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Using GIS for Wildland Search and Rescue

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esri

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In Memory of National Park Rangers

Randy Morgenson, Sequoia and Kings Canyon National Parks

and

Jeff Christensen, Rocky Mountain National Park

Rocky Mountain National Park, Summer 2005, View from Deer Mountain

(Photo credit: Jeff Christensen)

Acknowledgments

This book and the search and rescue (SAR) geographic information system (GIS) workgroup came together as a direct result of a number of us being within one degree of separation of Tom Patterson at Esri. Patterson is a former National Park Service (NPS) ranger and wildland fire fighter and now Esri's wildland fire specialist. He knows everyone (it seems) in the GIS community and was an active contributor in establishing a GIS program for fire operations in the mid-90s—a program now the standard in all lead government fire agencies. About five years ago, several of us had been referred to him as we individually flailed around trying to better use GIS in our own SAR programs. He put us in contact with each other. Intense and productive discussions started, a workgroup was created, a discussion forum was started, workshops followed, and a plan developed. MapSAR, *Using GIS in Wildland Search and Rescue*, and *The MapSAR User's Manual* are the current products of this incredibly creative collaboration.

The work of creating an effective use of GIS in SAR is ongoing and rapidly evolving. This book and that process are immensely helped by guidance and contributions from a huge number of people in the SAR and GIS community. Among the primary contributors are Jon Pedder and Arnold Gaffrey, MapSAR's lead developers from Sierra Madre SAR (SMSR) in California; Art Fortini, also of SMSR; Paul Doherty, formerly of Yosemite SAR, now at Esri; Don Ferguson, PhD, of the Mountaineer Area Rescue Group in West Virginia; Richard Laing, team manager, Ridge Meadows Search and Rescue; and Peter Lindstrom of the National Park Service. There was also major support from individuals at Esri who contributed hundreds of hours of volunteered time to give us the tools, code, and advice to integrate the SAR workflow and data needs into ArcGIS: Tom Patterson, Edan Cain, Matthew Baker, Doug Morgenthaler, Jennifer Schottke, Liz Sarow, and Brenda Martinez. Although giving time up from their families and lives, their constant enthusiasm and unerring ability to find the best brew pubs wherever we meet makes this effort a continued joy.

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While the support, advice, and guidance of all our colleagues make this book a true collaboration, any errors are solely those of the authors. Please send any ideas for future revisions, comments, or errors to help@mapsar.net.

Finally, a big thank-you goes to our spouses, Paige Meier and Eric Linaris, for putting up with us through this whole process, and of course all our family and friends!

Foreword

Highly successful SAR incidents rely on effective planning and a consistent workflow. Although some organizations still employ seat-of-the-pants decision making and still manage to accomplish the essential tasks, this approach will not always deliver professional results.

The public expects nothing less than professional tactics using the most current standards and practices on SAR operations. The industry standard for search management planning now includes the use of computerized GIS technology. Establishing a search area on an acetate overlay is a crude substitute and is subject to error. Employing GIS in search management permits updating search incident maps in a fraction of the time required to produce such results by hand and gives far more effective situational awareness. GIS now needs to be an established capability of any SAR organization.

We are unquestionably visual creatures at heart. This point is borne out by the scene of search personnel returning to an incident base following a long assignment in the field. Where do they naturally gather and analyze where the subject may be located? They routinely gather around the briefing map. SAR mapping products are also scrutinized by family members and the media. Preparing accurate and professional-looking maps in support of the incident strengthens the credibility of the team managing an incident. A sloppy incident map will convey incompetence and cast doubt on the tactics being employed in the field.

Unfortunately, any SAR organization can experience a bad day. Unsuccessful missions, particularly those involving fatalities, will be carefully scrutinized. This is particularly true of incidents involving the death of a rescuer. Incident commanders are now held personally accountable for the safety of personnel operating on the missions they manage. Maintaining a complete record of all aspects of the incident—and including the geospatial information as part of that record—is essential to accurately review the mission.

The process of creating these products using GIS during a SAR is not without glitches. Almost every member of the public today carries some sort of device that will give their coordinates: a paper US Geological Survey (USGS) map, a smartphone, a GPS, or an emergency locator device. When using coordinates reported from another source, responders routinely—and unknowingly—pass on coordinate and datum errors when communicating locations, especially when the proficiency of team members is limited. Unless all team members are properly trained, the various coordinate formats can generate confusion and a dangerously inadequate response. At the end of a field assignment, the transfer of GPS track logs can be hindered by a lack of compatible equipment. This book will help you avoid such common pitfalls when applying GIS within SAR operations.

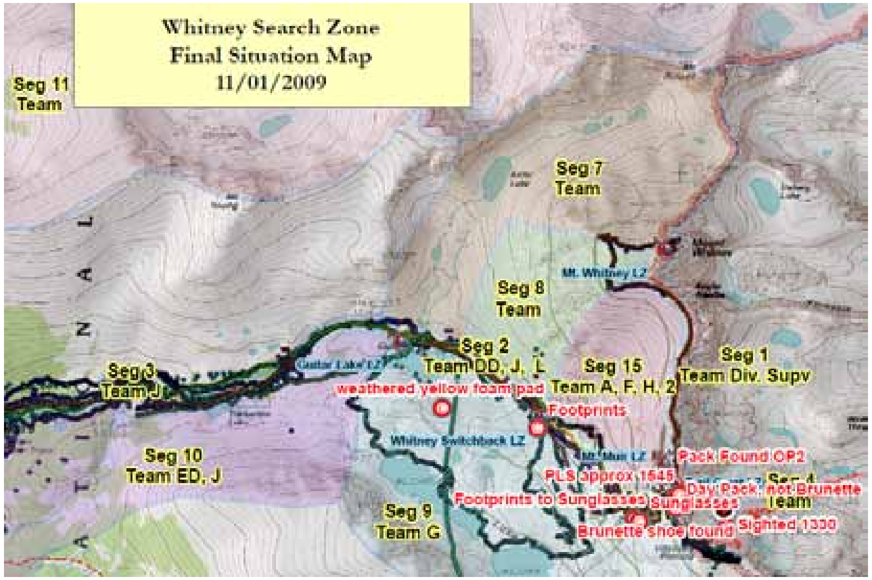
George Durkee and Vanessa Glynn-Linaris have produced a textbook that provides an effective connection between the disciplines of GIS and SAR, making a full GIS capability accessible to every SAR organization. Although there are numerous GIS texts in print, there is a shortfall in addressing how GIS can be employed within search and rescue. Hopefully, this textbook will reinforce the need to activate a SAR GIS specialist during SAR operations as a matter of standard procedure.

Ken Phillips—Branch Chief of Search and Rescue, National Park Service

Preface

Maps are at the core of any SAR operation. GIS allows us to make maps that layer an incident's geospatial information to show specific aspects of the operation that best visualize what is happening on the ground. This allows planners and decision makers to see and focus only on the information they need at the time. More effective situational awareness is the result, and when those maps are shared over a network, a greatly enhanced common operating picture throughout the incident command post (ICP) can be achieved. Equally important, the recommended GIS workflow and file structures allow an accurate review of the SAR long after the operation is ended. This is important in the case of future legal action or operational review or if the subject is not found and the SAR renewed when conditions improve or new information is developed.

In our experience, though, many SAR teams are not yet using GIS effectively on searches because there has been no single book or training series to show people how to do it. There is a critical need to provide standards, documents, and training to the national and international SAR community. To meet that need, a volunteer team of wildland SAR professionals has developed a workflow, model, and set of tools to better integrate GIS into SAR operations.



Brunette SAR, Sequoia and Kings Canyon National Parks, Final Situation Map (detail)

Our SAR and GIS workgroup has integrated the SAR workflow into a standard set of tools and methods for rapid deployment, increased effectiveness, and improved consistency in the use of GIS during a SAR. Using ArcGIS Explorer Desktop, ArcGIS 10 for Desktop, and MapSAR, our goal is to provide tools and instructional materials to serve as the core GIS training and development resource for SAR teams, government agencies, and college GIS courses. This book and *The MapSAR User's Manual* are the result of that effort.

The purpose of the *Using GIS for Wildland Search and Rescue* manual is to do the following:

- Introduce a wider audience to GIS techniques for SAR and other operations.
- Give all SAR people, whatever their technical background and skill, the tools and knowledge to effectively use GIS in their operations and communicate easily with team members who have more advanced GIS skills to obtain useful products.
- Establish protocols and a standardized workflow to carry out the mapping and planning function within the incident command system (ICS) structure.
- Speed up the planning cycle using MapSAR and ArcGIS 10 for Desktop.
- Introduce to planners and field people several types of devices that are now coming online that can make our tasks more effective and far safer.
- Keep more effective track of teams and assets for safety and operational efficiency.
- Get teams out the door more quickly, finding the lost and bringing them home safely.

Our goal is to create a one-stop resource for SAR teams—volunteer organizations, county sheriff teams, and government agencies—to develop and implement a modern GIS capability for incidents.

How to Use This Manual

This book is designed to be either read as a whole—allowing a SAR team to build and integrate a modern GIS capability into their operations from the ground up—or used for the particular section you need to learn from or reference. Some sections do require skills developed in previous chapters, but those sections are referenced if you don't have that particular knowledge. The size and scope of our book may seem intimidating at first glance, but learning these skills is well within the reach of SAR practitioners interested in more effectively applying GIS techniques to their team's operational workflows.

A SAR organization may find that the best approach is to create a GIS specialty within its team. The GIS specialist, who can also be recruited from the GIS department at your local planning agency or college, then masters the skills presented here and teaches the basic GIS skill set to the rest of the team. With training and skills practice twice a month, this can bring the whole team up to an effective GIS ability and standards within a few months.

The *Using GIS for Wildland Search and Rescue* manual is specifically written for SAR operations occurring in open space:

parks, wilderness areas, and mountainous terrain. We are calling this Wildland SAR to distinguish it from other types of SAR, such as searches carried out in urban settings with collapsed buildings (Heavy Urban Search and Rescue); operations led by the US Coast Guard in open sea and coastal waters; or the Civil Air Patrol for downed aircraft.

We use real-world examples, case histories, and short exercises to develop a solid GIS skill set for individuals and, ultimately, a GIS capability for your team. The print version of this book has a CD for the maps and data needed for each lesson. The data can also be downloaded from mapsar.net. As you gain confidence with a particular lesson and skill, we strongly encourage you to practice these skills using your own area's data. Appendix 2 "Resources and Support" includes links to sites with further online training as well as discussion forums to ask questions and keep up-to-date on techniques.

Recommended Skills

A working knowledge of GIS is critical to every member of a modern SAR team. Mistakes in understanding GIS concepts such as coordinate systems and datum and correctly reading coordinates from maps have led to expensive and almost fatal mistakes. To do our job successfully as SAR team members, we have to understand today's technology and advances in mapping techniques and workflow.

There are two levels of skill we recommend for SAR teams adopting GIS into their program. All team members should have the following basic skills, which we cover in chapters 4, 5, and 6.

- Find locations on a map when coordinates are provided.
- Provide locations to others accurately and clearly.
- Take an initial missing person report and establish initial planning points (IPP) such as point last seen (PLS), trail blocks, and assets that will be the basis of all geospatial planning to follow.
- Draw assignments and print team maps for the hasty search.
- Project saved track logs from GPS devices onto a map.
- Use a basic set of digital maps and data and know how and where to obtain them.

This skill set involves the following:

- Becoming proficient with GPS devices
- Understanding the coordinate systems and datum that different responders use
- Being able to establish protocols to send and receive that information for effective follow-up
- Being able to use a basic tool set in a mapping software program

A more advanced skill level uses ArcGIS 10 for Desktop and MapSAR for incidents. MapSAR is our workgroup's model and tool package that integrates the previously established workflow of a SAR into the GIS framework. This requires a little more training time but is within the abilities of many team members. Chapters 7 and 8 introduce you to ArcGIS and MapSAR.

Like other skills among SAR team members, perhaps only a few may want to develop this level of proficiency. Similar to the need for having technical climbing or swift water teams available, it is vital for a team's GIS capability that a few members become proficient at this higher level.

Summary

Although well established in wildland fire mapping, using GIS in SAR is a fairly new field. We have adapted our tools and protocols to established and time-tested SAR workflow and fit them into the ICS. We recognize, though, that this is a new field when applied to SAR. Experience and new technologies may evolve and suggest different ways of doing things. This means maintaining proficiency and keeping up with new tools, technologies, and workflows as we improve and adopt standards.

Although not ideal, it's also possible for teams without a well-developed GIS capability to call on another team with that expertise. If there's an Internet connection, one team creates GIS-based maps and databases from the information sent by the on-scene team. The maps can be sent to, for example, large plotters in the county planning office to print briefing maps. It has to be done very carefully to ensure critical information is not lost, but the Internet allows many SAR GIS functions to be carried out far from the incident area.

Finally, the technology must not interfere with your primary job: getting your teams into the field quickly, finding the missing, and bringing them and your teams home safely. *Using GIS in Wildland Search and Rescue* will allow you to smoothly integrate this exciting and vital technology into your existing workflow, leading to greater situational awareness as well as a more efficient and effective SAR operation.

Chapter 1: Introduction

A map is not the territory it represents, but if correct, it has a similar structure to the territory, which accounts for its usefulness.

—Philosopher and Scientist Alfred Korzybski, 1931

In the not-too-long-ago old days, the grizzled SAR team leader would slap a map on top of the hood of his truck, take a pencil and draw out search assignments for the gathered team, then send everyone on their way to find the overdue hiker. That approach worked, of course, but was not particularly effective at keeping track of where teams were going or where they'd searched. In multiday searches, any operation that depended on paper maps stood a high probability of missing important clues as they came in—there was just too much information to effectively keep track of everything. In the last 10 years, this situation has improved as many SAR teams have begun incorporating aspects of GIS into their operations.

What Is GIS?

GIS, according to Esri, is defined thus:

An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed.

Search and rescue is a challenging discipline requiring great skill and dedication: countless hours of mostly volunteered time spent in training and on actual SAR operations. As anyone knows who has worked a SAR, or any emergency operation where even small numbers of people are involved, such incidents are, at best, barely controlled chaos. They are held together by the incident command team planning and directing the field teams, who are out in often brutal conditions searching for the lost.

It's important to get teams into the search area as quickly as possible, but you also need to know where to search; make sure teams are briefed; know where to go and have accurate maps; have the right equipment and enough food and shelter; have a way of getting teams there; know who's where; coordinate with other agencies involved; make sure all information and clues reported from the field are routed and followed up on effectively; and that at every stage of the operation, the search teams can arrive, carry out their assignment, and be picked up safely.

Almost every aspect of a search consists of geospatial information, as well as other dynamic data (figure 1-1), that can be stored and represented graphically on a map of the search area. At its core, the SAR mission is saving lives. Using GIS on a SAR greatly enhances this mission. It allows teams to collect, organize, and visualize complex information for more effective search strategies. Assets, IPPs, subject information, reporting party information, team locations, clue locations, and track logs can all be gathered during an incident and then made immediately available to the ICP. (For unfamiliar terms used in this manual, see appendix 3 "Glossary and Acronyms.")

Using GIS effectively, the progression of the SAR can be layered (figure 1-2) and shown on planning maps, and specific data can be made visible or hidden to emphasize the different needs of

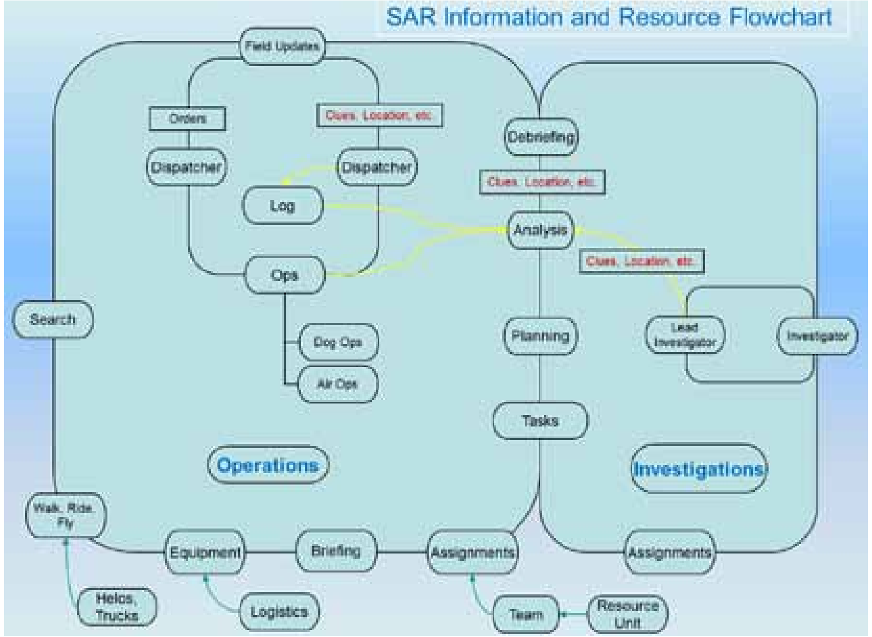


Figure 1-1: Information and Resource Flowchart for Search and Rescue (after John Dill, Yosemite SAR, NPS)

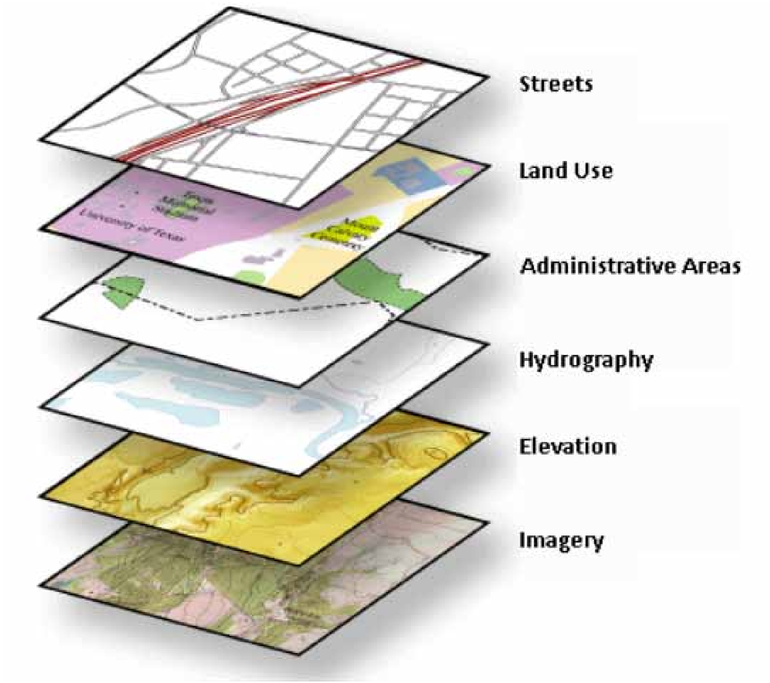


Figure 1-2: GIS applies data and information in a layered structure, which also allows specific layers to be displayed or not, depending on what aspect of a SAR needs to be visualized.

a planning team or for team maps used in the field. Without the effective use of GIS on a SAR, it is virtually impossible to keep track of the huge quantities of geospatial information coming in from such myriad sources as field teams, investigators, air operations, and plans. Almost every SAR team has a story about how a vital clue was lost in the controlled chaos of an operation. GIS can be used to better keep track of this mass of information, organizing it more efficiently and visualizing it more effectively to achieve a successful outcome—maybe saving a life.

Why Use GIS?

The foundation of every SAR is a map. GIS and ArcGIS for Desktop are becoming vital tools in every aspect of SAR by creating maps to both visualize and analyze terrain so that planners and field teams can keep track of a constant stream of information: point last seen of the victim; perimeter of the entire search and the individual segments each team is assigned to; clues such as footprints, a backpack or sunglasses found; and the GPS track logs of helicopter and ground teams. Prior to GIS, searchers would use acetate overlays on top of USGS maps to record such dynamic information. Now all that information can be recorded, projected onto a map as needed, and then archived for future use. The use of computers, GPS devices, and GIS software is a major advance in operations and is critical to effective situational awareness by incident command (IC) staff.

When used effectively, GIS will improve operational efficiency in four primary areas:

- **Field Operations**

  Maps are the most important resource for field teams who are critical to the successful outcome of a search. The primary goal when using effective GIS on a SAR is to quickly create maps with the information needed by teams to effectively carry out their assignment. By using MapSAR with ArcGIS 10, SAR planners can enter necessary information (PLS, description of missing person, locations of resources, weather safety message, etc.) and, using the Data Driven Pages feature, quickly produce customized team maps so field teams can start to look for the missing. Additionally, keeping track of assets and teams is a major logistical problem made much easier and safer using GIS and MapSAR.

- **Data and Information Management**

  ArcGIS and MapSAR will capture all the information and resource flow shown in figure 1-1. This is critical not only for an ongoing operation but also to archive data in an easily retrievable structure for later review. If the person is not found, a standardized and organized data structure allows future searchers to know exactly what was done and the areas searched should the operation be resumed.

- **Planning and Analysis**

  GIS software can utilize a variety of basemaps—in both 2D and 3D—to better visualize terrain for planning, including standard digital USGS topographic quadrangles, satellite imagery, agency brochure maps, or any other type of map that helps you plan strategy for a search. GIS also allows analysis—from simple calculation of segment size and length of trails to be searched to more complex tasks like using models to potentially predict how far a person might travel based on the actual terrain (e.g., slope, vegetation, and trail availability) that the person is traveling through.

- **Situational Awareness**

  In a networked computer environment, all teams at an incident command post are able to view the operation on a projected and automatically updated map, which can be viewed on a common screen or on personal computers connected to that network. Incident information can be displayed, such as PLS, search perimeter, segments, team deployments, team locations, clues found, asset location, and availability status. An advanced GIS specialist can set up ArcGIS for Server so that SAR dispatch can enter team information on a Flex Viewer map, which then becomes immediately available to all IC staff. Although this feature is beyond the scope of our manual, educational resources are available through Esri and mapsar.net.

What You'll Need

This user manual is based on ArcGIS software and some related and free utilities to run a SAR operation. All the exercises and our core model, MapSAR, are based on this software. We provide the data used in the exercise, but we strongly encourage readers to find and download the geospatial data for their own area of responsibility and practice with that. The section Creating a Minimum Essential Dataset gives ideas on how best to gather this information for your team.

Specifically, we'll be using the following:

ArcGIS Explorer Desktop

This is the free mapping software available from Esri's website. An installation batch file is included in the data CD accompanying this book, or it can be downloaded directly at resources.argis.com. Detailed instructions on download, installation, and use are found in chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks." ArcGIS Explorer Desktop is a robust and flexible mapping viewer. The advantage it has over other similar mapping software is that it can use shapefiles, which are the standard in the GIS community, to spatially represent the locations of points, lines, and polygons (for instance, roads, trails, and buildings). ArcGIS Explorer Desktop system also can download a wide variety of basemaps from Esri's free ArcGIS Online site (sign-up required), or you can use satellite imagery or USGS topographic maps available free from a variety of online sources (see the section in chapter 3 Creating a Minimum Essential Dataset). There is no proprietary data required. The maps and data you create can be exported to ArcGIS 10 for Desktop for more advanced analysis or uploaded to any ArcGIS Online group to be shared.

A necessary part of participating on a SAR team is to train, train, and train. Usually, that's a day or two each month on an exercise as part of an incident command; thrashing around a steep hillside calling out the name of a "victim"; or setting up rigging to lower an individual portraying a victim down a vertical wall.

We recommend that every team member be familiar enough with with ArcGIS Explorer Desktop to find and establish the initial geospatial information of a SAR, such as point last seen, and carry out initial mapping if necessary.

ArcGIS for Desktop and MapSAR

Every team has members who choose to specialize and train for different tasks. To create a fully effective GIS capability for SAR operations, a couple of team members should train at a more advanced level to use MapSAR, which is integrated into ArcGIS 10 for Desktop. Although this advanced GIS skill set is truly within the learning abilities of most SAR team members, a team may want to pursue recruiting a GIS specialist from a community college, land management agency, or county planning agency. SAR in the United States is a community effort, and people from all disciplines are willing to help if given an opportunity to volunteer their skills.

For a more complete understanding of ArcGIS software and how MapSAR works, see chapter 7 "ArcGIS 10 for Desktop—A Basic Introduction." Even if this level of proficiency doesn't interest you, it's still highly beneficial to read these sections to become familiar with what MapSAR is capable of and how it fits into the SAR workflow. Teamwork requires each member to be aware of the skills, needs, and capabilities of fellow team members, allowing everyone to work smoothly and effectively on an operation.

ArcGIS for Desktop—ArcGIS for Desktop is a software suite consisting of a group of GIS software products from Esri. The primary program we will use is ArcGIS 10 for Desktop, which consists of ArcMap, ArcCatalog, and ArcToolbox. Chapter 7 "ArcGIS 10 for Desktop—A Basic Introduction" explains in more detail the different components of ArcGIS, licensing levels, where your team might be able to obtain ArcGIS 10 at little to no cost, and a general overview of how to use it.

MapSAR—MapSAR works with ArcGIS 10 and is designed to capture a SAR's geospatial and incident information and then automate many of the mapping tasks. The goal of MapSAR is to create an "enter once, use many times" data collection and workflow. Filled in once, the same information is then automatically filled in on all operational maps (e.g., team, Incident Action Plan [IAP], briefing, plans). You can then display and save information in almost any combination you want. Clues can be shown by confidence level and relevance so a cluster of otherwise unnoticed clues (e.g., low-confidence dog alerts) might suggest a reason for follow-up. Search progress can be viewed by operational period and the previous day's effort temporarily removed from the map to reduce visual clutter and possible distraction.

Another great feature of MapSAR is that it incorporates the ArcGIS 10 Data Driven Pages feature (see figure 1-3). Once all the primary incident information has been entered and propagated throughout the database, the software automatically customizes a map for each team centered on its assignment area and with the assignment description, assigned radio call signs, weather, and other critical information printed on the map. Chapter 8 "Overview of MapSAR" provides further details and exercises in how MapSAR and ArcGIS can be integrated into SAR.

How to Use This Book

Creating a GIS capability for your SAR team is accomplished in several steps. The section Why Use GIS? introduces you to the importance of using these techniques, tools, and workflow in your operation. Chapter 2 "Implementing Effective GIS for Your Team" introduces the basic GIS skill set each team member should have. For the members who pursue more advanced GIS knowledge, this chapter specifies the skills they'll need to implement and run an effective GIS.

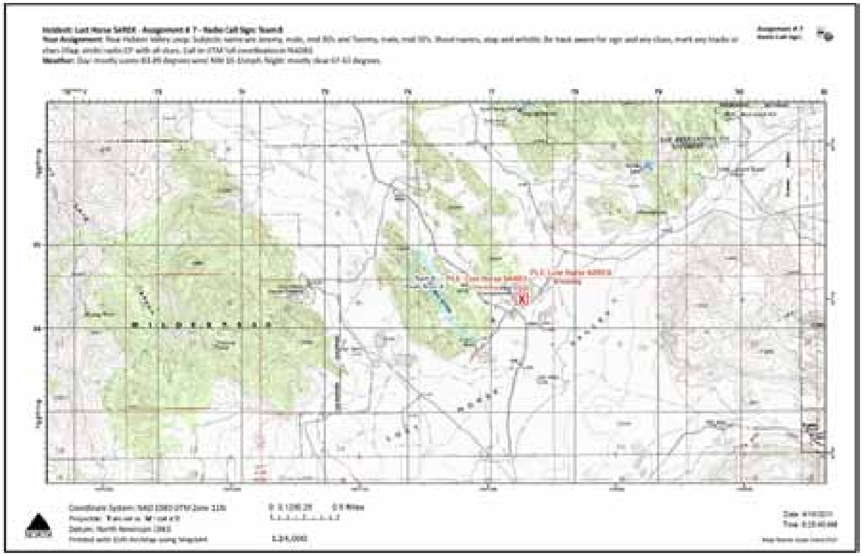


Figure 1-3: Team Map Produced in PDF Using MapSAR and the Data Driven Pages Function of ArcGIS 10

(Photo courtesy of Sierra Madre Search and Rescue)

Well before actually using GIS on an active SAR, you need to become familiar with the file structure and naming conventions you'll be using in preparation for any SAR. You also need to assemble the maps and data needed to conduct an actual SAR. Chapter 3 "Preplanning" will guide you through assembling a Minimum Essential Dataset (MED). The MED will contain all the maps and data you need for your team's area of responsibility. These two steps can be carried out by one or two of the geekier members of your team. It's not at all difficult, but it's not necessary for the entire team to learn these two steps. Everyone, though, should be briefed on how it all works and the importance of consistently using the same naming conventions and file structure on all operations.

Next, every team member needs to learn the skills taught in chapters 3 through 5. These chapters are where you need to practice as a team to develop a team's basic GIS skill set.

Chapter 4 "Understanding and Using Coordinate Systems" is critical to a confident understanding of coordinate systems so you don't make life-threatening or time-consuming mistakes.

Chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks" teaches the mapping skills for every team member to be able to begin establishing the geospatial information of a SAR when first on scene—find places on a map based on coordinates, establish the IPPs, and produce team maps for a hasty search. This chapter also provides an overview for downloading a GPS device and projecting track logs onto the SAR map.

Chapter 6 "Integrating GPS and Current Technologies into SAR Operations" familiarizes team members with how a GPS device works, considerations when deciding what kind to purchase, how best to integrate the GPS into SAR operations, and a team exercise to practice basic GPS skills. This chapter also introduces your SAR organization to emerging technologies that allow real-time tracking of teams, enhancing situational awareness and team safety.

Most SARs start and end in the first operational period. For those, it's likely that a team's GIS needs can be met by using the recommended basic skills of this manual. As a SAR becomes more complex (more teams, larger search area, additional information coming in), you need to seriously consider quickly calling in a GIS user trained in the use of MapSAR either from your team or your state's emergency management agency (EMA). Because the GIS specialty is still evolving, your EMA may not yet have a callout list for GIS specialists. This is another good reason to have several of your own team members trained or even recruit from your county planning agency or a local college's GIS program.

Chapter 7 "ArcGIS 10 for Desktop—A Basic Introduction" and chapter 8 "Overview of MapSAR" introduce the reader to using the advanced GIS capability of MapSAR and ArcGIS 10 for Desktop. Appendix 3 "Glossary and Acronyms" provides a reference for any unfamiliar terms or acronyms.

In talking to SAR teams throughout the country, we've found that while most would like to use better mapping or GIS software, they are intimidated by the perceived learning curve and the cost. *Using GIS in Wildland Search and Rescue* is, we hope, a solution to the first concern. The lessons are based on real-world situations and are presented at an easy pace.

In addition, training videos are being developed to supplement both this manual and *The MapSAR User's Manual*. Refer to the training and resources available at mapsar.net for links to videos as they become available.

Summary

On every search operation, time is critical to saving lives. GIS-driven technology, tools, and workflows are vital to speed up the planning cycle of a search, quickly getting teams into the field to search for the missing and, with skill and luck, saving lives. We don't know when—or even if—we're going to find the person or if our efforts are going to contribute to a successful outcome. All we know is that there's someone out there who needs help and our best effort. Even at its most effective, GIS will only be another tool in this effort. When applied to GIS, Korzybski's "the map is not the territory" is a warning not to make maps or computer analysis a substitute for local knowledge and a team's skill. For all this technology's potential, the lost and injured are found and rescued by dedicated searchers working in difficult and dangerous conditions far from help themselves.

Effective SAR is founded on the actions of searchers voluntarily leaving a warm and comfortable environment to go out in often horrendous weather and terrain to look for a missing person. SAR will always require people with specific knowledge of an area to be able to properly evaluate and make decisions based on that experience. It's often our hunches and guesses that allow true understanding of a situation that lead to solutions. GIS, though, can be a vital tool to efficiently and effectively envision complex information—turning a flat piece of paper into a better approximation of the territory. Using GIS in Wildland Search and Rescue is your team's guide to making this happen.

Chapter 2: Implementing Effective GIS for Your Team

The SAR GIS Specialist within the Incident Command System

The ICS is "a systematic tool used for the command, control, and coordination of emergency response." When properly used, it is a flexible and organized structure that will impose an effective response to any type of temporary event of varying size or complexity. The ICS is implemented as a standardized framework, imposing a chain of command and identified functions designed to be scalable according to the specific needs of an event or incident. An organization chart describes the chain of command and modular organization that can be formed in response to an incident. Not every module needs to be filled except the incident commander. More people can always be brought in to fill tasks according to the needs and extent of the incident.

Within the ICS wildland fire organization, the GIS specialist position is well defined in the organizational structure. The National Wildfire Coordinating Group (NWCG) gives the duties of the wildland fire GIS specialist. Adapted to SAR, these responsibilities include the following:

- Acquire and process incident data: Most often, this will involve downloading this data from search teams' GPS units and exporting to shapefiles. Incident data to maintain can include geospatial data associated with the SAR such as ICP, PLS, search segments, search assignments, trail blocks, helibase, staging areas, camps, helispots, drop points, and medevac sites.
- Create maps for (1) operational resources to use during their shifts (team maps), (2) management teams to use while briefing resources, (3) management teams to use in developing strategies, (4) aviation resources to use for mission planning, or (5) public information officers (PIOs) to distribute to the public.

Within the SAR organization, the GIS person would most often work for the situation unit leader or, if none exists, for the planning section chief. The important thing to remember about working any assignment within the ICS is that it is a defined structure with a clear chain of command. It's easy for the GIS person to become distracted or overwhelmed as requests come in from everyone for maps, location coordinates, search progress, team assignments, etc. The ICS structure exists to specifically prevent this situation. All requests have to go through the appropriate channels to triage requests according to priority and the workload of the GIS user.

Within the incident command system, GIS is within the planning section.

(Photo credit: NPS; photo taken by Ken Phillips and CJ Malcolm)

Basic GIS Skill Requirements

As with any essential team skill, there are some basic GIS skills that all team members should possess and some specialized ones that the team should have available when needed. To be an effective search team in today's digitally connected world, it is critical that all team members understand certain aspects:

- **Coordinate systems.** Everyone has a GPS or cell phone with them. Many have emergency locator devices such as a SPOT or Personal Locator Beacon (PLB). All report their positions in one of several types of coordinate systems, datums, and formats. Not understanding the coordinate string given by the person in trouble or the agency relaying them to the team from a distress call has led to numerous delays in response as well as teams wasting valuable time searching in the wrong area.
- **Knowing how to correctly plot coordinates using either paper maps or software.** Most teams train with USGS paper quads and have training standards for reading, finding, and reporting coordinates using those quad maps. The same is now necessary for digital maps. Teams use a variety of mapping tools: TOPO!, Google Maps or Google Earth, Terrain Navigator Pro, and others. While this manual will recommend the use of specific mapping tools (ArcGIS Explorer Desktop and ArcGIS for Desktop used with MapSAR), it's vital that each team pick a software package that will work for it and that each member becomes competent in that software.
- **Making team maps for a hasty search.** An efficient workflow requires that the first person to get to the team's HQ or the incident location know how to take down the reporting

party's information necessary to organize a hasty search. This information also needs to include correctly recording the geospatial information. That person should also then be able to produce team maps showing the basic geospatial information critical to the SAR: a digital basemap, IPP, point last seen (PLS), and assignments (or search segments).

- **Using ArcGIS Explorer Desktop as part of a standardized GIS workflow.** As noted, there are many mapping tools out there that different SAR teams use for their mapping needs. We strongly encourage the use of ArcGIS Explorer Desktop as part of an effective and efficient implementation of a GIS capability for SAR teams. The primary reasons for using ArcGIS Explorer Desktop are that it is a robust and easy-to-use software mapping tool, and it's free. More detail is given in chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks."

Advanced GIS Skill Requirements

An effective SAR team has members who develop specialized skills such as technical rigging or tracking. The same is true when integrating GIS into team operations. There are advanced skills, and in addition to the ones listed above, several team members should train in the use of MapSAR and other advanced GIS skills:

- **Using MapSAR with ArcGIS for Desktop.** MapSAR runs with ArcGIS 10 to store geospatial information, enabling SAR maps to be generated, stored, and printed quickly. MapSAR was created by a team of GIS and SAR professionals from the Sierra Madre Search and Rescue Team, Esri, Sequoia Kings Canyon National Park, Yosemite National Park, Grand Canyon National Park, and the Mountaineer Area Rescue Group. This manual provides a brief overview of MapSAR (see chapter 8 "Overview of MapSAR"), but we strongly recommend obtaining a copy of *The MapSAR User's Manual*, available free from mapsar.net in PDF format.
- **Being familiar with existing and emerging technology to enhance SAR capability and team safety.** There are a number of devices on the market—and more on the way—that give teams the ability to precisely locate in real time either users in distress or their own teams on a SAR. Knowing the location of the people in distress can dramatically speed up the team's response time. Such technology can also speed the planning cycle, because the ICP is aware of a team's progress. In addition, cell phones are increasingly becoming useful in locating people in distress. SAR teams have successfully talked lost hikers through downloading GPS applications, allowing them to then report their coordinates for the team to find them (see sidebar Technology Saves the Day). This requires a good knowledge of the applications

available on different phone operating systems and their strengths and weaknesses.

Learning these skills is pretty easy (really), and the rest of this manual will give step-by-step instructions on how you or your team can acquire them in an easy-to-learn way.

Many tools are used to assist during incidents—everything from helicopters to GIS.

(Photo credit: NPS; photo taken by Ken Phillips and CJ Malcolm)

Technology Saves the Day

In December 2011, a cell phone call was transferred from emergency dispatch to the Brecon Mountain Rescue Team (Wales, UK). A couple hiking on a nearby mountain without a compass, map, or flashlight were overtaken by darkness and couldn't find their way back. They did, though, have a cell phone and called for help. Talking to the stranded couple, a team member determined the type of phone they were using and then talked them through downloading a GPS application specific to that phone. He told them how to start the application and then read the coordinates shown. The team plotted those coordinates, determined where the lost party was, and responded to their location, saving the couple a very cold night on the mountain and possible injury or death. Imaginative thinking and an expert familiar with the capabilities of different cell phones, what software was available, and the ability to use the coordinates generated led to a swift and successful resolution of the emergency.

Technology saved us all a night on the mountain, but it can never take the place of a traditional map and compass and being properly prepared.

Mark Jones, Brecon Mountain Rescue Team

Technology Badly Confuses the Day

In June 2009, Kat, a young woman on a solo hike at 11,000 feet in the Sierra Nevada mountains of California, was rapidly losing strength and coordination as a result of hypothermia. She had a SPOT emergency locater device with her and decided her condition was critical enough that she activated the emergency button. The emergency signal went to a satellite and then to the Geodetic Earth Orbiting Satellite (GEOS) International Emergency Response Coordination Center (IERC) in Houston, Texas. Per established protocol, IERC determined the signal was coming from California and called the California Emergency Management Agency (Cal EMA). The Cal EMA duty officer established the location and gave IERC the contact number for the county sheriff's office responsible for SAR in that area. IERC contacted its SAR coordinator and gave the duty officer the coordinates received from the device. Those coordinates were plotted by the sheriff's SAR coordinator. A helicopter and ground teams were then sent to the location shown by the mapping software. After several hours of searching in the fading light, the helicopter and teams had found nothing.

This was the view from Kat's tarp shelter as she activated her SPOT emergency device.

There were multiple phone calls between IERC and the sheriff's SAR team to confirm that the coordinates were correct. No disparity with what was given by SPOT and what was heard by the sheriff's office was apparent. The numbers matched. The next day, Kat hiked out of the mountains, wet but alive. An interview determined that the search was carried out 20 miles north of her actual location.

An after-action review by two independent SAR professionals found the following contributing factors for the error:

- The SPOT IERC was contacted directly by the reviewers and asked to look up and read off the coordinates of the incident. The coordinates were given in decimal degrees, which the reviewer plotted and which correctly mapped to the location Kat said she was at when she activated the emergency button.
- The string of coordinate numbers given by SPOT and received over the phone by the sheriff's SAR coordinator were correct. It

seems likely, though, that the coordinate type given by IERC in its default of decimal degrees (DD.dd) was read off in a string (for instance: 36.7758, -118.4267) but was not identified as being in decimal degrees. There's also the suspicion by the reviewers that instead of a verbal "decimal" to represent the critical separation between degrees and the decimal degree string, a pause may have been used. For example, "Thirty Six <pause> seven, seven, five, eight" instead of "three six decimal seven . . . . " There are many cases the reviewers have found where this type of mistake has been made.

The sender of the coordinates assumes knowledge of coordinates by the person receiving them that may not be true. The receiver does not know the questions to ask to clarify the information.

- IERC had the capability to provide an e-mailed link to an online map to graphically show the location of the emergency signal but probably did not offer to send it for clarification. The sheriff's SAR coordinator did not ask, not knowing this was possible.

- The software the SAR team used had three boxes to enter coordinate values for each axis (that is, north-south and east-west). It was possible, but not clearly documented, that decimal degrees entered as one string in the first box would give a correctly plotted location. It is quite likely that the SAR coordinator divided up the DD.dd string to fit the three boxes, which would give a latitutde-longitude result for a degree, minute, second (DD MM SS.ss) coordinate value, thus: 36 77 58, -118 42 67. When the reviewers entered the SPOT coordinates in this format on the same software, the results showed as the area where the team searched: 20 miles north of the actual location.

When the authors of this manual ran this story by other SAR teams, almost everyone had a similar story of someone along the way not understanding coordinate values and not knowing enough to ask for clarification. This is at the heart of why it's critical that *every* member of a SAR team, as well as dispatchers and anyone in the chain of incident reporting, know how to report coordinates, what to ask for if presented with a string of numbers, what to ask if not given a datum, and how to use those numbers to find the correct location on a map. The training and protocols in this book are designed to prevent such incidents from recurring.

Chapter 3: Preplanning

Preparation makes a SAR team efficient, and training makes it effective. To successfully integrate GIS into your SAR team's operation, you need both. For GIS, your team's GIS users need to assemble the files and data you'll need ahead of time. They also need to set up a logical file structure so everyone knows where to put the information collected and created. When you're familiar with your data structure and file naming conventions, you quickly know where everything goes and where to find it. In the intensity of an active SAR, this is critical to an efficient and smooth operation.

Steps in preparing a team's GIS capability include the following:

- Assemble the files (maps and other geospatial information) for areas you typically work in. This will be your MED and will contain most every type of data you'd need when planning and responding to a SAR.
- Create a consistent and logical folder structure such that everything is easy to find and is consistent from one SAR to the next. MapSAR sets this structure up automatically when installed. Even if your team doesn't develop the technical expertise to use MapSAR and ArcGIS 10 for Desktop, we strongly recommend that you extract the MapSAR package to create or copy that folder structure for your data.
- Learn and use consistent naming conventions for the files and folders you create. Such naming conventions have been well established in the wildland fire GIS world and adapted to use in SAR. When MapSAR is installed, each folder, where warranted, has a text file with the standardized naming convention included. Standardized file names are critical so everyone understands what's in a particular file, when and for what incident it was created, and its purpose.
- When collecting and compiling incident-related geospatial information, implement and practice a consistent workflow for all team members to ensure data integrity and an efficient operation. The workflows recommended in this manual and in *The MapSAR User's Manual* will greatly enhance your team's mapping abilities.

Directory Structure; File and Naming Conventions

Central to using GIS in day-to-day or emergency operations is a consistent file structure and naming convention. This is critical if others are going to be able to find your files when you're not there and understand what's contained in them. Both the directory structure and standardized naming convention provide a framework for storing and using GIS data and documents efficiently and in an organized fashion. Standardization also promotes an efficient workflow, reduces ambiguity, and enables a data archival process for later retrieval if needed. It is critical, then, that directories and file structures be set up in advance of any incident and that the team becomes familiar with their locations. This is an important preplanning step.

We have derived many of our naming conventions from long-established protocols developed by fire GIS. These standards are in the *GIS Standard Operating Procedures on Incidents* manual (GSTOP), available from the National Wildfire Coordinating Group at http://gis.nwcg.gov/. However, the use of GIS in SAR and other operations is evolving and, though we emphasize the need for a logical and consistent directory structure and file naming conventions, we recognize that these preliminary standards may change with experience and need.

Files and Folders for GIS and MapSAR

MapSAR provides a ready-to-use folder structure for any SAR (figure 3-1). It is expandable for each new incident—you just extract UTM_xx_New_Incident.zip, drop it into the C:\MapSAR folder, rename the new folder according to your incident, and you have a basic structure to begin capturing the information generated by a SAR. Even if you don't have a team member able

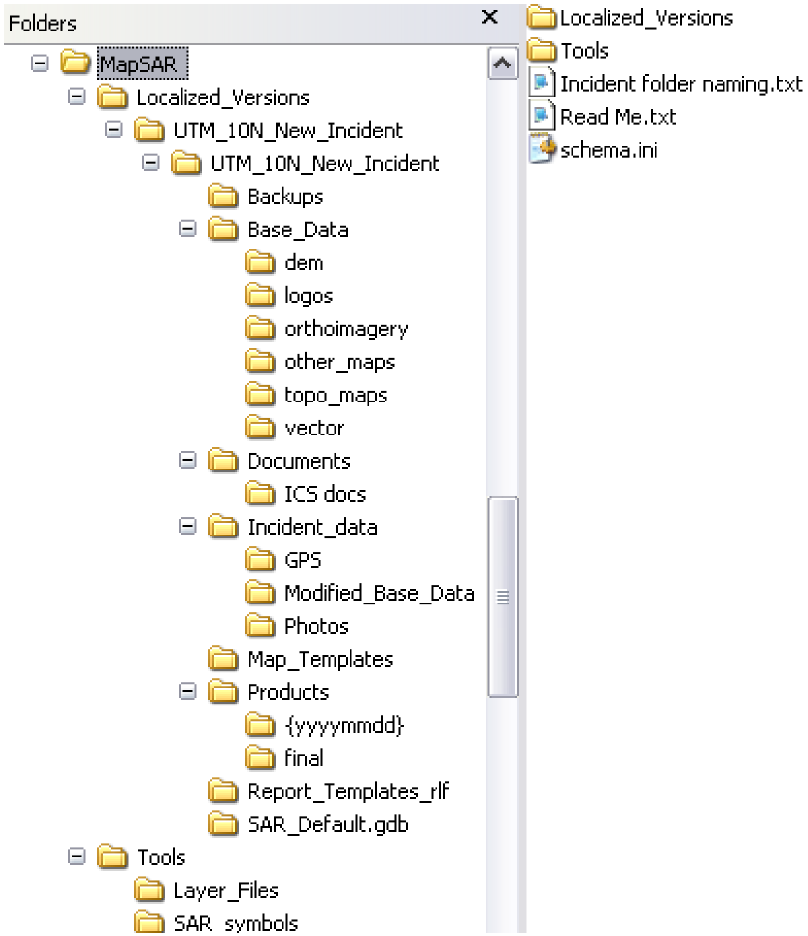


Figure 3-1: MapSAR Folder Structure

to use ArcGIS 10 and MapSAR, we strongly recommend that your team adopt this folder structure as the standard and promote an orderly and consistent way to store incident geospatial data, photographs, and reports.

When extracted, the folders include sample naming conventions for each incident as well as for individual files. For the tool to run correctly, those file paths must not change. You may, however, add folders and subfolders according to your needs. It's okay if your organization uses a slightly different GIS folder structure for SAR, but make sure this structure is clearly documented and the team has training in it. Keep in mind that when using MapSAR, changing some of the folder structure will break things and some will not, and many subfolders can be changed without risk. For instance, your organization may prefer to organize its products by file type, such as .pdf, or by map purpose (briefing maps, assignment maps, etc.) instead of by date or if your base data is better organized by category, such as hydrology and terrain, rather than by raster and vector data. Neither of these changes will affect MapSAR's function.

Installing these files requires no computer skill other than the ability to extract a compressed file. To create a MapSAR incident folder structure, read the instructions in chapter 8 "Overview of MapSAR." You need only read the first section, "MapSAR Download Instructions and Installation," through step 3 Opening MapSAR. Because you're only creating the folder structure to store your MED and incident files, you need not perform step 3. iv. Double-click **MapSAR**.

Read the next section, in that same chapter, Overview of MapSAR Folders, to understand each folder's purpose. Many of the data folders have text files reminding the user of the naming convention for files to be placed in that folder.

There is some flexibility in adding folders to meet your team or area's specific needs. However, information generated during the SAR should be kept in the relevant and established incident folder. Such standardization is critical so that everyone working with that data is familiar with the structure. Consistency makes saving and finding everything easier as new shifts take over. In addition, all data is stored in one place should it need to be retrieved months or even years later.

With MapSAR, a Base Data folder is created within each UTM_xx_New_Incident folder. As noted in the section Overview of MapSAR Folders, this location might not work for your team's needs. There are several considerations when deciding where your base data is kept, and you need to read that section to store the base data in a place that works for your needs. For the most part, though, the location is easy to change as your needs change.

According to Victoria Smith-Campbell, GIS coordinator, Colorado Division of Emergency Management, there are three general categories of data needed for a SAR:

1. Prestaged data (on a portable hard drive, for instance) that you keep for your region to cover whatever you might need, for example, USGS digital quads for your area and locations of buildings, roads, trails, and mine shafts.
2. Base data for the specific incident. During an incident, as you need your MED base data, move it into the folders for the incident. For instance, move the specific USGS quads and trail or road data you need from your prestaged MED to C:\MapSAR\UTM_xx_New_Incident\Base_Data as required by the incident.
3. Incident data. Files and data created during the incident or data you alter from your base data, for example, reporting party, PLS, clues, sectors, GPS files, and search grids created for the search.

There are other considerations in deciding where to store your base data:

- Will your data be part of a network? If so, you should create your structure in consultation with your IT department and agency's GIS specialist.
- If part of a network, do you need to restrict access? Will you be storing sensitive information (medical or law enforcement)? Again, your IT department can create an access group based on your criteria.
- There is a tendency to store data files on your personal or work station computer. This is a really bad practice for information that others might need should you not be available. In a stable and efficient network environment, network storage is best. It does happen that networks go down for extended periods of time. Also, of course, software glitches or other mistakes can cause you to lose data in the middle of a SAR. As with any data, you need to continuously back up work files on an external hard drive that could be available to all in the office. If your network is not trustworthy or is very slow, set up a login that everyone can use to access GIS data when shifts change, and/or store the primary set of data on an external drive in a central location that everyone knows about.

- Since many SARs or emergency incidents take place where an Internet connection is not available, you need to mirror your network structure on a portable USB drive. A major advantage of ArcGIS Explorer Desktop, ArcGIS 10, and MapSAR for SAR mapping needs is that they don't need an Internet connection. To run a SAR, though, you do need your MED in an accessible place. If the network goes down or you're at a forward command post, it's critical you have your

MED available. When you do mirror your data on a portable hard drive, you need to create a protocol to make sure files are updated and that you have a central archive for all incident data to be stored.

- If you decide not to use the MapSAR structure, the one you create should have separate folders to distinguish between incidents. The incident folders should be nested under a root SAR_Incidents folder and then categorized by year. If you don't extract MapSAR to use the folder structure, you can easily create it anywhere you want. To use MapSAR's full functionality, though, it has to be located at C:\MapSAR*.*.

File Naming Conventions

The goal of standardizing file names is to tell anyone who needs to access a file what's contained in it. The following naming conventions are adapted from *GIS Standard Operating Procedures on Incidents*, chapter 2. Here, we include examples of only those files typically used on a SAR or other non-fire operation. However, we have made a number of adaptations to work more easily with SAR. SAR file naming conventions will undoubtedly change in the near future to bring them more in line with ICS standards, so always stay current with the latest version of the MapSAR application (from mapsar.net), which will reflect these changes.

The necessary information is written in the sequence they should appear in the file name, separated with an underscore. The general format is: {date}_{incident information}_{other information}. The path names used in the examples are those created when the MapSAR data was extracted.

To install the MapSAR folder structure (even if you don't intend to use MapSAR), read the section MapSAR Download Instructions and Installation.

Table 3-1: MapSAR Naming Conventions

Path	File Type	Example
C:\MapSAR\UTM_xx_New_Incident	UTM_xx_New_Incident Folder Name = yyyymmdd_incident name_UTMzone.	20101218_DohertySearch_UTM11
C:\MapSAR\UTM_xx_New_Incident \Products\{yyyymmdd}	Variety including PDFs, JPEGs, TIFFs, etc.	Folder = 20120112
For the map product files located in those folders C:\MapSAR\UTM_xx_New_Incident \Products\{yyyymmdd}	yyyymmdd_time_IncidentName_OperationalPeriod_MapType_PageSize_Orientation Type of map: airops = Aerial Operations Map brief = Briefing Map iap = Incident Action Plan Map owner = Landownership Map plans = Situation–Plans Map prog = Progression Map trans = Transportation Map Page size: In inches (e.g., 8 x 11 or ANSI size A–E (e.g., AnsiE Orientation: land = landscape port = portrait	20101218_0700_DohertySAR_OP1 _IAP_11X17_Landscape 20101218_1300_DohertySAR_OP1 _Brief_AnsiE_Portrait time = the time the data was collected OP = what OP the product will be used for
C:\MapSAR\UTM_xx_New_Incident \Incident_data\GPS	GPS file: Filename: yyyymmdd_time-collected_incidentname_gpsFeatureType_source _csdatum yyyymmdd = the date, including the year when the data was collected hhmm = the time of data collection using a 24-hour clock incidentname = name of incident gpsfeaturetype = the type of feature such as gps_lin for line data, gps_pnt for point data, or gps_pol for polygon data source = the name of the person or the ICS position who collected the data cs = coordinate system, such as ll for latitude-longitude, u12n for UTM zone 12 North datum = the datum, such as w84 for WGS 1984, 83 for NAD 1983, 27 for NAD 1927	20120510_0930_Brown_gps_lin_Lewis _llw84.gpx 20120427_1230_Radford_gps_pnt _Clark_u11n83.txt
C:\MapSAR\UTM_xx_New_Incident \Incident_data\Photos	Photo Filename: yyyymmdd_time-collected_IncidentName_ContentType Type: Clue = (e.g., footprint, clothing, water bottle) Person Vehicle	20101218_1630_Doherty_footprint.jpg 20101218_1318_Doherty_person.jpg 20101218_1145_Doherty_CDL.jpg

Creating a Minimum Essential Dataset

GIS allows us to create maps and capture information more effectively, but it requires some preparation well before a search even begins. It is critical that your team assemble and practice using the geospatial data you'll need to better plan and visualize the SAR in your operational area. The files you assemble for your SAR needs are your Planning MED and will consist of what are called raster and vector data. You'll store them in the appropriate subfolders when you create your Base Data folder.

GIS data is data that can be "drawn" or visualized on maps and is spatially referenced. It represents a location on the earth. GIS data also has the ability to contain information about each particular object (called a feature) in an associated table or tabular format—similar to a complex Excel spreadsheet, but more like an Access database. For example, you can store not only information about where the roads are in space (and draw them on a map) but also what the name of each road is, whether it's paved or unpaved, who owns it, how many lanes it has, and any other information you can think of. You can add this information, called attributes, by creating additional fields in the attribute table component of the spatial data. All this makes for some pretty powerful data.

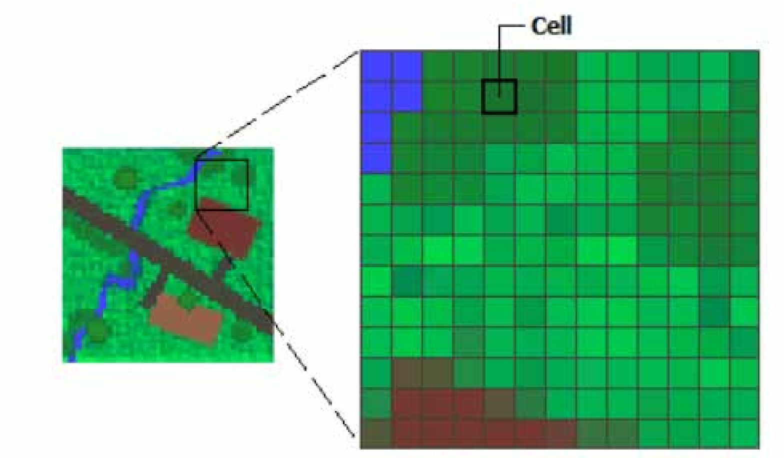


Figure 3-2: Detail of a raster file: Here, individual cells carry color and location information.

GIS data can be classified as either raster or vector data. Raster layers are made up of cells (think of the pixels when you zoom in to a photograph on your computer), and each cell has x- and y-coordinates that represent the cell's location and a value. That value may be a number that correlates to a color, a land-use category, an elevation, or anything else you can think of. These cells can make up an image such as a USGS topographic map or a satellite image, or the cells may show different types of land-use areas, as the example to the left demonstrates. Rasters are defined as "an array of equally sized cells arranged in rows and columns and composed of single or multiple bands. Each cell contains an attribute value and location coordinates."

Using various GIS tools, that information can be manipulated to show all sorts of relationships. But for the moment, at the most basic level, just think of a raster file to mean your basemap.

Vector data is spatial information consisting of points, lines, or polygons. Examples of vector point data include fire hydrant locations, telephone poles, signs, or IPPs. Spatial features such as roads, trails, streams, and GPS tracks may be presented as line data. Polygons are various shapes and include lakes, state boundaries, and search segments. These are the files you will often layer on top of your basemap (raster) layer to show operations and locations relative to your terrain.

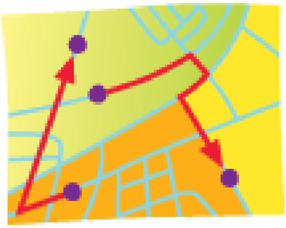


Figure 3-3: Vector Data: Lines, Points, and Polygons Located on a Raster Layer

GIS allows you a huge—often daunting—array of geospatial information to use. If it's well organized, you could actually compile whatever you think you'd need. The only disadvantage is the time it takes to gather the data and having sufficient storage space available on your SAR team's computers and external hard drives. The example MED files in tables 3-3 and 3-4 include nearly everything a SAR GIS person would use for the SAR operation's mapping and advanced analysis needs. Practice and experience, of course, are going to guide you in what datasets best contribute to your team's effective use of GIS.

Some teams are satisfied to just use the standard digital USGS topographic maps for their area. They are simple and easy to use, and everyone involved in SAR is going to be familiar and comfortable with them. To use either ArcGIS Explorer Desktop or MapSAR at its most basic level, nothing more is needed. It is our experience, though, that the more effectively you use GIS mapping techniques, the more SAR managers and teams will ask for different and more advanced types of mapping products. For instance, we've found that 3D imagery can be very popular for both IC managers and field teams. 3D imagery gives a realistic view of the challenges of the terrain. Team members arriving in their search area can quickly orient themselves to carry out their assignment. In addition, more extensive raster and vector spatial datasets will allow much greater flexibility for terrain and incident analyses.

So, although a SAR team can use the techniques taught here with only a very small number of data files, we strongly recommend gathering a more extensive set as you learn more about the potential uses for effective GIS in operations. Tables 3-3 and 3-4 are sample datasets created for Sequoia and Kings Canyon National Parks. Read the Purpose column for each file to get an idea of how this information can be used and the Source column for ideas on where to acquire similar files. For further ideas on files to include in your MED, see appendix 1 "Raster and Vector Data for MEDs." In addition, the section ArcGIS for Desktop Components in chapter 7, tells you more about the many different file types that ArcGIS can work with.

Sources for Geospatial Information

Finding the right data for your team can take some time. Basic data like a digital USGS topographic map, is pretty easy to obtain. Local trails, structures, and jeep roads can sometimes be more difficult. This is why it's important to start tracking down the data immediately. Also, your data needs will change over time, but once you gain experience with what you need and where to find it, you can update more easily as needed.

An excellent source for finding everything you need at once is through local agencies that perform mapping and planning. Your county's planning office can be a great resource for data. Another potential source is your state's GIS coordinator or the GIS coordinator at the land management agency you work with, for instance, the US Forest Service, National Park Service, or Bureau of Land Management. These agencies usually have all the data you need already assembled in a logical structure. Often, you can just find the person responsible for managing the data (e.g., the local GIS coordinator or the data manager), tell them who you are (county sheriff's SAR team), and what you need (see sample MED below) and why. The coordinator will often be happy to give you the data. Experience has also shown that the GIS community is still small enough and new enough that there's often an enthusiastic willingness to help others just beginning to learn these skills.

There may be restrictions on certain data. For instance, it may have been assembled under contract with an outside company and therefore not be part of the public domain. Some types of data may be sensitive and the agency may have reasons for not releasing it, for instance, archaeological sites or locations of endangered species in a wildlife database. It's unlikely, though, that you'll need these types of information for your MED. If there is resistance from an informal approach, the request may need to be formally made by the county sheriff (if you're a county SAR team under the sheriff's office) to the agency that has what you need. Either informally or by formal request, you should seek a clear understanding of where and when you'll use the data and any restrictions the agency might have on sharing it. You should also be aware that much of this data is often public domain and should have no restrictions.

If there is no central source you can find, then gathering the files can be similar to an Easter egg hunt. Table 3-2 shows some links and resources that you can use to start your search. Many online GIS data clearinghouses that are operated at a national, state, or local level or by a university or nonprofit have publicly available data. These clearinghouses often include elevation data, satellite imagery, hydrography (streams, lakes, and watershed boundaries), roads, vegetation cover, land use, and other datasets that are available in one place. California, for instance, has this data available at the Cal-Atlas Geospatial Clearinghouse (www.atlas.ca.gov/download.html). Many other states have or are developing similar resources. Finally, the national geospatial data that comes with an ArcGIS for Desktop license on DVD includes detailed roads, streams, USGS map indexes, and landownership files.

Table 3-2: Sources for Free Geospatial Information

Name	Resource Location	Types of Data Available
Data.gov	geo.data.gov	Largest collection of web-based US maps and data, has absorbed the Geospatial One-Stop (GOS) portal
US Census Bureau	factfinder2.census.gov	Free population, housing, economic, and geographic information.
National Interagency Boise Fire Center File Transfer Protocol (FTP) site	ftp://ftp.nifc.gov/BASE_INFO/Statewide_GIS_Data	An excellent source for most data needs for the western states (those that commonly have fires)
USGS	http://nationalmap.gov	Free digital USGS topographic maps for all of the United States in several scales (go to the USGS store)
USGS	http://seamless.usgs.gov/website/seamless/viewer.htm	National Elevation Data viewer and download.
National Hydrography Dataset	http://nhd.usgs.gov/index.html	Streams and watershed boundaries; excellent for establishing logical boundaries for search segments
Stanford University Library: Websites for Digital GIS Data	http://www-sul.stanford.edu/depts/gis/web.html	Links to spatial data in most every state
Esri Map Package	Provided as a DVD with ArcGIS for Desktop installation disks	An index of all USGS topo maps at different scales; most all roads; state; and county boundaries; public landownership; streets, streams, and rivers; and place-names (Some data is generalized and only useful at certain scales.)
National Agriculture Imagery Program (NAIP) Imagery (high-resolution satellite imagery)	To locate and choose the imagery for download from an online map viewer: http://viewer.nationalmap.gov/viewer	Detailed real-color imagery for most of the United States.

The Basemap (Raster) MED

The most basic raster maps you need are the standard USGS 24K quads of your area, digitized for GIS use. Some teams use nothing else, and neither ArcGIS Explorer Desktop nor MapSAR requires anything else. However, GIS does allow you greater flexibility in how you want to show the terrain. To effectively use GIS, you should assemble a good selection of basemaps to use as the basis for the data you'll overlay onto it. Remember that your goal is to help search managers visualize the SAR area for more effective situational awareness, meaning team assignments, resource allocation, safety, and clues, as well as to quickly create useful team and briefing maps.

If you have an Internet connection during your SAR, both ArcGIS Explorer Desktop and ArcGIS 10 allow you to download many types of basemaps directly to your workspace and easily switch among them as necessary. You can quickly change between a topographic map at different scales or satellite imagery. In ArcGIS Explorer Desktop, you can also switch between a 2D and 3D view, depending on your operational needs. Because an Internet connection is not possible at the ICP of many SARs, you also need to assemble the basemaps (raster files) that you'll need for your geographic area of responsibility and have them available on your hard drive.

