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From the pixels up : processes and procedures in the construction of a neural-site geographic information system

Christopher John Mason

FROM THE PIXELS UP

Processes and Procedures in the Construction of a Neutral-Site Geographic Information System

By

CHRISTOPHER JOHN MASON

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CHRISTOPHER JOHN MASON

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APPROVED:

DR. WALTER GUERRY GREEN, CHAIRMAN, THESIS COMMITTEE

ACCEPTED AND SIGNED:

ABSTRACT

This study examines the question, is it possible to develop a neutral-site Geographic Information System (GIS) that addresses information needs useful for the training of emergency management personnel? To answer this question a subordinate question requiring an answer is what specific steps are required to accomplish this goal? As a base for the data provided here, the history of cities as an initial root of civilization and the concept of emergency management are discussed. Direct intersections, where the specific applications of emergency management technology provide real benefits to local governmental organizations, such as those at the city level are also considered. One of these potential technologies is a Geographic Information System, or GIS. Using a qualitative method, with thick description, the process and procedures of creating a neutral-site GIS for use in training by organizations who do not currently have access to the technology is then described. The potential benefit for jurisdictions lacking a current GIS is clearly demonstrated. The study concludes with a summation of the research, development and construction of a neutral-site GIS. Specific lessons learned during the entire process are discussed. Finally, areas of further study the process brought to my attention are considered.

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THE RESEARCH QUESTION

(1) Geographic Information Systems present decision makers with a visual representation of a disaster via an electronically produced map containing specific data about the scene and the surrounding area. Is it possible to develop a neutral-site Geographic Information System (GIS) that addresses information needs useful for the training of emergency management personnel? If so, then a subordinate question requiring an answer is: what specific steps are required to accomplish the goal?

INTRODUCTION

INTRODUCTION TO THE STUDY

(2) The development and construction of a neutral-site geographic information system is a multi-step process involving two different software packages working together to complete the GIS. The purpose of the study is to discuss the process and provide a blueprint for undertaking the process. The study provides an opportunity for emergency management professionals with limited exposure to the technology to learn how to develop a GIS. Additionally, the EM professional will have an opportunity to gain fundamental knowledge concerning the operation of a GIS. Once these two objectives are met, the final goal is that emergency personal will have the ability to take the knowledge that they have gained and apply it in their home jurisdictions. The selected method used in my thesis is the case-study method.

GENESIS OF THE QUESTION (BACKGROUND)

(3) Global Positioning Systems (GPS) have been a part of my life since 1998, when I received an initial introduction to the technology at Fort McClellan, Alabama as a part of my basic certification in Disaster Preparedness for the United States Air Force. I received both initial training on the subject and subsequent refresher training to keep me abreast of new technologies and ideas related to GPS applications. However, I had no initial knowledge about the relationship between Geographic Position Systems and Geographic Information Systems.

(4) However, I was familiar with the concept of city simulation in its popular form. At the time, a popular personal computer-based game was SIM City. The word SIM in the title indicates 'simulation'. The object of the game is to create a city based on the individual player's concepts of urban planning and zoning. Using three-dimensional construction, players begin the process with an open field. They may shape the field in any way that they see fit, including creating mountains, rivers, plains, plateaus. Options exist to plant trees and place herds of animals.

(5) Players then construct a road and utility, infrastructure, create different planning and zoning models, and construct homes and businesses. Their final goal is to create a fully functioning city. As they proceed, players make decisions regarding educational needs, law enforcement, fire protection, and hospital coverage. One final caveat: the players must stay within a given budget amount. (Starr 1994).

(6) To succeed in the game, players must also create enough jobs to sustain city development and make provisions for the various disasters that strike. The last item is what interested me the most. I considered if it would be possible for me to construct an existing city in the SIM City software and use the built-in disaster models in order to test emergency response plans.

(7) It did not take long to determine that I lacked the necessary computer skills to carry out the plan. Moreover, after reflecting on my own difficulties, it became apparent to me that many local emergency planners would encounter the same difficulty. A different software platform would be required to make my idea work.

(8) In late 2004, I took two different classes that helped me solve part of the dilemma. The Technologies in Emergency Management course explained many of the current technologies that were available to the emergency manager and how they were applicable in both day-to-day use and emergency response situations. During the class, I received my initial introduction to Geographic Information Systems. I also attended a seminar that discussed the use of Global Positioning Systems within the Commonwealth of Kentucky to

create better and more accurate maps. These improved maps serve as the basis for the electronic Geographic Information System. I had found a platform that virtually any emergency management professional could use.

(9) The last and perhaps biggest problem to address was which GIS platform to use. Would it be practical to train a Los Angeles based emergency manager with New York information? Would an emergency manager in Ames, Iowa have the same concerns as one in Scottsdale, Arizona? The solution, it would seem, would be to create a neutral environment, where a national constituency of emergency managers could work with a variety of disaster challenges.

(10) The whole idea came together in May 2007, during a lunch I had with Dr. Walter Green, Chairman of the Emergency Management Services Department, at the School of Continuing Studies, University of Richmond. Dr. Green had used the concept of a virtual micro-nation, the Republic of Perilo. The nation of Perilo is a simulated country designed as a developing nation in which it is possible to conduct exercises for training and to test a variety of emergency management practices and concepts. Perilo's hand drawn cartography provided an opportunity to determine what processes and procedures would be necessary to create a GIS driven model of a training environment from the most basic format.

(11) The result of all of this input is a group of ideas, which are steps in the on-going development of a neutral-site Geographic Information System named Perilo. When it is complete, the GIS will provide future emergency management professionals with another tool to create, test, and coordinate future emergency operations plans. It will also aid in what is perhaps the most important, and often the most ignored aspect of emergency management, mitigation. The use of GIS and many other available tools will strengthen the emergency management community and has the potential to lessen or perhaps prevent some of the effects of future disasters.

STATEMENT OF THE PROBLEM

(12) Geographic information systems are huge geodatabases that provide a spatially-oriented, digital depiction of locations, activities, and resources in a community. Within a training context, the primary problem is the content of the displayed information. A neutral-site GIS promotes the ability to present any number of scenarios to a diverse group of emergency managers and allow them to receive training not tied to their specific jurisdiction. Such training has the benefit of allowing emergency personnel to receive training on a GIS, without focusing on a narrow range of problems that might be specific to a given community.

(13) Such training has the potential to produce a stronger and better-informed group of emergency management personnel. Today, many jurisdictions continue to make increasing use of interstate aid agreements such as the Emergency Management Assistance Compact (EMAC). The compact, which is in effect in all fifty states, Puerto Rico, the U.S. Virgin Islands, Guam, and the District of Columbia, provides form and structure to mutual interstate aid (Stier and Goodman, 2007). EMAC was tested in the days after Hurricane Katrina when Florida Department of Law Enforcement arrived in the heavily damaged gulf coast area of Mississippi and assumed law enforcement responsibility until the local departments had the equipment and facilities to resume their responsibilities (Stier and Goodman 2007). Because of the wide range of communities that emergency management personnel could serve both at home and abroad, training in a neutral environment could prove beneficial.

(14) Additionally, most states provide for assistance between jurisdictions within the state. For example, in 2003, Iowa passed 29C.22 The Statewide Mutual Aid Compact. The legislation enables the deployment of emergency personnel and equipment throughout the state of Iowa in support of jurisdictions that may be unable to respond to a disaster event due to personnel, facility, or equipment losses. (Iowa Code 2003). A quick check of the internet shows that at least twelve other states have legislation that is similar to that in

Iowa. Such legislation is becoming the norm throughout the nation. Emergency management personnel must have the capability to operate outside of their home communities. The development of a neutral-site GIS is one tool that could be useful in building a new skill set.

PURPOSE OF THE STUDY

(15) GIS is part of the emerging technology of emergency management. The goal of my study is to provide lessons learned from the construction of a tool employed to train emergency managers for GIS employment during an actual crisis. By examining my experiences in constructing the Perilo GIS, it is my hope that emergency professionals will be able to evaluate the potential uses of a neutral-site system, gain different perspectives of the underlying concepts of GIS, and be able to develop training that will improve the disaster decision-making process.

ASSUMPTIONS

(16) My study assumes four key points:

- Emergency Management professional staff and providers have a desire to receive additional training in GIS.
- A GIS-based simulation is an appropriate tool for training, and emergency management personnel will find that using GIS-Simulation will improve management and response capabilities.
- The professional staff that programs the neutral-site GIS will have the necessary skills to ensure high caliber training.
- ArcGIS© 9.2 is the principal software used in creating the neutral-site GIS due to the fact that ArcGIS© 9.2 is the software with which I am most familiar. However, there are other suitable software packages, such as AutoCAD© 3D, used to create many of the drawings in my product, which would also provide the same benefits.

SCOPE

(17) I limited the scope of this study to a city-level GIS. My final project includes a street grid that has both a tightly spaced downtown and a wider suburban street grid. I examined the construction of several different cities and incorporated five distinct districts that appeared in most major cities. These districts are residential, industrial, commercial, governmental, and transportation. In addition, I noted that most jurisdictions have planning and zoning within districts. I decided to divide each district into at least 3 zones, in order to allow the creation of scenarios that would have a stronger basis in reality.

