Hydrography Event Management Tools- New Features and EPA Add-ons
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Abstract
The Hydrography Event Management (HEM) tools, developed collaboratively by the U.S. Bureau of Land Management (BLM), U.S. Geological Survey (USGS), and the Environmental Protection Agency (EPA), are ArcGIS tools that can be used to create National Hydrography Dataset (NHD) events for state, federal, and private agencies. Hydrography events link water-related attribute information from a database with NHD surface water features. The EPA collaborated with the BLM and U.S. Geological Survey (USGS) to further enhance the HEM Tools with supplemental georeferencing functions, which are available through the EPA Add-On toolbar. Many of the functions from the EPA’s ArcView 3.x-based PC-Reach Indexing Tools (PC-RIT) are included in the Add-ons. An overview of the functions in the newest version of the HEM tools will be presented in addition to functions specific to the EPA Add-ons toolbar.

Introduction and Background
The National Hydrography Dataset (NHD) is a hydrographic database that interconnects and uniquely identifies the stream segments or reaches that comprise the Nation’s surface water drainage system. The NHDPlus is an enhanced version of the NHD that includes enhanced networking and hydrologic value added attributes. The current NHDPlus release is based upon USGS 1:100,000-scale hydrography data and serves as a national framework for geographically referencing (georeferencing or reach indexing) water quality-related information that can then be used in a Geographic Information System (GIS) to analyze upstream/downstream relationships and portray these data with other GIS data layers. The attribute that provides the link between georeferenced features and the NHD is the reach code. The reach code is a unique identifier for each stream segment. Once waterbodies have been linked to NHD/NHDPlus, water quality attribute data associated with these waterbodies can also be georeferenced and then geographically analyzed and mapped to better support decision-making and public communications.

Until approximately 15 years ago, the availability of spatial tools that allowed for water-related information to be linked to detailed hydrography layers was limited (Spoerri, et. al, 2000). As a result, many of the impaired waters in the United States had never been mapped (Cooter et. al, 2000). There are many kinds of surface water data that are suitable for mapping to a GIS hydrography feature class. One method for associating and linking attributes with an existing coverage is to create additional fields in the feature class attribute table and populate those fields with the desired values. Unfortunately, the problem with this methodology is that modifying the NHD attribute tables destroys the integrity of the nationally consistent NHD. If many programs modify the NHD attribute tables in different ways, these data become difficult to compile and analyze. Also, if the spatial structure of NHD is modified by an individual user, the function of the NHD reach codes as unique location data for individual reaches is destroyed. Therefore, it is undesirable to modify the underlying structure of NHD.
The Hydrography Event Management (HEM) tools are a set of ArcGIS tools that can be used to address the problems described above. The HEM tools allow users to georeference surface water information using nationally consistent data, the National Hydrography Dataset (NHD), by creating events that link water-related information to the underlying NHD surface water features. Events are related to spatial database components (NHD reach codes) without editing the spatial objects themselves. Multiple federal agencies, including the Bureau of Land Management, the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and U.S. Forest Service worked together to design and develop these tools. The HEM tool is implemented using the latest ArcGIS 10 technology (a 9.3.1 version is also available) providing users with a stable, responsive platform to support their indexing needs. The HEM tool works with NHDinGEO formats and operates on the NHDFlowline feature class (with a built network) when creating and modifying events.

Five kinds of georeferenced layers can be created and manipulated with the HEM tools:

- **Point event layers**, which are georeferenced to the NHDFlowline feature class.
- **Point on NHDPoint events layers**, which are georeferenced to the NHDPoint feature class.
- **Single Route Linear event layers**, which are georeferenced to the NHDFlowline feature class.
- **Multi-Route Linear event layers**, which contain one-dimensional information that can be located along a portion of multiple NHDFlowline features.
- **Waterbody (area) layers**, which are created using the NHDWaterbody feature class.

Building on EPA’s experience working with NHD events, the agency developed a supplemental set of indexing functions for the HEM tools in order to assist state environmental agencies in georeferencing their water related information. EPA’s Reach Address Database (RAD) stores this information. Features in the RAD can be linked to other databases that contain associated attribute information. The HEM EPA Add-on tools are available through the HEM EPA Add-On toolbar, shown in Figure 1.

