# Coverage Assessment
## Using Census 2000 TIGER Roads

*By Mike Price, Entrada/San Juan, Inc.,*
*and John Price, Bellingham Technical College*

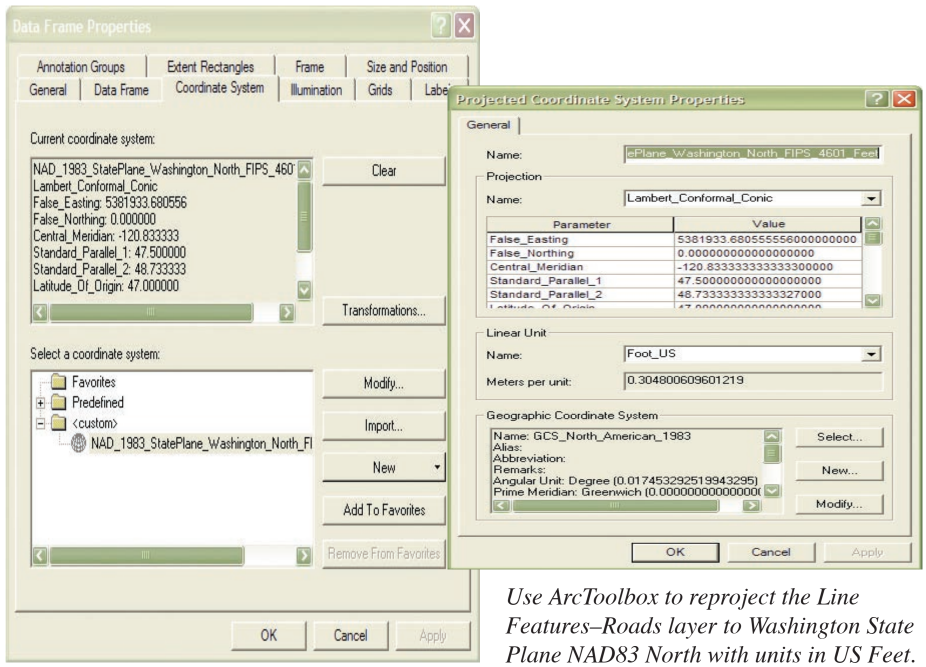
In the fast-paced world of public safety and emergency management, time is truly of the essence. Emergency service providers respond to structural fires, vehicle accidents, and medical emergency calls as quickly and safely as possible. To do this, they strive to obtain the highest quality, most current, and complete street network data possible.

The National Fire Protection Association (NFPA) has authored several standards for time- and action-based assessment for emergency responders. NFPA Standard 1710 introduces minimum fire company and emergency medical services (EMS) staffing levels and sets minimum time criteria for emergency response by career departments (i.e., as opposed to volunteer departments). NFPA 1720 also defines the minimum volunteer personnel levels necessary before initiating fire suppression activities and establishes time-based action levels on the fire scene. These standards stress safe, timely arrival on the scene by emergency responders.

This exercise teaches a skilled ArcGIS user to build a public safety coverage response assessment map for Whatcom County, Washington. The distance/speed/time-based transportation network will be constructed from widely available Census 2000 TIGER data and enhanced with locally generated data. Civil engineering and surveying students at Bellingham Technical College, Bellingham, Washington, obtained high-quality GPS positions for nearly all fire stations in rural and metropolitan Whatcom County using Magellan Meridian GPS equipment. Locations were captured geographic coordinates in North American Datum 1983 (NAD83).

### This Tutorial

- Stresses project organization and file management
- Reviews Census 2000 TIGER download procedures
- Teaches shapefile projection definition and reprojection using ArcToolbox
- Teaches table modification and field calculation with algebra and simple Visual Basic for Applications (VBA) scripting
- Teaches registration and mapping of *x,y* points as an event




*Use ArcToolbox to reproject the Line Features–Roads layer to Washington State Plane NAD83 North with units in US Feet.*

The fire stations were located on a TIGER street network, and five- and ten-minute networks and service areas were modeled. Data for the Washington Fire Protection Districts that was used in creating the networks was obtained from Whatcom County Planning and Development Services. Evaluating this data will let us assess the extent of fire protection provided by Whatcom County's rural stations.