SUMMARY OF THE METHOD

(18) The method that I selected for my thesis is the case study. I selected this method because the construction of a neutral-site GIS from the ground up is not something that is routinely accomplished. The purpose of my thesis is to provide insight on how I managed the entire process. Additionally, it is important to explain why I did it. In his text, *Case Study Research*, Robert Yin suggests that the best way to provide these answers is with a case study project (2003). I kept track of my data using a journal notes system. When an event that affected the construction of Perilo occurred, I made note of the time, date, the specific event, and what actions I took. What the data will show is the progression of the construction from its most basic idea, through a working model that I presented to Dr. Green in the fall of 2008.

LIMITATIONS

(19) Two primary limitations were addressed during the course of the project:

- I did not possess a full ArcGIS© 9.2 software package.
- The ArcGIS© 9.2 basic software package is not designed to function as a drawing program.

The first issue, the lack of the full software package, was a cost driven limitation. The total cost for an ArcGIS© 9.2 full suite was over $5800.00 dollars in 2009. Given the rapid changes in software design over a short period, I determined that it was not cost effective to purchase the full suite. Additionally, the program was not an optimum choice for extensive amounts of drawing, so the decision to bypass the purchase seemed to be a sound one. The second issue presented by these two limitations was in the actual design of the Perilo neutral-site GIS. I found that with the limited software package, drawing the various elements of the neutral-site was very time consuming and ultimately created alignment problems that I will discuss later in this paper.

(20) I was able to find effective solutions for both issues. I located an ESRI vendor who sold me a one-time license for the basic program. Software updates are not available, and the extensions that give the software more flexibility are extra, but I was able to complete the project. I addressed the design issue by switching my primary drawing program from ArcGIS© 9.2 to AutoCAD© 3D by Autodesk with a Carlson Software overlay. Making the switch made it necessary to eliminate much of my initial work, but at the end of the process, produced a better product.

DISCLOSURE OF THE RESEARCHER'S RELATIONSHIP TO THE PROBLEM

(21) I have been a working Emergency Management Professional since 1997. The vast majority of my work has been through the United States Air Force. I have been responsible for operational planning, member training, and technical operations under both peacetime and combat conditions encompassing several deployments to both the European and Middle-Eastern theaters. In that time, I have also had the responsibility of educating many Air Force personnel in emergency management processes and procedures, ranging from weapons of mass destruction response to proper actions in the event of inclement weather.

(22) Additionally, I have worked as a land surveyor's assistant for over twelve years. During this time, I have surveyed in both rural and urban environments. My extensive experience has enabled me to gain knowledge and apply the concepts involved with community design and operations. Surveying has also required me to develop an

understanding of spatial relationships and digital mapping, both of which are key components of geographic information systems.

DEFINITION OF UNIQUE TERMS

(23) Geographic Information Systems (GIS): A Geographic Information System is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (National Weather Service, 2008). This data can include basic information such as names, addresses, telephone numbers, and zip codes. More advanced details such as planning and zoning information, crime statistics, the locations of various types of businesses, and essential services are available for inclusion. In addition, sub-data sets will give specific information about the main data source. In this document, geographic information systems are abbreviated with the acronym GIS.

(24) Neutral-site geographic information system: A neutral-site GIS provides the same information as a normal GIS, but the data provided is not tied down to a specific jurisdiction. A neutral-site GIS will provide multiple scenario information and issues without addressing the problems that are unique to a given geographical area.

(25) Global Positioning Systems (GPS): Global positioning systems are hardware and software that work in conjunction to provide the specific coordinates of a given point that can be located on a computerized map. Depending on the equipment and software in use, these coordinates may have accuracy down to sub millimeter. However, most GPS systems purchased by the public are accurate within 10 meters.

(26) ESRI: Environmental Systems Research Institute, known today as ESRI (pronounced ez ree) and is headquartered in Ontario, California. ESRI owns the ArcGIS© 9.2 platform that is the dominant system in GIS technology today. Its website is located at www.esri.com .

(27) SIM City: Simulation City is the video game owned by Maxis Corporation (now a part of Electronic Arts (EA) Games) that provided the initial idea for this project.

LITERATURE REVIEW

(28) What is a city? What is emergency management, and what impact can it have on a city and its residents? How does GIS aid the development of a city? What impact can GIS use have on emergency planning? Each of these questions is important, because together, they provide solid reasoning for the development of a neutral-site GIS. By examining the historical perspective that surrounds each question, I hope to build a strong foundation for the overall purpose of my thesis: what is the benefit of developing and training in a neutral-site GIS?

WHAT IS A CITY?

(29) In his book, *The First Civilizations*, Glyn Daniel (1968) notes that some of the elements that comprise civilization include the wheeled cart, the sailboat, the plow, writing systems, and city life. Cities, therefore, are a basic unit of civilization. Clyde Kluckhohn took this rationale a step further by assigning a number to such a city. He stated that for civilization to exist, a town needed a population of at least five thousand people (Daniel 1968). While such a number is certainly not concrete, Kluckhohn believed that this number would represent the intent of a group of people to live in a specific area, have common goals, and understand the nature of commerce between different groups of people within the society.

(30) Exactly where the concept of city life began is subject to some disagreement. One example might be the ancient civilizations of Sumer, which existed from roughly the sixth millennium BC to the third millennium BC and included multiple peoples over a wide geographic area between the Tigris and Euphrates Rivers (Yoffee 1988). These civilizations are considered by some researchers to be the first examples of the city-state model in the western world (Yoffee 1988). In addition to civilizations in the Tigris-Euphrates river valley, significant examples of city dwelling exist near the Nile River in northern Egypt, the Indus River, in western India, and the Shang River in China. There is also evidence of city dwelling along the west coast of what is modern Peru, in southern Mexico on the Yucatan

Peninsula, and the jungles of Central America (Daniels 1968). Any one of these examples could represent humankind's first attempts at city living.

(31) Do these ancient examples assist in providing a modern definition for the word *city*? In its modern evolution, is a city the major metropolis comprised of massive skyscrapers and a teeming business district? Is it a midsized borough comprised of a town square and courthouse? Is a city anywhere where a local government congregates and makes decisions for its local populace? Depending on where in the United States people congregate, the definition may change (Gerckens 1979).

(32) Webster provides a possible definition of what comprises a city as "an incorporated municipality in the United States with definite boundaries and legal powers set forth in a charter granted by the state". Such a definition provides two key elements: establishes definitive geographic boundaries, and provides a legal component by acknowledging the charter that grants the city the legal power to act on behalf of her citizens. Such legal power could be a driving force in establishing a GIS.

(33) What is the importance of defining what a city is? Creating a GIS is an expensive proposition. Costs will include multiple software licenses, individual workstations, training on the new system, and data compilation (Tomlinson 2007). The organization or government entity that has the responsibility for the cost will ultimately decide if the effort is worth it. Making such a decision also provides some justification for a neutral-site GIS. Providing training in advance of the purchase and implementation of a geographic information system can help determine if there is a need for such an effort, and just as importantly, if the people who are supposed to use and maintain a GIS have the ability to do so.

HOW DOES EMERGENCY MANAGEMENT BENEFIT A CITY?

(34) The concept of emergency management has been in practice since the earliest recorded times. The ancient Egyptians accepted that the source of life was the flooding of

the Nile River. Further, the Pharaohs actually had a canal system engineered to spread the yearly flood out to various agricultural fields around the river. The challenge these early engineers faced was to provide for the flooded fields to drain as needed, while still maintaining enough elevation adjacent to the fields flooded by the Nile to allow for human occupation. Additionally, they needed to develop a plan that allowed for unexpected flooding (Castel and Otte 2001).

(35) The first organized efforts in emergency management within the United States occurred following the New Madrid Earthquakes in 1811 and 1812. Shortly after 2 o'clock on the morning of December 16, 1811, an earthquake so severe, that it awakened people in cities as distant at Pittsburgh, Pennsylvania, and Norfolk, Virginia. The quake rocked a large portion of the central Mississippi River valley. This event began the greatest earthquake sequence ever to occur in Continental North America (Johnston and Schweig 1996).

(36) Uplifts of over three meters occurred at one locality several hundred kilometers to the southwest of the earthquake epicenter. A lake formed by the St. Francis River had its water replaced by sand. The only evidence of a lake having been there were the numerous dead fish found in the former lake bottom. Large fissures, reportedly so wide that they were not crossable on horseback, formed in the soft alluvium. The earthquake made previously rich prairie land unfit for farming because of the deep crevices. Land subsidence converted good fields to swamps. Numerous sand blows covered the ground with sand and mud. Sand blows are defined by the USGS as patches of wet, loose sand that erupts when strong seismic waves pass through, causing the sand to act in a thixotropic manner. The heavy damage inflicted on the land by these earthquakes led Congress in 1815 to pass a relief act providing the landowners of ravaged ground with an equal amount of land in unaffected regions. Known as the New Madrid Claims, they are one of the earliest examples of government intervention in a post-disaster area in United States history. (Bagnall 1996).

(37) The modern incarnation of emergency management originated with the establishment of the Office of Civil Defense led by the mayor of New York, Fiorello LaGuardia in 1941 (Green 1999). The primary purpose of civil defense was the protection of the civilian population and the industrial capabilities during World War II. These programs paralleled the British model of Air Raid Precautions, and the German Luftschutze (Littlejohn 2007). LaGuardia held that position, mostly in a part-time capacity, until the Japanese attack on Pearl Harbor in December 1941, when he moved aside for full-time director James M. Landis who served until 1943. President Franklin Roosevelt re-assigned Landis as the American Director of Economic Operations in the Middle East after it became apparent that there was little chance of an attack of the mainland United States. The Office of Civil Defense disbanded in June 1945 (Winkler 1984).