![Figure 1. Hydrography Event Management’s EPA Add-on Tools toolbar](image)

**Georeferencing Water Quality Data to the NHD**

Each record in the HEM event table displays as an “event”. A unique identifier is stored for each surface water entity, or event, that can be linked to an outside database that contains detailed information about the entity. The use of events allows users to index multiple entities to the same NHD reach or set of reaches. The tools allow the user to index an entity to a portion of a reach without having to modify the spatial extent of the reach itself. Attributes of a feature can be displayed by simply specifying the start and end points of the feature along an NHD flowline. The start and end points of these dynamic segments are stored in the “F_meas” (From measure) and “T_meas” (To measure) fields in the HEM event table.
Linear events are displayed as linear features along the reach. Point event features have a single measured position (P_meas) instead of a “To” and “From” measurement and are displayed as a single point on a reach. The features in NHD (polygons) that represent lakes and reservoirs are referred to as “waterbodies” in NHD. The table structure for the waterbody events is similar to those for linear and point events, but there are no measure fields. In this case, the NHD waterbody reach is referenced.

The HEM EPA Add-on Tools also allow for the creation of custom point, line, and area events. Custom events are used to represent features that are not on the NHD. An example of this could be coastal polygons that represent beaches or shellfish areas. Custom events are contained in HEM event tables with regular NHD-based HEM events. The custom events tool will create custom events with Source Feature IDs and with corresponding metadata. Custom events, however, do not have reach codes or “from” and “to” measure values.

The HEM tools automate the process of creating NHD event tables and georeferencing surface water entities. The event tables created by the HEM tools provide four fields to store attribute data entered by the user: Source Feature ID, Source Data Description, Source Originator, and Event Type. Source Feature ID is the unique identifier that links the event to an outside database. Source Data Description can be used to store a non-unique descriptor about the surface waters, such as habitat type or substrate. Source Originator can be used to identify the agency that is the source of the information. Event Type can be used to identify the EPA program that the events are associated with.

Hydrography Event Management (HEM) Tools New Features as of FY2011.

The HEM tools are continually being improved to meet the needs of the user community. In the last fiscal year the BLM, USGS, and USEPA have enhanced and added functionality to the HEM tools. The HEM tools are modeled after the NHD, thus the current version of the HEM tools support NHD Model 2.0. Prior versions of the HEM Tool remain available, as well as tools to update existing HEM events to the current version. Users can also now create multi-part polygons. The fifth event feature type (Point on NHDPoint) was also added, which allows users to reference point events to NHD Points that are not necessarily on the NHD network. In addition, improvements have been made to the candidate form, the Source Feature ID interface, and the Import to Events and Import to Events QC tools.

Additional new functionality includes a stand-alone tool to convert any point feature into network flags in order to do network analysis. For example, this tool can be used to monitor the effects of dam removal or additions. It can also be used to model the spread upstream/downstream of invasive species using the network flags/barriers as locations where the distribution would be impeded. These are just a few examples of the modeling operations that can be done utilizing the NHD and these enhanced HEM tools.

There is also a new tool to allow editing of NHD event feature classes. These tools are for events that will be submitted for load back to the NHD. The first tool is a "To HEM" button on the ArcCatalog HEM Toolbar. This tool prepares the NHD geodatabase for HEM editing by adding the required HEM event
feature classes and tables. Once this step is completed, the NHD geodatabase is ready for editing and event edits can be performed in ArcMap using the same process as editing other HEM events. Once editing is complete, the editor saves edits and returns to ArcCatalog. The last step is to use the HEM ArcCatalog “To NHD” button to apply the HEM edits to the NHD workspace. All edits are tracked in the NHDStatus table and coded according to NHD 2.0 guidelines. This data is then ready for XML extract and load in accordance with NHD guidelines.

Currently, the HEM tools are in further development for the 2.5 version which will be released for fiscal year 2012. These improvements include batch synchronization, import, and Quality Control (QC). New functionalities will include batch Go X Distance, Source Feature ID length change to 100 characters, new candidate form options, creating events only on selected flowlines, and new batch synchronization options. In addition, web editing is currently undergoing requirements gathering and testing. In the future, the HEM tools will continue to be improved as the needs of the user community change.

