

May 2012

# Fire Mapping

Building and Maintaining  
Datasets in ArcGIS

Mike Price



# Table of Contents

## **4 Is Data Driving Your Fire Engine?**

- 5 Framework Data for Public Safety
- 5 My First Choice—Transportation
- 7 Second Pick—Cadastral
- 8 Third Choice—Orthoimagery
- 9 Fourth on My List—Administrative Units
- 10 Fifth and Sixth—Elevation and Hydrography
- 10 And Finally—Geodetic Control
- 10 Special Data—Shape of Things to Come
- 11 Acknowledgments

## **12 Is Special Data Driving Your Fire Engine?**

- 12 Introduction to Special Datasets
- 13 7 Categories of Special Data
- 14 Facilities—Essential and Critical
- 15 Infrastructure
- 16 Location and Descriptive Information
- 17 Demographics
- 17 Hazards
- 18 Historic Risk and Program Data
- 19 Modeled and Derived Data
- 20 Acknowledgments

## **21 Revisiting the Glenrosa Fire**

- 22 Part I: An Overview of Evacuation Modeling with ArcGIS Network Analyst
- 22 The ArcGIS Network Analyst Closest Facility Solver
- 23 Preparing Input Data
- 25 The Closest Facility Solver
- 27 Part II: Revisiting Glenrosa
- 28 Loading Shelters and Residences and Running a Prefire Model
- 29 Loading Polygon Barriers and Resolving
- 29 Expanding the Fire by Loading Buffers
- 30 Opening the Back Door
- 31 Finishing Up
- 31 Acknowledgments

## **33 Analyzing Frequent Responses**

- 33 Getting Started: Setting Up the Redlands Fire Map
- 34 Bringing Apparatus and Incident Spreadsheets into ArcGIS 10
- 35 Importing an Excel Worksheet into a File Geodatabase
- 36 Calculating USNG Addresses for 2010 Incidents
- 37 Table Updates and Tabular Joins
- 38 Summarizing and Looking at Statistics

# Table of Contents (continued)

- 39 Plotting, Saving, and Symbolizing Frequent Responses
- 41 Summary
- 41 Additional USNG Resources
- 41 Acknowledgments

## **42 More Emergency Services Modeling**

- 43 Getting Started
- 43 Modeling Response with Network Analyst Closest Facility Solver
- 44 Creating a Closest Facilities Template
- 46 Building and Solving Multiple Scenarios
- 47 Enhancing Closest Facility Data for the Base Case
- 47 Performing Two Joins
- 49 Calculating Travel Times
- 49 Joining and Calculating the Scenarios
- 49 Calculating Travel Improvements
- 50 Mapping
- 52 Summarizing
- 53 Future Opportunities
- 53 Acknowledgments

## **54 Introducing the United States National Grid**

- 55 Waypoint 1
- 56 Waypoint 2
- 56 Waypoint 3
- 56 Waypoint 4
- 57 Waypoint 5
- 58 Waypoint 6
- 58 Waypoint 7
- 58 Conclusion

To do the exercises and assignments in this book, you need to have ArcGIS 10 for Desktop software and ArcGIS Network Analyst 10 extension installed on your computer, or you can [download a trial version](#) of the software.

# Is Data Driving Your Fire Engine?

Finding, understanding, maintaining, and mapping spatial data for public safety

By Mike Price, Entrada/San Juan, Inc.

**Editor's note:** The author is the president of Entrada/San Juan, Inc., a natural resources and public safety consultancy. He is a licensed engineering geologist with more than 30 years of experience. For the last 12 years, he has been writing articles for ArcUser magazine that help GIS users understand, manage, model, and use data. Although this article targets managers of GIS data for fire departments and others involved in public safety, this data framework can be used throughout local government.

Public safety service providers everywhere are tasked with serving populations that are growing (or at least remaining static) as budgets decrease and resources become more scarce. In this budgetary environment, cost containment measures may include reducing staffing; redeploying apparatus; closing stations; and—in some cases—ceasing to serve some areas. Nonetheless, agencies still strive to provide the highest level of service through improving internal operating efficiencies, implementing interagency agreements, and creating regional authorities.

I am often asked by public safety mapping and administrative staff which datasets are necessary to perform various mapping and analytical studies. They are especially interested in the order of importance of these datasets. I keep careful notes on these



Kent Fire/Fire District 37 in southern King County, Washington, protects an area of approximately 49 square miles that encompasses urban, suburban, and rural areas. Here an engine travels to the City of Covington to a new station that provides a high service level in the eastern portion of the district.

essential public safety datasets and have noted which datasets provide the best value, how incorrect or inappropriate data can damage or derail a study, and what the best sources are for essential information.

In public safety, we perform many mapping and analytical tasks that include resource allocation and deployment, dynamic response modeling, historic incident analysis and reporting, and mapping of affected populations and values. These tasks combine to support large studies such as strategic, capital, master, and Standard of Cover plans. In this article, I have summarized my thoughts on and findings about public safety data. Public safety data is a very broad theme. In this article, I introduce and discuss framework data, as defined by the Federal Geographic Data Committee (FGDC).

Kent Fire/Fire District 37 is a career, rather than a volunteer, department in southern King County that protects a population living in approximately 49 square miles that encompasses urban, suburban, and rural areas. The district includes large warehouses and light industrial development. The district lies on a major north–south interstate freeway and a second high-speed arterial, and major north–south railroads traverse the city's downtown core. The district lies immediately southeast of SeaTac International Airport and approximately 10 miles from Port of Seattle's Duwamish seaport. Their fixed facilities include eight staffed fire stations and a Fire Prevention Bureau. In 2009, emergency responses exceeded 15,000 calls. Of these, approximately 76 percent were rescue and emergency medical service (EMS) calls; 5 percent were fire, explosion, and Hazmat calls; and 19 percent were service and other calls. The department serves a total population of more than 138,000 and

protects assets that were assessed in 2009 at approximately \$18 billion.

The Valley Communications Center (Valley Com), the region's dispatch center, is upgrading software and services. The district actively participates in the development of regional public safety datasets for deployment on mobile mapping and communication platforms.

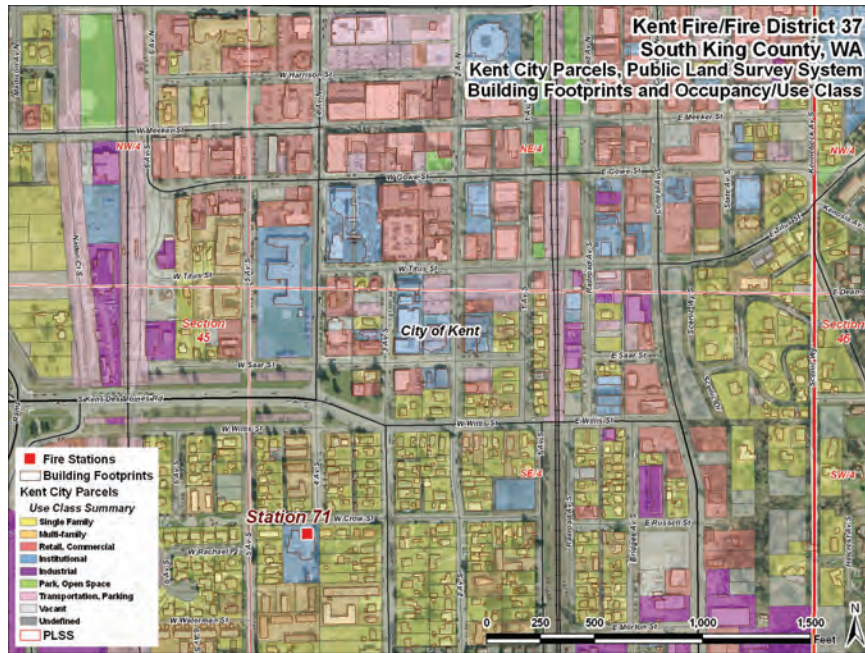
## Framework Data for Public Safety

FGDC, through the National Spatial Data Infrastructure (NSDI), has developed a framework for assembling and supporting geographic data on a nationwide basis to serve a variety of users. The seven key data elements identified by the FGDC are (listed in order): geodetic control, cadastral, orthoimagery, elevation, hydrography, administrative units, and transportation. These familiar datasets are typically developed, maintained, and used by public and private organizations within a specific geographic area. Public safety mapping uses data from all these framework data types. For more information about the FGDC Data Framework, visit [www.fgdc.gov/framework/frameworkoverview](http://www.fgdc.gov/framework/frameworkoverview).

## My First Choice—Transportation

To create and maintain time-based emergency response networks, current, accurate transportation data is essential. Detailed street data that supports both time-based travel and





Fire District 37 GIS technicians use current high-resolution imagery to update live maps showing parcel-based occupancies, values, hazards, and essential facilities.

incident geocoding is essential. Geocoding incidents also supports risk analysis by allowing historic incidents to be posted on maps. To start a study, I first look for the best available street dataset(s). Sometimes, the same street dataset will support both functions, but often two street sets, obtained from the same or similar sources, are enhanced, then maintained separately to support each task.

High-quality street data is available from commercial vendors. Reasonably current and accurate data is also available without charge from vendors and through the U.S. government. In many cases, locally constructed and maintained streets provide the most current, accurate, and adaptable solution.

For streets inside the district, Kent City Public Works maintains current streets for geocoding and, with minor enhancements, for emergency routing. For areas outside the district and throughout the South Valley, King County GIS provides regional streets. Valley Com is building a composite regional street dataset to support its dispatch and communications software implementation. County agencies provide their best street sets, which are being merged and standardized by a consultant. *[For more information about network streets, download "[It's All about Streets](#)" (PDF). To learn more about geocoding, check out "[The Call Comes In](#)" (PDF).]*

The U.S. Census Bureau is updating its MAF/TIGER Database (MTDB) for the 2010 Census. These streets should be available after they have been finalized. TIGER 2009 streets can also be [downloaded](#). Since 2000, there have been many significant changes in TIGER streets. Positional alignment has been improved, and addressing is more complete. Although TIGER 2009 streets provide a good address geocoding reference, they do not include the network impedance values or appropriate directionality and crossing relationships needed for performing time-based analysis. While it is possible to build a network

dataset from TIGER 2009 streets, it requires considerable effort and extensive local knowledge.

## Second Pick—Cadastral

Next on my public safety wish list is county assessor parcel data. Parcels are constructed on the broader cadastral framework. County assessors typically use the Public Land Survey System (PLSS) to catalog and store parcel information. The availability, content, and spatial representation of assessor parcels varies considerably by jurisdiction. In the best case, attributes may include owner/occupant information, occupancy and use type, appraised and assessed valuation, and structural information. A robust, current assessor parcel dataset will support hazard and value mapping throughout a county. Obtaining this data can necessitate developing a relationship with the county assessor, which can take time and require the appropriate introductions.

Since property values can quickly change in either direction, obtaining parcel data for several years may help. Assessor parcels are a key dataset when defining and structuring agency consolidations and developing or updating an agency's revenue stream. Also, with sufficient single-family and multifamily residential information, the occupancy percentage and average family size can be estimated prior to the release of Census 2010 data.

At Kent Fire/Fire District 37, assessor parcels provide information about new subdivisions and construction and changes in values and building occupancies. They define and support tax rates and are used for updating the Fire Benefit Charge. Parcel data can provide a reasonable estimate of street width and define candidate locations for proposed easements and new access. This data can also provide a framework for Fire Prevention Bureau staff as they perform inspections and update prefire plans. *[Fire Prevention Bureaus provide public education, inspection and code enforcement, and detailed plan review.]*



Assessor parcels, high-resolution imagery, transportation systems, and the Public Land Survey System (PLSS) combine to map parcel and building-level occupancies in the City of Kent.

There is one more use for assessor parcels: if you convert the parcel polygons to centroid points and associate the highly accurate and standardized assessor site addresses, you have an excellent, reasonably current E-911 geocoding point file! [See [\*"The Call Comes In"\*](#) (PDF) in the Spring 2010 issue of ArcUser for more information on geocoding point files.]

The district uses traditional cadastral data to define and map Fire Demand Zones (FDZs) and design response zones (or Fire Boxes). FDZs are defined by quarter section aliquots in PLSS. [An aliquot part is a standard subdivision of the area of a section based on an even division by distance along the edges, rather than equal area. Half section, quarter section, or quarter-quarter section are examples of these units.] In Washington State, the PLSS is administered by the Washington Department of Natural Resources. In your state, the land subdivision could be administered by the U.S. Bureau of Land Management or other agency. For additional information and to download PLSS data in the western or central United States, go to [www.geocommunicator.gov/geocomm/lsis\\_home/home/index.shtm](http://www.geocommunicator.gov/geocomm/lsis_home/home/index.shtm).

### Third Choice—Orthoimagery

With street alignment and parcel boundaries on a map, the next step is checking those layers against imagery. Imagery is the third item on my list because it can be used for visually validating the streets and parcels in coordinate space. Current, high-resolution

imagery is an invaluable tool for viewing and understanding many aspects of a street dataset including street alignment, lane count, intersection geometries, road width, and new construction. Aerial imagery shows the relationship between street edges, street centerlines, and parcel edges. It also shows the placement and orientation of structures on parcels. This is especially helpful when mapping and addressing apartments or condominiums that have many residential units on a single tax parcel.

At the wildland-urban interface, imagery provides a quick way to visualize fuels and measure the distances separating hazardous fuels from structures. In these areas, it is best to obtain two recent imagery sets—one with leaves on trees and one with leaves off trees.

In the district, recent, high-resolution imagery that was carefully rectified was used for validating the location, orientation, and footprint area for structures; the preferred method of access for large parcels; points of building ingress and egress; placement options for fire apparatus; and even fire hydrants. Public safety mappers are highly visual people who are continually finding new uses for aerial imagery. Kent City updates its high-resolution imagery every one or two years. In addition, a contractor provides biannual updates of registered vertical and oblique imagery. District staff is just starting to use the oblique imagery for prefire planning, building inspections, and tabletop scenarios.



## Fourth on My List—Administrative Units

With streets and parcels mapped and studied, administrative boundaries can now be refined. Boundaries, including county lines, city limits, fire districts, and Urban Growth Areas (UGAs) *[boundaries designed to contain urban sprawl]* are defined and maintained on a cadastre. The county clerk/recorder or surveyor often maintains this data at the local level. Regional boundary information may be recorded by state agencies (e.g., transportation, public lands, environmental). Federal agencies, such as the U.S. Forest Service, Bureau of Land Management, and Federal Emergency Management Agency (FEMA), can also provide boundary information.

At the Kent Fire Department, municipal and district boundaries are maintained by King County and Kent City. King County also maintains county, special district, and other boundaries countywide. Examples of special district boundaries for natural hazards and areas of environmental sensitivity are defined and maintained by the Washington Department of Ecology, Washington State Emergency Management District, FEMA, and other agencies.

The district includes regions of rapid urban and suburban growth. State-defined UGAs are essential, as they predict where and when additional services will be needed. During the 2009 reaccreditation, UGA-based growth projections provided key



Current, accurate transportation data is essential to support time-based travel. Geocoding incidents also supports risk analysis.

planning information. In a broad sense, all strategic/master plans and capital facility plans are guided by growth boundaries.

## Fifth and Sixth—Elevation and Hydrography

As an old firefighter and geologist, I have combined these two framework pieces and placed them toward the bottom of the list. However, in areas with certain natural hazards, these datasets should probably be listed first. Digital terrain data, including 10-meter digital elevation data, is available nationally from the U.S. Geological Survey (USGS) Seamless data site ([seamless.usgs.gov](https://seamless.usgs.gov)). Digital hydrography is available nationally from the National Hydrography Dataset at [nhd.usgs.gov/data.html](https://nhd.usgs.gov/data.html). Riverine inundation data may be previewed at FEMA's Map Service Center at [msc.fema.gov](https://msc.fema.gov). Data may be ordered from this site or it may be available without charge through your county or state emergency manager. Other terrain and water-based hazard information could be available through county or state emergency or engineering agencies.

In the district, 10-meter USGS terrain data provides a regional base. The Puget Sound Lidar Consortium provides terrain data as grids with 6-foot pixel resolution throughout the southern county. By combining high-resolution terrain with imagery, hydrography, geology, and transportation, district staff model new construction, flooding, critical slopes, winter operations, and travel slowdown on steep roadways. By combining different types

of framework data, district personnel can model, understand, and solve many complex problems.

## And Finally—Geodetic Control

Public safety mappers perform spatial mapping and analysis in a carefully defined and controlled coordinate-based world, though they tend not to focus on positional and spatial accuracy and instead are more concerned with getting trained personnel and sufficient and appropriate emergency equipment to incidents as efficiently and safely as possible. Behind the scenes, mapping data is carefully connected to a precise system of points and arcs that includes benchmarks, survey control points, and regional traverses. Local agencies rely on federal, state, and county agencies to establish and maintain the control net. For most agencies, the county surveyor is the resident expert.

Accurate and extensive survey control supports all that emergency response personnel do. Survey control is important and becomes more so as regional response models and communication protocols are developed. For now, public safety mappers should get acquainted with their county surveyor and engineer!

## Special Data—Shape of Things to Come

This article briefly summarized seven types of framework data that are used every day by public safety mappers. There is an

extensive set of essential information that does not fit directly into framework categories. Here is a short list of special data used for risk/hazard/protection/value mapping:

- Fixed and Portable Facilities (Protection)
- Apparatus
- Personnel
- Special Services
- Other Essential and Critical Facilities (Protection, Value)
- Historic Incident Data (Risk)
- Water Supply (Protection)
- Land Use/Zoning (Hazard, Value)
- Growth Management (Hazard, Value)
- Special Hazards and Occupancies (Hazard, Value)
- Industrial
- Natural, Environmental
- Cultural
- Census Demographics (Value)
- Communications, Command and Control (Protection)

## Acknowledgments

The author thanks the staff and administration of Kent Fire/Fire District 37 and their contributing agencies. Special thanks to Kent City Public Works, Valley Com, and the Zone 3 mapping group. Through partnering and mutual commitment, great things are possible.

(This [article](#) [PDF] originally appeared in the Summer 2010 issue of *ArcUser*.)

# Is Special Data Driving Your Fire Engine?

Finding, understanding, maintaining, and mapping special public safety data

By Mike Price, Entrada/San Juan, Inc.



Kent Fire analysts use risk maps to compare primary station response capabilities to urban, suburban, and rural areas within the district.

Every jurisdiction needs not only framework datasets, such as transportation and cadastral layers, but also highly localized datasets on facilities, infrastructure, and other assets. These resources, typically used on a daily basis, must often be captured or derived by local government. Having a strategy for acquiring, organizing, and maintaining this data is every bit as important as framework datasets.