(38) The post World War II abolishment of the Office of Civil Defense signaled the beginnings of a disturbing pattern that persisted for many years. There was never a perceived need for civil defense/emergency management at most levels. Leadership was often temporary. Programs at federal, state, and local levels often lost funding when government officials failed to see the value of spending money for events that had not occurred yet, or might never occur. Green (1999) points out that the federal government lacked critical leadership in regards to emergency management programs. Instead of providing guidance on the issue, the primary responsibility for national civil defense moved through twelve different offices between 1949 and 1979. It was not until the Federal Emergency Management Agency (FEMA) received a charter in 1979 that the program found a permanent home (Waugh and Tierney 2007). This reorganization represented a fundamental change to devote programmatic attention to natural and man-made disasters as well as attack scenarios.

(39) Today, emergency management exists in most communities as a locally managed program with considerable resource support from state and federal levels. Most cities, counties, and states have some form of an emergency management agency that can

respond to events as needed. The attacks on the World Trade Center and the Pentagon on 11 September 2001 resulted in the absorption of FEMA into the larger structure of the Department of Homeland Security (DHS). This arguably created a scenario that subordinated natural and man-made events in favor of terrorist activities. In short, the pre-existing mission of civil defense once again took center stage. The debacle that occurred in the days and weeks after Hurricane Katrina, and her often forgotten little sister Rita, moved Congress to restore much of the authority removed from FEMA in the years before the twin hurricanes struck (Haddow 2007). Today, FEMA still resides under the umbrella of DHS; however, most communities and governments understand the necessity of emergency management and planning as critical to their overall well-being.

(40) A well-managed emergency management program benefits a city by ensuring that the jurisdiction is prepared and equipped to handle any manner of emergency. The principal goal of emergency management at all levels is this: to do the very best to prepare for the worst that might happen in a community. A critical process used by emergency management professionals involves the four phases of comprehensive emergency management: mitigation, preparedness, response, and recovery (Petak 1985).

(41) Mitigation is perhaps the least used and yet the most powerful weapon in an emergency manager's arsenal. Mitigation is the pre-planning that takes place both before an event and changes that occur after one. The intent of mitigation is to prevent a disaster event from occurring, or to lessen the effects in the event that one does occur. Some of the most common mitigation strategies employed by jurisdictions include flood plain restrictions, building codes, and planning and zoning regulations (Petak 1985).

(42) Of the four elements in the emergency management cycle, mitigation is also the most cost-effective in the end, ultimately minimizing the need for expenditures in the other phases (Godschalk 1999). Godschalk goes on to state that the mitigation phase is an important national policy issue because the monetary and physical costs in lost homes and businesses are staggering. The federal government amasses huge debts in a post disaster

environment, largely due to rebuilding costs. Additionally, many private insurance companies will decline to offer policies in some geographic areas due to large and repeated payouts to those same areas (Godschalk 1999). A current example of this is the decision by State Farm Insurance, the second largest homeowner policy writer in Florida, to cease writing any new policies in the state and to completely withdraw from all existing homeowner's policies by 2011 (Plevin 2009). By enacting strong mitigation programs, communities can offset the need for massive rebuilding federal grants and stop insurance companies from fleeing affected states, leaving residents with no protection.

(43) The next phase of the emergency management cycle is preparedness. The definition of this phase is a state of readiness to respond to a disaster, crisis or any other type of emergency (Haddow 2008). Communities need a well-written emergency operations plan, which will help them make many of the pre-event decisions. Some of these decisions could include pre-selecting and coordinating shelter locations, selecting and training community volunteers, purchasing and testing needed response equipment. However, it is important to note that even a well-written Emergency Operations Plan (EOP) will not solve everything.

(44) Wilson makes an excellent point concerning disaster preparedness. He says that no matter how well a jurisdiction has planned for a disaster response, it will face situations and decisions that it has not foreseen (1991, p 16). Major events typically have many pre-conditions, which typically fall into place over an extended period, sometimes taking as long as several years to build up (Turner 1994). Consider the events surrounding the attacks by Aum Shinrikyo on the Tokyo subway System in April 1995. Aum was the chief suspect in seventeen other attacks involving chemical or biological weapons in the years prior to the subway incident (Ballard and Pate 2001). Yet despite repeated attacks, assassination attempts, and several suspected murders, government and law enforcement officials did not foresee just how far Aum would go in pursuit of its goals. The result: 12 dead and close to one thousand injured (Ballard, Pate 2001).

(45) A community can best offset these unexpected events by increasing its training program. Emergency operations center personnel, first responders, volunteers, non-governmental organizations (NGO's), local business owners and community members will respond to the challenges of unexpected events if they have had time to consider them and have some training and information to counteract the effects. The time to think about emergencies is before they happen. (McLoughlin 1985). Practicing response-oriented checklists, various levels of exercises, and the use of a neutral-site GIS could have the potential to give a community extra pieces of information that might make a difference in a real-world incident.

(46) The definition of a jurisdictional response to a disaster event is the employment of resources and emergency procedures as guided by emergency operation plans to preserve life, property, the environment, and the social, economic, and political structure of the community. Response may not have a specific timeline. The response phase in post-Katrina New Orleans went on for over a week. The specific threat will be the driving force behind actions taken during the response phase (Haddow 2008).

(47) Some of these actions could include implementation of the emergency operations plan, activation of the emergency operations center, and the evacuation of threatened populations. Shelters for those whose homes suffer damage or destruction may open. Additionally, mass care, emergency rescue, and medical assistance will need to be coordinated with the various agencies that provide these services. It is important to note that the Emergency Operations Plan may discuss many of these provisions, but the actual circumstances of the disaster will require change and flexibility with available resources. Fire fighting, urban search and rescue, emergency infrastructure protection and recovery of lifeline services (ranging from sandbagging levees to restoring electric power), and mortuary affairs are other services that fall under response (Haddow 2008).

(48) Response is the culmination of all of the mitigation and preparation that a community has undertaken. Any significant shortfalls in planning or operational preparation

will become evident during the response phase. History suggests that the unexpected will happen during the response phase. What a jurisdiction practices and the actual event will usually not mirror each other. A failure to give the proper attention to the first two phases of the comprehensive emergency management cycle will almost certainly guarantee failure in the third.

(49) Recovery is the final phase in the emergency management cycle. Haddow defines recovery as the restoration of normal day-to-day functions within the community (2007). It usually takes the longest of the four phases to complete, and can have the most far-reaching effects. A well-defined and practiced recovery plan will also consider the potential for future disasters and incorporate mitigation strategies. This completes the comprehensive emergency management cycle.

(50) Emergency management is a critical component in the effective administration of a city (Waugh and Tierney 2007). Additionally, the four phases of the comprehensive emergency management cycle provide a basic but sound structure that allows a community to survive a crisis event. By implementing the elements that each phase requires, and just as importantly, practicing the plans and programs that result from that implementation, a city increases its ability to navigate a disaster event successfully with less loss of property and of citizen's lives.

HOW DO GEOGRAPHICAL INFORMATION SYSTEMS IMPROVE EMERGENCY MANAGEMENT?

(51) In the introduction of the text he edited, *The History of Geographic Information Systems Perspectives from the Pioneers,* Timothy Foresman makes a critical point regarding the origins of GIS. "In truth", Foresman (2005 page 5) says, "the phenomenon is ineluctably linked to a myriad of influences." No single person or group can take credit for the technology known today as GIS. Further, depending on the discipline that is being emphasized, different users may have a different perspective on the history behind that discipline. However, most experts agree on one point. Dr. Roger Tomlinson is the father of

the modern GIS system. His efforts, driven by the need of technology to manage Canada's vast natural resources were the beginnings of modern GIS technology.

(52) In the early 1960's Canada realized that its natural resources, while vast, were also limited. For the first time, a national government thought what had been unthinkable: the government had a role to play in the decision-making process concerning land use, natural resource utilization, and how these factors could affect the environmental policies of a nation. (Tomlinson 2005).

(53) In 1971, the Canadian Geographic Information System or CGIS became an operational entity. Over the next several years, CGIS moved through several departments, including the Department of Forestry and Rural Development, The Department of Regional Economic Expansion, and finally, as the focus of the Canadian government's land management activities changed, the CGIS program moved to the Department of the Environment (Tomlinson 2005). In each new department, the basic goal of CGIS remained the same: to assist in the development of Canadian lands in a responsible manner, using geospatial data to provide information that allowed the government to make the best decisions possible. Moving from department to department expanded the coverage and fed more data into CGIS. By the time the system stopped receiving new data in 1989, it had over 10,000 overlay sheets of more than 100 types of geospatial data, all stored in electronic format (Tomlinson 2005).

(54) While the Canadian government was exploring, developing, and ultimately implementing a workable GIS, the United States government was dealing with many of the same issues. Initially, unlike the Canadian efforts, which brought cartography and data together early in the process, the USGS efforts kept the two core technologies in two distinct sections (Greenlee and Guptill 2005).

(55) The arrival of David Bickmore, who had been working in the Experimental Cartography Unit in London, England, changed the concept of keeping these technologies apart. Bickmore, who had been working in digital cartography since the early 1960's, had

two key thoughts that were critical to the development of the modern GIS in the United States:

- The old ways of map producing should not serve as graphic conventions that had grown out of the methods of cartographic draftsmen. If it was possible to use automatic cartography to produce maps, then the fact that maps used to be hand drawn was not relevant.
- The ultimate store of information in the computer-aided system is the geodatabase. Data should be arranged in the most general way possible so that its structure does not limit its usefulness. (Greenlee and Guptill 2005).