Hydrography Event Management (HEM) EPA Add-on Tools Functionalities

The Hydrography Event Management’s EPA Add-on Tools are a collection of ArcGIS tools that are designed to assist users in georeferencing state and EPA program data to the NHD. Several of EPA’s programs require states to report data yearly or every two years. The data is often accompanied by geospatial representations of the information that gets reported. The availability of tools that can aid in the creation of such data is beneficial. The use of these tools generates nationally consistent datasets, thereby reducing the diversity in state data submissions. Examples of EPA program data that can be used with the HEM EPA Add-on Tools include Clean Water Act Section 303(d) Listed Impaired Waters, Clean Water Act Section 305(b) Assessed Waters, Beaches, and Fish Consumption Advisories. The HEM Tools and EPA Add-ons can create two types of events:

- Event and waterbody layers georeferenced to NHD/NHDPlus and,
- Custom events, which represent features that are not represented in NHD/NHDPlus

The Hydrography Event Management EPA Add-on Tools toolbar currently contains the following tools:

Create Custom Events

Custom events are used to represent features not on the NHD. They can be created for features that are not included in the resolution of the NHD you are using, such as ephemeral ponds or intermittent streams. The Create Custom Events button on the HEM EPA Add-ons toolbar is used to create non-NHD point, line, and area features and adds them to the HEM event tables with regular NHD-based HEM events. Custom events cannot be split or updated because they do not have defined routes, but they can be deleted using the HEM Delete Event function.

Import Features from Existing Feature Class into HEM Event Table

This import tool allows a user to convert features from an existing feature class or shapefile into HEM event tables. The feature class or shapefile can have any geometry type; point, line, or area. The functionality is similar to the HEM’s Import to Events tool, but this tool is different because it also imports features that are not on the NHD. There are two methods by which existing features can be
imported into HEM event tables. The user has the ability to import all features in an existing feature class at one time, or the user can select a subset of the features and only import those. The user can also choose to import an ID from a field contained in the existing feature dataset. These IDs will get transferred to the Source Feature ID field in the HEM event table. The spatial extents are the same as they are in the source file. Therefore, no QC component is needed since the process does not involve moving or changing a feature to get it georeferenced to the NHD.

**Extract from Program Events**
Clean Water Act data are reported on a 2 year cycle. In most states, the majority of the assessment units do not change from cycle to cycle. Rather than creating the same events over again, events that were created during previous years can be extracted. The Extract from EPA Program Events tool extracts the geospatial extents and Source Feature IDs from existing HEM events and transfers this information to new HEM event tables. This tool can also be used to extract events from one EPA program, such as the 305(b) assessed waters, to create events for another program, like 303(d) impaired waters. It can also be used to link assessment unit IDs from a previous cycle with IDs in a newer cycle.

**Find Overlapping Waterbodies and Repair Overlaps**
There are many ways to create “duplicate” or “overlapping” events with the HEM tool. This problem can be difficult to detect, since only one of the overlapping events is visible. Overlapping events can result in erroneous water body sizes, which is significant for EPA Program data because sizes are used in funding allotment formulas and in reporting impaired assessment units. Overlapping water bodies are defined as events created on the same reachcode with intersecting spatial extents. The Find Overlapping Waterbodies tool will identify area events that occupy the same spatial extent on an NHD Waterbody feature. Overlapping Waterbodies can be corrected by using the Repair Overlaps tool, which generates a list and allows the user to remove or modify the overlapping features.

**Border Snap**
States can potentially run into obstacles moving upstream/downstream into the waters of other states so the border snap tool is used to make sure that point, line, and area events do not cross over into adjacent states. The Border Snap tool requires a state shapefile that includes a two letter abbreviation for the state in one of the attribute fields. Linear, area, and custom linear and custom area events are clipped at the state boundary and if there are any events that are entirely outside of the state, those are deleted completely. Points and custom points that are outside of the state are also removed. From and To Measure values in linear event tables and the shapes in area event tables are updated accordingly.

**Summarize Source Feature IDs**
The Summarize Source Feature IDs tool is a QC tool that allows you to generate a list of the IDs that have been indexed. This list can then be compared to a list of IDs from outside databases, such as assessment unit IDs in the National Assessment Database, to ensure that all events that should have been created were in fact created. The tool creates a .dbf output file that contains every source feature ID in the event tables, as well as the 8-digit HUC that each event is a part of, and the file name of the event table that each event is in.
QC Comparison
The QC Comparison tool is used to ensure the integrity of the QC Process by comparing the extent of events created by one person to the extent of the same events created by a quality control tester. This verifies that no obvious errors have occurred and reinforces strict quality control procedures through the georeferencing process.

Conclusions
The National Hydrography Dataset provides a framework that allows for the assigning of water-related attributes to a single, nationally consistent data layer. The Hydrography Event Management Tools and EPA Add-ons are interactive GIS applications that can be used to georeference and link this information to the NHD. The use of spatial tools that work with a nationally consistent dataset, such as the NHD, is beneficial to states and federal agencies because disparate information about the waters within particular jurisdictions can be compiled and decisions can more easily be made regarding the protection of surface waters.

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References


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