Raster Files to Consider

- USGS topographic maps are the primary operations planning map. They are now widely available as Digital Raster Graphic DRG) files from both the USGS store (free) as well as many other GIS resource websites. A very good summary and explanation of the various scales and uses of maps are found on the USGS site at http://egsc.usgs.gov/isb/pubs/booklets/usgsmaps/usgsmaps.html.
    - The USGS store has an interactive map to choose the map sets you need.
    - FTP sites have a map index layer showing where the quads are. You load the map index for the scale you want into ArcGIS Explorer Desktop or ArcGIS Explorer for Desktop and just click the information tool bar on the desired quad grid and get the information for the map name, allowing you to retrieve it from your files or online. This is a good layer to have as part of your MED.
- Digital Elevation Models (DEM) can be used to classify areas by steepness of terrain, where you might need a technical team, or where you wouldn't want to assign a K9 team. Hillshade files are derived from DEMs and allow you to add texture to a topo map—giving a 3D effect and a better sense of terrain for briefing or team maps. The figure shown in the preface is a regular USGS topo map with hillshade layered over it to give it depth.
- Satellite imagery is another excellent resource to show actual terrain. One of the best resources is the National Agriculture Imagery Program (PDF), which continuously updates the imagery available at 1-meter resolution. It's also possible to use a map server connection with either ArcGIS Explorer Desktop or ArcGIS for Desktop and have the imagery for your specific area of interest downloaded right to your basemap.
- In addition, remember that ArcGIS Explorer Desktop allows you to view and navigate terrain in 3D. It can download several types of imagery as a basemap. ArcGlobe, which comes with the ArcGIS installation and an ArcGIS for Desktop Advanced license, will also show 3D terrain views.
- It's also very useful to have a digital copy of whatever trail, recreation, or brochure maps are available in your area. Since these are often the maps your missing person will have, it

helps to see the terrain and navigation options that they see. These maps can be georeferenced so they layer exactly onto your planning map. You will need to use ArcGIS for Desktop to georeference a map or image or ask your friendly neighborhood GIS specialist to create such a map for you. *The MapSAR User's Manual* explains how to do this using ArcGIS 10.

These raster files from Sequoia and Kings Canyon National Parks are intended only as examples of some of the file types that can be used as basemaps to overlay with your vector files (see table 3-3) as well as use in terrain analysis. In this example, they have been saved into what's known as a file geodatabase (GDB), a file type used in ArcGIS that holds all the files in a capsule, like a folder. In assembling your own files, you can put them into appropriately labeled folders in your Base Data folder. Later, as you acquire skill in ArcGIS, you can add them to a file geodatabase. It's also likely that if you can obtain your MED

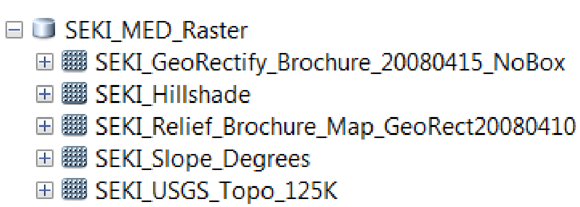


Figure 3-4 : Example Basemap (Raster) MED for Sequoia and Kings Canyon National Parks

files from a local agency, that they'll already be assembled in a file geodatabase. (1.gdb). A .gdb file is able to be used by both ArcGIS Explorer Desktop and ArcGIS 10.

You may only use some or even none of these files on a SAR but should have them available for potential planning or analysis needs. Notice that there are no spaces, dashes, or special characters in the file names. GIS software prefers that those characters not be used when naming files, so you will see that many spatial files use underscores in place of spaces or dashes.

Table 3-3: Sample Basemap (Raster) MED for Sequoia and Kings Canyon National Parks

Sequoia/Kings File Name	Purpose	Source
SEKI_MED_Raster.gdb	This is a file geodatabase. It is a convenient capsule available in ArcGIS for Desktop to store files. Initially, you'll want to assemble your files in regular folders, then create a file geodatabase to hold them.	It must be created in ArcGIS for Desktop but can be read and used by ArcGIS Explorer Desktop. In this example, only a few of the area files are put into a GDB. Because of the total size, it's better to keep USGS digital quads and satellite imagery in their own folders.

Sequoia/Kings File Name	Purpose	Source
SEKI_GeoRectify_ Brochure_ 20080415_ NoBox, SEKI_Relief Map_GeoRect20080410	This is the handout map that visitors to Sequoia and Kings Canyon Parks receive when they enter the park. Such a map is vital to knowing what the missing person had available and what decisions that person might have made as a result. Another advantage is that it's a relatively small file size and so loads quickly. It allows faster navigation to a desired area before loading larger (and slower) files.	Such maps are rarely in a format to be used directly by mapping software—they usually don't have coordinate information embedded in them. However, ArcGIS for Desktop has tools that make it possible to very roughly georeference maps that are to scale. Essentially, line it up with known points, match both maps, and then merge so that the geospatial information is the same on both maps. It's a fairly easy technique and creates a very useful resource for SAR teams.
SEKI_Hillshade	The park hillshade layer raster file adds shading to an otherwise flat USGS topo map, enhancing the appearance of slope and drainages.	It can be created using tools available in ArcGIS for Desktop but is also usually available through online sources as well as the local agency's files.
Slope_deg	This raster file shows slopes in degrees. It is very useful for identifying high-angle terrain to assign only to technical teams and warn other teams away from it. In ArcGIS for Desktop, the GIS specialist can define slopes of any degree and color them on a gradient scale to indicate difficulty.	Derived from contour files of an area using ArcGIS for Desktop tools, it may also be available through online sources as well as the agency's own geospatial files.
SEKI_USGS_Topo_125K	This is the entire park at 1:125,000 scale and is a good area map to accompany individual quads.	Many recreation areas and national parks have large-scale topographic maps of the entire area. USGS produces many, as do private mapping companies.
Area USGS Topo Quads	These are not included in this file geodatabase example. but you want a full set of your area's digital USGS topo files available in your Base_ Data folder and at several map scales (1:24,000—7.5 minute; 1:63,360—15 minute; 1:100,000—30 minute).	Use the USGS quad index to determine which individual digital maps you need for your area, then either download them from the USGS website or obtain them from your local planning or land management agency.
Area Satellite Imagery	Because of the size of the files, the table 3-3 example doesn't include satellite imagery. Imagery is an excellent way to illustrate terrain: forest, open rock, brush, etc. It's especially useful when mutual aid teams and incident managers might not be familiar with the area.	Use the NAIP map viewer listed in table 3-2. And, again, your local planning or land management agency should have it.

The Vector MED

These vector files are an example of a planning MED for Sequoia and Kings Canyon National Parks. On any SAR, you may only use three or four of these types of files during the operation. Nonetheless, it's a good practice to have them on hand as different situations arise and you find you need one for reference, or planning or to help in analysis. In the previous section Directory Structure; File and and Naming Conventions, we recommended best practices for storing your MED in a logical structure for easy retrieval. Table 3-4 lists each file, its purpose for SAR mapping, and potential sources for that type of file.

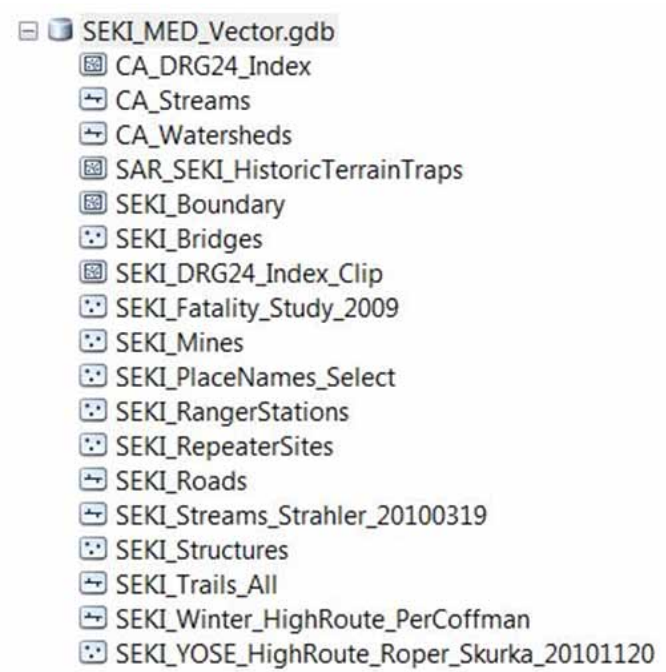


Figure 3-5: Example Vector MED (points, lines, and polygons) for Features in Sequoia and Kings Canyon National Parks.

Table 3-4: Example MED for Sequoia and Kings Canyon National Parks

Sequoia/Kings File Name	Purpose	Source
SEKI_MED_Vector.gdb	This is a file geodatabase (see previous section; Directory Structure; File and Naming Conventions). It is a convenient capsule used by ArcGIS for Desktop and ArcGIS Explorer Desktop to store files. Initially, you'll want to assemble your files in regular folders, then create a file geodatabase to hold them.	It must be created in ArcGIS for Desktop but can be read and used by ArcGIS Explorer Desktop.

Sequoia/Kings File Name	Purpose	Source
CA_DRG24_Index SEKI_DRG24_Index_Clip	This is the index of 24K USGS maps available for the entire state of California and clipped just for Sequoia/Kings Parks (SEKI). Creating a hollow box for the polygon and clicking inside that box with the Information tool tells you the name of the individual quads you need for your areas of concern. Indexes are usually available for any type of map set (e.g., DEMs, larger scale DRGs). Obtain the index for each set you're likely to use and put it in the MED. You should consider clipping it to the largest area for your SAR map needs.	A map index for several common size maps (e.g., 1:24,000 and 1:100,000) for the entire United States is included with the installation files for ArcGIS for Desktop. Indexes are also usually available at the top layer of FTP sites that make geospatial raster data available. You can bring up a large-scale map of an area and then put the index over it to determine the smaller-scale maps you'll need to retrieve from your area map folder.

Sequoia/Kings File Name	Purpose	Source
CA_Watersheds	Watersheds often serve as natural boundaries for search segments to be drawn as well as for division breaks. There are several types available, and each has its individual accuracy and detail. Several are included for different needs, but you probably only need one or two for actual planning needs. Several of these files cover areas much larger than you'll need, so create a polygon and clip them to your area's size. Because watersheds and streams are logical boundaries for search segments, they're very useful as guides to trace segments.	The National Hydrography Dataset is the primary source (http://nhd.usgs.gov/), but such files are often processed for specific local needs, so also check local agencies.

Sequoia/Kings File Name	Purpose	Source
SEKI_SAR_ HistoricTerrainTraps	This is a locally created polygon feature class. Its purpose is to capture local knowledge by asking experienced rangers, SAR team members, and area users what areas they consider historically or potentially dangerous where a person might become lost, hurt, or confused (e.g., routes that might be considered shortcuts by the inexperienced, trail junctions that are not clear, areas that historically tend to get searches or injuries.) This feature class is meant only as a reminder to plans of potential places to search or pay extra attention to. Generally speaking, historical data should not be used to predict any particular SAR unless specific terrain might lead to certain behaviors of lost individuals. Such a feature class is a good way of capturing the experience of your area's long-time staff, users, and SAR people.	The information is gathered by having a large ("C," which is 17" x 22," or "E," which is 24" x 44") paper map available to people with local knowledge and asking them to draw in the areas and include a description, examples of known SARs in that area, or its potential for danger or confusion. You then create a polygon feature class with appropriate fields and copy that information, saving it to your GDB.

Sequoia/Kings File Name	Purpose	Source
SEKI_Boundary	This is the agency boundary of the park. Boundaries are an important part of any MED to make sure that there's good communication and notification of different agencies potentially involved or to obtain permission to use air space, landing zones, etc.	Check directly with the agency's GIS coordinator. Most all federal land management agencies have spatial data specific to their area. Also, many state and county data sources have files showing landownership. Some of these are included with the ArcGIS for Desktop installation files.
SEKI_Bridges	It's critical to know where people can cross streams and good places to set up trail blocks.	This is available through local agencies.
SEKI_Fatality_ Study_2009	Fifty years of fatalities in Sequoia and Kings Canyon were compiled from reports, their locations established, and histories included in a geodatabase.	Like terrain traps, the graphic representation of fatal accidents can suggest search strategies.
SEKI_Mines	This shows potential hazards that always need to be checked on any search.	This is available through local agencies as well as environmental agencies responsible for pollution sources.

Sequoia/Kings File Name	Purpose	Source
SEKI_PlaceNames_Select	This provides selected place-names from the Geographic Names Information System (GNIS). This is a huge list for any given area and needs to be edited to a manageable size with only the common names in use for your area shown.	Available at http://geonames.usgs.gov/domestic/download_data.htm.
SEKI_RangerStations	Ranger stations, are used for staging and as places a lost person might go to or witnesses contacted. If available, a structures feature class should be included in an MED.	This is an agency-local file. Contact the appropriate land management agencies your group will be working with.
SEKI_RepeaterSites	Radio repeaters in Sequoia/Kings Parks are critical to determine communication potential in remote terrain.	This is usually an agency-local file. Contact the appropriate land management agencies your group will be working with.
SEKI_Roads	Critical to your transportation layers, it ideally should distinguish between primary, secondary, and 4WD roads and be reflected in the symbology.	Road geospatial data for primary roads is available as part of the basic map package available with ArcGIS. Roads not part of a primary transportation system, like 4WD and logging roads, are sometimes available through the local agency.

Sequoia/Kings File Name	Purpose	Source
SEKI_Streams_Strahler_20100319	Stream layer for Sequoia and Kings Canyon—streams are represented by their Strahler order—a classification based on how many feeder streams are upstream from any segment. As such, it gives an idea of their relative flow and danger to attempt a crossing and the symbology classed to stream order.	Stream layers are available through the National Hydrography Dataset: http://nhd.usgs.gov/index.html. They're also available through local agencies and may be more complete and better organized.
SEKI_Structures	Identifies all structures within SEKI. Maybe useful for orienting teams and checking buildings where missing people may be attracted to for refuge—especially important in rural or wildland SAR.	Check directly with the agency's GIS coordinator. It is also likely available through the county or state fire agency but might be restricted.
SEKI_Trails_All	Identifies all maintained, unmaintained but still visible, and many popular cross-country routes in Sequoia/Kings Parks. It also includes contiguous trails onto USFS areas to their trailheads.	This is an agency-local file. Contact the appropriate land management agencies your group will be working with. Some trail data is also available from public GPS'd trail sites such as GPS Trails: http://www.gpstrails.net/.

Sequoia/Kings File Name	Purpose	Source
SEKI_Winter_HighRoute_Ski_PerCoffman	Depicts an unmarked cross-country ski route across the Sierra in Sequoia and Kings Canyon Parks. Another example of a route not likely to be familiar to SAR managers and so important to have on hand.	It was developed from the ski mountaineering community (Coffman) and converted to a shapefile.
SEKI_YOSE_HighRoute_Roper_Skurka_20110120	This shows a cross-country hiking route (Roper High Route) that goes from Yosemite to Sequoia/Kings National Parks (not a trail or marked in any way). This is a classic example of a file necessary because few SAR managers would know where it goes.	This was developed from user information (Skurka) provided by the hiking community and converted (with permission) to a shapefile for use in ArcGIS. This is not publicly available.

Since this MED for Sequoia and Kings Canyon National Parks was set up for a wilderness area, it doesn't include other potentially important files such as power lines (hazard for air operations), cell phone towers (increasingly important for communication and locating cell phone calls for help), landownership (mutual aid, areas of responsibility), and other files not deemed necessary to this particular example area but which you should consider for your MED.

Exercise 3A: Assembling Your Minimum Essential Dataset

Only one or two of the people in your SAR group need to work on assembling your MED, but it is important for all members of the team to be familiar with the data once the MED is established. Ideally, the individuals working on collecting the MED are experienced with computers, file structures, and perhaps even ArcGIS for Desktop.

As mentioned previously, if your team is light on computer skills, consider approaching and recruiting a GIS specialist. Our experience is that people are generally eager to volunteer their skills toward search and rescue. SAR is about helping people and saving lives. Almost everyone responds to that and wants to help however they can. Again, your county planning department, land management agency's GIS coordinator, or local college GIS program are excellent places to recruit the expertise you might need to develop the resources for a solid GIS capability and to teach your team how to use those tools and techniques.

Step 1: Assembling Your Tools

To collect the data, you'll need the following:

- A contact list of the agencies in your area of responsibility that might have the geospatial information you need. This might include local, county, and state GIS coordinators as well as federal agencies and local organizations. If you are associated with your county sheriff's office (SO), you should approach your SO coordinator/liaison and explain what you want to do and why. They don't have to be directly involved, but you should have their approval. Don't contact them until step 4.

- A portable USB hard drive or high-capacity thumb drive. Collecting the data often means visiting the agency that's agreed to give it to you, so you'll want to take a portable drive to transfer the files directly. The capacity of the drive needed will depend on what files you've determined you'll need. Vector files and digital USGS topo maps aren't that big, so an 8 to 12 GB thumb drive might be sufficient, depending on the size of the area you're interested in obtaining. Satellite imagery, though, is fairly large and, if you want a number of those files to cover your area, the higher-capacity USB external drive is the better option. It's always wise to bring some blank DVDs in case you need more space or that agency does not allow outside external drives on its network.

- If agency or local resources don't exist for your area or, even going through official channels with the request, are resistant to getting you what you need, you'll need to obtain the files from the Internet and use the Esri geospatial files included with an ArcGIS for Desktop installation.

Step 2: Preparing a File Structure to Store and Organize Your Data

If you haven't already done so, read the previous section on Directory Structure; File and Naming Conventions to create a file structure to logically organize and store the data you're going to collect. You'll want to put everything into a folder called Base_Data and then put the individual files in the folders according to the file structure you created in step 1.

Step 3: Determining What Files You Want

Initially, you'll probably want to start with a very basic set, but it should have the ability to illustrate your terrain effectively as well as contain the files needed for advanced GIS and mapping techniques. These basics are fairly easy: you'll want a set of digital USGS topographic quads of your area at 1:24,000 scale (often labeled as 24K in GIS folder and file names). These are the same as your paper 7.5-minute quads. Next, you'll want to obtain roads and trails for your area. Again, when storing them, you'll be using the file structure created either when extracting MapSAR or simply creating the same folders yourself (see Files and Folders for GIS and MapSAR at the beginning of this chapter).

Next, you should sit down at an informal meeting with your SAR team, especially some of the longtime members and go over the example files listed in the MED example in table 3-4 and suggested elsewhere to determine how many apply to your area of responsibility. Create a list of target datasets. These are the files you should initially seek out from local agencies or start searching the Internet for.

This is also a good time to consider beginning to capture the knowledge of your experienced team members and even that of the community. The Sequoia Kings file SAR_SEKI_HistoricTerrainTraps is a good example of this type of effort. Also, consider mapping features that are not otherwise available in digital form but might be important on a SAR. For instance, in Shenandoah National Park, a person illegally looking for ginseng (a plant reputed to have medicinal properties) was overdue on a collection trip. The park had previously mapped the locations of the known ginseng populations. Overlaying that information onto the SAR maps helped narrow the search area. If your area has illegal marijuana-growing areas or any other type of potential hazard area, this is also critical information to highlight as places to avoid for team safety.

Other often unmapped features, such as mountain bike trails, commonly used cross-country ski and hiking routes, drainages, and old logging roads, can be crucial in trying to figure out where a person might have become confused and lost. These are long-term mapping projects you can involve the community in. Enlist community support such as hikers, 4WD enthusiasts, and mountain bike riders to carry a GPS to record routes and important waypoints. And, should you want to carry this sort of project a step further, you can contribute to community-based maps—online communities that compile geospatial information to share with everyone. (For example, Esri's Community Maps Program can be found at esri.com/communitymaps).

Step 4: Begin Gathering the Files

If you've found data locally, head off to your nearby agency with your portable USB hard drive to transfer it. If that isn't possible, begin using the Internet resources recommended here to find what you need. Start with the easy files: topographic maps downloaded from the USGS store; roads, streams, and place-names from either the Esri map data that comes with the installation files for ArcGIS for Desktop or the online sources suggested in table 3-2; or your state's data clearinghouse site. Vector files (roads, streams, place-names, etc.) should download quickly, assuming you're not using a dial-up connection. Raster data (topo maps) might take a bit longer depending on your Internet connection and the geographic size of the area you are obtaining.

Once you've gathered and organized your files into your Base_Map folder and appropriate subfolders, you're ready to start using it. It can then be retrieved using either ArcGIS Explorer Desktop or ArcGIS 10 for Desktop. A data CD provided with this book or downloaded from mapsar.net provides the geospatial data you'll need to learn the concepts. After you've mastered each lesson, we strongly recommend that you repeat the exercise using your area's data so that you become familiar with it.

As with anything we do, it's all about training and practice.

Chapter 4: Understanding and Using Coordinate Systems

Finding a specific location on a map that identifies an exact location on the surface of the earth can be very complex. There are entire fields of study and text that focus on the study of measuring the earth in real space, converting these locations into representations of the earth, and estimating the distortions and errors inherent in various calculations.

There is good news. To use GIS effectively, a SAR team member doesn't necessarily need to know how the various coordinate systems are derived, although it's certainly helpful in arriving at a basic understanding of why there are so many different ones. However, it is absolutely critical that each team member acquires this basic set of knowledge and skills:

- Recognize that there are different coordinate systems and become familiar with how coordinates are represented. For instance, know that both 36° 46'39"N, 118° 25'36"W (degrees, minutes, seconds) and 36° 46.655052'N, 118° 25.604709'W (degrees, decimal, minutes) are using a geographic coordinate system but presenting the coordinates in very different forsmats. To confuse them—or not know to ask for clarification when transmitting or receiving—is to invite disaster (see chapter 4 sidebar Coordinate Reporting: A Cautionary Tale).
- Know that certain agencies and entities tend to use specific coordinate systems and formats to meet their specific needs. For instance, aviation almost always uses a geographic coordinate system provided in degrees, decimal, minutes (DD MM.mm) when reporting locations. SAR team members need to be able to distinguish one coordinate system from another and specifically ask for datum and coordinate type when it is not explicitly stated.
- Know how to correctly enter coordinate strings on several types of software (e.g., ArcGIS Explorer Desktop, TOPO!, Terrain Navigator Pro, and Google Maps), as well as USGS map quads, to find a location.
- Know that you can use a handheld GPS to convert and display different coordinate types on the GPS screen (see chapter 6 "Integrating GPS and Current Technologies into SAR Operations.")

In this chapter, we will discuss some basic geography principles and then address how these translate to GIS software. We'll also provide tips and tricks relevant for all members of the team and helpful for SARs.

Geographic Coordinate Systems

There are two common types of coordinate systems: geographic and projected. Geographic coordinate systems (GCS) are based on a spherical surface and use two angular measurements to describe a location. The familiar latitude-longitude coordinates 36°46'39"N, 118°25'36"W are an example of geographic coordinates.

Graticules are the network of lines of latitude and longitude on which a map is drawn. As shown in figure 4-1, the graticules that run north–south are longitude and fan out from the prime meridian, ranging from 180 to -180 degrees. This can also be written as 180° E to 180° W. The prime meridian is 0° longitude and by convention usually passes through (or near) the Royal Observatory, Greenwich, in southeast London. East of the prime meridian is indicated by either E or the absence of a negative sign (occasionally written with a plus sign [+]). West of the prime meridian is indicated by a W or a negative sign (-). These graticules can be said to originate at the North Pole and end at the South Pole. They are not parallel to each other but furthest apart at the equator and meet at the poles, similar to the edges of orange slices.

Figure 4-1 also shows that longitude runs along the x-axis and latitude runs along the y-axis; this is helpful to note when entering x,y coordinates into software; you will enter longitude for x-values and latitude for y-values.

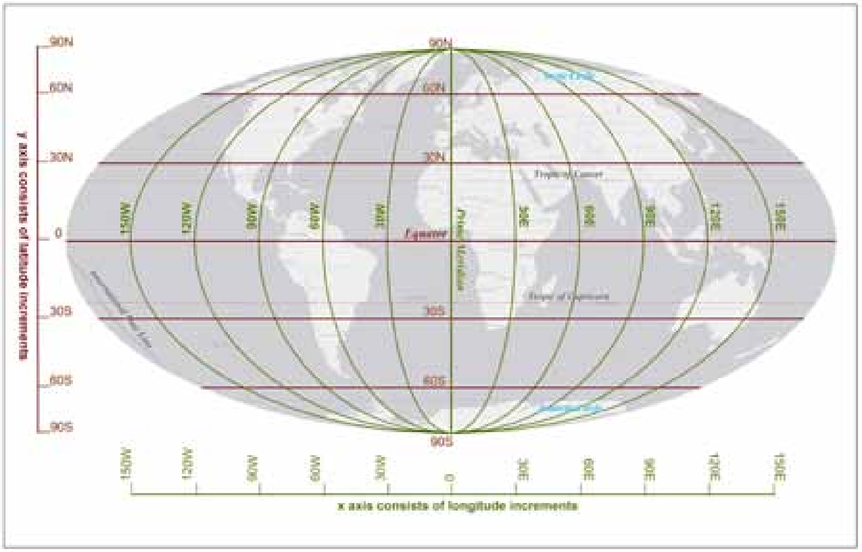


Figure 4-1: Display of latitude lines that run east/west and include the equator with longitude lines that run north/south and include the prime meridian. West and south quadrants can be symbolized by a - (negative sign) instead of W or S. Lines of latitude are parallel to each other, whereas lines of longitude are curved and meet at the poles.

The east–west-oriented measurements are called latitude, and the equator is at 0° latitude, with graticules parallel to the equator north and south, like belts around the earth. (When I was in middle school, we remembered it by calling it "fat-itude".) Using latitude and longitude, an angular unit of measurement, usually degrees, is used to describe a location. North of the equator is denoted by an N and the latitude, and south of the equator by an S. So a latitude-longitude in the northern hemisphere and west of London could be written as: 36°46'39"N, 118°25'36"W (or with a minus sign in front of the degrees instead of W at the end: -118°). It is important that you include the N, S, E, W or minus sign when entering coordinates in software; otherwise, it could plot to the wrong hemisphere. Become familiar with the coordinate ranges around your response area to avoid this problem.

Later in this chapter, we'll dive into different ways to describe geographic coordinates, such as decimal degrees (DD.dd); degrees, decimal, minutes (DD MM.mm); and degrees, minutes, seconds (DD MM SS.ss). Jump ahead to the section Communicating Geographic Coordinates if you need immediate pointers on this topic.

Projected Coordinate Systems

Projected coordinate systems (PCS) utilize mathematical equations to convert the three-dimensional earth into a two-dimensional (or flat) representation. For instance, UTM 11N 372681, 4071148 is an example of coordinates in a projected coordinate system. To project a three-dimensional orange, for instance, into a two-dimensional object, imagine taking the orange peel and flattening it out. There will be areas that don't touch or match up, and various characteristics will be distorted. Whenever you are making the spherical earth into a flat map, you will need to sacrifice some characteristics in the interest of others. These are informally referred to as the SADD, or shape, area, distance, and direction distortions. In ArcGIS help, if you look up a specific projection, there is a summary of which properties are distorted and how.

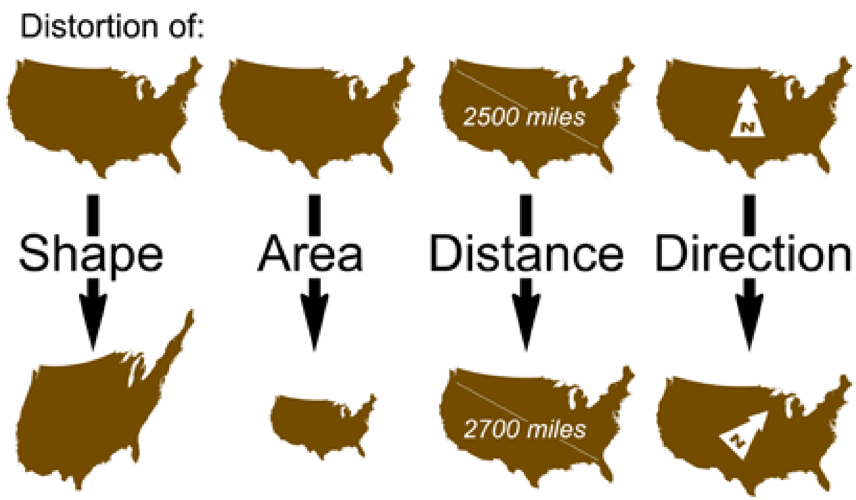


Figure 4-2: Distortions Caused by Making a 3D Globe into a 2D Flat Map (Referred to as SADD: Shape, Area, Distance, and Direction)

Not every team member needs to understand the intricacies of different coordinate systems. But everyone does need to know that different ones exist, that everyone on an incident should be using the same coordinate system if possible, and that different systems have different strengths and weaknesses. The more technical members of the team, including the folks assembling the MED, will want to understand a little more about coordinate systems and converting all the data to the projection that works best for the team/organization so that the software isn't converting it on the fly. It is also helpful to have a basic understanding of coordinate systems when gathering data from sources that do not have good documentation.

A great resource for sorting out errors related to projections in ArcGIS and some additional basics about coordinate systems is Margaret M. Maher's Lining Up Data in ArcGIS by Esri Press. Additional resources are listed in appendix 4 "References." It is also helpful to realize that the projection you choose (for the data frame and datasets in ArcGIS) can affect measurements such as calculating areas, distances, and direction. For this reason, MapSAR stores information in universal transverse Mercator (UTM), and the user needs to use the correct UTM zone for the area. A projected coordinate system is always associated with a specific geographic coordinate system. In this context, the geographic coordinate system is often referred to as a *datum*, which is discussed later in this chapter. Having the correct projection referenced to the wrong datum is a very common cause of positioning error.

There are different categories of projections used to preserve different properties such as conformal (preserves shape), equal area, equidistant, and true direction. The different projections can be thought of as describing how a piece of paper would be held up to the globe and the measurement axis transferred to the paper. Detailed descriptions of different projections and what qualities they preserve are available in a number of publications, including USGS's *Map Projection Poster*, which includes a summary table of distortions (http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html), and in the ArcGIS for Desktop help by searching for "projection."

Universal Transverse Mercator—You may have noticed that many USGS paper maps and National Geographic topographic maps

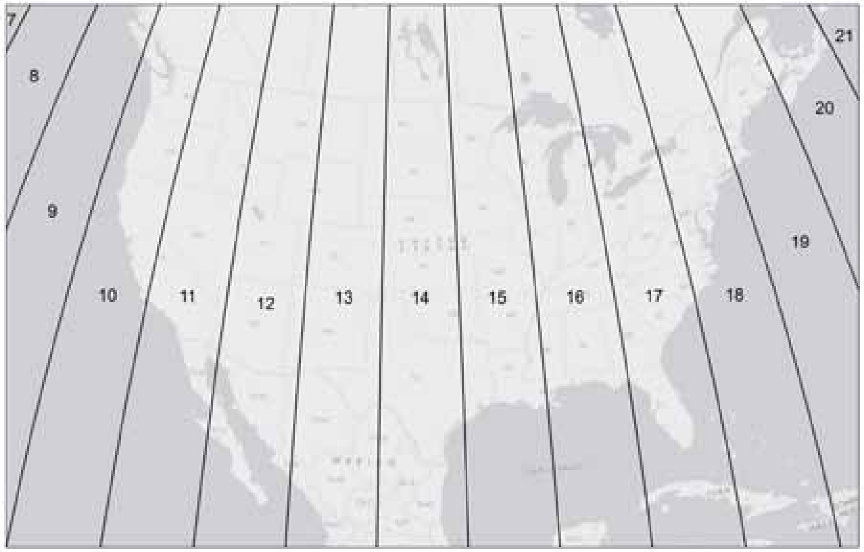


Figure 4-3: Universal Transverse Mercator Zones for the United States

show several coordinate systems along the edge of the map. The most recognized may be the latitude and longitude written in degrees, minutes, seconds, but what are those other numbers that are written in different sizes? They might be UTM eastings and northings. UTM divides the earth's surface (except for polar areas) into 60 zones (or 120 zones if considering northern versus southern hemisphere zones) with each zone equal to 6° of longitude. They are numbered from west to east starting at 180°W longitude. Sixty zones are used to minimize distortions within a zone, and a unique projection is utilized in each zone. The lower 48 states are within zones 10 to 19.

Each state, region, or county you are working in may be in two or more zones.

Within each zone, coordinates are measured east and north in meters. In figure 4-4, the shape shown in tan is the area of applicable coordinates for that particular zone. Keep in mind there are 60 of these zones around the globe, and they narrow at the poles. Each square in the figure represents 500,000 meters in each direction. For the northern hemisphere, northing values are measured from the equator as zero, as shown by the green origin point in figure 4-4. Therefore, the origin is outside the actual zone, but there is no risk of having negative numbers. As shown in figure 4-4, to avoid negative numbers for locations in the southern hemisphere, the equator utilizes an arbitrary false northing value of 10,000,000 meters and in the northern hemisphere uses 0 meters. For the easting measurements, each zone utilizes a central meridian with an easting value of 500,000 meters—in other words, a line is "drawn" down the middle of the

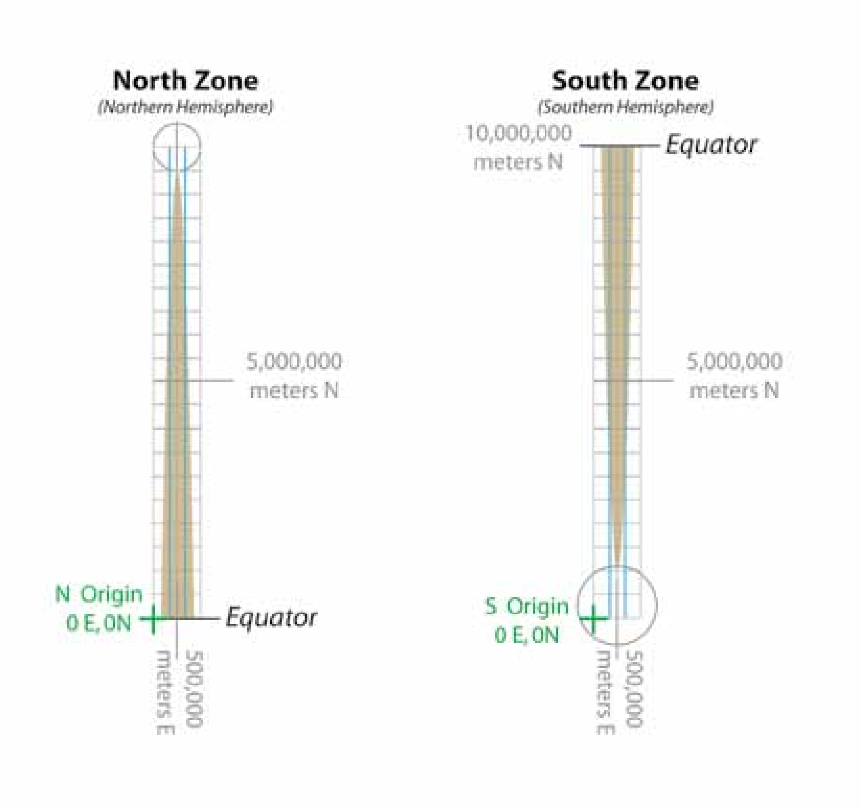


Figure 4-4: UTM easting and northing differences for northern and southern hemispheres. The tan area is where coordinates for that zone are usable. The green point is the origin, located at the equator for north zones and 10,000,000 meters south of that for southern zones. This is to avoid negative values for coordinates.

zone, and the origin is 500,000 meters to the west of that line, shown in the green.

The combination of zone numbers (which run vertically, include 1 to 60, and are 6° east–west each, as shown in figure 4-4), and zone designators defines grid zones. The zone number is always written first, followed by the alphabetical zone designator. In some situations, only north (N) or south (S) UTM zone designators are defined, such as in ArcGIS software. However, in other environments, the UTM zone designators range from C to X and represent 8° north–south. This second approach is what most handheld GPS units utilize. For example, at Sequoia and Kings Canyon National Parks, the UTM zone is 11, and the zone designator is S for GPS units. In ArcGIS software, though, if you used 11S, the software would think you are mapping in the southern hemisphere, so you want to use 11N to represent the northern hemisphere in ArcGIS, and disregard the options for C to X. This is a confusing detail, but just check to see the choices given in a particular task. If the options for zones are only N and S or C to X, you'll know which type to use.

If you're using a 24K or 50K map, the UTM ticks (usually small blue lines at the outside border of older paper USGS maps, which are becoming the primary grid system on some current maps) are at 1,000-meter intervals. The northing of the point is the value of the nearest grid line south of it plus its distance, in meters, north of that line; its easting is the value of the nearest grid line west of it plus its distance, in meters, east of that line, as shown in figure 4-5. The grid value of line A is 357,000 meters east. The grid value of line B is 4,276,000 meters north. Point P is 800 meters east and 750 meters north of the grid lines. Therefore, the grid coordinates of point P are east 357,800 and north 4,276,750. When reading from a paper map, you have to make an estimate,

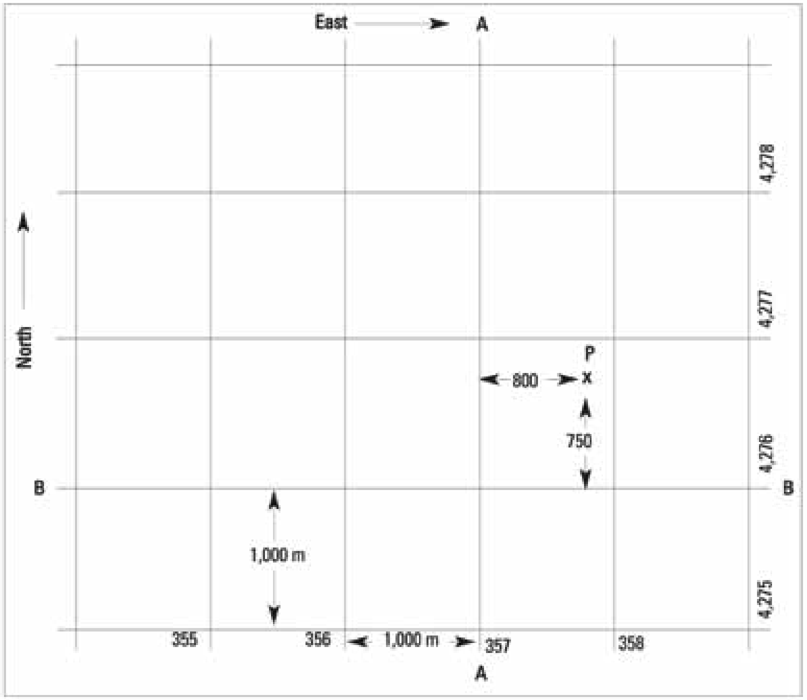


Figure 4-5: On a map, find the UTM grid and the nearest value. For point P, it is in the east grid square of 357 and north grid square of 4,276. Within that 1,000-meter grid square, it is another 800 meters east of the line and 750 meters north of the other line. Point P is located at east 357,800 and north 4,276,750. (Source: USGS Fact Sheet 077-01, August 2001. http://egsc.usgs.gov/isb/pubs/factsheets/fs07701.html)

called "eyeballing" a location. You can also buy clear plastic overlay grids for different map sizes for more accurate recording.

When using UTM, as was mentioned with latitude and longitude, in ArcGIS or other spatial software, you may be asked to enter the x,y coordinates. Remember that northing is your y-coordinate and easting is your x-coordinate, so they may or may not be entered in the order you expect.

State Plane Coordinate System—You may come across the abbreviation *SPCS*, which refers to the state plane coordinate system that was developed in the 1930s for local surveying and engineering purposes. The goal was to standardize determination

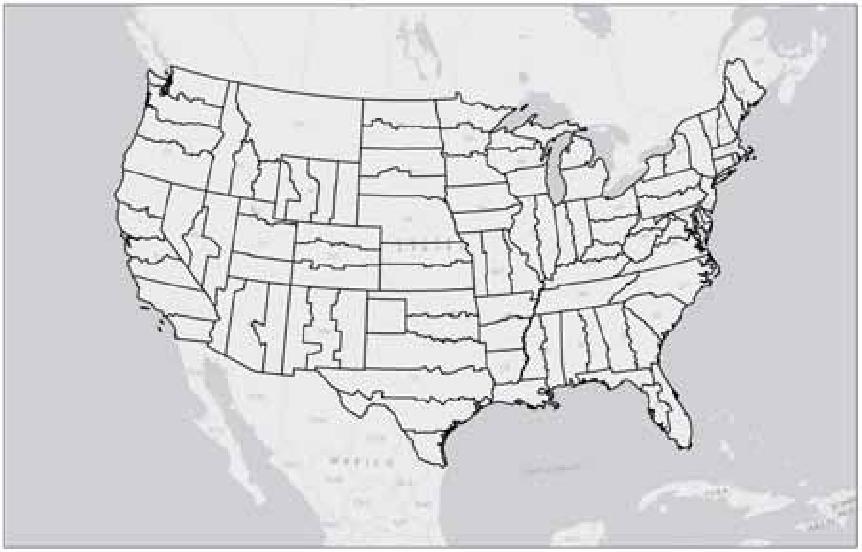


Figure 4-6: State Plane Coordinate System Zones in the United States

of coordinates and reduce distortion. Because of this, the zones usually do not cover as much area as UTM, for example. Some states have one zone, such as New Jersey, whereas some states have ten zones, such as Alaska. You can find out more about this system by using the ArcGIS help or an online search, but the important thing is to know that it exists and that you may receive local data in this type of coordinate system.

US National Grid

In an attempt to reduce confusion caused by the use of the many different types of coordinate systems in the event of emergencies, the Federal Geographic Data Committee (FGDC) has created the US National Grid (USNG) as a standard for describing locations. This is an attempt to reduce confusion caused by the use of local addressing, local grids, and multiple projections such as UTM and SPCS. The USNG can also be very useful during natural disasters or in rural situations when signs or landmarks are distant or destroyed and the military or multiple federal agencies are involved. USNG has been adopted as the standard for disaster response in many agencies. In ArcGIS, you will not see USNG as an option to store your data, as it isn't used as a projection but is instead simply a grid that you overlay on your map and use to exchange location information or assign grid squares to teams. Since USNG is based on UTM (North American Datum of 1983; more about datums later in this chapter), that is the most logical projection for your data in conjunction with USNG. You can display a USNG grid in ArcGIS (also referred to as Military Grid Reference System [MGRS]) and can learn more about this in ArcGIS help under "Adding an MGRS or a US National Grid." MapSAR will also print maps that include the USNG overlaid as a grid.

USNG utilizes letters and numbers to describe a location. If the full USNG value is used, this value is unique worldwide, but it can be abbreviated to shorten the value for use in specific regions or locally, as shown in table 4-1.

Table 4-1: United States National Grid Values and Explanations for Describing a Location

Organization of USNG Grid Value	USNG Value	Area Referenced
Complete USNG Value	18S UJ 2337 0651	Worldwide unique value
Without Grid Zone Designation (GZD)	UJ 2337 0651	Regionally unique value, where the grid zone is known
Without GZD and 100,000 m Square ID	2337 0651	Locally unique value where the grid zone and 100,000 m Square ID are known

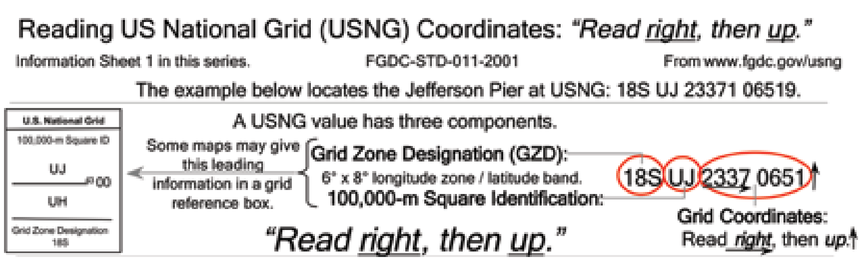


Figure 4-7: How to Read USNG Coordinates—Right, Then Up (Source: FGDC-STD-011-2001 from www.fgdc.gov/usng)

All USNG values are read from the right, and then up.

If we break the USNG coordinates into steps, they aren't as intimidating. Let's use the example in figure 4-7 of 18S UJ 23370651; we want to locate the 18S Grid Zone as shown in figure 4-8.

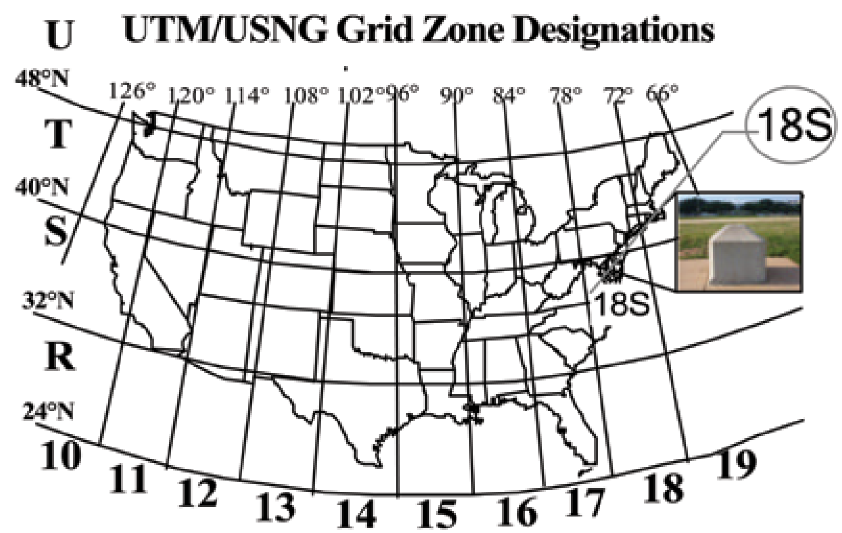


Figure 4-8: USNG Grid Zone Designations for the United States (Source: FGDC-STD-011-2001 from www.fgdc.gov/usng)

18S UJ 2337 0651: Within Grid Zone 18S, we now look for the 100,000-meter square labeled UJ, as shown in figure 4-9.

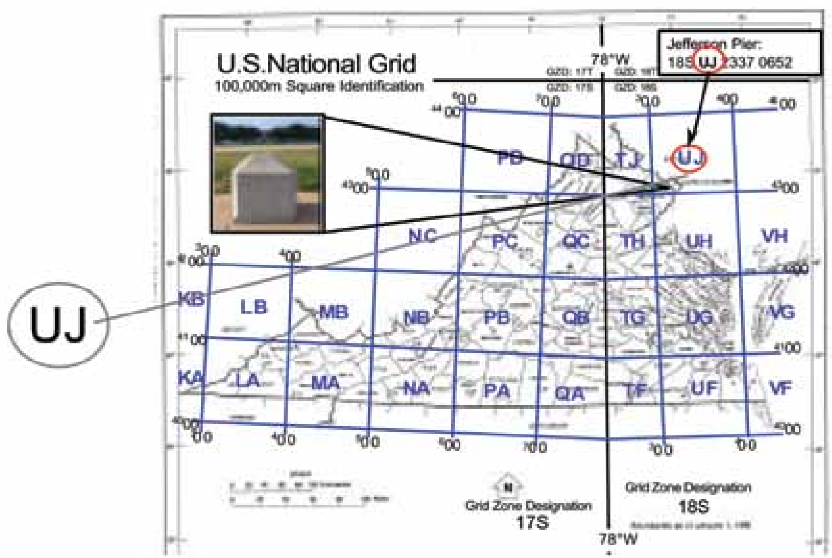


Figure 4-9: Locating the 100,000-Meter Square Identifier (Source: FGDC-STD-011-2001 from www.fgdc.gov/usng)

18S UJ 23370651: Within the UJ square, we break the coordinates into two groups, each with the same number of digits (4 each in this example)—2337 for the easting and 0651 for the northing. So look for the location between 23 and 24 on the horizontal axis (go right) and 06 to 07 (now go up) on the vertical axis. So we now know which 1,000-meter square we should be looking in (square 2306 in figure 4-10).

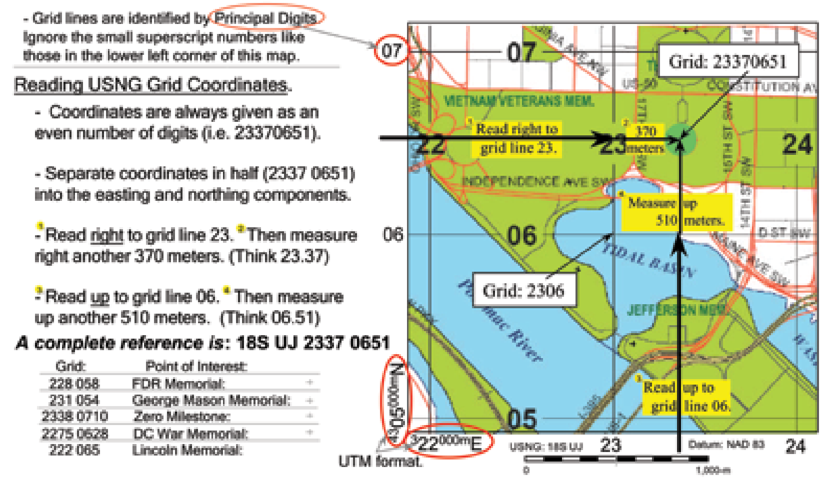


Figure 4-10: Locating the Principal Digits for the USNG (Source: FGDC-STD-011-2001 from www.fgdc.gov/usng)

18S UJ 23370651: Because the values used in the figure above are four digits for each axis (for a total of eight values: 2337 0651), these digits are providing a point within a 10-meter grid square, and we can then narrow it down further, as shown in figure 4-10.

Remember that you might see USNG coordinates written out in different ways—with or without the Grid Zone Designation (18S in this example) or the 10,000 Square Identifier (UJ in this example) if you are working in a smaller area and everyone knows the general area they are working in. For more precise measurements, you can also use the Romer Grid Scale or Reference Card—a plastic guide similar to a ruler that can be used to measure distances on a paper map of matching scale.

In actuality, your SAR team (in the United States) must use the USNG to be in compliance with federal SAR policy, but you must be prepared to respond to situations where teams have not adjusted to the standard. At the time of publication, SAR teams are still working to meet this policy. USNG provides a common way to communicate. As such, it's important that SAR teams become familiar with how to work with coordinates in USNG in addition to any other system their organization is utilizing. Further information can be found at www.fgdc.gov/usng.

Datums

In addition to the coordinate systems and coordinate locations that are used to describe a place on the earth's surface, the ability to correctly find that point will also be affected by what shape is used to describe the earth. Because the earth is not a perfect sphere (more like a bumpy pear), different models are used to imitate the earth's shape (called geoids). These models are adjusted occasionally as more information or precision becomes available. A simplified version of these models, called an ellipsoid or spheroid, is used to relate a coordinate system grid to the earth's surface. Different ellipsoids are used in different parts of the world. Reporting the datum associated with a set of coordinates is critical to accurately locating that spot on the earth. The datum you will commonly see and the ones your team needs to know are the following:

- NAD27: North American Datum of 1927—This is an older datum type but found on many paper USGS maps and other resources.
- NAD83: North American Datum of 1983—This is a more recent rendering of the earth's shape and the base datum for much modern GIS data.
- WGS 84: World Geodetic System of 1984—GPS devices use this datum for determining position coordinates. For SAR needs, it is nearly equivalent to NAD83 and is used interchangeably in this context.

In addition to being familiar with the above datums, the SAR GIS person may find it helpful to know that a datum is equivalent to a geographic coordinate system, and each datum is always associated with a specific ellipsoid. However, one ellipsoid can be used for many different datums. It also helps to understand how these datums are derived.

In North America, the NAD27 is based on the Clarke 1866 ellipsoid, with the initial control point at Meades Ranch in Kansas. NAD83 is based on the Geodetic Reference System 1980 (GRS 80) ellipsoid that is referenced to the earth's center of mass. GRS 80 is very similar to the WGS 84, which is the global ellipsoid (and datum) that GPS is based on.

Unlike NAD83 (the datum) and GRS 80 (the ellipsoid), the name *WGS 84* is used both for the ellipsoid and the datum, which is a source of confusion. What makes this confusing is that the GRS 80 and WGS 84 ellipsoids are nearly identical—they differ in size by less than 1 millimeter (0.4 inch)—but the NAD83 and WGS 84 datums differ by 1–2 meters (3 to 6 feet). So for applications where positions are not known or needed to better than a couple of meters (such as SAR), the NAD83 and WGS 84 datums can be considered the same. This is convenient, since most map products in the United States are referenced to NAD83, and GPS units give positions referenced to WGS 84.

You may also run across data sources that are given as NAD83 with an additional appended abbreviation, such as HARN. HARN stands for High-Accuracy Reference Network and is also referred to as High Precision Geodetic Network (HPGN). The HARN (or HPGN) is a refinement to the NAD83 datum determined on a more or less state-by-state basis using high-accuracy GPS observations. There have been other more recent local nationwide refinements as well, such as NAD83 (CORS96), NAD83 (NSRS2007), and NAD83 (2011).

The details can seem overwhelming, but the important thing to understand is that all these changes to NAD83 are essentially at the level of a few to several centimeters. None of the realizations of NAD83 differ from one another by more than a couple of meters, and most by much less than that. So for use in SAR, all versions of NAD83 can be considered the same.

For SAR applications, then, it is not important to understand these nuances but rather to realize you must pay attention to what datum and projection you, your teams, and your base datasets are utilizing and that you need to be consistent and include that information when reporting coordinates.

When working with reported coordinates or datasets, it is important to know what horizontal datum is being used to plot the location accurately. When switching between NAD27 and NAD83, the coordinate grid will move, and the coordinate values will change for all points on the ground. The map features or

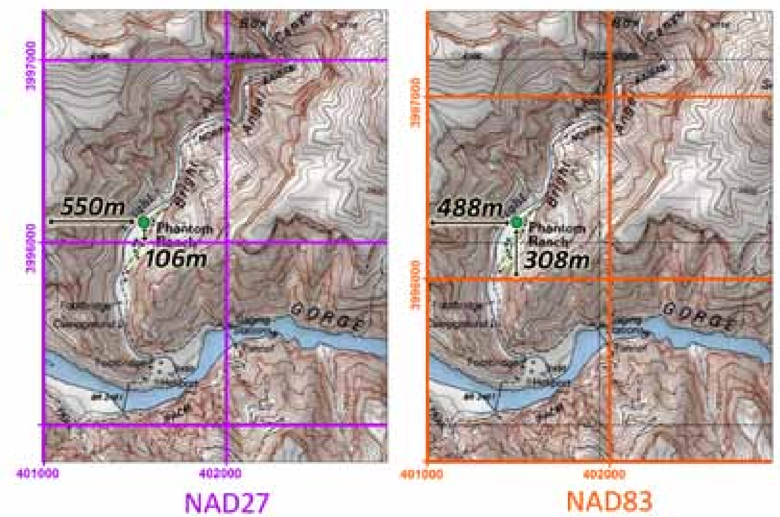


Figure 4-11: The descriptions of the location, or coordinates, are different even though the location of Phantom Ranch didn't change in reality. Only the locations of the grid changed—look at where the grids are in the lower left side of each image.

points on the ground don't move, but the grid does, which can cause confusion during SARs. Take a look at figure 4-11, the location of Phantom Ranch in Grand Canyon National Park when using NAD27 on the left and NAD83 on the right. Because the grid shifted, different coordinates must be used to describe the same location depending on the datum.

Using UTM NAD27, Phantom Ranch is located at easting 401,550 meters and northing 3,996,106 meters. But using UTM NAD83, the grid is shifted on the map, and Phantom Ranch is located at easting 401,488 meters and northing 3,996,308 meters. The location on the ground and on the map have not shifted, but the grid that is overlaid over them has changed; thus, the difference in coordinates describing the same location between NAD27 and NAD83. In other words, there is a shift of 62 meters east–west and a possibly critical difference of 202 meters north–south.

Mistakes like this often happen when a team member reads a coordinate from a paper map or a GPS unit that is using NAD27 then transmits to the SAR dispatcher or helicopter, who plots the point with a GPS or software using NAD83 as its datum. The difference can be several hundred feet, which can be critical when trying to return to a clue location or if the result puts a team on the other side of a ridge, as in figure 4-12.

As shown in figure 4-12 at the Grand Canyon, if a person in the field were given coordinates over the radio based on NAD27 and did not realize that the GPS unit was set on WGS 84 (basically equivalent to NAD83), then plugged those coordinates in without changing the datum in the GPS settings, the person would arrive at a point about 60 meters east and about 200 meters south of the desired location—on the wrong side of a ridgeline!

GPS units and GIS software allow you to set the datum before you enter coordinates (see chapter 6 "[Integrating GPS and Current Technologies into SAR Operations]"). It's vital to obtain and provide this information when discussing coordinates with others. The datum, coordinate system, and format of coordinates provided need to be included in the IAP of a SAR and announced during briefing so that everyone is on the same page. During

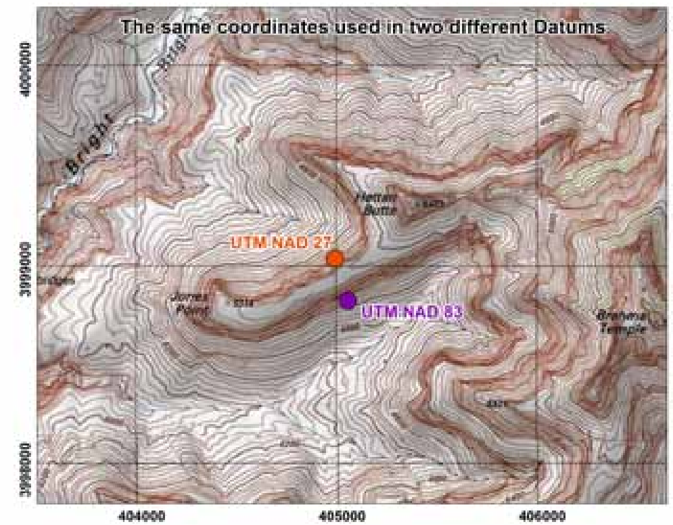


Figure 4-12: Coordinate Value E404823, N3999030 Entered into a GPS Receiver in Two Different Locations

an incident, datum shift can create a potentially dangerous situation or mislead teams on the ground. To ensure correct datum matching, a datum should be chosen at the beginning of an incident or established by the leading agency's policies—if you aren't sure what is being used, then ask and set your GPS accordingly before going in the field.

In addition to horizontal datum, there are different vertical datums as well, but they aren't as critical when determining locations during SAR incidents. But keep in mind that the vertical datum used can affect elevation measurements. The two most common vertical datums utilized in North America are the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88). Again, consistency is the most important consideration if you are working with vertical datums, but more information is also available at www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html.

Communicating Geographic Coordinates

Geographic coordinates can be described in a variety of formats, such as decimal degrees (DD.dd); degrees, minutes, seconds (DD MM SS.ss); and degrees, decimal, minutes (DD MM.mm). It is imperative that you understand what format you are receiving and providing latitude and longitude locations in. It is easy to confuse the different formats. Not understanding or incorrectly defining the coordinate system being used on an incident has led to serious and even life-threatening errors in SAR response.

Table 4-2: Communicating Geographic Coordinates

Geographic Coordinate System Format	Example Latitude-longitude in NAD 1983 for Charlotte Lake, Kings Canyon National Park, CA	Common Users
Decimal Degrees (DD.dd)	36.7758419, -118.426745	SPOT, GeoPro Messenger (default), OnSTAR
Degrees, Decimal, Minutes (DD MM.mm)	36°46.655052'N, 118°25.604709'W	Marine, Aviation
Degrees, Minutes, Seconds (DD MM SS.ss)	36°46'39"N, 118°25'36"W	Many MRA SAR teams, USGS maps

If you receive a location in one format, you can relatively easily convert to another format using most any mapping software or your GPS. This is useful to know when working with multiple agencies or groups. Aviation resources will almost always use only degrees, decimal, minutes, though this is not necessarily what the incident will be utilizing. Ideally, everyone will be using the same coordinate format, but this is not always the case, so the way you convey coordinates is very important. ***When reading off coordinates, clearly identify both the coordinate system and the datum.*** Then read the coordinates saying "degrees," "minutes," and "seconds" where appropriate as well as "decimal." Some have used just a pause between, for example, minutes and seconds and assume the person writing the coordinates down knows to enter the appropriate type. This has resulted in serious errors. In our experience, other than UTM and USNG, decimal degrees are easier to pronounce over the radio and type into

Coordinate Reporting: A Cautionary Tale

In September 2008, a medevac helicopter crashed while transporting two victims from a motor vehicle accident in Maryland to the trauma center due to inclement conditions (cloudy and foggy). The ground response was significantly delayed due to miscommunications regarding the status and whereabouts of the helicopter. The last known coordinates of the helicopter were reported to the responders as "three eight five two one seven north seven six five two two six." These were provided in the form of degrees, minutes, seconds by the helicopter dispatch center, but they did not specify this format or provide details, and the people receiving the coordinates did not verify what format the coordinates were provided in. The local dispatch center, after receiving the coordinates, entered the coordinates into Google Earth using decimal degrees, not realizing that this was a different coordinate format from what had been provided. This caused them to focus the search about 30 nautical miles southeast of the actual accident site. The wreckage was found approximately two hours after the crash with one survivor.[1]

[1] "Attachment 9: Sequence of Events Timeline, 16 Pages." National Transportation Safety Board, Washington, DC. Maryland State Police, District Heights, MD. September 27, 2008. MIA08MA203.

mapping software than degrees, minutes, seconds and degrees, decimal, minutes.

You can see this difference for yourself by plugging these into ArcGIS Explorer Desktop or Google Earth:

38.5217N 76.5226W (the location searchers focused on, based on *not* converting format, just using numbers provided in decimal degrees instead of degrees, minutes, seconds)

Mark that point. Now try putting in the actual location, converted from 38 52' 17"N 76 52' 26"W to decimal degrees correctly: 38.87138889 - 76.87388889.

When reporting coordinates, you need to be clear.

Whenever possible, follow up with a written record or e-mail and screen capture of the spot. When transmitting coordinates, whether by phone or radio, include a named geographic point nearby as an additional check. For instance; "Team 1, my location using a GPS is UTM, zone 11N at four zero seven one one four eight decimal seven two easting by three seven two six eight one decimal two seven northing. I'm on the north shore of Charlotte Lake." Note that each number is read individually; there is no "forty seventy-one one forty-eight" to confuse anyone. Note that a named geographic location is given as a further reference check.

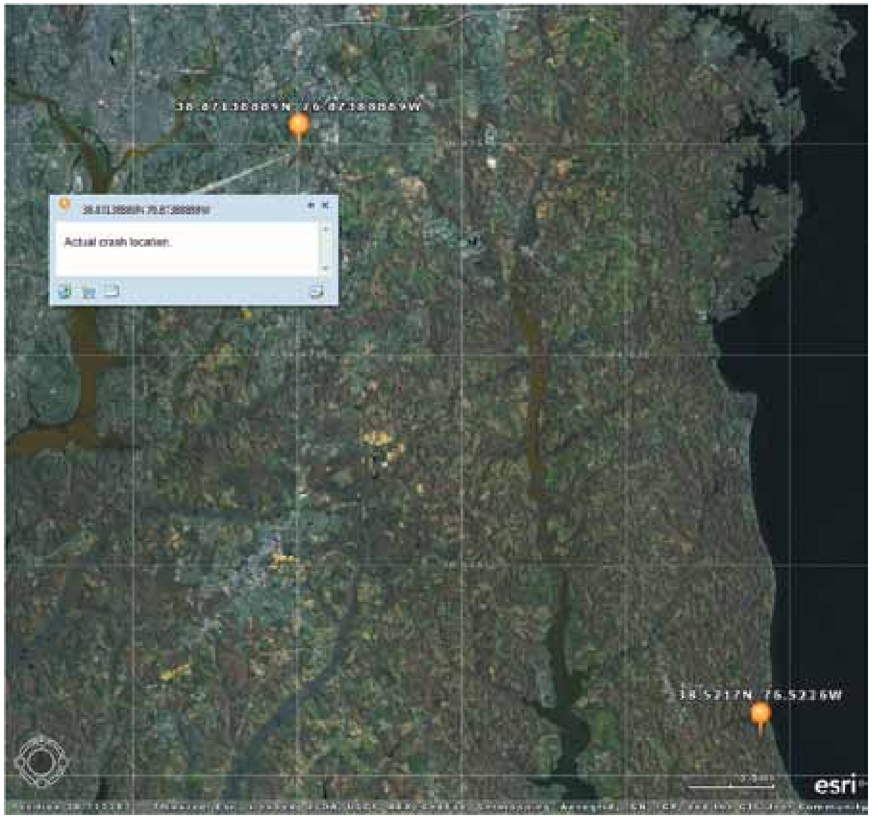


Figure 4-13: The northwest point shows the actual crash location by converting DD MM SS.ss to DD.dd correctly. The southeast point shows the location of the initial search based on taking DD MM SS.ss and inputting into DD.dd without proper conversion.