This exercise re-creates part of the students' exercise including acquisition of TIGER data, enhancement of street data to accommodate time-based networking, and mapping of rural fire stations. It concludes with posting and reviewing modeled networks and service or response areas.

Note that this exercise relies on unedited data and includes very basic assumptions regarding street networks and travel times. It is intended solely for training purposes; it does not represent actual conditions in the selected test area. TIGER data for roads was obtained directly from the Geography Network (www.geographynetwork.com) and has not been field validated or edited. Assigned speed limits are from a standard Census Feature Class Codes (CFCC) lookup table that is generalized for use across the nation. Creating a networked street set for your agency will require that you spend considerable time building the best available transportation network (or purchasing a high-quality commercial dataset). However, the TIGER road data used for this exercise provides a place to start learning how to build a transportation network.

### About Whatcom County

Whatcom County, located in northwestern Washington state, shares a border to the north with British Columbia, Canada. The county seat, Bellingham, is approximately 90 miles north of Seattle. In 2001, Whatcom County's population was slightly more than 170,000 people. The construction of many new residences in the Nooksack Valley and in the foothills of Mount Baker, rural areas east and south of Bellingham, led emergency services providers to recognize the need for expanding services, and several fire stations have recently been constructed.

### Getting Started

The article "Taming TIGER Data—Create Emergency Management Maps Using Census 2000 Data" in the January–March 2003 issue of *ArcUser* magazine showed how to acquire, improve, and map Census 2000 TIGER data. Building the basemap for the current tutorial uses similar techniques. Refer to this previous article, available online at www.esri.com/

news/arcuser/0103/files/tiger.pdf, if you have questions regarding the process.

Before downloading any data files, create the directory structure with two main folders called DBFFiles and SHPFiles. Under SHPFiles, make two subdirectories—LatLon83 and WASP83NF.

| Description | file |
|---|---|
| County 2000 | cty00 |
| Landmark Points | lpt |
| Line Features – Hydrography | lkH |
| Line Features – Rails | lkB |
| Line Features – Roads | lkA |

*Figure 1: The recommended TIGER data selections*

Go to the TIGER data pages of the Geography Network Web site (www.esri.com/data/download/census2000_tigerline/index.html), select Download Data, and click on Washington in the United States map or choose Washington from the pick list. Scroll to Whatcom County and select it. Select the layers listed in Figure 1 by checking the appropriate boxes. The TIGER abbreviations for these layers are explained in a Readme file that will be included with downloaded data. Click the Proceed to Download button and wait while the data is assembled. Save the zipped archive in the Whatcom\SHPFiles\LatLon83 directory. Use WinZip or a similar decompression utility to extract the data. The archived datasets begin with 53073—a combination of FIPS codes that represents Washington (53) and Whatcom County (073). Extract each file into Whatcom\SHPFiles\LatLon83.

Visit the *ArcUser Online* Web site and download the accessory data archive. Place this data archive in the root Whatcom directory and unzip it. This data package includes several dBASE files and shapefiles for the fire district boundaries, fire station locations, and the five- and ten-minute service networks and service areas. Place dBASE files in the DBFFILE directory and the shapefiles in SHPFiles\LatLong83 directory.

## Reprojecting Data

The data is mapped in geographic coordinates in NAD83 projection but will be registered in Washington State Plane NAD83 North with units in US Feet. To register this data on the fly, the default projection for all TIGER files must be defined using ArcToolbox. To properly calculate street segment lengths, the Line Features–Roads layer will also need to be reprojected.

**1.** Open ArcCatalog and navigate to the Whatcom\SHPFiles\LatLon83 directory. Open all datasets in this directory and verify that all TIGER data layers are present. Use ArcCatalog to view the metadata that describes these datasets and verify that minimal projection information is recorded.

**2.** Launch ArcToolbox, open the Data Management Tools folder, and choose Projections. Click on Define Projection Wizard (shapefiles, geodatabase).

**3.** Click on the button with the folder icon to browse to the Whatcom\SHPFiles\LatLon83 directory. Highlight all the TIGER shapefiles to select them and click Add. Click Next to continue and click Select Coordinate System. In the Spatial References Properties dialog box, click the Select button, then Geographic Coordinate Systems North America, and finally North American Datum 1983.prj. Click Apply. After verifying the details displayed in the panel, click OK. Click Next to continue. Verify that the Summary is correct and click Finish.