This article builds on a previous article, "[Is Data Driving Your Fire Engine? Finding, understanding, maintaining, and mapping spatial data for public safety.](#)" It presented Federal Geographic Data Committee (FGDC) framework datasets that are often used by public safety service providers. In this article, the processes of Kent Fire Department in southern King County, Washington, were used to illustrate how these datasets are acquired and used. The six framework types discussed in the previous article and descriptions of typical data types and sources of the Kent Fire Department are listed below in Table 1.

## Introduction to Special Datasets

There are datasets necessary for public safety activities that do not fit into framework categories discussed in the previous article. These are extensive datasets that responders use daily for mapping station locations, recent incidents, coverage areas, and protected values. Many non-framework or loosely connected datasets have also been included in this second group, which we will call special data.



**Table 1: FGDC framework datasets**

Dataset	Description	Source
Transportation	High-quality streets for time-based geocoding and incident geocoding	Kent Public Works, King County, TIGER 2009
Cadastral	Assessor parcels with complete attribution	King County Assessor
	Washington Public Land Survey System (PLSS)	Washington Department of Natural Resources
Orthoimagery	High-resolution orthoimagery	Commercial providers
Political units	City, district boundaries, and urban growth areas	State, county, and municipal data providers
Elevation	10-meter digital elevation model	U.S. Geological Survey
	6-foot LiDAR	Puget Sound LiDAR Consortium
Hydrography	Stream centerlines, water body polygons, flood maps	U.S. Geological Survey and FEMA

The scope, content, and sources of special data vary considerably. Many special datasets are generated and maintained by local jurisdictions using locally defined formats, styles, and standards. While framework data is closely aligned with FGDC standards for accuracy, scale, and completeness, special datasets are much

more free form. These datasets typically meet the needs and answer concerns of one or several agencies. Their structure is typically defined by commercial software and data providers. Computer-aided dispatch (CAD) and fire service record management systems (RMS) are two closely aligned datasets that often vary considerably between jurisdictions, so sharing special data is not always easy.

The National Fire Protection Association (NFPA) recognized the need for guidelines and standards for special data. NFPA recently formed a committee to evaluate domestic and international public safety data sharing needs. The Committee on Data Exchange for the Fire Service is now reviewing and preparing recommendations, guidelines, and standards for public safety data. In this article, special data has been divided into seven categories that will each be discussed separately. To provide a real-world example, the strategies and sources used by Kent Fire will be described.

## 7 Categories of Special Data

- Facilities
- Infrastructure
- Location and description
- Demographics
- Hazards

- Historic risk and program
- Modeled and derivative

## Facilities—Essential and Critical

Facilities are locations and resources. Although they are usually fixed, they can sometimes be mobile. They contribute to or are affected by emergency response and public safety activities. Facilities can be divided into two subgroups: essential facilities and critical facilities.

Essential facilities include services (e.g., apparatus, equipment, and personnel) to provide public protection and effect an emergency response. Critical facilities are major recipients of emergency assistance and have special needs during an incident. However, facilities are not always only essential or critical. A particular facility, such as a school, might fall under critical rules during one emergency, such as an evacuation or a safety lockdown, but during an evacuation sheltering scenario might perform an essential function. Table 2 contains a short and intentionally incomplete list of essential and critical facilities. Use local expert knowledge and intuition to add more valuable datasets to these lists.

Each of these facilities requires mapping and on-site assessment to determine the role, effectiveness, and interplay of these resources during an emergency. Facilities are often mapped as location points or parcel/building footprint polygons. Attribution

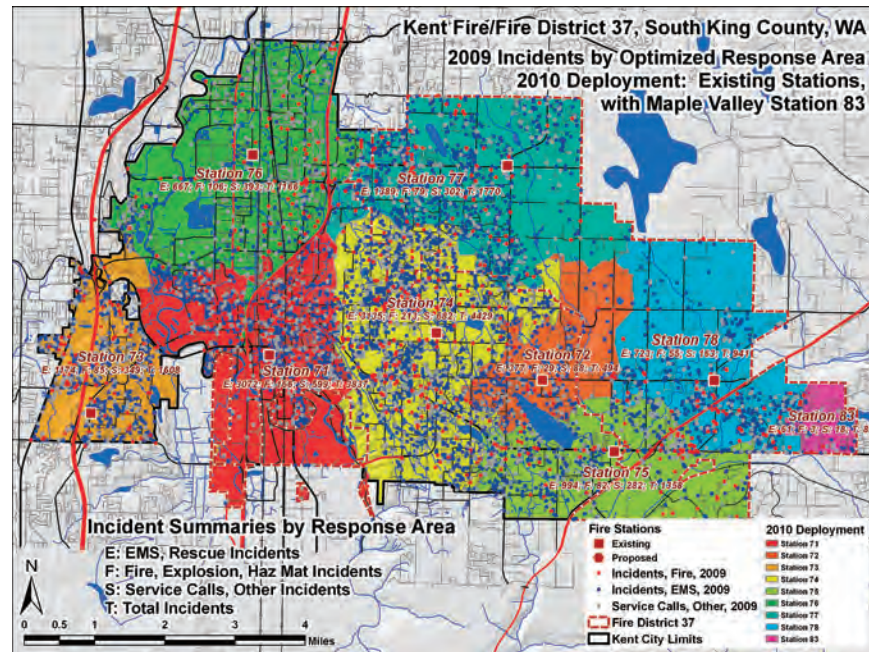
Table 2: Some examples of essential and critical facilities

Essential Facilities	Critical Facilities
Fire stations	Public buildings
EMS facilities	Hospitals and medical centers
Emergency operation centers	Public transportation centers and systems
Hospitals, medical centers	Convalescent homes and care facilities
Medical resources	High-occupancy residential complexes
Airports	High-hazard industrial, commercial sites
Emergency landing zones	Other high-risk sites that have a history of frequent response
Evacuation centers	Historic and culturally significant structures and sites

varies by jurisdiction and facility. Fire stations include apparatus and staffing; schools list student and staff occupancies and available evacuation resources. As a critical facility, a hospital might list typical patient and staff occupancies, areas with special evacuation needs, and hazardous or controlled substances. As an essential facility, resources for trauma service, patient handling, and medical quarantine might be listed.

Kent Fire maps essential and critical facilities at the parcel and building footprint level. For location points, aerial imagery allows points to be placed at front doors or street entrances for facilities such as fire stations. Attribution varies by facility type. Essential facility data includes available resources, such as equipment and personnel, contact information, and staffing schedules. Critical facilities information includes populations at risk, temporal

occupancy data, contact information, and emergency response plan links.



One year's incidents, mapped and symbolized by type, provide excellent benchmarks to analyze response effectiveness and identify regions where very high incident loads might overwhelm assigned resources.

## Infrastructure

Infrastructure can become a very broad category. In the fire service, water for fire suppression quickly comes to mind, but there are many more infrastructure players to consider. Table 3

lists several infrastructure types and the associated datasets that are important for Kent Fire.

**Table 3: Infrastructure types and datasets**

### Fire Suppression Water Supply

Type	Example
Water sources and storage	Reservoirs, wells, tanks, and towers
Water distribution system	Pipes, pumps, valves, pressure regulators
Water delivery systems	Fire hydrants, fixed fire protection (sprinklers)

### Communications

Type	Example
Emergency services communication	CAD center, emergency operations center, repeaters, portable and fixed radios
Public telephone	Land line and cell towers

### Utilities

Type	Example
Culinary water	Location, quality, and security, emergency backups
Electrical service	Distribution systems, service areas, emergency backups
Gas service	Distribution systems, service areas, emergency shutoffs and shutdown procedures
Sewer, storm sewer system	Collection systems, treatment facilities, environmental sensitivities

The Kent Fire Department maintains a close relationship with the Kent City Public Works Department, the primary water provider within the city. Data is updated and shared regularly, and neighboring water companies provide hydrant location and testing information. Prefire plans include information about buildings with sprinkler systems.

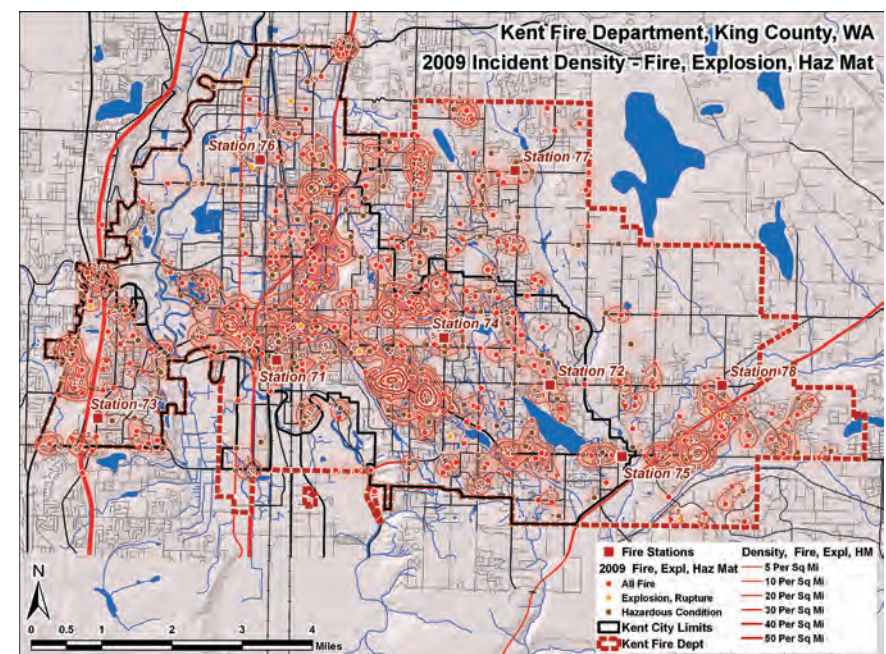
Emergency communications are managed by Valley Com, a regional center located in Kent's southeast suburbs. The communications links between agencies are tested regularly and are always improving. The regional center maintains call lists and radio frequency information for commercial service providers and utility employees who often participate during emergency drills. The Kent Fire Public Information Office has developed excellent relationships with the media and citizens in the fire district.

Kent Fire supports close relationships with commercial utility providers throughout its jurisdiction. Appropriate information is carefully shared and incorporated into emergency response plans. Utility data often includes secure, private information, so special arrangements between the two organizations protect sensitive information.

## Location and Descriptive Information

This category can become a catch-all for a variety of data. It is sometimes difficult to distinguish between a critical facility with very special needs and a target hazard exhibiting lesser hazard

or risk. This data has location or position information that is important to public safety mappers. Data types are typically points or polygons. Data sources can include assessor parcels, fire preplans, Environmental Protection Agency (EPA) inventories, or similar datasets.



Incident density, or "hot spot," maps show where fire, explosion, and hazardous materials incidents occur with greatest frequency.

Important location-based data might include

- E-911 address points



- Target hazards
- Cultural values
- Areas of critical environmental concern

Kent Fire works closely with the King County E-911 office to maintain a complete, current E-911 point set. Information collected from assessor parcels, building footprints, building permits, and field inspections keeps this data current. Kent Fire uses this point data as the source for its first order incident geocoding address locator because this data places incident points directly on the involved structure.

## Demographics

Demographic data is often the best way to identify which resident populations are at risk. The U.S. Census Bureau updates block-level statistics every 10 years. It is 2010, and Census 2000 data is out of date in many parts of the country. Kent and other agencies anxiously await the release of this 2010 data. In the interim, locally collected summary information is used to update census population counts. Many regional associations of governments estimate annual population increases for municipalities, but it is much more difficult to determine growth within special districts that do not match city boundaries. Growth studies often use Traffic Analysis Zone (TAZ) projections to estimate future population in reasonably small areas. At the local level—and until Census 2010 data is released—emergency

service planners use a variety of spatial and tabular information to update current populations and estimate future growth.

Sources of demographic data might include

- U.S. Census Bureau
- Community census updates
- Business statistics
- Building permits (both issued and finalized)
- Planning and community growth projections
- Local expert knowledge

At Kent Fire, GIS analysts filter current assessor parcel data to separate single family from multifamily dwellings. Building permits, fire preplans, and housing authorities provide multifamily data including unit counts and occupancy rates. Once the unit count is established, Census 2000 block records provide typical family composition throughout the jurisdiction. Population summaries are performed at the census block level and compared to city- and districtwide estimates for validation.

## Hazards

Hazard data often comes from various federal, state, and local sources. Typical hazard types might include

- Commercial and industrial hazards

- Cultural hazards
- Natural and environmental hazards
- Land use and land cover (existing and proposed)
- Zoning (existing and proposed)

Kent Fire maps and analyzes many sources of hazard data, including Federal Emergency Management Agency (FEMA) floodplain mapping, parcel-based occupancy data, EPA hazardous substance inventories, insurance service data, and site inspection notes. Earthquake, lahar (volcanic mudflows), terrain, slope failure, and other hazards come from U.S. Geological Survey, the Washington State Department of Natural Resources Geology and Earth Resources Division, and private studies. Hazardous inventories and substances on-site are mapped from EPA Tier II (chemical inventory) data, Superfund Amendments and Reauthorization Act (SARA) Title III material safety data sheets, and site inspections.

The department protects a major interstate highway corridor, two major railroads, and the second largest warehouse facility on the West Coast of the United States. Hazardous substances that are being stored or transported in the county are monitored through shipping documents and on-site storage information. Kent Fire supports a geographically distributed and highly trained Hazmat response team. King County and Kent City land-use and zoning maps identify areas where hazardous occupancies often cluster.

## Historic Risk and Program Data

For many emergency service agencies, the number one item on a special data list has been historic incident and response data. This information is essential for mapping response activity, measuring performance and risk factors, and assessing program development. Emergency service mappers geocode and analyze incident response data to understand program effectiveness, overload, and limitations. Incident-level data provides an incident location, incident type and severity, and time stamps that monitor the overall incident from call received to call complete.

Apparatus-level records include time information for each responding unit including when it is notified, how long it is en route, time spent on the scene, time when the scene is released, and the time in service. Apparatus data identifies the response time and capabilities of the first unit on scene and tracks the arrival and departure of all dispatched units. Postincident analyses recall when full concentration (i.e., sufficient apparatus) and a full effective response force are reached at the scene. Historic incident data reveals possible gaps in service in space and time. It provides invaluable baseline data for program tracking and modification, including performance studies, growth analysis, and public awareness/reporting. Incident analysis is a fundamental piece of the Standard of Coverage (SOC) study, now performed by many agencies to measure level of service and demonstrate to government officials and the public that the department is effective.

Risk and program data typically includes

- Historic emergency responses (by incident and apparatus)
- Fire inspections and preplans
- Special studies

The Kent Fire Department obtains incident data in real time from Valley Com. All information is transferred into the department's RMS for inspection. Once addresses are standardized, call types confirmed, and time stamps verified, the incidents are geocoded, mapped, and analyzed. In 2009, Kent Fire was reaccredited by the Center for Public Safety Excellence (CPSE). Historic incident data, analyzed to demonstrate agency performance and improvement, played a key role in the reaccreditation process. Kent Fire also monitors risk through special studies, including multiple responses to the same address, suspicious fires, and frequent false alarms. These studies guide fire operations planning and fire prevention programs.

## Modeled and Derived Data

After obtaining and validating a variety of framework and spatial datasets, public safety GIS analysts create even more data. These derived datasets might include

- Primary station response areas
- Emergency response

- Operation plans
- Mutual, automatic aid relationships
- Growth analysis
- Capital facility plans
- Standard of coverage

As they assemble information, Kent GIS analysts apply many standard and innovative workflows to analyze data. They will compare and contrast data reflecting value, hazard, and risk with levels of protection. They monitor growth within the community and carefully plan for today's operations and for the future.

Recent *ArcUser* articles include many examples of public safety modeling that use actual data provided by Kent Fire and address topics such as the fundamentals of planning, preparedness, response, and recovery; the use of data for master plans and capital facility plans; planning operations; and assessing and presenting performance measures.

On April 27, 2010, southern King County voters approved a proposition that merged the Kent Fire Department and Fire District 37 into a new Kent Regional Fire Authority (RFA), effective on July 1, 2010. The new Kent RFA continues to provide the highest level of fire and emergency medical service throughout the cities of Kent and Covington and in unincorporated areas of King County previously within Fire District 37.

## Acknowledgments

The author wishes the department all the best and thanks its staff and officers for the exceptional assistance and support they provided for public safety mapping; modeling; and, of course, data management.

### Recent *ArcUser* articles on performing public safety modeling

- [Under Construction: Building and calculating turn radii](#) [PDF]
- [Run Orders: Modeling and mapping public safety arrival orders](#) [PDF]
- [Do It Yourself: Building a network dataset from local agency data](#) [PDF]
- [Convincing the Chief: Proving that time-based networks really work](#) [PDF]
- [Using 9.3 Functionality and Scripts: Calculating transportation network slope and travel parameters](#) [PDF]

(This [article](#) [PDF] originally appeared in the Fall 2010 issue of *ArcUser*.)



# Revisiting the Glenrosa Fire

## Evacuation modeling with ArcGIS Network Analyst 10

By Mike Price, Entrada/San Juan, Inc.

### What You Will Need

- ArcGIS 10 for Desktop
- ArcGIS Network Analyst 10 extension
- Sample dataset downloaded from [ArcUser Online](#) [ZIP]

On July 18, 2009, at approximately 2:30 p.m., a small wildfire started in wooded hills west of Glenrosa, a neighborhood in West Kelowna, located on Lake Okanagan in southeastern British Columbia—an area that has seen its share of wildfires.

Pushed by 37 mph winds, the fire spread quickly to the Glenrosa neighborhood, and the residents of approximately 3,000 homes were quickly evacuated. An evacuation center was established at Royal LePage Center, a large civic complex next to the West Kelowna City Hall. In the five days required to contain it, the Glenrosa/Gellatly fire burned more than 900 acres and damaged or destroyed several homes. At its height, the fire caused the evacuation of more than 11,250 residents.

This ArcGIS 10 exercise shows how the ArcGIS Network Analyst extension can be used to identify, accumulate, and route an at-risk population from homes or workplaces to safety. This



On July 18, 2009, a small wildfire in the hills west of Glenrosa, in southeastern British Columbia, quickly spread and necessitated the evacuation of approximately 3,000 homes.