When receiving coordinates, read them back to the sender. Ask for clarification. Ask what coordinate system and datum is being used. Ask what the source is. Take no chances!

Scale

Map scale is the proportion between a distance on a map and a corresponding distance on the ground, with the map's unit of measurement reduced to 1. For instance, you may see *1:250,000* written on maps. This means that one unit on the map equals approximately 250,000 of the same units on the earth's surface. These fractions to depict map scale are inaccurate if the map is magnified or reduced by photocopying or other means. On a 1:24,000-scale map, .02 inches equals approximately 40 feet on the earth, whereas on a 1:250,000-scale map, .02 inches equals approximately 417 feet on the earth.

Terms that are often confused by folks unfamiliar with maps are *large-scale* and *small-scale*. Changing the scale of the map may also change the level of detail shown and how the different features are represented on a map. Therefore, the larger the map scale, the more detail can be shown. This is a good reason to utilize GIS and a cartographic eye to change the scale of a map rather than a photocopier so as not to exaggerate generalizations or simplifications or errors. It is also important to pay attention to the scale in which the GIS data was created and its intended use and not to zoom in past that scale.

A large-scale map shows a smaller geographic area than a small-scale map does. In the previous example, the 1:24,000 map would be the large-scale map (and show less geographic area in more detail) compared to the small-scale 1:250,000 map (displaying a larger geographic area in less detail). Topographic map series, such as USGS quads, usually utilize a consistent scale, such as the 1:24,000 series.

Maps also use a graphic to show map scale, such as bar scales as shown in figure 4-14, which remain accurate when maps are magnified or reduced. Keep in mind that depending on how large an area the map displays and what projection is used, the map scale may not be exact or consistent across the entire map because of distortion, but more of an average scale for that map.

Figure 4-14: Typical Scale Bar Showing Distance on Map

Review of Chapter Concepts

There are different types of coordinate systems that can be used to display or store geographic data that can affect the shape, area, distance, and direction spatially. Be familiar with the system that your SAR team uses.

When using a geographic coordinate system (latitude-longitude), clearly communicate what format you are providing or receiving the coordinates in and do not pause between groups; say "decimal" or "degrees," "minutes," and "seconds" between breaks. Better to ask than to guess.

Table 4-3: Communicating Geographic Coordinates

Geographic Coordinate System: Format	Example NAD 1983 for Charlotte Lake, Kings Canyon National Park, CA	Common Users
GCS: Decimal Degrees (DD.dd)*	36.77733, -118.42657	SPOT, GeoPro Messenger (default), OnSTAR
GCS: Degrees, Decimal, Minutes (DD MM.mm)*	36°46.640'N, 118°25.594'W	Marine, Aviation
GCS: Degrees, Minutes, Seconds (DD MM SS.ss)*	36°46'37"N, 118°25'36"W	Many MRA SAR teams, USGS maps
UTM	Zone 11N easting 4071120, northing 372697	Standard coordinate system for some SAR teams and datasets; MapSAR tool
US National Grid	11SLA7269971120	Standard for all federal SAR and emergency services agencies, though implementation has been slow

*Since the first three examples are geographic coordinate systems, they are not useful for measuring areas or distances in GIS software, so data should be projected for these uses.

Different datums are used throughout the world; the most common in North America are NAD27, NAD83, and WGS 84. Be sure to list this information when providing coordinates to or obtaining them from people, and, preferably, use the same datum throughout an incident including on GPS units and printed maps. If you are unable to use the same datum, make sure you know what data is in which datum. For example, if aviation maps are in NAD27, but the incident is using NAD83, make sure you (or someone on your team) provide helibase coordinates in NAD27 if needed.

Exercise 4A: Converting Coordinates

You can convert between different formats of latitude and longitude manually using straight mathematical equations. You can also use GIS software and your GPS. Another option is to use an online converter utility to convert not only between different geographic coordinate formats but also between GCS and UTM. This can also be done in GIS software, but for an individual location or a few, it may be fastest to use an online converter. In this exercise, we'll explore a specific converter using the Phantom Ranch location.

Open an Internet browser and navigate to http://www.rcn.montana.edu/resources/tools/coordinates.aspx.

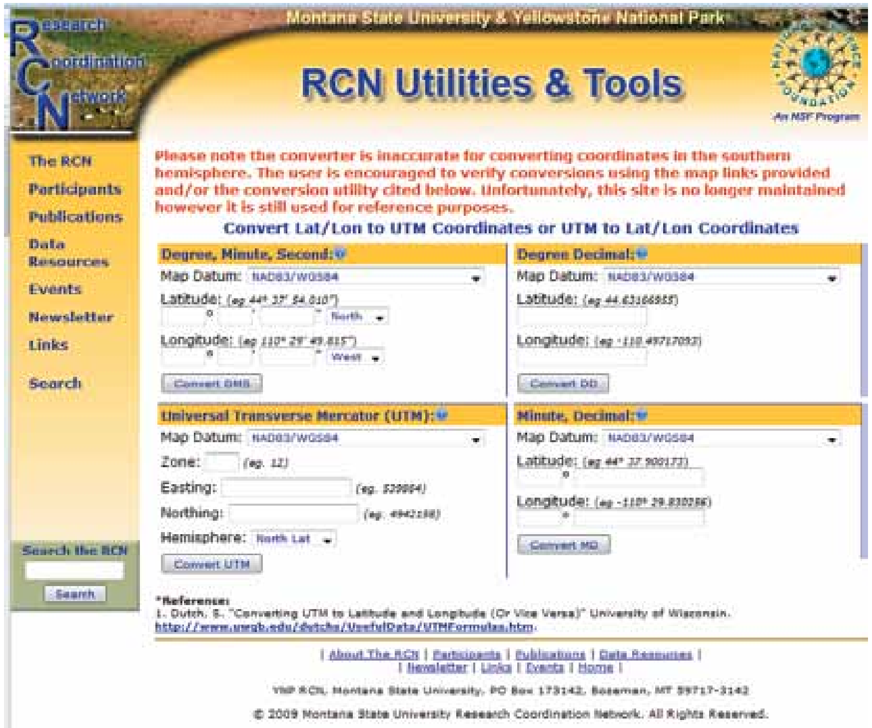


Figure 4-15: RCN Utilities Tool

Use the UTM coordinates for Phantom Ranch provided in the table below to fill in the blank fields.

Table 4-4: Exercise 4A

Coordinate System: Format	Example Using NAD83 Phantom Ranch at Grand Canyon, AZ
GCS: Decimal Degrees (DD.dd)	
GCS: Degrees, Decimal, Minutes (DD MM.mm)	
GCS: Degrees, Minutes, Seconds (DD MM SS.ss)	
UTM (Zone and easting, northing)	Zone 12N easting 401488, northing 3996308

Q: Of the four coordinate types shown above, which would be the best option to store your data in if you wanted to take measurements of length and area?

____

Table 4-5: Exercise 4A—Answer

Coordinate System: Format	Example Using NAD83 Phantom Ranch at Grand Canyon, AZ
GCS: Decimal Degrees (DD.dd)	36.1064313866444, -112.094479884811
GCS: Degrees, Decimal, Minutes (DD MM.mm)	36°6.38588319866372, -112°5.66879308863406
GCS: Degrees, Minutes, Seconds (DD MM SS.ss)	36° 6' 23.153" N, 112° 5' 40.128" W
UTM (Zone and easting, northing)	Zone 12N easting 401488, northing 3996308

A: UTM

Chapter 5: Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks

The first part of this chapter will discuss concepts, and at the end of the chapter is an exercise with step-by-step instructions that you can use to get hands-on experience. Data is provided on the accompanying DVD. The exercise is also written in such a way that you can apply the tasks to your own data, geographic area, and specific incident.

Esri's free GIS viewer, ArcGIS Explorer Desktop is a versatile program with potential to be used in all aspects of SAR operations. It comes in two formats, ArcGIS Explorer Desktop and ArcGIS Explorer Online. We will focus on ArcGIS Explorer Desktop, but it is worth investigating the online version to see if it suits your needs. Information about both can be found on esri.com or resources.arcgis.com.

Like Google Earth, ArcGIS Explorer Desktop is free and fairly easy for nontechnical people to use. It has both a 2D and 3D display mode and can visualize a wide variety of free and publicly available basemaps and other data. Unlike some other mapping programs, it also easily uses shapefiles (.shp) and file geodatabases (.gdb), which many government agencies and organizations use as their standard geospatial file type. There are a number of software mapping options available, and, ultimately, you should use what you and your teams are comfortable with. ArcGIS Explorer Desktop should be considered for its ability to use a wide variety of geospatial file types, its accessibility to nontechnical people, and its compatibility with the full version of Esri's ArcGIS for Desktop software.

There are two levels of GIS knowledge required for both incident management and GIS use in day-to-day operations. Many of the tasks described later in this book require the use of ArcGIS for Desktop. Although we have tried to make the workflow and methods as easy and automated as possible, MapSAR still requires an investment in software (ArcGIS for Desktop) as well as an intermediate knowledge of ArcGIS for Desktop and computer ability.

However, many GIS tasks can be more easily performed by the average search team member using ArcGIS Explorer Desktop. It offers many of the functions possible in other mapping software, such as TOPO! or Google Earth, but in addition to working with KML/KMZ files, ArcGIS Explorer Desktop accepts shapefiles and geodatabases, which are native to ArcGIS for Desktop and are the standard geospatial data file format. Equally important, ArcGIS Explorer Desktop allows you to view a wide variety of raster files, such as GeoTIFF and MrSID, which are types that are used for some basemaps such as USGS topo maps and satellite imagery. ArcGIS Explorer Desktop will also display several types of files derived from analysis of data (such as projected rate of travel of an individual through different types of terrain). For the public, these datasets can also be found on the Internet or even through a county's GIS or planning office (see the section "Creating a Minimum Essential Dataset" for data sources in chapter 3).

For SAR teams, applications of ArcGIS Explorer Desktop can include the following:

- Finding a location from coordinates (e.g., latitude-longitude, UTM, decimal degrees), for instance, the SPOT emergency center calls with coordinates of an emergency activation. All SAR team members should know how to find the location in any of several coordinate types, setting both the coordinate type and datum to obtain the correct location. This is becoming an increasingly critical skill that all team members need to have as the public and emergency devices such as SPOT are calling in emergencies and giving coordinates for their location. Mistakes are being made because the person giving or receiving the coordinate values doesn't understand them or doesn't identify them correctly.

- On a SAR or any incident, the first person on the scene can begin to establish not only initial planning points (PLS, Last Known Point [LKP], IC, and more) but can use the ArcGIS Explorer Desktop graphics tool to draw segments and assignments that can later be exported to ArcGIS for Desktop when the situation requires more extensive mapping and analysis.

- Finding coordinates from a location; for instance, you are able to establish a graphic point on a map and read the coordinates in any of several types, choosing the appropriate format and datum for ground teams and air operations or to be compatible with your agency's data standards (see the chapter "Understanding and Using Coordinate Systems").

- SAR team members with minimal training can create both maps and data files from almost any type of geospatial information they want.

- Creating 2D or 3D maps to illustrate many operational needs. Being able to visualize information allows both field teams and incident command staff to more efficiently and effectively envision complex information—perhaps to see clusters of incidents and relationships not otherwise apparent from tables and reports.

- A computer running ArcGIS Explorer Desktop can be plugged into a digital projector or wall monitor and project situation maps onto that as part of a briefing instead of paper maps. ArcGIS Explorer Desktop can be set to update from a file geodatabase or shapefile at any time interval. As such, it can show an incident's geospatial information such as team locations, assignments, clues (labeled), helispots, PLS, and more, to all members of an incident command as that data is entered by the incident's GIS user. Using ArcGIS Online or a GIS server, this same information can be shared anywhere an Internet connection is available.

- Track logs from GPS units can be downloaded from the device and then projected onto your ArcGIS Explorer Desktop map. The specific routes of SAR teams can be mapped by team members and those results saved in a format easily imported by a GIS user for later detailed analysis using ArcGIS for Desktop.

- Several devices now allow real-time tracking of field teams (see chapter 6 "Integrating GPS and Current Technologies into SAR Operations"). Not only can this dramatically improve situational awareness at the ICP, but it has the potential to speed up the planning cycle on an incident as well as reduce radio traffic when there is less need to report positions by radio. ArcGIS Explorer Desktop can display the output of several of these real-time tracking technologies.

In short, ArcGIS Explorer Desktop can have a number of applications for nontechnical people to plan the initial stages of a SAR, keep track of resources at a command post, and create maps to illustrate a variety of operational situations and needs.

Installing ArcGIS Explorer Desktop

ArcGIS Explorer Desktop is fairly processor and video card intensive. One of its disadvantages is that it will not run well on some older computers. It should also be noted that Internet access is necessary for use of the default basemaps. However, if you've gathered your MED, no Internet connection is necessary. The following are only very basic instructions to install and run ArcGIS Explorer Desktop. For more complete instructions, go to the Esri ArcGIS Explorer Desktop help files on resources.arcgis.com.

The first step in using ArcGIS Explorer Desktop is to make sure it runs on your machine:

1. Go to the ArcGIS Resource Center website (resources.arcgis.com) and look for the ArcGIS Explorer Desktop download. [Look under Products > Explorer or Free Viewers, or do a search on the website.]

    a. Make sure that your machine can handle the software. Check the system requirements provided on the website for ArcGIS Explorer Desktop and compare to your computer. If it is sufficient to run the software, proceed to the next step. If it isn't, ask around and see what other computer resources your organization or team members have that you might be able to utilize.

2. Check to see if there are any programs you will need to install before ArcGIS Explorer Desktop will run properly, such as .NET Framework, by running the utility program provided on the download page.

3. If you have administrative rights for your computer, download and install the latest version of ArcGIS Explorer Desktop. Note that if you are using Windows 7 or newer, you should right-click the download and select **Run as administrator** to launch the application for proper installation, and then click **Yes** when prompted. Then follow the Setup wizard.

    a. If you don't have administrative rights to your computer, you can download and install the Current User installation package from the ArcGIS Resource Center website. See the ArcGIS Explorer Desktop Current User installation guide for further information.

Exercise 5A: Setting Up ArcGIS Explorer Desktop

Setting Up and Using ArcGIS Explorer Desktop

1. The first time you open ArcGIS Explorer Desktop, it's also important that you install the Coordinate System Expansion Pack.

    a. In ArcGIS Explorer Desktop, click the **ArcGIS Explorer** button (figure 5-1), and click **ArcGIS Explorer Options**.

Figure 5-1

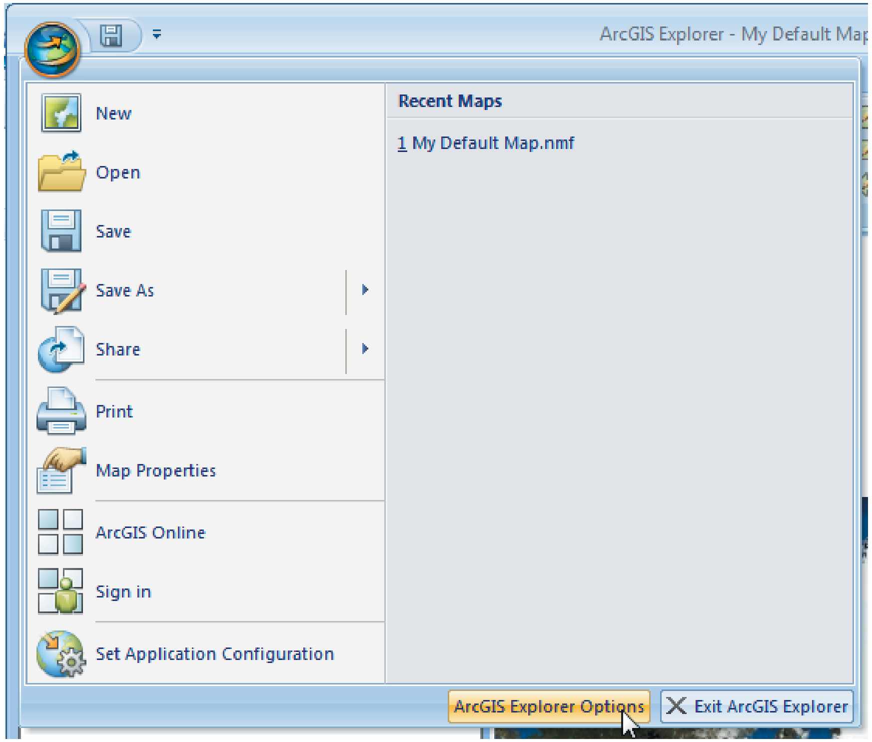


Figure 5-2

b. Select **Resources** and then **Expansion Packs** as shown below.

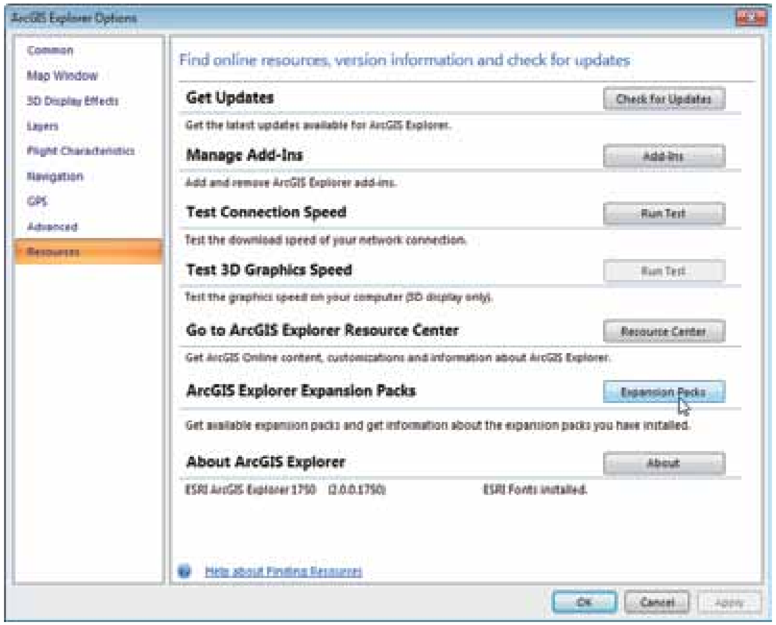


Figure 5-3

c. Click the **Get Expansion Pack** button. This will take you to the ArcGIS Resource Center for your version of ArcGIS Explorer Desktop and list all the expansion packs you can download. We are particularly interested in the Projection Engine Expansion Pack, but feel free to download and install any other additional expansion packs you might use.

d. Once you find the Projection Engine Expansion Pack, you want to download the appropriate version. The first one is for users who installed ArcGIS Explorer Desktop as an administrator, and the second is listed as the Current User version that is for nonadministrator installations. You must use the same type you used during the ArcGIS Explorer Desktop installation.

e. Click **Download** and then **Save File** when prompted.

f. Once the download is complete, navigate to where you saved the file and, in Windows 7, right-click it and click **Run as Administrator** and **Yes** if using the standard extension, or just double-click the file if using the Current User version.

g. Follow the prompts in the expansion pack's Installation Wizard.

Figure 5-4

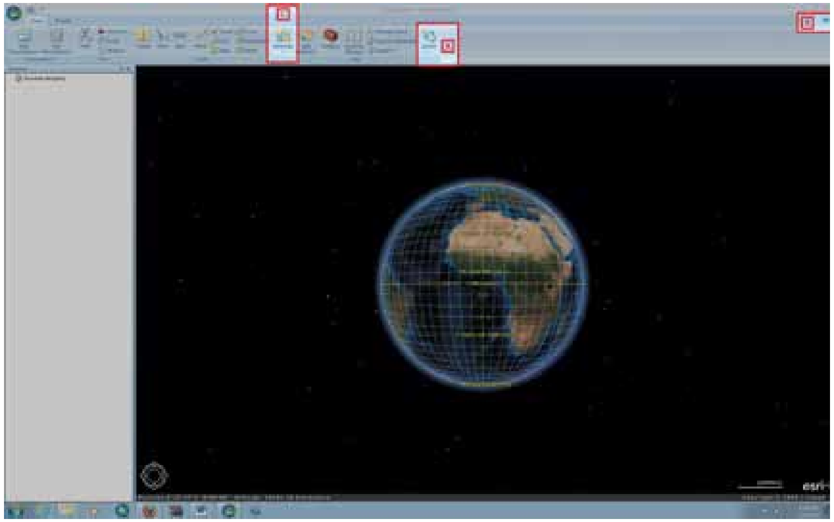


Figure 5-5

2. Start ArcGIS Explorer.

   Your initial screen will probably show the earth in either 2D or 3D.

   a. When you are in 2D, it will show a flat aerial image (figure 5-4), and in 3D display, you will see a globe, such as in figure 5-5. When you switch to 3D (figure 5-6), a tilt bar becomes available on the compass tool to the lower left of the screen.

Figure 5-6 Use the 2D/3D button to toggle between the views you want.

   b. As in many other software packages, you can find more information on the specifics of ArcGIS Explorer Desktop by clicking the blue question mark button in the upper righthand corner. Help includes a list of contents, index, and search function.

c. The map background is called your basemap. You can choose from a variety of different types, showing terrain in either a USGS topo-type map or as satellite imagery. Esri provides online access to a number of different types of basemaps. The advantage of ArcGIS Explorer Desktop is that you can also access other basemaps, such as USGS topographic maps or imagery, from files kept on your computer rather than the Internet. With ArcGIS Explorer Desktop, you don't need an Internet connection for effective mapping if you have data available on your machine.

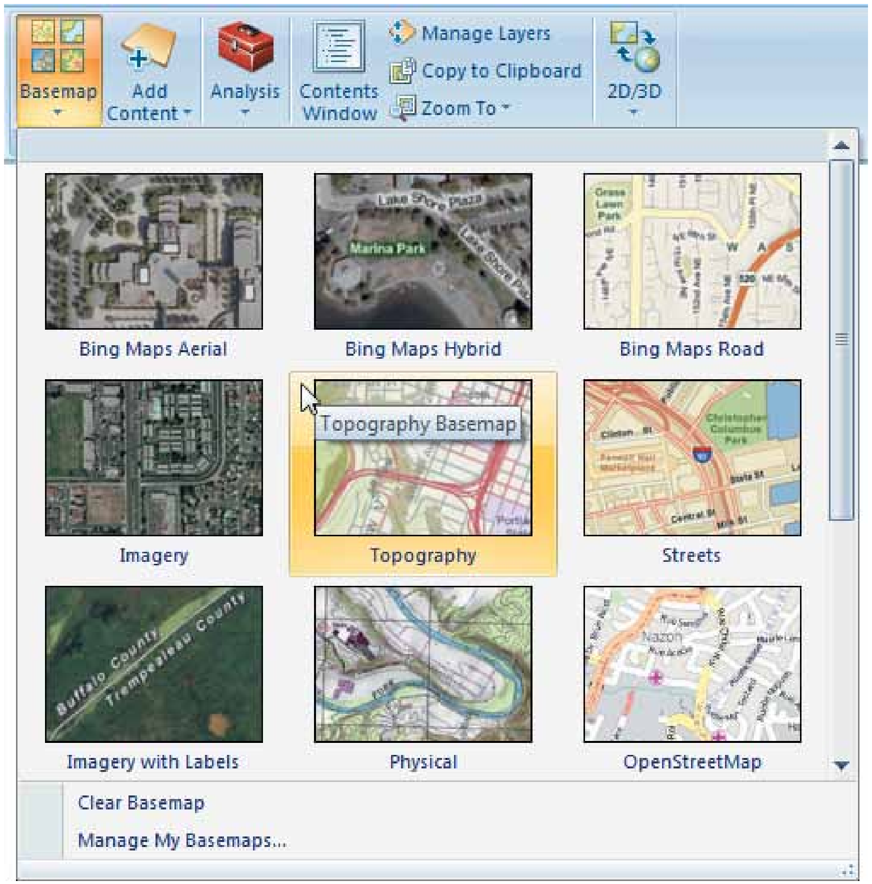


Figure 5-7 Choose the basemap you would like to use for your map backgrounds.

d. Using either the wheel of your mouse or the navigation compass on the lower left (the righthand bar of that tool is the zoom level), you can focus on the area you want to see in more detail. Start zooming in and stop occasionally to click the mouse to grab and center the map view as you go. Until you gain experience, it's also easy to lose your area of interest and find yourself off in the middle of the Pacific Ocean or somewhere. To restore the default world view, click the **Full Extent** button below the **Navigation Ring**. If you're connected to the Internet, you can often use the **Find** command to navigate to a specific town or other geographic location.

e. Once you get to your area of interest, you may want to try different basemaps to see which suits your task best. To view and load different ones, do the following:

   i. Choose the **Basemap** drop-down list from the menu icons.

ii. There are two basic types of basemaps: Standard topographic maps (World Topography or World Physical) or several different types of aerial imagery (Bing Maps or World Imagery). Try several different types to become familiar with them.

iii. Also note that it's often easier to view maps in a topographic basemap and 2D for quicker loading—zoom to the specific area you want and then switch to 3D and imagery. You can also use the circle to rotate the view.

iv. Once you've made a nice-looking map (reference the upcoming steps), you will want to save your map. Click the **ArcGIS Explorer** button in the top left corner and click **Save**. It will be saved as your default basemap, and whatever data and basemap you saved most recently will automatically be loaded when you start ArcGIS Explorer Desktop. If you're working on a specific project (e.g., a tabletop SAR exercise), you can click **Save As** and give it an appropriate name and date of creation. You can then choose to open that map when you work on that project.

f. When you're happy with your choice of basemap (which you can change at any time), you should choose a coordinate system and units your distances will be in.

   i. Click the **Display** tab.

   ii. Use the **Coordinates** drop-down menu to choose from degrees, minutes, seconds; decimal degrees; etc. If you've installed the Projection Engine Expansion Pack, you can use UTM or many other projection types. For UTM, you'll need to know what zone you're in. Scroll down to **<More>** and navigate to Projected > UTM > NAD1983 > NAD1983UTMZonexxN for your particular area.

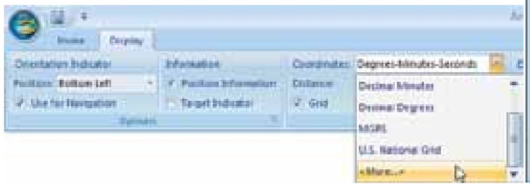


Figure 5-8

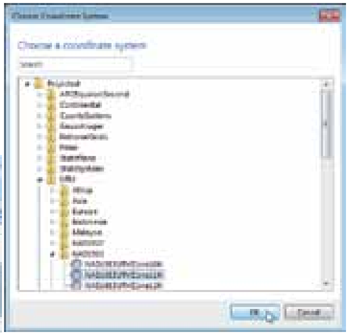


Figure 5-9

iii. Next, choose your distance units in either feet/miles or meters/kilometers. Note that coordinates are displayed in the lower left and a scale bar in the lower right.

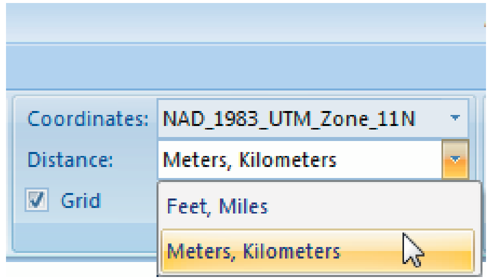


Figure 5-10

Adding Data

ArcGIS Explorer allows you to layer many forms of data on top of the basemap and make them visible or hidden by checking or unchecking the check box to the left of the layer's name in the **Contents** window.

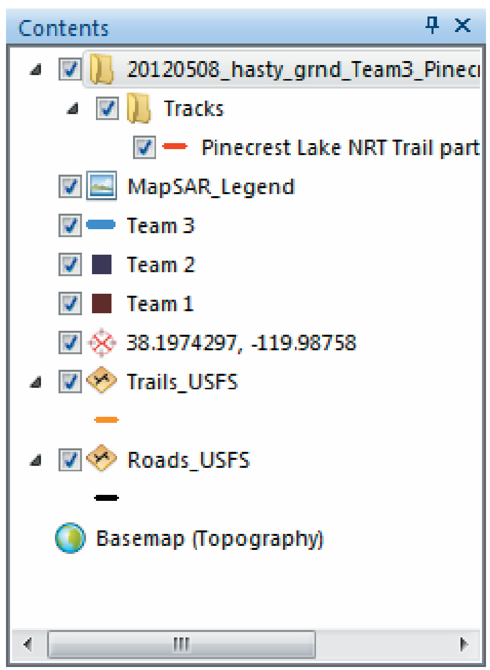


Figure 5-11

You can also drag the order of the layers in the **Contents** window to make some layers draw on top of others. The layer at the top of the list will draw last and will obscure anything below it. That's why it is helpful to keep your basemap at the bottom of the list so it does not cover any important SAR information.

You can add or create individual points; download track logs from GPS devices; and add trails, building, cell tower sites, etc., from existing agency or public databases. If there are coordinates associated with the file—whether text, Excel, or shapefile—you can establish its location on a map and represent it with a symbol and note tag. You can also add photographs that have geospatial coordinates embedded in them or use ArcGIS Explorer Desktop to add that information to an existing photo.

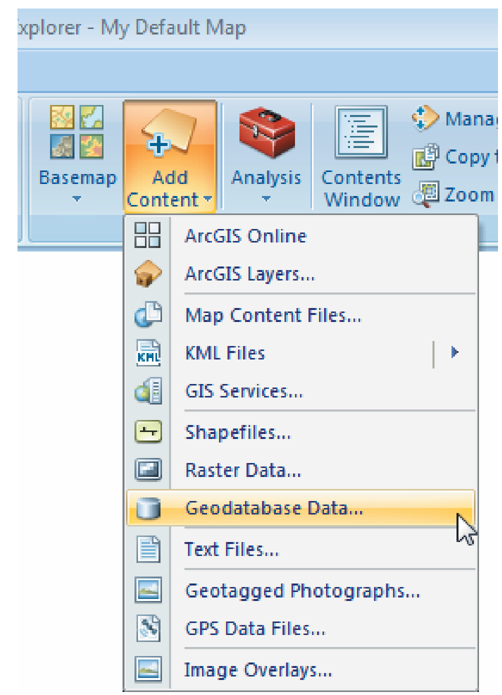


Figure 5-12

Using Find to Establish a Point

Be aware of what datum your coordinates are in and always ask for the datum. For instance, if the coordinates are being read to you by a field team using a USGS Topo map, the coordinates are often in NAD27. Some paper maps use NAD27, and some use NAD83 as their reference. A GPS can be set to provide coordinates in any coordinate system, but the default is usually WGS 84 (which for SARs is comparable to NAD83). It is important to confirm the datum to avoid a possible error of several hundred meters. For more information about coordinate systems and protocols for communicating coordinates, see chapter 4 "Understanding and Using Coordinate Systems."

For these steps to work, you must have the Projection Engine Expansion Pack installed, as explained above.

1. From the **Display** tab, set the coordinate system and datum to match the one you will enter. This is an extremely important step. If you forget this step, you could plot the incorrect location and mislead field teams and decision makers. For instance, if you've been given a SPOT emergency activation in decimal degrees, set the Coordinate type to Decimal Degrees and NAD83.

    a. If the coordinates are given to you in NAD27, for example, a paper USGS map with a datum of NAD27, you can change this in two ways. If the coordinates are in UTM, choose **Display > Coordinates <More... > UTM > NAD1927** and then navigate to and choose the zone you're in. For all other coordinate types, the process is slightly different. Click the **ArcGIS Explorer** button (the globe in the upper left) and then go to **Map Properties > 2D Coordinate System > Coordinate System > More... > Geographic > North America** and choose **NAD1927**. Remember to change it back when no longer necessary for your incident.

2. From the **Home** tab, click the **Find** icon (binocular). A new box will open. Enter the coordinates on the blank line. It's best to enter the latitude first, then longitude for most coordinate types. (Latitude is represented by lines that go around the earth, like the equator, and are arranged north and south from the center, while longitude lines run from the North Pole to the South Pole and spread out east and west of the prime meridian. You should also note that, in ArcGIS Explorer Desktop, UTM coordinates are represented on the x-axis for latitude and y-axis for longitude). Depending on the coordinate type, make sure you enter the appropriate symbols to identify the location as northern or southern hemisphere and east or west of the prime meridian. For North America, latitudes would be W for western and N for northern hemisphere. For decimal degrees, longitude would be preceded by a minus sign (-).

3. When you enter the coordinates successfully, a symbol will appear on the map, and ArcGIS Explorer Desktop will zoom in on that point. Note that those coordinates will appear below in a new box with a check box by the values. As you enter more coordinates to find, you can check and uncheck to show or hide the symbol.

4. *Those values and symbols are still temporary.* When you want to make them a permanent part of the map, right-click the values and choose **Move to Map**. The symbol moves to the **Contents** window on the left side of the screen. (From the **Home** tab, click the **Contents** window icon to activate it, or, if visible, click the **Contents** tab on the left side of the screen).

5. You can then add a note to identify the point. In the **Contents** window, right-click the point and choose **Show Popup**. In the lower right corner of the note box, click the **Note/Pencil** icon to edit. You can then change the header note value (the coordinates) as well as add a longer note. You can also left-click and hold to move the entire note box to a position you want. Hide it by clicking **Show Popup** again.

6. To change the symbol or size, highlight the point in the **Contents** window, right-click, and choose **Symbol**. Then scroll through for the symbol you want. You can also change the symbol from the **Appearance** tab. Just highlight the symbol you want to edit and choose a new symbol, size, or color. You can create your own customized symbols and add them to the available Symbol Gallery in ArcGIS Explorer Desktop.

Establishing a Point at a Geographic Location

ArcGIS Explorer Desktop also allows you to draw freely on the map to describe locations of things or mark the map up. From the **Home** tab, choose **Point** from the toolbar, move the cursor to the place on the map where you want to establish it, and click. A note box appears. You can label the point and add identifying information as well as change the symbol type. The same can be done with the other drawing types: Line, Area, Circle, Rectangle, and Arrow. Read the pop-up text when you hover over the tool to find what it does.

Remember, when establishing geospatial information, save often and save to an appropriate map name.

Creating a Point on the Map to Obtain Coordinate Values

There will be times when you need an easy way to obtain the coordinates for a particular location. You know, for instance, that there's a usable landing zone at a particular meadow. Helitac needs the coordinates to drop off a team.

1. Set the coordinate type to what you'll need. For instance, if the coordinates are going to aviation, go to **Display > Coordinates to Degrees-Minutes-DecSeconds**.

2. Go to **Home > Measure**.

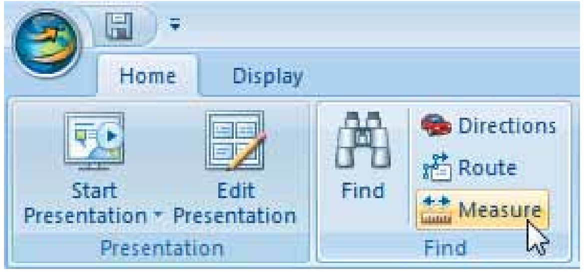


Figure 5-13

3. Click the **Find Coordinate** icon.

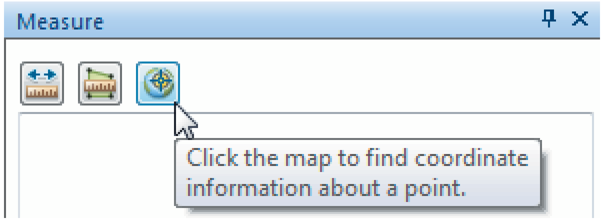


Figure 5-14

4. Click on the map where you want to find the coordinates.

5. Click **Add to Map**.

6. The point will be added to the map with the coordinates, which will be shown in the **Contents** window.

Downloading GPS Units and Projecting Track Logs and Waypoints to ArcGIS Explorer Desktop

ArcGIS Explorer Desktop has several ways to bring in and project track logs from your team's GPS units. For further information and exercises on how to use a GPS unit, read chapter 6 "Integrating GPS and Current Technologies into SAR Operations."

After you've used your GPS unit to record track logs or waypoints, you need to transfer the data to a program that will show that information on a map. The Garmin 60CSX model is one of the more popular GPS units for SAR teams, and our instructions will be based on these. Most GPS units are similar, and downloading data is a matter of having the appropriate cable for connection between the GPS unit and the computer and software that will do the transfer. Consult the user manual for your particular GPS model to follow the steps below.

During the exercise, we will go through the steps for downloading GPS data into ArcGIS Explorer Desktop. Notice that there are many other options for transferring your GPS data onto your machine; some of the other options we will cover in chapter 6 "Integrating GPS and Current Technologies into SAR Operations."

Sharing Data Created in ArcGIS Explorer Desktop

There are a couple of ways to share data that you've created in ArcGIS Explorer Desktop with others. You can create map content files (*.nmc), a layer package (.lpk), or a KML/KMZ (.kml/.kmz) file from data for users with other types of software to use:

- ArcGIS for Desktop users can open LPK or KML files (and NMC files using a long workaround).
- Google Earth (and other software application) users can open KML/KMZ files.
- All three file types can be exported directly from ArcGIS Explorer Desktop into a file on disk or as an e-mail attachment, and map content and layer packages can be posted directly onto ArcGIS Online to share with others.

To begin, select the individual layers in your **Contents** window that you want to share and either right-click them and select **Share** or go to the **Tools** tab and click the **Share** button under **Organize**. If you receive these types of files from another source, you can go to the **Home** tab, click the **Add Content** button, and select the appropriate file type.

Exercise 5B: Using ArcGIS Explorer Desktop in the Search for Danny

The following section will walk you through a hands-on exercise for using ArcGIS Explorer Desktop and brings together the concepts we've covered in this chapter. You will be using data from the Internet and from the included CD or from mapsar.net. You should already have ArcGIS Explorer Desktop installed, following the instructions previously provided if needed.

Scenario: Background

It's a beautiful spring day in California's central Sierra Nevada Mountains, and Mr. Smith has taken his son to Pinecrest Lake for some father-son fishing time. About an hour after eating their brown bag lunches, Smith is distracted when he catches a particularly impressive fish. After his initial glee, he looks around to share his moment of glory with his son. Little Danny is out of sight, and Smith assumes he must have wandered off somewhere nearby. After yelling his name without a response, Smith gathers his fishing gear and begins looking in the general vicinity. After 10 minutes, he begins to worry and starts yelling "Danny!" louder. Some nearby hikers and fishermen hear his calls and offer to help look around. After 30 minutes of calling and searching, Smith uses his cell phone to call 911 and report his nine-year-old son missing.

The call gets routed to the county sheriff's office around 1330, and staff put a call out to the Tuolumne County Search and Rescue team. Several SAR team members are able to assemble quickly, arriving at the station to grab gear and plan. You are one of the initial responders and have been assigned to create a basic map that establishes the point last seen and draw assignments where your teams are going to search. The team arrives at the area where Danny was last seen around 1500 and completes a hasty search by 2000. They return to the station to give you their GPS units and plan for the next operational period (OP).

Scenario: Using ArcGIS Explorer Desktop

It'll be dark in only a few hours, so you need to get your teams out the door with their search maps as quickly as possible. You're most comfortable using ArcGIS Explorer Desktop, so we will start there. You're glad you took the time to gather the MED for your area and practice using ArcGIS Explorer Desktop over the past few weeks (see Creating a Minimum Essential Dataset in chapter 3).

The MED data for this exercise is on the accompanying CD or online from mapsar.net titled 5_AGX_Ex_Data.zip. Before you begin, copy and extract this data from the CD/Internet to your computer into a folder, such as C:\SAR_Book folder. For the exercise, we've put the data in a file geodatabase (.gdb), Esri's capsule file type. If you've created your own MED using shapefiles, that's no problem. They both work the same way. Even if you hadn't created an MED, if you have an Internet connection, you could still create a basic map using ArcGIS Explorer Desktop.

1. Copy exercise data to your computer as described above.
2. It's 1345, and you have a map to make. Open ArcGIS Explorer Desktop. From the **Display** tab, change **Coordinates** to **Degrees-Minutes-Seconds (DMS)** and **Distance** to **Feet, Miles**.
3. From the **Home** tab, click **Basemap**, and select **Bing Maps Road** (upper left).
4. On the **Home** tab, click the **Find** button.

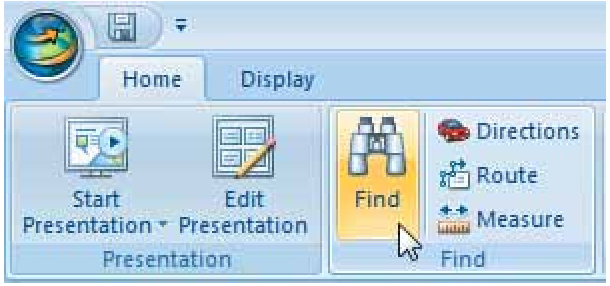


Figure 5-15

5. Enter the coordinates for Pinecrest Lake, California: **N38°11'45" W119°59'02"**. (To type a degree symbol, hold down the **Alt** key and type **248** on your numeric keypad [do not use the numbers on the qwerty keyboard]. Once you

release the Alt key, a degree sign will appear. If you are using a laptop, you may need to hold down the **Fn** key in addition to the above.) Enter these into the **Find** window, as shown. Be careful to enter them precisely; note that this matches the DD MM SS.ss format we chose earlier, with the latitude listed first.

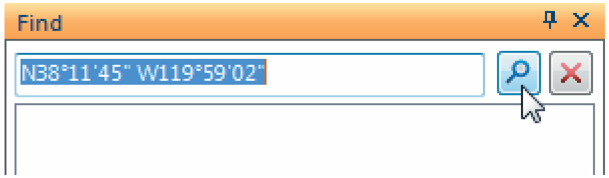


Figure 5-16

6. Click the **Find A Place** icon (blue magnifying glass in same pane), and ArcGIS Explorer Desktop will zoom and mark that location. Your screen should look similar to this:

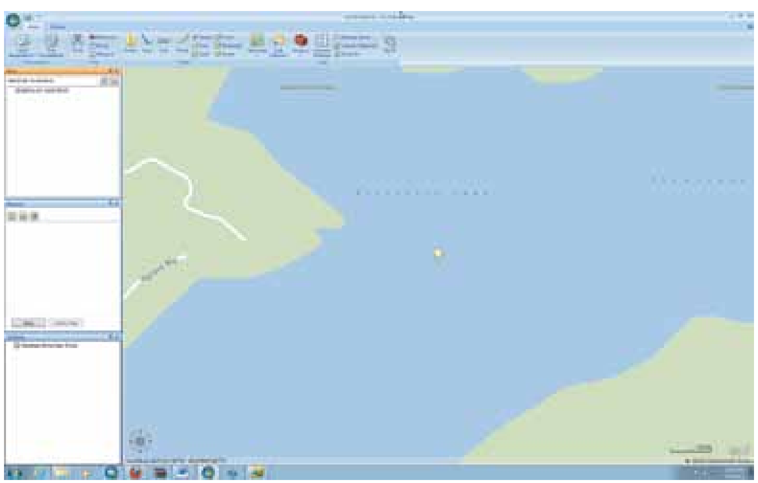


Figure 5-17

7. Use the wheel of your mouse or the zoom out navigator (the compass ring in the lower left corner of your screen) to zoom out and pan around the lake so you can become familiar with the area. If you zoom in or out too far, double-click the coordinates in the **Find** window to return to the initial view.

8. You haven't ramped up the search yet, so it's only you and the incident commander. You discuss it and decide you just need a map showing trails, roads, the PLS where the father last saw his son, and search segments. Search segments are the polygons or area shapes where a team will be assigned to look for the subject.

   a. Trails and Roads: You are going to add some data from your previously collected MED files (that you've already transferred from the accompanying DVD to your computer).

i. From the **Home** tab, click the **Add Content** button and **Geodatabase Data** as shown.

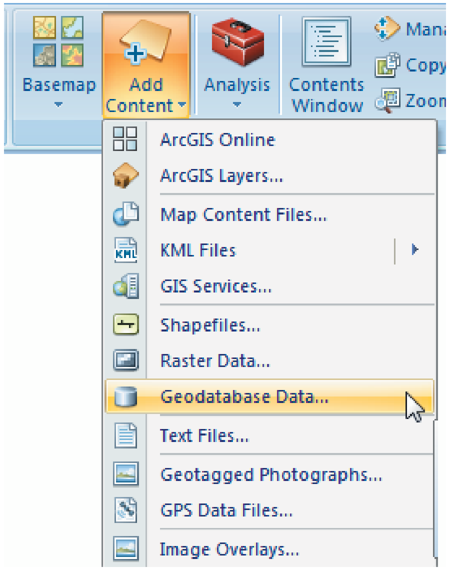


Figure 5-18

ii. For Geodatabase type, choose **File Geodatabase**. Click the **Browse** button and navigate to the folder where you stored the exercise data. Select the **TuolumneCounty.gdb** and click **Next**.

Figure 5-19

iii. Choose the **Trails_USFS** feature class, then hold down the **Ctrl** key and click the **Roads_USFS** feature class.

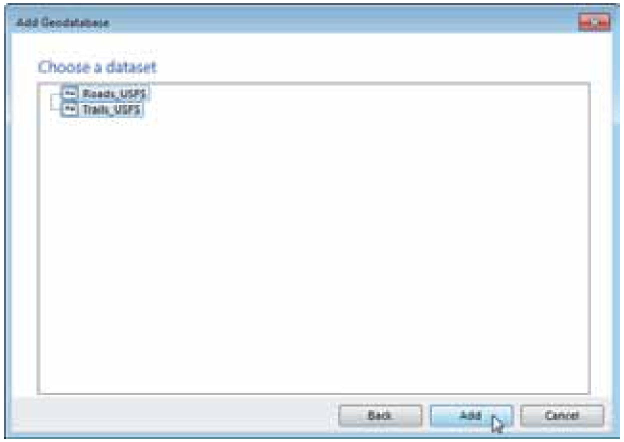


Figure 5-20

iv. Click the **Add** button. The map may zoom out to show the full extent of these datasets. But right now, you're interested in the area around the lake, so zoom back to the pin that marks Pinecrest Lake. (If it disappeared, just double-click the coordinates in the **Find** window. Alternatively, you can right-click and choose **Go To**.)

v. Now you can clearly see the trails and roads overlaid on the basemap, and you now have two more tabs—**Tools** and **Appearance**—to work with. But the trails and roads are both shown as red lines.

vi. Change the symbol for the trails to orange. In the **Contents** window, right-click the **Trails_USFS** layer and click **Symbol** and click the thin orange line as shown.

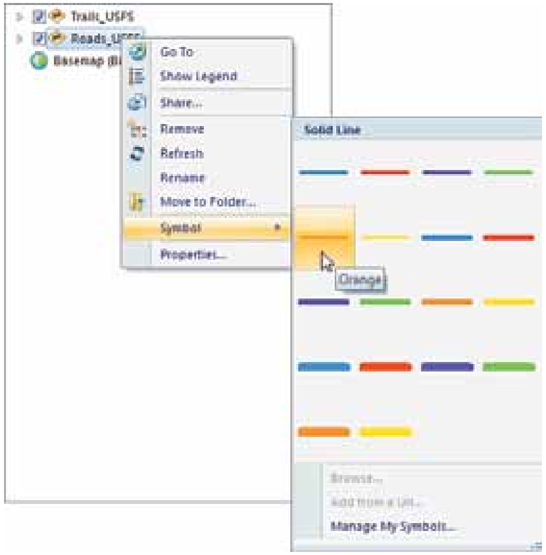


Figure 5-21

vii. There is another way to change the look of your data; click the roads layer in the **Contents** window and click the **Appearance** tab. Click **Color** and select the black swatch.

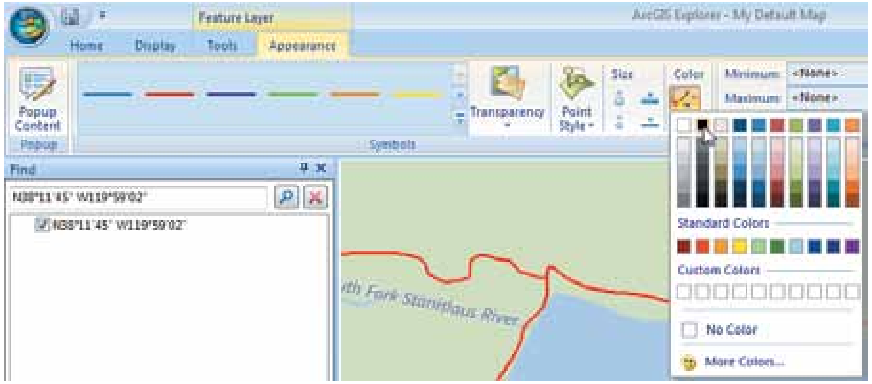


Figure 5-22

b. Now that you have the roads visible from your MED on the map, change your basemap so that you're using a different basemap. Go to the **Home** tab and click **Basemap**, and then select the **Topographic** basemap. (Note: If you didn't have MED data, you might use a basemap taken from the Internet as your background.) Notice that the data from your MED and the basemap do not match up precisely. This is common and another reason why local knowledge of the area and your data are so important.

c. Don't forget to save your map. Click the **ArcGIS Explorer** button in the upper left corner, click **Save As**, and call this map 2012508_Pinecrest_Lake_Search_Danny_OP1.nmf. Remember, no spaces or dashes are allowed in the file name.

d. For PLS, you want to add a point of the location where the father last saw his son. One of the nearby hikers had a GPS unit and has provided coordinates in decimal degrees for this location: 38.1974297, -119.9875358. Remember from chapter 4 "Understanding and Using Coordinate Systems" that these same coordinates could also have been reported as 38.1974297 North, 119.9875358 West. ArcGIS Explorer Desktop will recognize either format.

    i. First, change the coordinate type in the **Display** tab to **Decimal Degrees**.

    ii. Carefully type the coordinates in the **Find** window. (If your Find window isn't currently shown, go to the **Home** tab and click **Find**.) Remember to enter the latitude first.

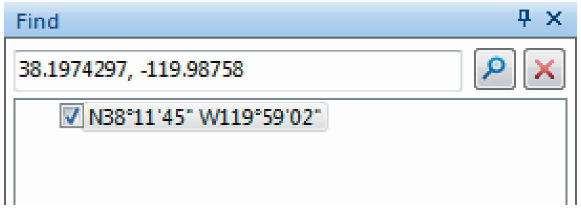


Figure 5-23

Since your longitude is a heading of west, you need to use a negative sign in front of it. (Otherwise, you end up in the Gulf of Chihli near Asia; try entering the coordinates in different ways so you understand the consequences of incorrectly entering coordinates.)

    iii. When you've determined that this is the correct location (that is, you're not in the Gulf of Chihli) you want this to be a permanent point on the map. Right-click the coordinates in the **Find** window and click **Move to Map**.

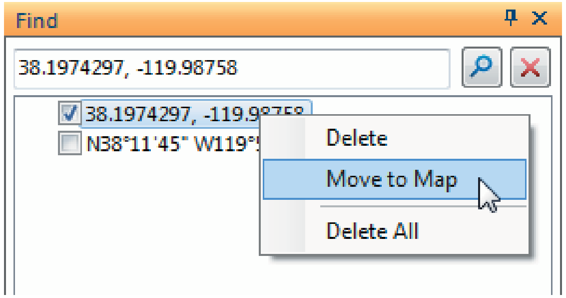


Figure 5-24

iv. Your point should now be listed in the **Contents** window and should be in this location:

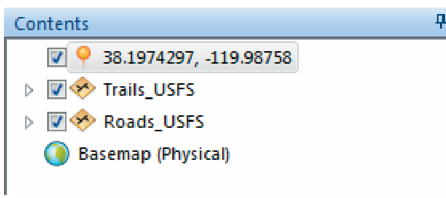


Figure 5-25

Figure 5-26

v. You want to use a better icon for the PLS. In addition to the MED data, the standard SAR symbols as used in the current version of MapSAR are provided on the accompanying CD or found online at mapsar.net. Right-click the orange pin and select **Symbol** and **Manage My Symbols**. Click the **Browse** button, navigate to the folder where you copied the data for this exercise (C:\SAR_Book\5_AGX_Ex_Data), and open the **MapSAR_Symbols** folder.

Figure 5-27

vi. Scroll down, select the **PLS Icon** file, and click the **Open** button. A circle with a red **X** will appear in the window. Click **Close**.

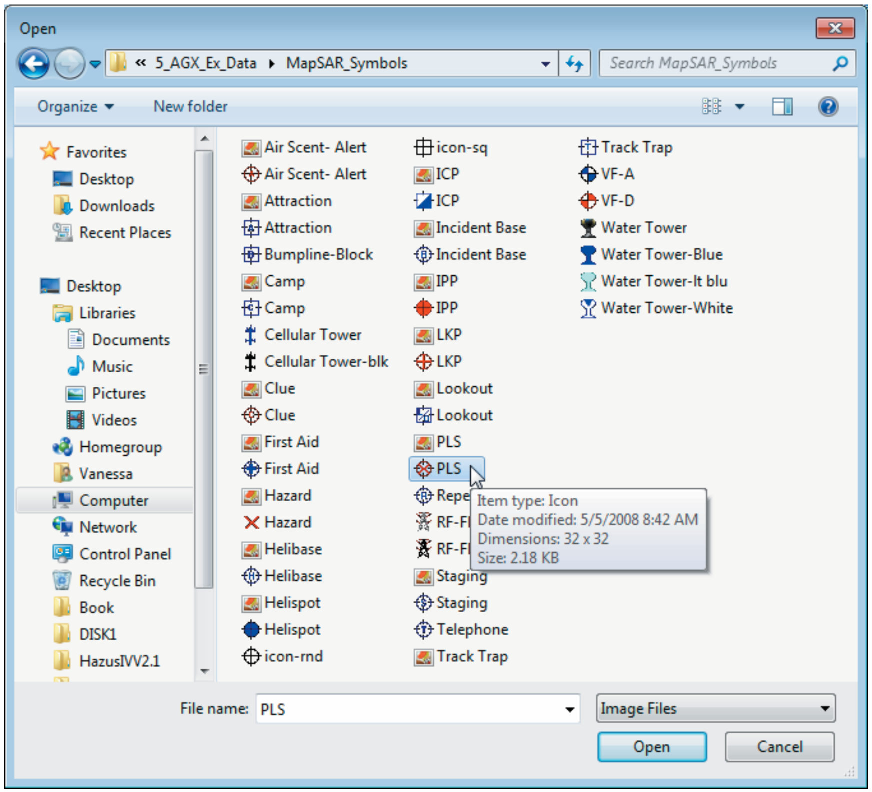


Figure 5-28

vii. Right-click the orange pin and choose **Symbol** again. Select the newly added **PLS** symbol.

Figure 5-29

At this point, your map should look something like this:

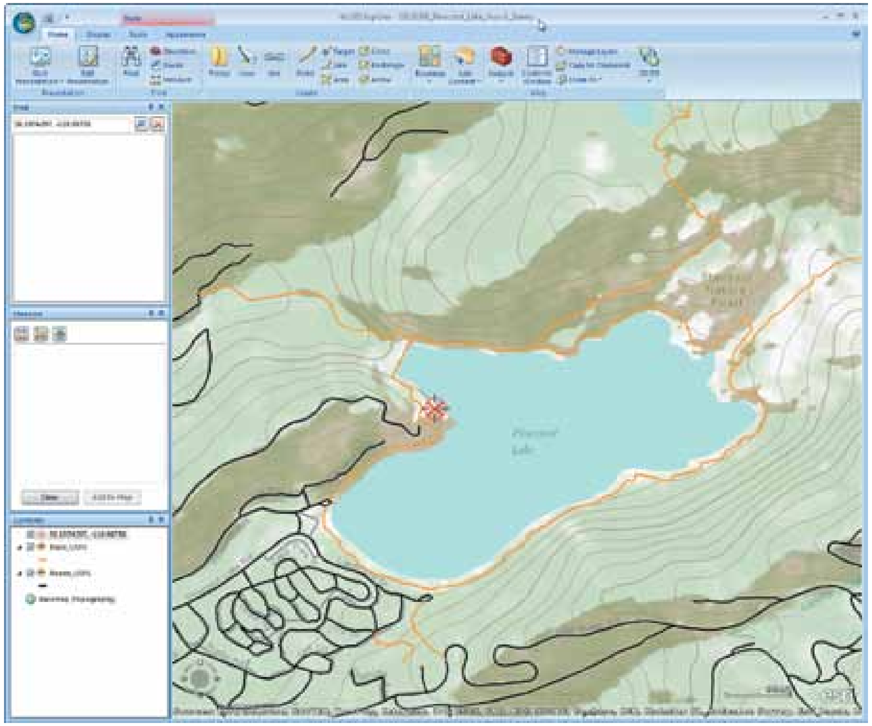


Figure 5-30

Remember to save your work often.

e. For an initial hasty search, teams will usually quickly check the most likely areas, including trails. Draw on the map the areas you want the three hasty search teams to check before the sunlight fades. You want to break the sections into three: one team looking along the streets in the neighborhood to the southwest of the lake, one team walking the trail along the lake as thoroughly as possible, and the other team covering the one eastern and two northern trails that break off from the lake. Before drawing on the map, make sure you have the entire area you want to capture in view; if you don't, zoom and pan until you do.

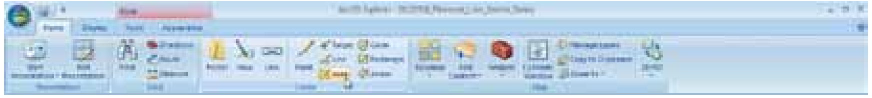


Figure 5-31

i. On the **Home** tab, click **Area**.

ii. Click on the map and begin drawing a shape around the residential area, including the streets. Click each time you want to put down a vertex (a vertex is the click point where you want to change the direction of the line you're drawing). This may take some practice the first few times. Double-click to complete the polygon. If you don't like what you've drawn, just complete the shape, then right-click the new layer in the **Contents** window and click **Remove**, and then click the **Area** tool to start over. If you want to move the map over, you can hover over the direction controls in the lower left corner and click to move north, east, west, or south. When you've finished the first search area, it should look something like this:

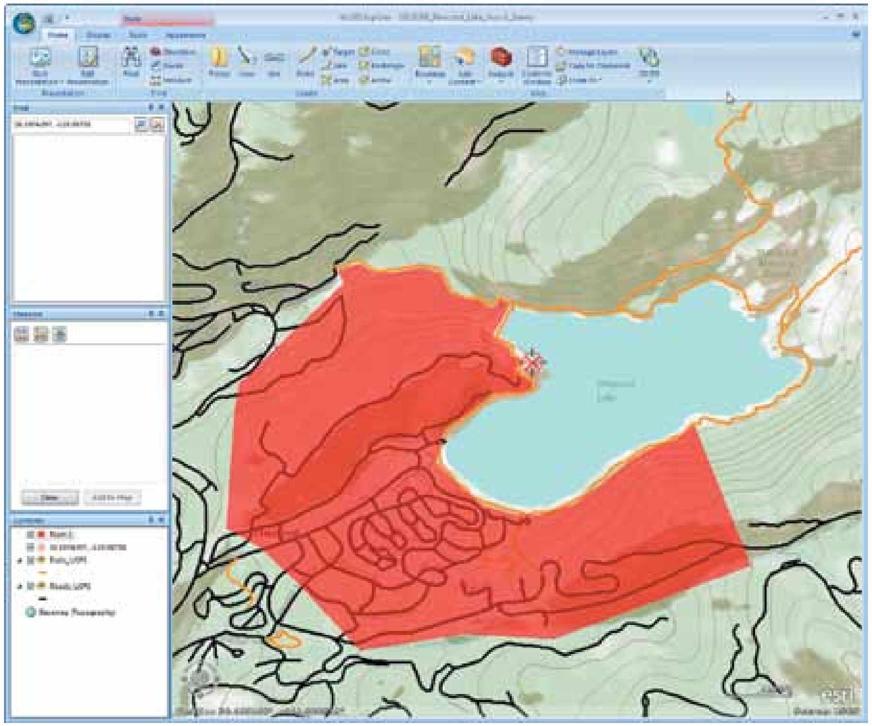


Figure 5-32

iii. When you finish drawing an area, a pop-up window appears where you can add information about this polygon. In the top box of the pop-up window, give it a title of **Team 1**. In the next text box below, type the text as shown in figure 5-33.

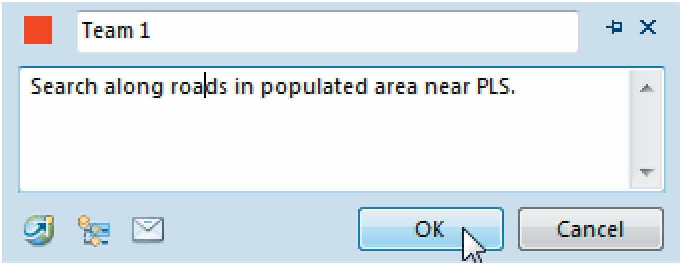


Figure 5-33

iv. Click the **OK** button. If you need to edit the pop-up window later, click the icon in the lower right-hand corner. You can move this note to center it on the polygon. You can also hide the note using the **Pin** icon (double-click the polygon to have it reappear).

v. Change the color to dark red. Go to the **Appearance** tab and click **Color**. Use the pencil **Line Color** tool to change the line to **No Color**.

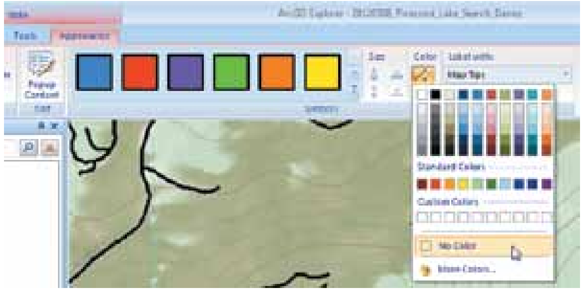


Figure 5-34

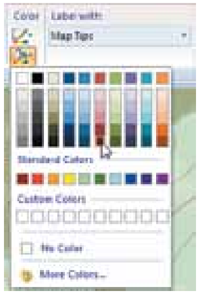


Figure 5-35

Use the paint bucket **Fill Color** to change the fill color to **Red, Darker 50%**.

Note: If you need to change a shape after you've drawn it but want to preserve the other properties (color, text, etc.), you can click that note in the **Contents** window or on the actual shape on the map, then go to **Tools** and **Replace** and redraw the shape.

vi. Draw the other team area to the north of the lake; add text; and change the color to something that makes sense for you, for example:

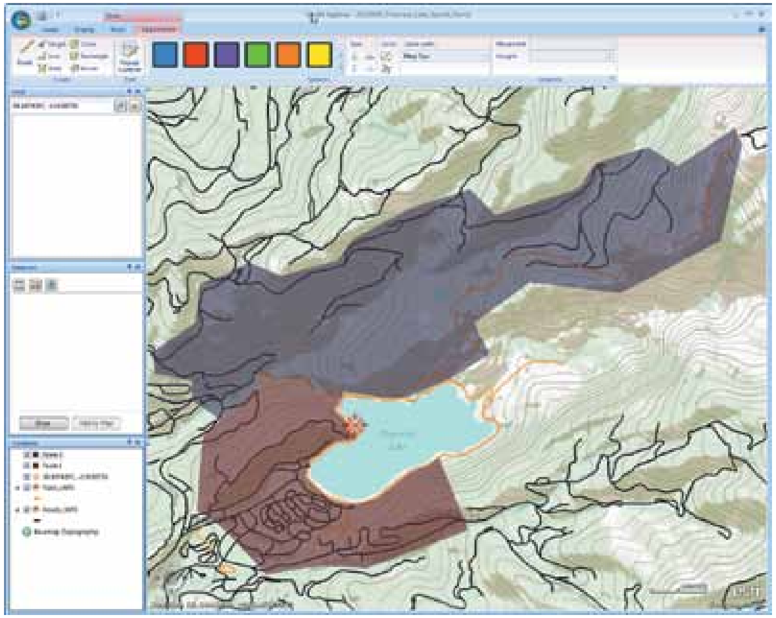


Figure 5-36

vii. You want the team that did a hasty search to look along the trail that circles the lake and the easternmost trail, so use a line to represent that area. Go to the **Tools** tab and click the **Line** tool. Trace the trail around the lake and type the team's assignment in the **Notes** pop-up window.

viii. Your map should look similar to this:

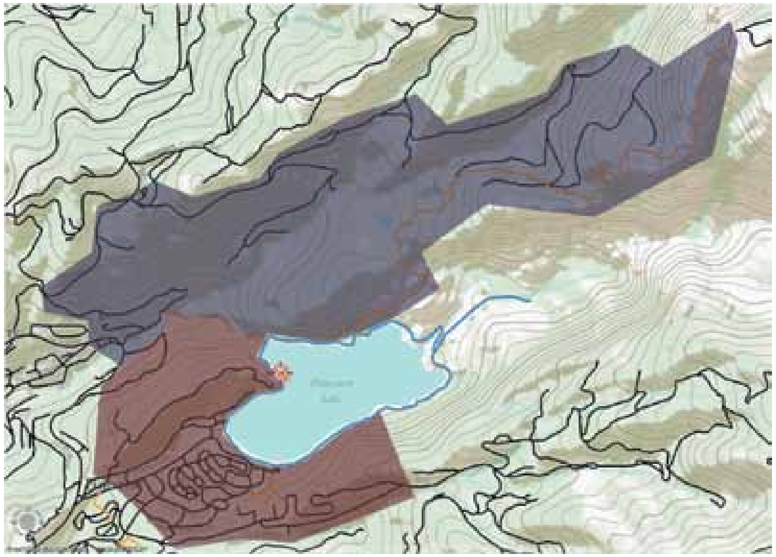


Figure 5-37

9. Legend: In the ArcGIS Explorer Desktop folder is a standard MapSAR legend for use with MapSAR symbols provided. You can use this for printing purposes or to create one yourself and save it as an image file. The legend shows all the symbols

provided and may be too large and include symbols you aren't using—ArcGIS Explorer Desktop does not offer any cropping or editing options once you've brought an image into the map. If this is the case, edit the legend in image editing software and save as a .bmp, .jpg, .png, .gif, or .tif file. You can also use this same technique to add your agency's logo to your maps.

a. To add the legend, click **Add Content** and select **Image Overlays**.