**4.** Reproject the roads dataset into Washington State Plane. Choose Data Management Tools > Projections > Project Wizard (shapefiles, geodatabase). Navigate to the LatLon83 directory, select Tgr53073lkA.shp, and click Add. Verify that the coordinate system is GCS_North_America_1983. Click Next and set the output location to Whatcom\SHPFiles\WASP83NF and retain the same name (Tgr53073lkA.shp). Click Next and click on the Select Projected Coordinate Systems button. In the Spatial References Properties dialog box, click on the Select button and choose Projected Coordinate Systems then State Plane then NAD 83 (Feet). Scroll down and select NAD 1983 StatePlane Washington North FIPS 4601 (Feet).prj. Click Apply. Check the Spatial Reference Properties and click OK. Click Next, accept the default extents, and click Next again. Verify that the input summary is correct and click Finish. Close ArcToolbox when processing is complete, and inspect the dataset in ArcCatalog and verify that it is properly projected.

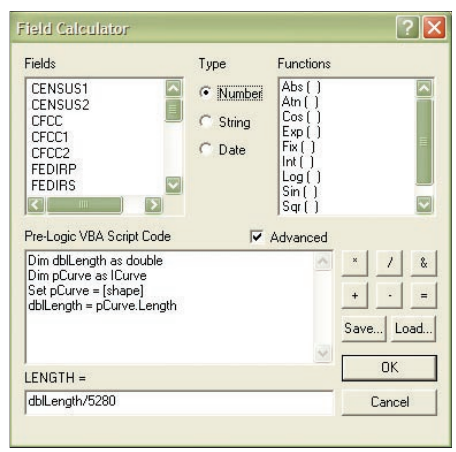
## Loading TIGER Data Into ArcMap

Start an ArcMap session with a new, empty map. The TIGER data is registered in decimal degrees using NAD83 but the project data should be in Washington State Plane North, Feet. The on-the-fly projection capability of ArcGIS can reregister most vector data.

**1.** In the Table of Contents, right-click on the data frame and choose Properties from the context menu. Click the General tab and rename the data frame 1. WA State Plane NAD83 North US Feet. Set the map units to feet. Do not click OK.

**2.** Click on the Coordinate System tab, select Predefined then Projected Coordinate System then State Plane then NAD 1983 (Feet), and finally Washington State Plane NAD83 North FIPS 4601 (Feet). Click the Modify button and verify that units are set to US Feet. Click Cancel to return to the previous dialog box. Click on the General tab again and verify that map and display units have been set to feet. Click OK.

**3.** Click the Add Data button and navigate to the Whatcom\SHPFiles\LatLon83 directory. Select all TIGER datasets except tgr53073lkA and add them to the map. Click and navigate to \SHPFiles\WASP83NF and add the reprojected copy of tgr53073lkA.shp. Do not add any other data. Save the map document as Whatcom1.mxd.




*The Field Calculator used with a Visual Basic for Applications (VBA) script will recalculate road segment lengths. VBA comes with ArcGIS. ArcMap's online help contains the script and instructions required to perform the calculation.*

*Continued on page 56*

# Coverage Assessment Using Census 2000 TIGER Roads

*Continued from page 55*

**4.** Provide meaningful names to the TIGER files using the file naming convention supplied in Figure 1. Abbreviations for all available data layers can be found in the Readme file that was provided with the data downloaded from the Geography Network. Right-click on each layer, choose Properties, click on the General tab, and rename each layer. Save the map again.

## Updating Road Segment Lengths With a Field Calculation

The TIGER Roads layer contains a numeric field called LENGTH which represents distance in statute miles. The Field Calculator will be used with a Visual Basic for Applications (VBA) script to the recalculate road segment lengths in the LENGTH field. VBA comes with ArcGIS and ArcMap's online help contains the script and instructions required to perform the calculation.

**1.** Press F1 to invoke ArcMap's online help. Type "length" in the Index Keyword box. Highlight "Calculating for lines" and click on the Display button. On the Making Field Calculations page, locate and expand the topic called "Updating length for a shapefile."

**2.** Follow the steps under this topic. Remember that the reprojected road layer is in feet, not miles.

**3.** In step 7, enter "dblLength/5280" in the text box next to LENGTH=. Click OK and wait while the lengths of nearly 18,000 road segments are recalculated. Check the results by measuring several segments on the map.