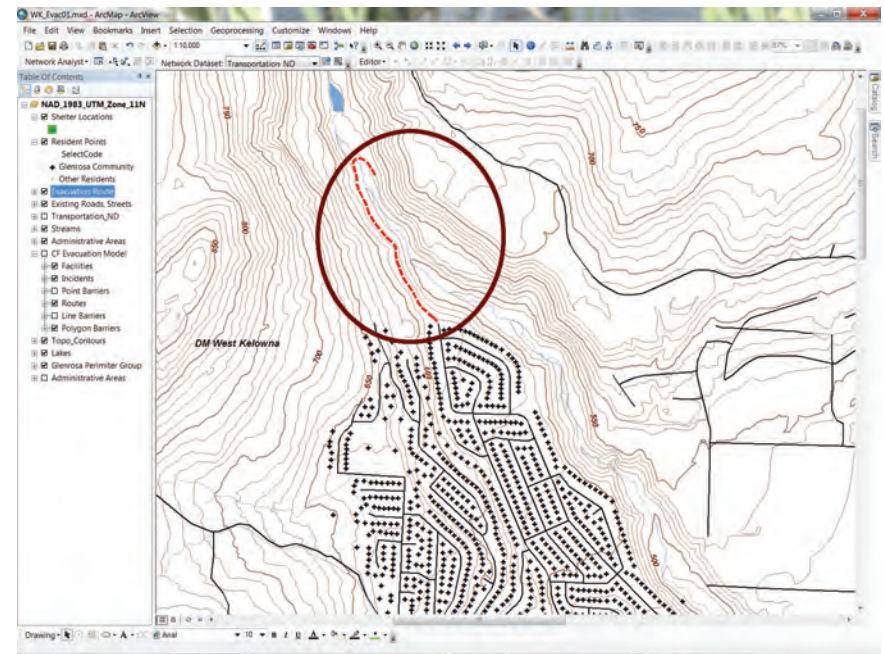
exercise walks the reader through assessing the evacuation potential of over 1,000 homes in the Glenrosa neighborhood and testing evacuation options using the actual Glenrosa/Gellatly fire footprint. Had the fire expanded only slightly, the entire community would have become cut off from safety. To respond

to this scenario, the exercise will test a hypothetical "back door" that might allow evacuation of many residents directly away from the advancing fire.

## Part I: An Overview of Evacuation Modeling with ArcGIS Network Analyst

Time-based evacuation modeling is a key component in any community disaster plan that requires assembling and relocating many residents to safe areas or having them simply leave their homes and workplaces. Because evacuations typically involve coordinating the actions of private citizens who may or may not be well informed, are traveling primarily in private vehicles, and are responding to an immediate or near immediate event, successful outcomes depend on careful planning, proper notification, and safe and timely community response. Defining, understanding, and anticipating traffic behaviors are key to a safe and efficient evacuation.

ArcGIS Network Analyst is an excellent tool for mapping and modeling time- and distance-based travel. Network Analyst's Closest Facility (CF) solver connects evacuee points with identified shelters or egress points and calculates the optimal time and distance for travel by many evacuees to one or more safety points. Roads blocked by fire, flooding, wind damage, and other obstructions may be modeled. Multilane routes can be modeled to include both responding and evacuating traffic. Analysis identifies high-volume and restricted intersections and



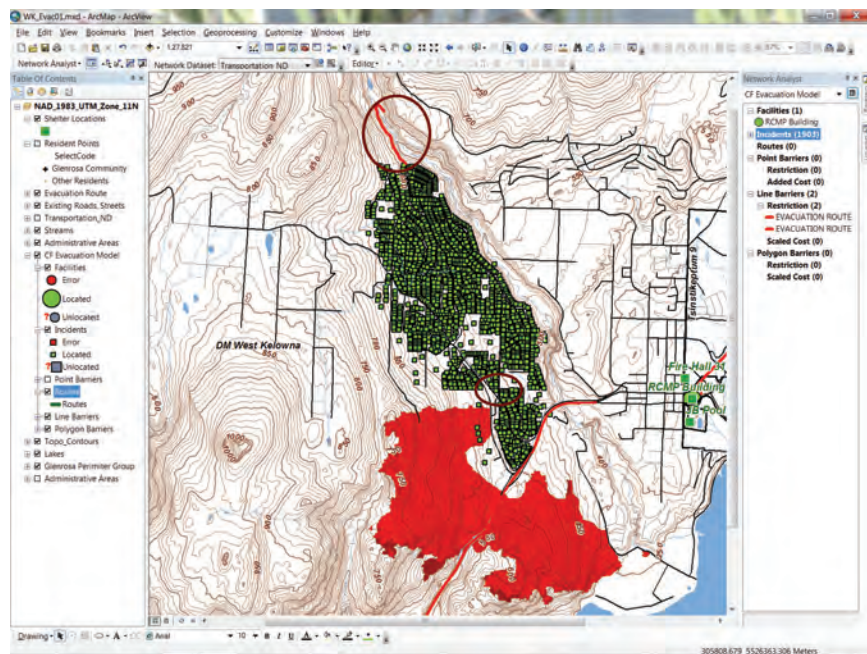
This is one of the two ovals on the map that highlight critical parts of the model. They will be used to refine the evacuation plan.

where traffic may be managed by traffic control or by diverting certain evacuees to an available secondary route.

## The ArcGIS Network Analyst Closest Facility Solver

The Network Analyst extension contains several robust solvers that allow emergency service modelers to map and model many time and distance travel issues. The CF solver was designed to locate the closest service or care facility to a specific event. For example, in response to an automobile accident (i.e., Incident), a

patient may require transport to a hospital (i.e., Facility), and a towing company may be needed to remove damaged vehicles from the scene. The CF solver maps the accident location and searches for one or more nearby medical facilities using a travel time solution. Because the services of a tow truck are not time sensitive, the CF solver might identify facilities based on the shortest travel distances from the accident.



In the table of contents, right-click the CF Evacuation Model, select Properties, and open the Analysis Setting tab to verify that travel is set from incidents to one facility and no time cutoff has been applied.

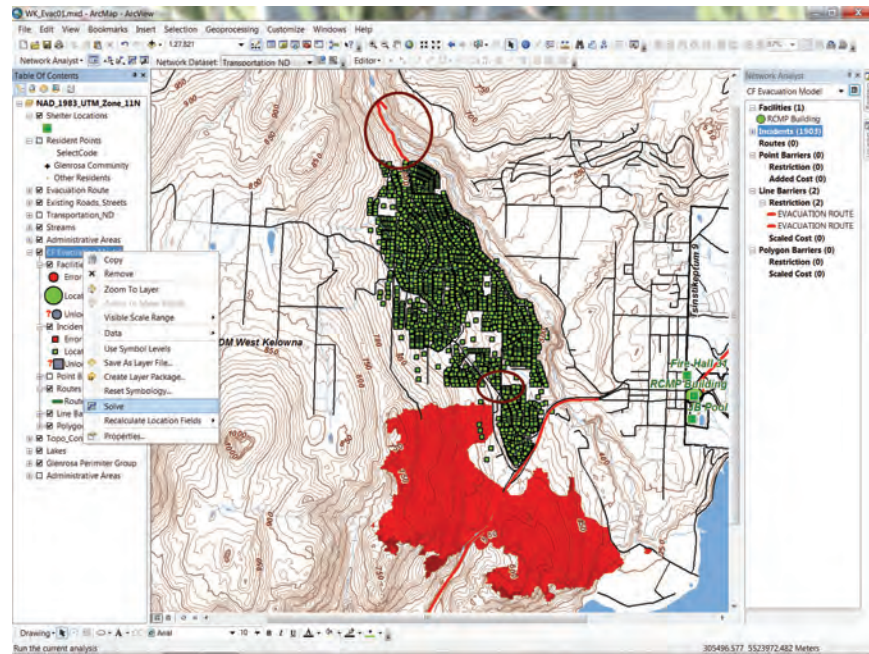
To model evacuees with the CF solver, the evacuated households and other occupancies become the Incidents, and the evacuation centers, outside gates, or other points of egress become Facilities. If several shelters or gates are available, all evacuees may be modeled using several destinations. The solver returns an arrival time, arrival order, and distance traveled for each evacuee at one or more destinations. In ArcGIS 10, point, polyline, and polygon barriers may be used to restrict and reroute travel to simulate the effects of roads closed as a result of flooding, wildfire, earthquake, toxic plumes, or other adverse conditions. In addition to routing, the solver also identifies residents who may become trapped if the area involved in the Incident expands.

## Preparing Input Data

Time-based travel modeling requires accurate, current, complete street datasets that have been properly designed and prepared. Street datasets must perform predictably in a network modeling environment and include proper impedance values (for speed and distance), connectivity, directionality, crossing geometries, and turn modifications. For more information about network streets, read "[It's All about Streets: Tips and tricks for obtaining, building, and maintaining time-based network streets](#)" [PDF] in the Fall 2009 issue of ArcUser. If possible, compare streets to current aerial imagery and check alignments for accuracy, completeness, and connectivity. Imagery also aids locating



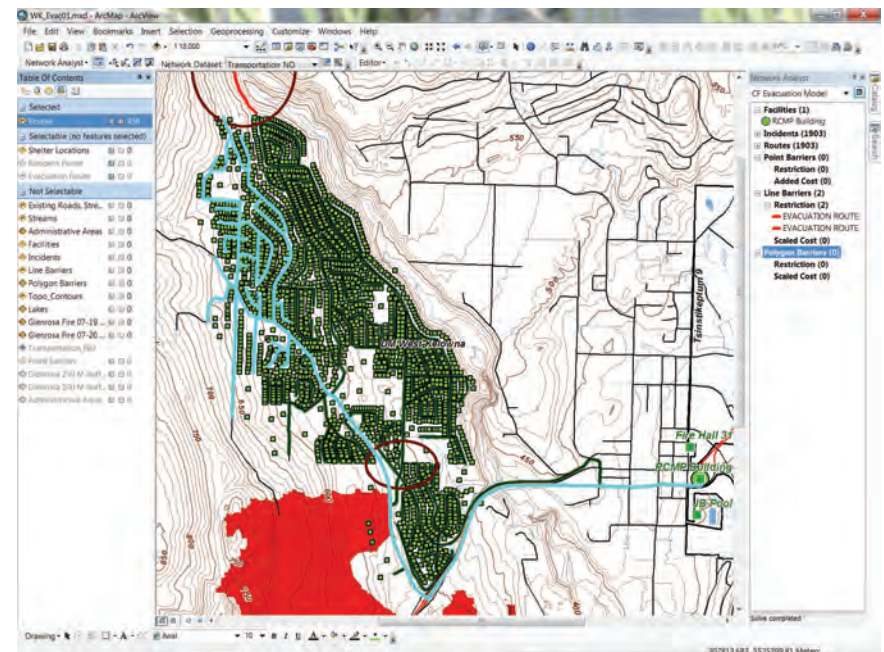
and counting individual occupied structures or when mapping obscure, often private access to houses.



After checking the properties for the CF Evacuation Model, right-click it in the TOC and choose Solve.

Next, identify the residents likely to be evacuated and locate them on a map. For existing residents, the county assessor's parcel map and actual building footprints are very helpful. If you have good aerial imagery but no building polygons, you can add residence points to individual structures. As Census 2010

block-level data becomes available, rooftop dwelling counts can be verified. If the community has performed community-level mapping and a structure vulnerability assessment, include this information, too.



Using the Select By Polygon tool shows an accumulation of 456 residences evacuating on Glenrosa Road just below Country Pines Gate.

Future populations at risk may be derived from development plans, neighborhood as-built drawings, and population projections from growth plans. Proposed transportation corridors



will come from transportation plans and growth management information. Add these corridors to a separate version of the primary street network or include them as a separate feature class included in a transportation feature dataset maintained in a file geodatabase.

Shelter capacity and shelter opening requirements must be determined and mapped. Many local and regional emergency response plans identify and describe evacuation shelters and the evacuation corridors leading to them. If possible, incorporate values for the carrying capacity of evacuation corridors into the street dataset. Locate and describe alternate shelter sites to accommodate both anticipated and unexpected changes in the development of an Incident. Define natural and man-caused hazards and risks in the community and include them in the study.

Finally, develop a community notification and communication network. Inform residents of the notification procedures, the primary egress routes, and locations and capacity of alternate shelters.

## The Closest Facility Solver

After obtaining, standardizing, and mapping the data listed in Table 1, build a preliminary evacuation model. First, create an ArcGIS network and test it for connectivity and performance. Next, add evacuation shelters and/or egress portals to the map. Finally, add residence points. Each point represents an

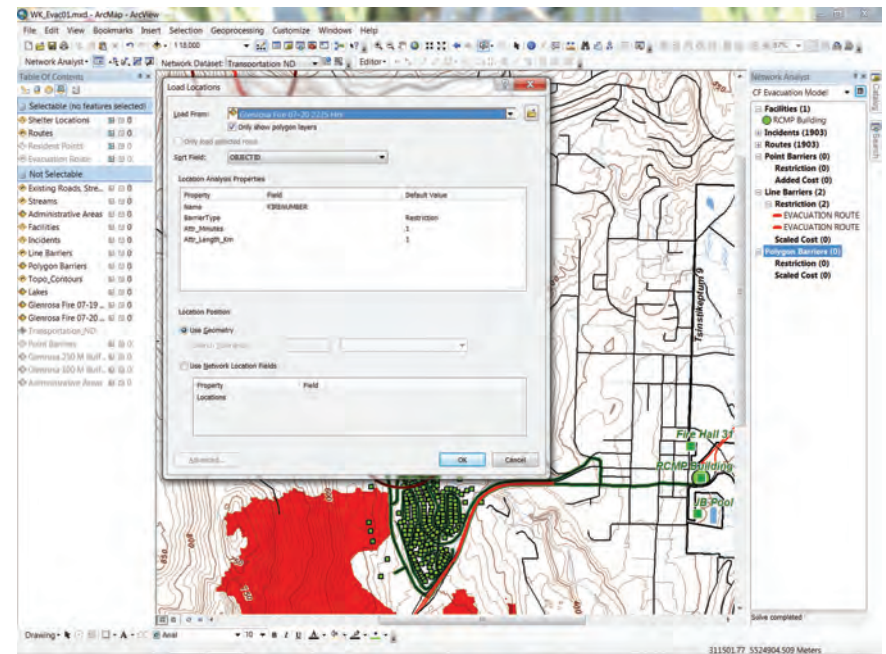
occupied structure, not an individual or vehicle. If available, add commercial or institutional facilities with attributes describing their occupancy.

**Table 1. Sources for data**

Data Sources for Evacuation Candidates	
Existing communities	Proposed development
Census block-level data	Site plans
Assessor parcels	Tentative tract maps
Residence counts based on use class, zoning designation, building footprints, or effective area	Estimated points
Data Sources for Network Streets	
Existing communities	Site plans
Local jurisdictions	Tentative tract maps
Commercial streets	Estimated centerlines
Proposed development	
Data Sources for Evacuation Destinations and Shelters	
Existing communities	Proposed development
Site plans	Local or regional jurisdiction(s) having authority
Emergency response plans	Tentative tract maps
Local or regional mapping datasets	Estimated locations
Data Sources for Evacuation Hazards	
Recognized hazards	Anticipated hazards
Local or regional jurisdiction(s) having authority	Modeled natural hazards (slope, vegetation/fuels, geologic hazards, flooding, wind damage, ice storm)
Emergency response plans	Transportation concerns (roads, bridges, terrain, blockage)
Local or regional mapping datasets	

After loading all input data, construct an initial CF solver. Shelters and egress points are loaded as Facilities, and the occupied structure points are loaded as Incidents. Multiple potential facilities may be modeled, routing evacuees to closest and alternate destinations. Set the travel direction from Incidents to Facilities. For most evacuation models, do not specify a maximum travel time. The CF solver is now ready to run; egress routes for the street network can be constructed, and travel times and distances can be accumulated along those routes.

Inspect and verify the preliminary results. A large model with many residences and multiple egress points requires some time to run, so be patient. Once completed, you can inspect and count the number of evacuees using specific egress routes. Using procedures presented in a future article, you may join and tabulate and superimpose stacked evacuation routes on the underlying street dataset and apply polyline symbols of varying width and color to represent the accumulation of evacuees along assigned routes. Stacked routes at street intersections may be summarized to provide counts of all vehicles that will pass through specific intersections. If certain routes or intersections are overloaded, secondary evacuation routes may be assigned to selected evacuees. Routes and intersection events may be recounted, certain evacuees can be redirected to alternate routes, and the model can be run again.



In the Network Analyst Window, right-click Polygon Barriers and choose Load Locations. Load locations from Glenrosa Fire 07-20-2225 Hours and set the Sort field to OBJECTID and the Name field to FIRENUMBER.

If you add closed or restricted egress to the model, save and replicate this CF model as a base case. In ArcGIS 10, you can add point, polyline, or polygon barriers that represent road closures or blockages. New in ArcGIS 10, polygon and polyline barriers can include fire progression shells, expanding flood areas, and mobile toxic plumes. You can run multiple copies of the CF model to test the effect of an expanding or moving hazard.

## Part II: Revisiting Glenrosa

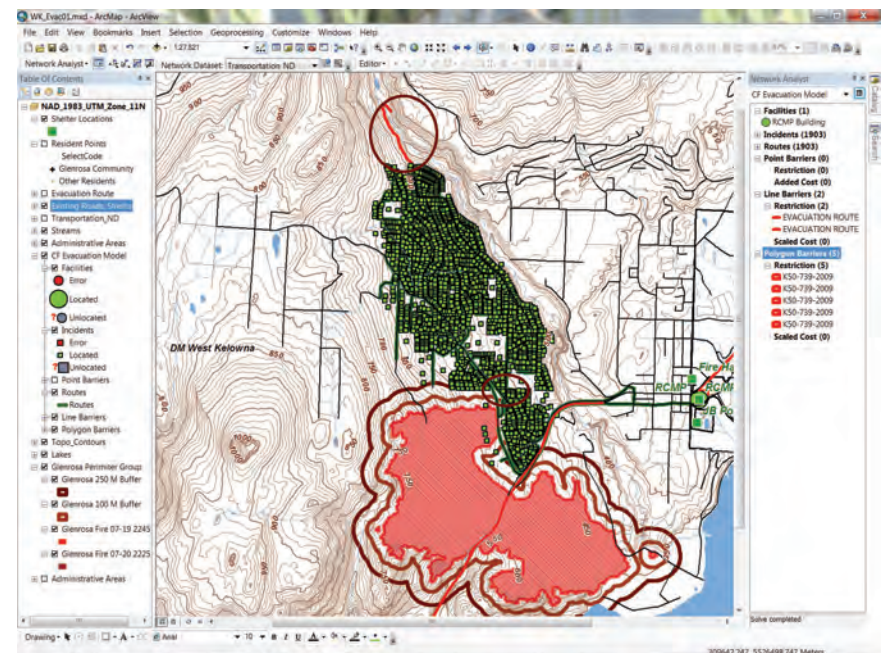
To begin this evacuation modeling exercise, download and unzip training data from [ArcUser Online](#) [ZIP] locally. Start ArcMap 10, navigate to the WK\_Evacuation folder, and open WK Evac01.mxd. Notice the many Residence Points within the Glenrosa neighborhood and the three Shelter Locations near the lake. The ultimate destination for evacuees will be the Royal LePage Center located approximately 3 miles east of the RCMP Building, so the RCMP facility will be used as the preliminary destination.

