

**UNITED STATES NATIONAL FOUNDATION GEOSPATIAL DATA MAINTAINED BY THE  
U.S. GEOLOGICAL SURVEY AS PART OF THE NATIONAL MAP**

CRAUN K.

*U.S. Geological Survey, ROLLA, UNITED STATES*

**ABSTRACT**

The U.S. Geological Survey (USGS) maintains national coverage of geospatial data in eight data themes or layers for the United States. These data themes include: digital ortho imagery, terrestrial elevation, earth cover, hydrography, transportation, structures, governmental units, and geographic names. The content of these data themes initially was described in "*The National Map: Topographic Mapping for the 21st Century*," published by the USGS in 2001 (U.S. Geological Survey, 2001). Since that report was written, the USGS has completed national coverage\* for all of these data layers; currently (2011) work is being done with partners in the public, private, and academic sectors to upgrade and update the information. These data generally are available in the public domain, although there are some limited cases where licensed data obtained from private sector sources are incorporated as part of the national coverage. The USGS is the A-16 lead agency, as defined in OMB Circular A-16 (United States Office of Management and Budget, 2002) for stewardship and coordination of 5 of the 8 data themes defined as part of *The National Map*.

*The National Map* data may be categorized according to either raster or vector data type. Raster data include digital ortho imagery, terrestrial elevation data, and earth cover. The digital ortho imagery consists of the best publicly-available imagery at horizontal ground resolutions ranging from 7.5 cm (centimeters) to 1 m (meter). The terrestrial elevation data available as part of *The National Map* are included in a multiresolution database called the "National Elevation Dataset." Data are stored at 1/9 and 1/3-arc second where available and at 1-arc second horizontal resolution for the conterminous United States, Hawaii, Puerto Rico, and the island territories. Earth cover data are included in the National Land Cover Dataset (NLCD), a 30 m horizontal resolution dataset, containing 21 classes of land-cover data and per pixel estimates of surface imperviousness and tree canopy.

Vector datasets include the National Hydrography Dataset (NHD), a networked, surface water feature dataset completed nationally at a level of detail equivalent to a 1:24,000-scale cartographic product. The NHD is actively maintained by a group of authoritative data stewards at the state level who provide updates and improvements to the USGS to be incorporated into the national dataset. The NHD is by far the most mature vector data layer in *The National Map*. Other vector data under development at the national level include: structures information, including the location and characteristics of manmade facilities; transportation features, including roads, airports, railroads, and other features associated with transport; and governmental units (boundaries) data, including state and county boundaries provided by the U.S. Census Bureau. All of these other vector data layers are being developed and stored in national level databases, although the USGS is the A-16 lead agency for only the NHD and not the other vector data layers. Finally, the USGS is the A-16 lead agency responsible for maintaining and providing access to authoritative geographic names in support of the United States Board on Geographic Names. Historically, this information has been housed in a separate database as part of the Geographic Names Information System. This year, the USGS is integrating geographic names information with other vector data into a combined gazetteer/vector database to provide better spatial information associated with feature names and to make maintenance of this information more efficient.

Data included in *The National Map* are an extremely valuable national geospatial data asset. This paper describes each of these data layers, including the current data model, upgrade and maintenance strategy, major partners, licensing status, and a description of on-line access to the data. A focus is placed on those data for which USGS is the A-16 lead agency, including terrestrial elevation data, digital ortho imagery, earth cover, hydrography, and geographic names.

\*Data in Alaska generally are developed at a lower resolution than in other parts of the United States.

**INTRODUCTION**

The National Geospatial Program within the USGS provides national base geospatial data assets for the United States. Although this information has been in development through the USGS mapping program for more than 100 years, it was first described in the USGS report defining *The National Map* (U.S. Geological Survey, 2001) as a, "...composite of continuously maintained basic spatial data for the United

States and its territories and will serve as the Nation's topographic map for the 21st century...". Ideal characteristics described in the vision for The National Map data include:

1. Composed of eight thematic layers, including high resolution digital ortho imagery; high resolution terrestrial elevation data; vector feature data for hydrography, transportation (especially roads, but also including railroads and waterways), structures, boundaries of governmental units, and administrative boundaries of publicly owned lands themes; geographic names; and land cover information;
2. Currentness based on cyclical inspection and revision;
3. Seamlessness such that features across the nation will be represented in their entirety;
4. Consistent classification of features across the Nation;
5. Variable resolution dependent on the features on the landscape and the best available data for an area of coverage;
6. Completeness, including all mappable features;
7. Consistency and integration such that relative positions of features on the ground are preserved;
8. Variable positional accuracy based on the source data for a feature or set of features;
9. Standardized spatial reference systems, content, and metadata based on documented, national standards; and
10. Temporal versions maintained so that datasets and features may be time-stamped and a history of change maintained. (U.S. Geological Survey, 2001)

Nearly 10 years after the publication of the USGS National Map report, *The National Map* data are being actively maintained and significant progress has been made toward meeting the goals defined in the target characteristics described above. These data layers are included and described as part of the "National Geospatial Data Asset Portfolio" defined by the U.S. Office of Management and Budget (OMB) in its supplemental guidance to OMB Circular A-16, issued on November 10, 2010 (Office of Management and Budget, 2010). It is significant to note that the data have been built through partnerships with other Federal, State, and local governments, as well as with significant contributions by the academic and private sectors. This paper describes the status of each of *The National Map* data layers and near term plans for improving this information. An emphasis is placed on the data themes for which the USGS has been designated the lead agency by the OMB through Circular A-16.

### **The National Map Data**

Descriptions of data that are part of *The National Map* will be subdivided in this section into two major categories according to either raster or vector data type. The rationale for this is because the data are fundamentally different in terms of how they are acquired, managed, and maintained is dependent, to a large degree, on the data model type.

### **RASTER DATA**

#### **Terrestrial Elevation Data**

The National Elevation Dataset (NED) (U.S. Geological Survey, 2006) contains the terrestrial elevation data that are part of *The National Map*. The NED is a multi-resolution, seamless, gridded elevation dataset that represents the earthen terrain. The data are stored in geographic coordinates and referenced to a consistent horizontal (NAD83) and vertical (NAVD88) datum. The grid spacing of data currently (2011) included in the NED are 1-arc second, 1/3-arc second, and 1/9-arc second (approximately 30, 10, and 3 meters at ground, respectively). Source data in the NED primarily were collected and processed to the standards defined in the USGS Digital Elevation Model Standards (U.S. Geological Survey, 2007). In the last few years, source data has been collected at higher resolutions using Light Detection and Ranging (LIDAR) technology. The USGS has issued a draft set of guidelines and base specification for acquisition of LIDAR data to guide private sector contractors and partners in the collection of this type of information (U.S. Geological Survey, 2010, March 1). Source elevation datasets, modified to remove vegetation and man-made structures, ultimately are merged into the seamless NED using processes described on the National Elevation Dataset Web page (<http://ned.usgs.gov/Ned/about.asp>).

Coverage of the 48 conterminous United States, Hawaii, Puerto Rico, and the island territories is complete at a resolution of 1-arc second. The horizontal resolution of the NED in Alaska is 2-arc seconds. The USGS is working to complete coverage in the conterminous United States at 1/3-arc second by the end of September, 2011. At the same time, higher resolution terrestrial (bare-earth) elevation data are being collected in large areas of the United States, mostly through the use of LIDAR technology. These new data are continuously added to the 1/9-arc second layer of the NED and the lower resolution layers are regenerated through interpolation of the new, higher resolution data. Areas of coverage in the

conterminous United States based on NED source data resolution as of January, 2011, are shown in figure 1.



*Figure 1. National Elevation Dataset (NED) Source Data Resolution in the Conterminous United States*

Future plans for terrestrial elevation data in *The National Map* include continuation of improvements to resolution, quality, and consistency of the NED. As higher resolution source data become available, they will be incorporated into the dataset. The USGS also is conducting an analysis of user requirements for terrestrial elevation data in the United States that may form the basis for a National Enhanced Elevation Program (NEEP). The NEEP would consider collection, storage, and maintenance requirements of not only bare-earth, gridded elevation data, but, also terrestrial elevation information for features above ground captured as part of the LIDAR point cloud. In addition, a seamless land-water interface or topographic/bathymetric surface has been studied and could form the basis for a future addition to the NED.