## Joining TIGER Data With CFCC Codes

In the article "Taming TIGER Data—Create Emergency Management Maps Using Census 2000 Data" in the January–March 2003 issue of *ArcUser,* a tabular join was used to associate meaningful text with cryptic Census Features Class Code (CFCC) names. This same technique will be used to enhance the Whatcom data. A basic description of the process follows. Consult the print or online versions of this article for additional information, if necessary.

**1.** Add the CFCC table into the map from the \DBFFiles directory.

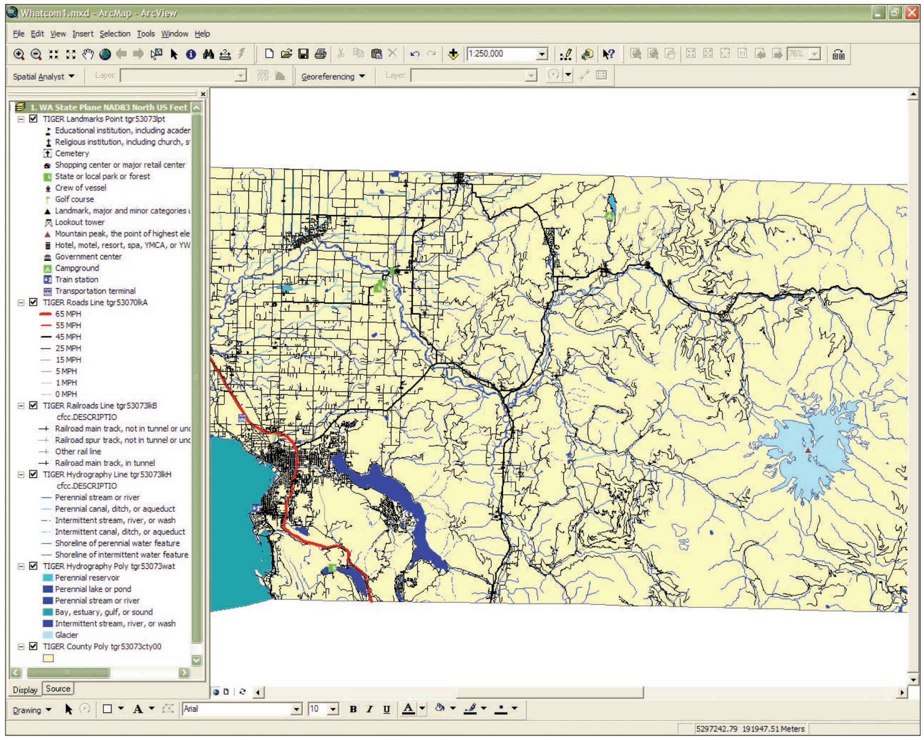
**2.** In the Table of Contents, right-click the TIGER Roads layer and choose Joins and Relates > Join.

**3.** In the first drop-down box, choose Join Attributes from a Table.

**4.** Select CFCC from the next drop-down box as the field in this layer that the join will be based on.

**5.** In the next drop-down box, choose CFCC as the table to join.

**6.** In the last drop-down box, select CFF as the field in the table to base the join on. Click OK. Verify that the joined tables contain a new text field named DESCRIPTIO. Save the map.




*Provide meaningful names to the TIGER files using the file naming convention supplied in Figure 1. Abbreviations for all available data layers can be found in the Readme file that was provided with the data downloaded from the Geography Network.*

**7.** To make the joins permanent, right-click on the Roads layer in the Table of Contents and choose Data > Export. Name the new shapefile Roads CFCC and save it to the \SHPFiles\WASP83NF subdirectory. Save the map.

## Calculating Travel Time

The accurate segment lengths and the CFCC speed limit data in the Roads CFCC layer can be used to generate travel time in minutes. For each segment, the travel time in minutes equals the road length in miles times 60 minutes divided by the segment speed limit.

**1.** To calculate travel time, open the Roads CFCC attribute table, click on the Options button, and choose Add a Field. Name the field TravelTime. Make the field type float and set the precision to 6 and the scale to 2.