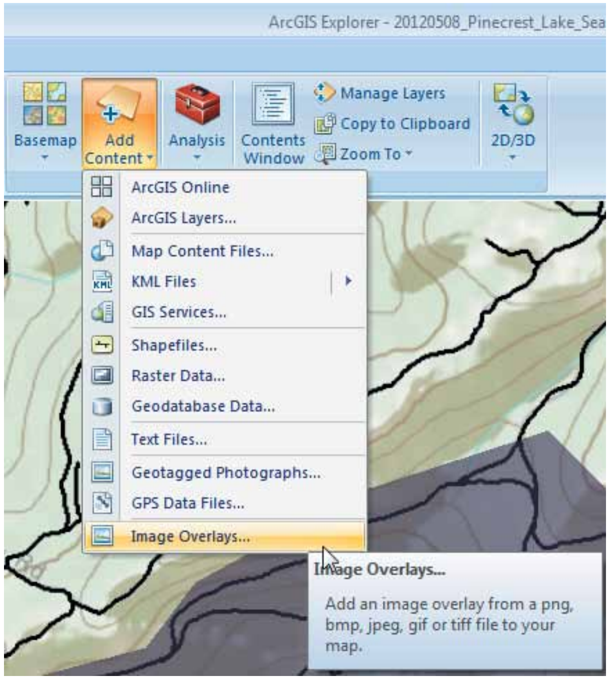


Figure 5-38

b. Navigate to the legend in the 5_AGX_Ex_Data folder, select **MapSAR_Legend.png**, and click the **Open** button.

c. The MapSAR_Legend is now in your **Contents** window and placed in the middle of the map. Right-click the **AGX_Legend** layer in the **Contents** window and select **Position**. Select the layout where the image is in the lower left corner.

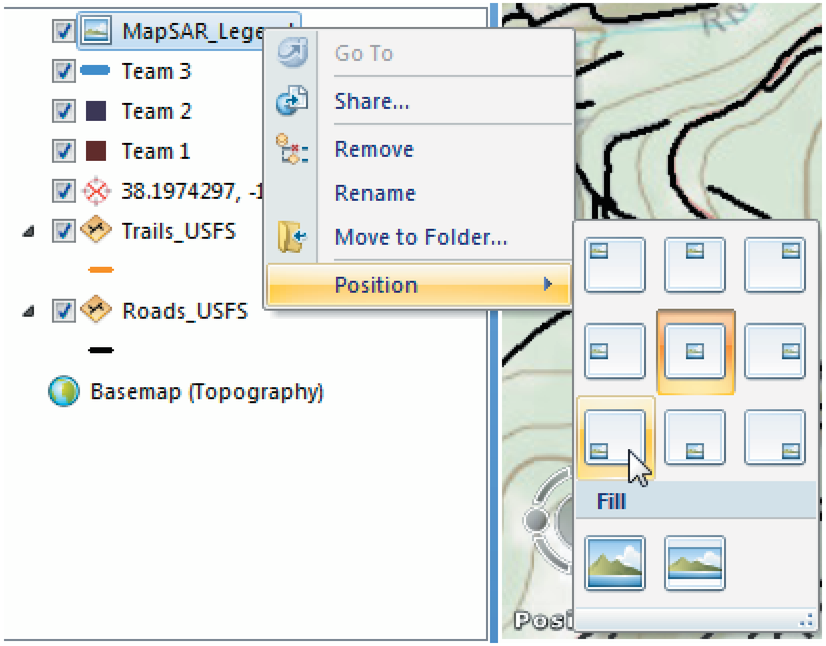


Figure 5-39

10. Adjust the map's layout and get it printed so the teams can get out in the field with a paper copy.

a. To make the text you added to the notes during the previous steps visible, right-click one of the team polygons and choose **Show Popup**. The pop-up box appears. Click the pin in the upper right corner so it is vertical (this makes the pop-up box stay visible). Repeat for the other two search assignments.

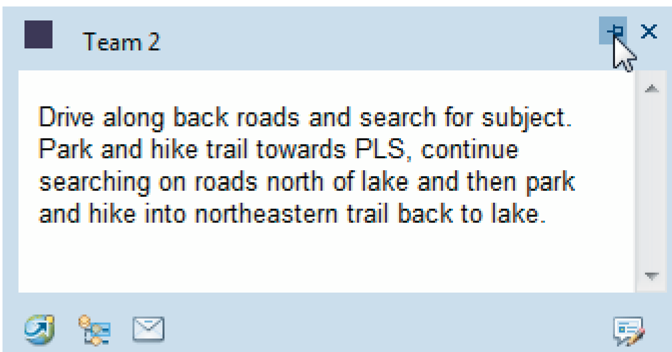


Figure 5-40

b. Zoom and pan to get a good layout and reposition the pop-up boxes so that the polygons and important features are visible. The pop-up boxes will readjust as you move the map, so it may take a few tries to get a good layout; something like this works:

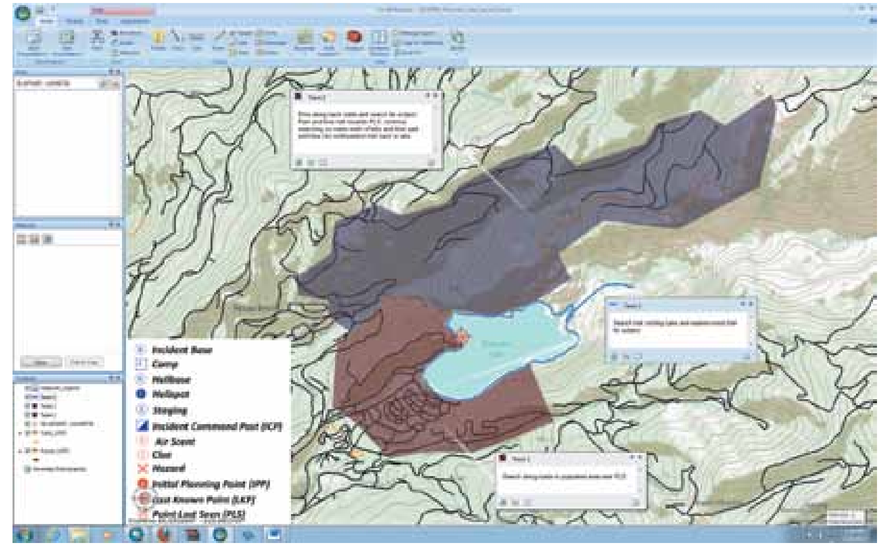


Figure 5-41

c. If you want to save this position of the map, you can go to the **Home** tab and click **View**. It will add a view layer to your **Contents** window that you can rename. You can double-click this later if you move the map around and want to return to this view.

d. Click the **ArcGIS Explorer Button** in the top-left corner and select **Print** (or use Ctrl+P).

e. Add a title to your map describing what it is and the date, such as "Pinecrest Lake Search for Danny: Hasty Teams 5/8/2012, 14:45."

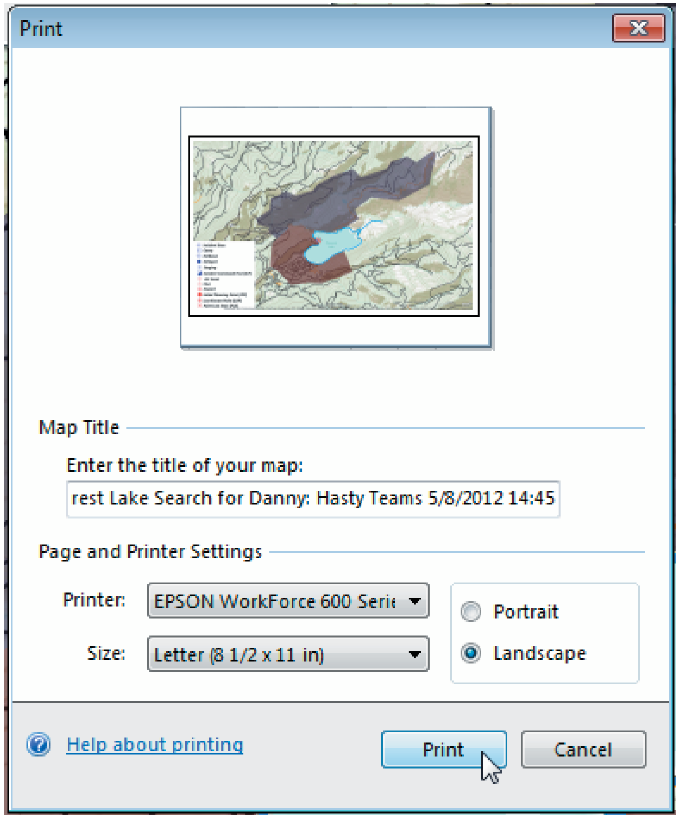


Figure 5-42

f. Change the layout to Landscape instead of Portrait and send it to your printer.

Note that ArcGIS Explorer Desktop has a known bug where sometimes the notes will not show when printed. If this isn't fixed by the time you read this, a workaround is to, from the **Home** tab, click the **Presentation** tools, and click **Start Presentation**. This will give you a full screen of your map, including the notes indicating your team assignments. Use your system **PrtScn** key (usually at the top of your keyboard) to capture the entire screen. Open a word processing program (e.g., Word), create a landscape page, then paste the map into the new document and resize by grabbing the corner and dragging to fit the page.

Now you can send the teams into the field with a printed map. You could print a map with a different layout, zoomed in on a specific search segment for each team so they can see more detail of their assigned area.

Scenario: Using ArcGIS Explorer Desktop Part II

It's 2000 hours, and the teams that did a hasty search just came back to the station without finding Danny. Team #3, assigned to the Pinecrest Lake trail, has returned with its Garmin 60CSX. The IC has asked you to display the tracks on the ArcGIS Explorer Desktop map to see what area was covered during the hasty search today in preparation for tomorrow's operational period. Always make sure you have the USB cord that connects your GPS unit to your computer.

If you have a GPS unit to download during a search, here are the basic steps. Using the Garmin 60CSX as an example, the general sequence is going to be similar to whatever GPS type you have. When set to Save to the SD card, the Garmin 60CSX saves tracks and waypoints in .gpx format. This file type can be imported directly into ArcGIS Explorer Desktop. For your own GPS, the goal is to convert whatever file type your device creates into .gpx. (See chapter 6 "Integrating GPS and Current Technologies into SAR Operations" for further instructions on downloading GPS units and your GPS device's user/technical manual.)

1. Turn the Garmin on using the power button on the top of the unit.
2. Once it's on, press the **Menu** button twice.
3. Go to **Tracks** and press the **Enter** button.
4. Use the arrows to navigate to **Setup**.
5. On the **Data Screen Setup**, use the arrows to highlight **Log Track to Data Card** and press **Enter**.
6. Press the **Menu** button twice to return to Tracks. Select **Enter**.
7. Select **Save Tracks**. Now your tracks are saved on the memory card, and you will be able to access them from the computer.
8. Plug the USB cord into the back left side of the GPS unit (under the rubber cover) and into your computer.
9. On the 60CSX, press the **Menu** button twice, scroll to **Setup**, and press **Enter**.
10. Go to **Interface** and press **Enter**.
11. Scroll down to the **USB Mass Storage** option and press Enter. Now your computer can see the GPS unit and has assigned it a drive letter, similar to your camera or a jump drive.

Now you will use a GPX file provided with the 5_AGX_Ex_Data folder to create the map with GPS tracks.

1. From ArcGIS Explorer Desktop, go to the **Home** tab, click **Add Content**, and select **GPS Data Files**.

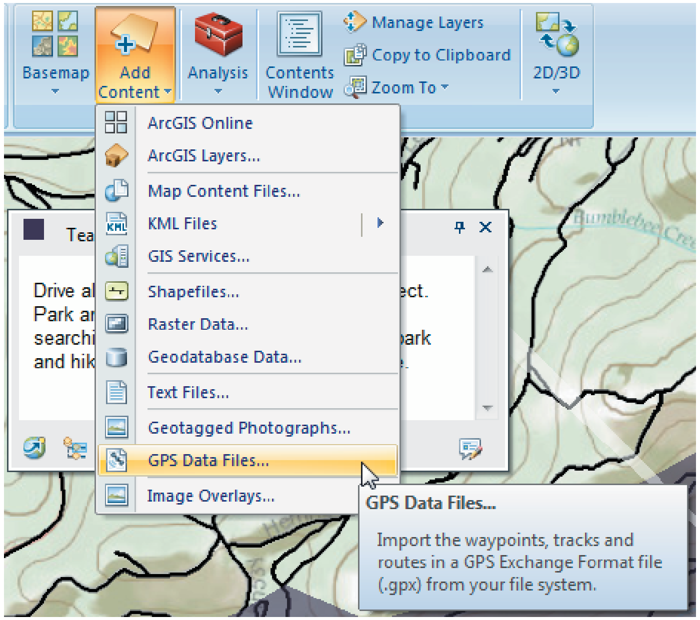


Figure 5-43

2. Navigate to the **C:\SAR_Book\5_AGX_Data \GPS_20120508** folder, select **20120508_hasty_grnd _Team3_Pinecrest_Lake_Trail_trk.gpx**, and click **Open**.

   Note: If you had a GPS unit hooked up to your computer with GPX files, you would navigate to the unit and look for the drive letter; it may be called Removable Disk.

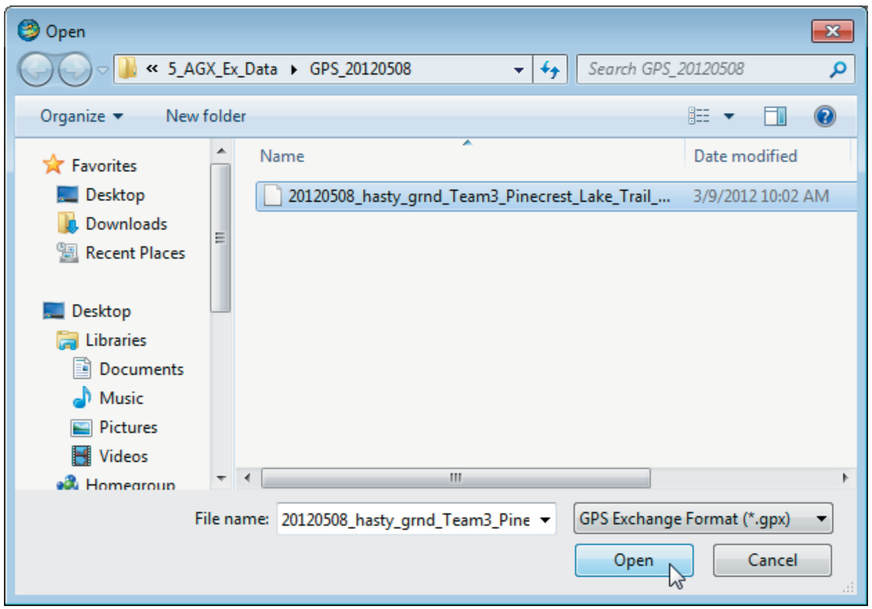


Figure 5-44

3. Check the boxes next to **Tracks** and **Attach to surface** and make sure all other boxes are unchecked. Click **Add**.

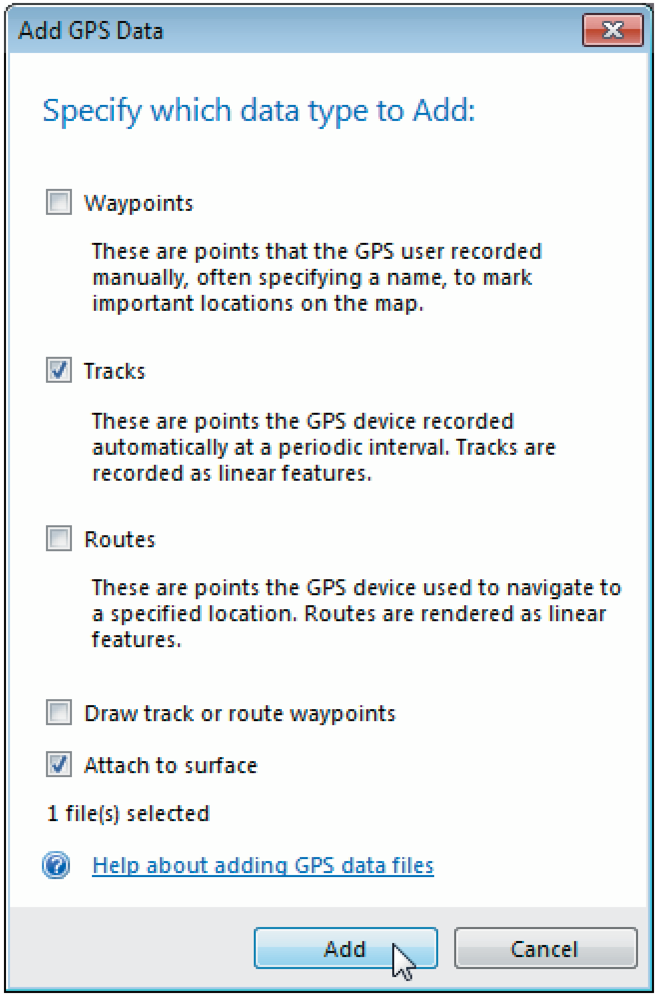


Figure 5-45

4. In your **Contents** window, you'll now have a folder with a subfolder for tracks. It appears the team missed part of the trail, so you would want to check to see if this is an issue of them turning the GPS off or that they actually did not search that part of the trail.
5. Change your symbol for the GPS track and print a map showing the IC the new search track that you added.

Remember: Practice, practice, practice. Use your area MED and different tabletop scenarios to quickly produce team maps. Then run a couple of field exercises until you're comfortable with your data and ArcGIS Explorer Desktop as your initial mapping tool.

Additional Tips

Save often—after every step! ArcGIS Explorer Desktop has no undo, so if you do something you don't like, you can close it without saving and then reopen to the last time you saved. And as with all technology, things can crash unexpectedly, so save your work.

Use the Help Resource; it has a lot of information on how to use ArcGIS Explorer Desktop, as do the blogs and forums online. About once or twice a month, a new post is added to the ArcGIS Explorer Desktop blog and walks you through how to do something specific and different in ArcGIS Explorer Desktop.

Also be aware that, although ArcGIS Explorer Desktop is an excellent program, it is limited in many ways in how it can be expected to handle the avalanche of information and data generated by a SAR. This is why we again strongly recommend that teams develop the capability to also use ArcGIS for Desktop and MapSAR (chapter 7 "ArcGIS 10 for Desktop—A Basic Introduction" and chapter 8 "Overview of MapSAR").

Chapter 6: Integrating GPS and Current Technologies into SAR Operations

Accurately plotting a SAR operation's geospatial information is vital to effectively integrating GIS into your operations. The difference between a team creating a hand-drawn map of its search assignment during debriefing and a track recorded by a team's GPS unit in the field can be significant. With an exact GPS track, the plans section has a much more accurate view of what was really searched. In addition, current technology now allows GPS coordinates to be sent via radio or satellite signal, allowing incident command to watch all the teams' progress in near real-time. This can significantly speed up the planning cycle. The plans section doesn't need to wait until teams return and are debriefed to know how much of their assignment they were able to complete, allowing the next day's resource requests to be made earlier. Keeping better track of teams also means a safer operation.

While GPS and other location-based technologies are vital to the effective use of GIS, the two are sometimes difficult to integrate. Many of the devices on the market today have proprietary software and file types; different cables to connect to a computer; and, of course, different buttons to push to make it all happen. As a result, importing location data into GIS software can sometimes be challenging.

This chapter is divided into two sections: Using Your GPS for SAR and Introduction to Advanced Location-Based Technologies. The GPS section provides an overview of the standard handheld GPS devices, their capabilities and limitations, what to consider when purchasing a device, protocols for field use, and how best to integrate GPS use into the SAR workflow. The section on location-based technologies will provide a brief introduction to existing devices that can be integrated into SAR operations to create a more efficient planning cycle while increasing team member safety.

Using Your GPS for SAR

GPS units are electronic devices that receive satellite signals to show your position in a variety of coordinate systems. The GPS receives the signal from several of its more than two dozen satellites in orbit, then calculates the relative time differences of those signals, triangulating your position and giving the coordinates for your location. If you are receiving signals from at least three satellites, you'll get a 2D position (latitude and longitude). If you're locked on to at least four satellites, you'll get a 3D position—altitude being the additional position. They work reliably in all weather conditions and require no subscription fee for the device to perform its basic function of giving you accurate location information. Accuracy can be affected by terrain, buildings, vegetation cover, or anything else that can get in the way of the signal and, of course, the number of satellites you are receiving a signal from.

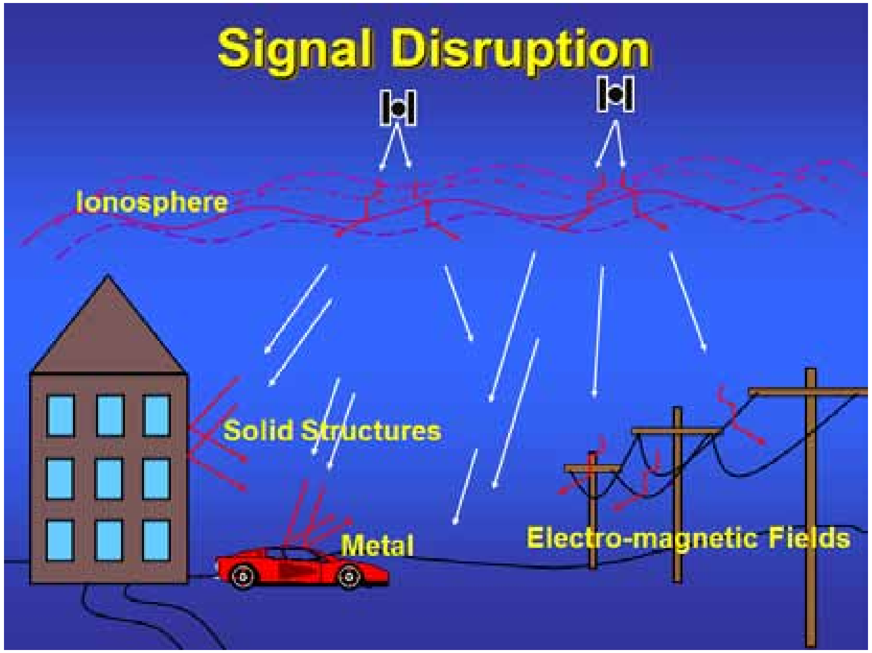


Figure 6-1: Potential Signal Disruptions for GPS

(© GPS for Fire Management and ICS, National Interagency Fire Center)

Modern GPS devices are capable of the following:

- Recording a continuous series of the GPS coordinates at preset time or distance intervals (Called track logs or bread crumbs, these points can be downloaded to a number of mapping software programs and the track displayed as either individual points or, when converted, as a line.)
- Marking individual locations, called waypoints, on the GPS
- Displaying coordinates in a number of different coordinate systems and datums
- Displaying a USGS topo map of the area on a screen with the user's location indicated by a symbol
- Displaying your recorded track log and waypoints on the map screen
- Entering coordinates and navigating to them using a "go to" or "find" function (The result will give you a distance, bearing, and even estimated time once you begin moving.)
- Downloading your track log and waypoints from the GPS to mapping software on a computer
- Uploading track logs or waypoints from a computer mapping program to the GPS unit
- Showing the correct time, as well as sunrise and sunset times, for your location

There are many GPS receivers available. The type you choose will depend on the features and level of accuracy you need and the price you can afford. For SAR and many operational needs, a low-cost handheld will probably be sufficient to obtain accuracy of between 15 to 75 feet. In choosing a GPS device, team considerations should include several elements:

- **File format.** GPX (GPS eXchange format) is a standard file format for recording and sharing GPS-obtained data. Many GPS devices use GPX as their default file format. With some devices, you need to convert the file from their format to GPX before it can be used by other devices or software. The fewer steps you have to take to move the data from the device to your GIS software, the better.
- **Battery life and battery type.** For field use where teams may be in remote terrain for extended periods, you want a standard-size battery that can be easily replaced (e.g., AA). Battery life is dependent on things like color display, backlighting, and how many functions you might have running at once. Most devices allow you to adjust settings to preserve battery life.
- **Availability of basemaps.** The basemap is the map loaded onto the GPS unit that will give you a terrain view of where you are. Depending on the unit's capabilities, it can be a very basic single color background showing only major roads and some place-names, a USGS topographic map or even satellite imagery. Many manufacturers charge extra for their detailed map sets and require a proprietary format type. This does not affect the accuracy of the coordinates the GPS unit displays—only the map background you view your position marker on.
- **Memory.** Memory size determines how many maps your device can hold as well as track log and waypoint storage. A GPS with a removable SD card allows you to increase storage capacity. You can also remove the card to download the data or read it directly as a USB drive while still in the device.
- **Cables.** There are as many GPS-device-to-PC cables as there are devices on the market. It can be incredibly frustrating to be at the debriefing table, downloading teams' GPS devices, and be handed a device for which you have no connection cable and which the team member forgot to bring. The easiest and most universal connection is a USB cable, and that should be a strong consideration when purchasing devices for your team.

Each GPS brand comes with software to allow you to download or upload waypoints, tracks, routes, and maps. It's essential that you read the detailed instructions for the specific software that comes with your device. That will tell you how to download your waypoints and tracks to your computer and how to convert that data to the GPX file format so it can be read by mapping programs.

We strongly recommend ArcGIS Explorer Desktop and ArcGIS 10 for Desktop for all SAR mapping. ArcGIS Explorer Desktop has an excellent GPX file import function, allowing you to project your tracks and waypoints onto a map (see chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks"). As noted earlier, many devices allow location data to be saved directly in GPX format. If the device also allows you to connect directly to the SD card storing the data, you can download your track logs and waypoints directly to ArcGIS Explorer Desktop with a cable connection between the GPS device and your computer.

MapSAR, which manages the geospatial information and maps for a SAR, has a utility for ArcGIS 10 that will automatically import all GPX files into your SAR's data structure and display it.

There are two useful and free utilities a SAR team should be familiar with that will help manage GPS files. One, DNR GPS (www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html) will connect directly with any Garmin GPS device; download the geospatial data; and allow the user to save in several file formats, including .gpx, .kml (keyhole markup language file type that can be used with various software including Google Earth), .shp (spatial data file that can be used in ArcGIS), and .csv (a text format that can be used in Excel or ArcGIS). Even if you don't have a Garmin GPS, this utility is useful to convert files to .shp or .gpx then import to MapSAR or ArcGIS for other uses.

The latest version of DNR GPS includes another utility, GPS Babel, which is able to translate and convert between dozens of different GPS file formats. It can do this either with a saved file or, in some cases, a cable connection to the device. For instance, it can take the Magellan GPS format and convert it to .gpx. You could then use DNR GPS to export the .gpx file into ArcGIS 10 or ArcGIS Explorer Desktop.

Another glitch can be the cable connection. Many—but not all—cable connections today are a standardized USB to the computer. The end that plugs into the GPS may be specific to that device or could be a mini-USB. You may find that some older GPS devices use a serial (COM or RS-232) cable connection. This is the type that connects to a computer's serial port—an older type of cable interface that's not even built into many computers now. Your team, or another called to your SAR, may have these older cable connections, and the computer you're using may not have an RS-232 port to connect to. There is a workaround, but you need to be prepared ahead of time by purchasing a special USB-to-RS-232 adapter cable with a driver to run it. (See appendix 2 "Resources and Support").

As your team builds a GIS capability, you'll need to assemble a basic set of cables to connect the most common GPS devices to a computer. First, of course, you need to look at all the GPS devices your team members use and assemble one of each type of cable into a kit you'll always carry to a SAR. Then consult area teams you often work with and find out if they use GPS you don't have cables for.

For your own team, standardization is the goal: one cable type for all devices. The USB cable is the best solution to this problem and should be considered when buying or upgrading your GPS devices. But each team member must always bring the cable connection for their particular device to a SAR just in case.

To add to the confusion, some software doesn't recognize the USB connection to a GPS device, but only a COM/serial port. The current version of DNR GPS will recognize and automatically connect to either. If an SD card is present in the GPS, you can usually set the device to read directly to the card as you would with any USB device. ArcGIS Explorer Desktop will connect directly to the SD card as if it were any other drive but will not connect to the device's internal memory if you wanted to directly download the active track log.

The Basic GPS Skill Set

There is a set of basic and relatively easy GPS skills that every SAR team member should be able to perform:

1. Know how to read and set different coordinate systems as required by SAR needs.
2. Set up the GPS unit to record a track log while on an active operation.
3. Create and save a waypoint on the GPS device to record specific locations, such as a clue or landing zone.
4. Be able to navigate to a saved waypoint.
5. Be able to navigate to coordinates provided by someone else.
6. Use the GPS unit to convert one coordinate type to another or one datum to another.
7. Download data from your GPS device using either the manufacturer's supplied software or DNR GPS.

With so many GPS devices available, it's not possible to give specific instructions that are useful for each individual type of GPS device. However, it is possible to give a general sequence to follow for each. Although we'll use the names and sequence used for many Garmin units, check your users manual for how to perform these functions on your own GPS device. When reading your users manual, you'll need to learn how to use the several buttons or toggles or touch screen on your GPS unit to perform tasks:

- Navigate from one screen to another (page in the instructions below).
- Navigate within a screen and press **Enter** to make choices (using the rocker key or cursor control).
- Carry out the menu choice using the **Enter** key.

Track Logs (aka bread crumbs)

1. Power on your GPS unit.

2. Page to the main menu and choose **Tracks**.

3. Within **Tracks**, page to **Setup**. Choose the parameters you want the tracks to be recorded in. The choices are usually setting the interval according to time or distance. For SAR operations, a good interval is to set **Time** to between 30 seconds and about three minutes. The longer the interval, the less accurately the results reflect the search track, but the shorter the interval, the bigger your dataset will become during the day; therefore, your GPS unit's storage capacity is another consideration. Setting the interval to Time also allows later analysis of how long a team was in a certain area. For instance, you'd probably want a very frequent interval on a search along a river. Terrain might force a team away from a clear view of the river. A frequent tracking interval will later show this on a map, perhaps leading to sending another team to recheck those missed areas. If a GPS unit is set to Distance or Auto, that information may not be as obvious. For teams searching on a vehicle—such as an ATV—you'd want an even higher tracking time interval set.

   Often there's an Auto recording rate available. In this case, the GPS device determines the most efficient rate to record track points based on speed, distance, and change in direction. This can mean fewer points recorded and thus save system memory but has some of the disadvantages described above. Experiment.

4. After setting your tracking interval, you should save your existing active track log. Choose **Save** and give the track log a name. Practice a number of times with the keypad that appears when giving a name to a file so it can be done quickly and accurately in the field when your hands are frozen and it's raining.

5. Choose **Clear** to dismiss the existing track log. When beginning on a SAR, it's very important that only the tracks relevant to the current incident are recorded on the GPS unit. This is especially important when the GPS units are downloaded upon return from an assignment. Software, including MapSAR, will often connect the individual track points with a line based on the time stamp of the individual points. When you have several days of tracking data spread over different assignment areas, the resultant map can become a spaghetti mess, with lines drawn connecting different days and areas, and it can take a while to manually edit the data after the fact.

6. Set tracking to **On**.

7. Page out of the Track Setup menu. While on, the GPS will now record your position at the interval you set. It will also show your track on the Map screen as you travel.

Waypoints

1. There are usually two choices to work on waypoints:

    a. A button on the GPS unit, when pressed, will bring up a menu showing the coordinates at your location, a default name for the point, and other user-defined information.

    b. You can page to a menu offering **Waypoint** as an option, which will bring up the same menu.

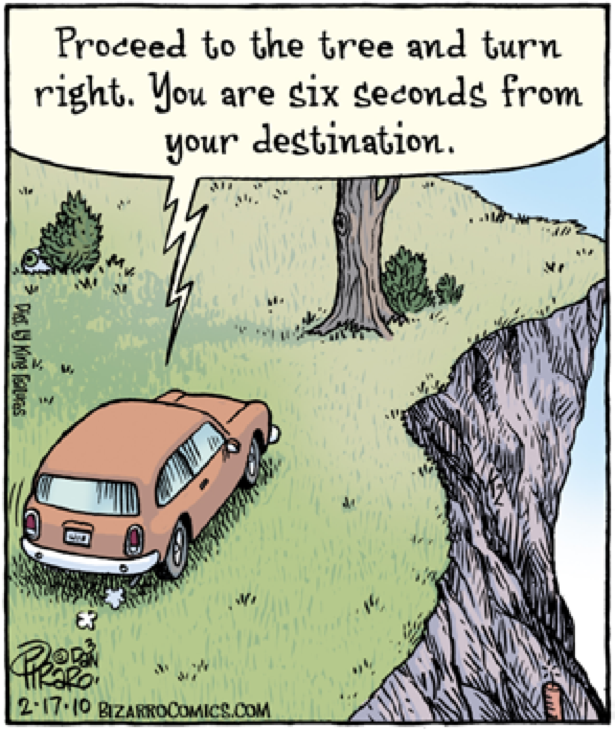


Figure 6-2

2. Highlight the name and press **Enter** to bring up a keypad to enter a new file name.

3. Change the name to something that will tell you and the GIS team that later downloads your data what that waypoint is. This is a critical best practice to prevent clues and search information from getting lost. For instance, enter **Clue1_Footprint**. In addition, you need to write down the waypoint name; coordinates; a more thorough description, and photo number, if any, on a waypoint form. You can download a waypoint reporting form for SAR use from the included CD or online at mapsar.net. This completed form is included with the GPS download at the team debriefing.

    If the waypoint marked is related to the search, then you should also radio it in to the incident command post. As described in chapter 4 "Understanding and Using Coordinate Systems," make sure you follow that protocol when reporting coordinates, clearly stating each number; identifying decimals as "decimal"; and identifying units as "degrees," "minutes," and "seconds" or "decimal degrees" or "decimal minutes." You must also state the datum and how the coordinates were arrived at (e.g., from a GPS).

4. After recording the information, save the waypoint then page to the menu screen you want—likely your map screen. A graphic symbol with the name you gave it will appear on the map screen.

Navigation

You are given coordinates, for example, another team's location needing assistance or a helicopter landing zone. There are often a number of ways to accomplish this, and again, it's important to read your unit's instruction manual. With many GPS devices, the best way is to create a waypoint and navigate to the coordinates you entered.

1. Change your GPS unit to the same coordinate type for the location of the coordinates you were given. Be absolutely sure you understand the coordinate system, format, and datum of those coordinates. If it wasn't made clear, ask. See chapter 4 "Understanding and Using Coordinate Systems" for more on this critical topic.

   In your user manual, find the menu sequence to navigate to the GPS unit's coordinate settings. On a Garmin, the sequence is as follows:

   a. Page to the main menu.

   b. Choose **Setup**.

   c. Choose **Units**.

   d. Change both the **Position Format** and **Map Datum** to match those of the coordinates you were given.

   Remember, this will only change how coordinates are displayed on your GPS, not how they are received from the satellite system, which is always WGS 84. The change is not permanent. Whatever you change your coordinate format to is what will show for your location and all your created waypoints.

2. Create a waypoint as described in the waypoint section:

   a. Enter a name that describes the waypoint (e.g., **LZ 1** for Landing Zone 1).

   b. Highlight the coordinates shown (which will be your current location) and press **Enter**.

   c. The graphic keypad will appear. It's easy to make mistakes here, but carefully use the cursor keys and number pad to enter the coordinate values you want to navigate to. Double-check the values you entered.

   d. When the coordinates are correctly entered, press **OK** to save and exit those values.

   e. Still in the Waypoint menu, and having entered a name for the waypoint and the new coordinates, choose **Save**. On many Garmin units, you can also choose **Map**, which will take you to the map screen with the waypoint, bearing, and distance to the waypoint from your current location, which you can use to navigate to that location.

f. Alternatively, once the waypoint is entered and saved, you can use **Find** to choose the saved waypoint, and then **Go To** will take you to the map screen with bearing and distance.

In addition, actually traveling to a point using a GPS unit to navigate is a skill that requires reading the manual on how to orient the GPS device and follow its pointer, bearing, distance, and compass readings. Practice.

Finally: The map is not the territory! The GPS unit will choose a straight line bearing and distance, which will stay accurate relative to your location as you travel. However, you have to consult your detailed map(s) and use your team's experience and terrain knowledge to get to that location safely and quickly.

Converting Coordinates Using a GPS Unit

When different agencies come together on a SAR or other emergency incident, they may well come with different protocols for using coordinate systems. Aviation, for instance, almost always uses degree decimal minutes. Land management agencies often use universal transverse Mercator as the standard for their existing geospatial data, such as landing zones and building and feature locations.

The IAP for the SAR should establish the standard coordinate system and datum that all teams will use in reporting and recording geospatial information. To avoid errors, though, teams need to be aware of the different coordinate systems that may be used, ask for clarity if that system is not identified, and be able to set their GPS to use the different systems if necessary (see also chapter 4 "Understanding and Using Coordinate Systems").

The Converting Coordinates exercise in chapter 4 "Understanding and Using Coordinate Systems" explored how to convert coordinate types using an online utility. Your GPS unit is capable of doing the same thing. The steps to do so are to change the GPS unit's coordinate system, as described above in Navigation, step 1. For instance, your team is given coordinates of a landing zone by the helicopter pilot. The pilot tells you to come to "decimal degree minutes of latitude 38°11'50.74"N and longitude of 119°59'15.12"W. The datum is NAD83." In the real world, of course, the pilot may just give the coordinates and not separate the number values with their identifiers (degree, minutes, seconds, decimal). It's your job to ask for clarification. (Yes, we're probably driving this point into the ground, but it's amazing how many serious errors are made by emergency responders when coordinate values are not clarified and understood.)

The IAP instructed all GPS units to be set to UTM. You need to enter a waypoint in the decimal degree minute coordinates the pilot gave you. To do so, consult your manual for the steps and menu names specific to your GPS. For many Garmin models, the steps are the following:

1. Page to the main menu.

2. Choose **Setup**.
3. Choose **Units**.
4. Highlight **Position Format** and scroll to **hddd° mm.mmm'**. Press **Enter** to accept.
5. Go to **Map Datum** and scroll to **NAD83** if it's not already chosen.
6. Press **Quit** or page out of the **Units** menu.

All the GPS unit's readings and saved waypoints will now display in degree decimal minutes. Next, follow the steps in Navigation, step 2, to create a waypoint and enter the coordinate values given to you by the pilot. Use **Find** or **Go To** to reach that waypoint.

Downloading Data from Your GPS Receiver

As with all the skills we've discussed, how you get your location data from the GPS device into software that can show it graphically on a map depends on a number of factors. The manual for your device should explain how to transfer the data using the manufacturer's accompanying software. Both ArcGIS Explorer Desktop and MapSAR will import GPX files onto maps. The goal, then, of downloading from your GPS and then projecting that data onto a map is to create a GPX file. Many GPS models save data to the GPX file format, either automatically or using specific settings. Often the GPS device can be set up to record to a removable SD card. The card can be read directly either by removing it from the GPS and inserting it into a USB card reader or by using a direct cable connection to the device and setting it to read the SD card rather than the GPS unit's internal system.

If you haven't already, review the steps outlined for downloading the track log and waypoints from a Garmin 60CSX in chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks" and the section Scenario: Using ArcGIS Explorer Desktop Part II.

What's important to recognize is that getting tracks or waypoints into a mapping program is usually two or, depending on your GPS type, even three distinct steps:

1. Download the tracks and waypoints from the GPS using the device's software.
2. Convert to GPX using either the manufacturer provided software or DNR GPS.
3. Import to ArcGIS Explorer Desktop or the MapSAR Incident_Data/GPS folder.

Figure 6-3: Always check the IAP for what coordinate system and datum you should set your GPS receiver to for a specific incident. Everyone should know how to use both a paper map and a GPS unit.

Exercise 6A: Using Your GPS

Many teams train and practice using a GPS device, as they do with all the other skills required of a SAR team. Our goal is to recommend a workflow and protocols that better integrate GPS use into SAR operations. While the entire team needs to master the essential GPS skills, a few should develop the expertise to teach those skills. Ideally, these would be the team members who will be responsible for GIS on operations, but that isn't absolutely necessary. The following exercises can be carried out by individuals or as part of a team exercise led by whoever develops an expertise in the use of GPS.

Track Logs and Waypoints

This one's easy. Go for a short walk and take your GPS unit with you. Before you start, you can quickly create hasty search assignments using ArcGIS Explorer Desktop, as described in the previous chapter. If you have an Internet connection, you can use the online maps from Esri or, if you've created your MED (see the Creating a Minimum Essential Dataset section in chapter 3 "Preplanning"), you can load the maps for your area. Then create a map of the segments, label as assignments, and print and hand them out to your teams for an exercise. Later, you can download the tracks, import them to ArcGIS Explorer Desktop, and see exactly how well an assignment area was searched.

This exercise can be done anywhere: city streets, a park, or during a full field exercise. Once again, read the manual for your own device, but the basic steps are as described in Track Logs (aka bread crumbs):

1. Save and clear your existing (Active) track log.

2. Make sure the tracking function is set to **On**.

3. Just start walking. Check occasionally to see if a line is showing your track as you travel. If not, check your manual. There may be another setting you need to activate to create a graphic track line.

An important skill to develop is to remember not to focus on the GPS device. You need to be familiar enough with your assignment and the terrain features that you should glance at it only occasionally to make sure you're in the right place. When you're focused on your GPS device, you're not looking for the lost person.

Practice with different settings to see what frequency of track recording works best. A 30-second to three-minute interval is good for a team on foot. See what works best for a vehicle. When projected onto a map—especially when the individual points are connected into a line—the importance of frequency will become apparent when the line cuts across curves you followed while walking. Of course, the scale of the map will affect this as well.

While traveling, use the Waypoint function to record five or so waypoints along the route. Again, your manual will tell you how to do this. The general sequence is below:

1. Press **Mark** or page to the **Waypoint** screen on your GPS.
2. Give it a name such as "Clue 1."
3. Also, record it on the waypoint form found in the accompanying CD or online at mapsar.net. This is an important part of the protocol because this is what each team will turn in when the assignment is finished.
4. If you have two-way radio capability, radio in the clue. This is good practice for correct coordinate reporting protocols. See chapter 4 "Understanding and Using Coordinate Systems."
5. When you finish your walk, either turn off the GPS or turn off the tracking function. You want to stop capturing data not relevant to your actual search assignment so it's not imported onto a search map.

We'll use these track logs and waypoints later for download and importing into ArcGIS Explorer Desktop.

Navigation

Use the waypoints collected in the previous steps and navigate back to them. Navigating using a GPS device can be tricky in that you have to be moving before the device can show you a direction relative to the waypoint you're going to. Many GPS units have an electronic compass and a way to sight a bearing, but these are often somewhat clunky to use. After entering a waypoint in the **Go To** field, the Map screen will display a bearing and distance as well as show your relative positions and, often, a line between the two. As you start moving, a time to destination will also show based on your travel speed. Note that as you move, the bearing will change but always give you a straight-line distance to the waypoint.

A good exercise to start with is to establish a waypoint on a large open field, mark it with a flag, and then go back a distance and watch your GPS as it adjusts to the location you set. With practice, you can learn to glance occasionally at the GPS unit's screen to determine the direction to your chosen waypoint. Although there's distance error inherent in GPS devices, most should be able to get you to within about 30 feet of the waypoint.

Converting Coordinate Types

In this section, you'll use the GPS device to convert coordinates from one type to another. This is also a good exercise to do as a group. One person reads the datum, the coordinate type, and the coordinates following the protocols presented in the section Communicating Geographic Coordinates in chapter 4 "Understanding and Using Coordinate Systems." The team uses its GPS unit to enter those coordinates and convert them. This is excellent practice in correctly reading and entering coordinates, determining if the location entered is correct, and then converting to another type to relay to a helicopter (using degree decimal minutes) or another team with only a paper map (giving it either UTM or degrees, minutes, seconds, which are shown by tick marks on USGS paper quads). When reading the coordinates, the team leader should occasionally withhold datum or coordinate type or identifying words like "decimal" or "degrees," etc., to make sure people get in the habit of asking for clarification when critical information is not given.

You can use this same exercise to enter these coordinates with ArcGIS Explorer Desktop using the **Find** function as described in chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks." The answers will include a description of the geographic location to double-check your results.

1. You've received a report of an emergency activation from a SPOT device. The coordinates are in decimal degrees (DD.dd) and WGS 84. Convert DD.dd of latitude N 38.19742, longitude W 119.98753 to degrees, minutes, seconds (DD MM SS.ss). Remember that DD.dd can also be written as 38.19742, -119.98753.
    a. Note also that WGS 84 and NAD83 are close enough to be interchangeable for our purposes (about a meter difference).
2. Enter degrees, minutes, seconds: NAD83, latitude N 38 11' 50.7", longitude W 119 59' 15.1". Convert to UTM.
3. Enter decimal degree minutes (DD MM.mm): NAD83, latitude 38°11.613146', longitude -119°59.601119'. Convert to UTM.
4. A hiking party comes to the ICP and reports they found the missing subject. One person from their party stayed with the subject. They don't have a GPS unit but marked the spot on a USGS paper map and wrote down the coordinates from tick

marks on the edge of the map. The coordinates are easting 372,700 and northing 4,070,900.

a. What other important information do you need?

   i. Look for the datum in the lower left corner of the map. This map would show a datum of NAD27, as do many USGS paper maps.

   ii. On a paper map, there may only be two coordinate choices from the tick marks at the map's edge: UTM or degrees, minutes, seconds. The coordinates written down are in UTM. Presumably, the ICP is in the same UTM zone as the missing person, but the map will also show the zone in the grid section at the lower left. In this case, it's zone 11. If a report comes from a team over the radio, remember to ask for the datum and zone (a zone designation is only needed for UTM) of the map.

b. You need to convert the NAD27 UTM coordinates to NAD83. For North America, this is a difference of only a couple hundred feet—not a lot, perhaps, but if it's the difference between one side of a ridge or a river and another, it's a critical one.

c. Set the GPS datum to NAD27 CONUS and enter the coordinates in UTM Zone 11S. You'll have to read the manual on how to change the grid zone (the *S*). On Garmin devices, for instance, you highlight the *S* with the keypad, and then use the up or down arrows to get the grid zone you want.

d. Convert from NAD27 to UTM NAD83 to relay to another team in the field.

e. Convert again to degrees decimal minutes in NAD83 to give the coordinates to a helicopter.

5. Your team has been called to a major search with multiple jurisdictions and agencies involved. The IAP has established USNG as the common coordinate system everyone will use. A landing zone has been established at USNG NAD83 11S KC 3,839, 31,939. Your field team has reported that its GPS unit is dead, but it does have a USGS Quad for the search area. You need to provide coordinates to your team for a paper map in NAD27. Convert to both UTM and DMS.

   a. Note: On many GPS devices, USNG is displayed as separate strings; that is, the easting and northing values are on different lines. As explained in chapter 4 "Understanding and Using Coordinate Systems," standard notation for USNG is as one string, with the x (easting) and y (northing) values written as two numeric strings with an equal number of digits: 11SKC3839031939. Note the addition of the "0" to balance the string from the GPS. This is also the way you'd enter it in the **Find** function in ArcGIS Explorer Desktop or any other software that accepts USNG.

Results

1. Decimal degree latitude N 38.19742, longitude W 119.98753 is latitude N 38 11 50.7, longitude W 119 59 15.1. If you've plotted this in ArcGIS Explorer Desktop or have the GPS map set for this area, it will show as on the west shore of Pinecrest Lake, California, just north of the water tanks (and the same as the PLS given in the Search for Danny Exercise 5B in chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness and Basic Incident Management Tasks."

2. Decimal degrees: NAD83, latitude N 38 11' 50.7", longitude W 119 59' 15.1" will show 11S 0238379, 4231939. The geographic point will be the same as in #1: Pinecrest Lake.

3. Decimal degree minutes of NAD83, latitude 38°11.613146', longitude -119°59.601119' will show as UTM Zone 11S 0237854, 4231527 and will also be at Pinecrest Lake, but at the end of the road just west of the boat ramp.

4. For coordinates NAD27 UTM 11S with an easting 372,700 and a northing 4,070,900 converted to NAD 83, the results will be as follows:

    a. The coordinates will be UTM 11S 03720, 4071098 and will plot to the north shore of Charlotte Lake in Kings Canyon National Park, California.

    b. In degree decimal minutes, the results in NAD83 will be N 36 46.627 and W 118 25.645.

5. For USNG NAD83 11S KC 3839, 31939, the results will be as follows:

    a. DMS in NAD27 is latitude N 38 11' 51.0", longitude W 119 59' 11.5".

    b. UTM in NAD27 is 11 S 0238460, 4231740.

    c. All these coordinates will again plot to the results of problem #1: the small bay on Pinecrest Lake.

Downloading Your GPS Device

Once again, you'll have to consult your user manual for the steps specific to your GPS model. You can use the software that may have been included with the GPS unit or, if you have a Garmin, you can use DNR GPS. The goal here is to get your track and waypoint data from the GPS, convert to GPX format, and then import that data into ArcGIS Explorer Desktop. Once you have a file in GPX format, you can skip to Importing and Projecting Your Downloaded Track Log into ArcGIS Explorer Desktop in the section below.

For this exercise, we'll show the steps to download using DNR GPS and save the file as GPX. If you're using your model's software, find out how to create a GPX file, then follow the steps from that point. DNR GPS has a good help file that installs with the utility. After starting DNR GPS, go to **Help > Local Help**

File > Menu Options > GPS Menu. You also need to make sure your PC-to-GPS cable is the correct one. If your GPS has a serial RS-232 cable connection at one end, you'll need to buy a USB-to-RS-232 adapter and load the driver that comes with it before starting this exercise.

Downloading Directly from a GPS Device's SD Card

If your GPS device has an SD card and you've saved your track logs to that card, you don't need to use DNR GPS. For Garmin GPS devices, or any others with an SD card that saves to GPX format, follow these steps:

1. Connect the appropriate cable between your computer and the GPS.
2. Navigate to **Setup > Interface > USB Mass Storage**.
3. The SD card of your GPS should now appear as an individual USB drive on your computer.
4. On your computer, navigate to **\Garmin*.gpx** and choose the **.gpx** file for the day's tracks and waypoints you want.

Once your file is in GPX format, skip to Importing and Projecting Your Downloaded Track Log into ArcGIS Explorer Desktop in the section below.

Downloading the Active Track Log from the GPS Unit

1. Start DNR GPS.
2. Connect the appropriate cable between your computer and the Garmin GPS device.
3. Turn on your GPS device.
    a. Older Garmin GPS devices require you to navigate to **Setup > Interface** and choose **Garmin** as the connection type. Newer ones are already configured to connect when it's on and the cable is connected to a computer.
4. Click **GPS > Find GPS** (figure 6-4: Connect Your GPS). The utility will search all ports—both serial and USB—for an active GPS connection.

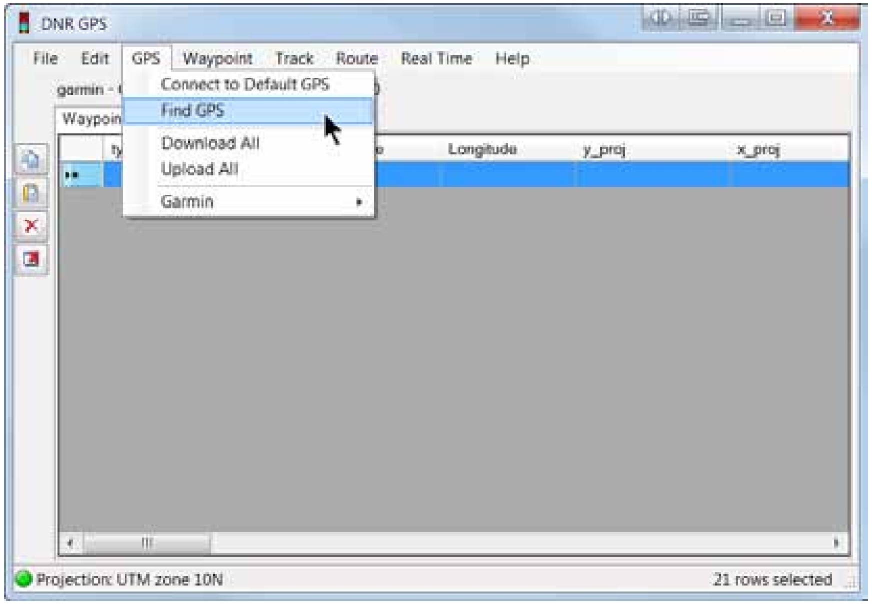


Figure 6-4: Connect Your GPS

5. When successfully connected to the computer and found by DNR GPS, the model type will show up below the top menu bar.

6. To download both the waypoints and track log, choose **GPS > Download All**. Depending on how many tracking points you have, it might take a minute or two to download everything.

7. DNR GPS will sort waypoints and tracks into the appropriate table. The number of points downloaded for each will show in the tabs.

   a. When you clear and save your previous track logs, they are saved by date on the internal memory of the GPS. DNR GPS will download all these saved track logs and the active track log. Look at the **ident** field in the **Tracks** table and note that they're ordered by date until you get into the active (current) track log points—the one that hasn't been saved.

8. Since you only want to save and project the track log you recorded in the Track Logs and Waypoints exercise, you'll either save only the active track log you downloaded or delete the previous one. You can choose to delete whichever one is easier for you.

   a. Use **Shift/Select** to highlight all the track points you either want to save or delete (figure 6-5: Highlight Tracks to Save or Delete). For instance, to delete all the records where the **ident** field is a date and not active, click once on the far left bar to highlight the first record you want to delete. Scroll down to the first record where the **ident** field is active, hold down the **Shift** key, and click and highlight the record just above that. All the previous records will be highlighted. Press **Delete**. Now you have only the active track log from your exercise.

That may seem a bit of a pain, but it's important to do it here rather than have to edit the file once you import it into either ArcGIS Explorer Desktop or MapSAR.

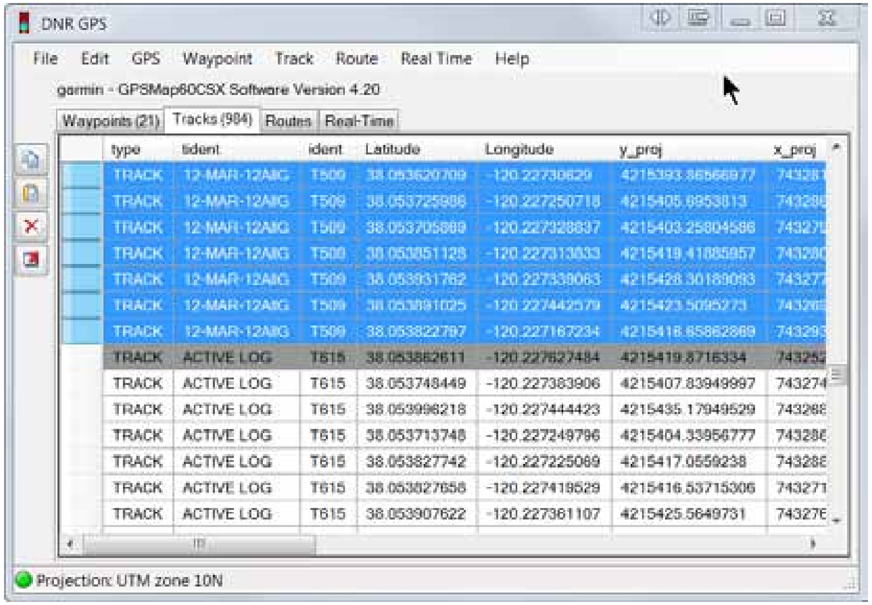


Figure 6-5: Highlight Tracks to Save or Delete

b. Alternatively, you can use the same Shift/Select technique to highlight only the active track points. When you save them in the next step, only those records highlighted will be exported to a file.

Now you'll save both the tracks and waypoints to a GPX file:

9. Having deleted all but the active track log records *or* with only those records highlighted, go to **File > Save To > File** (figure 6-6: Save Tracks and Waypoints).

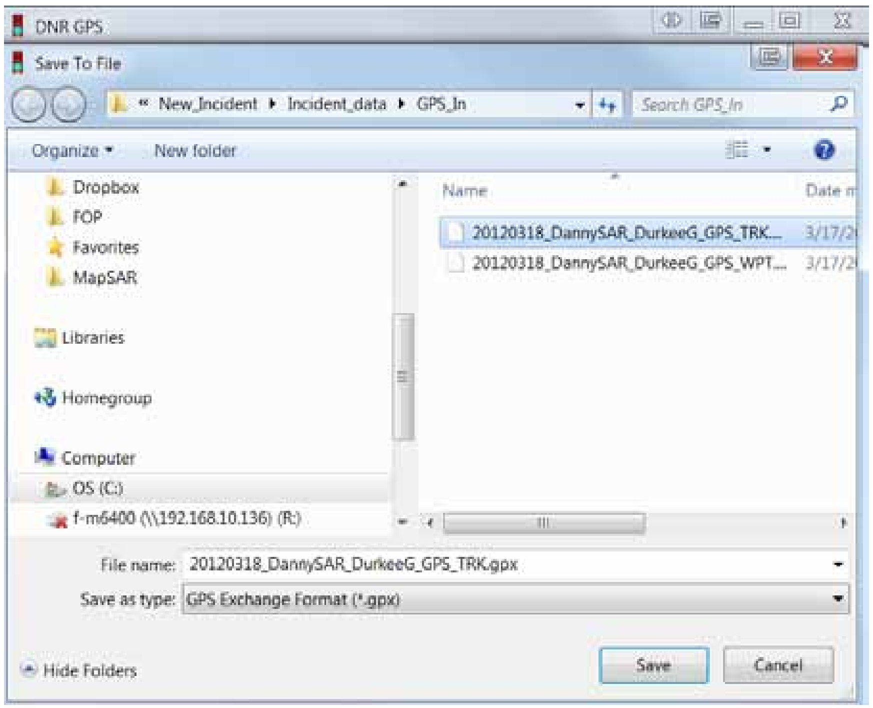


Figure 6-6: Save Tracks and Waypoints

a. Navigate to the folder you want to save the data in. As described in the Directory Structure; File and Naming Conventions section in chapter 3, the best practice is to save incident GPS files to the operation's C:\MapSAR\UTM_xx_New_Incident\Incident_data\GPS folder. Later, when you start using MapSAR, this is where the GPX Import tool expects to find the SAR's GPS data.

b. In the **Save As Type** box at the bottom, choose **GPX**.

c. Enter a name for the file. Use the naming convention for GPS files as described in the File Naming Conventions section: yyyymmdd_time-collected_IncidentName_GPSfeatureType_source_csdatum. (See the File Naming Conventions section in chapter 3 "Preplanning" for a full explanation.)

d. On the next dialog box, click **Tracks** and then **OK**.

10. For waypoints, it's the same process. In the Waypoints table, highlight the waypoints from the date you need, and then follow the instructions in step 9 to import into the GPS folder.

Importing and Projecting Your Downloaded Track Log into ArcGIS Explorer Desktop

To import your GPX file into ArcGIS Explorer Desktop, then project it onto a map, go to the section Scenario: Using ArcGIS Explorer Desktop Part II in Exercise 5B. At step 13, navigate instead to the folder you put the GPX files into (in your exercise, C:\MapSAR\UTM_xx_New_Incident\Incident_data\GPS). Follow steps 14 to 16.

After you've projected your track log, you should practice turning on and off the flag symbols that are the default for each point. Do this from the Contents window. You can also change the symbol type and line color and even delete track points that are incorrect.

Introduction to Advanced Location-Based Technologies

Recent and ongoing advances in technology have the potential to make many aspects of SAR operations more effective and efficient and meet the essential need for safety in the field. Both day-to-day and emergency operations have a critical need for dependable communication, keeping track of field personnel and recording and archiving that information for later evaluation. Use of GIS software and a number of technological devices now being introduced can be combined to provide solutions to these operational needs.

This is a rapidly emerging field, and many devices and software applications are appearing on the market. A number of devices have been tested and used on SAR operations, but the field is so new that, though many SAR members see the potential, adoption is still experimental in many cases. In addition, it's difficult to develop the technological expertise as one more adjunct to a team's skill set. It's important, though, that SAR teams are generally familiar with what's out there and can start evaluating and considering them for their own needs. This section will only briefly familiarize you with several technologies and devices currently available that can enhance situational awareness and safety during operations.

There are several general categories of devices. The Resources section lists sample devices for each category, but they are *not* recommendations—only a source for teams to begin researching location-based technologies as a way to meet team needs.

1. **GPS-capable smartphones.** These are, of course, increasingly ubiquitous and are being used by SAR teams to track their movements and communicate in the field. They have also been successfully used to obtain exact location information from lost or injured people who are able to communicate with the SAR team using the phone. The phones are limited, of course, by cell phone coverage of the area they're in.

   Resources—Because of the rapid increase in calls for help coming in via cell phones, SAR teams and emergency dispatchers need to familiarize themselves with their capabilities. A person calling for help can be talked through finding their coordinates on their phone or even directed how to download an app that will give their location to responders. Go4AWalk.com reports a web application, SARLOC, developed by Russ Hore of Ogwen Valley Mountain Rescue Team, Wales, UK:

> *If the walker in trouble is using a smartphone, then he/she is sent a text message with a link to a webpage. Clicking on this link opens a page in the phone's browser, which queries the phone to identify its location as a Lat/Long coordinate. This location data is then displayed to the user and automatically added over the Internet to the Mountain Rescue Team's database.*
>
> *The MRT call handler can then see the phone's (and hence the caller's) location displayed on a digital OS map display.*
>
> *As of April 2011 SARLOC had been tested on a variety of iPhones (3GS, 3G, 4.0), the Blackberry Storm, the HTC Desire HD (Android 2.1), and the Samsung Galaxy S.*
>
> *The accuracy has been reported to be on average +/- 100 metres.* [2]

[2] "Mountain Rescue Teams using smartphone app to help locate hill walkers in trouble" January 2012 http://www.go4awalk.com/the-bunkhouse/walking-news-and-discussions/walking-news-and-discussions.php?news=710222.

In addition, of course, cell phone companies can, under certain circumstances, provide location information of a distress call based on which towers the cell pings off of. Such strategies should be considered early in a SAR where cell coverage exists. A processing tool for mapping possible cell phone signals is part of the MapSAR package, with instructions for use in *The MapSAR User's Manual*.

2. **Satellite Emergency Notification Devices (SENDs).** As the name implies, these devices communicate through satellites and provide the capability to signal an emergency, sending the device's GPS-derived location as part of the emergency signal activation. Depending on the type, some can provide one-way (outbound) or two-way text capability. They also have limited to full-function GPS capability to establish coordinates and send them to a third party through a web portal or directly as a text to a cell phone or an Internet address.