#### **Digital Ortho Imagery**

The USGS and its partners completed coverage of the conterminous United States with 1 meter ground-horizontal-resolution digital ortho imagery in the 1990's. The imagery was processed to quarter-quadrangle format (3.75 degrees latitude by 3.75 degrees longitude) and was acquired and processed in accordance with the USGS Standards for Digital Orthophotos (U.S. Geological Survey, 2007). Following the completion of this initial coverage, digital ortho imagery began to be collected in the United States in a wide variety of formats and spatial and spectral resolutions. Overall, the strategy of the USGS remains to continue to work with partners to increase the quality and currentness of digital ortho imagery across the nation.

Two specific programs that are strongly supported by the USGS are the Urban Area Imagery Partnership (UAIP), a high resolution program focused on the nation's urban areas, and the National Agricultural Imagery Program (NAIP), a program managed by the United States Department of Agriculture and focused on collection of imagery during the growing season (U.S. Department of Agriculture, 2010). The UAIP is being conducted in partnership with the National Geospatial Intelligence Agency (NGA), along with a large number of other Federal, State, and local government partners. The UAIP specifications are 0.3 m or better horizontal ground resolution, natural color, digital ortho imagery provided in a TIFF format with a world file (U.S. Geological Survey, 2010). A map of the urban areas is shown in figure 2.

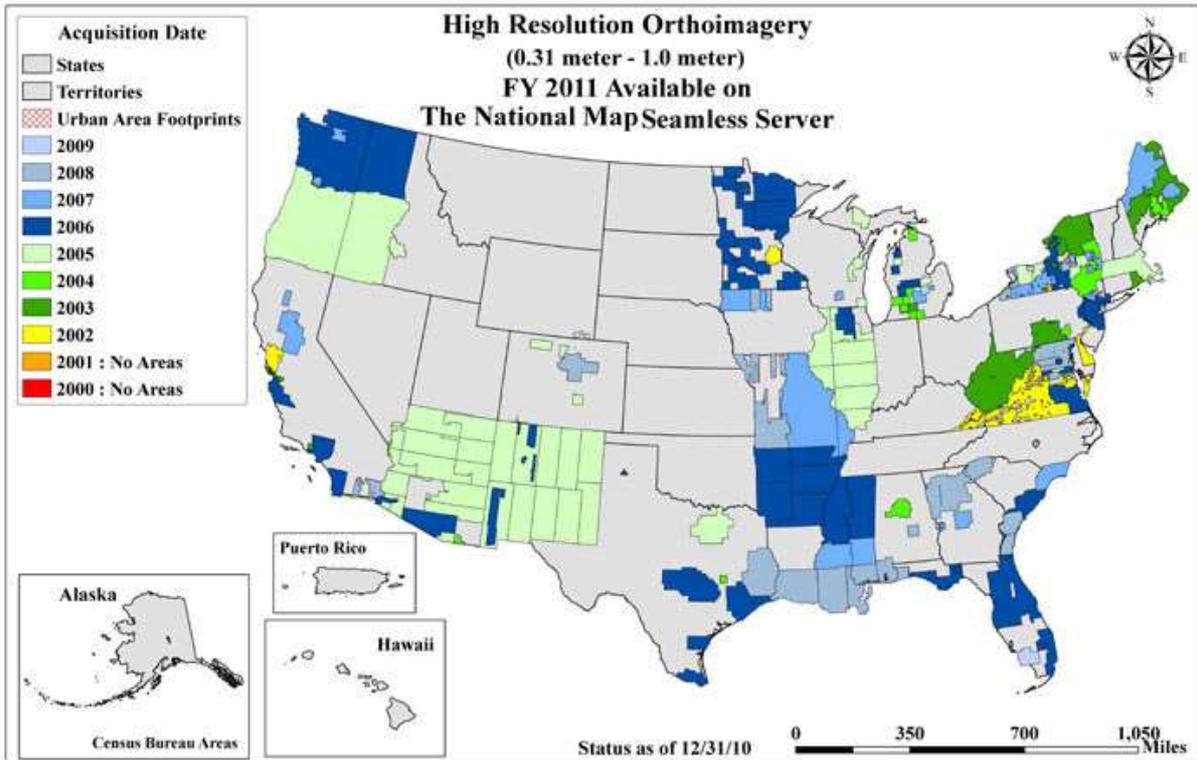


Figure 2. UAIP Image availability as of January, 2011

An example of typical imagery collected for the UAIP is shown in figure 3. It should be noted that many state and local (urban area) partners are collecting data at much higher resolutions than the minimum requirement of 0.3 m. Some local imagery is collected and available at 4- and 6-inch ground horizontal resolutions. The maintenance strategy for the UAIP is to attempt to repeat coverage of the most important areas every 3 years.