In the table of contents (TOC), inspect the CF Evacuation Model. For readers who are new to ArcGIS Network Analyst, the author has created a composite Network Dataset and initiated a CF solver. No Facilities (Shelters) or Incidents (Residences) are included in the solver; these will be added during the exercise.

1. In the TOC, right-click CF Evacuation Model and select Properties. Review the Analysis Setting tab and notice that Incidents are only routed to one Facility and there is no time limit.
2. Open the table for Line Barriers. There are two records. These lines block the proposed evacuation route.

3. Inspect the three Shelter Locations and the Residence Points. The RCMP Building will be a destination staging area where evacuees will be sent before going on to the Royal LePage Center located a little more than 3 miles to the east.

This model includes 1,903 Glenrosa residences that were separated from other residences with a definition query. Residences, not occupants or vehicles, will be counted. Notice the ovals in the north and south, which will be used to highlight critical parts of the model.



Resolve the model and inspect the Lower Glenrosa evacuation route. How many evacuees use this route now? How many use Glenrosa Road?

4. In the TOC, make the Glenrosa Perimeter Group visible. This group contains perimeters for the evenings of July 18 and July 19 and two buffers for the July 19 perimeter. These will be used to refine the evacuation plan. Note that the fire burned right up to Glenrosa Road, the major access road for the community. If this road was blocked, evacuation could become very difficult.
5. Switch from layout view to data view, the view in which modeling will be performed. With the Glenrosa perimeter visible, zoom in to the southern ellipse, an area where blocking just two roads—Glenrosa, Webber, and Lower Glenrosa Roads—will isolate all residents north of this area. Using the Measure tool, determine that it is less than 250 m from the July 19 perimeter to the center of this critical area.
6. Now, zoom north to the second ellipse. The dashed red line represents a proposed secondary route in and out of the community. This hypothetical route will be used to test evacuation options if the southern route is blocked. Zoom back out using the map document bookmark WC 1:25,000.
7. Verify that Network Analyst is available and load its toolbar. Open the Network Analyst window and dock it on the right side of the interface.

## Loading Shelters and Residences and Running a Prefire Model

1. In the Network Analyst window, right-click Facilities and select Load Locations. Load from Shelter Locations, select Index as the Sort field, set the Name to Label, and note the tight search tolerance of 0 meters. Click OK.
2. Right-click Incidents in the Network Analyst window and load the Glenrosa residences as Incidents from Residence Points. Set both the Sort field and Name to Index. Check the map and save it. Multiple iterations of this solver could be used by copying and pasting the original solver back into the TOC, renaming each copy. However, this exercise will modify just one solver.
3. In the TOC, locate the CF Evacuation Model and make Line Barriers visible. These lines are the current blocks on the proposed northern egress. Right-click the CF solver, select Properties, and open the Analysis Setting tab. Verify that travel is set from Incidents to one Facility without a time cutoff.
4. Close Properties and solve the model. Right-click the CF solver in the TOC and choose Solve. Close the warning message after reading it. After the solver has finished working, inspect the results and save the project.
5. To quickly count evacuee routes, switch the TOC from List By Drawing Order to List By Selection. Make only Routes, Shelter



Locations, Residences, and Evacuation Routes selectable and use the Select By Polygon tool to move to a location anywhere in the network to create a small selection box across the evacuation routes leading toward the shelter.

6. In the TOC, look at the count of routes that have accumulated. The count shows an accumulation of 456 residences evacuating on Glenrosa Road just below Country Pines Gate and 217 houses being evacuated from Herbert Road, about 0.7 km west of the RCMP Building. Testing just west of the RCMP Building should show that all 1,903 residents can safely reach the shelter.

## Loading Polygon Barriers and Resolving

The next step will be to load the Glenrosa fire perimeter. ArcGIS 10 doesn't require placing and managing many barrier points to emulate complex geometries. Instead, restricting network travel is accomplished more simply by loading polyline and polygon barriers.

1. In the Network Analyst Window, right-click Polygon Barriers and select Load Locations. Load from Glenrosa Fire 07-20-2225 Hours. Set the Sort field to OBJECTID and set Name to FIRENUMBER. Click OK and save the project.
2. Because the TOC is set to List By Selection, solve the model again by clicking the Solve icon on the Network Analyst toolbar. (This solves using the current solver in the Network

Analyst window, so be careful if the TOC contains multiple solvers.)

3. When the solver is finished, the Glenrosa fire perimeter should have closed Glenrosa Road, and 1,897 residences will now have to evacuate by sneaking around on Lower Glenrosa Road.

## Expanding the Fire by Loading Buffers

What happens if the fire crosses Glenrosa Road and extends into the Webber/Lower Glenrosa area? How will the thick smoke and close proximity to the flames along Glenrosa Road affect evacuation efforts?

1. Load the 100 m and 250 m buffers to test this possibility. In the TOC, momentarily return to List By Drawing Order, open the Glenrosa Perimeter Group, and make Glenrosa 100 M Buffer and Glenrosa 250 M Buffer visible.



What happens if the fire crosses Glenrosa Road and extends into the Webber/Lower Glenrosa area? How will the thick smoke and close proximity to the flames along Glenrosa Road affect evacuation efforts?



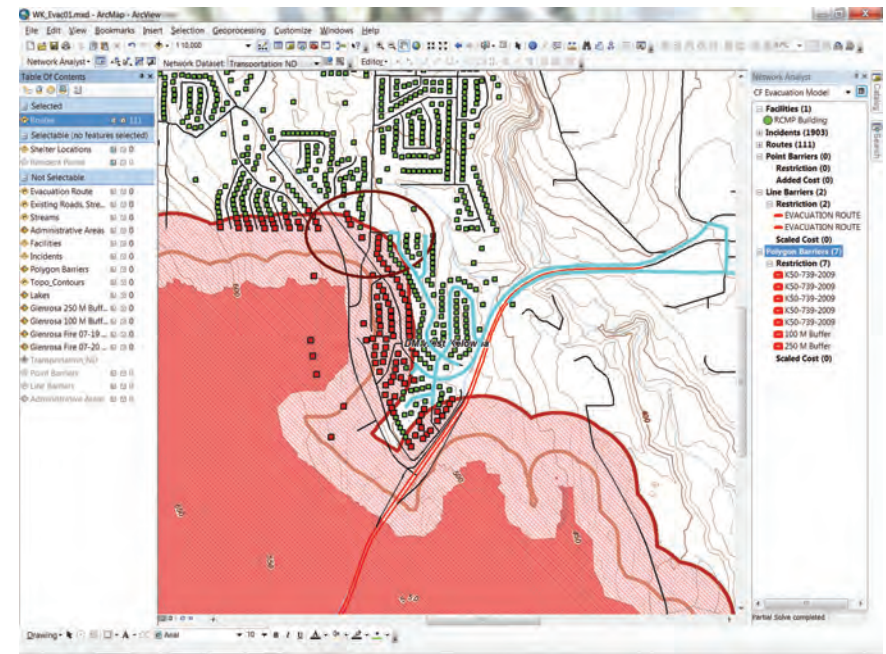
2. Change the TOC back to List By Selection. Right-click Polygon Barriers in the Network Analyst window and choose Load Locations. Load the Glenrosa 100 M Buffer and specify OBJECTID for the Sort field and Label for the Name field. Resolve the network and inspect the Lower Glenrosa evacuation route. How many evacuees use this route now? How many use Glenrosa Road? Save the project.

Challenge Question: How many residences are burned over, and where are they located? How many residences are not accounted for in this iteration of the model? The answer is given at the end of the article.

3. To expand the fire footprint, load the Glenrosa 250 M Buffer in Locations and specify OBJECTID for the Sort field and Label for the Name field. Resolve the model and inspect the results. Select and count the evacuees arriving at the RCMP Building. Now 111 residences can evacuate, but 1,792 residences have been burned over. This must be fixed.

## Opening the Back Door

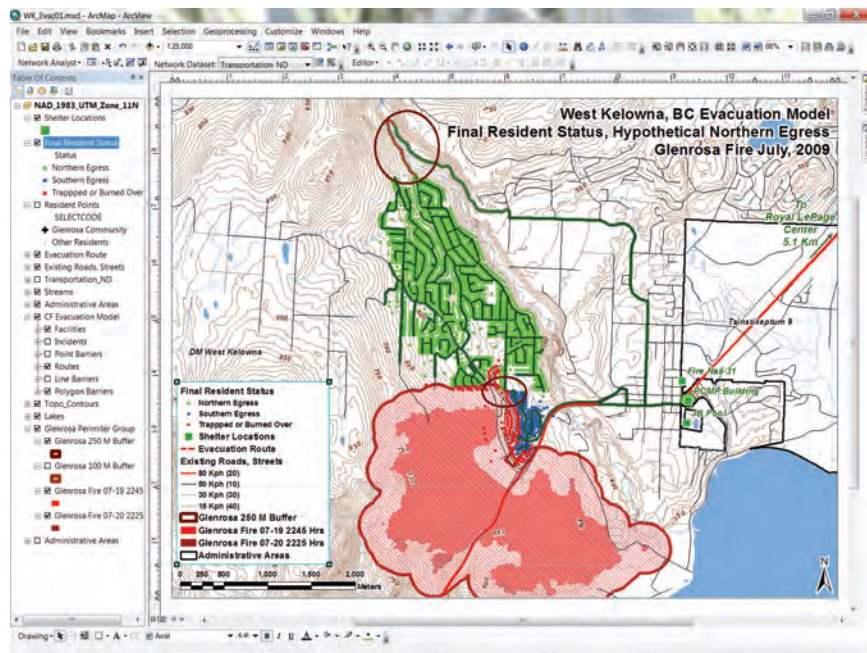
In the area where urban development meets forest land (the wildland-urban interface), it is important for communities to have alternate means of egress in the event that primary routes are blocked. Using topography, imagery, and existing roads and trails, the author designed a hypothetical northern egress route



After adding the Glenrosa 250 M Buffer, only 111 residences can evacuate, and 1,792 residences are threatened.

that exits the Glenrosa community in the far north. However, to use this route requires opening the gates and instructing many evacuees to travel north instead of south. This proposed route is narrow and slow, but it is far from the fire threat.

In the Network Analyst window, right-click Line Barriers and select Delete All. Save the project and solve it again. Now, 1,643 residents have egress along the northern portal, and 111 residents will still be evacuated in the south. Unfortunately,



The Final Resident Status shows how relates, spatial selects, and some minor editing were used to code all Glenrosa residences to evacuation routing, taking into account the full 250 m fire buffer and the proposed northern egress. Residences subject to entrapment and direct fire exposure are noted.

149 residences will be burned over. By preparing a series of relates and attribute queries, where residents live and work can be quickly determined so they can be quickly moved out of harm's way.

## Finishing Up

1. To finish this exercise, switch back to List By Drawing Order in the TOC and zoom to the WK 1:25,000 bookmark.
2. Navigate to \WK\_Evacuation\SHFiles\UTM83Z11 and load the Final Resident Status Layer file.
3. Add this layer to the map's legend. Open its table, move to the far right, and inspect the Status field. Using a series of relates, spatial selects, and minor editing, the author coded all Glenrosa residences with their assigned evacuation routing using the full 250 m fire buffer and the proposed northern egress. Residences subject to entrapment and areas subject to direct fire exposure are identified. This map shows one way this data could be presented to the community.

Challenge Answer: Lower Glenrosa: 1,886; Glenrosa: 3;  
Unaccounted for: 14

## Acknowledgments

The author thanks the staff of the District of West Kelowna—especially GIS analyst Kevin Wang—for the opportunity to re-create the Glenrosa Fire incident with actual district data and experiment with alternatives to extend and test the evacuation model. Thanks also go to the Vancouver and Kelowna offices of ESRI Canada Limited for their encouragement in choosing this incident to model.

Thanks go as well to the Esri Network Analyst development team members for their patience, recommendations, and support (both moral and technical) in the author's continued testing of this very effective and innovative product. Thanks for the polyline and polygon barriers—they are great!

(This [article](#) [PDF] originally appeared in the Winter 2011 issue of *ArcUser*.)

# Analyzing Frequent Responses

Using a US National Grid spatial index

By Mike Price, Entrada/San Juan, Inc.

## What You Will Need

- An ArcGIS 10 for Desktop (ArcView, ArcEditor, or ArcInfo) license
- [Sample data](#) [ZIP]

An index of US National Grid (USNG) coordinates can be summarized to provide public safety mappers with response statistics including number of calls for service, number of units deployed, and total deployment time.

Public safety providers know that calls to certain locations occur at a much higher frequency than others. Medical centers, care homes, schools, public buildings, and hazardous transportation locations are examples of places that receive a disproportionate number of emergency responses each year. Service providers carefully monitor trip counts and time in service for these locations and schedule apparatus and personnel to accommodate the high frequency of these calls. However, to understand these demand locations requires mapping, analyzing, and summarizing them.

Modern computer-aided dispatch (CAD) centers often provide longitude and latitude coordinates for emergency destinations. In the past, these longitude and latitude strings have been

concatenated, or added together, to create a single text location index.

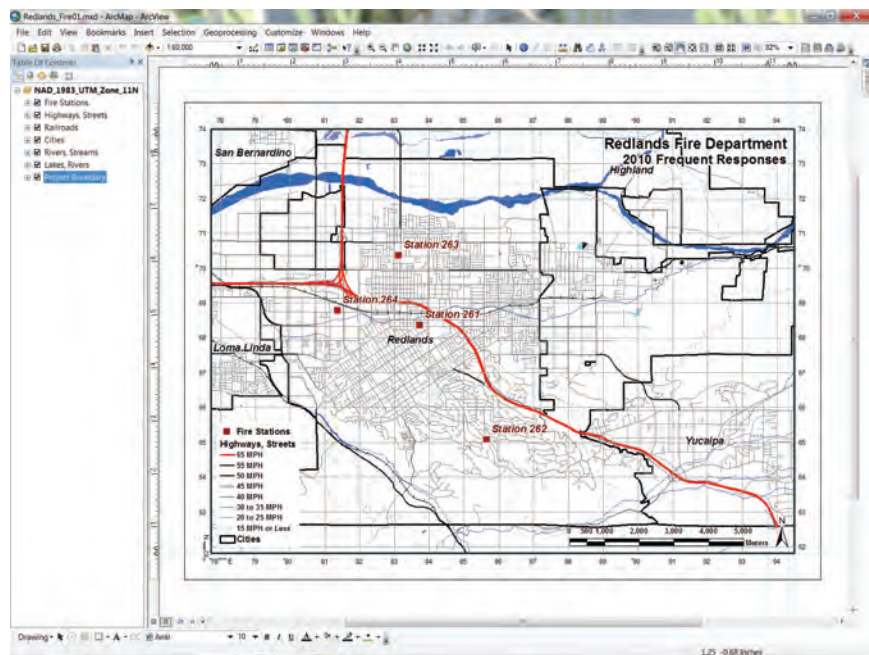
USNG provides a unique single-string address for every location on the planet. Using USNG, a single location may be described as a 15-character string with a resolution of one meter. ArcGIS 10 provides tools for calculating USNG addresses for points when other coordinates are available. Because modern CAD centers provide destination coordinates in longitude-latitude, this data can be used to index frequent responses.

In this exercise, we will summarize recent incident data for Redlands, California, and apply a USNG spatial index to count and summarize repeated travel to these high-demand locations. Once these frequent response locations are identified, the emergency facilities that serve these locations can be reviewed, and a preliminary understanding of typical time in service for these locations can be gained.

## Getting Started: Setting Up the Redlands Fire Map

Download the sample dataset for this exercise, [nationalgrid.zip](#) [ZIP]. Unzip it into a project folder and open Redlands\_Fire01.mxd.





Open Redlands\_Fire01.mxd. It shows highways and streets in the Redlands area and five fire stations that protect the area.

This map shows highways and streets in the Redlands area and five fire stations that protect the area. The exercise uses actual incident-level data for 2010 responses in and around Redlands. Notice that this map's coordinate system is universal transverse Mercator (UTM) North American Datum of 1983 (NAD 83) Zone 10, and the unit of measure is meters. The Redlands Fire Department typically maps in California State Plane System, but because the exercise will use USNG (which uses metric units) to index these locations, the map in the sample dataset uses UTM

coordinates. Although this switch is not required, it simplifies data validation and map grid display.

## Bringing Apparatus and Incident Spreadsheets into ArcGIS 10

Microsoft Excel spreadsheets are often referred to as the "fire chief's database." Public safety data analysts often compile, convert, and transmit data in spreadsheets. In the past, GIS analysts often trained spreadsheets to behave like a database and exported the tabular data in dBASE format, which is compatible with the Esri shapefile format.

Newer versions of Excel (2007 and 2010) do not export dBASE files directly, so another approach was needed. ArcGIS can read Excel spreadsheets directly, but querying, editing, and other analytic functions are restricted or not possible. Using the file geodatabase, Excel worksheets can be imported into a GIS format with full table functionality.

1. Open ArcCatalog and navigate to \Redlands\_Fire\XLSFiles\RFD\_App\_2010\_Sample.xls. This sample of Redlands Fire apparatus-level data will help you better appreciate the complex nature of response data obtained from a CAD center. This spreadsheet contains one worksheet that lists several hundred sample response records for individual apparatus. Notice that each incident is assigned an incident number, alarm date, station and shift, incident type and initial dispatch



code, unit ID, and numerous date/time stamps. Notice, too, that each apparatus record contains longitude-latitude coordinates and a descriptive address.