(56) He had clearly identified the problem, much as Tomlinson has done at CGIS. Bickmore understood that the science of cartography would grow and be far more useful if there were ways to link it to a geodatabase. He continued to work with the engineers of the Topographic Section of the USGS through the 1970's and made plans to coordinate on the National Atlas to be produced in 1980. The atlas, produced by the geography section, was just one way the gap between the two sections began to close. Both sections agreed that it was important from an institutional point of view that technology that could collect and utilize spatial data needed to be developed. How the two sections got there was less important than the fact that they arrived at the same place. (Greenlee and Guptill 2005).

(57) The remainder of the 1970's and into the early 1980's saw many advances in GIS technology. Although the people at USGS were not at the forefront of their invention, as they had been with the Geographic Information Retrieval and Analysis System (GIRAS), they were some of its most eager customers. USGS's long history with the GIS process gave them a unique perspective on the advancing technology. They understood how the utilization of GIS would create a better overall system. Some of this technology included the use of satellite imagery, which replaced high altitude aerial platforms, newer software, such as the first ARC INFO which processed the data much more accurately with fewer interpretation errors, and of course, much faster computer systems. The transistor gave way to the microchip allowing for more memory within the computer systems, and therefore shorter processing times for the collected data. The result of these advances was the ability

for the Department of the Interior (DOI) and the USGS to have better information with which to make land management decisions (Greenlee and Guptill 2005).

(58) Today GIS continues to be the primary tool used in making land management decisions. It is also important to note that increasingly, these decisions consider an emergency management point of view. Why is this critical? According to a Massachusetts Institute of Technology study published in *The Review of Economics and Statistics Journal* using data from 1980 thru 2002, the United States has a higher annual rate of disasters than any other nation. (Kahn 2005)

Table 1: Disaster events by nation (top 10)

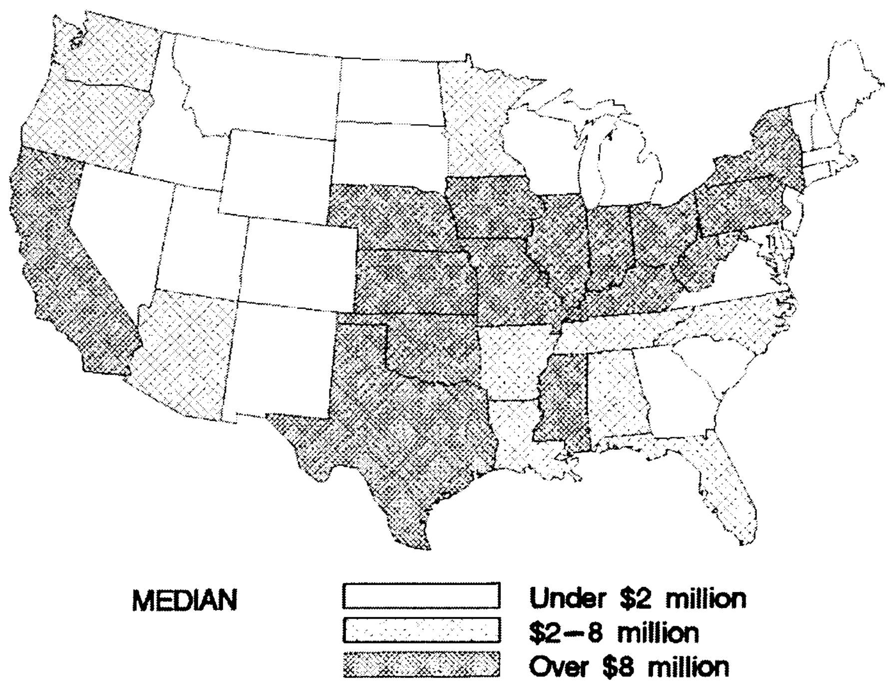
Country	Annual average total Count of Disasters	Annual Average of total deaths per million people	Average deaths per earthquake	Average Deaths per extreme Temperature Event	Average deaths per Flood	Average deaths per landslide	Average deaths per windstorm (tornado)
United States	17.9565	1.3337	7.9444	115.8333	6.3820	0.0000	17.2361
China	13.9130	1.7657	36.9039	29.1429	328.4300	63.9091	71.7268
India	10.0870	4.7195	2294.0720	328.7692	291.7245	91.1429	332.0606
Bangladesh	6.2609	65.9391	6.0000	139.6667	211.4565	0.0000	1940.4940
Russia	6.0000	2.8809	400.2000	107.4667	14.4815	56.7500	18.6364
Indonesia	5.7826	1.9380	92.5455	0.0000	46.3939	47.5000	0.6667
Iran	4.3043	41.2894	1105.3260	0.0000	69.0625	26.5000	39.0000
Australia	4.0000	0.6741	7.6667	5.7500	3.5926	14.0000	1.6964
Vietnam	4.0000	11.6504	0.0000	0.0000	98.8333	110.5000	270.9091

(59) As the data in Table 1 indicates, the United States, despite its smaller population than India, Russia, and China, and its smaller land mass than China and Russia, is still the number one nation in the world for reported disaster events over the twelve year study period. However, even with more incidents than any other nation, the United States also ranks lowest in terms of deaths. Kahn (2005) states that death tolls are lower in the United States because the nation has more economic development than many of the other countries cited in the study. I believe that he is only partially correct. Economic development is a critical factor, but just as important is what a jurisdiction does with that

development. I would argue that from the community level up, leadership has adopted an emergency management mindset.

(60) Further, U.S. Census Data indicates that over one-half of the United States Population now lives along an ocean or inland waterway. Additionally, one of the fastest growing areas is the southeastern Atlantic coastal zone, which showed an increase in the population density of over 75% from 1970 thru 1990 (Kunreuther 1996). What these numbers suggest is that people want to live near water and will either not consider the inherent risk, or will expect that their insurance will serve to shift the risk of any difficulties that they might encounter.

Figure 1: Level of median annual flood damage (in 1995 dollars) in each state for 1955-1978 and 1983-1999.



Source: Downton, Miller-Barnard, and Pielke Natural Hazards Review 2005 Volume 6, Issue 1; Pages 13-22. Reprinted with permission of the American Society of Civil Engineers

(61) However, what people believe and what the reality is are often two different things. A standard homeowner's policy and a business owner's insurance policy, required by most banks and financial institutions as a condition for granting a mortgage, will provide

protection against wind damage, but not the damage caused by water. In the past, insurance firms have experimented with providing this coverage, but concluded that the risk was uninsurable (Kunreuther 1996).

(62) In 1968, the federal government decided that the mounting losses from water damage were growing too fast. It launched the National Flood Insurance Plan (NFIP). The NFIP, which is marketed by private insurance companies but administered by the federal government, provides subsidized flood insurance at about one-third the rate of the cost of the policy if it were privately purchased (Kunreuther 1996).

(63) The one caveat to being eligible for this insurance is that the community must enforce land-use regulations and hazard mitigation requirements, which usually go hand-in-hand (Browne and Hoyt 2000). GIS is critical in this effort. The maps provided by a GIS provide a strong visual representation of where flood plains are currently located, and just as importantly, where the floodplain has been located in the past and where it could potentially move to in the future. These visual representations are important in both land management and emergency management decisions.

(64) Floodplain management is largely a part of the mitigation phase of the emergency management cycle. GIS also has possible applications in the response phase as well. A critical part of the response function includes the evacuation of community residents from potentially dangerous areas and the sheltering of those residents. Poor planning or execution of either of these could result in a scenario much like New Orleans after Hurricane Katrina, with the horrifying images from the Superdome being repeated (Waugh and Tierney 2007).

(65) What does a successful evacuation plan involve? The evacuation plan must be flexible to respond to various types of disasters that have been pre-identified by emergency management personnel. An evacuation plan is not going to look the same for a flood scenario as it would for a toxic industrial release near a manufacturing facility or a railway carrier. Waugh points out that in the days following Hurricane Katrina, the federal

government mandated that all cities needed to create and maintain mass evacuation plans (2007). However, this seemed little more than a knee-jerk reaction. Even during the events of Katrina, evacuation of the whole city was unnecessary. A study by the RAND Gulf States Policy Institute states that the city was largely evacuated, *after* Hurricane Katrina. Despite the widespread devastation, RAND estimates that up to twenty-five percent of New Orleans suffered little or no flood damage. Areas such as Garden District, French Quarter and Algiers largely escaped Katrina's devastation (McCarthy and Peterson 2006). Most disasters do not lend themselves to enough time to allow for such an action before the event. Imagine trying to evacuate Oklahoma City in May 1999 when an F-5 twister struck the city (one of three to impact the Oklahoma City area that day) (Speheger and Doswell 2001). Even with advance warning, it would not have been possible to move that many people with so little time.

(66) What an evacuation plan can do is aid response forces in at least two critical ways. First, the plan can aid in determining where evacuees are going to be relocated. Second, it can determine how they going to get to this location? Tomlinson (2007) suggests that the application of an in-vehicle routing display and GIS can help in the process by providing visual information regarding which roads are open, which are closed due to damage or congestion, etc. These two factors would aid in routing emergency service vehicles through to routes that are moving most efficiently.

(67) In 2002, the University of Alabama studied the evacuation process. Using Baldwin and Mobile Counties, located on Alabama's Gulf Coast, as their testing ground, the University research team of Akhilesh Pal, Michael Triche, and Andrew Graettinger combined Arc View 3.2 and the Oak Ridge Evacuation Modeling System (OREMS), a traffic modeling software package, to develop evacuation models for the two counties.