**2.** Because travel times can only be determined for roads that have posted speed limits, these roads without speed limits must be queried out. With the Roads CFCC attribute table still open, click the Options button, choose Select by Attributes, and create a query that selects roads with speed limits greater than zero (i.e., SPEED_LIMI > 0). This query should yield 17,490 records.

**3.** Right-click on the TravelTime field header and choose Calculate Values from the context menu. Click OK to calculate outside of an edit session and enter

```
[LENGTH]* (60/SPEED_LIMI])
```

in the Field Calculator formula box. Click OK.

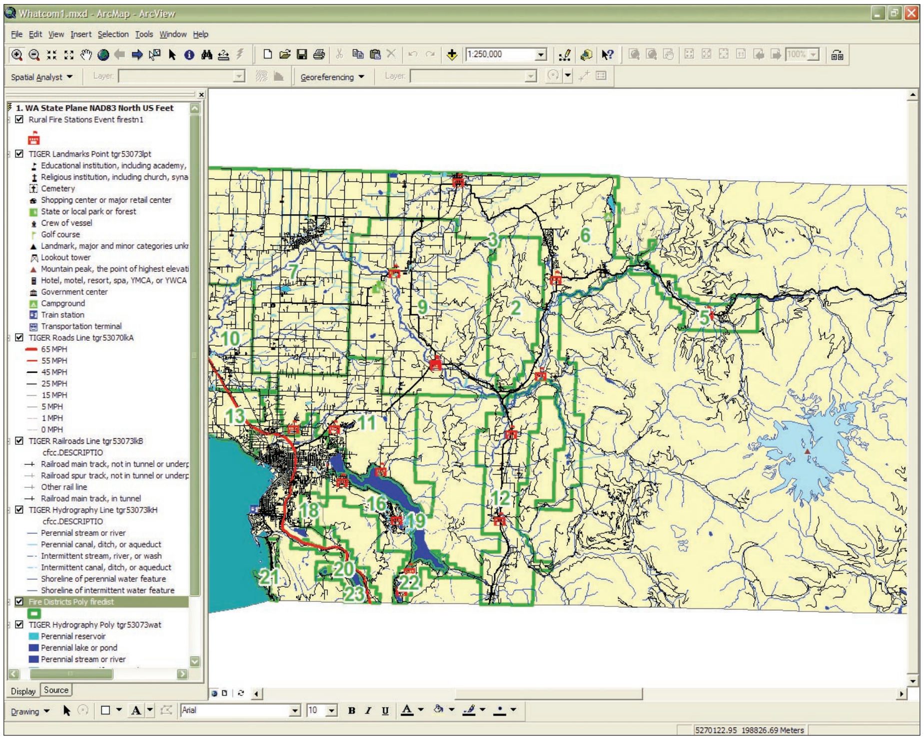
**4.** By assigning a high value for travel time to roads without speed limits, these road segments will be excluded from network analysis work. Return to the Select by Attributes and change to query to SPEED_LIMI > 0. This will highlight roads without speed limits. Right-click on the field header and choose Calculate Values. In the Field Calculator, assign a value of 9999 to these segments.

A more thorough analysis for a real-world application would require locating each segment without a speed limit value and assigning a speed limit. However, in the dataset for this tutorial many segments lack speed limits because they are driveways and loops in a subdivision on the east side of Lake Whatcom.

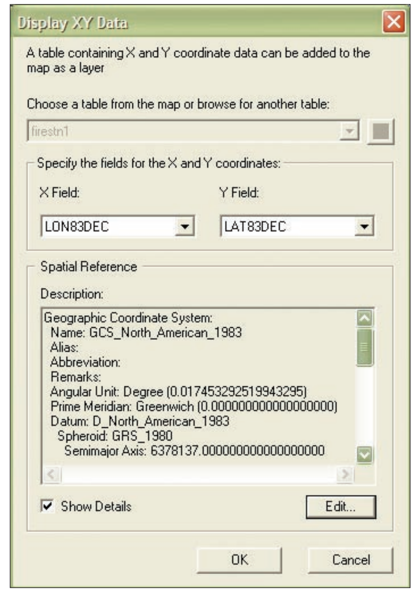
## Fire Stations, Fire Districts, Service Networks, and Service Areas

Fire station location data captured by Bellingham Technical College students, fire district boundaries from Whatcom County's GIS department, and emergency response service networks and service areas created for this exercise in ArcView Network Analyst will be added now.