2. Scroll across the table for RFD\_App\_2010\_Sample.xls. Because this is apparatus-level data, one incident may have more than one apparatus assigned, which generates multiple records for a single incident number. In the First\_On\_Scene field, the numeric code 1 indicates that this apparatus was the first to arrive at the incident. Response time for that incident will be measured by this unit's performance.
3. Preview the Database sheet for RFD\_Inc\_2010.xls. This incident-level data for 2010 will be imported into an ArcGIS file geodatabase. This table is a summary of more than 16,000 original records in the apparatus dataset. The total incident count for 2010 was 8,281. On average, two apparatuses were assigned to a typical incident, although many incidents required only one responding unit.
4. Sort this table on Responder\_Count to see the maximum number of apparatuses assigned to each 2010 incident. This table also summarizes the total time accumulated for each incident from the time dispatched (T2) to the time cleared (T5). Look for these fields in the sample data. These times are stored in a legacy format (Lotus 1-2-3 Date/Time). They can now be managed directly in ArcGIS 10—a great enhancement

for public safety analysts, for whom time is certainly of the essence.

## Importing an Excel Worksheet into a File Geodatabase

After reviewing the source data table, import it into an existing file geodatabase.

1. In ArcCatalog, right-click RFD\_Inc\_2010's Database sheet and select Export, then To Geodatabase (single). Set Output Location to \Redlands\_Fire\GDBFiles\CASP835F\Incidents.gdb and name it RFD\_Inc\_2010. Because this spreadsheet will be exported to a geodatabase, long field names will be preserved. Click OK to export the table.
2. Open the exported table in Incidents.gdb and verify that all 8,281 records were transferred. Sort the exported table on Responder\_Count to see incidents with 12 responders.
3. Look at the data in the T5\_T2\_Sum1 column. Sort in descending order in this field. Notice that total deployment time for all apparatuses for the first incident was more than 340 minutes, so the average time per apparatus was just under 30 minutes. This incident is coded as a vehicle accident with injuries, and it appears that many medical units were needed. The 100 series incidents are mostly structure fires (code 111), which often require many apparatuses. Close ArcCatalog and return to ArcMap.

## Calculating USNG Addresses for 2010 Incidents

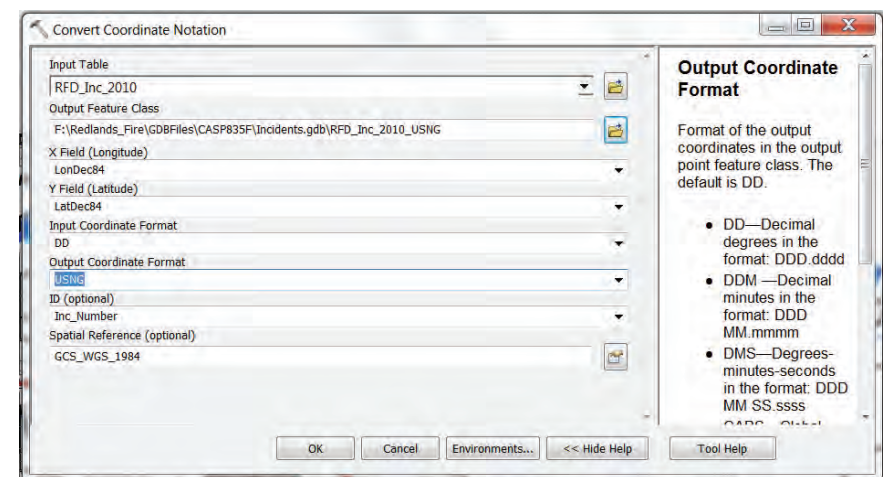
1. In ArcMap, switch from Layout View to Data View. Click Add Data and navigate to \Redlands\_Fire\GDBFiles\CASP835F\Incidents.gdb and add the RFD\_Inc\_2010 table. After adding it to the map, open the table and verify that it contains 8,281 records. The next step is to assign USNG coordinates to all records as a new point feature class. Inc\_Number will be the unique string used to support the tabular join performed later in the exercise that will allow USNG coordinates to be joined to the RFD\_Inc\_2010 table.
2. Open ArcToolbox and choose Data Management Tools > Projections and Transformations toolset > Convert Coordinate Notation. This tool converts a table containing point coordinate fields to a point feature class. The coordinate field

Table 1: Convert Coordinate Notation dialog box

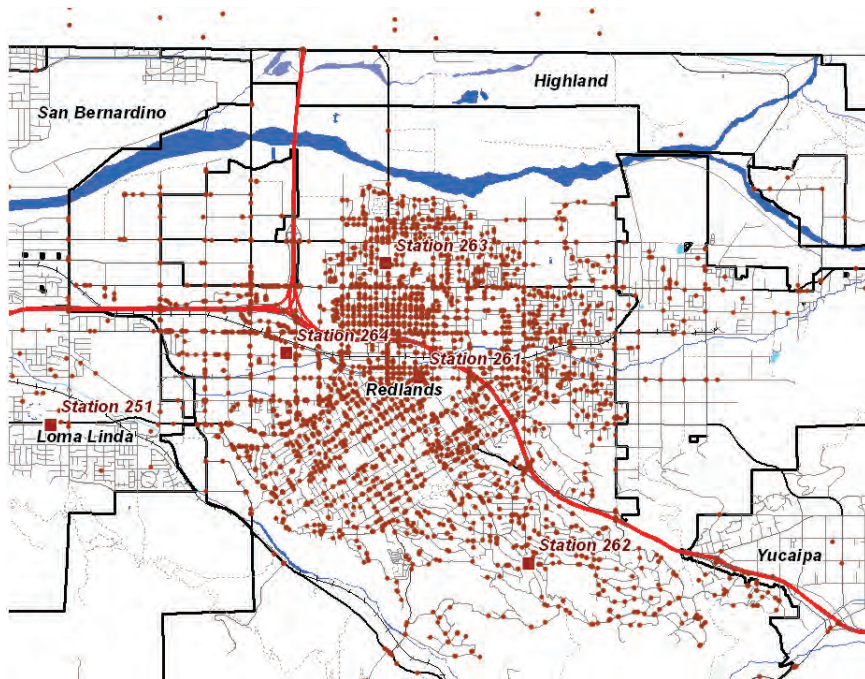
Dialog box field	Value to input
Input Table	RDF_Inc_2010
Output Feature Class	\Redlands_Fire\GDBFiles\CASP835F\Incidents.gdb\ RFD_Inc_2010_USNG
X Field (Longitude)	LonDec84
Y Field (Latitude)	LatDec84
Input Coordinate Format	DD
Output Coordinate Format	USNG
ID (optional)	Inc_Number
Spatial Reference (optional)	GCS_WGS_1984

for the input table can be one of many notations (Global Area Reference System [GARS], Military Grid Reference System [MGRS], and others). The output point feature class contains a point coordinate field in the coordinate notation you choose—USNG in this case. Complete the dialog box as indicated in Table 1, making sure to set Output Coordinate Format to USNG.

3. Click OK to build this new point feature class. When the points are added to the map, open and inspect the table. It's pretty simple, but it is also very powerful. By joining on Inc\_Number, all incidents in the table can be populated with a USNG coordinate.



Use the Convert Coordinate Notation tool to convert a table containing point coordinate fields in RFD\_Inc\_2010 to a point feature class with a point coordinate field in USNG.



Map the new USNG point feature class.

## Table Updates and Tabular Joins

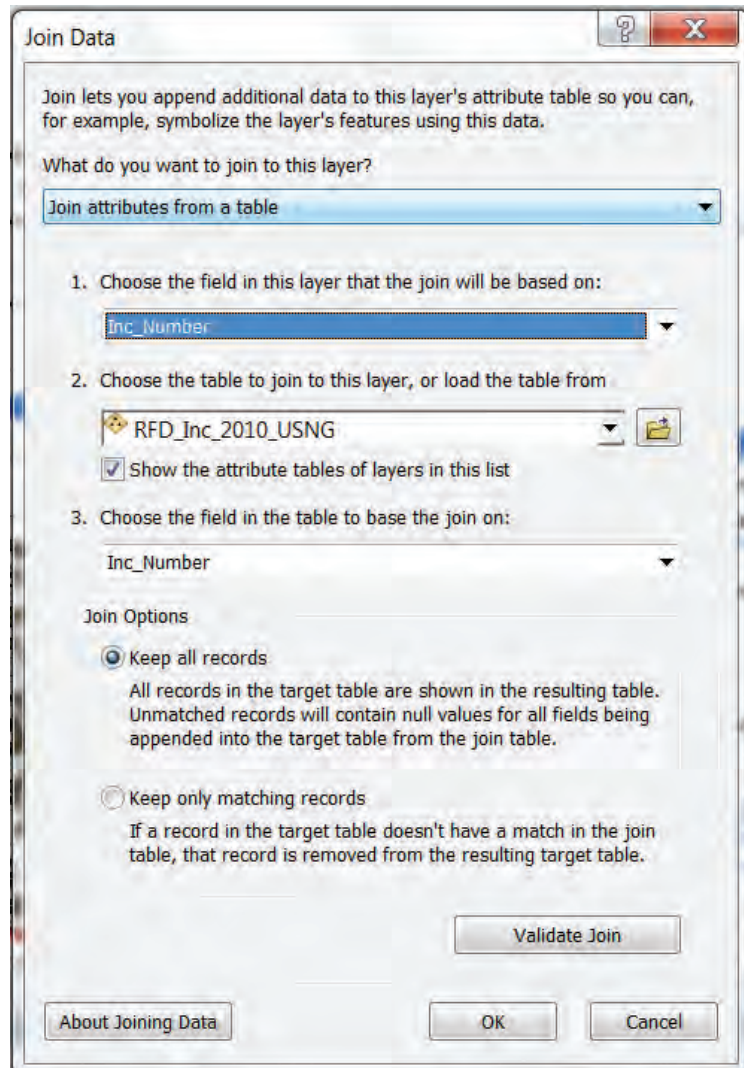
1. Add a field to RFD\_Inc\_2010 to store the USNG coordinate. Open the attribute table, click Table Options in the upper left corner, and select Add Field. Name the field USNG, select Text as the field type, allow NULL values, and set the width to 20 characters. As presently deployed, USNG coordinates contain up to 15 active characters. With additional space for readability, it will become slightly longer.

Field Properties	
Alias	
Allow NULL Values	Yes
Default Value	
Length	20

After populating the new USNG field using the Field Calculator, summarize the data in that field.

2. Join the RFD\_Inc\_2010 table to the RFD\_Inc\_2010\_USNG table using Inc\_Number as the join field. Click OK to complete the join. Inspect the work and save the project.
3. Now populate the new USNG field with coordinates obtained from the joined table. Select USNG in RFD\_Inc\_2010 (the host table) and open Field Calculator. Make sure VBScript is selected and use the following string to calculate this field:

**[RDF \_ Inc \_ 2010 \_ USNG.USNG]**



Join the RFD\_Inc\_2010\_USNG table to the RFD\_Inc\_2010 table.

4. Click OK and inspect the values in the USNG field. You may need to drag out the cell for the USNG field. If it has been populated with the correct values, remove the tabular join. Close ArcToolbox.

## Summarizing and Looking at Statistics

Because every incident contains a specific USNG address, the new USNG field can be used to summarize the total number of responses to each address. By tracking and summarizing the number of apparatuses assigned and the total deployment time for each incident, the equipment and time allocated to each location can be reviewed.

1. In the RFD\_Inc\_2010 table, right-click the new USNG field heading and check Summarize. In the summarize dialog box, expand Responder Count and check Sum.
2. Expand T5\_T4\_Sum1 and check Sum. Remember, this represents total time between dispatch and unit cleared for all apparatuses. Expand LonDec84 and LatDec84; set both to Average. Expand the Address1 text field and check First. Interestingly, many coordinate addresses have identical text addresses, but some have more. If you are curious, select Last as well and check the results. Store the summary table in \Redlands\_Fire\GDBFiles\CASP835F\Incidents.gdb and name it RFD\_Inc\_2010\_Sum1. Click OK to summarize.

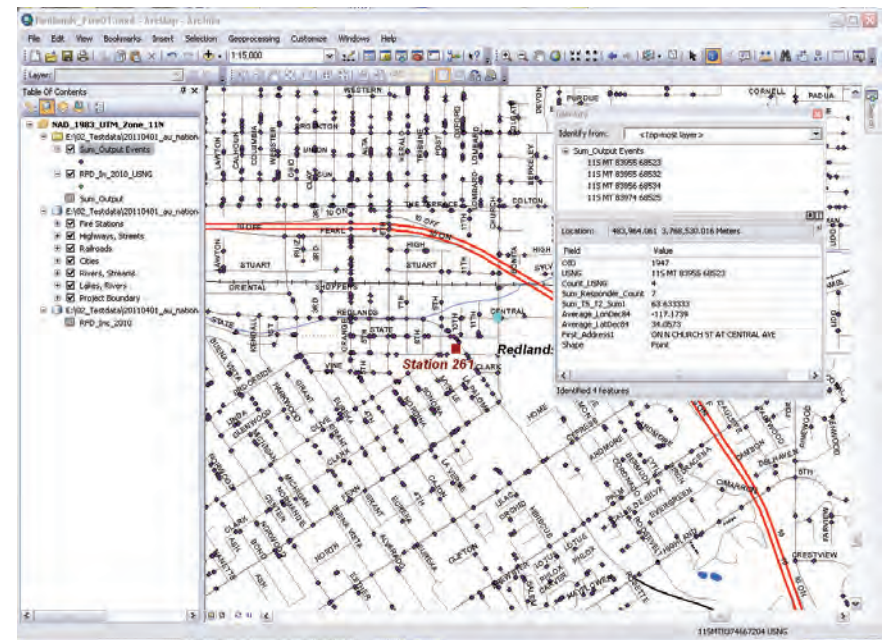


3. Add and open the table; inspect your results. You should have 3,235 records. Save the map.

If you sort Count\_USNG in descending order, you will see that 2010 included 129 trips to 1618 Laurel Avenue, involving 275 apparatuses and nearly 5,400 minutes (90 hours) of deployment time. There are four other addresses that generated more than 100 responses in a year. As you might imagine, these facilities are extended care/convalescent medical care facilities. In most jurisdictions, this type of facility generates the most calls. Let's put them on the map.

## Plotting, Saving, and Symbolizing Frequent Responses

1. In the table of contents (TOC), right-click RFD\_Inc\_2010\_Sum1 and select Display XY Data. In the dialog box, set Ave\_LonDec84 as the X Field and Ave\_LatDec84 as the Y Field. Click the Edit button and change the coordinate system to Geographic > World > WGS\_1984. Click OK to add these points as an event theme.
2. Zoom in and query several points. In the Data Frame properties, set Display Units to US National Grid and check out point coordinates by comparing the USNG field for a point to its map coordinates. They should be identical. If not, something is wrong.



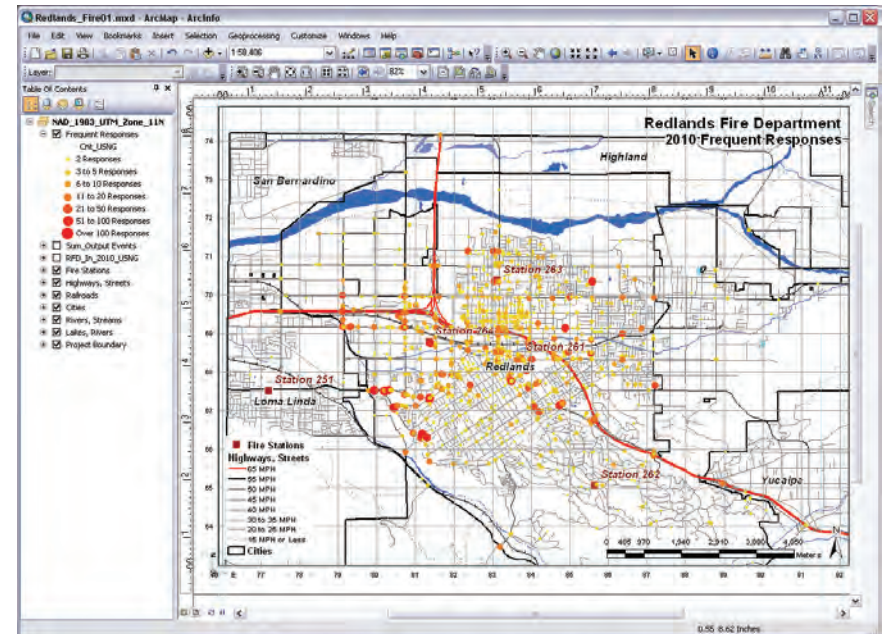
While most locations have only one incident, extended care/convalescent medical care facilities typically have many calls.

3. To test this, use the Info tool to examine the intersection of Church and Citrus. You can see how street names and addresses alone don't provide a good spatial index. When finished, zoom back out to Bookmark Redlands Fire 1:60,000. Save the project.
4. To make these points permanent, the XY theme should be exported to a geodatabase feature class. In the TOC, right-click RDF\_Inc\_2010\_Sum1 Events and choose Data > Export Data. Export all features in the data frame's coordinate system



and store them in \Redlands\_Fire\GDBFiles\CASP835F\Incidents.gdb. Name the feature class RFD\_Inc\_2010\_Sum2.

5. Add these points in the map and inspect the table. Check that all 3,235 records are properly posted, then remove the event theme and save the map again. Practice sorting and selecting records to identify locations that cause frequent and time-consuming responses.
6. Wouldn't it be nice to load a predefined legend that shows the frequent responses by size and color? If you carefully studied the sample dataset, you might have noticed a layer file named Frequent Responses.lyr. This file will apply visual symbology to the sites of frequent responses. Before loading the legend, use a definition query to exclude points that have only one response. In the TOC, right-click RFD\_Inc\_2010\_Sum2, select Properties, and open the Definition Query tab. Create and apply a definition query stating "Cnt\_USNG > 1". It should reduce the point count to 1,073 points.
7. Finally, apply a legend. Reopen Properties for RFD\_Inc\_2010\_Sum2, select the Symbology tab, and click the Import bar. Navigate to \Redlands\_Fire\GDBFiles\CASP835F\ and select Frequent Responses.lyr. Apply the Value Field to Count\_USNG and click OK. Before leaving Layer Properties, return to the General tab and rename this layer Frequent Responses. Click OK to apply these changes and inspect your work.



After using a definition query to suppress the locations with only one call, thematically map the remaining calls by frequency using the Frequent Responses layer.

8. Finally, switch to Layout View and add Frequent Responses to your legend. Inspect your work and save one last time.

For some additional challenges, go back to the source incident data and map the responses by number of apparatuses per call or by total and average time on calls. You might even try mapping calls by National Fire Incident Reporting System (NFIRS) type. (Hint: 100 = fire; 200 = rupture or explosion; 300 = rescue or EMS; 400 = hazmat. Values above 500 are service and other calls.)