(68) The Alabama study re-emphasizes two things about an evacuation. First, not everybody in a given area will need to evacuate. The severity and course of the event will be the determining factors. Thus, the need for a full city evacuation plan seems to be

excessive, at best. Second, planning will be critical to determine how the population will get out, and what routes they will use. GIS will lend critical support to the evacuation process.

(69) The result of the Alabama study indicated with proper planning and the implementation of a GIS and OREMS system, a ninety-five percent evacuation of a major gulf coast county with an impending hurricane could be achieved in just over seven hours. Thus, even allowing for unpredictable human elements, which are difficult to incorporate, the use of a GIS assisted in significantly improving the evacuation process and further aided emergency management personnel in carrying out their assigned tasks.

(70) A final use of GIS in the response phase is the tracking of emergency response forces. There is an accepted piece of logic in military operations: he who wins the reconnaissance battle, wins the war (Antal 1998). It is much the same in emergency management. Emergency management leadership will have a good idea about where the hazard is, but having the ability to keep track of where response assets are located is the equivalent of winning the reconnaissance battle. A GIS map, linked to GPS locators in emergency vehicles could solve the problem. Some cities, such as Denver, Minneapolis, and Chicago have already outfitted their police and fire vehicles with this technology. In a critical response, time is the one element that cannot be recovered. It can, however, with the proper technology, be bought. GIS/GPS may well be that technology.

METHOD

DESCRIPTION OF THE METHOD

(71) The purpose of my thesis is to show not only the value of a neutral-site GIS, but to highlight the steps involved in the construction of one. I wanted to show not only how the process flowed, but also the mistakes that were made during the overall construction. Ordinarily, discussing the errors that occur during a research process might not be something that should be highlighted in any research document. However, the construction of a neutral-site GIS is a new process. There are few other examples to examine for reference. It is my opinion that the missteps are just as important as what I did right. For

these reasons, I decided to use the qualitative case study method which examines how the entire process occurred using a four-step approach. These steps are situation, approach, solution, and evaluation.

DESIGN OF THE STUDY

Situation

(72) Making communities more disaster resistant is the goal of emergency management in general and the principal use of the training environment that is created by a neutral-site GIS. However, such a site is not readily available at this point. Many communities have taken comprehensive steps toward creating local GIS platforms. Emergency management is only one possible application of the hundreds that GIS can influence (O'Looney 2000). The creation of a neutral-site GIS presents a unique opportunity for the emergency management community to receive training that might otherwise be more difficult to coordinate.

(73) However, such a GIS must meet several different criteria. First, it must be accessible to emergency personnel nationwide without necessarily having to travel to a central location. Second, specific training in the principal software that the GIS is written in must be available. Third, the GIS must address specific hazards that a local emergency manager would require training in. No one community has the exact same hazards as any other, so adopting the all-hazards approach common to emergency planning would seem to alleviate any concerns regarding the usefulness of a neutral-site GIS. The creation of a training tool that meets these requirements was my overall goal, and one that I think I have met with the construction of the Perilo/Glencoe GIS project.

Approach

(74) In order to construct the neutral-site GIS I had to undertake appropriate training from the very beginning of the process. Because I selected ArcGIS© 9.2 as my platform, much of my training was through ESRI, who owns the rights to all ArcGIS© 9.2 software. Training is available in several different formats, as the table from the ESRI website shows.

Table 2: ESRI Training Course Formats

Training Format	Format Specifics
Web Course (W)	Written concepts or recorded lectures, hands-on software exercises, and an exam provided for self-paced training over the Internet. Courses with a recorded lecture require a broadband connection. Students must have access to the software to complete the exercises. For many courses, you can try the first module free. Courses may range from two through thirty hours to complete, and a completion certificate is issued.
Training Seminar (TS)	A recorded lecture and software demonstration provided for self-paced training over the Internet. Recordings are from the ESRI Live Training Seminars, and require a broadband connection. Courses are typically one hour long and no completion certificate is issued.
Instructor- Led Course (IL)	Lectures and hands-on exercises presented in a traditional classroom. The instructor is available for questions and guidance throughout the class. ESRI will also host a private class for your organization at the ESRI training facility. Courses range from two through five days to complete, and a completion certificate is issued.
Instructor-Led Virtual Classroom Course (ILV)	Lectures and hands-on exercises presented in an interactive classroom over the Internet. The instructor is available for questions and guidance throughout the class via the telephone and typed messages. Course is typically 1-3 days long and a completion certificate is issued.
Instructor-Led Course offered by Professional Services	Leveraging their expertise in real-world projects, the ESRI Professional Services consulting staff design and teach courses for specific industry solutions or products. The format varies from course to course. Course is typically 2-5 days long and a completion certificate is issued.

www.esri.com//gateway/index.cfm?a=trainingOptions.gateway accessed on 20090305.

(75) Initially, I opted to familiarize myself with Arc software by taking two training seminars: Introduction to ArcGIS© 9.2 Online and HAZUS-MH, which stands for Hazards United States, Multi Hazard. These seminars provided me with baseline information regarding what capabilities ArcGIS© 9.2 could provide an emergency manager. I found the information important, because it helped me to understand what ArcGIS© 9.2 could do for a community.

(76) After completing the training seminars, I decided that I needed to see specific use of a GIS in emergency management. ESRI offered a web course entitled Solving Disaster

Management Problems Using ArcGIS© 9.2. The course was broken down into five different sections, each unit building upon the previous one. Such a stepping stone approach allowed me to examine how the employment of GIS from the ground up through the phases of comprehensive emergency management.

(77) In the Disaster Management Problems course, I worked with processes involving mapping for natural disasters, multi-hazards, and human-caused disasters. I looked at how GIS is appropriate for use in shelter planning and disaster assessment.

Solution

(78) One of the basic concerns that needed to be addressed prior to the development of a neutral-site GIS was the identification of the neutral-site. Initially, I considered the use of a medium size city, like Kansas City, Missouri and adapted it to suit my needs. However, the following three critical issues convinced me that the best way to manage the construction of a neutral-site GIS would be to select a locality over which I had a measure of control:

- The volume of data for an actual city was overwhelming given the time available for this study
- Some jurisdictions expressed concerns regarding the release of data that might be politically sensitive or raise security concerns
- Private entities could be unwilling to release information that they considered proprietary to operations

(79) The Republic of Perilo, a virtual micro-nation, provides just such a place. Virtual micro-nations exist only on the internet and vary widely from complete fantasies to semi-serious attempts to establish communities based on hypothetical forms of government (Ryan and Dunford, 2006). Perilo is the only fully structured micro-nation designed for research, testing, and training I have been able to identify. It includes established geographical, demographic, and organizational data. Perilo allows for the simulation of disaster events, testing of various approaches, and notionally, a platform for providing training for emergency services personnel to respond to those events.

(80) Perilo is located in the southern hemisphere (WGS_1984_UTM_Zone_36S), approximating the location of the nation of Madagascar. It is comprised of several climate regions, ranging from a desert in the north, to a much more temperate area to the south. A large lake with deep-water access is in the Eastern Province, and the western border is a large river named the Big Muddy. Several smaller rivers transect the nation.

(81) Politically, Perilo is divided into four provinces named for their geographical area. These provinces are named the Northern, Northwestern, Southwestern, and Eastern. Each has a provincial capital, with the autonomous National Capital Region incorporating the city of Glencoe.

(82) This study creates a GIS map of the micro-nation of Perilo and specifically a detailed map of the national capitol, the city of Glencoe. By incorporating features that are typical to many cities throughout the nation, the ability to train emergency personnel is enhanced, without having to worry about gathering information regarding a specific city, and its plans and programs. Additionally, the variety of climates and locations that exist within Perilo allow for nearly limitless scenario building exercises that can test the response to virtually any type of disaster. The addition of a GIS will add modern technology to the process, and provide the most up to-date training using the most up-to-date tools.

SAMPLE AND POPULATION

(83) The focus population of this study is the residents of the entire virtual micro-nation, the Republic of Perilo. However, it was impractical to attempt to generate a virtual population for an entire nation. Instead, I chose a subordinate level, by examining the virtual population within the city of Glencoe. Neither the geographic area that is represented by Perilo nor the population associated with each parcel within Glencoe actually exists. This raises an issue: the validity of studying a group of people who exist only as electronic files or in the imagination of the author. However, experience in exercise planning and participation in several other exercises, suggest emergency management personnel who use

the neutral-site GIS for training, research, and testing will accept the underlying assumption that the electronic population is real.

(84) Theoretical populations and simulation models have been used as the basis for scientific studies and the eventual determination of policy. For example, in 1998, the University of Minnesota School of Public Health studied the role of genetics and environmental conditions in the development of lung cancer within families. In this study, the researchers acknowledged that to create accurate results, they needed to simulate a population of lung cancer families that had a predisposition to the development of the disease. Although three generations of Louisiana of actual families were a key component of the study, the results required the use of a simulated population of 200,000 individuals (Sellers and Weaver 1998).

(85) In 2000, researchers stated that simulation models are used as a way to test the performance of management strategies and explore the results under a broad range of assumptions. They go on to note that simulation trials can assess strategy performance before risking a strategy on the population itself, highlighting when strategies are most likely to fail (Milner-Gulland and Shea 2000). Using simulations and theoretical populations to test theories, ideas, and strategies is an established way to test outcomes before making policy or procedural changes.

