD and is interested in seeing the development of an NHD stewardship program. Survey participants had many comments and their interest and enthusiasm bodes well for the future of NHD stewardship.

This proposal identifies likely candidates to fill the role of NHD steward. We recognize that to meet these recommendations, substantial issues with regards to additional data development, software and GIS tool development, user training, agency support, and sustainable funding will need to be addressed.

The foundation has already been established to build upon West Virginia's leadership role as an early adopter of the National Hydrography Data program. In the coming years, West Virginia will continue to work with the United States Geologic Survey to ensure that this valuable data resource is used and maintained.

APPENDIX A – Existing NHD Stewardship Programs

State	POC	Agency	MOU Status
Alabama	Phillip Henderson	AL Dept. Of Economic and Community Affairs, Office of Water Resources	Final
Alaska	AGDC Hydro Subcommittee - Lynette Nakazawa	USGS Alaska	Draft
Arkansas	Kathryn Hattenhauer	State of Arkansas Dept. of Environmental Quality	Draft
California			????
Connecticut	Howie Sternberg	Natural Resources Center, CT Dept. of Environmental Protection	????
Delaware	Debbie Sullivan	Dept. of Natural Resources and Environmental Control	Final
Florida	David Anderson	Dept. of Environmental Protection	Final
Idaho	Linda Davis	Idaho Dept of Water Resources	Final
Illinois	Jennifer Sharpe	USGS - Illinois Water Science Center	Final
Iowa	Calvin Wolter	Iowa Dept. of Natural Resources	????
Kansas	Travis Rome	USDA/NRCS Kansas	Final
Louisiana		*Unknown*	Draft
Maryland	Frank Siano	Maryland Dept. of the Environment	????
Michigan	Everett Root	Michigan Center for Geographic Information	Final
Minnesota	LMIC - Susanne Maeder	Minnestoa Land Management Information Center	Draft
Montana	Gerry Daumiller	Montana Natural Resource Information System	Final
Nebraska			Final
New Hampshire	Jennifer Lingeman	New Hampshire Statewide GIS Clearinghouse	Final
New Jersey	Seth Hackman	New Jersey Deps. of Environmental Protection	Final
New York	Cheryl Rose	New York Dept. of Environmental Conservation	Final
North Carolina	Joe Sewash	NC Center for Geographic Information & Analysis	Draft
Oklahoma		OK Water Resources Board	Final
Oregon	Bill Kaiser, Dan Wickwire	USFS - Oregon, BLM - Oregon	Final
Pennsylvania	John Griffin	PA Dept. of Environmental Protection	Final
Texas	Miguel Pavon	Texas Natural Resources Information System	Draft
Utah	AGRC - Cindy Clark	Utah Automated Geographic Reference Center	Draft
Vermont	VCGI - Mike Brouillette	Vermont Center for Geographic Information	Final
Washington	Dan Wickwire	BLM - Washington	Final