**1.** Fire station locations are stored in the FireStn1.dbf table located in the DBFFiles directory. Add this data to the map, right-click on it in the Table of Contents, and select



Create joins for all TIGER data except the Water Polygons and County 2000 layers using the CFCC field as the common field to add meaningful data to the map.




*Fire station location data captured by Bellingham Technical College students is stored in the FireStn1.dbf table located in the DBFFiles directory. Add this data to the map. Right-click on it in the Table of Contents, and select Display XY Data from the context menu.*

Display XY Data from the context menu. Set the X Field to LON83DEC and the Y Field to LAT83DEC (if it does not default to this). Assign Geographic NAD83 as the Spatial Reference by clicking on the Select Coordinate System button. In the Spatial References Properties dialog box, click the Select button, then Geographic Coordinate Systems North America, and finally North American Datum 1983.prj. Click Apply and OK.

**2.** Inspect the fire station locations. At first glance, there appears to be very good coverage around the lakes and in the foothills.

**3.** Add the Fire District boundaries (firedist.shp) from the SHPFiles\LatLong83 directory. Note that the stations haven't been plotted in cities and in western county areas covered by Districts 7 and 10. Use the Identify tool to explore this data. Save the map.

**4.** Add snet05.shp, snet10.shp, sarea05.shp, and sarea10.shp, the prebuilt response time service networks and service areas files.

**5.** Arrange the layers in the Table of Contents as shown in Figure 2. Save the map document.

## Resolving Emergency Management Questions

This exercise teaches data acquisition and development for public safety and emergency management response modeling. This model can be used to study historic response patterns, standards of coverage, and the population and values at risk in Whatcom County. To continue exploring this area using the model, block centroid Census 2000 data could be clipped to the Whatcom County extent and used to tabulate the number of people living in the five- and ten-minute response areas for the county's fire stations. Adding the 1990 Block centroid data could be used to map growth patterns and match them with new fire stations. With this model, areas of new, rapid growth could be anticipated and alternatives to construct new facilities considered. These alternatives could include making staffing changes, purchasing additional equipment, and drafting mutual aid agreements with neighboring emergency service providers.

## Optional Activities

The accompanying illustrations show how the CFCC table can be joined to the other TIGER layers. The descriptive fields in the CFCC table can be used to enhance the legends for each of these layers.

## Summary

Because TIGER data is generally available across the United States, it provides a good, low- cost start-up dataset for modeling emergency response capability. This exercise made several basic assumptions about data completeness and consistency. Consequently, the model does not provide definitive solutions for rural Whatcom County. It is intended to teach emergency management data development and inspire GIS users to think about ways to use this data to solve specific problems. It is a starting point for teaching more complex networking and response analysis.

Remember that this model is not intended to be a simplified solution to creating re-