(86) The focus of the neutral-site GIS is the capital city, Glencoe. For the purposes of this effort, I identified 42121 parcels within the city/suburb area. The details of the specific parcel development structure appear in the Results chapter of this document. These parcels were divided in the following ways:

Table 3: Parcel Types

Parcel Type	Number of Parcels	Percentage of Total Parcels
Residential	23398	54.5%
Commercial	15628	36.4%
Government	782	1.8%
Industrial	2794	6.5%
Parks	330	0.8%

Total	42932	100%

Each parcel represents specific ownership of a piece of land, either by an individual, a company, or by one of the levels of government. Who owns the parcel, and what they have placed on it is critical in the use of a GIS.

(87) The majority of the parcels are zoned RESIDENTIAL (throughout the remainder of the study, major layer names are shown in capital letters for clarity purposes) indicating that the structure placed on it is likely a residence, with at least one person living in it. This is a key factor in the use of a GIS because location and time of day of an incident helps determine the scope of emergency response and will have an effect on the final injury and death totals. Although data for Perilo does not exist, according to the American Time Use Study conducted in 2003, Americans spend over nine hours per day in their homes doing various activities (Hamermesh and Frazis, 2005). What this means is that a disaster event that occurs at ten o'clock in the morning will have a significantly different response structure than one that occurs at seven o'clock in the evening.

(88) An example of the effects of time and location on a disaster event occurred during the 1989 Loma Prieta earthquake. In October of 1989, just before the start of the third game of the World Series, a magnitude 6.9 quake struck the Bay Area. The epicenter, located near the Loma Prieta peak in the Santa Cruz mountain range, was approximately sixty miles south of San Francisco. Sixty-three people were killed and over 3700 were injured. Many of the deaths occurred when the Cypress Viaduct, which was a part of Interstate 880, collapsed on itself during the quake. Forty-one of the sixty-three deaths occurred here (Wilson 2002).

(89) The California Department of Conservation suggested in a 2002 news release that the death toll could have been much higher, both in general and specifically at the I-880 site. Young stated that because the series occurred between the two teams on opposite sides of the bay in 1989 that many people left work a good deal earlier than usual. This

significantly reduced the flow of traffic at 5:05 pm when the earthquake occurred. A normal day would have produced much heavier traffic, and likely far more casualties (Wilson and Oldfield 2002).

DATA GENERATION

(90) For the purposes of the case study, data generation occurs with the construction of the neutral-site Perilo GIS. The study details with rich description every step of the process of researching, designing, and building a neutral-site GIS. My data reports each action that I took and the problems identified in the process. Because this process was iterative, each step evolved based on lessons learned from the previous step. In this process, I was able to identify two logical phases into which all of the steps could be retrospectively grouped.

MEASURES OF RELIABILITY AND VALIDITY

(91) Qualitative research is evaluated differently from the standard methods of reliability and validity that are essential to quantitative research. Because qualitative research is often exploratory and employed on problems that have not previous studies conducted or that are not easily generalized, issues of the ability to replicate studies is not as important. Instead, it is critical that the reader can understand exactly what I, as a researcher, did and can arrive at an assessment of the truthfulness of my research. This means that the qualitative standard emphasizes detailed description of actions taken and precision and description of outcomes with less focus on whether the results can be duplicated (Winter 2000) This study establishes trustworthiness through triangulation (Holloway 1997) and thick description (Denzin 1994). Holloway defines triangulation as a process in which an investigation of a problem or phenomena occurs from different perspectives. Denzin states that thick description is a process in which a small slice of interaction, experience, or action is recorded in great detail.

(92) Establishment of evaluation criteria for case studies is problematic. Lee (1989) points out that there are problems associated with the application of traditional methods in relation

to the case study. He states that the case study will have methodological problems in regards to controlling observations and deductions, and that replicability may be an issue. (93) To address this, I selected two approaches. First, I examined exactly what it is I am constructing, used this information as a baseline, and compared it to several communities I have observed while working as a land surveyor's assistant. The GIS is supposed to simulate data at the local community level. By employing my perspectives as both a land surveyor and as an emergency manager, I established that a neutral-site GIS and an actual city should have similar features and functions. Commonly accepted features almost universally present in any city are identified in Table 4. Note that these have been narrowed to a comparison of features and functions that are essential to the mission of emergency management. Triangulation is an accepted method to establish credibility, one of the elements of trustworthiness (Holloway 1997).

Table 4: Comparison of Perilo GIS Infrastructure to typical United States City Infrastructure

Feature in City	Feature in neutral-site GIS	Explanation
Transportation infrastructure	Transportation Infrastructure	This feature is comprised of the road systems that exist within a city. All types of roads are considered from the major interprovincial highways (similar to an interstate) down to the local feeder roads that supply traffic to the larger boulevards that crisscross major cities. Bridges are also included in this category.
Emergency Services Infrastructure	Emergency Services Infrastructure	This feature is comprised of all of the elements that are incorporated in an emergency service response. These include police, fire, and medical personnel, and the specific locations of facilities that they would be assigned to (i.e. police stations, fire departments, and hospitals). Additionally, the location of the Emergency Operations Center (and its alternate) is also highlighted.
Property Ownership Infrastructure	Property Ownership Infrastructure	This feature is comprised of each individual parcel within the neutral-site GIS. Each parcel may be owned by an individual, company, or government entity within the city. In an actual city, this is one method for determining city population. In the neutral-site GIS, it creates the actual residents of Glencoe, Perilo

Planning and Zoning	Planning and Zoning	Planning and Zoning designate how a parcel of land may be used within a community. Planning and zoning determine what type of facility is permitted on a given parcel of land, and how a facility may be used. It also determines the number of people allowed in a facility at a given period. Such information is critical when writing a shelter plan in the event of a disaster.

(94) The second method to establish trustworthiness was thick description. Every step taken was described in detail with the additional benefit of establishing an audit trail to provide the reader a means of following the steps of the research. Thick description and audit trails are critical methods of establishing dependability as a second element of trustworthiness (Holloway 2007).

RESEARCH RESULTS

(95) The following paragraphs will show, in great detail, exactly how I constructed the GIS map for the Republic of Perilo. There were two distinct phases during this construction: the Provincial Phase and the Glencoe Phase. The provincial phase included the construction of both a national map, which is comprised of data for the entire nation, and a provincial map that allowed me to select province-specific data. This process served as a test bed for the later and more detailed development of the Glencoe region. The Glencoe phase included the construction of the capital city. Processes that were used during the phase are broken down in detail later in the paper. Both the successful events and the setbacks that occurred during construction are discussed. I believe that examining the process from both aspects will give a better understanding of the research that went into this preparation, development, and eventual distribution of this product.

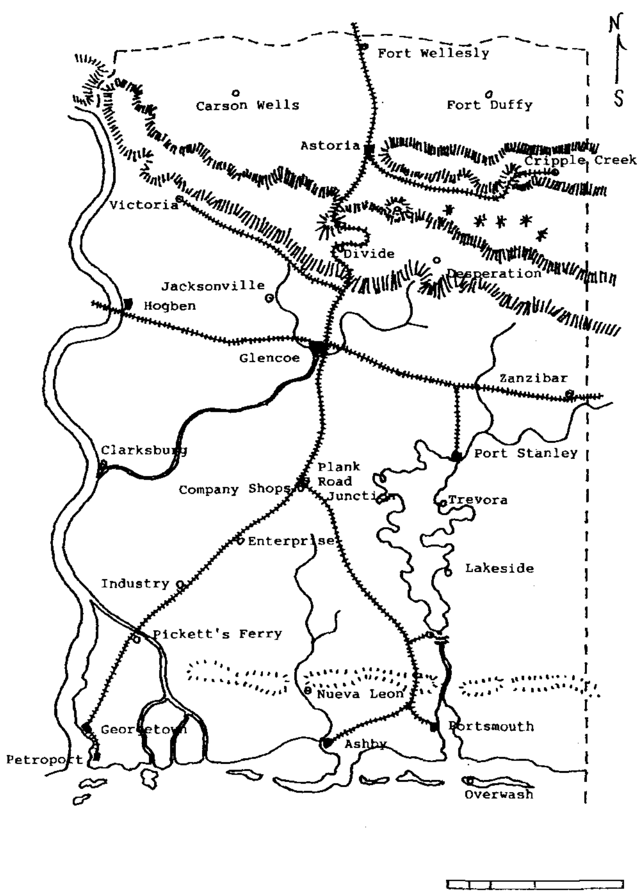
Provincial Map Phase

(96) In January 2008, I began drawing a GIS for the Republic of Perilo. I started the process using ArcGIS© 9.2, which was useful in the early process of creating the country portion of the GIS. There were several steps in this initial process.

(97) First, I obtained a series of maps for the Republic of Perilo. Each of these maps had different information on them, such as provincial boundaries, rail lines, physical relief features, or airdrome/airway systems. The original maps of Perilo looked like the example shown in Figure 2 and were first hand drawn in pen and ink. At the beginning of the project the existing map set, which was available at http://perilo.net/, included the following maps:

- Map of the natural features of the country
- Map of the provincial boundaries
- Map of cities, towns, and larger villages showing major rail lines
- Map of smaller villages, townships and settlements
- Republic of Perilo road map
- Republic of Perilo airways and aerodrome chart

Figure 2: The Republic of Perilo as an HTML file



Source: The Republic of Perilo: http://perilo.net/mapcity.html

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(98) Using the non-digital computer-drawn maps, I employed ArcGIS© 9.2 software to create the digital version of Perilo. I scanned the printed maps, and then converted them to tagged image format (.TIF) files. ArcGIS© 9.2 software failed to open the .HTML files that existed on the Perilo website; however, .TIF files were easily accepted by the software.