   Resources—The GeoPro Messenger and the SHOUT nano device have real-time tracking and two-way text capability (both free-form and preprogrammed messages) to any addressable short message service (SMS) device or Internet address; emergency locator button activation; waypoints; and the ability to be queried by an administrator for location. Tracking and emergency monitoring are done from the company's web portal for all devices within a shared group.

SPOT and DeLorme GPS provide devices capable of one-way (outbound) preprogrammed and free-form text (depending on the device) and emergency signal activation.

This class of device can be used to track team progress from anywhere an Internet connection is available as well as reduce radio traffic using text capability. Tracking data can be imported into search maps prior to a team's return and debriefing. Data subscriptions are required for these devices.

3. **Radio frequency-based location devices.** A number of devices transmit their location over radio frequencies either as stand-alones or as microphones (mics) attached to radios. The mics allow regular two-way radio function on an operation but in addition transmit GPS coordinates, text messages, or relative locations of other mics in the group.

   Resources—The Infinity Mic is one among several radio-based GPS devices that give location information. It has a screen, allowing the user to see the relative location of others in a shared group, and two-way text capability and acts as a standard voice mic to your radio. Separately developed software allows the location data to be captured and ported to ArcGIS Explorer Desktop for real-time tracking. No data subscriptions are required.

4. **Portable broadband satellite terminals.** These are devices that make it possible to use satellites for Internet and phone communication from the field.

   Resources—Broadband Global Area Network (BGAN) is a global satellite Internet network portable terminal. It provides both phone and Internet connectivity from any location where a 30-degree view of the horizon is available.

   A computer or smartphone can be directly connected for voice- or computer-based transmitting and receiving frequencies (Tx/Rx) of documents, photos, reports, video, or any other data exchange to or from field operations. The basic unit weighs about 6 lbs. and is battery operated, making it possible to carry to most any field ICP or spike camp. The telephone function also allows incident traffic to be secure from monitoring as well as reducing radio traffic. A data subscription is required for this device.

   SAR teams and other emergency agencies are only recently exploring the opportunities for safer and more effective operations as a result of these devices.

Review of Chapter Concepts

To fully integrate GIS into SAR operations, teams must be skilled in the use of GPS devices and familiar with the potential applications of emerging technologies. Teams need to carefully choose GPS and other tech devices based on compatibility, ease of use, and what they can afford. But team managers need to remember that it's probably better to build a GPS cache slowly, getting what they want rather than saving money and purchasing devices that are difficult to use and not easily integrated into a SAR workflow.

As with all SAR skills, proficiency requires understanding and frequent training exercises. Training needs to be often enough so a skill—for instance, a sequence of menu choices to establish and name a waypoint—can be done in driving sleet with frozen hands.

Chapter 7: ArcGIS 10 for Desktop—A Basic Introduction

In the Introduction and Why Use GIS sections, we talked a bit about why you should use GIS to assist you and your SAR team, and in this chapter we'll review some basic concepts and tasks in relation to Esri's ArcGIS software and help answer basic questions on how to use ArcGIS. We're often asked how long it takes to learn ArcGIS. The answer depends on what you're doing with it and how in depth you'd like to get, but it can range from days to years. The purpose of this section is to introduce you to the basics of using ArcGIS 10 for Desktop and so be able to use MapSAR. An excellent supplement is to read *The GIS 20: Essential Skills*, by Gina Clemmer and published by Esri Press.

As you read through the section, it helps to open an ArcGIS project file (.mxd) and try out the tools being introduced. Much of the skill in using MapSAR and ArcGIS is just being able to find and apply the right tool when running the GIS function of a SAR.

ArcGIS for Desktop Licenses

ArcGIS for Desktop is not free, but many local, county, and state organizations have an enterprise license agreement (ELA) that allows the organization to use a certain number of copies of the software. Because many SAR teams are associated with the county sheriff, it's possible you can borrow a license from one of the county agencies that uses ArcGIS, such as the local planning or GIS department. This is an arrangement that many SAR teams have worked out. Your IT department or GIS department should be able to advise you if they are part of an ELA that will allow you to borrow a license. Esri also offers an ArcGIS for Home Use license for about $100 a year and offers grants for software for many nonprofit organizations. Determine which category you and your team may fall into and explore your options. Esri also offers a free 60-day trial version of the software on its website at esri.com/eval.

There are different license levels that allow you to have more or less functionality (and are progressively more expensive):

- **ArcGIS for Desktop Basic** (formerly ArcView) allows you to view spatial data, create layered maps, and perform basic spatial analysis.
- **ArcGIS for Desktop Standard** (formerly ArcEditor), in addition to the functionality of the Basic license, includes more advanced tools for manipulation of shapefiles and geodatabases.

- **ArcGIS for Desktop Advanced** (formerly ArcInfo) includes capabilities for data manipulation, editing, and analysis.[3]

[3] Esri website esri.com/software/arcgis/arcgis-for-desktop/pricing.html.

MapSAR runs correctly at all three license levels. For various specialized analyses, there are also extensions for three-dimensional work, statistics, networking, advanced spatial studies, and many others. These extensions carry an additional cost, but you do not need any of these for the type of SAR work we are suggesting you do with ArcGIS at this level.

Keep in mind too that you need to have decent hardware capabilities for your machine to run ArcGIS efficiently. With each release, the suggested system requirements change, but they can be found on Esri's website, currently at esri.com/AG10systemrequirements.

Currently, for ArcGIS 10 for Desktop, Esri suggests a CPU speed of 2.2 GHz or higher (hyperthreading or multicore recommended); Intel Pentium 4, Intel Core Duo, or Xeon processors; at least 2 GB of RAM; at least 2.4 GB of disk space (plus 50 MB of space in the Windows System directory); and additional video/graphics, networking, screen, and display properties. You can run ArcGIS on Windows XP, Vista, or 7. Esri also supports ArcGIS on Linux operating systems (OS), but to run the software on a Mac, you will need to use software that emulates a Windows operating system, and ArcGIS is not supported on the Mac OS.

ArcGIS for Desktop Components

ArcGIS for Desktop consists of multiple components that serve different functions and have slightly different interfaces. ArcMap is thought of as the main piece of the software; is the primary display interface; and is where you can create, edit, display, analyze, and print your maps. It lets you link datasets to a map file (.mxd) and overlays them to visualize a map. The .mxd file is your primary work or project file. This is what you will click to open a map project that stores links to all the data that will appear in the map document.

ArcCatalog is used to browse and manage your data and create text information about the spatial data, called metadata, that stays with the dataset. Metadata may consist of information such as who created the data, what about the data has been changed, what the accuracy is, when the data was created, what processes were used to create the data, coordinate system and projection, and datum of the data. ArcCatalog is what you would use when assembling your MED to find out information about the spatial data from different sources. ArcCatalog is also what you should use for moving, copying, or deleting spatial datasets—not Windows Explorer.

ArcToolbox is a collection of tools that asks the user for certain parameters to complete a function. If you want to convert one file type (such as a shapefile) to another type (.kmz), you would find the tool that does that and use the wizard to answer questions about how to go about this conversion. There is a wide variety of tools, and you do not need to know what they are—merely that they are there if you need them.

In version 10, ArcMap, ArcCatalog, and ArcToolbox can be accessed in one interface.

Throughout this book, we've mentioned using ArcGIS software's help to look things up or find out further information about a topic. To access the help, just open ArcGIS, use the Help menu, and scroll down as shown in figure 7-1; or press F1 at any time.

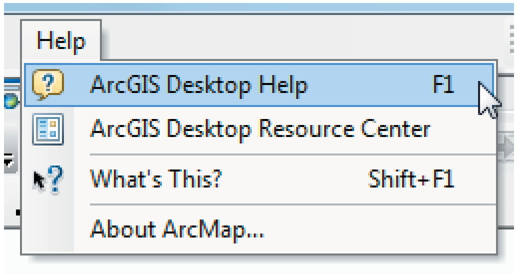


Figure 7-1

Remember that the power of GIS data is the spatial information combined with the tabular attribute information that can be used for visualization and analyses.

There are many different data file types that ArcGIS accepts. The main file types that you will probably use to store your data are geodatabases (both), shapefiles (vector), and Esri grid (raster).

A geodatabase is basically a container for all your information (similar to a folder for files). Within a geodatabase, you can further organize your data by using feature datasets to store feature classes of the same coordinate system. Feature classes are where the attributes are kept for a group of objects/features that have the same geography—all points, lines, or polygons. Feature classes can be at the root of a geodatabase or inside a feature dataset. There are different types of geodatabases that can be used in ArcGIS including file geodatabases (.gdb), personal geodatabases (.mdb), and ArcSDE geodatabases (.sde). If you are creating a geodatabase to store your MED data, the file geodatabase is your best option. Shapefiles are a simple format to store spatial data whose features can be points, lines, or polygons.

You may also come across some older file data types such as coverages and e00 (ArcInfo interchange). If this is the only format that you can obtain essential data in, there are ways to work with these files, with many suggestions on Esri's resource and forum websites.

ArcGIS can also work with Microsoft Excel files (.xls), database files (.dbf), Comma Separated Values (.csv), and other files that are tabular in nature, in addition to .kmz files.

Authorization and Installation

Authorization and installation will vary slightly depending on what type of license you will be using and the setup of your computer. To activate Esri software, you will need either a registration number or authorization file, and it is recommended that you have Internet access for this process. Besides the three different license levels listed above, there are also concurrent or single use type installations. For concurrent installations, you will also have to install License Manager in addition to ArcGIS for Desktop. Esri provides an overview in the Quick Start Guide that is included on DVD installation disks and is available online, along with the full Installation Guide (help.arcgis.com/en/arcgisdesktop/10.0/install_guides/arcgis_desktop_install_guide/index.html). After successful installation, you should always check on Esri's website to see if there are any service packs available for the software and install them.

ArcMap Interface

When you open ArcMap, there are a lot of different menus and tools. Figure 7-2 shows a common opening screen, though yours may look slightly different depending on your setup.

Here's a general overview of the interface:

- The window bar across the top tells you the name of the file you're working in (in this example, GRCA), the software you are using (ArcMap), and the license level (ArcInfo).
- Across the top of the screen are various menus such as File, Edit, View, Bookmarks, Insert, Selection, Geoprocessing, Customize, Windows, and Help.
- The toolbars can be made visible or not and moved around as you see fit.
- The left panel is your table of contents (TOC), where the data linked to the map is listed (in this example, Rimline and Boundary_GRCA).
- The large pane on the right is where your map is shown. This is your main workspace, where you can draw new data or insert legends, scale bars, etc.

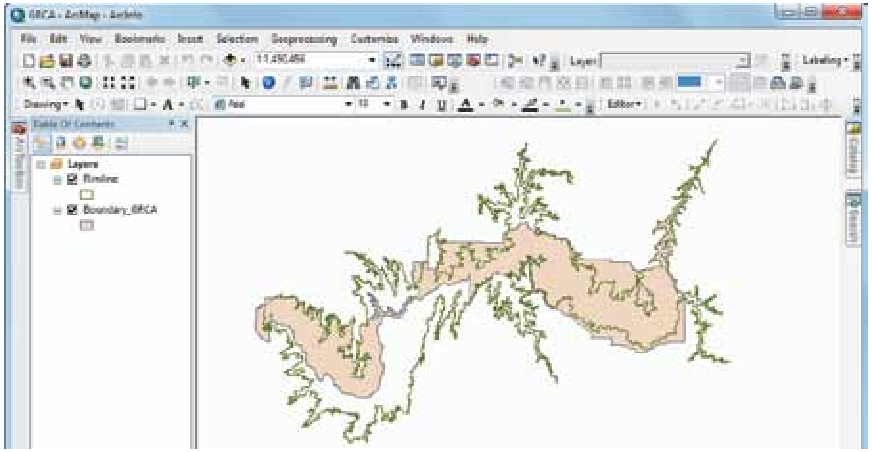


Figure 7-2

Menus—The drop-down menus have a wealth of functionality, but it is not essential to know where everything is located. If you have a copy of ArcMap, open it now to explore what the menus have to offer. Figure 7-3 shows the options for the File menu.

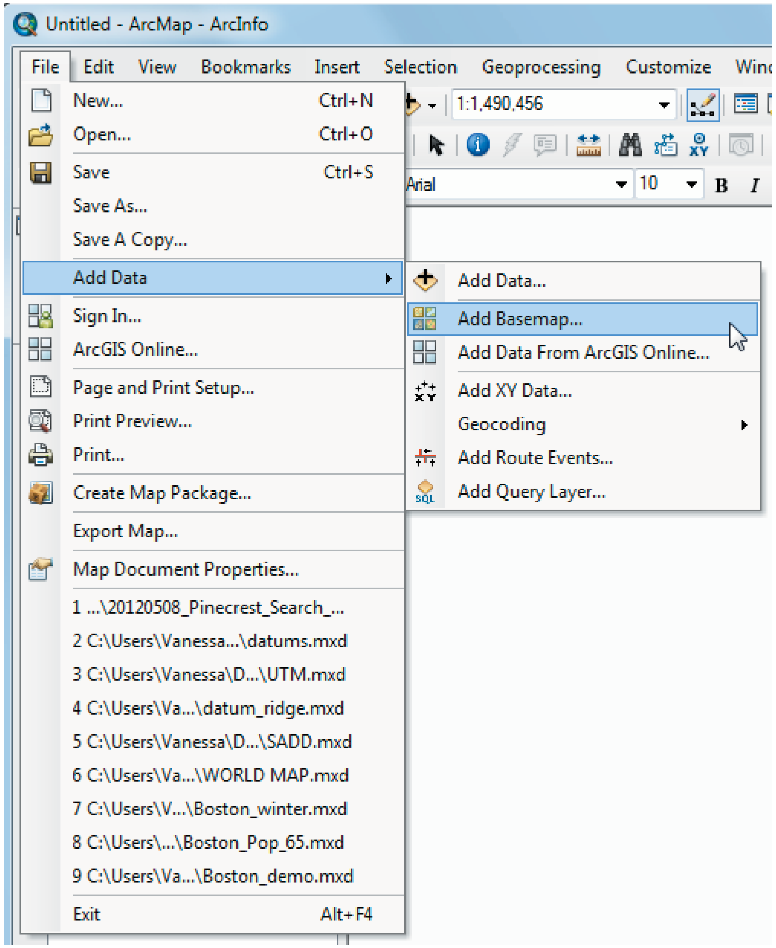


Figure 7-3

Some of the options under the File menu are of significance if you have a high-speed Internet connection. You can use free online data to add information to your maps by going to **File > Add Data**. If you are looking for a basemap, choose **Add Basemap** as shown in figure 7-4.

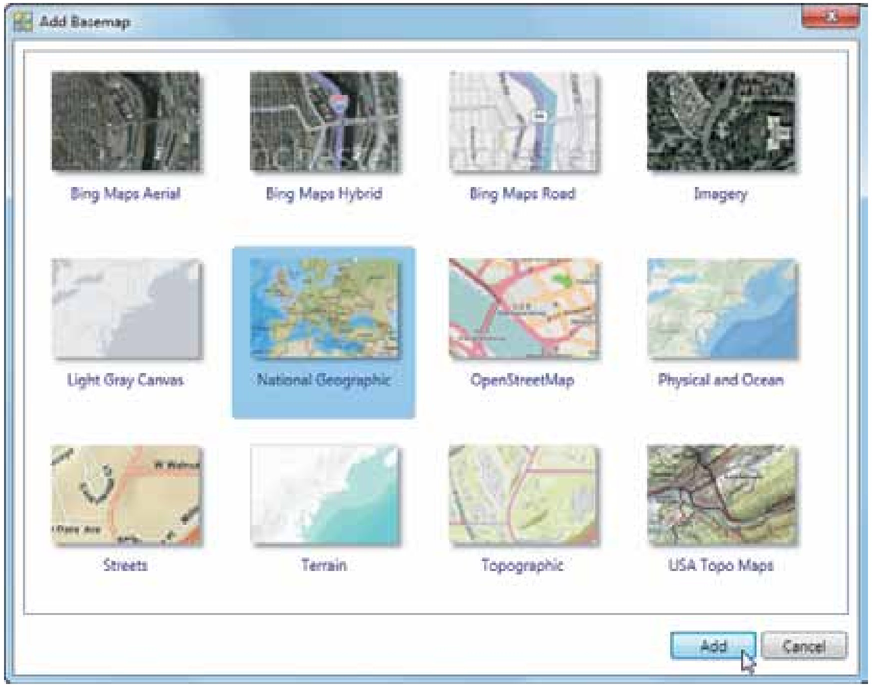


Figure 7-4

If you want to add all types of data (not just basemaps), you can click **File > Add Data > Add Data From ArcGIS Online**, and then search by a particular topic to find the specific data you need. In figure 7-5, we searched for trails and received a number of data options we can add to our .mxd file. You can also click **Details** to find out more about a specific dataset, such as a description, who created it, user ranking, when it was modified, credits, extent, and spatial reference.

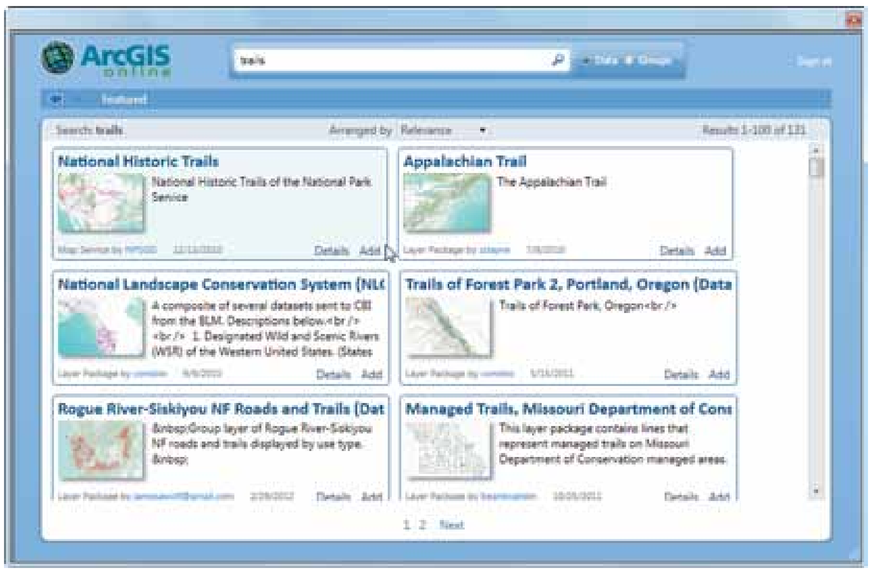


Figure 7-5

Toolbars—The first row of icons underneath the menus is your Standard toolbar and includes **New**, **Open**, **Save**, and **Print** tools, which should look similar to other programs you've seen and repeat some of the options in the File drop-down menu. These toolboxes can be moved around and docked or undocked so they float somewhere in the interface.

Figure 7-6

In that same toolbox is a tool that looks like a yellow diamond with a plus sign called **Add Data**. If you click this tool, you can add the datasets we've provided on the included CD or online at mapsar.net (or all those datasets you put together in chapter 3 "Preplanning") to your map. You can also click the tool and in the new window that opens (shown in figure 7-7), link to the datasets one at a time or hold down the **Shift** or **Control** key and add multiple datasets at once; then you can click **Add**, and the layers will show up in your TOC, similar to figure 7-8.

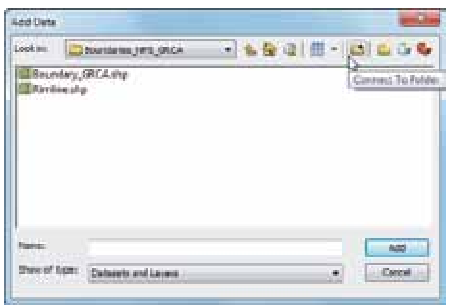


Figure 7-7

If you are using data from a specific folder often, you can also use **Connect to Folder**  to make a shortcut to that location rather than having to browse to that folder's location each time. Once you click **Connect to Folder**, a new window opens that will appear similar to figure 7-9. Select the folders you will use most often—maybe a project folder that you can then use to easily drill down into subfolders or maybe the subfolder that you will be using to pull data from often.

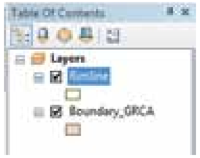


Figure 7-8

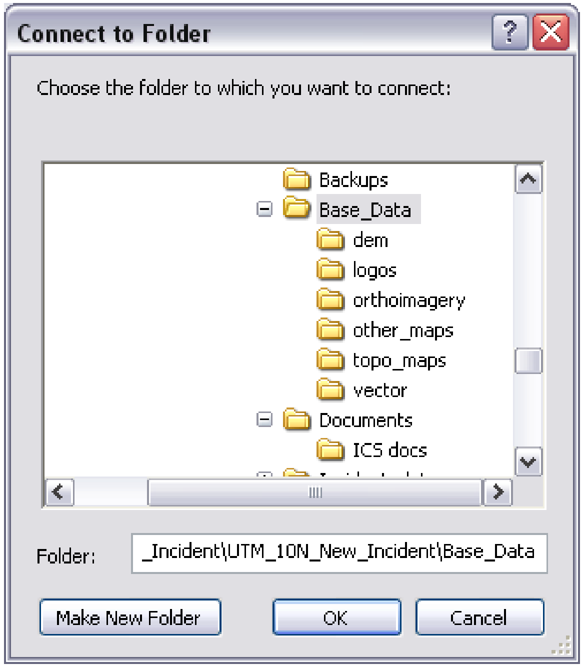


Figure 7-9

Another tool on the **Standard** toolbar is the scale of the map you are viewing.

You can use the pull-down menu for predefined scales or simply type in a scale you want to view your map at, and it will instantly zoom to that level.

Figure 7-10

The next toolbox is called the **Tools** toolbar and has some additional familiar tools, such as zoom in (magnifying glass with plus sign), zoom out (magnifying glass with negative sign), and pan (the hand that allows you to move around the map).

Figure 7-11

The earth-looking tool is called **Full Extent** and will position the map so that all the layers are shown as far out as they extend. The fifth and sixth tools (the squared arrows) are another way to zoom in and out at a set increment. They're called **Fixed Zoom In** and **Fixed Zoom Out**. The blue left and right arrows allow you to go to your previous extent or show the map at the scale and position you previously had. The white arrow with the square is your **Select Features** arrow and enables you to select features by using a rectangle, polygon, lasso, circle, or line. The white box that is currently unavailable is shown if feature(s) are selected and is used to deselect all the features. It is called **Clear Selected**

Features—The solid black arrow, **Select Elements**, allows you to select, resize, and move text, graphics, and other items on the map (not features). The blue circle with the *i* is the Identify tool and when clicked on a map feature will provide a pop-up box with that feature's associated information.

The ruler tool allows you to measure distances or areas on your map visually. The tool with binoculars is **Find** and asks you what word or value to search for, and you can also limit which fields the search is performed on. For example, if you want to see which line segments make up Bright Angel Trail, you would type in "bright angel", and you could specify all visible layers or a specific layer or an individual field you want ArcMap to search in. Then a list will appear in the bottom of the window with the features that include that information. You can then right-click a feature and make it flash, or pan to it.

There are many more toolbars within ArcMap, but these are some of the primary tools available to you for use during an incident.

Table of Contents—The panel on the left side of the ArcMap interface is your TOC. This lists the datasets you just added to this map, or layers. Your map will be drawn with the bottom-most layer displayed first, each layer overlaid on top of the previous layers. So if you have a search segment displayed that is covering your last known point or clues, check your TOC and make sure that the search segment layer is closer to the bottom of the layers and the point layers are above the search segment. You can click to highlight, and then hold and drag layers to where you want them. You can also turn the visibility for a layer on and off using the check box to the right of the layer name, as shown in figure 7-8. You can also group layers together to better organize your data or turn multiple layers on and off more easily. In figure 7-8, the data frame name is **Layers**, and you can have multiple data frames (or map layouts) in an .mxd file.

If you right-click a layer, as shown in figure 7-12, you get a context menu that allows you to access a lot of functionality including, at the bottom, **Properties**. In the Properties window, you can see what folder the data is coming from and the coordinate system/projection/datum the dataset is stored in (on the **Source** tab, as shown in figure 7-13), change transparency (the **Display** tab, as shown in figure 7-14), create labels (Labels), and change the display of the data on the map (the **Symbology** tab).

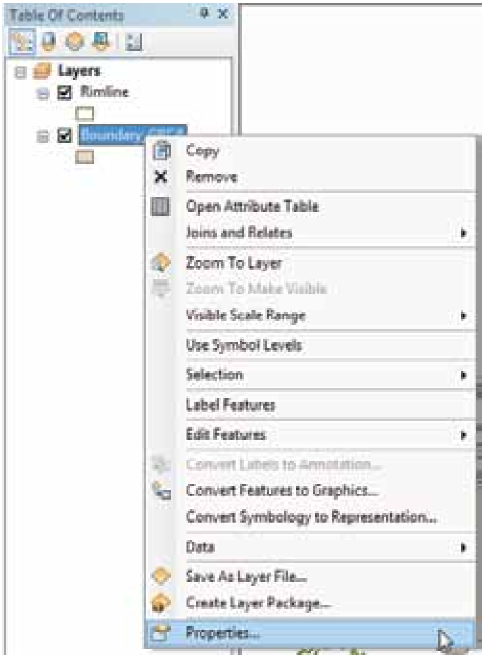


Figure 7-12

When you bring data into ArcMap, the software defaults to a random

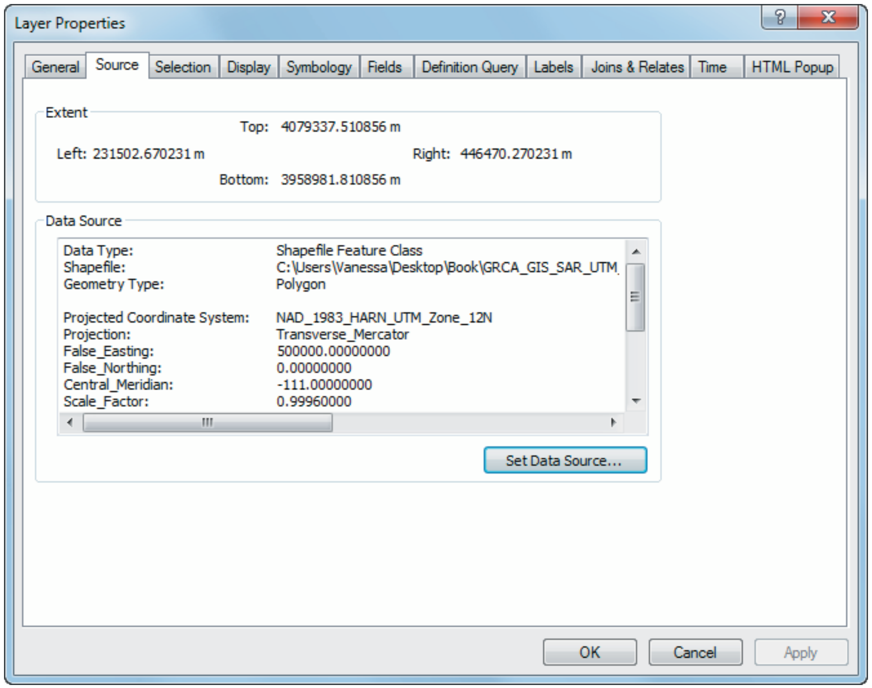


Figure 7-13

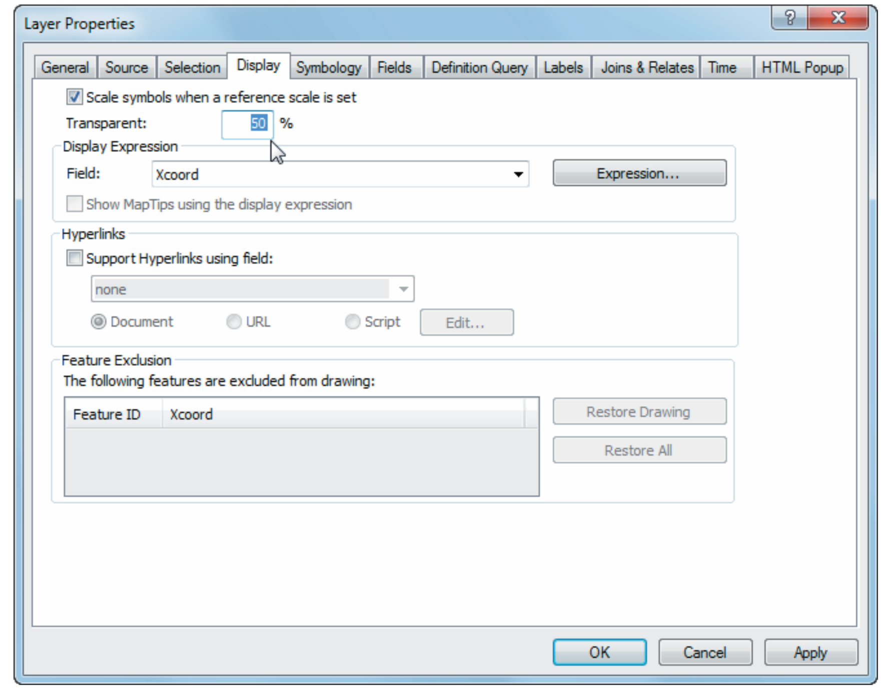


Figure 7-14

symbol for all the features in that data, but that might not make the most appealing map or portray the information the way you want.

If you click the **Symbology** tab, shown in figure 7-15, you can change the shape or symbol for point vector data; the width, color, or outline symbol for line vector data; the color/pattern or outline symbol for area vector data; or the representation for raster data. You can also make data display differently by using categories or unique values based on the information in the data using the options in the Show panel on the right.

An example is if you had 2010 Census Bureau demographic data and wanted to make the map display counties based on ranges of population. You could break the data into five categories (or as many categories as you thought appropriate) and then make the counties in the least populated range a light blue, making each subsequent category a darker shade of blue. This would create a visual pattern that the viewer can easily identify where highly populated counties are.

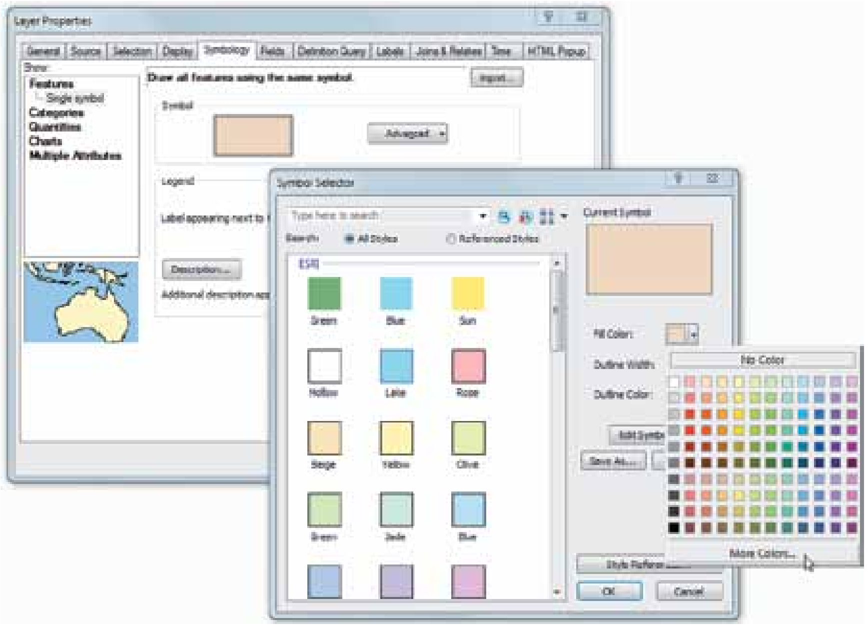
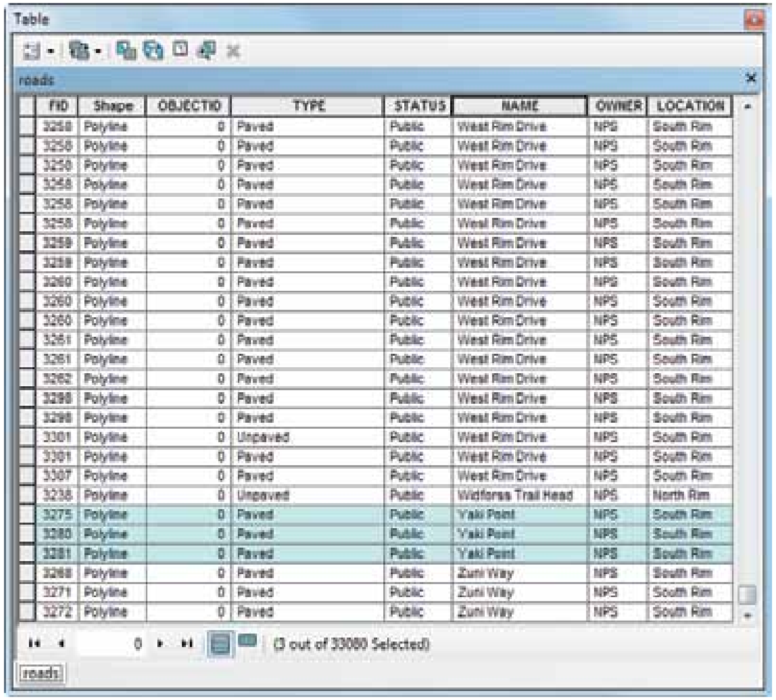


Figure 7-15

Next, in the TOC, right-click a layer and choose **Open Attribute Table** (figure 7-16). The attribute table is where all the data associated with the visual feature drawn on your map is stored. You can create new fields and add information about all the different features in this table, delete fields, or edit and calculate new values. To appreciate the power of GIS, it is important to understand that you aren't just looking at a picture or a line you can view on a map but that there's additional information behind the graphics, and you can add or take away or combine data to create new data.



Table

roads

FID	Shape	OBJECTID	TYPE	STATUS	NAME	OWNER	LOCATION
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3258	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3259	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3259	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3260	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3260	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3260	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3261	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3261	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3262	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3298	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3298	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3301	Polyline	0	Unpaved	Public	West Rim Drive	NPS	South Rim
3301	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3307	Polyline	0	Paved	Public	West Rim Drive	NPS	South Rim
3238	Polyline	0	Unpaved	Public	Widforss Trail Head	NPS	North Rim
3275	Polyline	0	Paved	Public	Yaki Point	NPS	South Rim
3280	Polyline	0	Paved	Public	Yaki Point	NPS	South Rim
3281	Polyline	0	Paved	Public	Yaki Point	NPS	South Rim
3268	Polyline	0	Paved	Public	Zuni Way	NPS	South Rim
3271	Polyline	0	Paved	Public	Zuni Way	NPS	South Rim
3272	Polyline	0	Paved	Public	Zuni Way	NPS	South Rim

0 (3 out of 33080 Selected)

roads

Figure 7-16

As shown in the above attribute table for Yaki Point features, you can also highlight specific features to select them. Selecting specific features helps you to see which features in the table match which features on the map. The selected features are highlighted on the map and can be exported as their own newly created dataset. Remember that white arrow with the blue and white square in the toolbars section? You can also select features on the map using that tool and then open the attribute table to look at more information about that set of selected features.

The menu in the upper left corner of the attribute table provides several other options including selections, turning all fields on or off, creating graphs from the data, printing, and exporting, among others. If you wanted to add a field so you could include the ownership for each road, you could use the **Add Field** option, as shown in figure 7-17.

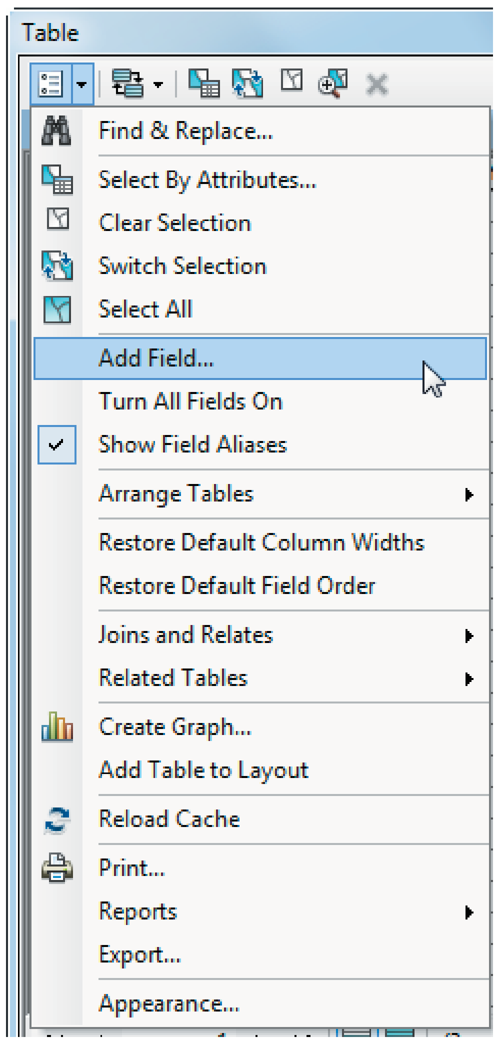


Figure 7-17

When you add a field, you need to select which type of field you would like to add: Short integer, Long integer, Float, Double, Text, or Date. If you were adding a road ownership column, you would choose Text as in figure 7-18 and specify a length that would be appropriate for the information you will be entering—not too short that it would limit your entries but not excessively long to make the file larger.

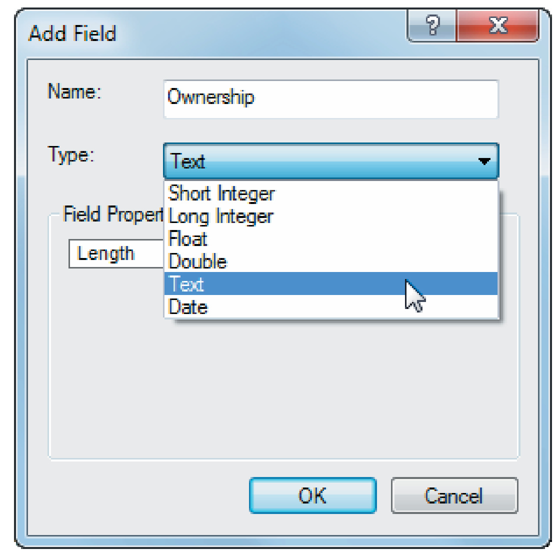


Figure 7-18

The numeric field types of Short integer and Long integer allow you to store only whole numbers. Both have a numeric range limitation, the latter being larger. Float and double allow you to store values with decimal places, with double having a larger numeric range limit than Float. All four allow you to store positive or negative values. These four types will also ask you for a precision number—basically, what the limit on field length is. Float and Double will want a value for scale, which is simply the number of decimal places. If you aren't sure what to use, Float is the most common for numeric values—but remember, you can always look up details in ArcGIS for Desktop help.

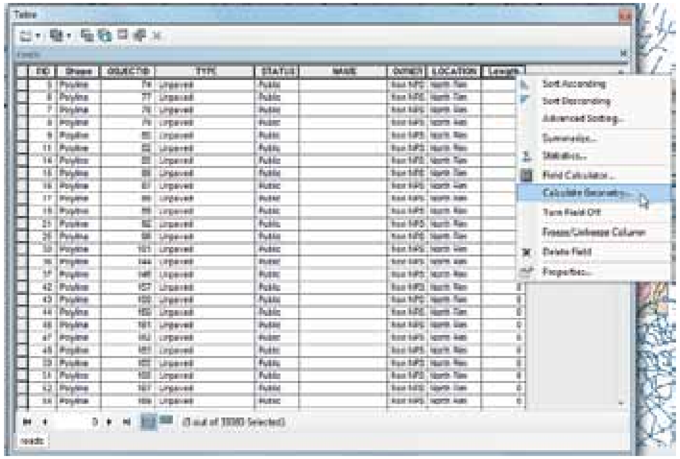


Figure 7-19

Figure 7-20

If you have a new field (or existing field that you want to overwrite) and want to calculate length (for polyline features) or area (for polygon features) or the coordinates of line start, midpoint, or end, you can use the Calculate Geometry option. Simply right-click the field name at the top of the column you want to create values for, as shown in figure 7-19.

In this example, you can calculate the length for each road segment in miles. Depending on the number of records you have, you may see a calculating window and then—voila!—there are all the lengths you requested in figure 7-20.

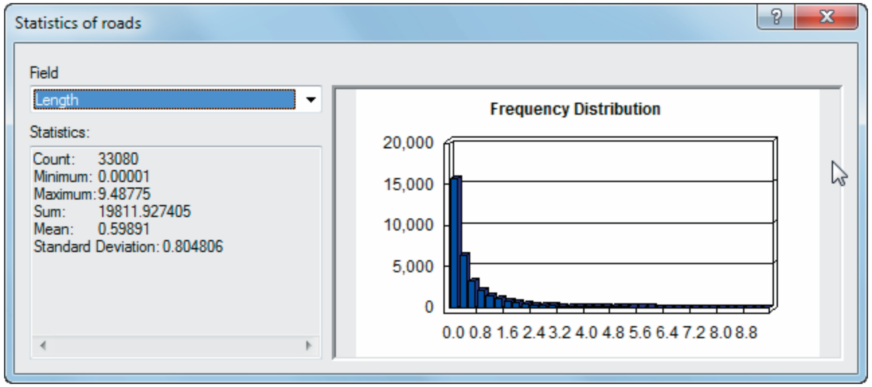


Figure 7-21

Now that you have the length of all the segments, you want to know the grand total. Right-click the Length field name and choose Statistics. You will receive a pop-up window, shown in figure 7-21, that provides different information about your data, including the sum of 19,811.927405 miles.

Note that the statistics will be provided for only the selected records or, if none are selected, statistics for all the records.

Map Window and Bringing All the Components Together—In the main map window of ArcMap, you will see your visible data (shown with a check mark next to the layer in the TOC) displayed on your map within the area you are viewing and at a particular scale. Remember, you can change the symbology in the TOC by right-clicking Properties and going to the Symbology tab. You can also reorder the layers in the TOC so that they draw and display the information you want. The top layers will draw over the bottom layers. The area that your map is drawn in is called the data frame, which was mentioned in the TOC section. You can have multiple data frames. For instance, if you wanted to make side-by-side maps in one .mxd file for easy comparison or make an inset map in the corner and on top of the main map, you would create a new data frame for each.

You can also find the information contained in the attribute table for a specific feature by clicking the Info tool and clicking that particular feature. A pop-up window will show you the different fields and information for that feature.

To select features, we've already talked about manually selecting features both in the map window using the Select Features arrow tool and drawing a rectangle to select features and in the attribute table by clicking features. There are some other options that are very useful, including **Select By Attributes** and **Select By Location**.

You can access **Select By Attributes** through the **Selection** menu as shown in figure 7-22 or in the attribute table under Table Options, shown in figure 7-17.

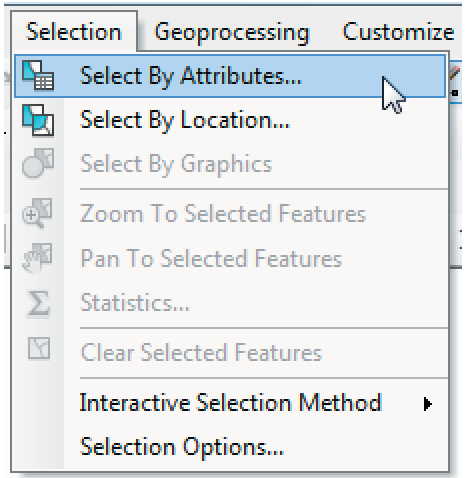


Figure 7-22

Select By Attributes allows you to choose features based on information in the attribute table. You might want to select all the counties with a certain population range, or you might want to select which roads are unpaved, as in figure 7-23. In this figure, the software will search in the Type field and select only features listed as Unpaved, not ATV, Converted to Trail, Paved, or Re-Vegetated. If you wanted to export this selected subset of data to create a new shapefile, you could do this by right-clicking the layer in the TOC, going to Data > Export Data, and choosing to only export Selected Features in the first drop-down menu.

Select By Location can be accessed from the Selection menu as shown in figure 7-22. This tool lets you pick features based on their location in relation to features in another layer. For example, if you wanted to know which roads overlapped with an endangered species migration route, you could select the roads

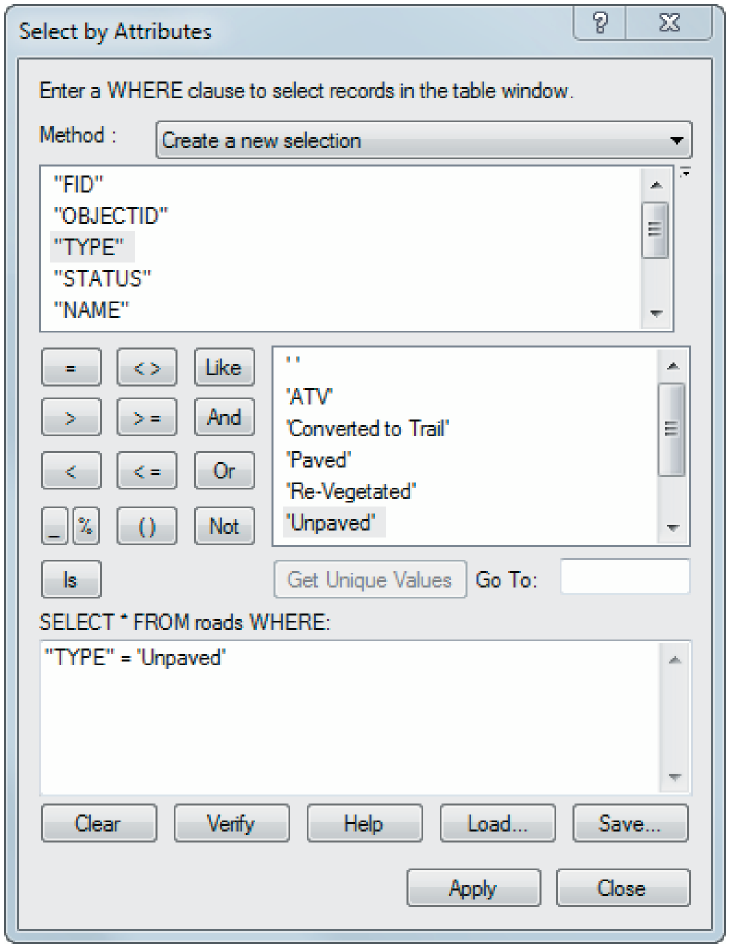


Figure 7-23

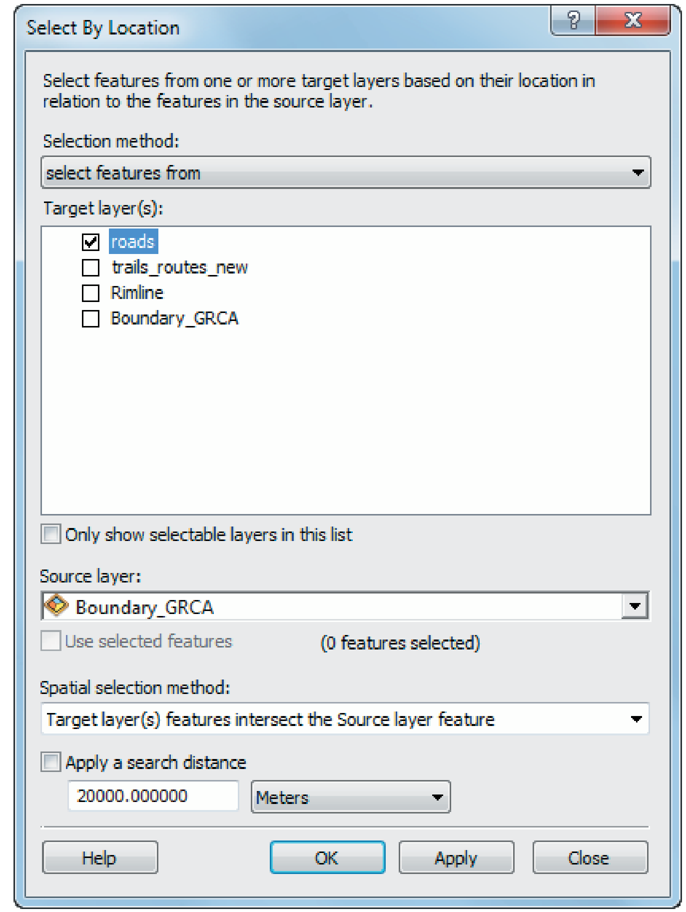


Figure 7-24

based on the migration route polygons. Or if you want to know which roads intersect the Grand Canyon National Park boundary, your **Select By Location** window would look like figure 7-24, and your results like figure 7-25.

Notice that there are many different choices for your selection method, including intersecting, within a distance of, containing, completely containing, within, completely within, identical to, touch the boundary, and so on.

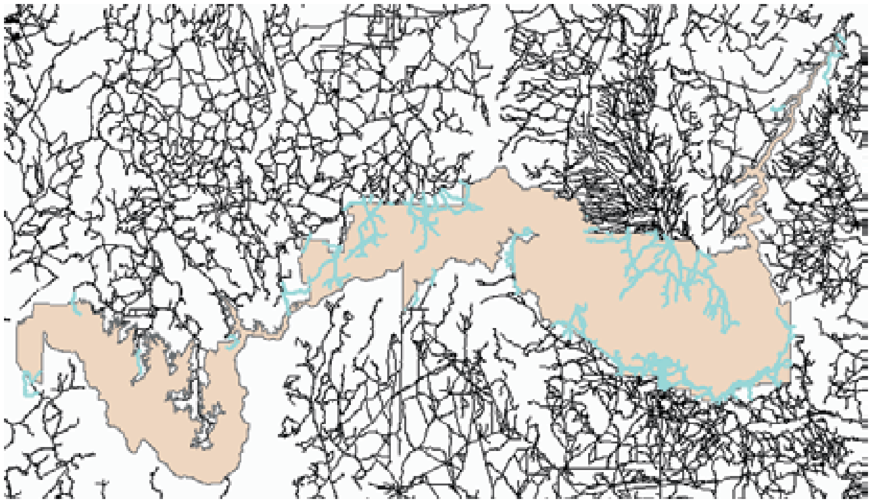


Figure 7-25

If you want to change the ownership or flag these particular roads in some way, or redraw them, or add new roads, you need to begin editing. You need to start, save, and end edit sessions because this tells the software to access the original dataset and change that file permanently. Therefore, if you have data that is linked to multiple map documents and do not want to change that data in all the maps, you should first make a copy of that dataset and then alter it so as not to disturb the other maps. (This is not true for symbology; symbology is unique to the map documents.) For example, if you wanted to see what all the trails would look like after they build three new proposed trails over the next 10 years, you don't want to alter the original trails data; you want to make a copy and name it something like Trails_proposed.

Editing—To begin an editing session, click the **Editor** toolbar (as shown in figure 7-26 when the toolbar is floating and isn't docked to the top of the interface), and click **Start Editing**.

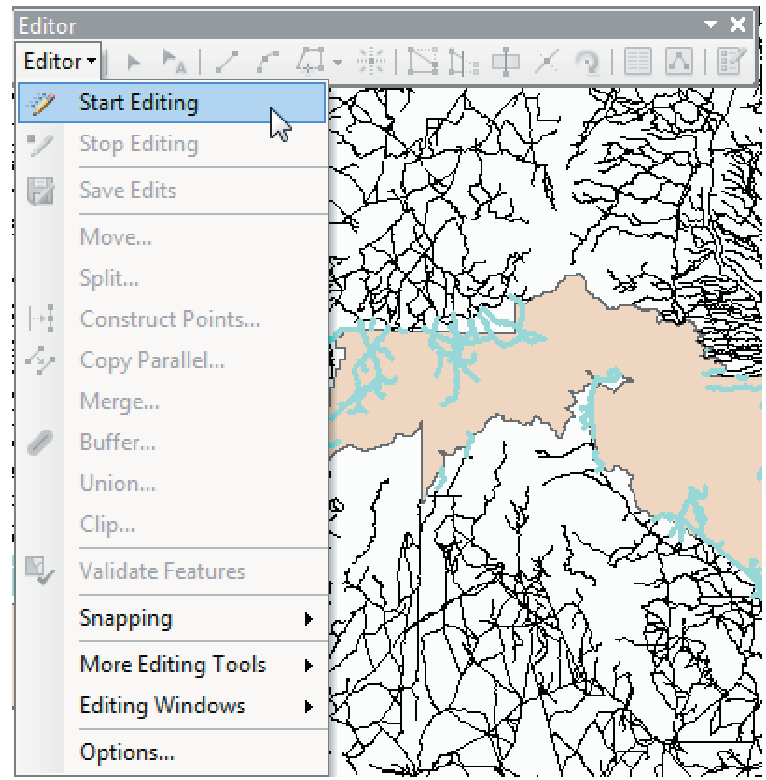


Figure 7-26

Because all the data is in different folders, a window asks which source you want to edit, shown in figure 7-27. In this case, the roads layer is in Transportation_NPS_GRCA, so it is highlighted; click OK.

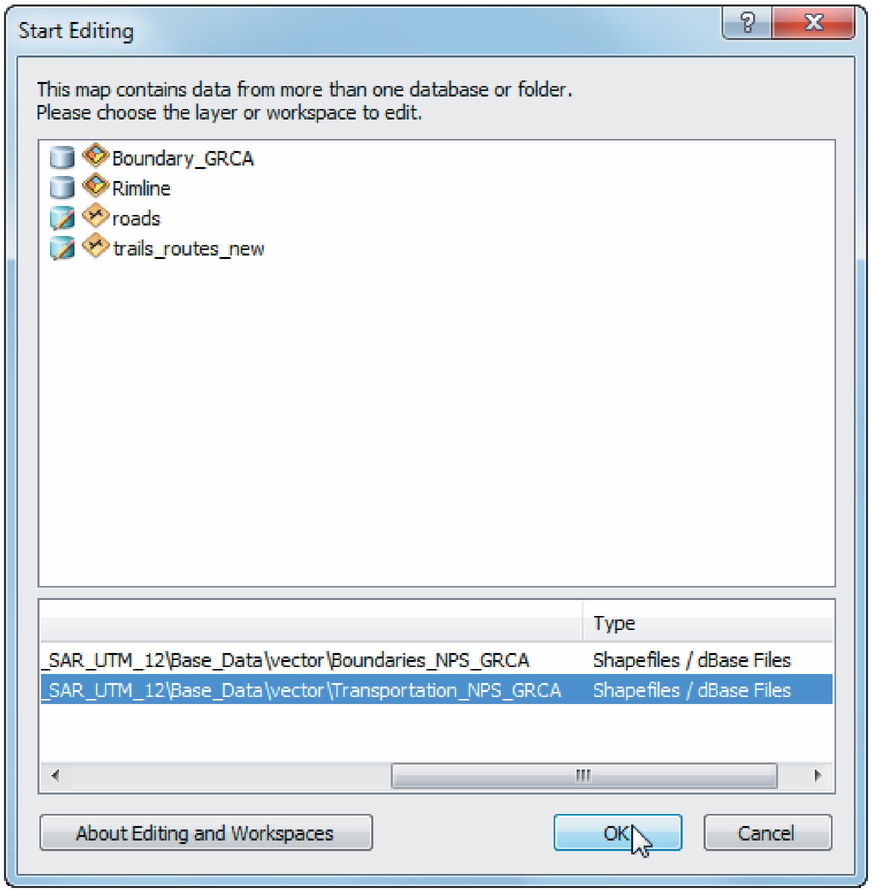


Figure 7-27

On the right side of the interface, there is now a **Create Features** panel, as shown in figure 7-28. In this area, you can select what type of features (roads) to create and the tools you use to construct them, for instance, using a line, rectangle, circle, ellipse, or freehand tool. There are also auto-complete options that may be available. Each layer needs to have at least one feature template before you can create new features, and generally, at least one is generated by the software.

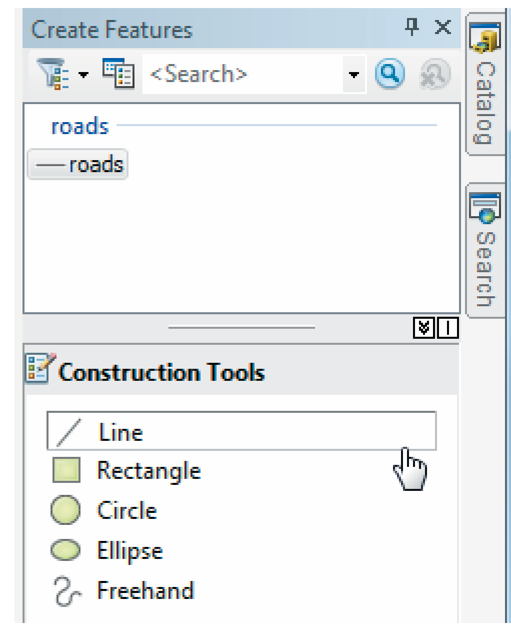


Figure 7-28

Feature templates are listed in the top window of figure 7-28. New templates can be created and organized using the **Organize Templates** tool, second to the right under the **Create Features** title. This will open a new window, as shown in figure 7-29, where new templates can be created.

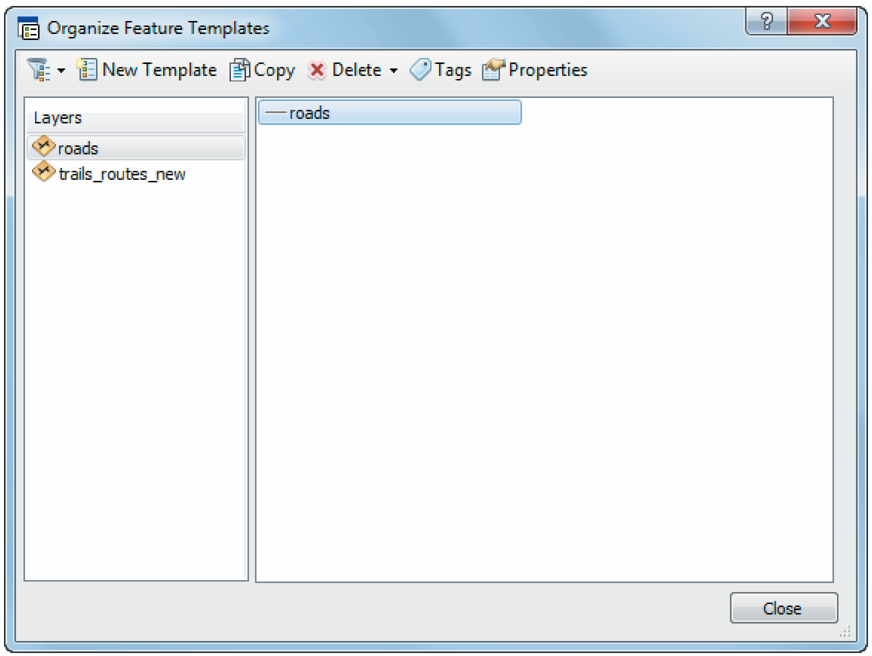


Figure 7-29

To draw a new road using the line construction tool, you would select the Line tool, zoom in to the area of interest, and draw a new road while snapping to existing vertices of the boundary polygon, shown in figure 7-30. Each click establishes the drawing at that point and allows you to change directions. The green points show the new road vertices—each representing a click of the mouse.

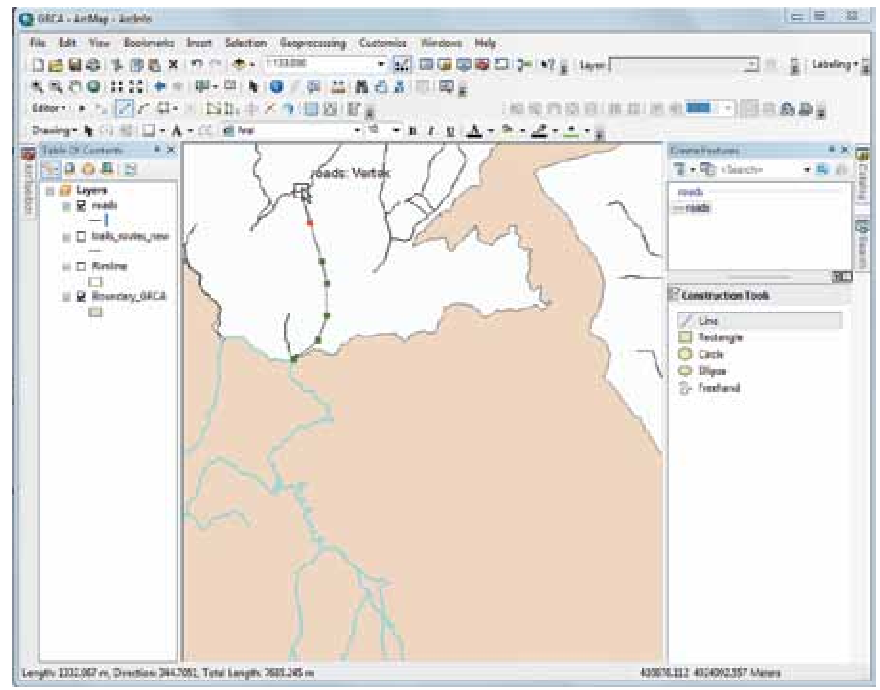


Figure 7-30

To edit features that have already been created, use the **Edit Vertices** tool on the Editor toolbar, shown in figure 7-31.

Figure 7-31

This allows you to move individual vertices (green points) and essentially redraw the line—in this case, the new road, as shown in figure 7-32. The light blue line is where the road was drawn, and the green vertices connect the new segments that have been moved to better reflect where the new road will be.

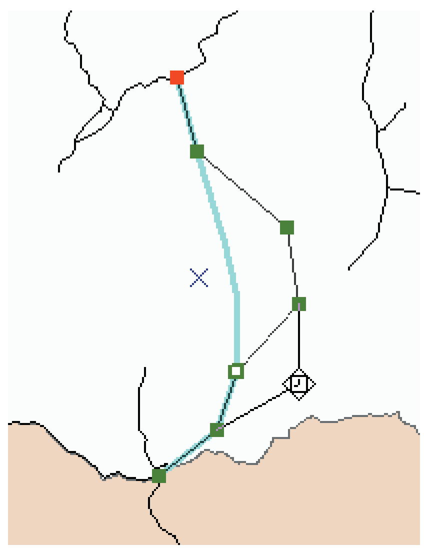


Figure 7-32

Another useful feature is the **Buffer** tool, as shown in figure 7-33. You may, for instance, want to create a buffered distance from a line—creating a polygon. You might do this to indicate the sweep width (sight distance) of a team on a trail—how far they can see on either side. To do this, you select the trail using the **Select** tool. The buffer window will appear in the template, and the distance you want to buffer needs to be chosen, as shown in figure 7-34. The results look like figure 7-35.

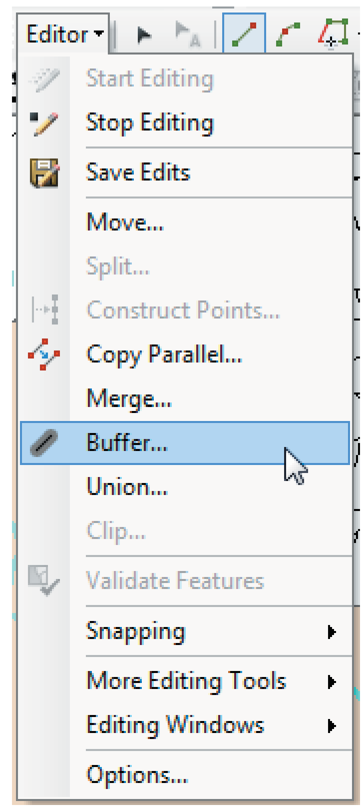


Figure 7-33

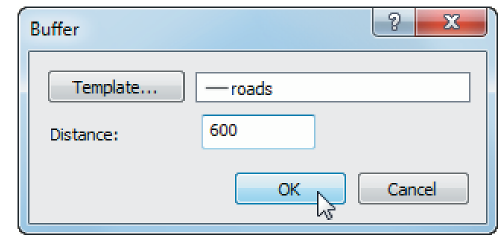


Figure 7-34

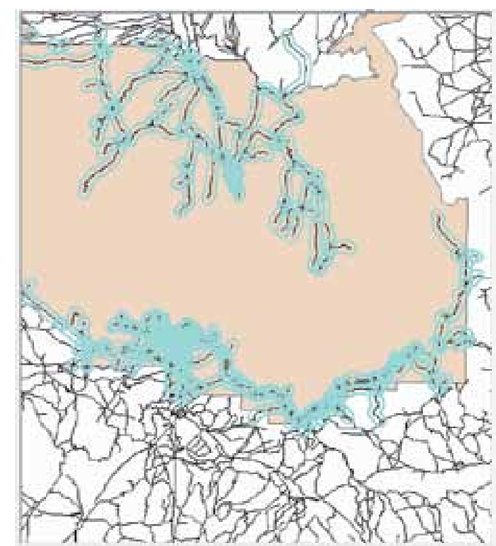


Figure 7-35

When you are done editing, click **Stop Editing** on the Editor menu and, when prompted, choose Yes to save edits if you are confident in your changes and prepared to permanently alter the dataset (if you choose No, your edits will be lost completely).