Figure 3. Sample of UAIP imagery in St. Louis, Missouri, USA

The NAIP is a 1-meter ground-horizontal-resolution digital ortho imagery program collected in the “leaf-on” season in either natural color or 4-band (RGB plus near infrared) mode. Although the program varies in terms of cyclical collection, the aim is to collect data for the 48 conterminous states on a 3-year cycle. Imagery is not collected under the NAIP program for Alaska or Hawaii. The USGS, along with a number of other Federal, State, and local government organizations share the cost of the NAIP imagery. As with the UAIP, these NAIP partners may “buy-up” e.g., pay the additional cost, to acquire the data at a higher horizontal ground resolution or to get additional spectral information (U.S. Department of Agriculture, 2010).

### **Earth Cover**

The National Land Cover Dataset (NLCD 1992) and the National Land Cover Database (NLCD 2001) are the earth cover data components of *The National Map*. As with other National Map datasets, NLCD is consistent across the United States. In the case of NLCD 1992, a consistent, hierarchical, 21-class land cover classification was applied across the United States to create the data. The primary data source was Landsat (5) Thematic Mapper imagery acquired in the mid-1990’s. The classification scheme is shown in figure 4.



Figure 4. NLCD 1992 Classification Scheme

The National Land Cover Database 2001 was developed in the 2000's as a comprehensive, consistent set of land cover information, packaged and delivered with important ancillary data, derived products, and accuracy and other metadata information. The concept behind the NLCD 2001 was to not only provide the classified land-cover information, but, also to provide other necessary data useful for application of the NLCD. The NLCD 2001 includes the following main components: independent DEM ancillary data layers of slope, aspect, elevation and topographic position; classified land-cover data derived from imagery and ancillary data using a decision tree; and independent per-pixel estimates of imperviousness and tree canopy derived from imagery and ancillary data using a regression tree (U.S. Geological Survey, 2010).

The USGS and its partners recently released (2011) a national database that provides land cover information updated to nominally 2006. The data were created using spectrally normalized Landsat images and NLCD 2001 data layers. The product is called NLCD 2006. USGS researchers also developed a "Retrofit NLCD 1992/2001 Land Cover Change Product." This product provides a consistent, accurate comparison between the 1992 and 2001 NLCD products. Because of classification differences between these products, the NLCD team determined this type of change product, developed by experts in both datasets, would be useful for those most interested in change detection.

## VECTOR DATA

### Hydrography

The National Hydrography Dataset (NHD) contains the surface water features that are part of *The National Map*. These features, such as streams, rivers, lakes, ponds, and canals, are part of a network containing information about water flow direction and "reach codes" or stream address information. Reach codes allow users to uniquely identify specific locations on the network and to link other information, such as water quality or fish population, to that location. NHD features also carry a rich set of attributes, allowing the user to do a detailed analysis of the surface water in an area and to map the information using a variety of symbology related to the variation in attributes. Complete U.S. coverage for the NHD has been completed at levels of detail equivalent to 1:100,000-scale and 1:24,000-scale cartographic products. In some areas, higher level detail information has been collected, equivalent to a 1:5,000-level cartographic product.

In 2011, the USGS and its partners are integrating the Watershed Boundary Dataset (WBD) into the NHD. Watershed boundaries delineate the areal extent of surface water drainage to a point in the network and are derived using specified hydrologic and topographic criteria. Documentation, including a data user's guide, interactive feature catalog, and a diagram of the NHD data model (version 2) are all provided online by the USGS (U.S. Geological Survey, 2011).

The catalog view of the NHD Geodatabase model is shown in figure 5.