Table 5: Add Layer in ArcGIS© 9.2

1.	Open ArcGIS© 9.2ArcMAP Program (the globe icon). Select the map file to be opened. If this is a new map, select New Map File. See Figure 3 for an example.
2.	Double click the selected file. Depending on the amount of data already present in the file, the map may take several moments to open.
3.	On the STANDARD tool bar, select the ADD DATA button. It is the yellow diamond with the black cross in the middle. See Figure 4. The dialog box in Figure 5 will appear.
4.	Use the globe icon with the yellow horizontal arrow to navigate to where the data is located.
5.	Double click the file to be added. Only GIS or geodatabase files will be shown and can be added into ArcMAP.
6.	File will appear in ArcMAP TABLE OF CONTENTS. Newly added files will appear at the top of the TABLE. Files may be dragged to desired position within the TABLE depending on the needs of the user.

Figure 3: Open ArcMAP© Dialog Box

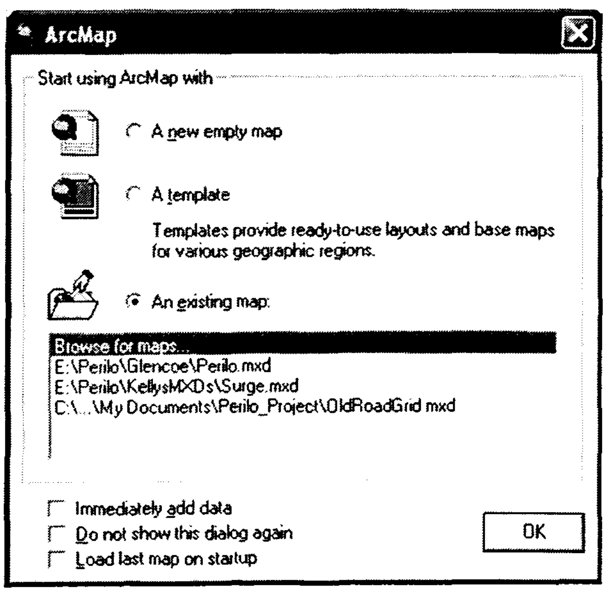
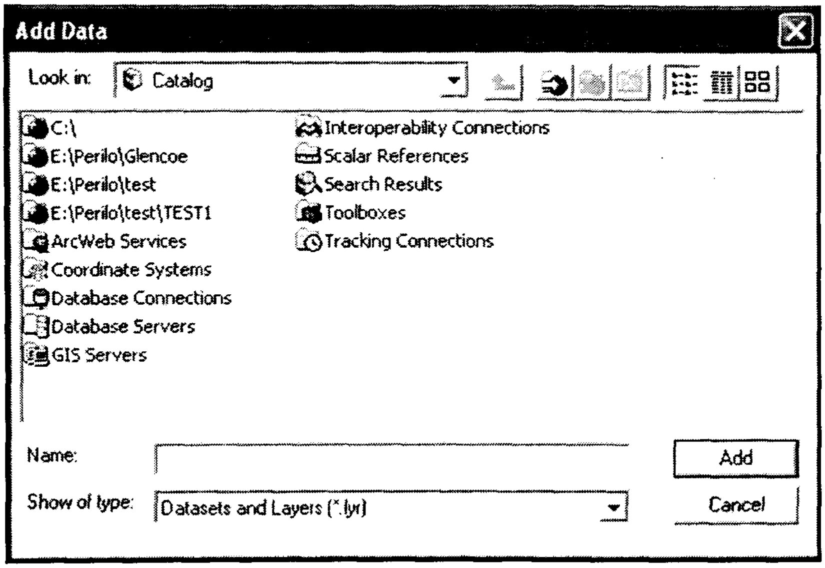


Figure 4: The ArcGIS© 9.2 Standard Toolbar

Figure 5: Add Data Dialog Box



(99) After the Perilo.TIF file was available as a layer, digitizing it was an uncomplicated process that involved tracing the lines on a page. A LAYER represents a specific set of data available to a user. It has the ability to be turned on (made visible) or turned off (made not visible) depending on the needs of the user. Table 6 explains the step-by-step process. Figures 7-9 show the screens, as they should appear during the process.

Table 6: Digitizing a Tagged Image Format (.TIF) Map

1.	Open ArcGIS© 9.2 ArcMAP Program (the globe icon). Select the map file to be opened. If this is a new map, select New Map File. See Figure 3 for an example.
2.	Double click the selected file. Depending on the amount of data already present in the file, the map may take several moments to open.
3.	Select the .TIF File to be digitized. The file will open in ArcMAP.
4.	If a LAYER has not been created in another program, the new LAYER will need to be created in ArcMAP. To accomplish this, open ArcGIS© 9.2 Arc Catalog Program (the file cabinet icon).

5.	Right-click the PERILO.mdb geodatabase. Select NEW and FEATURE CLASS. See Figure 6 for an example. The ADD FEATURE CLASS dialog box will open.
6.	With the ADD FEATURE CLASS dialog box open, select a name for the LAYER and an alias. The name is the program designation for the LAYER, the alias is what appears in the table of contents. No spaces are permitted in the name but are allowed in the alias. The two may be the same or can be different. See Figure 7 for an example.
7.	The new LAYER must have a type designated. If a LAYER needs to be closed, and filled in (such as a province or a parcel), select POLYGON FEATURES from the pull-down menu. If a LAYER is an unclosed line (such as a street or creek), select LINE FEATURES.
8.	To begin drawing the new map, select the file that was added using the ADD DATA procedures. It is likely a .TIF or .JPG file
9.	Using the ZOOM command pick a point on the map to begin drawing. See Figure 8 for a specific example.
10.	Using the EDITOR toolbar, click on EDITOR; then select START EDITING
11.	On the EDITOR tool bar, at the task pull-down menu, select CREATE A NEW FEATURE. At the TARGET pull-down menu, select the new LAYER that was created for this purpose.
12.	Select the SKETCH tool (it is the pencil on the EDITOR tool bar.) Begin drawing. On a polygon, the line must be continuous, and begin and end at the same point to have the ability to close and fill in. Line or point LAYERS do not require this. See Figure 8 for a specific example.

Figure 6: New Feature Class Selection Menus

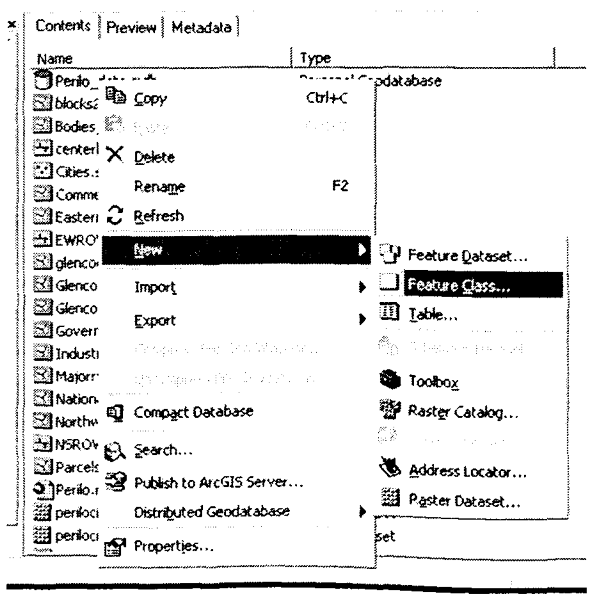


Figure 7: New Feature Class Dialog Box

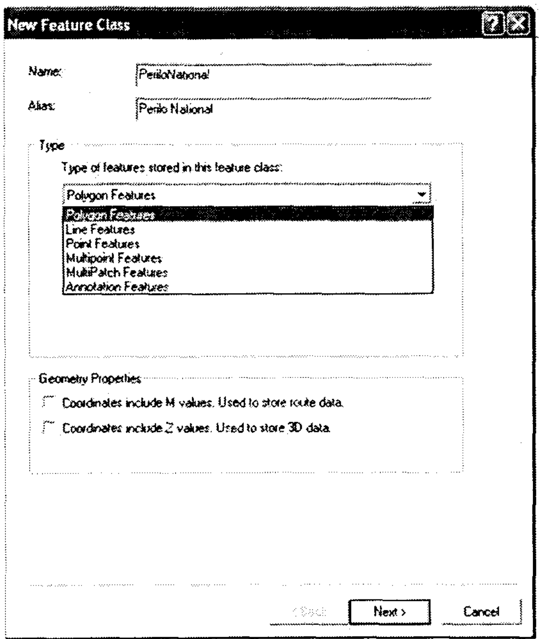
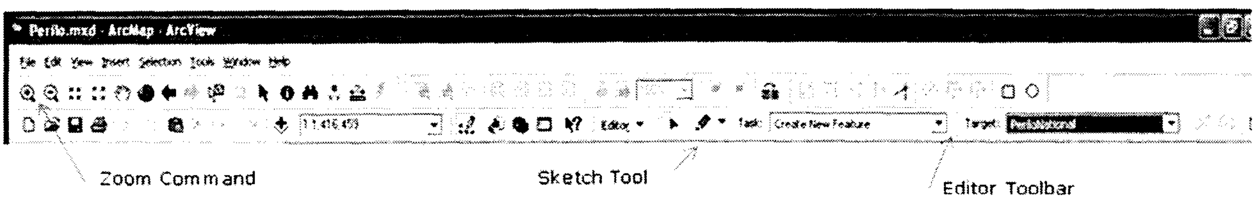
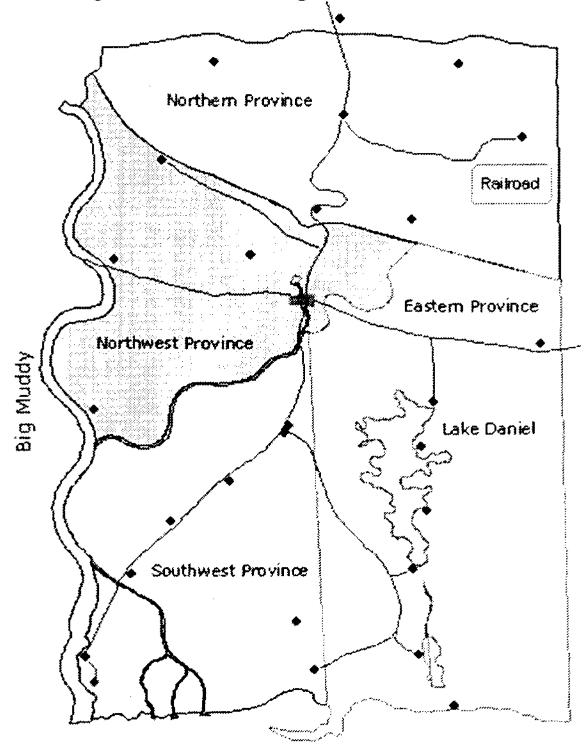