## Summary

So what do you think? Is this a new use for USNG? Do you understand national grid data just a little better? For years, we have built complicated, unfriendly spatial indexes so we could efficiently summarize spatial data. Now, by simply applying a full 15-character USNG address to an incident set, we can quickly summarize and evaluate the data. Think of other ways to use this method (such as summarizing Doppler rainfall data over time). Index fire hydrants using USNG, and no two hydrants will ever have the same unique ID (unless, of course, they are on top of each other).



## Additional USNG Resources

See "[Introducing the United States National Grid](#)" and "[Rescue Behind the Rocks](#) [PDF]." Both articles ran in the June–September 2005 issue of *ArcUser*.

## Acknowledgments

Thank the fine staff of Redlands Fire Department and City of Redlands GIS for providing this very interesting and complex dataset. The actual data you just modeled supports ongoing public safety planning and deployment analysis in Esri's hometown.

(This [article](#) [PDF] originally appeared in the Summer 2011 issue of *ArcUser*.)

# More Emergency Services Modeling

Analyzing changes in response using Network Analyst

By Mike Price, Entrada/San Juan, Inc.

[Sample dataset](#) [ZIP]

This tutorial shows how to use the Closest Facility (CF) solver in [ArcGIS Network Analyst](#) to model travel from a single facility to the closest incidents. The model will be modified to reflect proposed changes in station locations.



In the current economic climate, public safety administrators and planners are often faced with complex decisions regarding moving or closing essential facilities. Fire station closure,

consolidation, or relocation studies occur throughout the United States. Public safety officials try to make best use of existing resources and provide comparable or improved levels of service. To analyze existing and future conditions, comprehensive data is required to represent current conditions, reflect past performance, and plan for the future.

In Esri's home town of Redlands, California, the Redlands Fire Department is facing considerable commercial and residential growth in the northern part of the city. Redlands is currently protected by four fire stations in Redlands and a station in Loma Linda, located to the west.

In 2010, Redlands firefighters and emergency medical technicians (EMTs) responded to more than 8,000 incidents in and around the city. By mapping the likelihood of where, when, and how incidents have occurred, historic incidents often provide the best estimate of community risk. Historic risk is used to demonstrate an adequate Standard of Coverage; identify underserved, problem, or frequent call locations; and project future demand for services.

The CF solver in ArcGIS Network Analyst is an excellent tool for modeling optimal travel from fixed facilities to historic incidents.

By adding or substituting new or relocated stations in CF templates, it is easy to perform multiple analyses.

## Getting Started

To begin this exercise, [download](#) [ZIP] the zipped training dataset. Unzip it in a project area on your computer. Open ArcCatalog and navigate to the \Redlands\_Fire folder and explore its contents. This project contains two file geodatabases and several small utility files. The training data is projected in California State Plane North American Datum 1983 (NAD83) Zone 5 US Feet. To support a US National Grid spatial reference, the data frame projection is set to universal transverse Mercator (UTM) NAD83 Zone 11 Meters.

Inspect the geodatabase feature classes and layer files in the geodatabases. In the Fire Data geodatabase, open the Response\_Model feature dataset and inspect Response\_Model\_ND. To quickly start the analysis portion of this tutorial, a very functional network dataset was prebuilt.

Notice that two layer files, First Due Station Group and Travel Time Improvement Group, cannot be viewed. **Do not load them until instructed.** These layer templates will be added to the map later to display results.

## Modeling Response with Network Analyst Closest Facility Solver

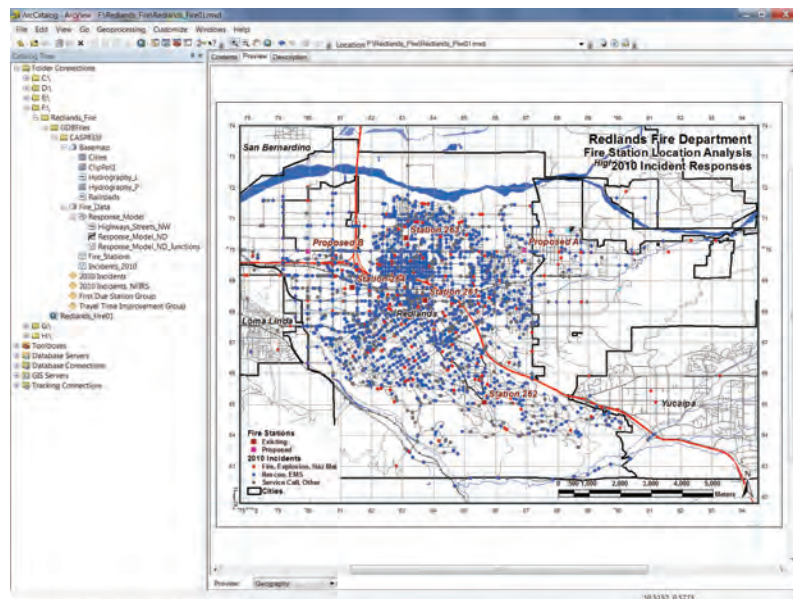
The CF solver is traditionally used to locate one or more destination facilities within reasonable travel time of a specific incident. Turned upside down, the CF solver maps travel from one or more fixed facilities to multiple incidents. In this exercise, the CF solver will be used to model travel away from single facilities toward the closest incidents, but facilities will be modified to reflect station changes.

Using actual 2010 incidents and a section clipped from the street network provided by the regional dispatch center, this tutorial will use the CF solver to compare optimal existing coverage to coverage provided by adding one or two proposed stations in northern areas of Redlands. For another innovative use of the CF solver, see another article in *ArcUser*, "[Run Orders: Modeling and mapping public safety arrival orders](#)" [PDF], in the Fall 2009 issue.

1. To begin the exercise, close ArcCatalog and start ArcMap. Open Redlands\_Fire01.mxd and inspect its contents. If you completed the exercise in the article "[Analyzing Frequent Responses: Using a US National Grid spatial index](#)" in the Summer 2011 issue of *ArcUser*, this map will look very familiar.
2. Open and inspect the 2010 Incidents attribute table. Study the rightmost fields that are filled with zeros. These fields will be used to record response statistics. The table includes fields for station numbers and travel times to accommodate

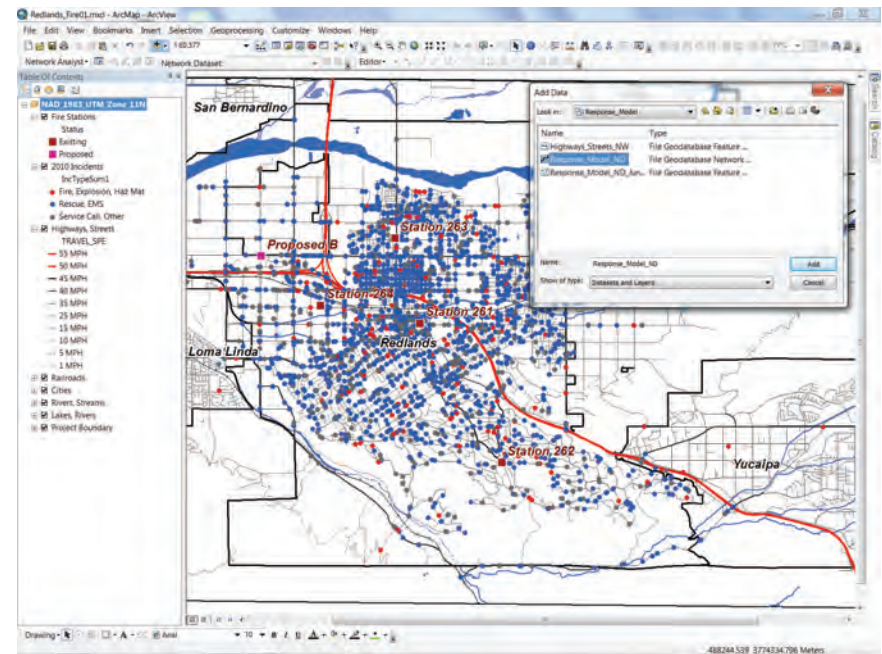


a base case and three scenarios. Three fields on the far right will soon contain differential travel times between the base case and each scenario. This map includes a new time-based street dataset so its network dataset must now be loaded.



To begin the exercise, open Redlands\_Fire01.mxd in ArcMap.

3. Switch from layout to data view. Click Add Data and navigate to \Fire\_Data\. Expand the Response\_Model feature dataset and add only the Response\_Model\_ND file geodatabase network dataset. Do not add other participating feature classes.



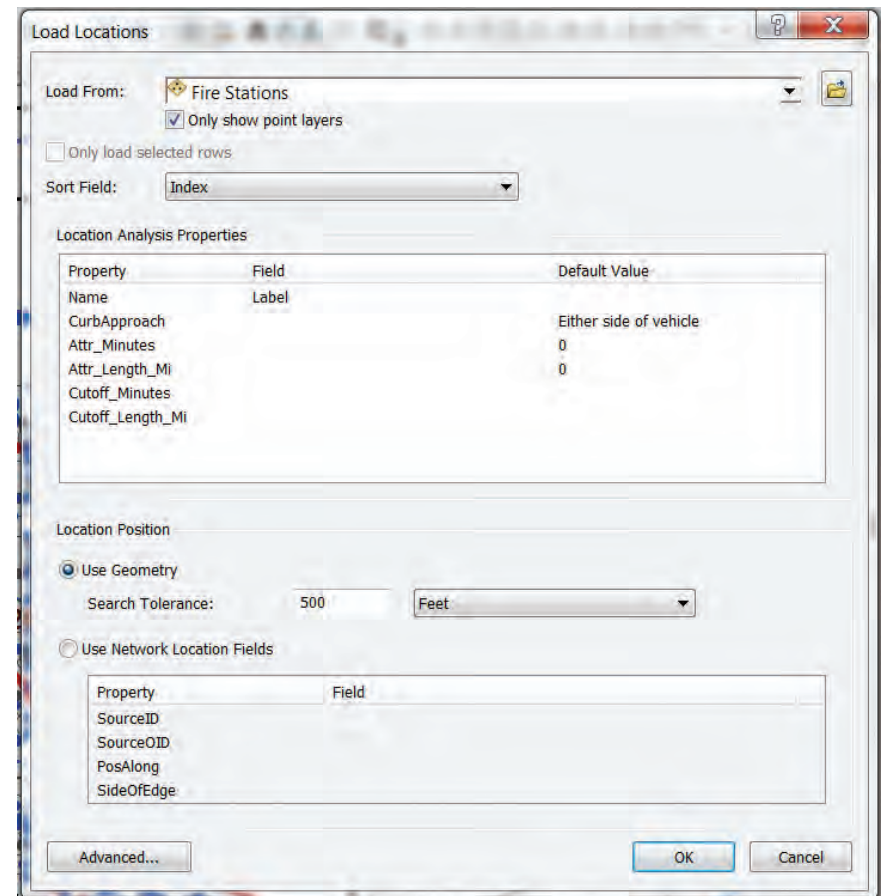
In the Fire Data geodatabase, expand the Response\_Model feature dataset and add only the prebuilt Response\_Model\_ND network dataset.

4. In the table of contents (TOC), move Response\_Model\_ND below Highways, Streets and make it nonvisible. If necessary, enable the Network Analyst extension and load its toolbar.
5. Save the project.

## Creating a Closest Facilities Template

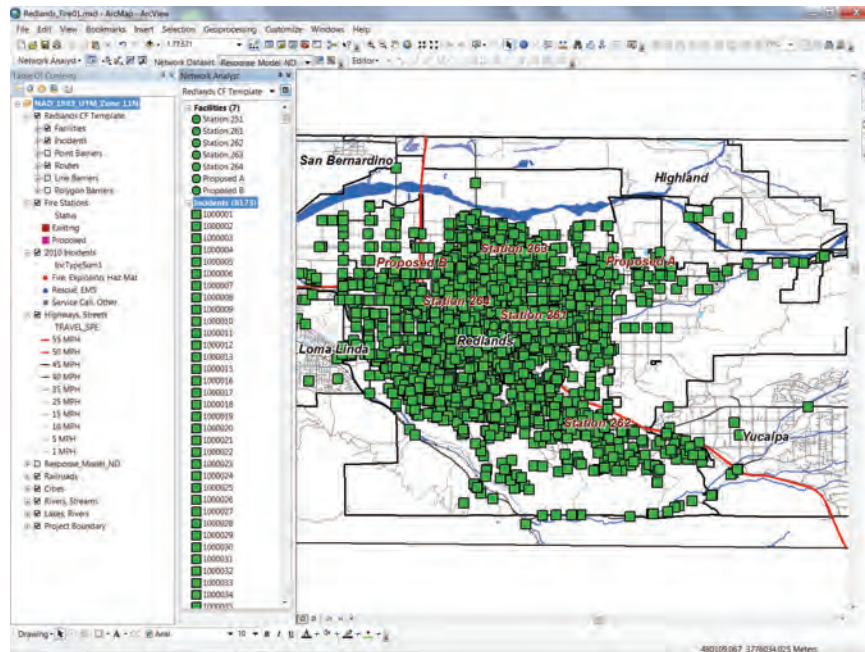
1. In the Network Analyst drop-down, select and load New Closest Facility.

2. Once loaded, open its properties and click the Analysis Settings tab. Set Travel From to Facility to Incident and Facilities to Find to 1. Under the Accumulation tab, check both Length\_Mi and Minutes. Click the General tab and name the solver Redlands CF Template.
3. Before cloning this template, all facilities and incidents will be added using the Network Analyst window. From the Network Analyst toolbar, click the Network Analyst Window button and dock the window to the right of the TOC.
4. Right-click Facilities and select Load Locations. Set Load From to Fire Stations, Sort Field to Index, Name to Label, and Search Tolerance to 500 Feet. Click OK and check your work.
5. To load incidents, right-click Incidents and click Load From 2010 Incidents. Set the Sort Field to OBJECT\_ID and select Inc\_Number for Name. Click OK and wait patiently as all 8,173 incidents load.
6. Choose the bookmark Redlands Fire 1:60,000 and verify your work.
7. In the TOC, right-click the Redlands CF Template and select Copy. Right-click the data frame name and select Paste Layer(s). Repeat this procedure until you have four copies of the original Redlands CF Template at or near the top of the TOC.



- Right-click Facilities and select Load Locations. Set Load From to Fire Stations, Sort Field to Index, Name to Label, and Search Tolerance to 500 Feet and click OK.
8. Select all five Redlands CF Template layers and right-click any one of them. Choose Select Group, rename the Group layer

Redlands CF Group, make all group elements nonvisible, and move the group to the bottom of the TOC.



To load incidents, right-click Incidents and click Load From 2010 Incidents. Set the Sort Field to OBJECT\_ID and select Inc\_Number for Name. Click OK and wait patiently as all 8,173 incidents load.

## Building and Solving Multiple Scenarios

1. Rename the first four CF templates as Redlands CF Base Case, Redlands CF Prop A, Redlands CF Prop B, Redlands CF Prop A, B. Save the project.

2. These templates still have all seven stations listed as Facilities, so the next step is to remove specific stations to customize each scenario. In the Network Analyst window, select Redlands CF Base Case > Facilities, hold the Control key, and select Proposed A and Proposed B. Right-click and select Delete.
3. Next, select Redlands CF Proposed A and delete Proposed B.
4. Finally, select Redlands CF Proposed B and delete the Proposed A facility. Save again. Now you have a five-station base case, two six-station scenarios, and one seven-station scenario for a total of four scenarios. You also have a template that can be cloned for additional analyses.
5. Solve all four scenarios by right-clicking each scenario in the TOC and choosing Solve. Do not solve the template. These scenarios are rather large, so be patient.
6. After successfully solving all four scenarios, inspect the results. Open any of the Routes tables and look at the fields. The FacilityID name is a concatenation of each incident's closest station and incident number. IncidentID will be used to join each route back to its incident point. Total\_Minutes provides the modeled travel time from the closest facility to each incident. To expand mapping area, close the Network Analyst window and zoom to the bookmark Redlands Fire 1:60,000. If all looks well, save again.

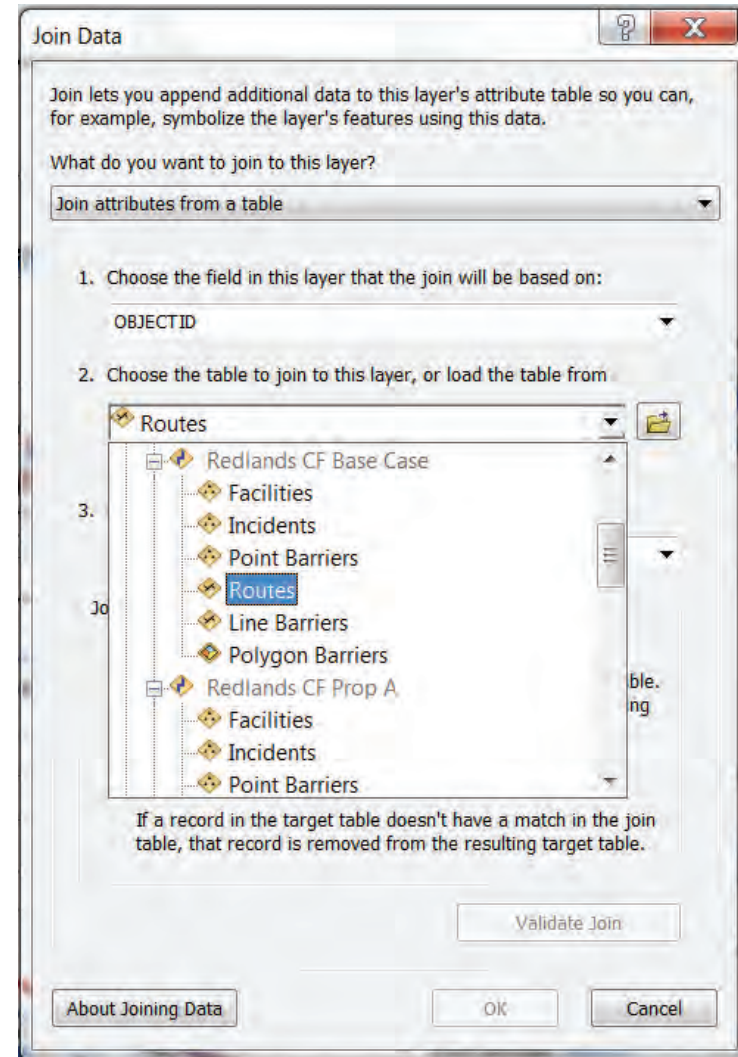


## Enhancing Closest Facility Data for the Base Case

Now comes the tricky part. If you tackled the Fall 2009 exercise in "[Run Orders: Modeling and mapping public safety arrival orders](#)" [PDF], you might remember performing a series of tabular joins coupled to field calculations. You will perform similar joins and calculations with this data, but this time, you will create two consecutive joins. Follow along carefully because this workflow is very specific.