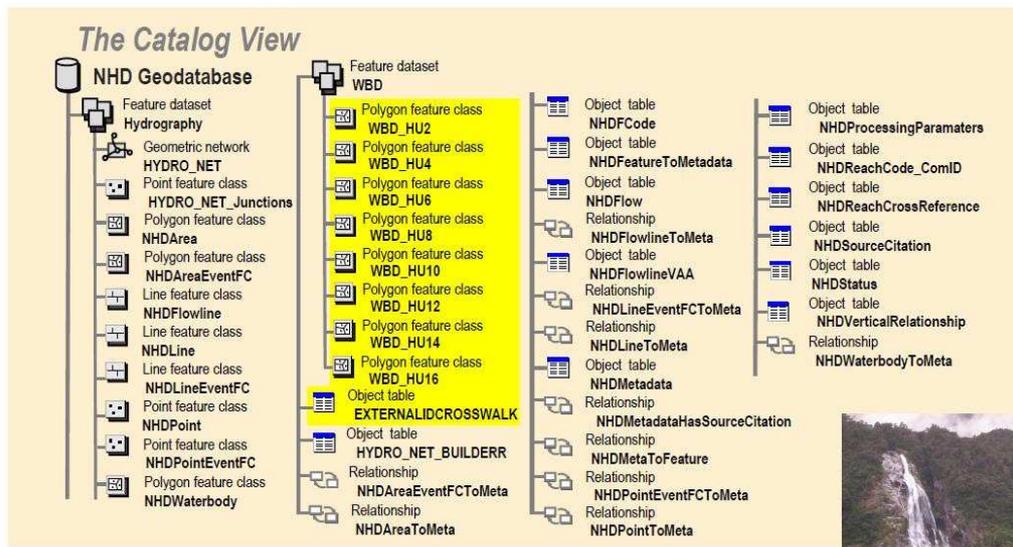


Figure 5. NHD Geodatabase model: Catalog View

A key aspect of the NHD maintenance strategy is the development of a nationally distributed network of NHD data stewards. These data stewards typically are located in state agencies whose missions are supported by the maintenance of the NHD. In other words, both the NHD data stewards and the USGS gain mutual benefit from the update and improvement of the dataset. As of February 2011, 35 states had signed agreements with the USGS to maintain the NHD. Stewards check out data from the NHD for their area of interest, update and add content to the data, then, return the data to USGS for quality assurance and incorporation into the national dataset. Note that all previous versions of NHD features are maintained by the USGS, so, it is possible to study changes through time for NHD features where they have been edited. To facilitate this process, the USGS maintains a suite of GIS-based tools for NHD stewards to edit and process the NHD data. Information about these tools is located at <http://nhd.usgs.gov/tools.html>.

Because of the structure of the NHD, including flow direction and reach codes, this information is incorporated as a primary data source for numerous GIS-based applications. One example is a GIS application called the “Massachusetts Sustainable-Yield Estimator (MA SYE) (Archfield and others, 2010). The MA SYE is used to determine the amount of water available for sustainable withdrawal. It is a decision support tool that allows community and natural resource managers to understand how much water is available in a watershed, and to make comparisons with a statewide water-use database to understand how much water is being used. Water resource managers can then estimate if water use is exceeding the supply, and either take mitigating action or be aware that other sources of water must be made available. This is just one of many examples of applications that use the location, flow, and attribute information contained in the NHD.

### **Geographic Names**

In support of the U.S. Board on Geographic Names, the USGS maintains the authoritative source data for geographic names used on Federal mapping products for physical and cultural features such as mountains, valleys, bays, populated places, hospitals, schools, churches, and cemeteries. The USGS data holdings include the Federally recognized name of each feature and define the feature location by state, county, USGS topographic map, and geographic coordinates. Other attributes include names or spellings other than the official name, feature designations, feature classification, historical and descriptive information, and for some categories the geometric boundaries.

A unique, permanent feature identifier, the Feature ID, is assigned to each geographic name and is the only standard Federal key for accessing, integrating, or reconciling feature data from multiple data sets. The names are data collected from a broad program of partnerships with Federal, state, and local government agencies and other authorized contributors. Users of this information range from all levels of government to the public and access the information through numerous applications including a Web query site, Web map and feature services, file download services, and customized files upon request.

In the past 2 years, the USGS has changed its database model for storing the geographic names information. Previously, this information was stored in a separate database (the Geographic Names

Information System (GNIS) database). Geographic locations associated with the names were single points. Now, the USGS is transitioning to a model in which the names information is stored as an attribute of a vector feature and the geographic location information for that name corresponds to its associated feature. This model should be transparent to users who still have access to the names information in gazetteer, as well as other, formats.