APPENDIX B – West Virginia NHD Users

Name	Agency	Email	Phone
Kurt Donaldson	West Virginia GIS Technical Center	Kurt.Donaldson@mail.wvu.edu	
Evan Fedorko	West Virginia GIS Technical Center	Evan.Fedorko@mail.wvu.edu	
Greg Elmes	West Virginia GIS Technical Center	gelmes@wvu.edu	
Kevin Kuhn	West Virginia GIS Technical Center	kevin.kuhn@mail.wvu.edu	
Jackie Strager	Natural Resource Analysis Center	JMStrager@mail.wvu.edu	(304) 293-4832 Ext:4455
Jerry Fletcher	Natural Resource Analysis Center	Jerry.Fletcher@mail.wvu.edu	
Mike Strager	Natural Resource Analysis Center	Michael.Strager@mail.wvu.edu	(304) 293-4832 Ext:4453
Tony Simental	West Virginia Office of GIS Coordination	Tony.A.Simental@wv.gov	
Paul Kinder	Canaan Valley Institute	paul.kinder@canaanvi.org	
Jannette Bennet	Canaan Valley Institute	janette.bennett@canaanvi.org	
Jane McColloch	West Virginia Geologic and Economic Survey	janemc@geosrv.wvnet.edu	(304) 594-2331
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Mike Shank	West Virginia Department of Environmental Protection	mshank@wvdep.org	(304) 926-0499
Marc Barraclough	West Virginia Department of Environmental Protection	mbarraclough@wvdep.org	
Doug Brown	West Virginia Department of Environmental Protection	dbrown@wvdep.org	(304) 926-0499
Michael Dougherty	West Virginia Division of Natural Resources	michaeldougherty@wvdnr.gov	(304) 637-0245
Jeff Gula	WVDOT - West Virginia Department of Highways	jgula@dot.state.wv.us	(304) 558-0601
Matt Blackwood	West Virginia Department of Agriculture	mblackwood@ag.state.wv.us	(304) 558-2212
Johnathan Feng	West Virginia Department of Health and Human Resources	jfeng@wvdhhr.org	(304) 558-6764
Tom Galya	Office of Surface Mining	tgalya@osmre.gov	(304) 347-7162 Ext:3047
Katherine Paybins	United States Geological Survey	kpaybins@usgs.gov	(304) 347-5130 Ext:236
Craig Neidig	USGS Liason for West Virginia	cneidig@usgs.gov	(304) 558-4218
George Heleine	United States Geological Survey	gheleine@usgs.gov	(573) 308-2652
Mike Owen	U.S. Forest Service - Monongahela National Forest	mdowen@fs.fed.us	
Sam Lammie	U.S. Forest Service - Monongahela National Forest	slammie@fs.fed.us	(304) 636-1800 Ext:207
Tim Prescott	Natural Resources Conservation Service	Timothy.Prescott@wv.usda.gov	(304) 284-7590
Debbie Chase	Natural Resources Conservation Service	Debbie.chase@wv.usda.gov	(304) 284-7568
Don Evans	Environmental Protection Agency, Region III	evans.don@epa.gov	(215) 814-5370
Tommy Dewald	Environmental Protection Agency, Office of Water	dewald.tommy@epa.gov	(202) 566-1178

Jon Ludwig	Tetratech, Charleston Office	jon.ludwig@tetratech-ffx.com	
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Jennings Starcher	WV Health Care Authority	jstarcher@hcawv.org	(304) 558-7000
Chris Clark	WV Health Care Authority	cclark@hcawv.org	(304) 558-7000
Paul F. Ziemkiewicz	West Virginia Water Research Institute	pziemkie@wvu.edu	(304) 293-2867 Ext:5441
Allison Jones	The Nature Conservancy	allison_jones@tnc.org	(304) 637-0160
Andrew Gould	Michael Baker	agould@mbakercorp.com	
Larry Butler	Greenbrier County Assessor	lbutler4@assessor.state.wv.us	(304) 647-6645
Connie Ervin	Preston County Assessor's Office	crervin@assessor.state.wv.us	(304) 329-1220
Terry Funk	Preston County Assessor's Office	tlfunk@assessor.state.wv.us	(304) 329-1220
Tony Simental	WV Tax Department	jsimental@tax.state.wv.us	
Mike Strogen		mstrogen@assessor.state.wv.us	
Robert Shaffer	Wood County Assessor		(304) 424-1818
Steve Valentine	Wood County Assessor	-	(304) 424-1818
Joshua Snyder	Assessor		
Stacy Denovchik	State Historic Preservation Office		

APPENDIX C - References

Horizon Systems, 2007. NHDPlus Home. http://www.horizon-systems.com/nhdplus/ (Accessed October 31, 2007).

USGS (U.S. Geological Survey). 2007. National Hydrography Dataset. http://nhd.usgs.gov/index.html (accessed October 31, 2007).

APPENDIX D.