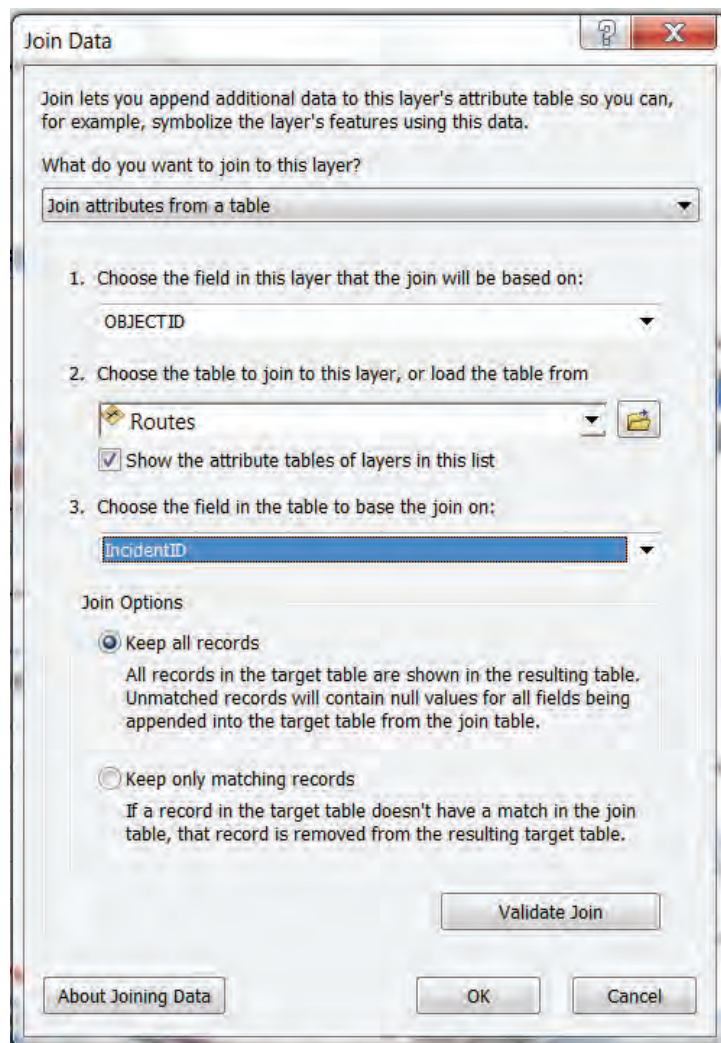
## Performing Two Joins

1. In the TOC, right-click 2010 Incidents and choose Joins and Relates > Joins. For Item 1, select OBJECTID.
2. For Item 2, specify Redlands CF Base Case > Routes. Be sure to specify Base Case.
3. For Item 3, select IncidentID. Click Validate and, when validation is complete, click OK to join. Don't index (because you are joining to an active Network Dataset, indexing does not work).
4. To build the second join, right-click again on 2010 Incidents and choose Joins and Relates > Joins.
5. For Item 1, select FacilityID.
6. For Item 2, select Fire Stations.
7. For Item 3, select Index. Validate and click OK again. This time, indexing will work, so allow indexing.

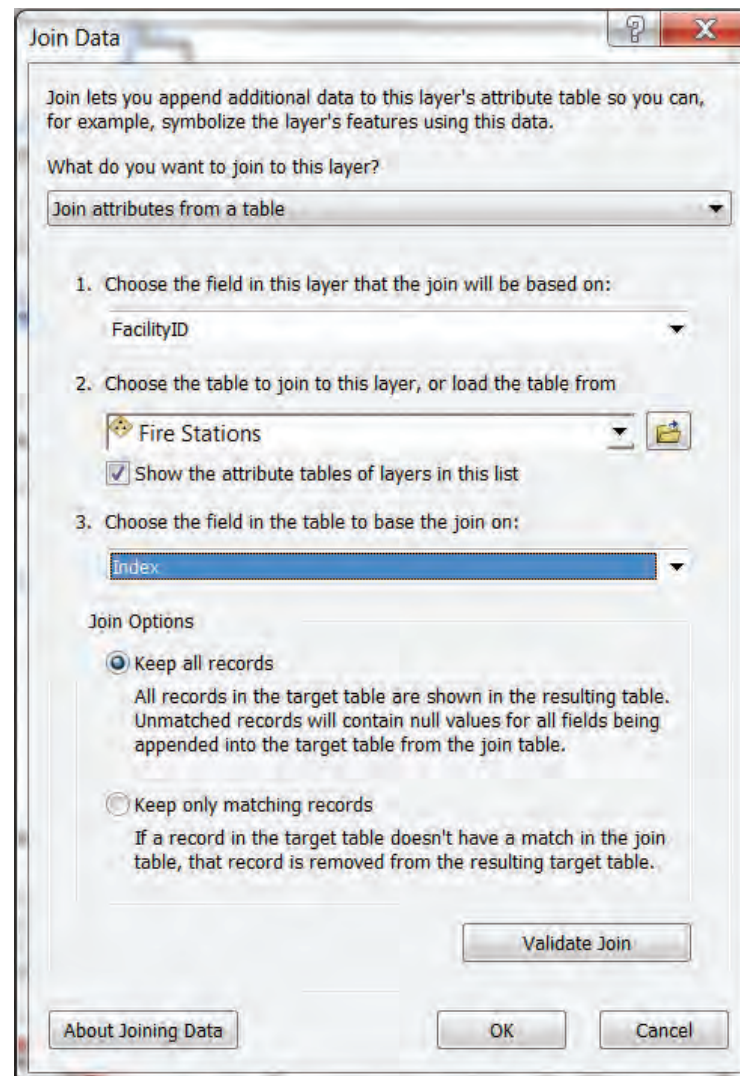


In the TOC, right-click 2010 Incidents and choose Joins and Relates > Join. For Item 1, select OBJECTID, and for Item 2, specify Redlands CF Base Case > Routes. Be sure to specify Base Case!





For Item 3, select IncidentID. Click OK to join and bypass indexing. Since you are joining to an active network dataset, indexing does not work.



For the second join, set Item 1 to FacilityID, Item 2 to Fire Stations, and Item 3 to Index.

8. When the second join finishes, open the 2010 Incidents table and verify that Base Case Routes and appropriate station data have been successfully joined to all incidents. If the join was not successful, remove all joins and try again.

## Calculating Travel Times

1. To calculate the closest base case stations and travel times for all incidents, open the 2010 Incidents attribute table and locate the Station\_Base and Time\_Base fields. Right-click Station\_Base, select Field Calculator, and click Load. Navigate to \Redlands\_Fire, open Station\_No.cal, and click OK. Watch as ArcGIS assigns the closest Base Case stations to all incidents.
2. Next, right-click Time\_Base, select Field Calculator, load Total\_Minutes.cal, and click OK to post Base Case travel times.
3. Finally, right-click 2010 Incidents in the TOC and select Joins and Relates > Remove Join(s) > Remove All Joins. **This is an important step. Do not skip it.**

## Joining and Calculating the Scenarios

Now that the closest station and travel time have been calculated for Base Case, the same procedure will be used for each scenario. The only difference will be that in the first join, Item 2 will change (e.g., Redlands CF Prop A > Routes, Redlands CF Prop B > Routes, and Redlands CF Prop B > Routes). *Although*

*the workflow becomes a bit tedious now, it is critical to proceed carefully.* Make the two joins for each layer, successively calculate the Station\_A, Time\_A, Station\_B, Time\_B, and Station\_AB and Time\_AB fields, making sure to remove all joins after calculating the stations and time for each scenario. Carefully check the calculations and save the project. If one or more joins/calculations did not work, clear and rebuild the necessary join and recalculate.

## Calculating Travel Improvements

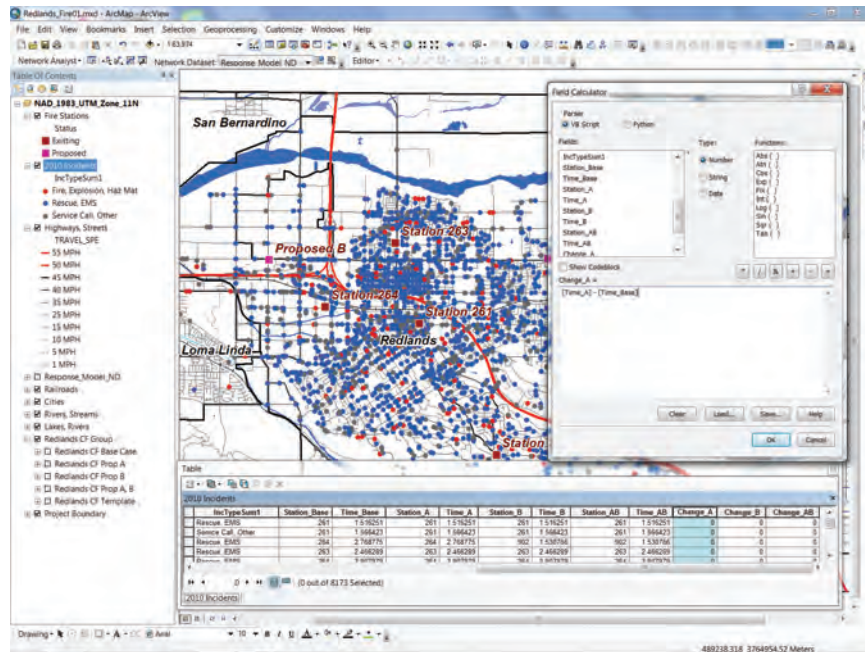
With Base Case and scenario times for all analyses, you can use the Field Calculator to calculate the Change\_A, Change\_B, and Change\_AB fields that are currently filled with zeros in the 2010 Incidents attribute table.

1. In the 2010 Incidents table, right-click Change\_A and choose Field Calculator. To calculate the time change between the Base Case and all incidents modified by response from Proposed A, select or type the expression below in the calculation window and click OK:

**[Time \_ A] - [Time \_ Base]**

If the Proposed A station, located in northeastern Redlands, can access a 2010 incident before the closest Base Case station, this field represents the time differential as a negative number. If Proposed A is not the closest station, the number will remain zero. If you were modeling closed or relocated stations rather than proposed stations, this number might be

positive, representing the additional time required to access an incident, compared to an earlier location.



To calculate the time change between Base Case and all incidents modified by response from Proposed A, select or type `[Time_A] - [Time_Base]` in the calculation window and click OK.

2. Calculate the time differential for Scenario B and Base Case in field `Change_B`, modifying the expression:

`[Time_B] - [Time_Base]`

Negative values in this column represent improved responses from the Proposed B location in northwest Redlands.

3. Finally, calculate the combined effect of Proposed A and Proposed B by right-clicking the `Change_AB` field and modifying the expression to read:

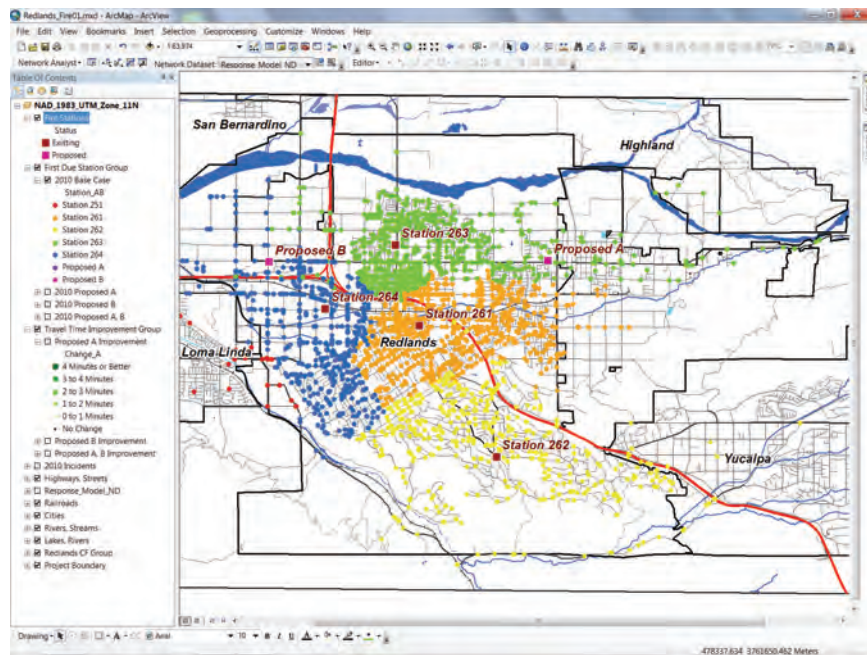
`[Time_AB] - [Time_Base]`

4. Sort and review the differential times to see that some incidents improve, while many remain unchanged. Since you have not removed any stations, no incidents display positive values that represent a net travel time increase. Save the map.

## Mapping

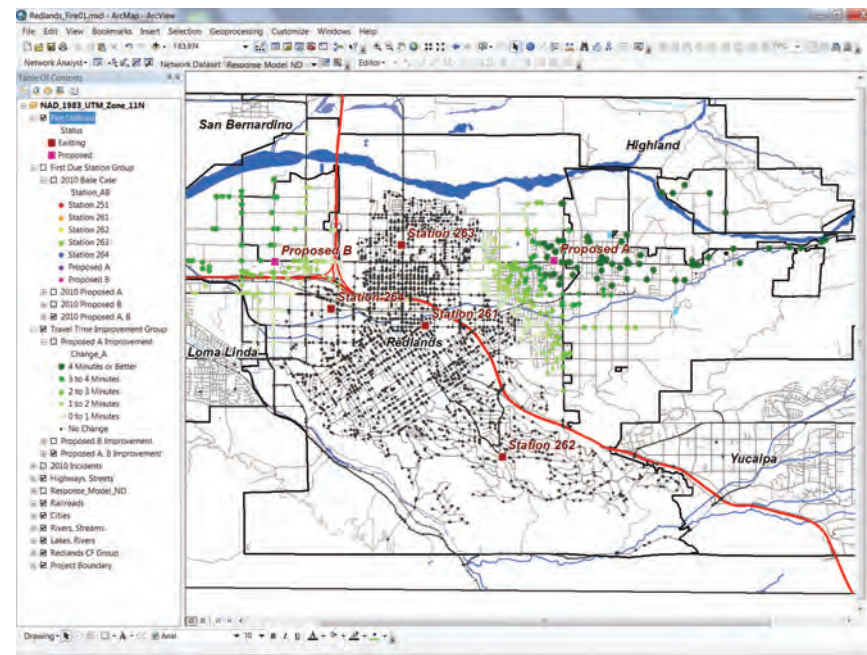
Look at the results on a map. There are many ways that you could map and chart these time-based analyses. A rather basic map would plot closest stations to all incidents for each scenario. Because you have assigned a station number to all incidents, you can readily map this relationship. `Station_` field is an integer. Proposed A is designated as 901 and Proposed B is designated as 902. A second map series can show the time change between the Base Case and the three scenarios. You can use a graduated size and color scheme to show how much time is gained or lost as stations open, close, or move. The fields holding differential calculation times contain necessary double precision values.





In the First Due Station Group, turn on 2010 Base Case and inspect the incident distribution.

1. Now you can load the layer files for First Due Station Group and Travel Time Improvement Group. Click the Add Data button and navigate to \Redlands\_Fire\GDBFiles\CASP835F to add these groups and quickly create several map series. Position the two groups in the TOC just below Fire Stations.
2. In First Due Station Group, turn on 2010 Base Case and inspect the incident distribution. Notice how incidents in differing colors cluster around closest stations.



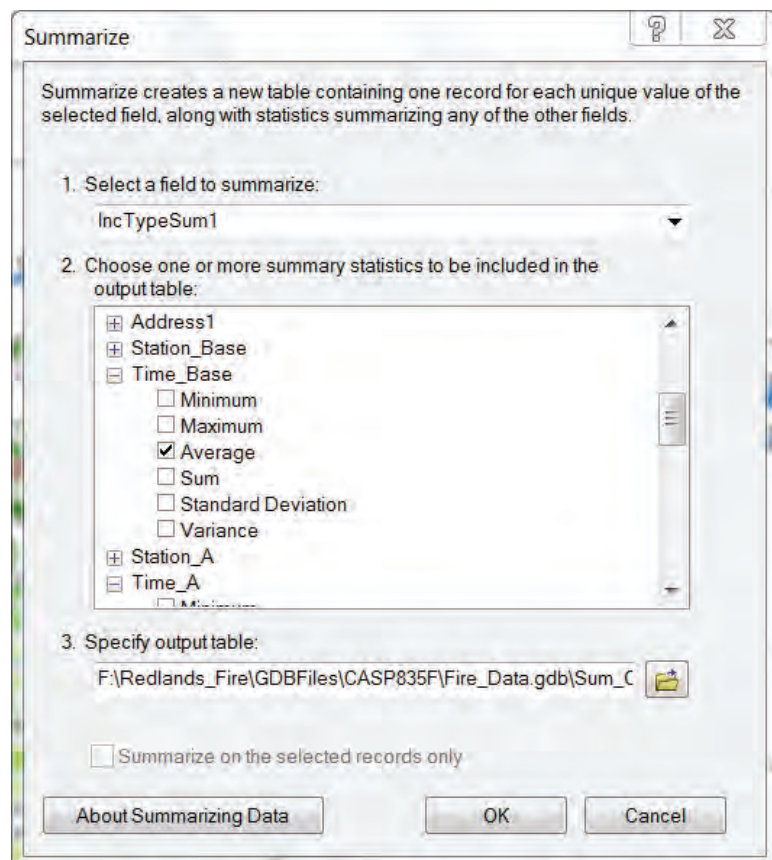
Individually open the Travel Time Improvement Group series. This shows effects of Proposed A plus Proposed B.

3. Individually turn on 2010 Proposed A, 2010 Proposed B, and 2010 Proposed A, B. Individually open the Travel Time Improvement Group series to show the time decreases for Proposed A, Proposed B, and Proposed A plus Proposed B. Green is good; this is the kind of information that the fire chief and commissioners like to see.