There are two ways to view the map window: Data View or Layout View. Data View is more of a real-world perspective on your map and is what the map document defaults to. Generally, you will spend most of your time in Data View for editing, querying, and analyzing data. Layout View is when you are getting ready to print your map. This is where you put the finishing touches on your map, such as text, north arrows, and a scale bar. What you see is what will print. You can use the buttons at the bottom left side of ArcMap or use the View menu to toggle between the two views, as shown in figure 7-36.

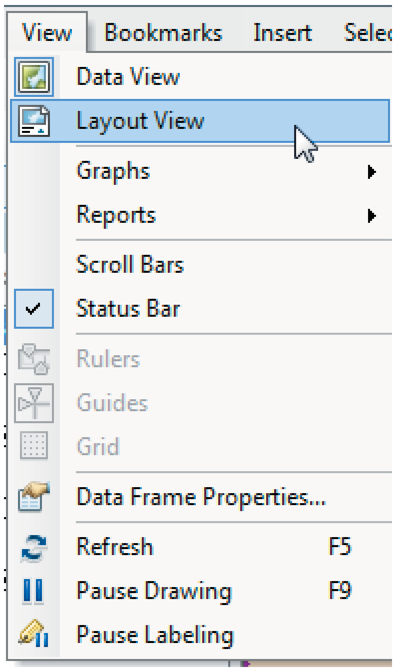


Figure 7-36

In Layout View, the borders of the paper are shown, and the data frame can be adjusted to fit more comfortably in the printed area by resizing the corners. If you want to change the print orientation to landscape or the page size or any other print-related settings, go to **File > Page > Print Setup**. The window, as shown in figure 7-37, will allow customization.

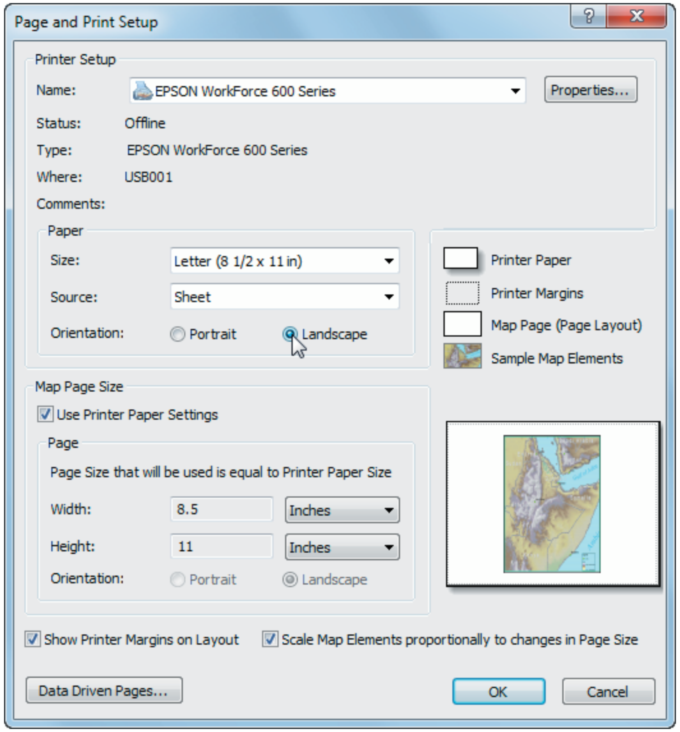


Figure 7-37

Pay particular attention to what printer you will be using for this document and what size paper it takes—is it a standard office inkjet that only takes letter-size (8.5" x 11") paper? Or is it a plotter (large-size printer) with a specific size of paper available? Do you want the roll width to be the width or length for your document? For example, if you need to make an oversize briefing map, but only have 36" wide paper, you can still make a 36" x 48" map if you orient the document on the roll correctly.

There is an additional Layout toolbar (shown in figure 7-38). This consists of tools very similar to the tools on the Tools toolbar, but they are for moving around the page instead of the map. This way, you can zoom in to the document without changing the scale of the area that is printed. These are helpful when positioning text and other elements on the page. You need to be very careful to use only this toolbar while in Layout View mode. This toolbar will not change the relative location of your map and layer files but only resize the page. If you use the standard toolbar, with zoom in, zoom out, and the hand tool, you actually change the map and layer locations. When you create a layout view you like, it's a good idea to bookmark it. If you move the map with the standard toolbar, you can quickly return to the view you saved.

Figure 7-38

It is important to set up the print size and layout before you begin putting finishing touches on your map, as resizing and changing settings will cause you to have to go back and rearrange items and resize text. Focus the map on the area of interest at the scale needed to convey information to the viewer.

Figure 7-39

Use the Insert menu to add text, titles, a legend, north arrow, and a scale bar to your map before printing, as shown in figure 7-40. Each option will open a wizard that will walk you through choosing the look and size of the items.

In many realms of GIS, there is a saying that every map should show a legend and STANDD: Scale, Title, Author's name, North arrow, Date, and Datum. Make sure your map includes the information needed for the user to understand the situation and make decisions based on your map. Use the **Select Element** tool (the solid black arrow on the Tools toolbar) to position and size elements once added to your map.

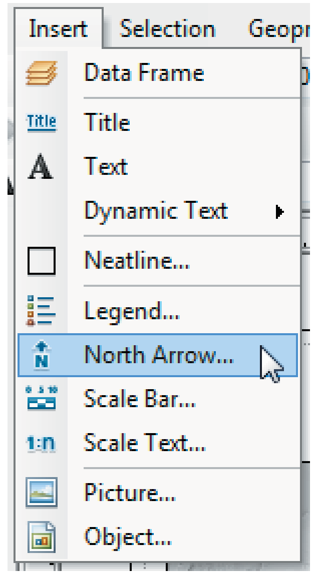


Figure 7-40

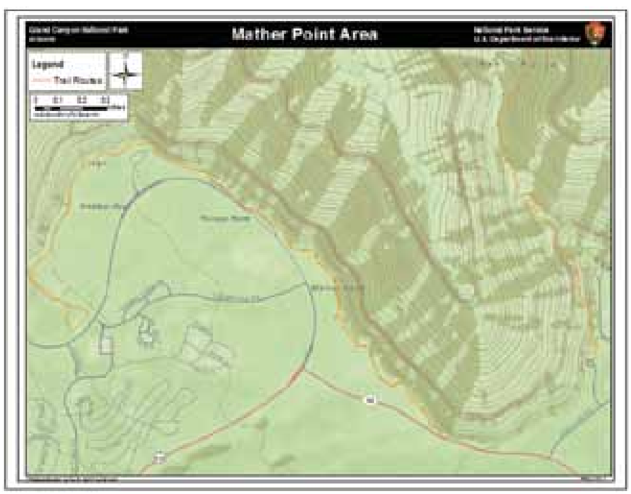


Figure 7-41

You already set up the printing and document, but when you go to **File > Print**, as in figure 7-42, you may need to double-check your settings and make additional adjustments before printing, such as checking that the print quality and layout are perfect.

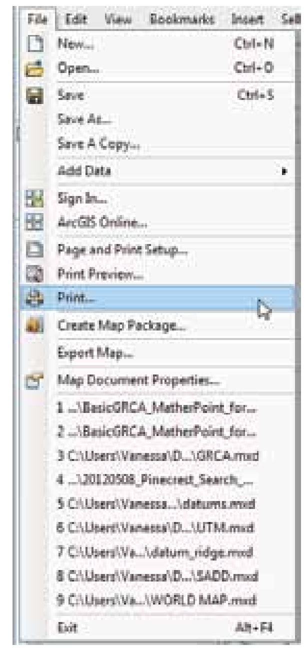


Figure 7-42

Figure 7-43

Now that you've got the hang of how to make a map in ArcGIS, explore using different datasets and layouts, creating features, and editing existing features to increase your experience and comfort level with the software.

Exercise 7A: ArcGIS for Desktop—Explore the Software and Make a Map

In this exercise, you'll use ArcGIS 10 for Desktop to load and display the basic data needed for a SAR, and then print a map. The goal is to get a feel for the basic features and tools of ArcGIS 10. This will give you an excellent foundation for using MapSAR later.

If you have not installed a copy of Esri's ArcGIS, take a look at the trial license you can download from Esri for 60 days for free. Once ArcGIS is installed, you can complete the steps in the exercise using the accompanying data from the included CD or online at mapsar.net. Copy the 7_ArcGIS_Ex_Data.zip from the source onto your computer and extract the file. If you do not have a compression tool, you can download WinZip at www.winzip.com. For this example, put the folder with your data on the root of your C:\ drive.

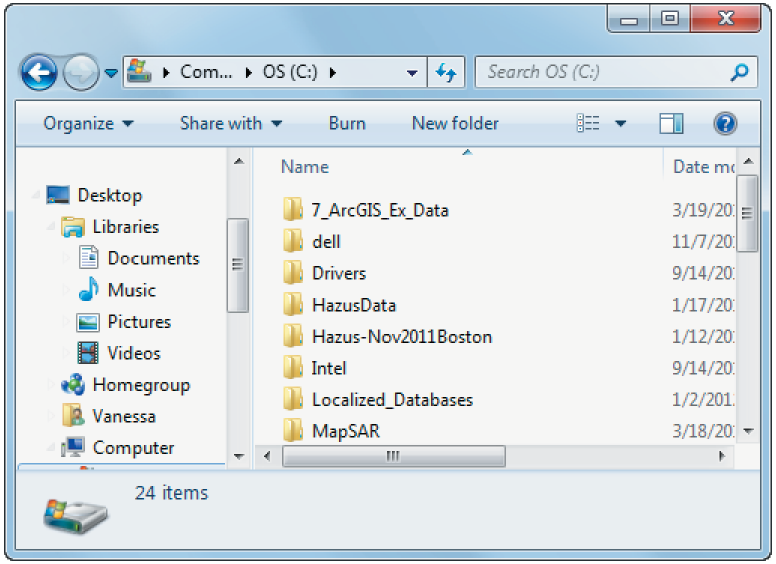


Figure 7-44

If you choose to put your data folder elsewhere, just remember where you are putting it and substitute that location whenever you see the instructions referencing C:\. These datasets are for the Pinecrest Lake area and include trails, roads, contours, topographic map basemap (DRG), a hillshade (illustrates the elevation data using an imaginary light source so that you can easily understand the terrain), and search segments. Go through the steps to add this data to a map document, change the symbology, check the size of the search area, create a hand-drawn path for a team that has returned from the field, and create a working map.

1. After downloading, uncompressing, and placing the exercise data on your machine, open the ArcMap software through either a shortcut or from **Programs > ArcGIS > ArcMap**.

2. When the **Getting Started** window pops up, select **New Maps** in the left column and click the **Blank Map** icon and then **OK**.

Figure 7-45

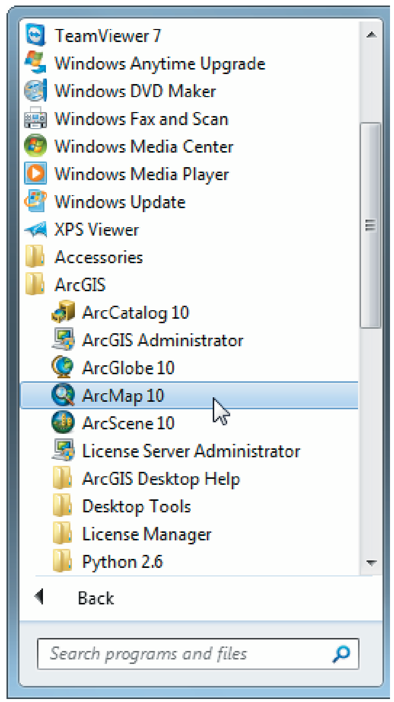


Figure 7-46

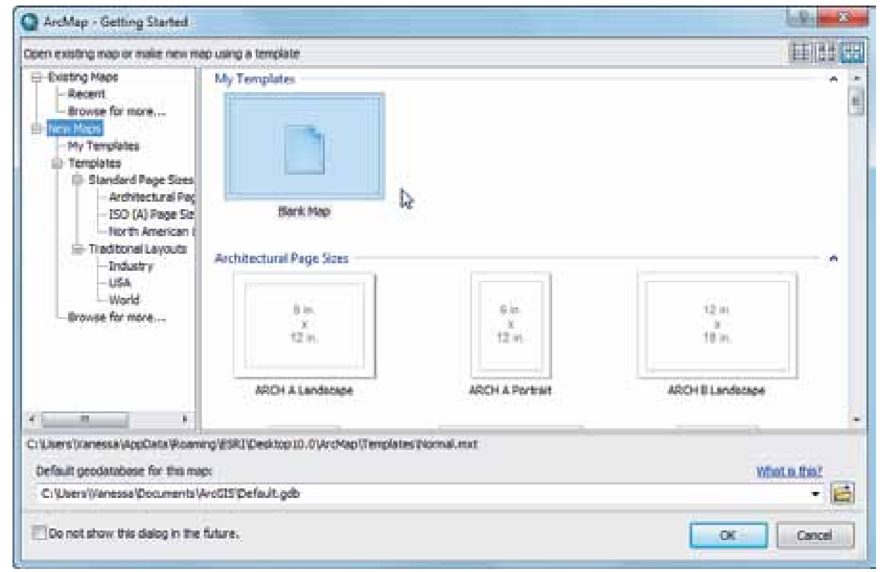


Figure 7-47

3. The ArcMap interface will open with a new, empty map document. Click the **Add Data** button and navigate to the **C:\7_ArcGIS_Ex_Data\7_Base_Data_raster** folder.

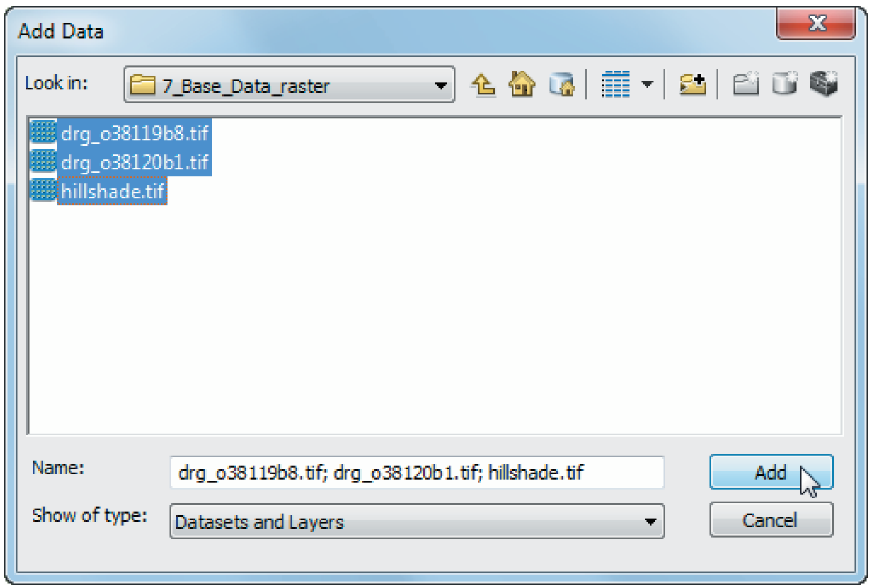


Figure 7-48

4. Click all three files while holding down the **Shift** or **Control** key. Once highlighted, click **Add**.

   Since these are the first layers being added to the new map document, the data frame/map will take on the coordinate system and datum of this data. In this case, all of your data is consistent in NAD83 UTM Zone 11N, but this is something to keep in mind if you are using data from multiple sources that has different projections or datums.

5. You should now see the DRGs and hillshade listed in the TOC and visible in the map window.

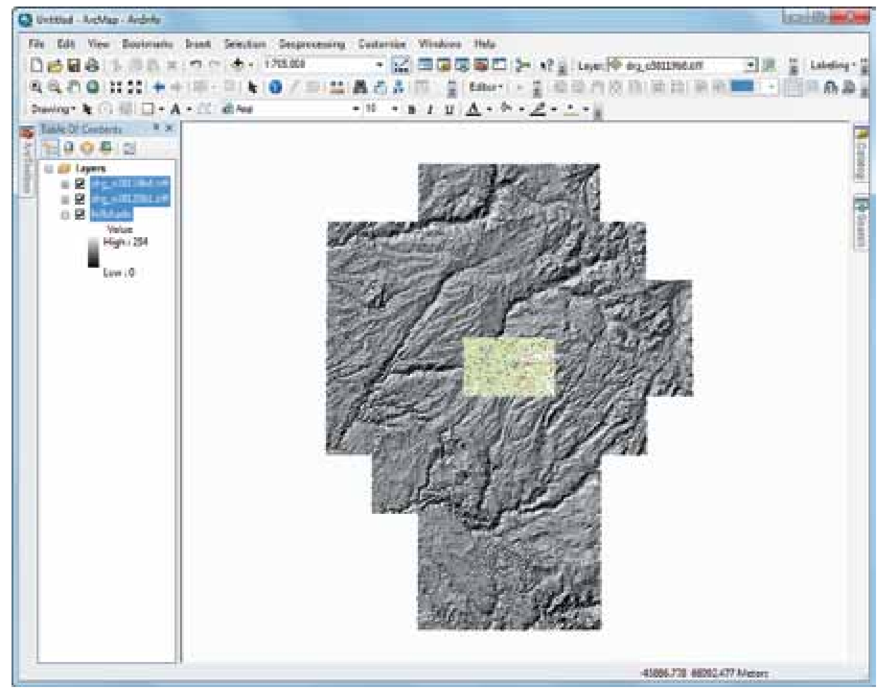


Figure 7-49

6. Put these three layers into a group layer so that you can turn them on and off in one click and keep them better organized—this isn't a big deal when you only have two layers, but if you had 16 DRGs you wanted to keep together, group layers are a must.

   Right-click the data frame, currently called Layers, and select **New Group Layer**.

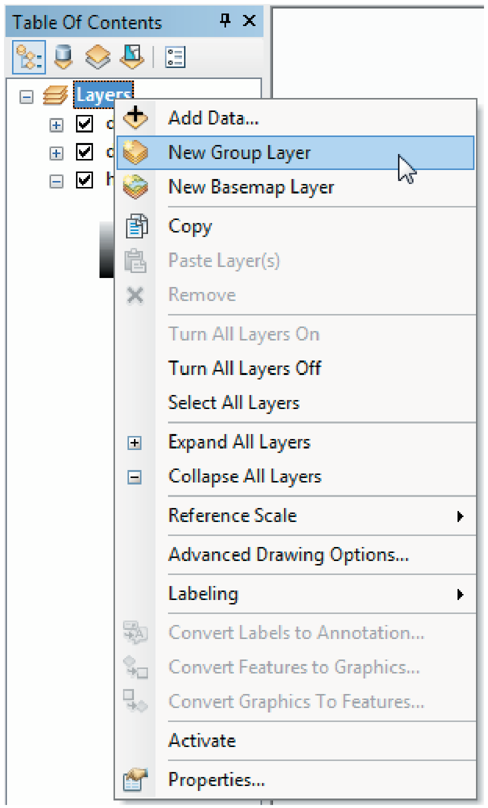


Figure 7-50

7. Click the newly created group layer once and rename it **Base**. Drag the three layers into this group. You can tell if this is successful if they are now indented slightly to the right of the group layer name (indicating that they are in that group layer). Try turning the visibility on and off by unchecking and checking the box to the left of Base. Feel free to rename any of the files to make them more recognizable to you as well.

8. You also need to add the vector data to your map document, so repeat steps 3 and 4 to select the Roads_USFS, Trails _USFS, and contours_40ft files in **C:\7_ArcGIS_Ex_Data\7 _Base_Data_vector.gdb**. It may take a little while to draw.

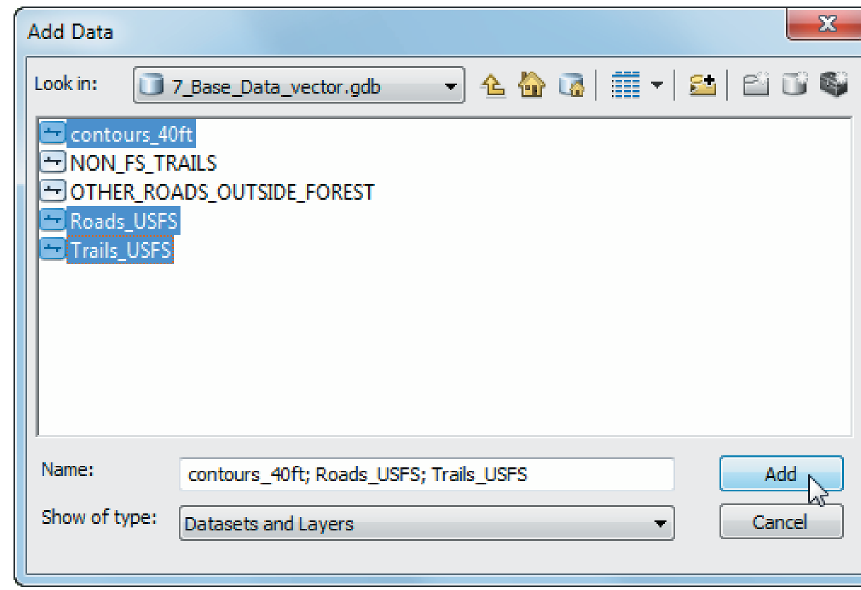


Figure 7-51

9. Turn the **contours_40ft** layer off by unchecking the check box to the left of the layer name in the TOC.

10. Add the two datasets from **C:\7_ArcGIS _Ex_Data\7_Incident_Data.gdb**.

11. You should now have eight layers listed in your TOC.

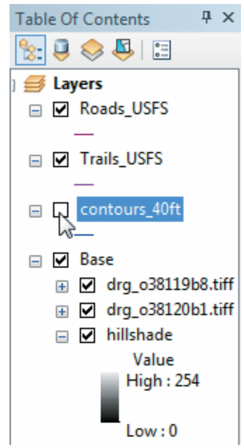


Figure 7-52

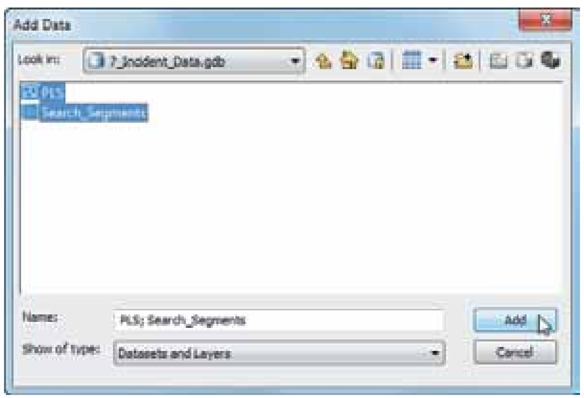


Figure 7-53

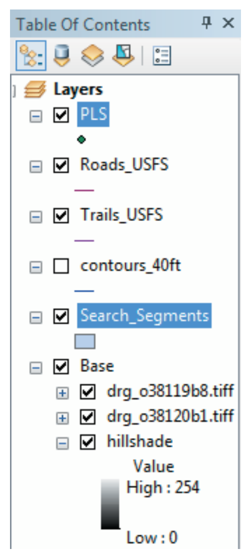


Figure 7-54

12. Now that there's some data in your map document (.mxd), you need to save your work. Click **File > Save**, navigate to the **C:\7_ArcGIS_Ex_Data** folder, and type **7_Ex.mxd** for the file name.

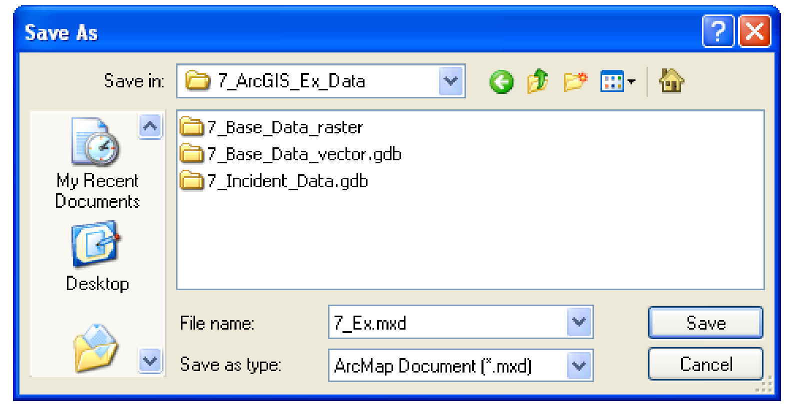


Figure 7-55

The file name at the top of the interface may or may not change to reflect the name you saved it as. This is a known bug (hopefully fixed by the time you read this). If you're more comfortable seeing the name of your file up there, close ArcMap (if it prompts you to save, do so), and then double-click **C:\7_ArcGIS_Ex_Data\ 7_Ex.mxd** to reopen; now the name will be there.

13. ArcMap uses a default scale and symbology for your map. You could use the zoom in, zoom out, and pan tools to center your map on the area you're interested in. But in this case, there's

an easier way. In the TOC, right-click the **Search Segments** layer and select **Zoom To Layer**. (Note: If this option isn't visible, you aren't clicking in the correct place, or you have more than one layer selected.)

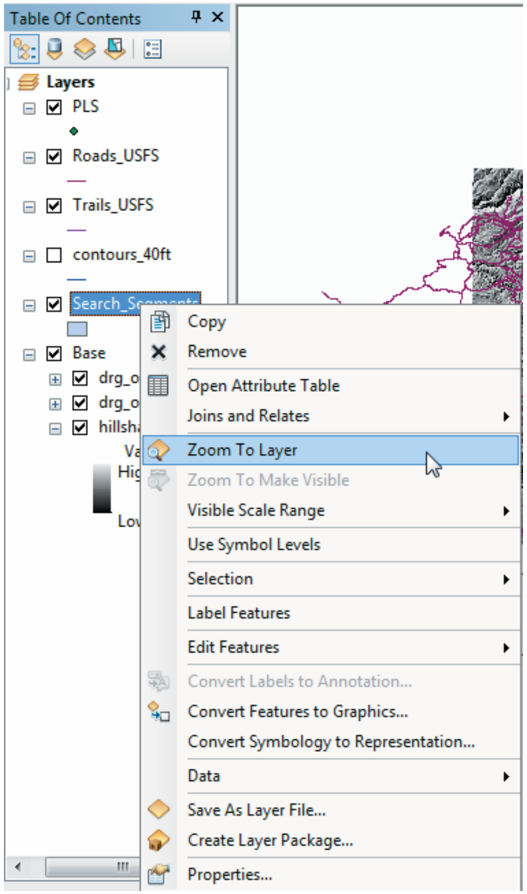


Figure 7-56

14. The layers draw from the bottom to the top, so the top layers are what is shown on the map. ArcMap defaults to putting your data with points at the top, then lines, then polygons, but this isn't always the order you might want. To demonstrate, drag the **PLS** layer to below the Search Segments layer. As you drag, a black line will appear to show where the PLS layer would go if you released it right then. Now you are unable to see the point for PLS because it is drawing underneath the Search Segments. Move the layer back to the top by either dragging it back up, pressing **Control + z**, or clicking the **Undo** tool or **Edit > Undo**. As with most things in ArcMap (or any software), there are many ways to approach a problem.

15. Now that you've zoomed in, you can see a problem with the DRGs—there is what appears to be a big white space between the edges—actually, this is the white of one sheet overlapping with the sheet underneath.

Figure 7-57

All you need to do is expand the symbology for the DRG that is on top of the other one, which in this case is drg_o38119b8.tif, by clicking the plus sign next to the layer.

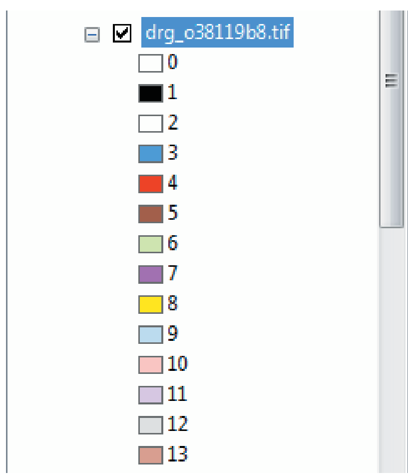


Figure 7-58

16. Double-click directly on the white rectangle next to the zero to open the **Symbol Selector** window. Click the **Fill Color** pull-down menu and select **No Color**. Click **OK**. Now the white edge is gone, and the background looks much better.

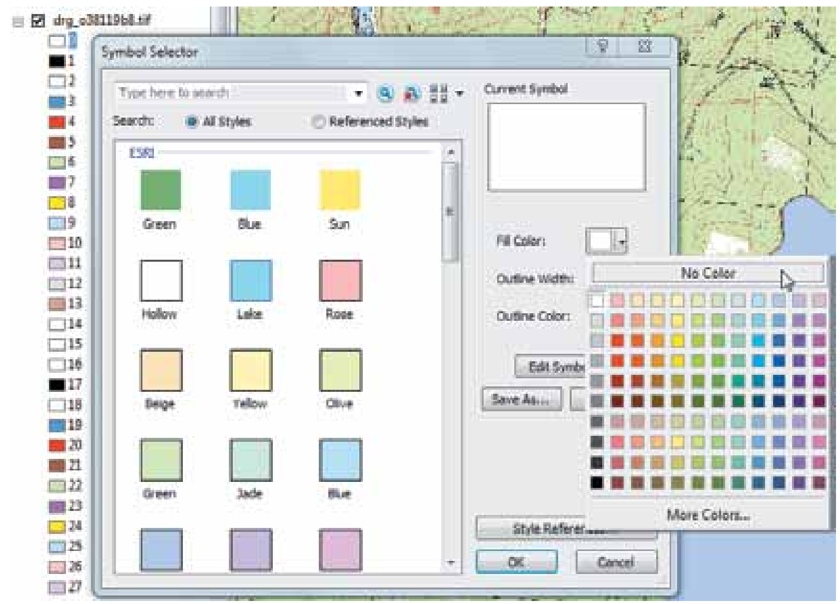


Figure 7-59

17. The map still looks pretty messy, and there may be odd color choices for different data. To change the symbology for Roads_USFS, right-click the layer name and select **Properties** (the last option on the menu). Click the **Symbol** box to open the Symbol Selector window.

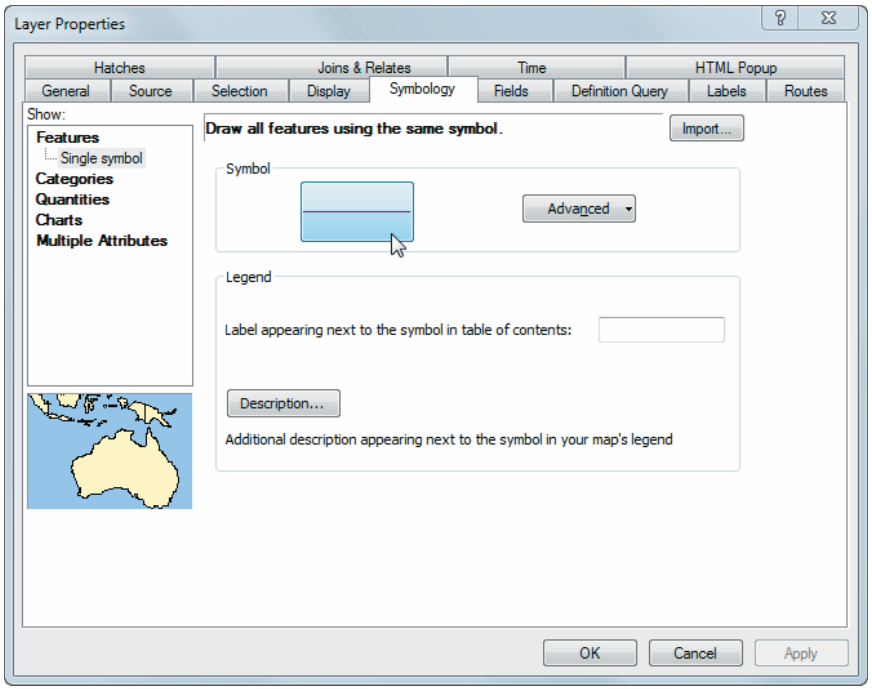


Figure 7-60

18. In the right panel, click the **Arterial Street** icon in the styles, and the software will load black for the color and a width of 0.80. Click **OK** twice to accept the symbology changes and close the two pop-up windows.

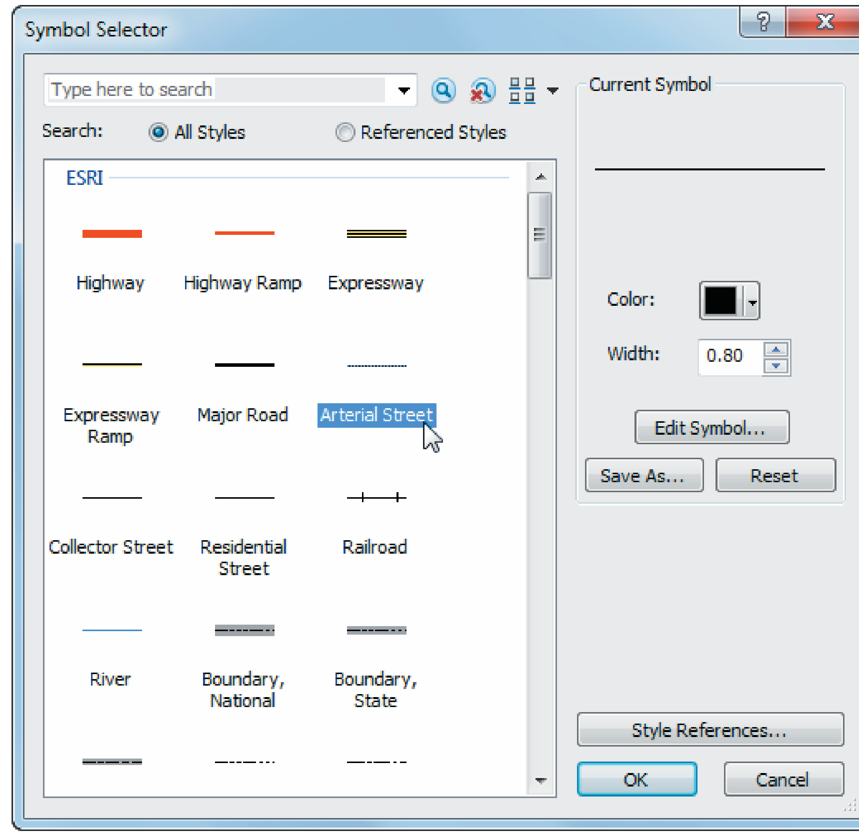


Figure 7-61

19. Right-click the **Search_Segments** layer and select **Properties**. Then click the rectangle for the symbol color to open the **Symbol Selector** window.

    A way to customize the symbology rather than using the style template for roads is on the right side of the window in the **Current Symbol** area—use the pull-down option for the swatch to change the color to a preloaded color or select **More Colors**. In this case you want to make the search segments transparent with only a line along the outside, so click **No Color**.

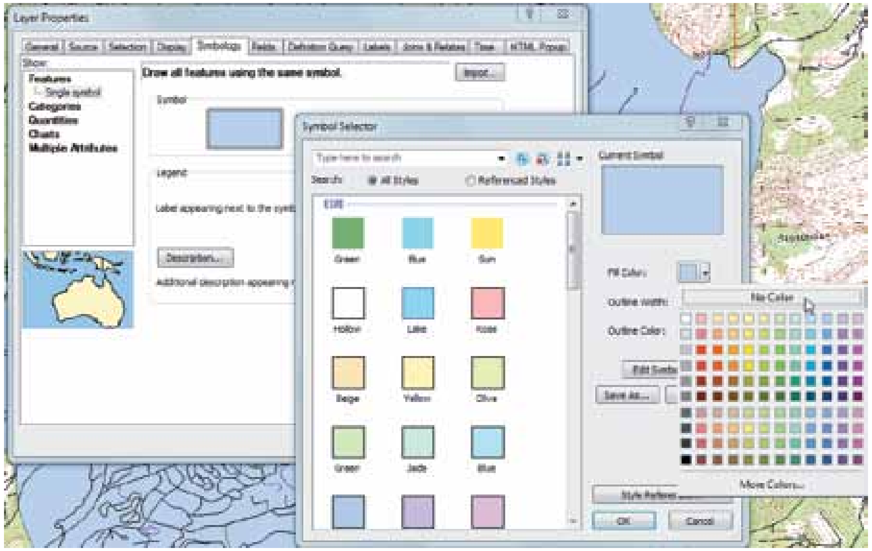


Figure 7-62

20. You also want to change the outline symbol (not just the color), so in the **Symbol Selector** window, click the **Edit Symbol** button.

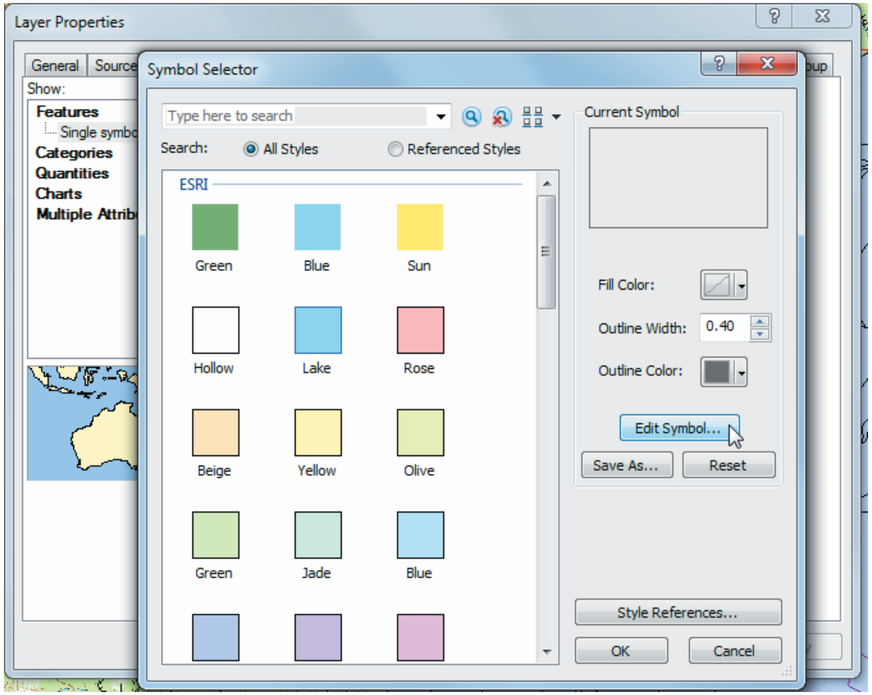


Figure 7-63

21. On the **Symbol Property Editor**, click the **Outline** button.

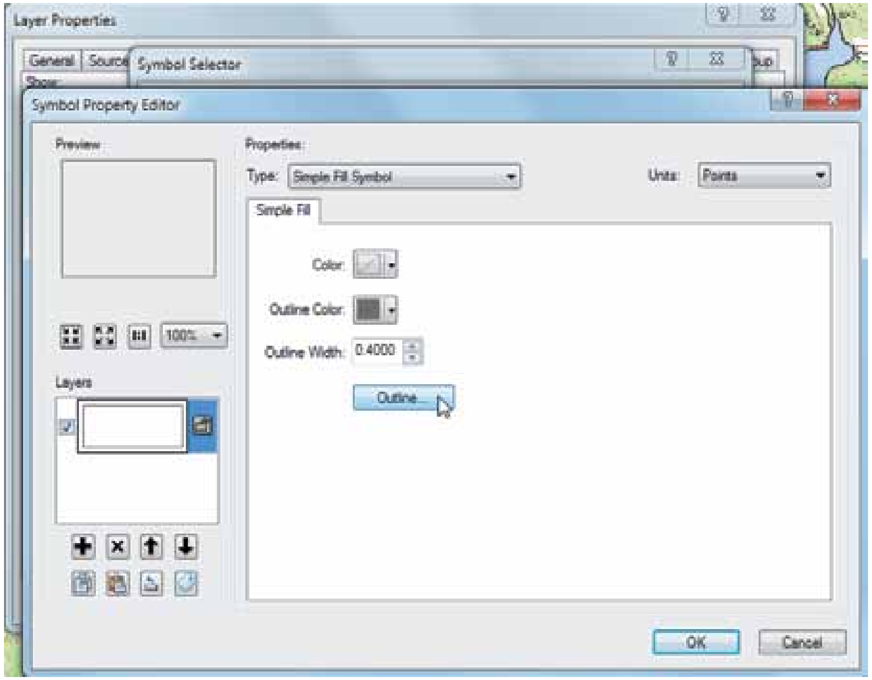


Figure 7-64

22. A second **Symbol Selector** window opens where you can change the outline symbology including the color and width. You want the search segment boundaries to stand out, so click the **Highway** style to change the color to red and width to 3.40.

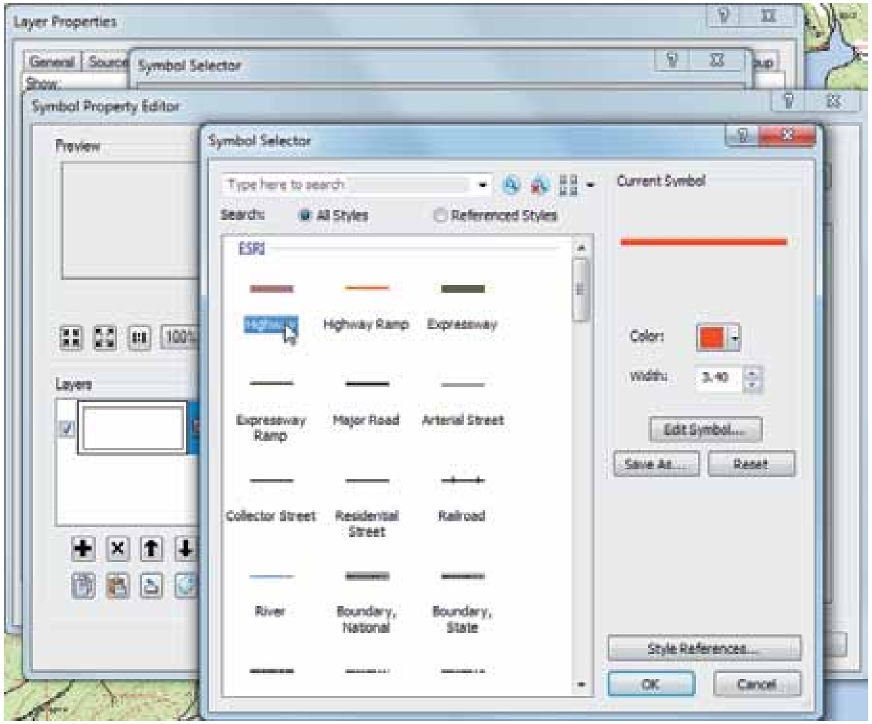


Figure 7-65

23. Now click **OK** four times to accept the symbology changes and close all the windows.

    Your map should look something like this:

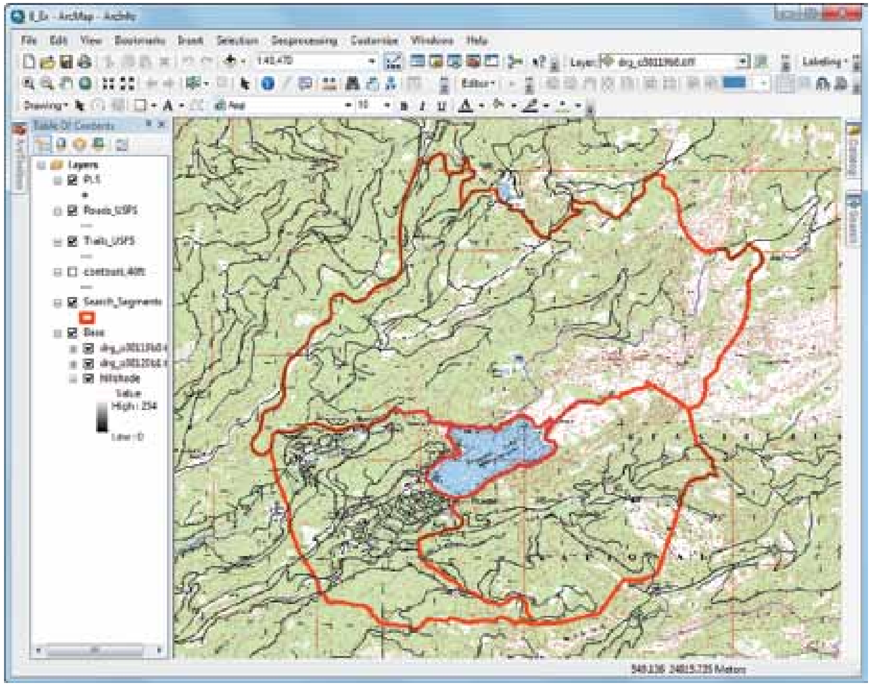


Figure 7-66

24. This is starting to shape up. Make the trails layer a color and width you find appropriate and can see against all the other information. This exercise will use Seville Orange with a width of 1.7, but you can play around with different styles.

25. Change the PLS to the ICS symbol if you have it available in style templates or to a bright star or something noticeable.

26. You still have that hillshade layer that is underneath the DRGs and so it currently isn't visible. Keeping it within the Base group layer, drag the **hillshade** layer above the two DRG layers.

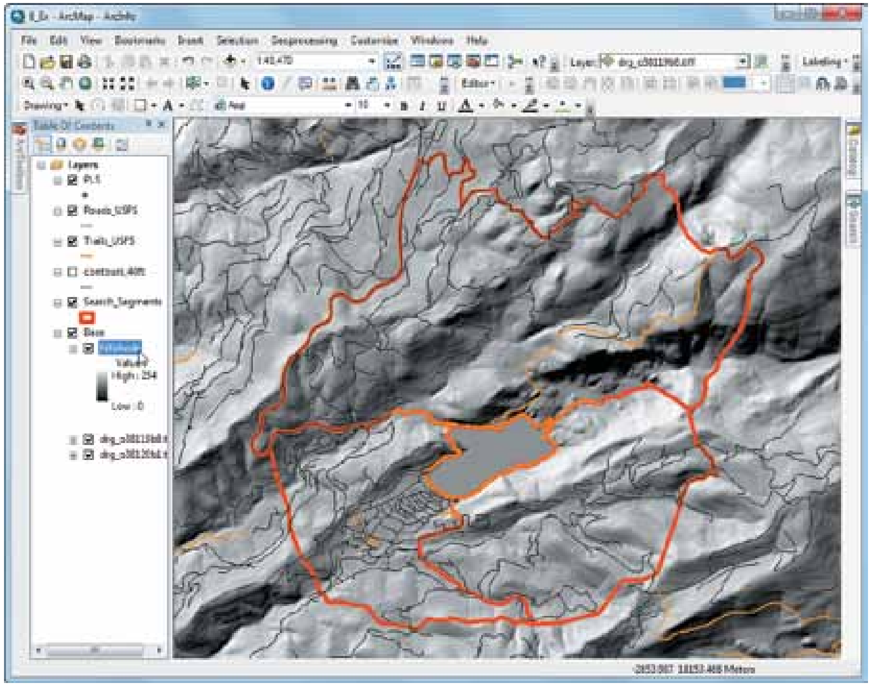


Figure 7-67

27. You want to make the hillshade partially transparent so you can see the topographic information below in the DRGs. Right-click the **hillshade** layer, select **Properties**, and click the **Display** tab.

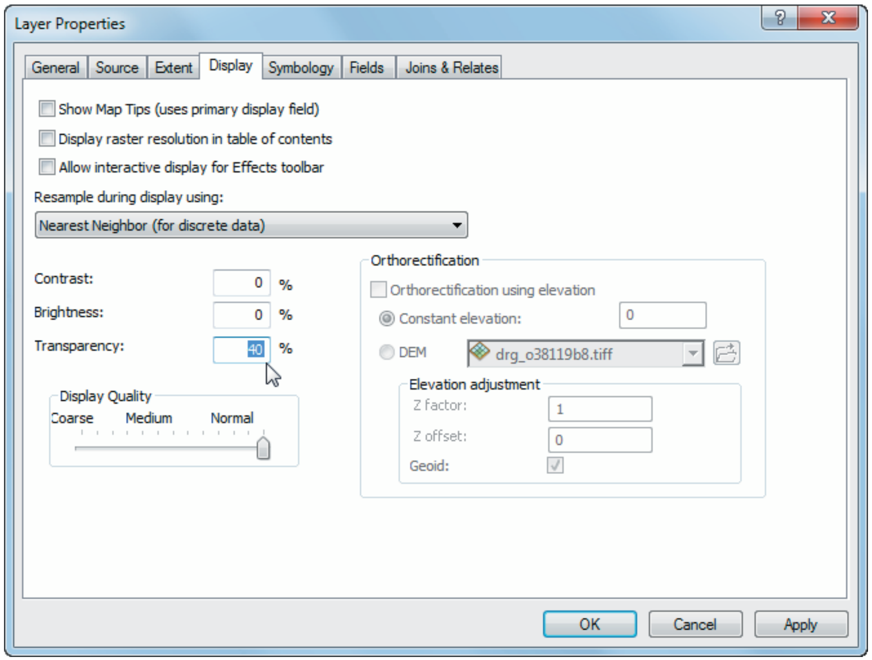


Figure 7-68

28. Change the **Transparency** value to 40 and click **Apply** (not **OK**) so you can see if you like the results, without closing the window.

29. The hillshade still looks too opaque or dark on top of the DRGs; try 65 for the **Transparency** value and click **OK**. That gives it some balance.

30. Make it so the name of each search segment is displayed inside the segment. First you need to familiarize yourself with what data is available for the search segments and see if you need to create a new name field or if it already exists. Right-click the **Search Segments** layer name and select **Open Attribute Table**.

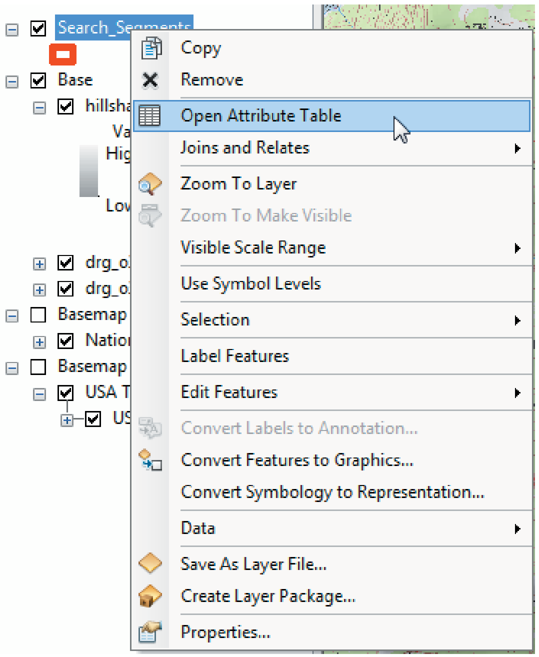


Figure 7-69

31. The existing fields are OBJECTID (an internal ArcMap identifier for each feature), SHAPE (what type of geometry the feature consists of, such as polygon or polyline or point), SHAPE_Length, SHAPE_Area, Searched, and Operational _Period. None of these allow a place for the segment layer name, so make a new field and add this information.

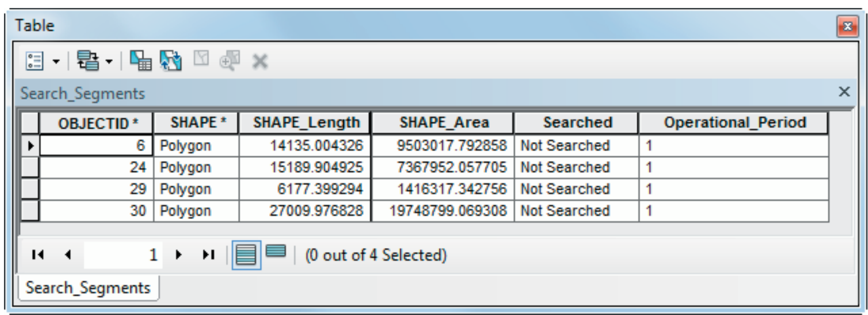


Figure 7-70

32. Click the **Table Options** menu and select **Add Field**.

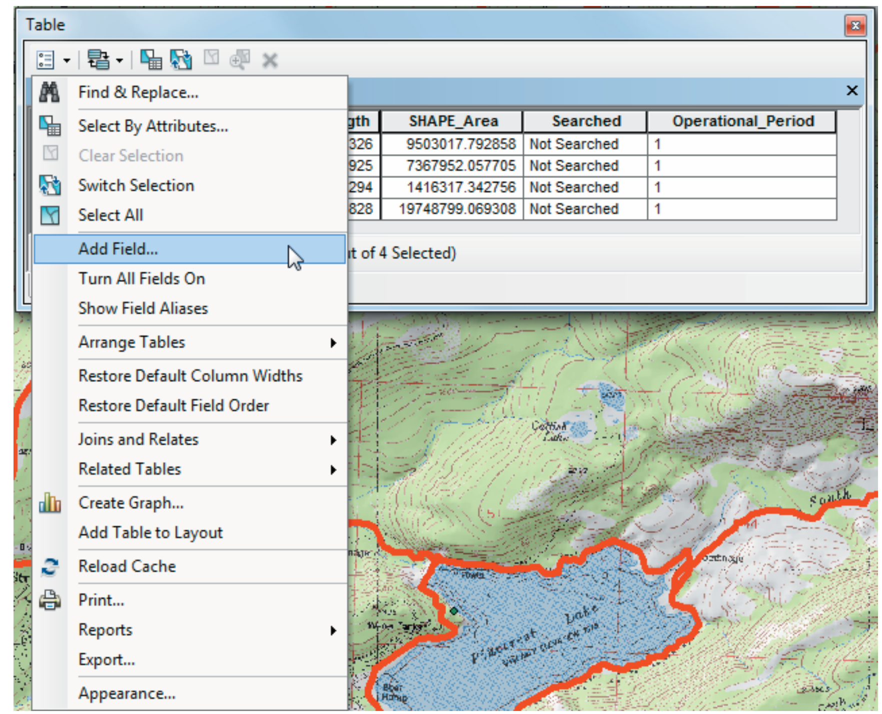


Figure 7-71

33. For the Name entry, type **Name** (note that you cannot use spaces or dashes in field names, but underscores are fine, and there is a length limit). In the **Type** field, type **Text** and in the **Length** field enter **5**. Click **OK**.

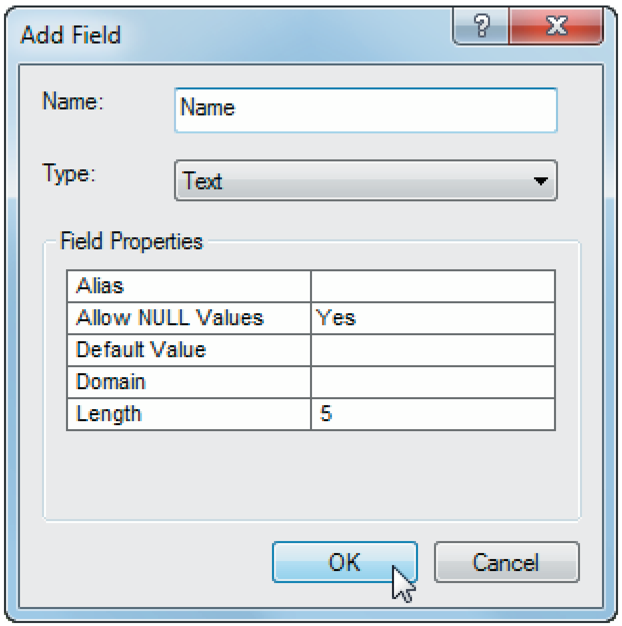


Figure 7-72

34. To enter information in the **Name** field, you need to start editing. Click **Editor > Start Editing**.

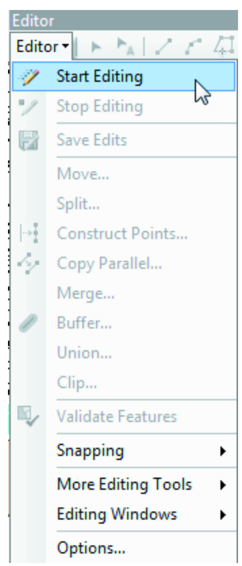


Figure 7-73

35. Because you have data stored in different locations, the software wants to know which one you want to edit. Click **Search_Segments**, and pencils will appear on all the layers in this database that are editable if selected. Click **OK**.

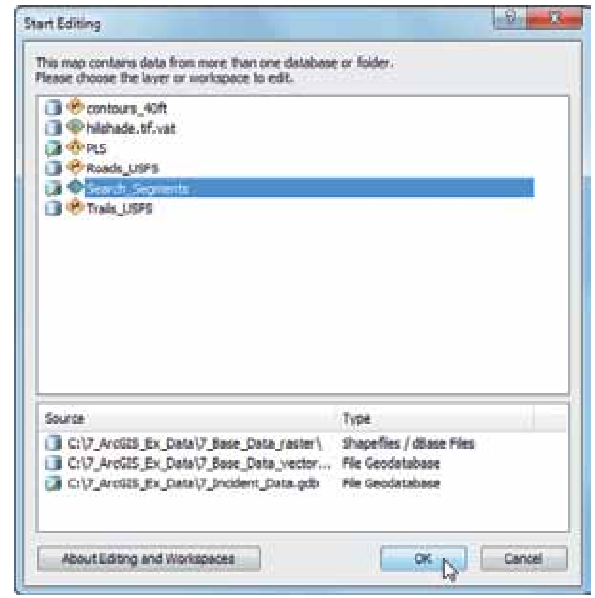


Figure 7-74

36. In the attributes table for the **Search_Segments** layer, type **A**, **B**, **C**, **D** in the **Name** field where it says <Null>. Close the attribute table.

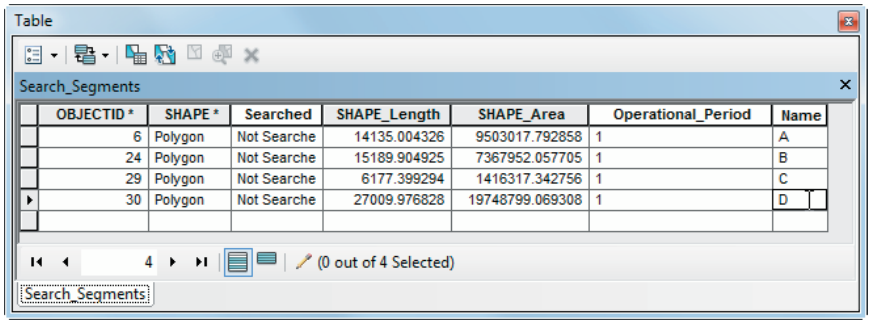


Figure 7-75

37. Click **Editor > Stop Editing**. You will be prompted to save your edits; click **Yes**.

38. To open the **Search_Segments Layer Properties** window, right-click the layer's name and select **Properties**. Click the **Labels** tab.

39. On the **Labels** tab, check the check box next to **Label features in this layer** and change the **Label Field** to **Name** since that is what you want to use for your labels. Change the font size to **16** so that it is larger and the color to match the red you used for the outline of the search segments. Click the **B** button (bold). Click **OK**.

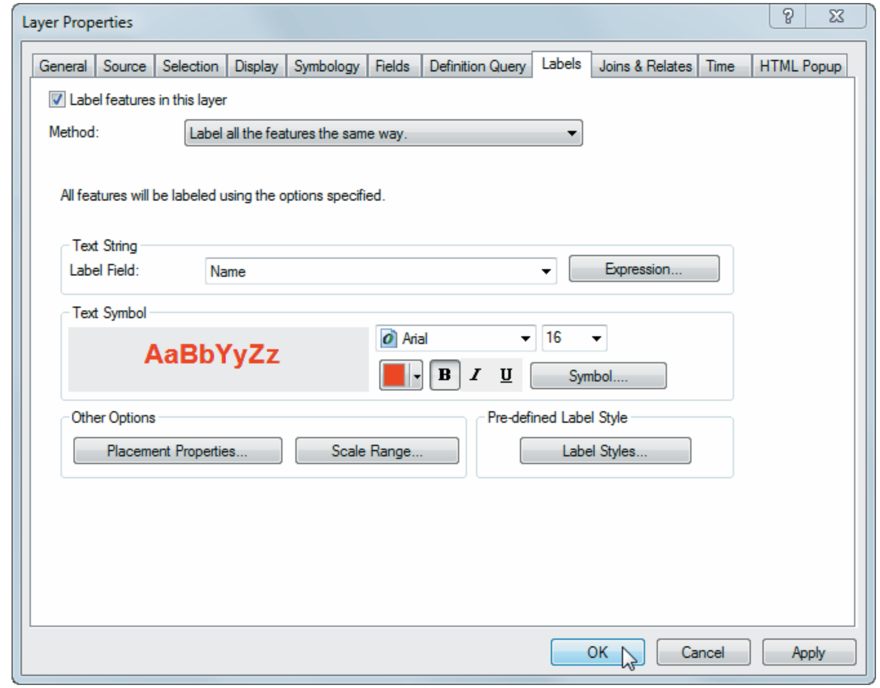


Figure 7-76

40. You should explore and become familiar with the options in the tabs under Layer Properties, especially Source, Display, Symbology, and Labels. If you get stuck, do a search using ArcGIS help or press the F1 key to open the Help screen.

41. Another option for your base layer, if you have a good Internet connection, is to use data from ArcGIS Online. You should have a backup in your MED in case your Internet connection goes down, but there are some very good basemap options online including aerial imagery, hybrid, road maps, physical,

terrain, and topographic basemaps. If you want to try this, click **File > Add Data > Add Basemap** and select any map you like (try National Geographic for something different or USA Topo if you are looking for a DRG replacement).

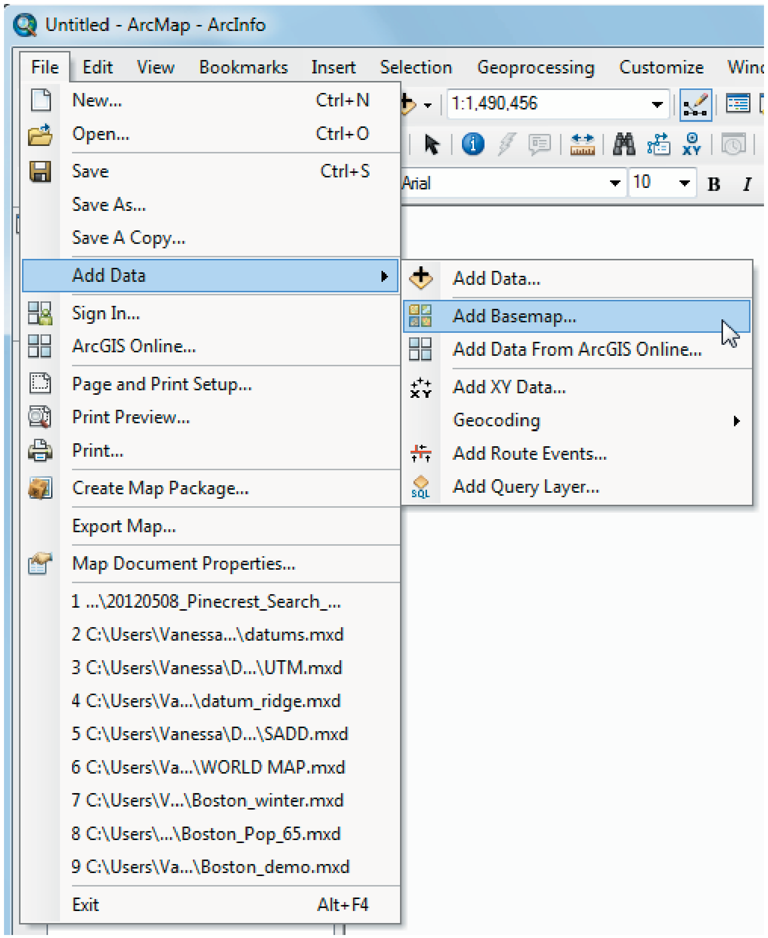


Figure 7-77

Figure 7-78

42. If you can't see your newly added basemap (which may take a few seconds to load—be patient), you need to turn off the DRG and hillshade layer visibility by unchecking the check boxes to the left of the layer name.