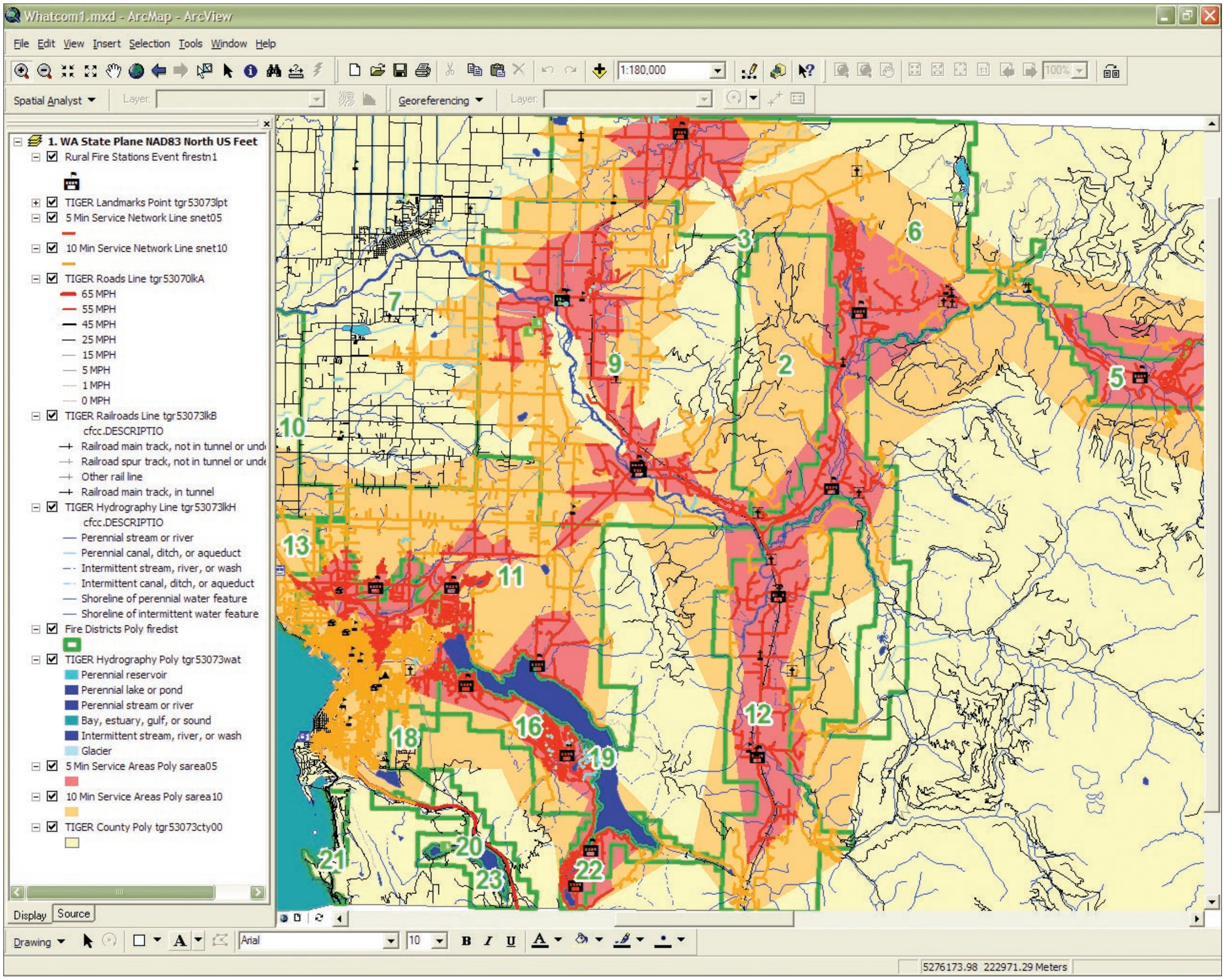
| Rural Fire Stations |
|---|
| TIGER Landmarks |
| 5 Min Service Area Line |
| 10 Min Service Area Line |
| TIGER Roads Line |
| TIGER Railroads |
| TIGER Hydrography Line |
| Fire Districts |
| TIGER Hydrography Poly |
| 5 Min Service Area Poly |
| 10 Min Service Area Poly |
| TIGER County Poly |

*Figure 2: Layer order in Table of Contents*

*Continued on page 58*

# Coverage Assessment Using Census 2000 TIGER Roads

*Continued from page 57*




*Because TIGER data is generally available across the United States, it provides a good, low-cost start-up dataset for modeling emergency response capability. This exercise makes several basic assumptions about data completeness and consistency and is intended only to teach emergency management data development. The model constructed in this exercise can be further enhanced by creating legends based on the additional information contained in the joined CFCC table as shown above.*

sponse assessment. Real-world application of these techniques would require data that is extensively field tested and most likely be edited for accuracy and relevance. High-quality commercial street data, already prepared for networking and address geocoding, can be purchased from ESRI data partners such as Tele Atlas (www.teleatlas.com), NavTech (www.navtech.com), and Geographic Data Technology, Inc. (www.geographic.com).

For more information, contact
Mike Price, Principal
Entrada/San Juan, Inc.
Moab, Utah
E-mail: mike_price@frontiernet.net

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## About the Authors

*Mike Price* is the president of Entrada/San Juan, Inc., based in Moab, Utah. He specializes in natural resources and public safety/emergency management mapping. He does GIS modeling throughout the United States with emphasis on geologic hazard analysis and Wildland/Urban Interface training and modeling through the National Fire Protection Association's Firewise Communities program.

*John Price* is a student at Bellingham Technical College, Bellingham, Washington whose major area of study is surveying and mapping technology. John is currently interning as a surveyor/locator helper with Skagit County.

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