## Summarizing

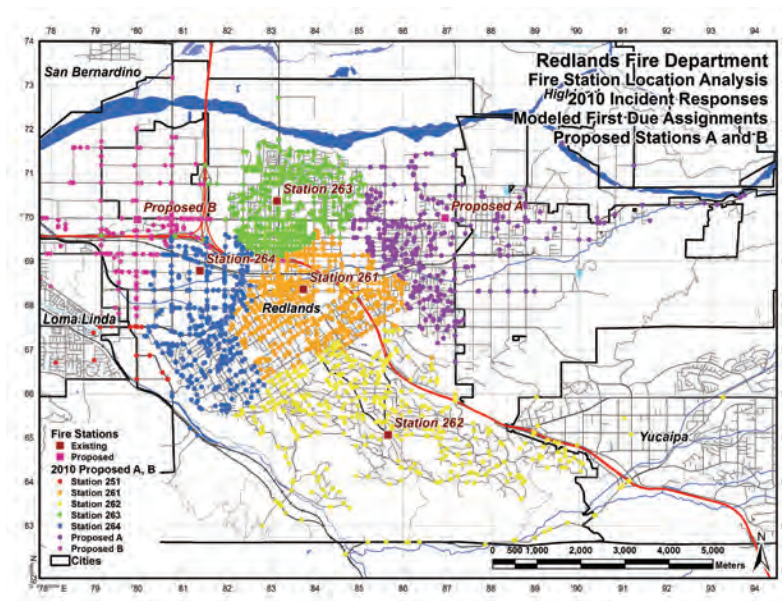
Finally, summarize the Base Case and Scenario times for different incident types. Open the 2010 Incidents table, right-click the



Return to the 2010 Incidents table and locate the IncTypeSum1 field. Right-click this field and select Summarize. Save the summary table in Fire\_Data.gdb and calculate average times for Time\_Base, Time\_A, Time\_B, and Time\_AB.

IncTypeSum1 field, and choose Summarize. Under Item 2, expand Time\_Base, Time\_A, Time\_B, and Time\_AB and check the Average box under each. Under Item 3, save the summary table as IncType\_Time\_Sum1 in Fire\_Data.gdb. Add the resultant summary table to the map.

Inspect the results and notice the average times for fire responses, emergency medical service (EMS) calls, and service calls. The proportions and time trends in this table are not unusual. More than 75 percent of all 2010 responses were EMS or rescue calls and average times for these calls are typically the



Final map showing modeling of 2010 incident with both Proposed A and Proposed B stations.

shortest. Nearly 18 percent of all calls are classified as service calls or other calls. Fire and related calls comprise less than 6 percent of all responses. Check out the average times for your scenarios. The average modeled travel time for Proposed A plus B is closing in on two minutes.

## Future Opportunities

You have only scratched the surface of emergency services modeling. There are many more analyses, maps, charts, and determinations that could be prepared with this data. For a challenge, experiment with actual station relocation or removal. For example, try removing Station 263, located between Proposed A and B, and see how times increase and decrease. Also, experiment with charting in ArcGIS or your favorite spreadsheet program to graphically display the changing data. This is a training dataset, so use your imagination and have fun.

## Acknowledgments

Thanks to the fine staff of Redlands Fire Department and City of Redlands GIS for providing this very interesting and complex dataset. Thanks also go to the Confire Communications Center dispatch center for the opportunity to use its excellent time-based streets network in this exercise. The Redlands Fire Department will use many of the same methods and procedures presented here to model and analyze historic, current, and future protection capabilities. Redlands and Esri are very fortunate

to have the high level of emergency fire and medical response provided by the Redlands Fire Department.

(This [article](#) [PDF] originally appeared in the Winter 2012 issue of *ArcUser*.)

# Introducing the United States National Grid

By Mike Price, Entrada/San Juan, Inc.

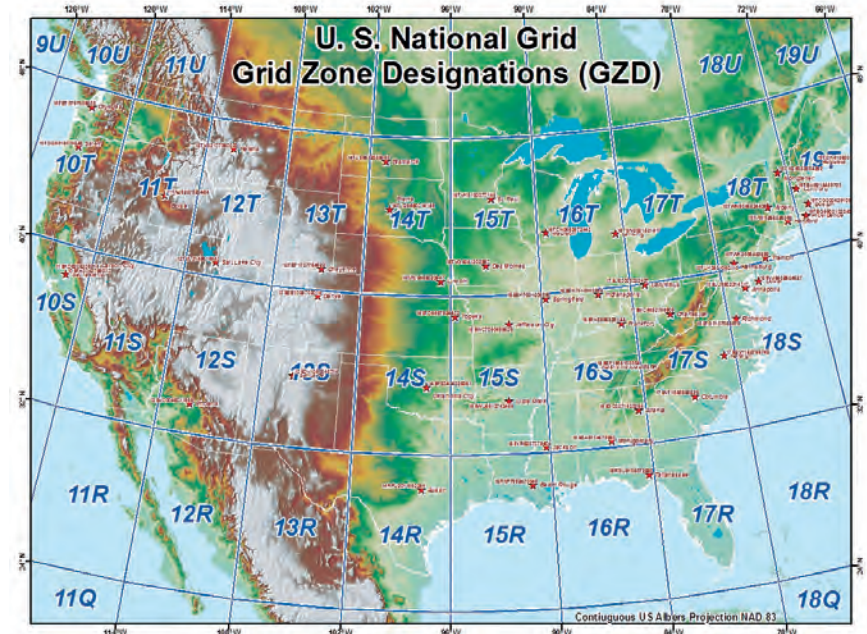
In 2005, the Department of Homeland Security (DHS) recommended that any DHS grant submission reference the use of a nationally defined coordinate system for all spatial referencing, mapping, and reporting. DHS recognizes that many different coordinate systems can be used to reference incident events in time and space. The expanding use of portable GPS-enabled devices, public safety access points (PSAP)-enhanced cell phones, and automated vehicle location (AVL) technology has increased the need for accurate and consistent identification, communication, and mapping of ground coordinates.

*The objective of this U.S. National Grid standard is to create a more interoperable environment for developing location-based services within the United States and to increase the interoperability of location services appliances with printed map products by establishing a nationally consistent grid reference system as the preferred grid for NSDI applications. The U.S. National Grid is based on universally-defined coordinate and grid systems and can, therefore, be easily extended for use world-wide as a universal grid reference system.*

*Fiscal Year 2005 Homeland Security Grant Program*

*Program Guidelines and Application Kit*

A consistent system is important because people cannot easily convert between multiple reference systems without the aid of location services appliances, calculators, or conversion tables.



The United States National Grid is a nonproprietary alphanumeric referencing system derived from the Military Grid Reference System (MGRS) that is being promoted to increase the interoperability of location services appliances with printed map products by providing a nationally consistent grid reference system.

DHS has proposed that the United States National Grid (USNG) be used to increase the interoperability of location services appliances with printed map products by providing a nationally consistent grid reference system.

USNG relies on the familiar Universal Transverse Mercator (UTM) coordinate system and is applied not only in the United States but also worldwide. USNG is a nonproprietary alphanumeric referencing system derived from the Military Grid Reference System (MGRS). Many GPS receivers, from recreational to survey-grade instruments, support and report positional information in an MGRS/USNG format. ArcGIS 9.1 includes grid and graticule support for map layouts. The Esri Military Analyst extension supports MGRS with a dynamic coordinate conversion and provides batch conversion of data from decimal degrees to MGRS coordinates in addition to degrees, minutes, seconds (DMS) and UTM. This article introduces USNG to both casual and experienced GIS users by taking the reader on a virtual tour of the available resources for learning about USNG. It is organized as a series of stops or waypoints that are numbered from 1 through 7.

## Waypoint 1

The Federal Geographic Data Committee (FGDC) develops policies, standards, and procedures that enable organizations to cooperatively produce and share geographic data. This interagency committee is composed of representatives from

many federal agencies. FGDC, in cooperation with state, local and tribal government organizations, the academic community, and the private sector, is developing the National Spatial Data Infrastructure (NSDI). Positional reporting and spatial accuracy are necessary when using and sharing spatial information. FGDC is a key player in the development and deployment of positional standards in government, academia, and industry. USNG provides a standard method for plotting and reporting positions across the United States.

Visit the FGDC home page ([fgdc.gov](http://fgdc.gov)) and look at the bottom of the page. The line immediately below the FGDC street address reads USNG: 18STJ94731361. The alphanumeric sequence, 18STJ94731361, is the FGDC's USNG address. Clicking on this link displays the location of FGDC's headquarters in the National Map Viewer. This ArcIMS-powered Web site provides a framework for geographic knowledge and gives the public access to high-quality geospatial data and information from multiple partners. Return to the FGDC home page.

Click on the USNG link at the bottom of the page to go to FGDC's USNG site and bookmark it. It contains links to the FGDC USNG standard, information on reading a geoaddress, articles, a link to The National Map portal, and other resource sites.



## Waypoint 2

Type [www.xyproject.org](http://www.xyproject.org) to go to The Public XY Mapping Project Web site. Formed by a group of concerned citizens in 1997, The Public XY Mapping Project is a nonprofit science and education corporation dedicated to the development and implementation of spatial addressing in the United States. Spatial addresses complement conventional one-dimensional street addresses. Two-dimensional addresses can provide location information during a disaster when signs or streets are destroyed or for sites that are removed from a road network.

One of The Public XY Mapping Project's goals is to increase public awareness of the need for consistent addressing and develop and recommend FGDC/NSDI standards for a national system. USNG standards were proposed in 2000 and adopted in 2002. Since then, the project has focused on training and implementation activities.

Click on the link [United States National Grid for Spatial Addressing](#) to view a document written by N.G. "Tom" Terry Jr., The Public XY Project executive director. "A Proposal for a National Spatial Data Infrastructure Standards Project" introduces USNG and explains how it is related to the familiar Universal Transverse Mercator (UTM) coordinate system. UTM zones are six degrees wide. With USNG, these UTM zones are further subdivided into eight-degree latitude slices called Grid Zone Designations (GZDs). This article discusses the concept

of address precision. Print or save this document for future reference.

## Waypoint 3

Return to the FGDC USNG page and click on the USNG Coordinate link to read an article written by Terry that appeared in *Professional Surveyor* magazine in October 2004. "The United States National Grid" provides more information on GZDs, 100,000-meter-square identification, and grid coordinates at various scales. Terry discusses numeric precision, the power of truncation, and string concatenation/presentation. This article also introduces the practice of "read right, then up" when locating a USNG address on a map. Save or print this comprehensive article.

## Waypoint 4

Return to the FGDC USNG page and click on "Geoaddress—Where is It?" This article, also by Terry, appeared in *Professional Surveyor* magazine in November 2004. It tells how USNG addressing is used to report, map, and respond to public safety emergencies in the Washington, D.C., area. It discusses the importance of integrating digital positional devices, emergency communications, digital framework data, and paper maps. This article provides a realistic look into the future of coordinate-based emergency response.

## Waypoint 5

Go to the FGDC USNG page ([fgdc.gov/usng](http://fgdc.gov/usng)) and click on the first link to view the USNG standard (FGDC-STD-011-2001). This long document (43 pages) presents the objective, scope, applicability, and structure of USNG and detailed instructions for its use. Because this is a standards document, it mandates implementation rules. These rules are summarized below. Although dry, these rules are important, particularly Rule 4—Spatial Reference. An understanding of datums is necessary to properly apply USNG.

### FGDC USNG Standards—The Rules

(Adapted from the United States National Grid Standards Working Group Federal Geographic Data Committee, December 2001, FGDC-STD-011-2001)

#### Rule 1—Conformance, MGRS

USNG coordinates shall be identical to the MGRS numbering scheme over all areas of the United States including outlying territories and possessions.

#### Rule 2—Conformance, UTM

USNG basic coordinate values and numbering are identical to UTM coordinate values over all areas of the United States including outlying territories and possessions.

#### Rule 3—Structure

Numbering scheme shall be alphanumeric as follows:

- **Grid Zone Designation (GZD)**—The United States geographic area shall be divided into six-degree longitudinal zones designated by a number and eight-degree latitudinal bands designated by a letter. Thus, each area is given a unique alphanumeric GZD.
- **100,000-Meter-Square Identification**—Each six-by-eight-degree GZD area shall be covered by a specific 100,000-meter square identified by a two-letter pair.
- **Grid Coordinates**—A point position within the 100,000-meter square shall be given by the UTM grid coordinates in terms of its easting and northing. For specific requirements or applications, the number of digits will depend on the precision desired in position referencing. In this convention, reading shall be from left with easting first, then northing. An equal number of digits shall always be used for easting and northing.

#### Rule 4—Spatial Reference

The standard datum for USNG coordinates shall be the North American Datum 1983 (NAD 83) or its international equivalent, the World Geodetic System 1984 (WGS 84).

#### Rule 5—Accuracy

Paper maps using the USNG grid shall conform to the National Map Accuracy Standards.

#### Rule 6—Precision

For general field applications, a precision of 100 (or 10 meters) will be typical. For general applications, precision of up to one meter may be used. For special applications, USNG can provide precision greater than one meter.

### Waypoint 6

Visit the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS) Web site at [ngs.noaa.gov](http://ngs.noaa.gov). At this site, click on Download Software and choose USNG from the list of utilities. Download the documentation as well as the utility.

This free DOS utility converts geodetic latitude and longitude or UTM to USNG and vice versa. When the utility is run, it prompts for direction of conversion, input datum, input coordinates, and other information. The program processes single points at the command line, and it converts properly formatted file data to create a second output file. Read the documentation carefully.

### Waypoint 7

Visit the National Information and Support Center for Geoaddressing ([fgdc.gov/usng/resources/index.html](http://fgdc.gov/usng/resources/index.html)) at George Mason University in Fairfax, Virginia. Bookmark this page and visit it periodically, especially the Resources area, to learn about new applications for USNG and stay in touch with others deploying and using USNG.

### Conclusion

Watch for opportunities to use USNG coordinates and visit the sites listed in the article for updates, utilities, and new information. Visit [Rescue Behind the Rocks](#) [PDF] to download an exercise and the sample dataset that includes a polygon shapefile of GZDs that can be used with data for the continental United States in an ArcMap document to determine the USNG coordinates for a location.

Note: U.S. National Grid Tools for ArcGIS capabilities are included in ArcGIS 10 for Desktop. There is no separate add-on or download needed for releases of ArcGIS 10 for Desktop and higher.

(This [article](#) originally appeared in the July–September 2005 issue of *ArcUser*.)

Copyright © 2012 Esri  
All rights reserved.  
Printed in the United States of America.

The information contained in this document is the exclusive property of Esri. This work is protected under United States copyright law and other international copyright treaties and conventions. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or by any information storage or retrieval system, except as expressly permitted in writing by Esri. All requests should be sent to Attention: Contracts and Legal Services Manager, Esri, 380 New York Street, Redlands, CA 92373-8100, USA.

The information contained in this document is subject to change without notice.

US Government Restricted/Limited Rights  
Any software, documentation, and/or data delivered hereunder is subject to the terms of the License Agreement. The commercial license rights in the License Agreement strictly govern Licensee's use, reproduction, or disclosure of the software, data, and documentation. In no event shall the US Government acquire greater than RESTRICTED/LIMITED RIGHTS. At a minimum, use, duplication, or disclosure by the US Government is subject to restrictions as set forth in FAR §52.227-14 Alternates I, II, and III (DEC 2007); FAR §52.227-19(b) (DEC 2007) and/or FAR §12.211/12.212 (Commercial Technical Data/Computer Software); and DFARS §252.227-7015 (DEC 2011) (Technical Data – Commercial Items) and/or DFARS §227.7202 (Commercial Computer Software and Commercial Computer Software Documentation), as applicable. Contractor/Manufacturer is Esri, 380 New York Street, Redlands, CA 92373-8100, USA.

Esri Trademarks and Service Marks:  
@esri.com, 3D Analyst, ACORN, Address Coder, ADF, AML, ArcAtlas, ArcCAD, ArcCatalog, ArcCOGO, ArcData, ArcDoc, ArcEdit, ArcEditor, ArcEurope, ArcExplorer, ArcExpress, ArcGIS, ArcGlobe, ArcGrid, ArcIMS, ARC/INFO, ArcInfo, ArcInfo Librarian, ArcLessons, ArcLocation, ArcLogistics, ArcMap, ArcNetwork, ArcNews, ArcObjects, ArcOpen, ArcPad, ArcPlot, ArcPress, ArcPy, ArcReader, ArcScan, ArcScene, ArcSchool, ArcScripts, ArcSDE, ArcSdl, ArcSketch, ArcStorm, ArcSurvey, ArcTIN, ArcToolbox, ArcTools, ArcUSA, ArcUser, ArcView, ArcVoyager, ArcWatch, ArcWeb, ArcWorld, ArcXML, Atlas GIS, AtlasWare, Avenue, BAO, Business Analyst, Business Analyst Online, BusinessMAP, CommunityInfo, Database Integrator, DBI Kit, EDN, Esri, Esri—Team GIS, Esri—The GIS Company, Esri—The GIS People, Esri—The GIS Software Leader, FormEdit, GeoCollector, Geographic Design System, Geography Matters, Geography Network, GIS by Esri, GIS Day, GIS for Everyone, GISData Server, JTX, MapIt, Maplex, MapObjects, MapStudio, ModelBuilder, MOLE, MPS—Atlas, PLTS, Rent-a-Tech, SDE, SML, Sourcebook America, SpatialLABS, Spatial Database Engine, StreetMap, Tapestry, the ARC/INFO logo, the ArcGIS logo, the ArcGIS Explorer logo, the ArcPad logo, the Esri globe logo, the Esri Press logo, the GIS Day logo, the MapIt logo, The Geographic Advantage, The Geographic Approach, The World's Leading Desktop GIS, Water Writes, arcgis.com, esri.com, geographynetwork.com, gis.com, gisday.com, and Your Personal Geographic Information System are trademarks, service marks, or registered trademarks or service marks of Esri in the United States, the European Community, or certain other jurisdictions.

Other companies and products mentioned herein may be trademarks or registered trademarks of their respective trademark owners.





Esri inspires and enables people to positively impact their future through a deeper, geographic understanding of the changing world around them.

Governments, industry leaders, academics, and nongovernmental organizations trust us to connect them with the analytic knowledge they need to make the critical decisions that shape the planet. For more than 40 years, Esri has cultivated collaborative relationships with partners who share our commitment to solving earth's most pressing challenges with geographic expertise and rational resolve. Today, we believe that geography is at the heart of a more resilient and sustainable future. Creating responsible products and solutions drives our passion for improving quality of life everywhere.



## Contact Esri

380 New York Street  
Redlands, California 92373-8100 USA

1 800 447 9778

T 909 793 2853

F 909 793 5953

[info@esri.com](mailto:info@esri.com)

[esri.com](http://esri.com)

Offices worldwide

[esri.com/locations](http://esri.com/locations)