Criteria used in collection of stream and waterbody features from SAMB 2003 aerial photography. (Source: BAE Systems SAMB Project documentation)

- This feature shall represent all bodies of water such as lakes, reservoirs, ponds, rivers, streams, etc.
- Each category of feature shall have its own unique feature type
- Streams and Rivers as 3D *lines*. Only streams with visible water shall be collected. Streams shall be single line up to 10 feet wide for 100 scale, or 50 feet wide for 400 scale. Double lines, representing left and right bank, shall be collected where those dimensions are exceeded.
- Lakes and Ponds as *polygons*. Lakes and ponds shall not be differentiated. Only lakes and ponds with visible water shall be collected. The minimum dimension shall be 100 feet in length or width.
- Swamps and Marshes as *polygons*. Swamps and marshes shall be considered the same feature class and shall not be differentiated. Only clearly identifiable swamps and marshes shall be collected. The minimum dimension for collection is 1000 feet in length or width.
- Intermittent features (water not present at time of photo) shall not be collected.
- No flow direction will be required, but consistent digitizing in one direction is preferred.
- No hydrographic feature names or reach codes shall be required.
- Lines shall have single coordinate triplets where they meet and shall not have undershoots or overshoots where the lines come together.
- All hydrographic features shall be collected at the visible land-water interface.
- Edge matching within and between production blocks shall be required.
- Hydrographic features in the DTM, when overlaid on the final orthophoto, shall appear within 3 pixels of the same feature on the orthophoto with 90% confidence.
- Hydro lines shall be continuous but not edited for topological integrity or connectivity. Lines shall be continuous when passing under bridges.

APPENDIX E. Results of 2008 NHD User Survey

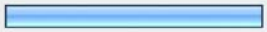
1. Spatial data users in West Virginia who are interested in streams have many options. Of the following datasets, which are utilized by your agency? Please check all that apply.

	Never Use	Sometimes Use	Frequently Use	Rating Average	Response Count
1:100,000 EPA River Reach 3	**61.1% (11)**	27.8% (5)	11.1% (2)	0.50	18
1:100,000 NHD (Medium Resolution)	35.3% (6)	**64.7% (11)**	0.0% (0)	0.65	17
1:24,000 NHD (High Resolution, completed in 2002)	0.0% (0)	33.3% (6)	**66.7% (12)**	1.67	18
1:24,000 DLG Hydro Lines	**50.0% (9)**	38.9% (7)	11.1% (2)	0.61	18
1:4,800 SAMB Hydrography Lines (completed in 2003)	11.1% (2)	33.3% (6)	**55.6% (10)**	1.44	18
Commercial Dataset, Other (Describe Below)	**90.0% (9)**	10.0% (1)	0.0% (0)	0.10	10
			Other (please specify)		1
			answered question		**18**
			skipped question		**1**

2. What are the different uses of the stream/surface water GIS datasets for you or your agency? Please check all that apply.

	Never Use	Sometimes Use	Frequently Use	Rating Average	Response Count
Cartography/Map Making	11.1% (2)	11.1% (2)	**77.8% (14)**	1.67	18
Linear referencing of datasets to on stream locations	31.3% (5)	**56.3% (9)**	12.5% (2)	0.81	16
Flow/network modeling functions	23.5% (4)	**64.7% (11)**	11.8% (2)	0.88	17
Cross referencing data between stream datasets (e.g. referencing EPA River Reach to NHD)	**52.9% (9)**	35.3% (6)	11.8% (2)	0.59	17
Public Health/Water Quality Monitoring	**43.8% (7)**	31.3% (5)	25.0% (4)	0.81	16
Recreation	**43.8% (7)**	**43.8% (7)**	12.5% (2)	0.69	16
Hazard Preparation and Emergency Response	**56.3% (9)**	18.8% (3)	25.0% (4)	0.69	16
			Other (please specify)		3
			answered question		**18**
			skipped question		**1**

3. In your work, have you utilized any of the advanced features of the 1:24,000-scale (High Resolution) NHD such as flow direction or addressing (linear referencing) of features? If so, please briefly describe in the comments section.