43. A field team has drawn its travels for the day on a paper map, and you want to include this on your map. First you need to create a file to store this data in. Open ArcCatalog (**Programs > ArcGIS > ArcCatalog** from the Start menu on your computer or from a shortcut).

44. Navigate to the **C:\7_ArcGIS_Ex_Data** folder and click **7_Incident_Data.gdb** in the left Catalog Tree window. On the right **Contents** tab, right-click in the white space and select **New > Feature Class**. You are creating a new location to store this team's search data within your incident data geodatabase.

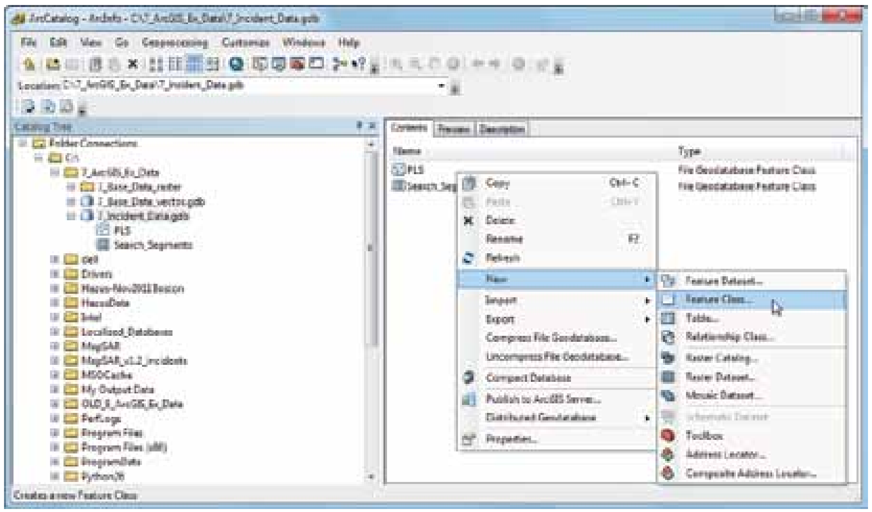


Figure 7-79

45. In the **New Feature Class** window, enter **Team_Track_Drawn** in the **Name** field (during an incident, you want to follow the proper naming conventions, including the date, type, and who collected the data, in the format yyyymmdd_type _personsname_trk/wpt). Change the **Type** field to **Line Features**.

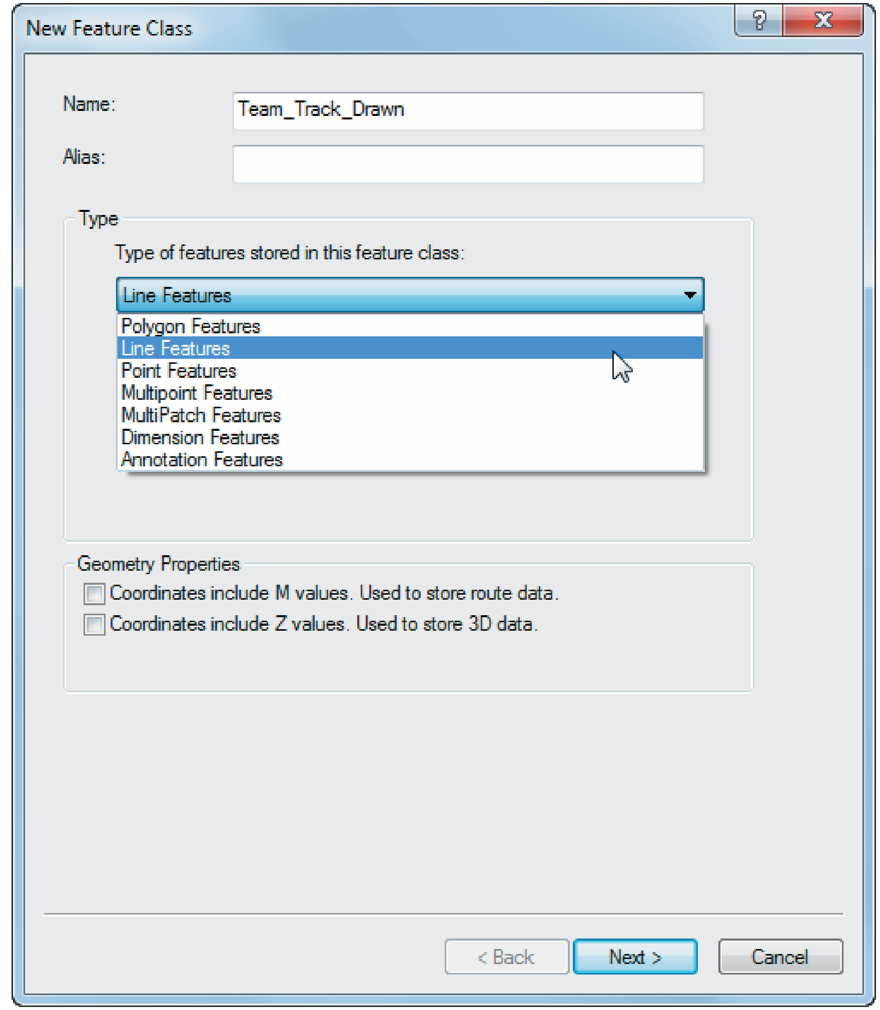


Figure 7-80

Click **Next**.

46. You want to make sure your data is in the exact coordinate system as the others, so import that information from another file instead of manually choosing your coordinate system. Click the **Import** button. Browse to the **7_Incident_Data.gdb** location and select **Search_Segments** as the data whose coordinate system you will copy. Click **Add**.

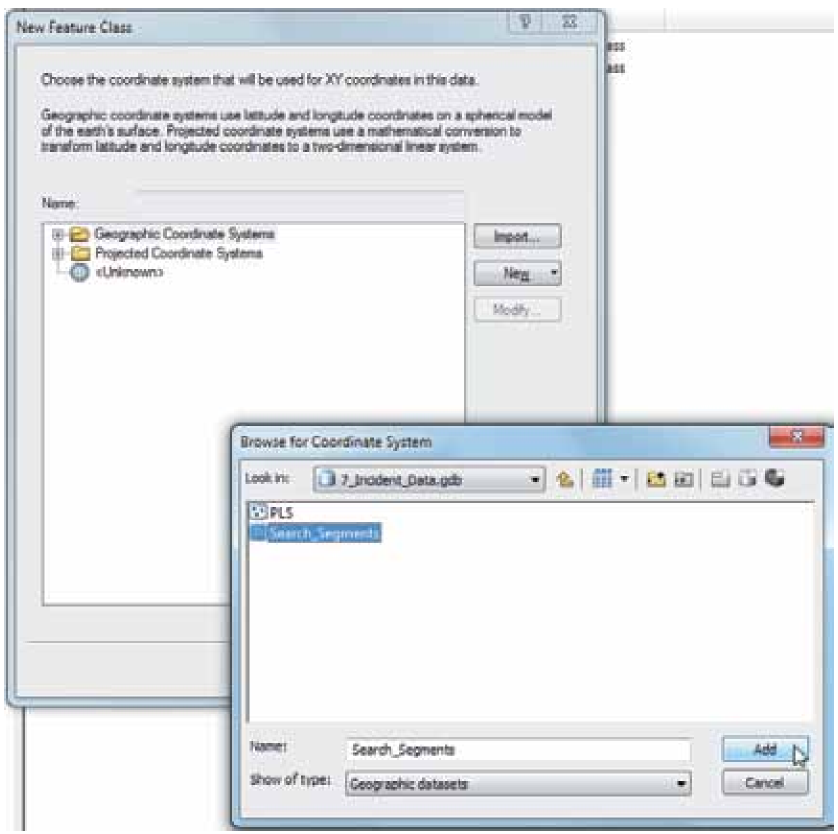


Figure 7-81

Note that the Name field will now read NAD_1983_UTM _Zone_11N. **Click Next**.

47. Click **Next** to accept the default XY Tolerance. Click **Next** again to accept Default storage configuration. Click **Finish** to accept the default fields.

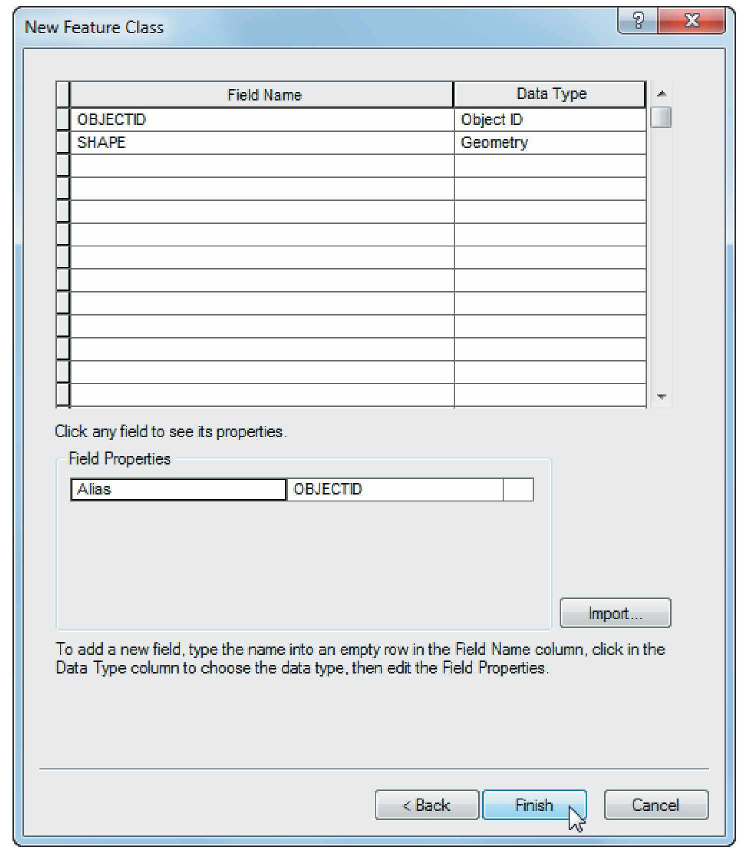


Figure 7-82

48. You will now see a new feature class on the **Contents** tab in ArcCatalog.

Figure 7-83

49. To add it to your ArcMap document, you can either use the **Add Data** tool or just select the Team_Track_Drawn feature class and drag it over to ArcMap.

50. You can close ArcCatalog now.

51. In ArcMap, change the symbology for your newly added Team_Track_Drawn layer to something you can see—purple with a width of 2, perhaps.

52. Click **Editor > Start Editing**. Select **Team_Track_Drawn** and click **OK**.

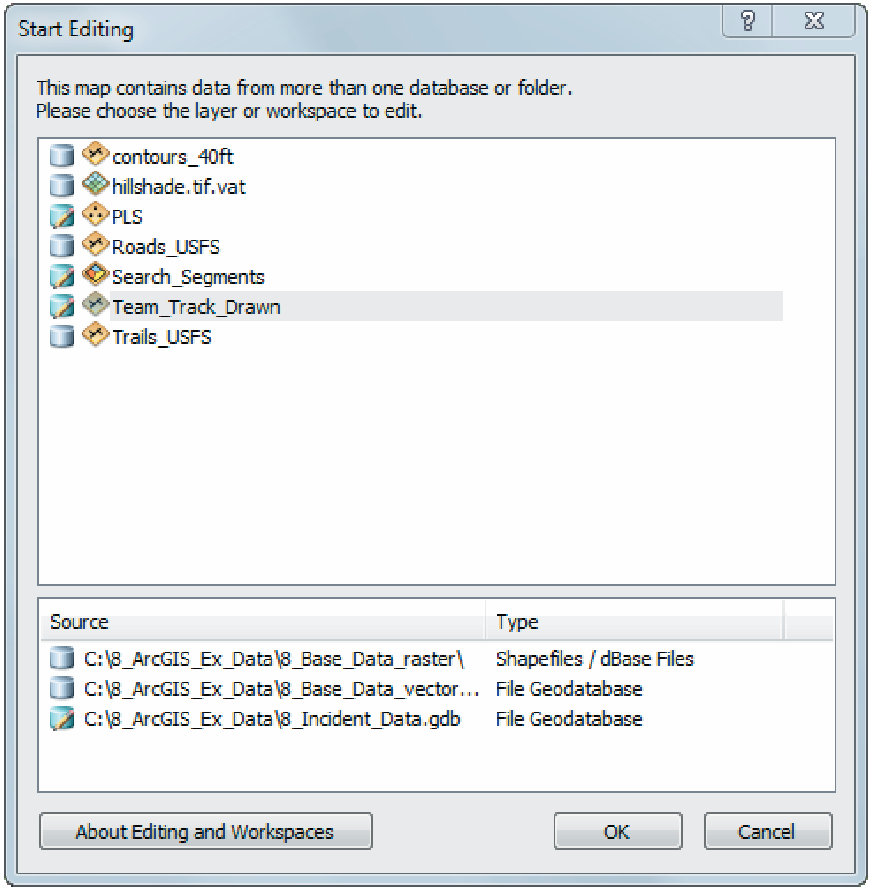


Figure 7-84

On the right side of the interface in the **Create Features** panel, if there isn't a template for the Team_Track_Drawn layer, click the second icon (Organize Templates).

53. Highlight **Team_Track_Drawn** in the **Layers** panel and click **New Template**.

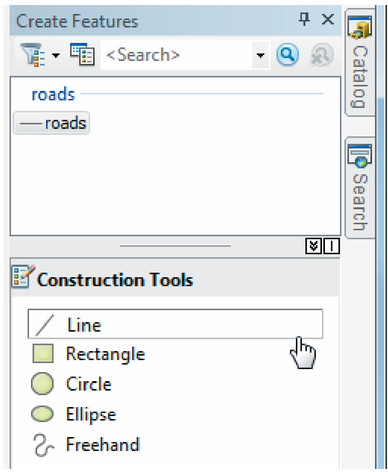


Figure 7-85

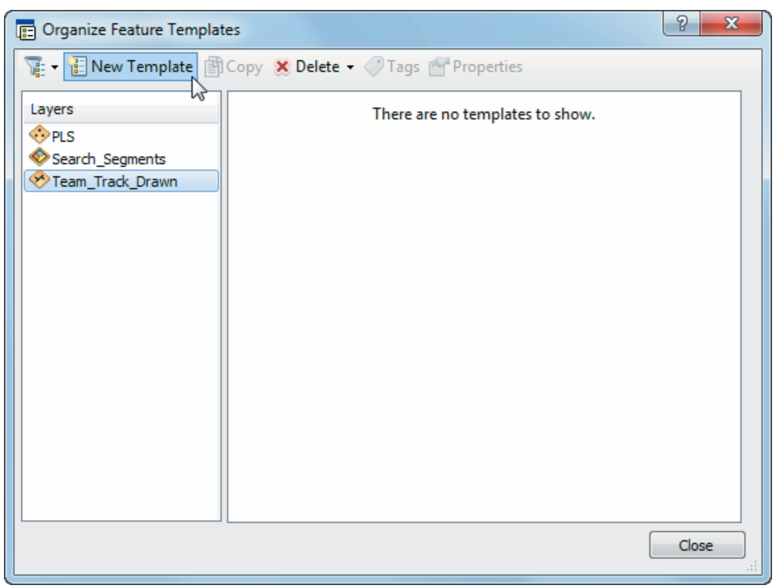


Figure 7-86

54. Check the box next to **Team_Track_Drawn** and then click **Finish**.

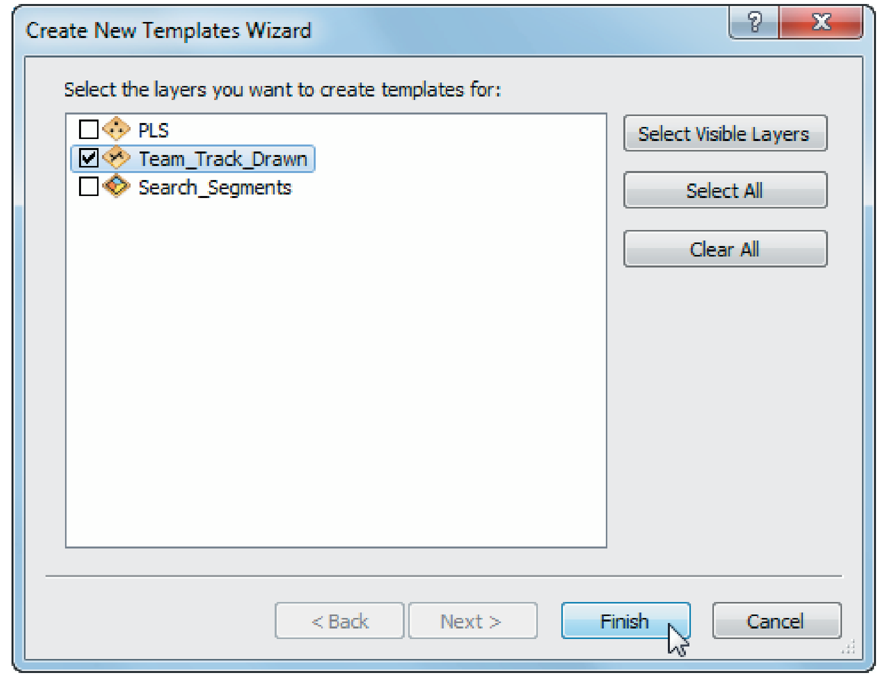


Figure 7-87

55. Click the **Close** button in the **Organize Feature Templates** window.

56. **Team_Track_Drawn** should now be listed in the Create Features panel. Click it, and Construction Tools will appear. Select **Freehand**.

57. With the **Freehand** tool selected, you will be able to draw directly on the map. Focus on search Segment A and practice drawing freehand to follow a route a search team might take, following roads, creeks, ridges, and other features. If you make a mistake, simply use **Control + Z** or the **Undo** tool. Until you save, you can use **Control + Z** to undo each drawn line in sequence. This is a good way to practice with the freehand tool until you get a feel for it.

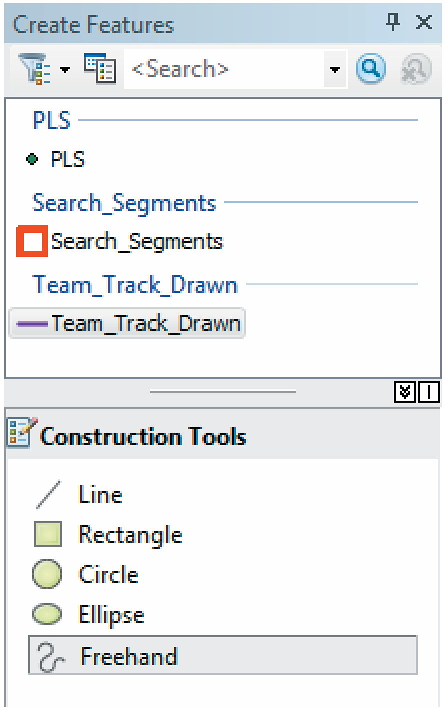


Figure 7-88

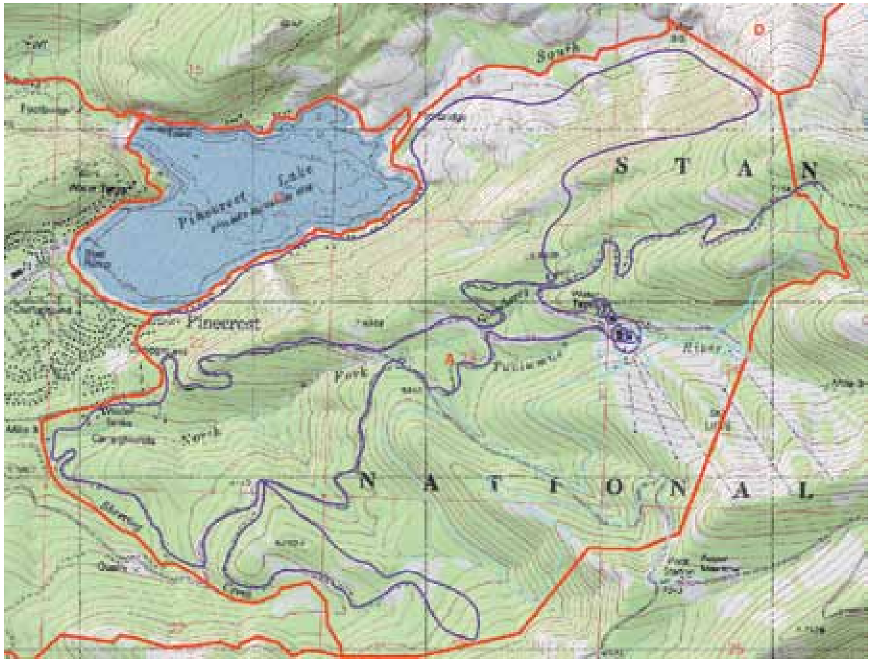


Figure 7-89

58. Once you are happy with your team tracks, click **Editor > Stop Editing** and, when prompted, click **Yes**. If you are doing complex editing, a good practice is to occasionally save your edits through **Editor > Save Edits**.

59. You're ready to put the finishing touches on your map and layout, so you need to switch to layout view. Click **View > Layout View** at the top of the screen.

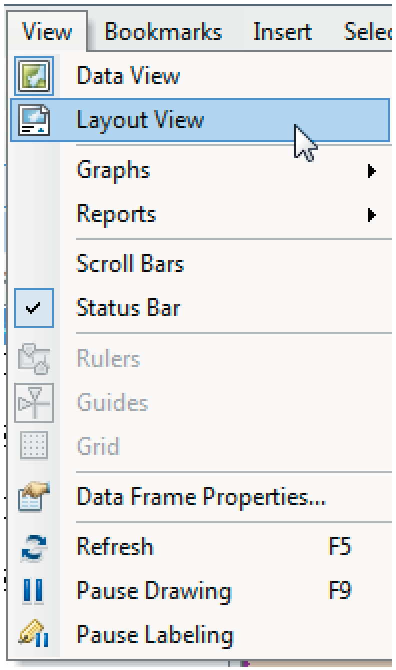


Figure 7-90

60. For this particular map, you want to focus on Search Segment A. It is a bit wider than it is taller, so you should use a landscape setting. Click **File > Page and Print Setup**.

61. Select the printer you would use to print this map. Under the **Comments** field, click the **Landscape** button and click **OK**.

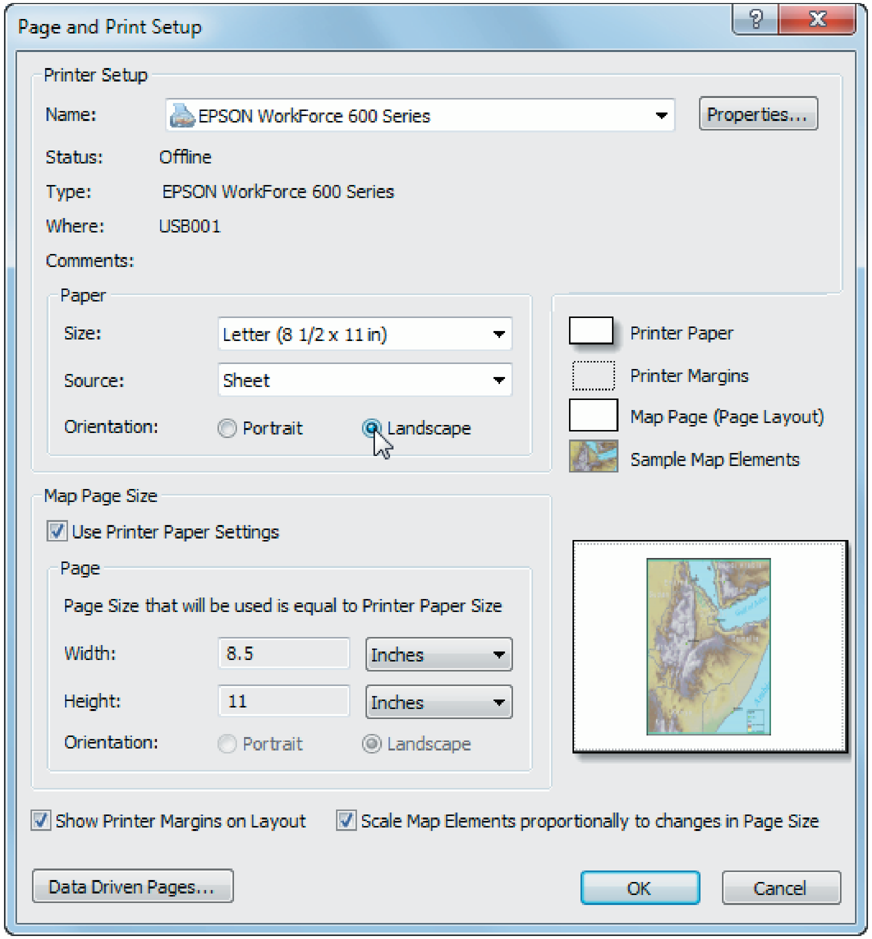


Figure 7-91

62. Your map doesn't fit in your print area anymore, so resize it to fit into the landscape layout using the **Select Elements** (black arrow) tool. Leave some space at the top for a title.

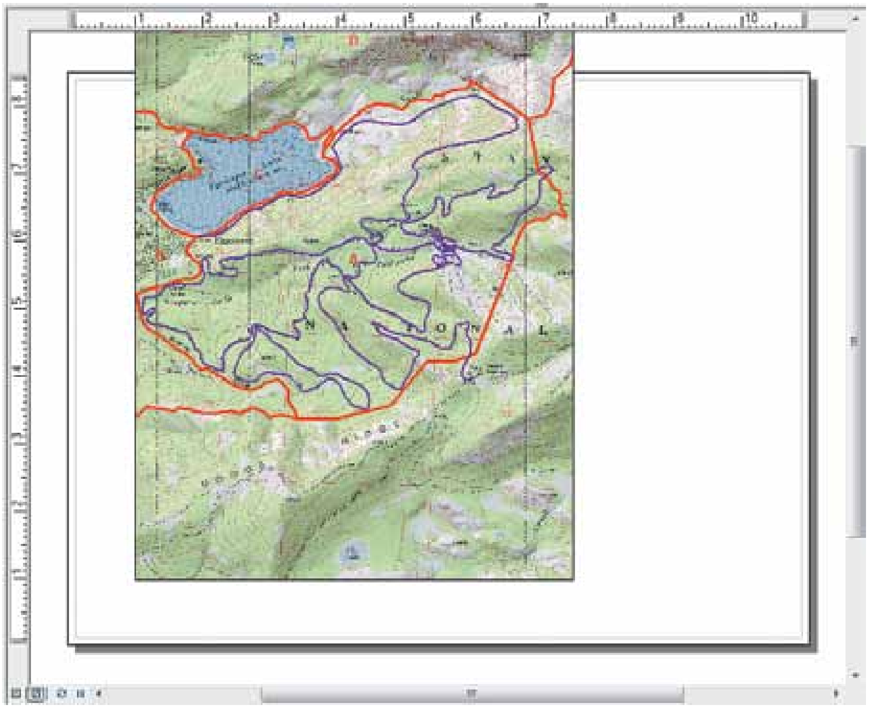


Figure 7-92

63. Use the zoom and pan tools to position the map with a focus on Search Segment A.

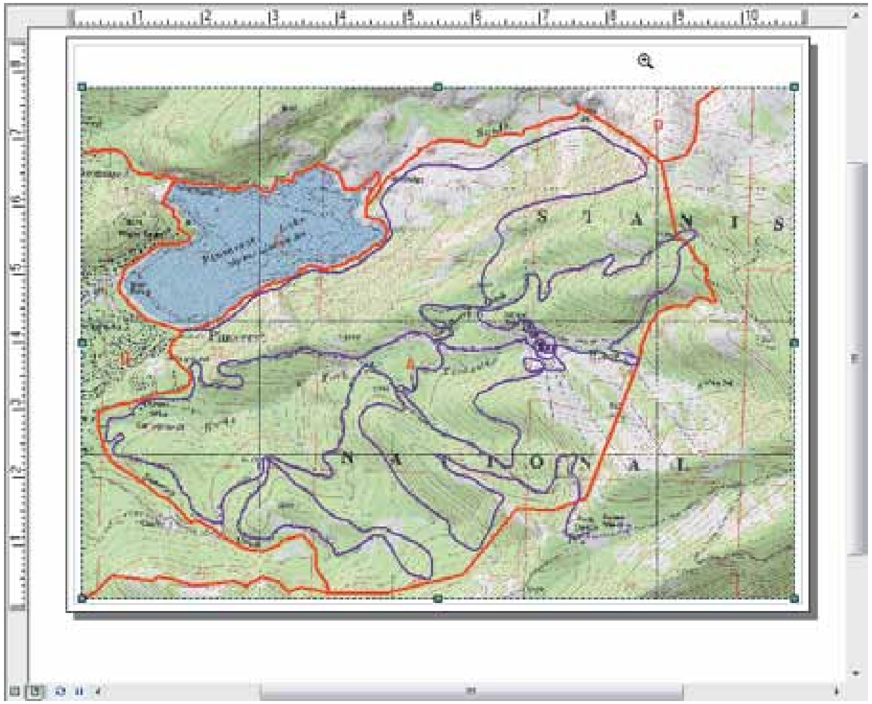


Figure 7-93

64. Use **Insert > Text** or **Title** to add a header to your map. Type a name and close it. Change the font, size, or color by double-clicking the text box.

65. Using Insert, you can add additional elements such as text, a legend, north arrow, and scale bar to your map (remember STANDD on page 137). They'll be inserted as graphics, which you can then drag to position where you want them.

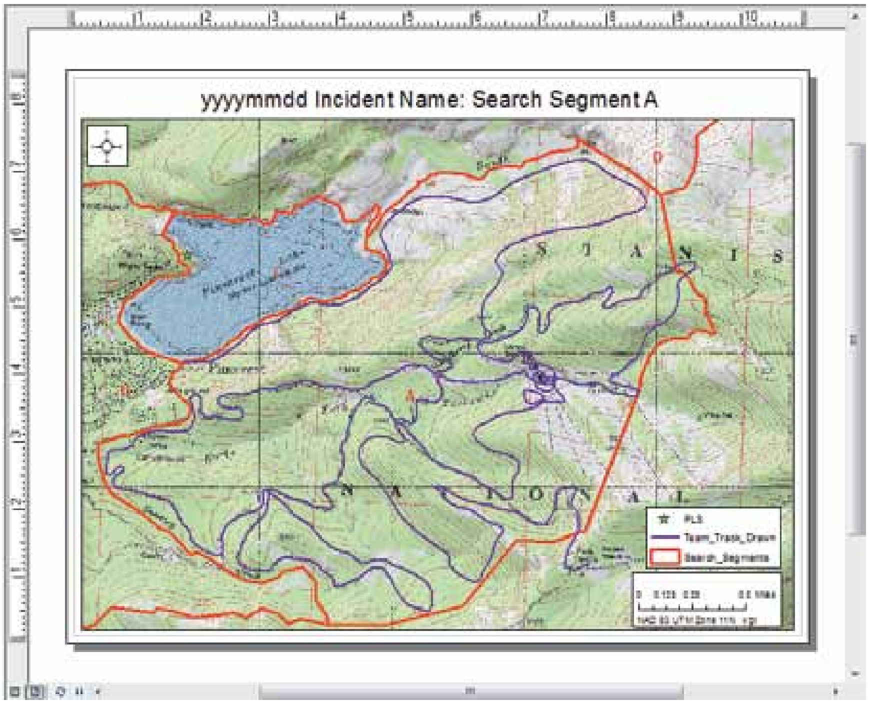


Figure 7-94

66. You should be all set to print now after double-checking your settings. Click **File > Print** and check everything.

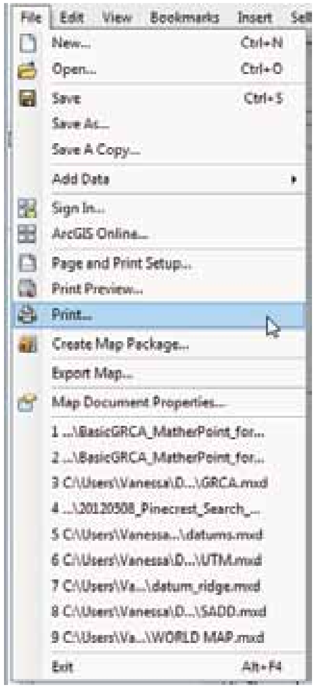


Figure 7-95

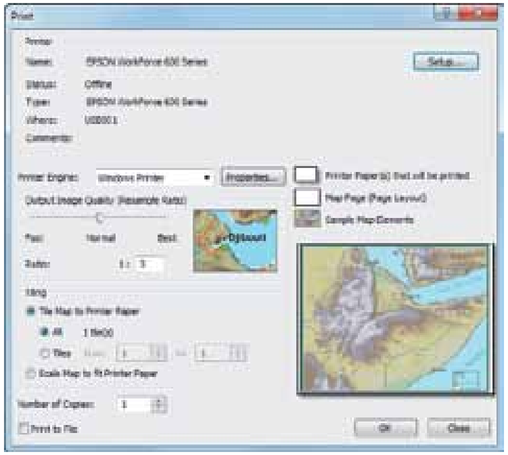


Figure 7-96

And there you have it—your first mapmaking experience!

Chapter 8: Overview of MapSAR

MapSAR works with ArcGIS 10 to help organize spatial data in a standardized format that fits the existing SAR workflow and helps get search teams out the door quickly, with maps in hand. Generally, MapSAR is for large-scale incidents lasting longer than a single operational period where the amount of incoming and outgoing information can accumulate and become very complex. Anyone can learn how to use MapSAR, but it takes practice. The time to learn is *not* during an incident. A GIS specialist may have less of a learning curve for MapSAR, but many non-GIS team members are now using it proficiently. The concepts in the previous ArcGIS chapter laid the foundation for using this tool. However, The *MapSAR User's Manual* is dedicated to the explanation of the intricacies of this tool, which can be downloaded from mapsar.net. This chapter will simply provide an overview of MapSAR and an introductory exercise.

MapSAR works with ArcGIS 10 or later, at any license level. Refer to the previous chapter, "ArcGIS 10 for Desktop—A Basic Introduction," for the hardware and system requirements for ArcGIS 10. You can use MapSAR anywhere, with or without an Internet connection. If you choose to use it (or ArcGIS) without an Internet connection, you will need to store all your data on your computer (or network) rather than using basemaps or datasets online. It is good practice to always have some version of the data you need on your machine anyway, as unforeseen circumstances can cause already established network and Internet connections to go down during incidents at the most inopportune times.

For a large-scale incident, it is strongly recommended that the MapSAR user not also be responsible for downloading GPS tracks from incoming field teams. This can cause a delay in the workflow. It's best to train other team members to download GPS tracks on a separate machine from the one running MapSAR, and then transfer this data to the MapSAR machine once all downloads for the time period are completed (or there is a lull in activity).

In this chapter, we'll start with where to get MapSAR and how to install it, and then provide a basic introduction to the structure and layers used for the tool in ArcGIS. Once you complete these steps, you can explore it during the file structure section below. If you aren't prepared to complete the installation now, you can read through the sections and get a sense of what to expect when you are ready to use MapSAR.

MapSAR Download Instructions and Installation

The following steps and file structures are correct at the time of publication but may change over time as MapSAR is updated. We will try to update the e-book version of this document to keep up with the changes as they occur.

Installation and Setup

1. Download: Go to mapsar.net or use the enclosed CD and download the MapSAR.zip to your C: drive.

2. Extract: For this step, you can use any compression tool you already have installed or prefer. Note that MapSAR compressed file is in .zip format, so WinZip is a good option. You can download it at winzip.com.

   a. Use the extraction utility to extract the MapSAR.zip package and place it at the root of your C: drive. You should have **C:\MapSAR** and the folder structure shown in figure 8-1.

      It is critical that you have the **MapSAR** folder on the root drive (**C:**). Several MapSAR functions use the **C:\MapSAR** path as a reference, and the tool will not run correctly if the path is different.

      i. For easy access to MapSAR, make a shortcut of **C:\MapSAR** and place it on your desktop.

         (a) To create a desktop shortcut, from Windows Explorer, right-click the **MapSAR** folder, choose **Send To**, and then choose **Desktop Shortcut**. An icon will be placed on your desktop that will take you to the MapSAR folder.

   After extracting MapSAR.zip, you should see this file structure (figure 8-1).

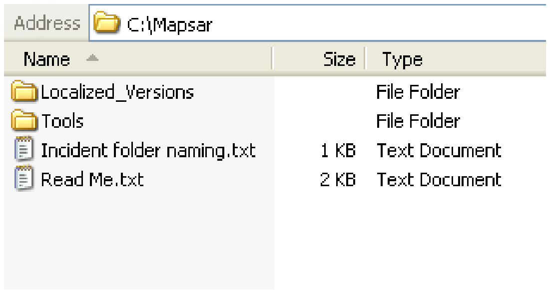


Figure 8-1

3. Install Add-ins.

   a. Open the **Tools** folder (C:\MapSAR\Tools).

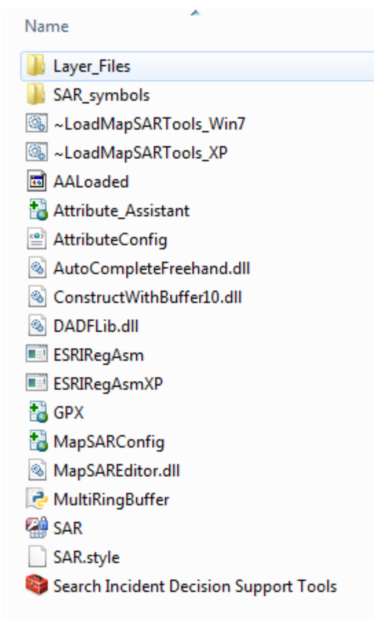


Figure 8-2

b. If you're running Windows 7, right-click the **~LoadMapSARTools_Win7** batch file and select **Run as administrator**. Windows XP users should simply double-click **~LoadMapSARTools_XP**. This process registers all the necessary drivers (DLLs) and installs the add-ins used throughout. If any "failed to install" messages occur, they need to be corrected prior to using MapSAR.

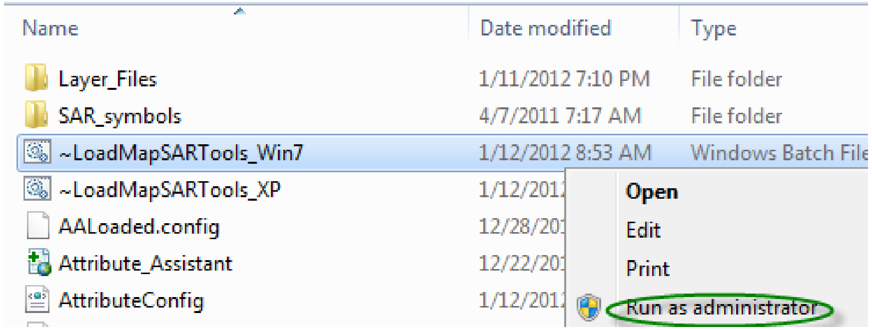


Figure 8-3

i. Click **Yes** if asked if the Windows Command Processor can make changes to this computer.

ii. You'll get several dialog boxes. Click **OK** or **Install Add-In** when prompted.

4. UTM Zone: Determine the UTM zone you will be working in. This is very important because projecting data from one zone into a project template set for another can result in serious distortion and measurement errors. This is also covered in *The MapSAR User's Manual*, MapSAR First Time Setup > Customizing and Opening MapSAR.

   a. UTM zones can be found at http://www.nps.gov/gis/gps/UTM_Zones_USA48.jpg.

   b. Copy the appropriate UTM_xx_New_Incident.zip (based on your zone) from the Localized_Versions folder on the C:\MapSAR directory.

5. Opening MapSAR: To start a new search incident, you'll need to extract the **UTM_xx_New_Incident.zip** file for each new SAR incident, rename the New Incident folder, and add your incident data.

   a. Open the **MapSAR** folder. Again, it is critical that MapSAR is located at the root of your **C:** drive or else it won't run correctly.

i. To extract the UTM_xx_New_Incident.zip (that you just copied to C:\MapSAR), right-click on it and select **Extract to folder C:\MapSAR\UTM_xx_New _Incident** as shown in Figure 8-4.

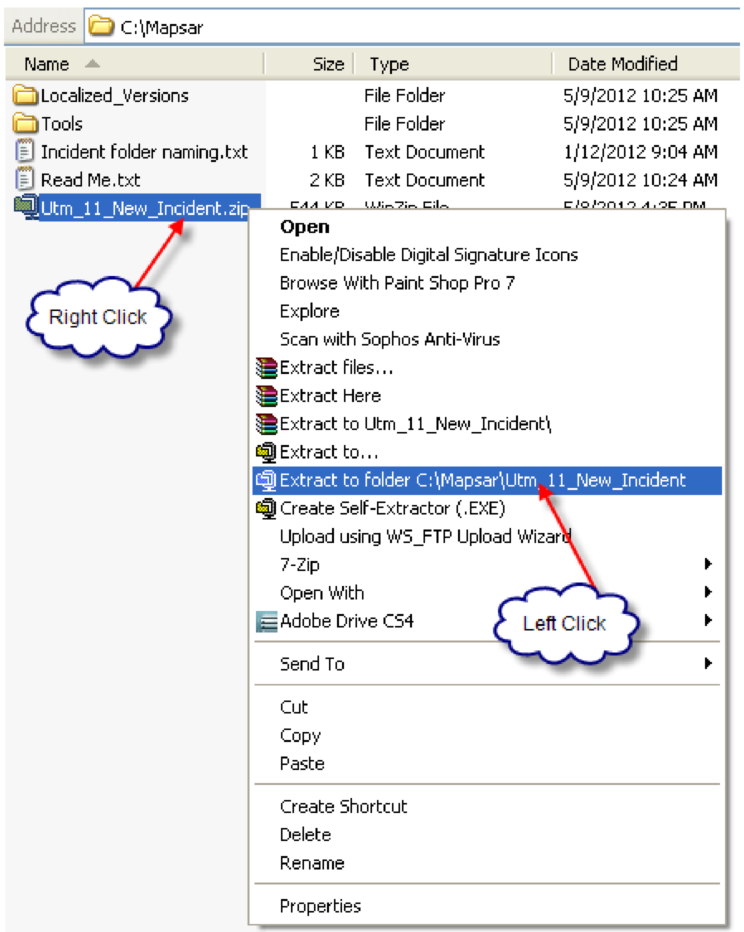


Figure 8-4

ii. If you're creating a search incident, rename the folder from UTM_xx_New_Incident to the following standardized incident naming protocol: yyyymmdd _IncidentName. If this is just the initial setup and you're not running an exercise or actual SAR, you can leave the folder named as UTM_xx_New_Incident. Note that there's also a file called **Incident folder naming.txt**. This reminds you of the file naming convention to use for a new folder.

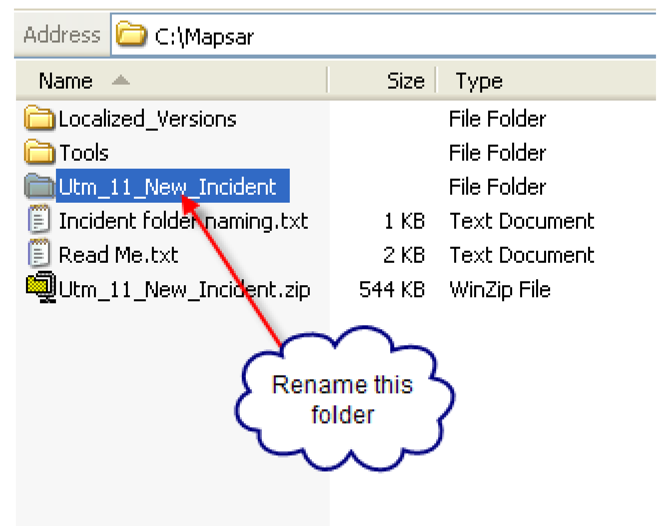


Figure 8-5

iii. Open the incident folder (renamed above).

iv. Double-click **MapSAR**. This starts ArcGIS 10 and opens to the new incident.

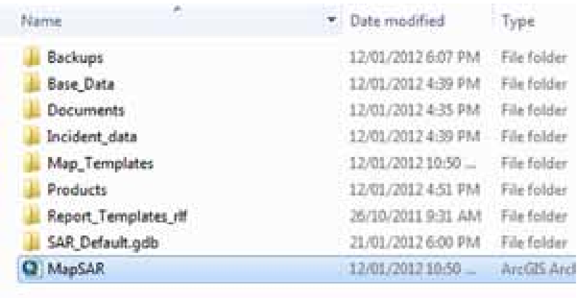


Figure 8-6

b. The initial view of MapSAR—The window size will vary depending on the size of your monitor.

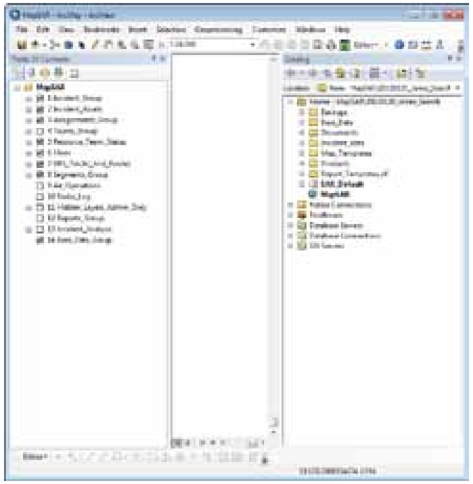


Figure 8-7

i. Verify that SAR.style is available:

(a) Select the **Customize** menu and **Style Manager**, click **styles > Add style to list**, and navigate to **C:\MapSAR\Tools\SAR.style** > **Open** > **OK** > **Close**.

ii. Set the correct Azimuth for editor:

(a) Click **Editor** > **Options**.

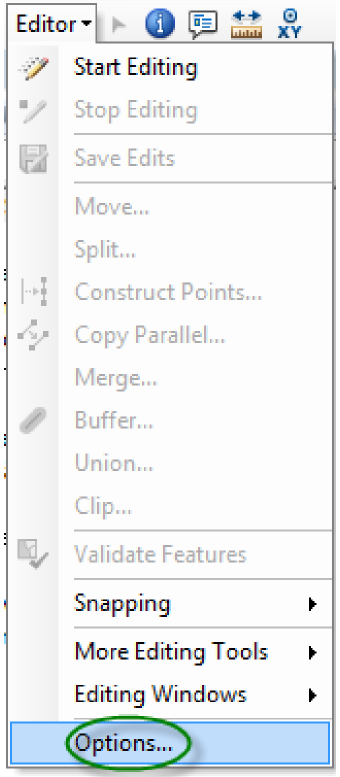


Figure 8-8

(b) On the **Units** tab, change the **Direction Type** to **North Azimuth** and **Directional Units** to **Decimal Degrees** and set the Display angles using 0 decimal places. Click **Apply** > **OK**.

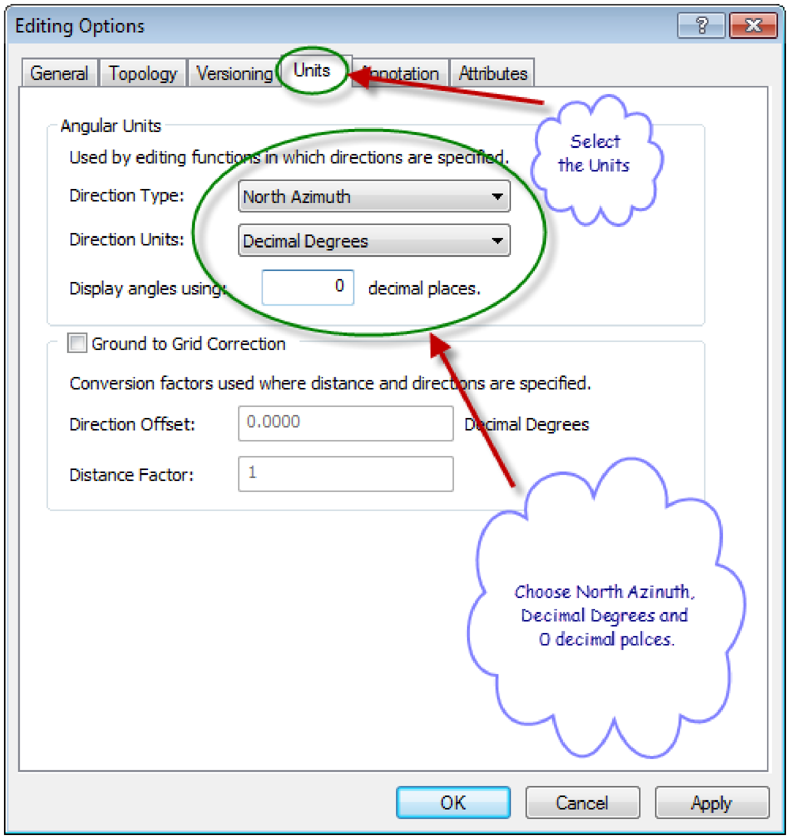


Figure 8-9

iii. Save changes to the .mxd file.

There are some additional, optional steps in *The MapSAR User's Manual* that may be helpful for you to complete if you plan on using MapSAR to its fullest potential.

The MapSAR User's Manual includes useful sections on creating bookmarks, troubleshooting, and advanced features. We also recommend that MapSAR users read *The MapSAR User's Manual* for a more thorough explanation of how the tool works and different functions. However, for an introduction to MapSAR, to get a feel for how it works, and to run this exercise, it is not necessary to complete those steps.

MapSAR Toolbar

When you open MapSAR, the interface is slightly different from what we saw in ArcMap. What the developers decided to do was take all the ArcMap tools you would use most often and put them onto one toolbar, discarding all the other tools to reduce clutter and confusion. The intention is that you do not need to be an ArcMap guru to use MapSAR. But, if there is a toolbar you want, it's still available by going to **Customize > Toolbars** and turning that particular toolbar back on.

The MapSAR toolbar is very long, so here is what it looks like, broken up into three sections:

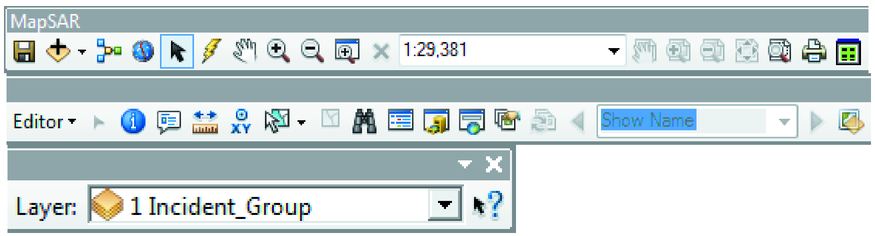


Figure 8-10

Most of the tools look familiar, but there are a few new ones. Important to note is the third button from the far left, called Update Domains, with the blue, yellow, and green small squares. This is used after you have edited or changed data and stopped editing. You then want to update all the information you just entered and basically feed it to the other linked datasets to fill in and update. The tool to the right of this is called GPX Importer (earth with a red track) and makes importing GPX files (from GPS units) very easy. You will become more familiar with these tools during the exercise portion of the chapter.

Overview of MapSAR Folders

The UTM_xx_New_Incident folder is renamed according to the naming conventions and specifics of your SAR, as explained in step 3.a.ii) in the previous section. This folder contains the working data model and is where all data created from the SAR should be stored. We recommend that you keep everything associated with an incident inside this single folder, so it can be easily archived when completed.

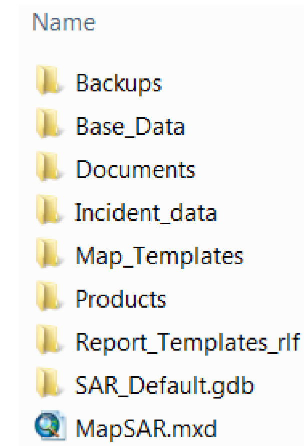


Figure 8-11

Review the folders in the UTM_xx_New _Incident folder and what the purpose of each is:

- **UTM_xx_New_Incident:** Rename to yyyymmdd_incident_name (e.g., 2012_SearchForBilly), where yyyy = the year the incident started, mm = the month, and dd = the day, plus an underscore and the incident name.
- **Backups:** Folder to store and back up copies of the database, map documents, or files. This is very important. You don't want to lose your work in the event of a computer glitch or human error. It's good practice to make sequential backups of the SAR_Default.gdb every few hours during an incident. This also allows you to start over from a known working point should data get badly corrupted.
- **Base_Data:** Base data not created on the incident. Note that your base data (MED) is not required to be here for MapSAR to run properly. Other considerations, such as data duplication or network structure, may cause you to have it elsewhere, though used during the incident.

- **Dem:** Digital elevation model data and derived products
- **Logos:** Agency logos, typically in nongeospatial raster format such as a .jpg
- **Orthoimagery:** Ortho-corrected imagery
- **Other_maps:** Scanned maps such as visitor or district maps
- **Topo_maps:** Scanned USGS quad maps known as DRGs
- **Vector:** Vector data file types such as roads and trails

Note: If you work in the same area regularly, it would be more efficient to make a primary base data folder in C:\MapSAR\Base_Data and store all your local base data there. If you store your MED in C:\MapSAR\UTM_xx_New_Incident|Base_Data, you'll end up duplicating it for each new incident. This works if you work a lot of incidents over a wide geographic area that you're not likely to go back to. But if you work in one general area, C:\MapSAR\Base_Data is likely your best location for much of your MED. Another thing to keep in mind with this approach is that if you are working with others on an incident and package your MapSAR data up to share with them, you will also need to bundle that other base data folder you create.

- **Documents:** These are spreadsheets, text documents, radio logs, digital photos used on maps, and others.
    - **ICS Docs:** These contain basic ICS templates that can be edited in Microsoft Word.
- **Incident_Data:** This is data created during the operation, stored by date or operational period.
    - **GPS:** Contains GPX files such as track logs and points, organized either by date or operational period. A best practice is to create a new folder per day for each day's team GPS track logs and waypoints.
    - **Modified_Base_Data:** This is base data edited for the incident (i.e., roads, trails, ownership, and structures that have been altered in some way).
    - **Photos:** These are photos taken during the incident organized either by date or operational period and team.
- **Map_Templates:** This is where the templates for other map sizes are stored.
- **Products:** Contains GIS product files produced during the incident, such as assignments and briefing maps, organized either by date or operational period and usually in .pdf, .jpg, or .tif format. These can include assignment, briefing, PIO, situation, and air operations maps and any other map types your incident may need to be successful.

- **Report_Templates_rlf:** A selection of templates available for you to use as is or modify to suit your needs. Note that these are .rlf files, which identifies them as ArcGIS templates.

- **SAR_Default.gdb:** Don't open or mess with this folder. Bad things will happen. Modifying this folder outside ArcGIS will cause permanent damage to your data.

Overview of MapSAR Structure

MapSAR utilizes both search assignments and search segments. Many teams use search segments as the central organizing structure of a SAR. Segments do not change during a search. Central to MapSAR, though, is the concept that assignments are unique. Assignments are created once and executed only once. *Every assignment must have a unique assignment number.* Search assignments are meant to be unique and given to a team as its job for that operational period, whereas segments do not change during a search. An assignment may be for a team to thoroughly search only a part of a search segment and can change daily. Assignments were added to MapSAR to provide more flexibility. Many SAR teams only use search segments and use these as their teams' assignments. If this is the case with your incident, you can simply use the assignments and ignore the Search Segments layer. Your assignment becomes, in effect, your segment.

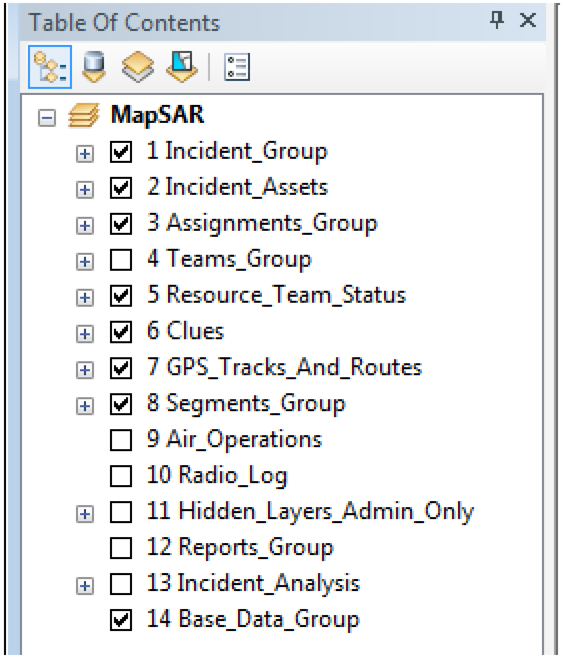


Figure 8-12

The MapSAR structure consists of several numbered layers or groups, and we suggest you open MapSAR and explore the layers while you read through this section.

Some of the data in MapSAR is organized and stored in a geodatabase with specific relationships established between different data. You don't need to think about or understand these connections because they go on behind the scenes. But if you're an advanced user of MapSAR, you can alter these relationships or tweak the data structures to meet the needs of your team.

MapSAR Table of Contents

MapSAR has the simplicity to be used on small searches to keep track of hasty search teams, but it also has the capability of running multiday mutual-aid SARs covering large areas. As your needs expand, more data layers can be added, and you can begin using different tables, such as Assets, Teams, or Air Operations.

1. **Incident Group**

   This group includes Reporting Party (RP), Subject, PLS, the timing of the Operational Periods, and the Communications Plan. For small searches, this information is optional and not required for MapSAR to function but, at a minimum, the PLS should be well documented. For the most part, this layer contains text data; the only data in this layer that is mapped—that is geospatial in nature—is the PLS and the location where the subject was found.

2. **Incident Assets**

   Incident assets refer to geospatially located assets such as the locations of the Incident Command Post (ICP), Helibases, Staging, Medical Station, etc. For small searches, this information is optional and not required for MapSAR to function.

3. **Assignments Group**

   The assignments group stores information on where field teams are assigned to search. Note that we differentiate between search Assignments and search Segments. A segment may be searched more than once, but each assignment given to a field team is unique. For small searches, where the teams are staying on trails, roads, or streams, creating assignments by drawing a squiggly line on the map is extremely easy. If desired, MapSAR will automatically draw a buffer around the line that represents the trail/road/stream/etc. to show the effective sweep width. If it is a larger search, the assignments may be general areas whose boundaries might consist of logical terrain segments separated by, for instance, rivers, trails, roads, or ridge lines.

4. **Teams Group**

   This layer stores information about who is in the field, which team they're with, what kind of a team they're on, what their radio call sign is, etc. For small searches, this information is optional and not required for MapSAR to function. For larger searches, though, it's a very useful tool for keeping track of personnel. It's important to remember, though, that it's not the most efficient use of resources to have the user completing check-in of personnel. That task is best handled by Logistics.

5. **Resource Team Status**

   This layer is used to plot points showing the locations of field teams. Different symbols are used to indicate whether the team is on assignment, hunkering down for the night, awaiting pickup, etc. As with many included features, MapSAR will still function properly if you choose not to enter this information.

6. **Clues**

   MapSAR uses different symbols for different clue types. Physical clues, such as a water bottle, use one symbol; cell phone hits use another; and the Direction Finder signal strength symbol from a cell phone ping yet another. For physical clues, different colors are used to signify the initial evaluation for its relevance. This evaluation, of course, can be changed at any time as more information is developed. Even on small searches, being able to place clues on the operations map is extremely useful.

7. **GPS Tracks and Routes**

   This is where track logs from various resources are stored. To make the map more readable, track logs from field teams and aircraft can be turned on or off separately.

8. **Search Segments**

   Once the search becomes large enough that you need to create segments, this tool becomes invaluable. Several drawing tools are available to simplify the task. In addition to simple geometric shapes and freehand tools, there are also auto-complete tools that will use the edge of an existing search segment as the boundary of the one you're currently drawing—no more need to trace over an existing line, and no more sloppy boundaries between segments.

9–13. **Other Layers**

These layers consist of primarily text-based information:

- The **Air Operations** layer (9) is a table that keeps track of deployments and extractions where air assets are used.
- The **Radio Log** (10) can be used to store radio traffic data that has been tabulated elsewhere. You don't want the MapSAR technician to get bogged down keeping the radio log, but if the SAR dispatcher keeps a running log in a spreadsheet, the data can be easily imported into MapSAR for later review and archival purposes.
- **Hidden Layers** (11) are hidden to prevent the user from accessing them. These are necessary for MapSAR to run, but unless you're a GIS expert, ignore them.

- The **Reports Group** (12) also requires no user intervention; its presence in the TOC simply allows the reporting templates to draw data from the other items.

- The **Incident Analysis Layer** (13) is used to draw circles on the map denoting typical distances traveled by different types of missing subjects. It is also used to define the outer limits of the search area and thus define the rest of the world.

14. **Base Data Group**

    This is where additional basemap layers are stored. For example, if you want to add aerial photos or overlay a USDA Forest Service (USFS) map onto your topo map, this is where the additional layers would be placed. Since this type of information covers a wide area, it is important that they be located near the bottom of the layer stack. If you put them near the top, they will hide the underlying layers, and make things like clues and search segments invisible.

    - **Basemap.** For all searches, a basemap layer is needed. This most often consists of a digital USGS quad of the search area. As the name implies, the basemap is placed as the bottom layer, with other data layers over it. For small searches where only limited resources are used and documentation needs are minimal, the basemap layer may be all you need.

Exercise 8A: MapSAR

We will build on the chapter 5 "Using ArcGIS Explorer Desktop for Situational Awareness" exercise scenario where little Danny went missing near Pinecrest Lake. We'll start the MapSAR exercise with the second operational period as the search is beginning to ramp up. Because Danny was not found by the end of OP1, incident command has decided more resources need to be called in. Last night, Matt, the team's GIS lead, arrived on scene and began to set up the incident using MapSAR. This morning, you will continue working with MapSAR as the primary incident mapping resource.

1. You will need to install MapSAR to complete this exercise. If you have not already downloaded and installed MapSAR, refer to MapSAR Download Instructions and Installation at the beginning of this chapter for step-by-step directions.

2. From either the CD or mapsar.net, copy the exercise data onto your computer. Extract the 8_MapSAR_Ex_Data.zip and place the 20120508_Pinecrest_Search_Danny folder directly in the C:\MapSAR folder. This is very important. Your C:\MapSAR folder should now look like this:

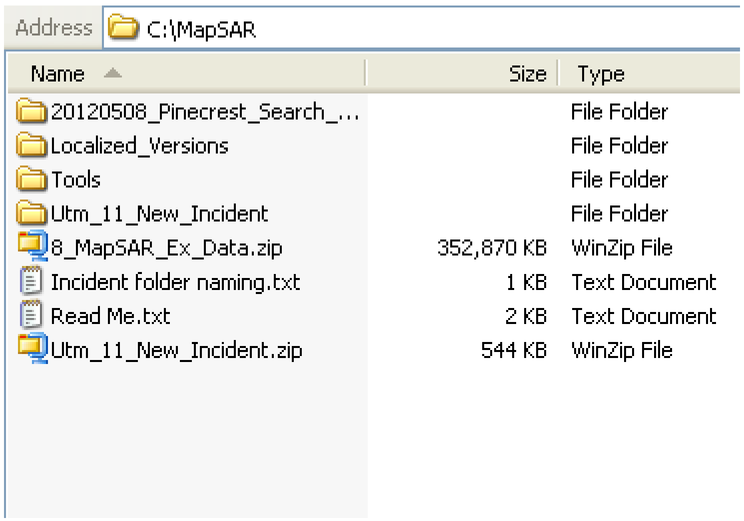


Figure 8-13

3. Open the 20120508_Pinecrest_Search_Danny folder and double-click the **20120508_Pinecrest_Search_Danny.mxd**, and it will open MapSAR. You want to make sure you open MapSAR projects by clicking the .mxd, not by starting ArcMap separately, because you won't have the correct toolbars if you simply open ArcMap. Here is what the MapSAR screen will look like—similar to ArcMap—but some noticeable

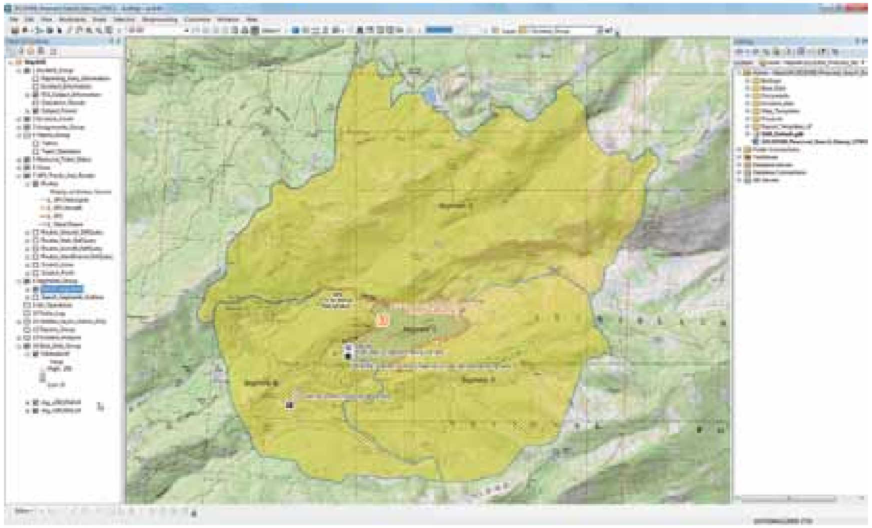


Figure 8-14

differences in the interface and toolbars.