As with the NHD, the USGS relies on a distributed network of partners for providing updated geographic names information. There is also a set of processes in place which must be used in order to change an official name. These processes involve decision-making by State and Federal Boards on Geographic Names (Orth and Payne, 2003).

Transportation, Governmental Units, and Structures

Although the USGS is not the A-16 lead agency for the transportation, governmental units, and structures data themes, it does maintain some level of national coverage for these data themes. This information is structured according to the USGS, vector-based, Best Practices Data Model and is held in national level geodatabases by the USGS. An example of the Transportation Best Practices Data Model is shown in figure 6.

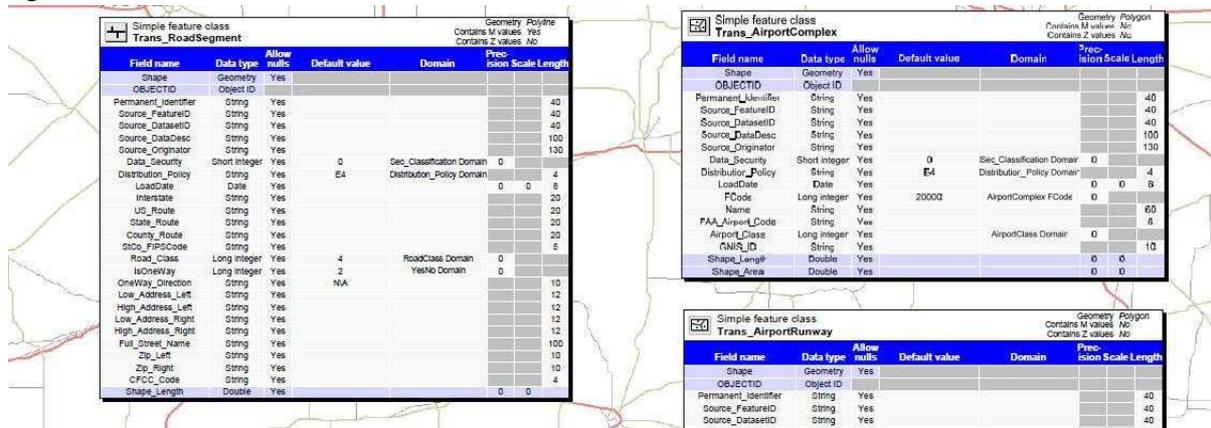


Figure 6. USGS Best Practices Transportation Data Model

For these three data themes, data are derived primarily from a number of authoritative sources, transformed into a consistent data model, and made accessible to the public by the USGS. Transportation data come from a variety of private and Federal sources, including the U.S. Census Bureau, the U.S. Forest Service, and private sector vendors. Governmental data come from the U.S. Census Bureau, international boundary commissions, U.S. Forest Service, and soon from other Federal authorities. The structures database initially was populated with data from the Federal Emergency Management Agency (FEMA)'s Hazus dataset. That information gradually is being replaced by data from other Federal and state sources. The USGS also is beginning a pilot project to incorporate volunteer-provided information about high priority structures, such as schools, hospitals, and police stations.

Access to The National Map data

There are multiple ways to access data that are part of *The National Map*. Two of the primary access points provided by USGS are through *The National Map* viewer at <http://viewer.nationalmap.gov/viewer/> or through the seamless data server at <http://seamless.usgs.gov/>. Data available through the seamless data server include the most current digital ortho imagery, terrestrial elevation data (NED) and earth cover. The USGS also provides access to data through Web map and feature services; at this point, the Web map services are by far the most mature. For a list of available services, reference the seamless data server web site listed earlier or right click on the data layer in the layer list on *The National Map* viewer Web site. The USGS is working to improve its services, to include feature and coverage services that would allow users to incorporate these data easily into their own Web applications. It should be noted that *The National Map* data can be seen in a large number of other government and commercial applications including Google Maps and ESRI's base map services.

**SUMMARY**

The USGS is making excellent progress toward meeting the goals outlined in the 2001 document defining the vision for *The National Map*. For the data themes for which the USGS is the A-16 lead agency, national coverage exists, at a minimum, at a level of detail equivalent to a 1:24,000-scale cartographic product. Near term plans (2012) for USGS include moving to a more defined 3-year cycle of

update for *The National Map* data. The success of these plans largely will be dependent on sustainable resource (funding, people) availability for the USGS and its primary partners.

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