		Response Percent	Response Count
Yes		44.4%	8
No		**55.6%**	10
		Comments	6
		answered question	**18**
		skipped question	**1**

4. Have you or your agency edited the 1:24,000-scale NHD to meet your needs?

	Response Percent	Response Count
Yes	**66.7%**	12
No	33.3%	6
answered question		**18**
skipped question		**1**

5. Does your agency inventory and/or collect new or updated stream geometry (e.g., higher resolution stream lines, new drainage from physically altered landscapes such as mines) or attributes (e.g. alternative names)?

	Response Percent	Response Count
Yes	47.4%	9
No	**52.6%**	10
answered question		**19**
skipped question		**0**

6. What is the geographic extent of that information? Please expand upon your answer in the comment field.

	Response Percent	Response Count
Local (e.g., a city or town)	11.1%	1
County	11.1%	1
Regional or Watershed-wide (many counties or a large watershed, e.g. The Little Kanawha River)	22.2%	2
Statewide	**55.6%**	5
Comments		3
answered question		**9**
skipped question		**10**

7. How is that information being stored? Please mark all that apply.			
		Response Percent	Response Count
Tabular format (e.g. Microsoft Excel)		12.5%	1
Shapefile		**100.0%**	8
Geodatabase		62.5%	5
	Other (please specify)		2
	answered question		**8**
	skipped question		**11**

8. Do you believe that West Virginia should establish a stewardship program in order to edit, update and maintain the 1:24,000-scale (high resolution) NHD? Please feel free to comment.			
		Response Percent	Response Count
Yes		**100.0%**	18
No		0.0%	0
Not Sure		0.0%	0
	Comments		4
	answered question		**18**
	skipped question		**1**

9. If a stewardship program for NHD data is established in West Virginia, what agency do you believe would be best suited to act as the principal steward? You may select from the drop down list and/or comment in the "other" field.

	Response Percent	Response Count
WV Department of Environmental Protection (DEP)	**41.2%**	7
WV Division of Natural Resources (DNR)	5.9%	1
WV Department of Health and Human Resources (DHHR)	0.0%	0
WV Office of GIS Coordination	11.8%	2
WV GIS Technical Center	17.6%	3
Canaan Valley Institute, Trout Unlimited or other NGO	0.0%	0
Other, or Shared Stewardship (Please describe below)	23.5%	4
Other (please specify)		7
answered question		**17**
skipped question		**2**

10. If a stewardship program for NHD data is established in West Virginia, would you or your agency be interested in contributing to the effort to update and maintain the NHD? If you'r answer is yes, how might you be able to contribute (data, funding, field checking, GIS or DB expertise)? Please provide a few details and/or examples in the comments section.

	Response Percent	Response Count
Yes	**66.7%**	12
No	11.1%	2
Not Sure	22.2%	4
Comments		9
answered question		**18**
skipped question		**1**

11. Please tell us a little about the agency or entity you represent.			
		Response Percent	Response Count
Federal		33.3%	6
State		**55.6%**	10
County		5.6%	1
Local/Municipal		0.0%	0
Non-Profit/NGO		5.6%	1
	answered question		**18**
	skipped question		**1**

Appendix F. Web Editing/Data Collection Tool development

Power Point format presentations from Texas and Alabama given at the 2009 NHD Stewardship conference on the development of their respective tools are available from the USGS.

Texas
Contact: Daniel Pearson
Links: http://www.crgsc.org/Training/Archives/etgc2009/docs/EastTexasNHD_final.pdf; http://water.tnris.org; http://www.tnris.org

Alabama
Contact: Philip Henderson
Links: http://www.adeca.alabama.gov/Office%20of%20Water%20Resources/default.aspx

Vermont
Contact: Mike Brouillette
Links: http://www.vcgi.org/; http://maps.vcgi.org/swamt/