4. For easier navigation to add data files, you'll find it more convenient to work from the **Catalog** pane on the right side of the workspace. To do this, you create a new folder connection. At the top of the **Catalog** pane, click the **Connect to Folder** icon and navigate to **C:\MapSAR** (or whatever folder or drive you want to add). Highlight it and click **OK**. That path is now available in Folder Connections in Catalog.

   Notice that Matt provided you with a dataset to explore MapSAR so that you can get a general idea of how the tool is set up. Look at the group layer 14 Base_Data_Group; if it isn't already expanded, click the plus sign to see the layers that are part of the group. We've provided the DRGs that show the USGS topographic maps for the Pinecrest Lake area. If you have an Internet connection during the incident, you could use a basemap from ArcGIS Online, but remember that though technology is great, you should have a backup plan if it fails.

   Matt also set up the 1 Incident_Group, 2 Incident_Assets, 4 Teams_Group, 7 GPS_Tracks_and_Routes, and 8 Search_Segments for the incident. Take a few minutes and explore the layers that he filled out by right-clicking each layer in the group and opening the attribute tables.

# Team Name	Team Type	Status	Leader	Description	Radio Call Sign
Brown	Ground Team	Not Assigned	Phil Brown	Type 3: Team of 6 with good navigation and communication skills	CR124
Cairo	Ground Team	Not Assigned	Adam Cairo	Type 3: Team of 5 with local knowledge: avid hikers	CR135
Gubler	Ground Team	Not Assigned	Dave Gubler	Type 3: Team of 5 with canyoneering and technical climbing skills	CR3
Westin	Ground Team	Not Assigned	Laura Westin	Type 3: Team of 6 with strong outdoor and water skills	CR29

Figure 8-15

   What you need to do is create a new operational period for today and then set up the three assignments group, add a clue, and print a map.

5. To add a new operational period for today, click **Editor** > **Start Editing**.

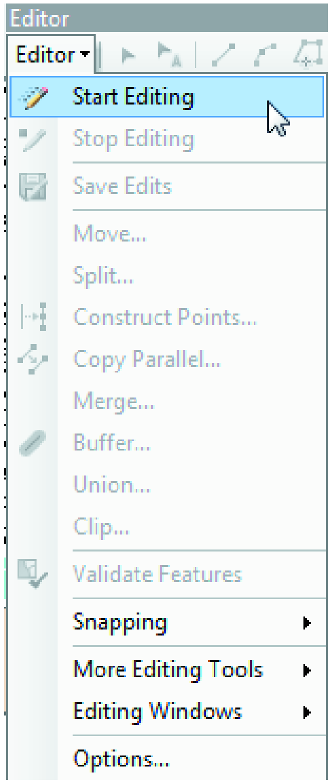


Figure 8-16

The **Create Features** window should automatically open on the right side of the interface. If it doesn't appear automatically, click **Editor** > **Editing Windows** > **Create Features**.

6. The **Start Editing** window will open. You want to edit the **Operation_Periods** layer, so scroll to that and select it. All the data that is in the same location as the data you selected will now show a pencil on the gray database icon to the left of the name. In the **Source** window, the SAR_Default.gdb is also shown as editable. In the future, if you know you're editing data inside this geodatabase, you can simply select the geodatabases in the **Source** window instead of scrolling through all the datasets. Click **OK** to start editing.

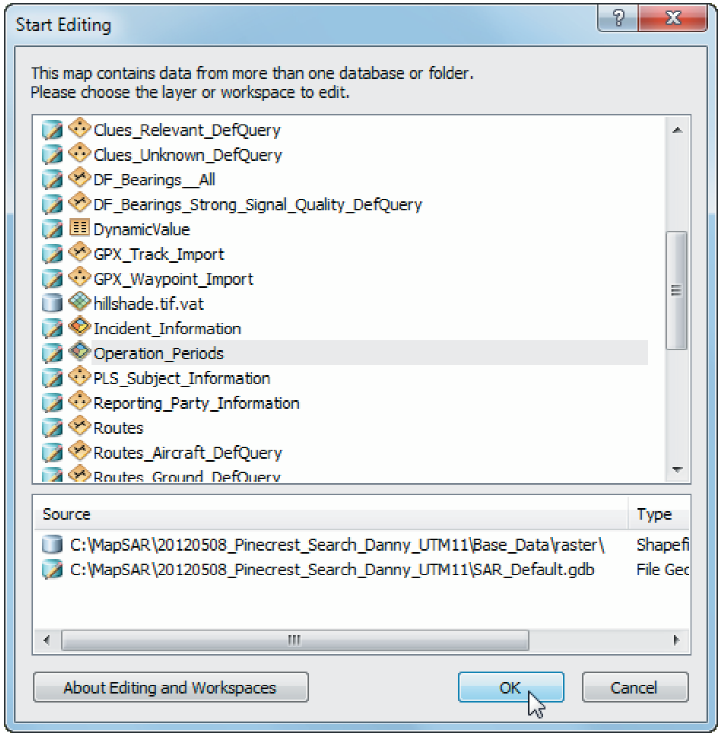


Figure 8-17

7. In the TOC, right-click the **Operation_Period** layer under the 1 Incident_Group and select **Open Attribute Table**.

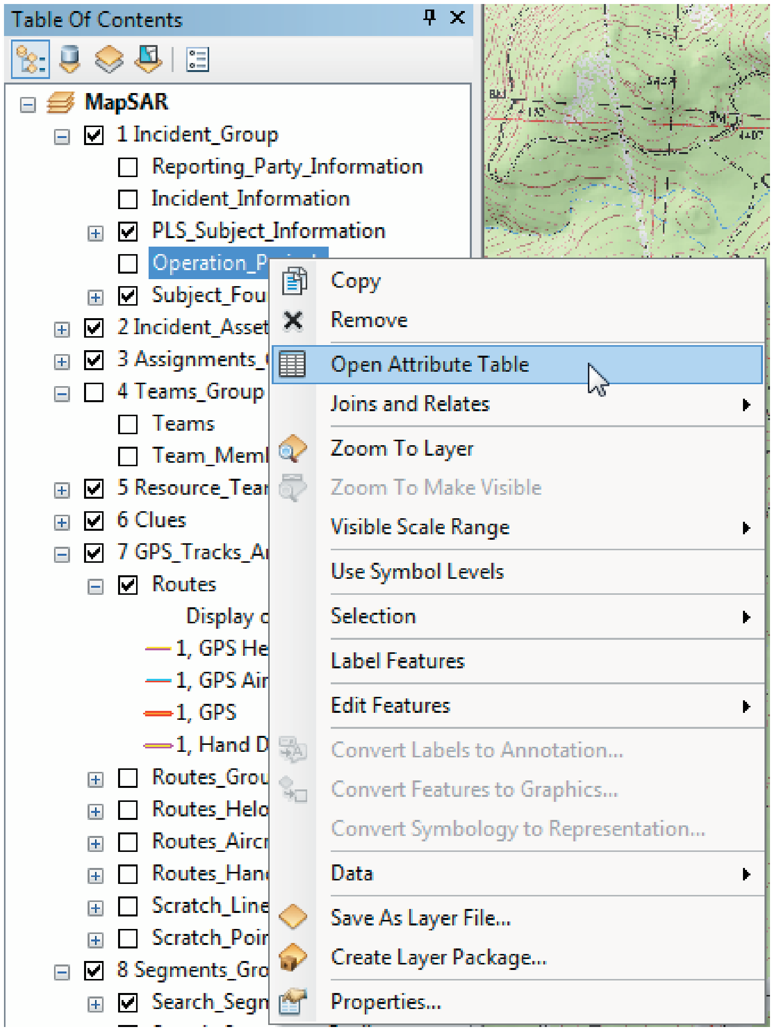


Figure 8-18

8. The first operational period was already entered by Matt. Today is the second operational period and started on 5/9/2012 at 6:00 a.m. Type this information into the attribute table.

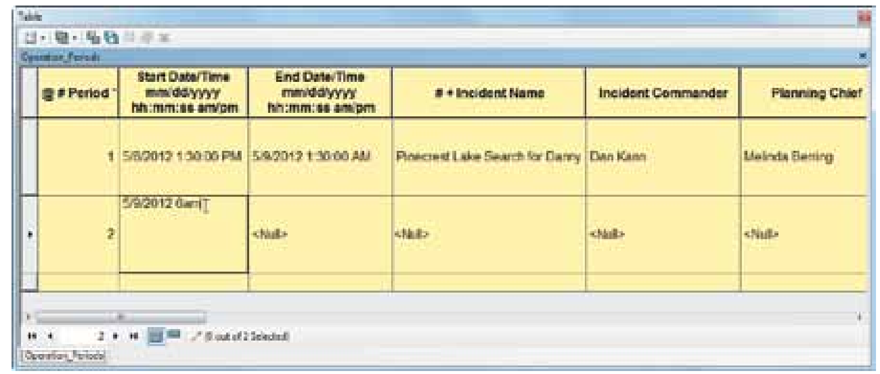


Figure 8-19

9. Do not enter anything in the **End Date** field, but use the drop-down menu to select **Pinecrest Lake Search for Danny** as your **Incident Name**. As you move on to additional fields, the start date will change into a specific format, and the end date will auto-populate. Continue entering information for all the other fields—you can use names of people you know or make them up for this exercise. Reference what was used in the first operational period if you are unsure what should be entered in the field.

Figure 8-20

10. Once you are satisfied with your entries, close the attribute table. Click **Editor** > **Save Edits and Stop Editing**. Remember that Editor > Save is different from File > Save. The latter saves the whole project. Edits must always be saved separately.

11. Now you need to send the information you just entered throughout the database and the tables that are linked behind the scenes. It sounds complicated, but you just have to remember to click the **Update Domains** button when you stop editing. MapSAR does the rest. This is a very, very important step.

    On the MapSAR toolbar, the third icon from the left is the **Update Domain** tool (it looks like a blue/yellow/green flow diagram). When you don't recognize a tool icon, you can hover the cursor over the tool, and a text box will appear that tells you what it is.

Figure 8-21

12. In addition to clicking the tool, you also have to make sure the Update Domains runs successfully. A pop-up box will appear while the tool is processing. When it is finished, it should say **Succeeded at…**. If it does not say this, or has "failed" errors that show in red, *stop and fix this* by referencing *The MapSAR User's Manual*'s Troubleshooting section to solve the issue. If you do not fix this, MapSAR will not work correctly.

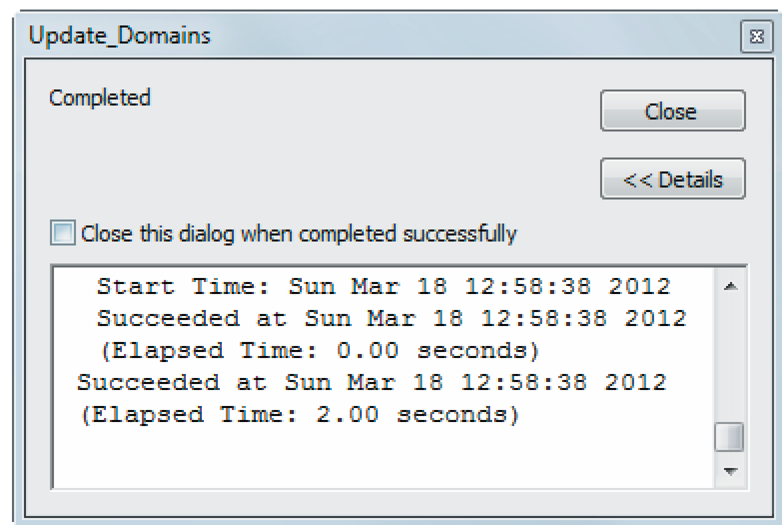


Figure 8-22

13. Click **Close**.

14. Now that there is another operational period established for today, you will set up the assignments.

15. Click **Editor** > **Start Editing**. Make sure the source is C:\MapSAR\20120508_Pinecrest_Search_Danny_UTM11 \SAR_Default.gdb and click **OK**.

16. Since you already have search segment polygons that Matt created, you can use MapSAR to turn those segments directly into assignments. Click the **Edit** tool (to the right of the Editor menu on the MapSAR toolbar; it looks like a black arrow top).

Figure 8-23

17. Select **Segment A**. It will be outlined in bright blue to show it is selected. If you select the wrong area, click the **Clear Selected Features** tool (white square with squiggles to the left of the binoculars) and try again.

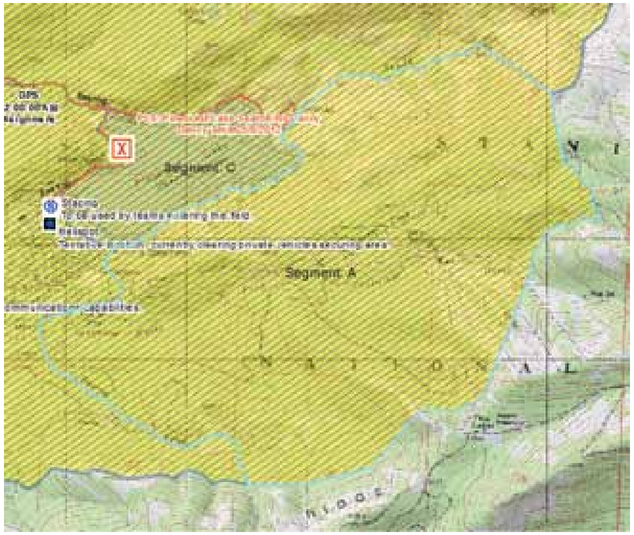


Figure 8-24

18. Click **Editor** > **Buffer**. Click the **Template** button.

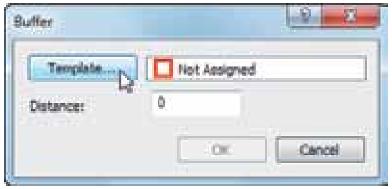


Figure 8-25

19. You want to make sure you have **Assignments** as your selected template, because this determines which layer the new buffered shape will be in. With **Assignments** highlighted, click **OK**.

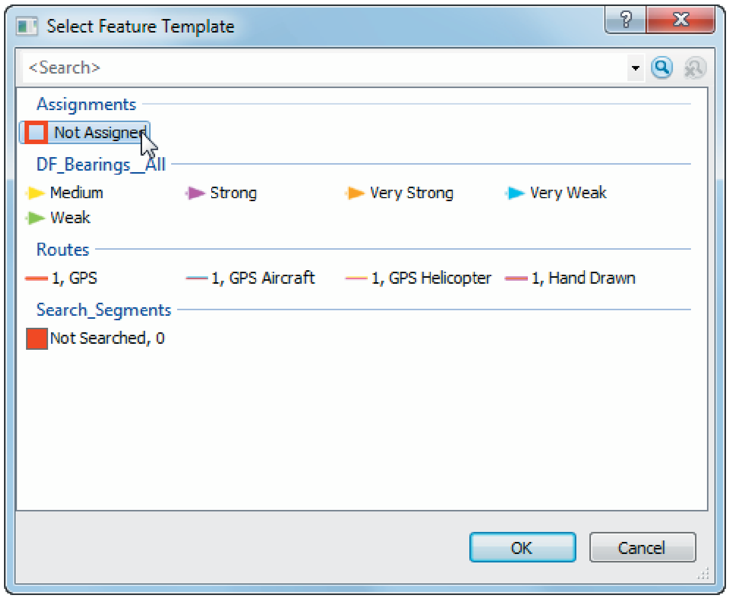


Figure 8-26

20. Change the **Distance** field to **1** in the buffer window and click **OK**.

Figure 8-27

21. By buffering the segment by 1 meter, you have created a new polygon that will now be an assignment. The segment is still there as a segment. The **Attributes** window will appear so that you can fill in information about the new buffer feature you created. Enter the following information: **@ # Assignment Number = 1, + Display on screen = True, # + Operational Period = 2, + Assignment Status = Assigned, + Team Name = Brown**.

Scroll down and enter: Assignment Description: **Search all roads, trails, and water tank areas thoroughly. Contact everyone and ask if they've seen a boy with Danny's description. Check any culverts, creeks, valleys, and other challenging terrain as you are able. Record route for debriefing purposes with GPS set to NAD83 UTM 11.** Leave all other fields alone. Click **OK**.

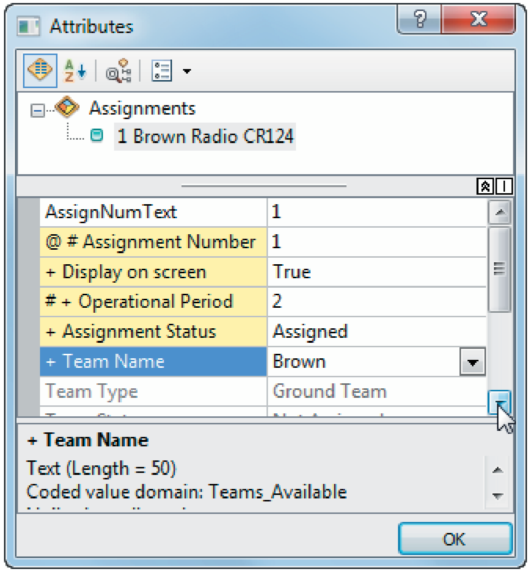


Figure 8-28

22. The feature in Assignments has now been created, and a label for the area with the assignment number, team name, and call sign is shown on your map.

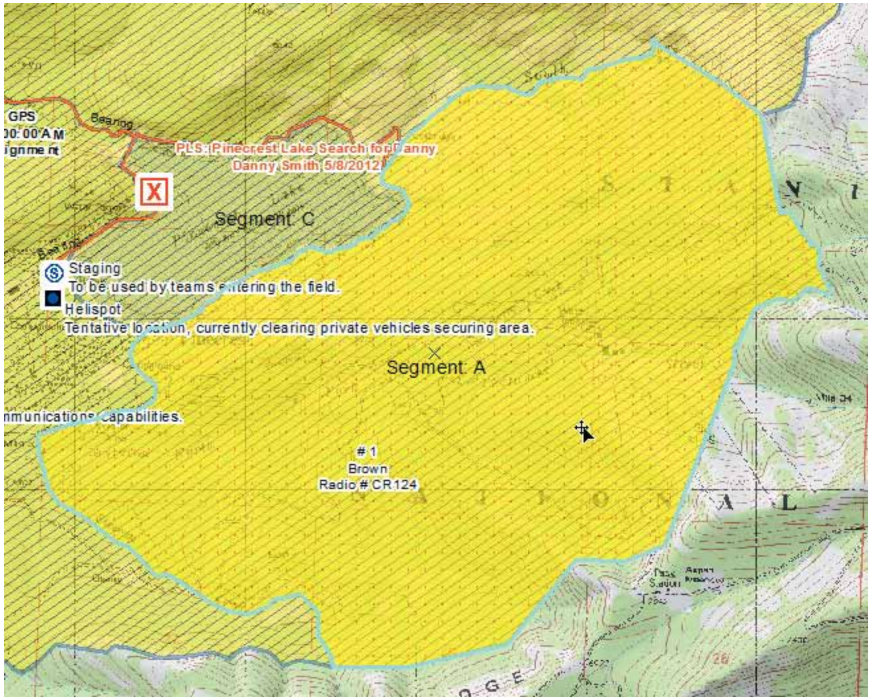


Figure 8-29

23. If all went well, click **Editor** > **Save Edits**. (Do not click **Stop Editing**; you have more editing to do.)

24. Create assignments for the other three teams using search segments B, C, and D by repeating steps 16 through 23. Make sure that the operational period is 2 and they are assigned so that you can select a team for each assignment.

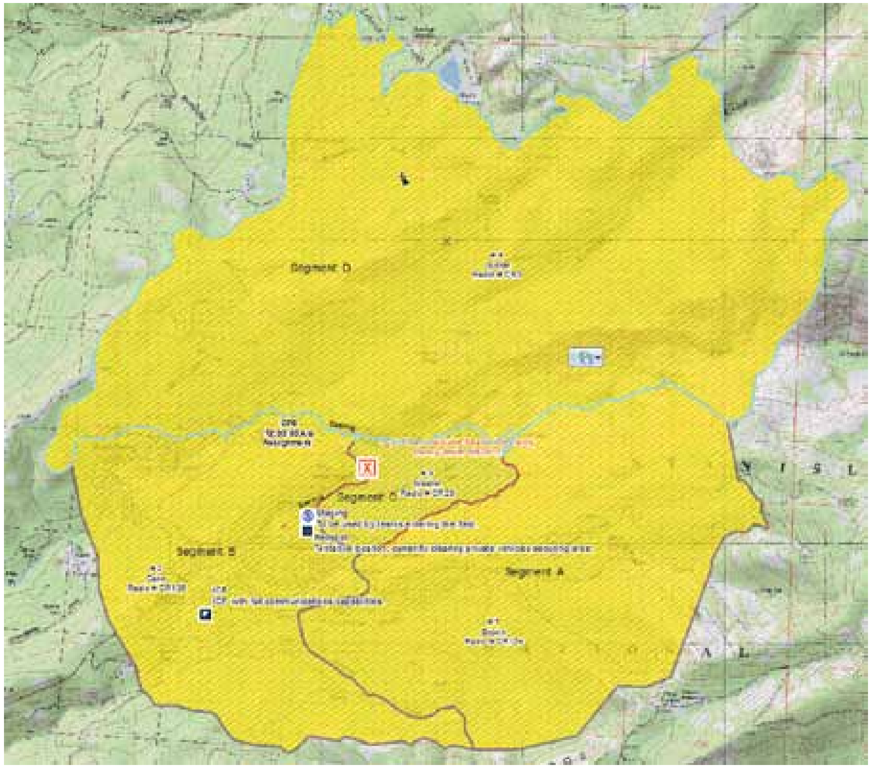


Figure 8-30

25. Once you have completed all four assignments, click **Editor** > **Save Edits** > **Stop Editing**. Click the **Update Domains** tool.

Figure 8-31

Important—Click **Close** when it has run successfully.

26. A message has just come in from dispatch that a clue was found—a candy wrapper that is the same brand Danny had with him when he went missing. Click **Editor** > **Start Editing**. Make sure the source is C:\MapSAR\20120508_Pinecrest_Search_Danny_UTM11\SAR_Default.gdb and click **OK**.

27. In the **Create Features** window on the right side of the screen, click **Relevant** under Clues_All.

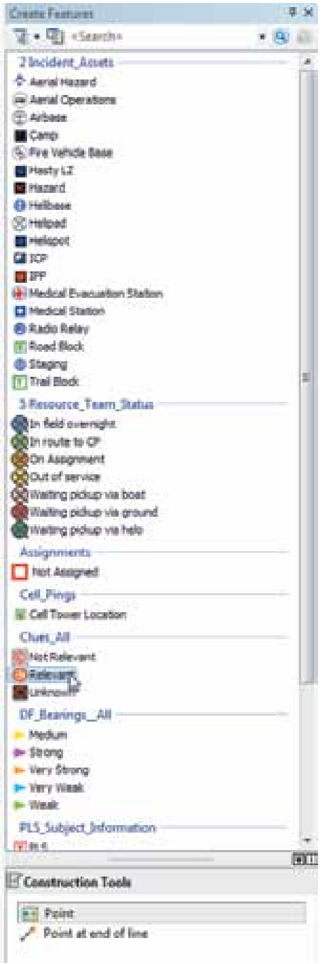


Figure 8-32

28. You could click a described geographic location on the map to create the clue point, and this is what you would do if given the name of a place or description. In this case, the team and dispatcher have given you the exact location of the clue from their GPS. As you bring the **Clue** tool out over the map, right-click and choose **Absolute X, Y** (you could alternatively press the **F6** key).

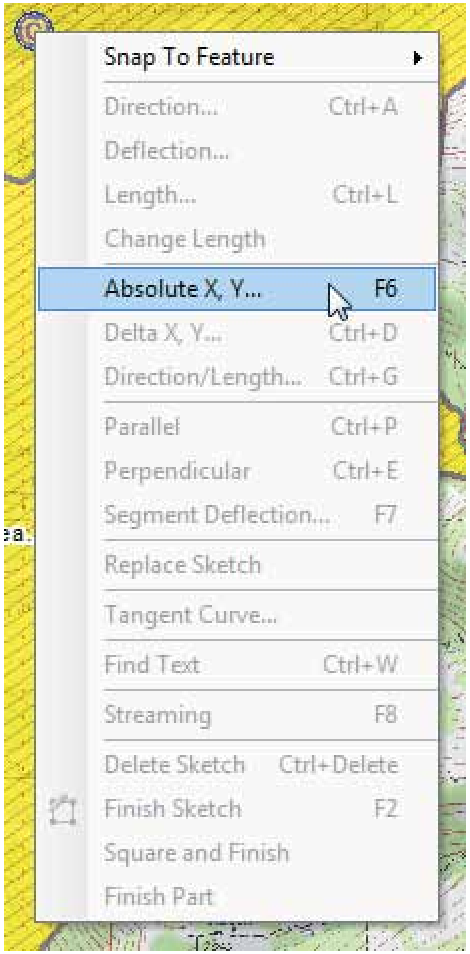


Figure 8-33

29. Using the drop-down arrow on the right, change the entry unit to **UTM**. Type in the following location: **11N2373604233052** (see more about coordinates in chapter 4 "[Understanding and Using Coordinate Systems]").

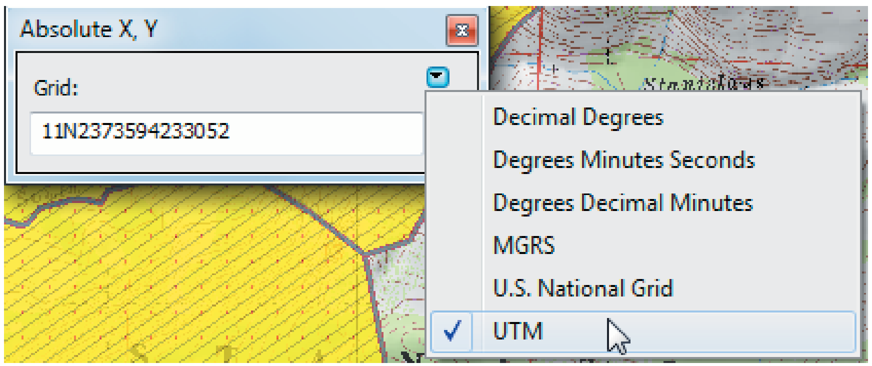


Figure 8-34

30. Click the **Enter** button.

31. The Attributes window will open so you can enter information about this clue. Enter the following information: **# + Assignment Number = 4, + Display on screen = True, # + Operational Period = 2, @ # Clue Number = 1, Date & Time found = 5/9/2012 1:00:00 PM, Clue Found (What was it?): Chocolaty Brand Candy Wrapper, Verbal Location of clue (Where was it?): Team provided coordinates, Verbal Description of clue (What did it look like?): Appeared to be eaten and the wrapper licked clean, + Relevancy of clue: Relevant, Comments: This is Danny's favorite candy and had one in his pocket when he went missing, + Source of entry (Entered by hand…): GPS**. Leave all other fields alone. Click **OK**.

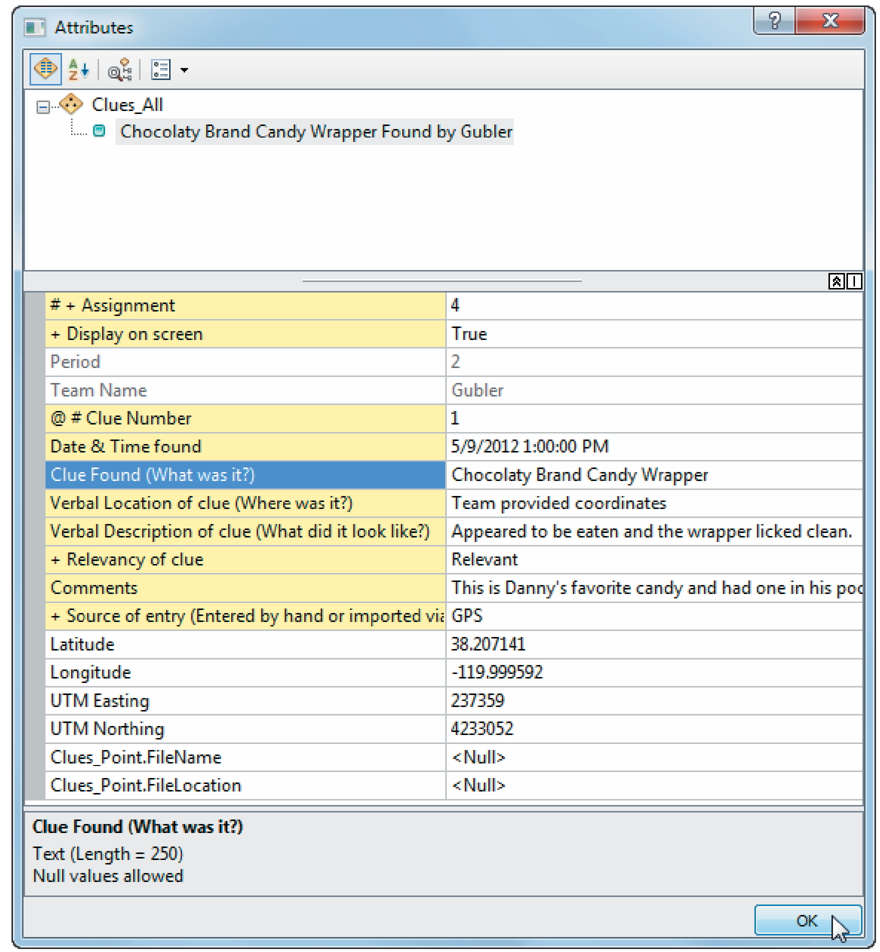


Figure 8-35

32. Click **Editor** > **Save Edits** > **Stop Editing**.

33. Click **Update Domains**.

34. Now you're ready to work on getting your map ready to print; this will be a different workflow than in ArcMap because you will use templates to assist with your layout and Data Driven Pages capabilities. Data Driven Pages assists in laying out a grid and index for you to print from for a map book (for example, for each team's assignment) and keep some elements consistent throughout the series.

    Click **Customize** > **Toolbars** > **Data Driven Pages**.

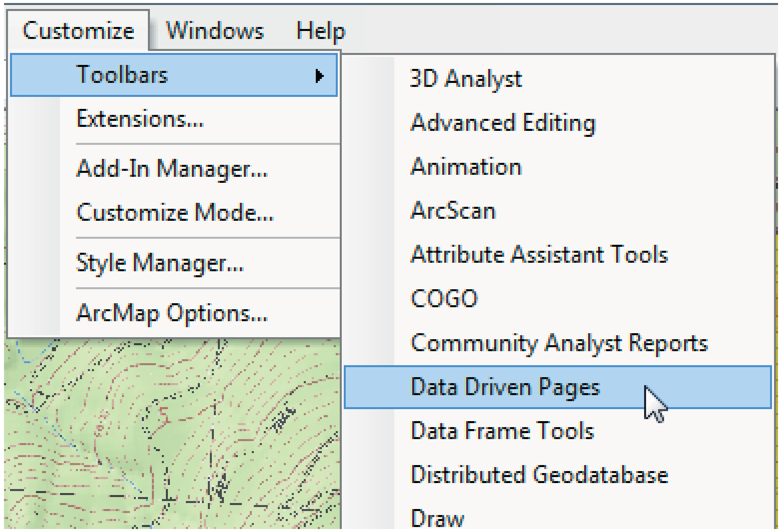


Figure 8-36

35. You want to print a unique map for each assignment, with only the information for that assignment showing on that map. To do this, go to the **TOC** and make sure the Assignments_DDP layer is unchecked. Select the **Assignments** layer.

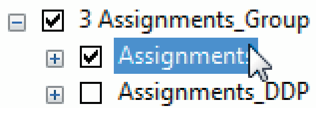


Figure 8-37

36. If the Data Driven Pages toolbar (shown below) is not visible, right-click the toolbar and, when the full list of ArcGIS 10 tools is displayed, click **Data Driven Pages**. That toolbar will now appear. Move it to dock it on the main toolbar.

37. On the **Data Driven Pages** toolbar, click on the **Data Driven Page Setup** tool.

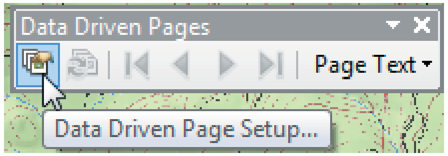


Figure 8-38

38. In the **Setup Data Driven Pages** window, on the **Definition** tab, check the **Enable Data Driven Pages** option. Change the options to the following: **Data Frame = MapSAR, Layer = Assignments_DDP, Name Field = Assignment #,** and **Sort Field = Assignment #**.

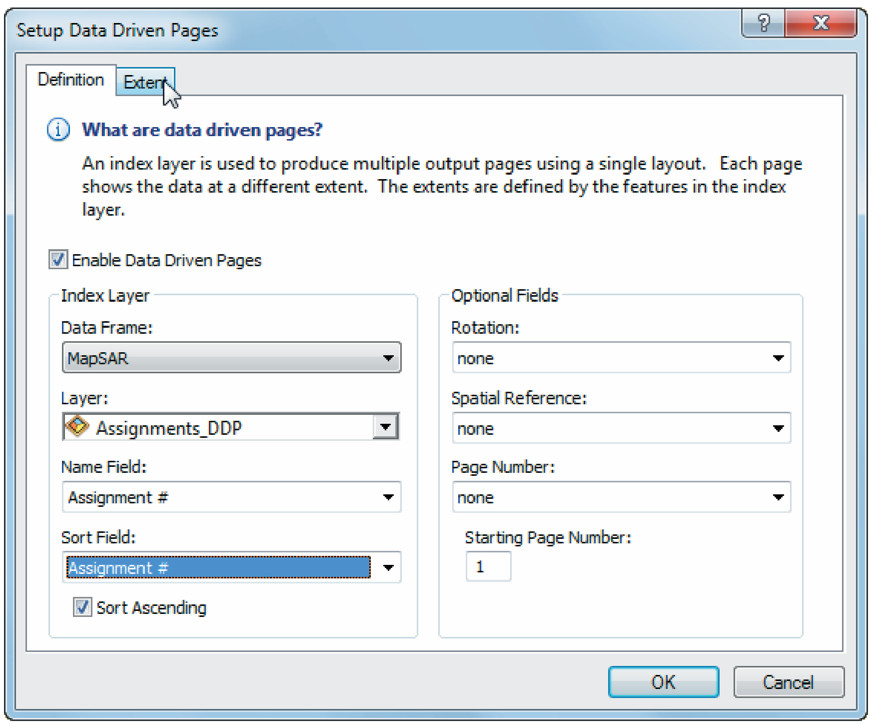


Figure 8-39

39. Click the **Extent** tab. Click the button for **Center And Maintain Current Scale**. Click **OK**.

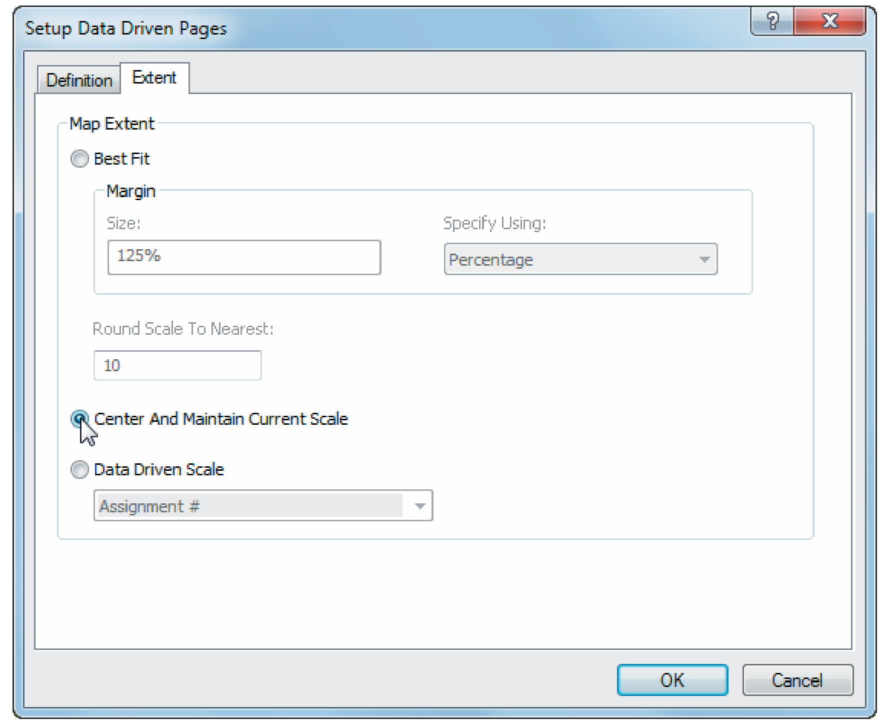


Figure 8-40

40. In the TOC, right-click the **Assignments** layer name and select **Properties**. Click the **Definition Query** tab and select **Page Definition**.

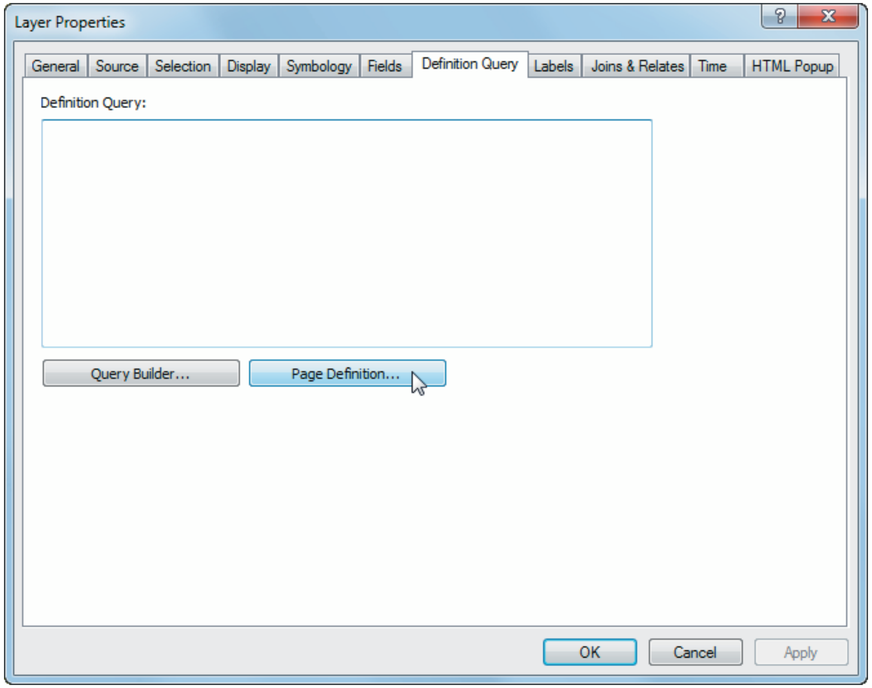


Figure 8-41

41. The **Page Definition Query** window opens. Make sure **Enable** and **Match** are selected. Change the **Page Name Field** to **@ # Assignment Number**.

Figure 8-42

42. Click **OK** and click **OK** again to close the windows.

43. Click **Customize** > **Toolbars** > **Layout** to add the Layout toolbar to the interface. Notice that many of these tools look similar to those in the Standard toolbar. The difference is that if you use the Standard toolbar, you will move the map's position and scale within the data frame. If you use the newly added Layout toolbar, you will be moving the page you'll be printing around your screen or zooming in and out of the document without changing the map's position in the data frame.

44. Click **View** > **Layout View** to change from the data view to the area where you will prep your map for printing by working on the layout.

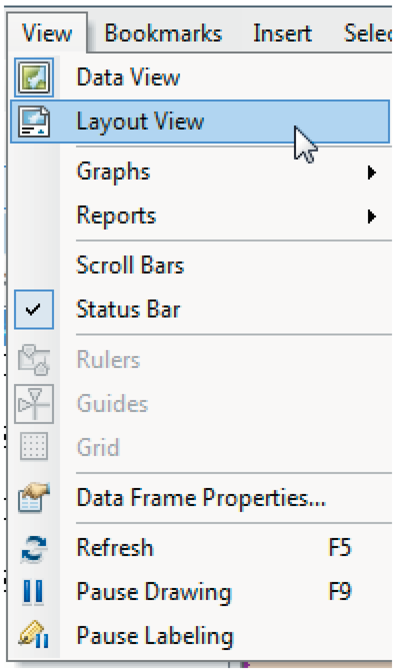


Figure 8-43

45. Use **Layout** tools (not the Standard tools) to navigate to the bottom right corner of the page. Use the **Select Elements** arrow (black arrow, fifth icon from the left on the MapSAR toolbar) to double-click the text box that says **Map Name Goes Here.PDF**.

46. A **Properties** window will open. In the Text box, type the file naming structure for PDF maps: **20120509_600_Pinecrest_Lake_Search_Danny_OP2_letter_land.pdf**. This is the name of the PDF you will save for this product. Click **OK**.

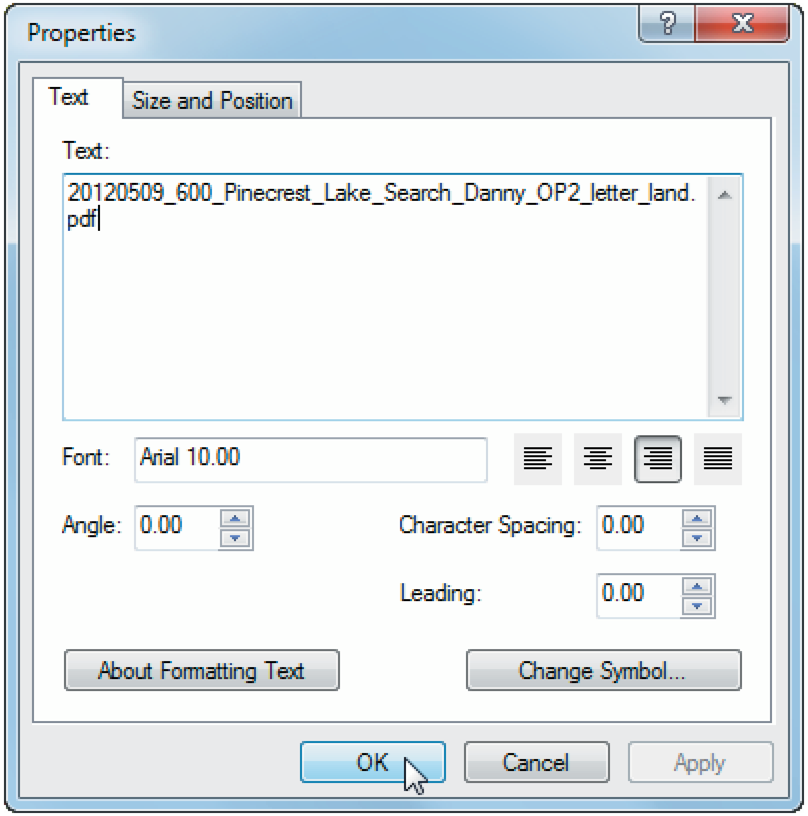


Figure 8-44

Position and resize the map features inside the data frame by using the zoom in and out tools (magnifying glasses) and pan (hand) tool from the Standard toolbar so that the largest segment fits in the data frame. In this case, Segment D is the biggest, so the scale will be about 1:37,000. When using Data Driven Pages in this manner, scale doesn't change (even though the sizes of your assignments do).

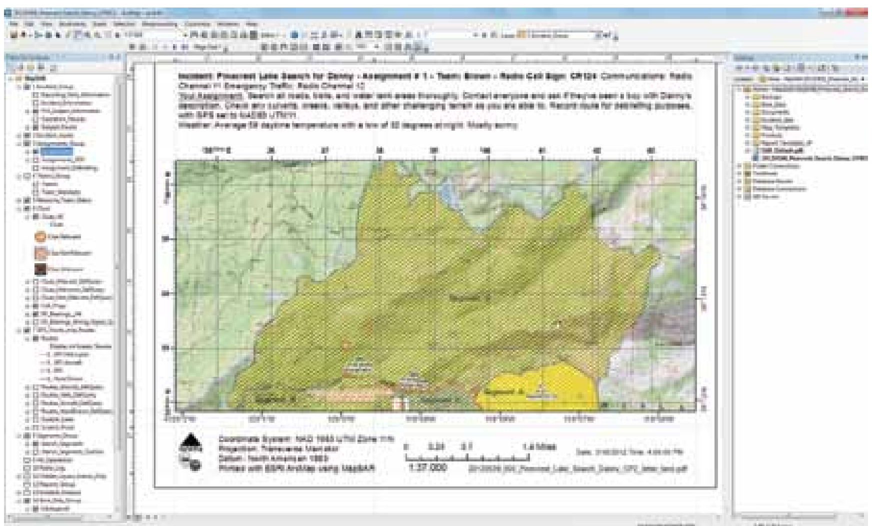


Figure 8-45

47. Once you've chosen your scale, turn off the visibility for **8 Segments_Group** layer by unchecking the box next to the name in the TOC. This is so that the search segments don't print on your assignments.

48. Without changing the scale, use the pan tool from the Standard toolset (the one that will actually move the map) to recenter Assignment #1 in the data frame.

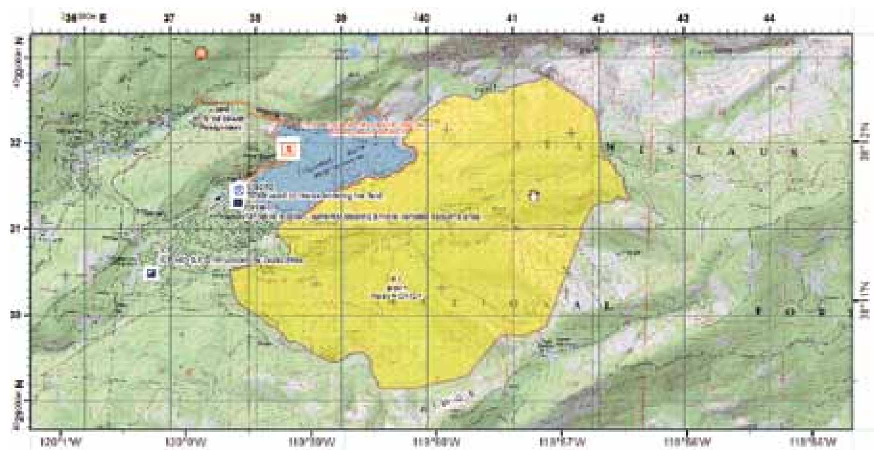


Figure 8-46

49. If you're all set to print, go to **File** > **Export Map**. Navigate to the **C:\MapSAR\20120508_Pinecrest_Search_Danny_UTM\Products** folder and change the {yyyymmdd} folder to the 20120509 folder by clicking it and typing. Then type in the file name **20120509_600_Pinecrest_Lake_Search_Danny_OP2_letter_land.pdf** (to match what you typed at the bottom of the page for the file name). Change the file type to **PDF** and, on the **General** tab, set the **Resolution** to **300**.

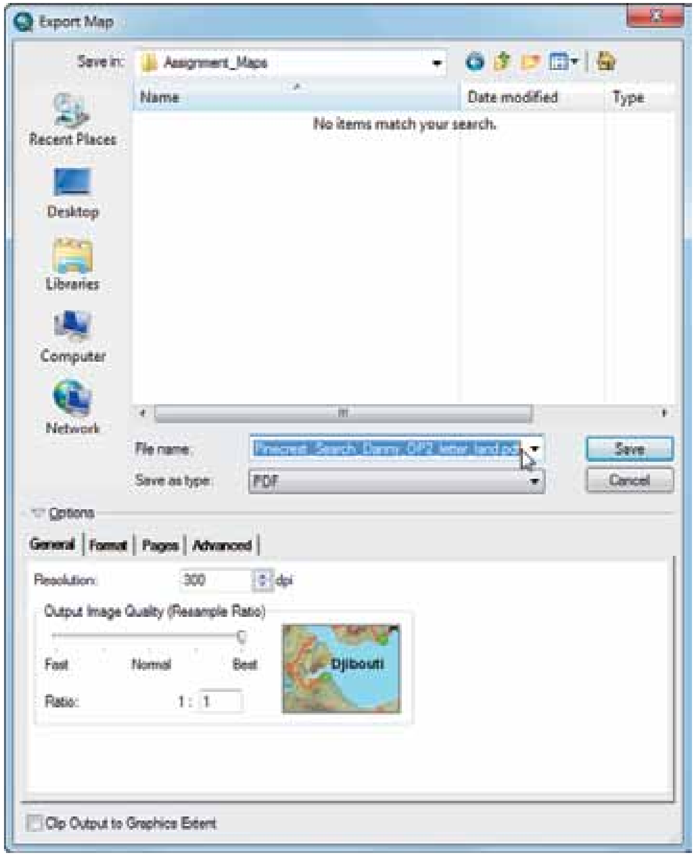


Figure 8-47

Note that the products are stored by date as part of the MapSAR default setup, in accordance with established GSTOP. However, some SAR groups prefer to store their maps by type of map or file type in folders, such as Assignment_Maps, or PDFs. If this is your preference, you can change the folders in this Products area to your liking, and it won't break anything in MapSAR.

50. Click the **Pages** tab and click the **All (4 pages)** button. Make sure **Single PDF** is selected for **Export Pages As**. This will create all your assignment maps as one PDF file.

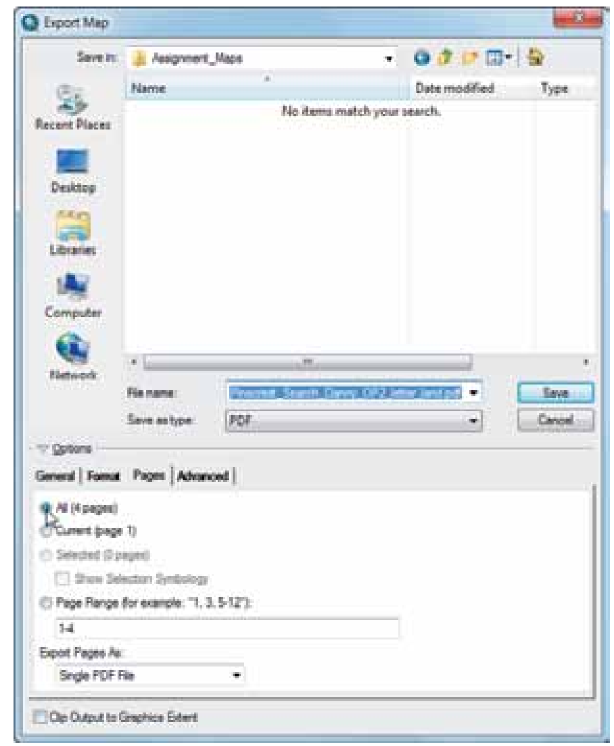


Figure 8-48

51. Click the **Save** button.

52. Your map is now saved as a .pdf product. Using Windows Explorer, navigate to **C:\MapSAR\20120508_Pinecrest_Search_Danny_UTM11\Products\20120509** and open the new .pdf.

Pretty cool—your first assignments map file! You can go ahead and print these on your printer from Adobe Acrobat or just take a look at them digitally.

Epilogue

SAR team members know that a search can turn on a single seemingly insignificant clue. When the candy bar wrapper was reported, the IC decided to send another team into the area. It had been the only bit of information that had been found even hinting at Danny's whereabouts. ICP radioed those coordinates to a team just finishing its assignment about a mile away from the clue. That team programmed a waypoint to those coordinates on each of their GPS devices and entered Go To. About half a mile from the clue, they heard an answer to their whistles and calls of "Danny!"

"I'm over here! Over here!"

It's a great moment for any team. They rushed through the trees and dense vegetation and found Danny, still with his fishing pole leaning against a downed tree. He was scratched up a little bit but smiling and waving. In two hours he was with his father at the parking lot and eating a pizza, as if he hadn't eaten anything in days.

Appendix 1: Raster and Vector Data for MEDs

Raster Data for the MED

Raster data is that spatial data best represented by pixels in a grid. It includes basemaps, digital elevation models, and imagery. Usually, each pixel represents a single value, such as elevation or band reflectance, as a digital number. Various remote-sensing techniques are used to derive the data such as cameras and sensors mounted on satellites, airplanes, and unmanned aerial vehicles (UAV).

1. Basemaps
    a. Index of area maps
    b. USGS quadrangle maps represented as digital raster graphics
    c. Community basemaps
    d. Brochures and recreation maps that lost persons might have as a reference
2. Digital elevation models
    a. USGS National Elevation Datasets (NED) in 10 m or 30 m resolution
    b. Light detection and ranging (lidar) finer than 10 m resolution
    c. Bathymetry
3. Imagery
    a. Index of area maps
    b. High spatial resolution—USDA NAIP at 1 m resolution with red, green, blue, and near-infrared
    c. High temporal resolution
    d. Moderate spatial and temporal resolution—commercially available IKONOS, SPOT

Vector Data for the MED

Vector data is that spatial data best represented by feature coordinates (points) or groups of coordinates (polylines and polygons) and feature attributes. These generally describe places and their characteristics, such as the outline of a road, along with the road name and its class (paved, four-wheel drive, seasonal, etc.).

Within a file geodatabase files are often set up by type. For instance, roads and trails are placed in a .gdb labeled Transportation. If you're not using a .gdb, you can create a folder structure that does the same thing: C:MapSAR\Base Data\raster\transportation and put your roads.shp and trails.shp files in there. Then do the same with Infrastructure (buildings, radio repeaters, cell towers etc.).

1. Transportation
    a. Trails
    b. Roads
    c. Landing zones
2. Infrastructure
    a. Buildings
    b. Repeaters
    c. Power lines (hazard)
    d. Signs
    e. Key assets
3. Hydrology
    a. Streams, rivers, lakes, and coastlines
    b. Watersheds/Ridgelines
4. Cultural
    a. Place-names
    b. Landownership
    c. Jurisdiction
    d. Land cover
    e. Mines (hazard)

5. Locally acquired data

    a. This is a general category to acquire data that is very specific to your area and which might help a search effort.

        i. Locally acquired terrain traps or attractants: Interview local subject matter experts (land users, rangers, etc.) and capture their knowledge—as points or polygons and a description field—about areas that either have historically caused navigation errors or which they believe have the potential to do so. Displayed on a map, such a layer would serve as a reminder that perhaps it should be searched earlier.

        ii. Locally unique data that might help

            1. Marijuana growing areas (both as hazards to be avoided or where only law enforcement SAR should go and as potential areas where people might be in trouble)

            2. Land-use activities: mountain biking trails not on agency maps—available through local user groups; ski trails and routes; climbing areas and approaches

            3. Other attractants such as a ginseng location used to help locate a missing ginseng poacher at Shenandoah National Park; landownership boundaries that might have unmapped fences serving as containment

To organize these datasets, the best container is a geodatabase. The best source for setting up a geodatabase is the ArcGIS 10 help file. *The GIS 20: Essential Skills* by Gina Clemmer, from Esri Press, includes the data and an exercise to create a file geodatabase.

Appendix 2: Resources and Support

Because the use of GIS in search and rescue is such a new discipline, resources and information are scattered in a number of publications, online sources, and individuals. While one of the goals of this manual is to provide a single source for much of this information, the GIS user will find there will always be the need to track down resources to meet particular needs. Here's a very basic list to help in that quest:

Resources

Information

- **Using GIS for Wildland Search and Rescue**
  (mapsar.net)

  Web site companion for this e-book with links to the exercise data, MapSar, and resource information.

- **MapSAR User's Manual**
  (mapsar.net)

  User manual with step-by-step instructions on how to use MapSAR including a tutorial and advanced skills.

- **MapSAR.net**

  Websites for the latest MapSAR build and instructional material. It will also have contacts to SAR people who are skilled with GIS and MapSAR and can help if you've got problems. If you have problems or questions, you can contact us at help@mapsar.net. You can also use this address for help on an active operation. E-mail will be forwarded to several team members, so there's a good chance of a quick response.

  Remember that, while not ideal, the Internet and data files make it very possible to outsource many of your mapping requirements. If you don't have the expertise or facilities, you can work with another team or individual who does.

- **Using GIS in SAR for Emergency Responders**
  (http://groups.google.com/group/sar-and-gis)

  A Google Group discussion forum for SAR and GIS. This requires approval, but it is usually quickly granted. It's a good place to ask questions about any problems you're having or suggest better techniques or workflows.

- **The National Alliance for Public Safety GIS Foundation** (napsgfoundation.org)

  This is a research and education foundation to further the effective use of GIS in emergency services.

- **Esri.com**

  An excellent resource for all things GIS and ArcGIS, Esri online support offers a number of help options including access to forums where you can ask questions of other users, extensive and up-to-date help files on all aspects of the ArcGIS software, product help for licensed users (and dependent on the license level), and an extensive collection of specialized scripts (including MapSAR) that automate or enhance many GIS tasks.

- **ArcGIS Online** (arcgis.com)

  Source for community and Esri geospatial data and a site to share data in user groups. One application of ArcGIS Online might be to share data of an active SAR with geographically separated command posts or another team helping in analysis or SAR mapping. A free account creation is required.

- **Coordinate conversion and datum conversion** (http://www.rcn.montana.edu/resources/tools/coordinates)

Equipment

- Data cables for common GPS types
  - **USB-to-Com Port for Garmin** (USB works fine for DNR GPS, but for direct live connect to ArcGIS, it only recognizes serial/com port with ArcGIS 10)
  - **RS-232 (Serial or Com port) to USB:** This can plug any Garmin RS-232 cable to an adaptor (www.usbgear.com/CA-232-1MB).
  - **Workaround for live feed to ArcGIS 10:** ArcGIS 10 has a tool to receive and directly map GPS data streaming into it. However, it will not recognize a USB port, only a serial (RS-232) port. GPS Gate software can port a GPS feed directly into ArcGIS 10 when the GPS is connected to the USB port. It's rare when you even need to do this but might be required sometimes.
    - GpsGate Client Express for Windows emulates a Com port as USB. It also directly converts Garmin GPS strings to NMEA (gpsgate.com).

Appendix 3: Glossary and Acronyms

Assets—Resources, either equipment or personnel, used in the SAR operation; examples: SAR dog team, helicopter, transportation

Assignments—Tasks given to SAR resources to be completed within a given operational period

Attribute Table—A database that contains information about a set of geographic features; typically arranged in rows and columns, where each row represents a feature and each column represents a single feature attribute

Create Features Template—Allows the use of construction tools to create points, lines, or polygons in the map document; active only in Edit mode

Domains—Rules that describe the legal values of a field type in an attribute table; used to ensure the values are within the range of acceptable attribute values

Esri—Manufacturer and distributor of ArcGIS products including ArcMap and ArcGIS Online

Feature Class—Collections of features having the same spatial representation, such as points, lines, and polygons, as well as a common set of attribute columns

Georeferenced—Defined and established location of an object using a coordinate system and/or map projections

Georeferencing—Defining and establishing the location of an object in physical space

GIS Specialist—Geographic information systems specialist (In wildland fire, this is a qualifying position with training and a task book, not established in SAR yet.)

GPS—Global Positioning System, a space-based satellite navigation system used to provide location and time information anywhere on the earth (The system requires an unobstructed line of sight to four or more satellites in a geosynchronous orbit around the equator.)

GPX—GPS eXchange Format, an XML schema used as a common GPS data format to describe waypoints, routes, and tracks as well as store time, location, and elevation

Graticule—Grid of intersecting lines that maps are drawn on such as latitude and longitude

ICP (sometimes CP)—Incident command post, the location at which the primary command functions are carried out (The ICP may be shared or located with the base or other incident facilities and is typically located at or in the immediate vicinity of the incident site. There is only one ICP established for each incident.)

IPP—Initial planning point, where the initial focus of the search is centered (This may be the PLS. The IPP may be used in the absence of a PLS. Once established, the IPP does not change.)

Operational Period (OP)—The period of time scheduled for the execution of the incident action plan (Operational periods can be of any duration but typically are 12 hours and usually do not exceed 24 hours.)

PLS—Point last seen, the point where the missing person was physically seen by a person or recording device such as a CCTV

Point Feature Class—Feature class containing only point representations, for example, ICP, helipads, radio relay

Polygon—A closed series of lines that define an area

Project/MXD—The ArcMap document that contains all the information relating to the map including symbology, layout, etc.

Reporting party (RP)—The person from whom the initial information is received, usually the person who calls in the missing person report

Routes—Typically two or more waypoints connected together

SAR—Search and rescue

Schema Lock—Occurs when more than one user is reading and editing the data at the same time

Schema—The structure or design of a database

Segments—A defined portion of the search area or region that is to be searched by SAR resources (The boundaries of the segment are based on the resources' ability to complete the task.)

Subject—The lost, stranded, injured, or deceased person that is the focus of the SAR operation

Table of Contents (TOC)—Contains a list of all the data used in the map (The display window of the TOC shows how each layer is shown in the data frames. You can turn the layers on and off within the TOC, work with the property layers, and rearrange the drawing order of the layers.)

Track Logs—The sequence of GPS coordinates or track points that make up the track

Waypoints—Sets of coordinates that identify a point in physical space

Appendix 4: References

Additional References That May Be of Interest

Research Coordination Network's conversion utility for coordinates: http://www.rcn.montana.edu/resources/tools/coordinates.aspx

National Geodetic Survey page showing vertical shift between NAVD 88 and NGVD 29: http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html

NOAA's UTM conversion tool: http://www.geodesy.noaa.gov/TOOLS/utm.shtml

NOAA's SPCS conversion tool: http://www.geodesy.noaa.gov/TOOLS/spc.shtml

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About the Authors

George Durkee

George Durkee has been a seasonal National Park ranger for over 40 years. He has worked primarily as a law enforcement wilderness ranger in both Yosemite and Sequoia and Kings Canyon National Parks in California's Sierra Nevada mountains. For 20 winter seasons, he also worked as a back-country ski patroller at Yosemite's Ostrander ski hut. Over the decades, Durkee has worked hundreds of searches both as a field SAR grunt and, recently, as part of incident command teams in plans and as a GIS specialist, responsible for maps and planning. In addition to hundreds of hours of self-taught use of ArcGIS 3, ArcGIS 8, ArcGIS 9, and ArcGIS 10, he is also cofounder of the Google Group, Using GIS in SAR and Emergency Services. He has completed the National Wildland Fire Training Center's S341, GIS for Incident Management. He authored "GIS Joins Search for a Missing Hiker on California's Mount Whitney" for *ArcWatch* online magazine and is adjunct instructor for SAR and GIS training at Columbia College, Sonora, California.

Vanessa Glynn-Linaris

Vanessa Glynn-Linaris currently owns a GIS consulting firm called GeoRevs, LLC, and works as a volunteer/emergency hire for Grand Canyon National Park's Emergency Services during search and rescue incidents. In addition to software-testing Hazus-MH and FEMA's loss estimation software and writing hazard mitigation plans for communities and creating risk assessments, she is an authorized trainer for FEMA's Emergency Management Institute and teaches a variety of field courses integrating GIS, Hazus-MH, and emergency management. She completed S341 in 2008 and is a GIS specialist on the all-hazards National Area Command Team 1 and worked on the Wallow and Las Conchas fires in summer 2011. She previously worked for FEMA Region III (Philadelphia) as the GIS/risk analyst and has made numerous professional presentations and posters for regional and international GIS conferences. She received her master's degree in GIS from Pennsylvania State University's World Campus. Her first introduction to SAR was in 2004 and 2005 at Rocky Mountain National Park, where she worked as a seasonal park ranger.

Cover Image: Starlight Search and Rescue, Kings Canyon National Parks (12,600 feet)

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