Figure 8: ArcMAP © Tool Bar set for digitizing a map.



(100) Each class of features on the map was grouped into a different layer. For example, with a map of the provisional divisions, I traced the complete boundary of each province and then assigned it to its own layer so it could be turned on (made visible) or turned off (made not visible) depending on my needs. The same process was applied to bodies of water, cities, rail lines and rivers. The resulting digitized map is shown in Figure 9 (this can be compared to Figure 3.)

Figure 9: The Digitized Perilo Provincial Map



Glencoe Phase

(101) With the construction of the national map complete, I started the next phase of the Perilo GIS. Because the original project was inspired by the game Sim City, my design concept was to develop a city map. I was also reminded of a phrase that I had heard since my earliest days in emergency management: all disasters are local. I decided that the focal point of the Perilo GIS should be the city of Glencoe, with things common to most cities such as streets, highways, water, a downtown business district, and a suburban region. (Davis 1998).

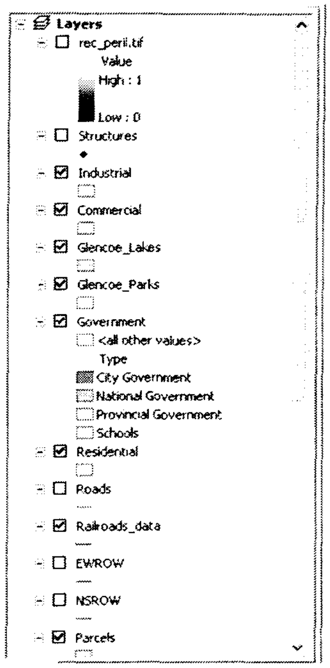
(102) At this point, before I continue the discussion regarding the construction of Glencoe, I think it is important to note that I made a critical and time-consuming error at the start of this phase of the project. As I discussed earlier, I initially opted not to purchase the full-suite of ArcGIS© 9.2 based on the list price of the software. Additionally, software updates,

which are periodically required to keep a software package current, can also be quite expensive. Finally, because ArcGIS© 9.2 is not normally engaged as a primary drawing program, owning the whole suite did not seem to be of great benefit. Much later in the process, I discovered that ESRI software resellers would make the software available at a significantly reduced price if the purchaser were a student. This last fact is important to note not so much at the professional use jurisdictional level, but more for the individual who is trying to study the GIS process and might have a use for the complete software package.

(103) Nearly three months into the project, as I was completing the planning and zoning portion of Glencoe, I encountered a major problem. As I discussed earlier, the process of creating a GIS is dependent upon constructing data layers. Each layer represents different information that is either visible or not visible on the GIS, depending on the needs of the user. Layers are the key to a GIS. A layer can represent whatever information the user requires, such as the location of shelters, the number of emergency personnel, or a specific evacuation route that is open or closed. Being able to turn these layers on and off allows for virtually an unlimited amount of information to be available to the GIS user.

(104) I had already created several layers within Glencoe, including a CENTERLINE STREET GRID and the corresponding PARCELS between each street. In order to populate the country, and more specifically, the city of Glencoe, population numbers, in the form of a table, had to be assigned to one of the GIS layers. The PARCELS layer was selected since it is a basic unit of land ownership and development. Much of the ownership information, and therefore the population information would be attached to the PARCELS layer. Figure 10 details the initial Table of Contents associated with the Perilo GIS.

Figure 10: Table of Contents Showing Perilo's Initial Layer Setup



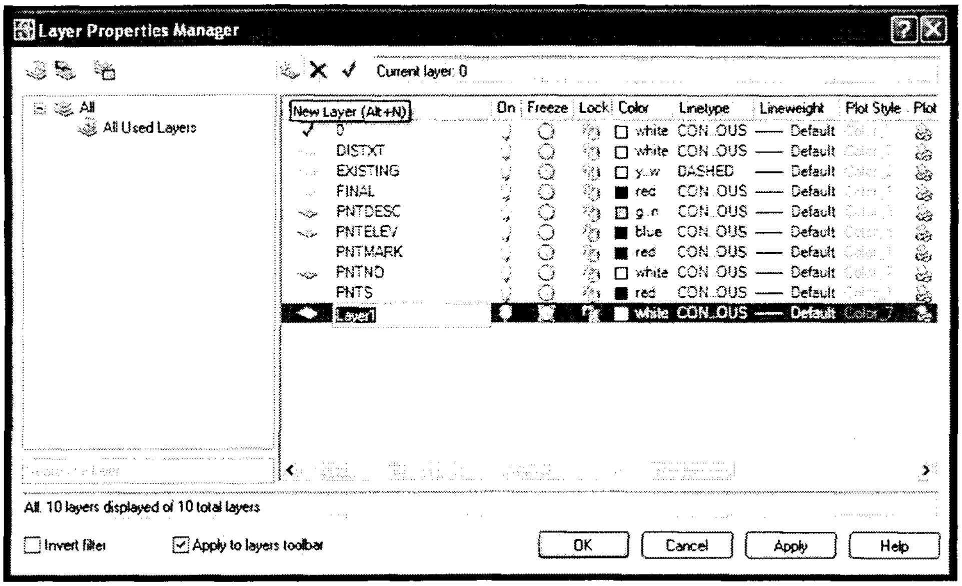
(105) However, as I began to create the PARCELS layer by filling in the spaces between the CENTERLINES, I noticed that PARCELS were not maintaining alignment with the CENTERLINE. The misalignment became more pronounced as more and more PARCELS were added. I spent several days trying to re-align CENTERLINE with PARCELS and vice versa. Despite my best efforts, the PARCELS would not retain alignment. The experience I had gained up to this point left me with only one choice.

(106) I created a series of test drawings. These drawings showed that LAYERS made in AutoDesk® 3D could be converted from drawing files (.DWG) files to shape files (.SHP) which could then be read by the ArcGIS© 9.2 software. I decided to reconstruct Glencoe using a program that was drawing specific. I found that AutoCAD© 3D allows for the construction of very detailed drawings. Just as importantly, AutoCAD© operates in the same manner as ArcGIS© 9.2, using a layer system. This was a critical component in the reconstruction of Glencoe.

Table 7: Creating the Street Grid LAYER in AutoCAD®

1.	Open a new AutoCAD® window. Create new LAYER for street grid. Click on NEW LAYER button adjacent to the LAYERS window. The screen in Figure 11 will appear. Select NEW LAYER. The un-named LAYER will appear at the bottom of the list. Name the LAYER, and select a color for the new LAYER to appear in. It is best to use widely contrasting colors for each LAYER. The new LAYER will now appear in the LAYER pull-down menu on the main AutoCAD® screen.
2.	Set the LAYERS pull-down menu to CENTERLINE. This ensures that the grid will appear in the proper layer and will transfer to ArcGIS© 9.2 later in the process.

Figure 11: Create a new LAYER in AutoCAD®



Autodesk AutoCAD® screen shots reprinted with the permission of Autodesk Inc.

(107) I started at the beginning and re-created the CENTERLINE grid in AutoCAD®. I created a new layer, drew a single line down the middle, then using the OFFSET command copied the line repeatedly until I had enough horizontal lines to complete the centerline of each street that ran east and west. I completed the same process for the north and south streets as well. Figure 12 shows the completed centerline and highlights the two principal commands I used to create the base centerline drawing.

(108) One of the advantages of re-creating the drawing was the chance to correct another earlier mistake. In my initial drawing, I had only drawn in the centerline of the streets. However, by doing this, when this layer was turned off, it would leave only a narrow

corridor to represent the street. This created a factual inaccuracy in the actual street design. In my second attempt, I made sure to create not only the centerline of the street, but also the right-of-way for each street. The right-of-way, usually measured from the center of the street, is the property that is owned by a maintaining authority. Any person may use the right-of way, but the city, county, state, or federal government retains its ownership for its own use at any time. Right-of-way laws vary from jurisdiction to jurisdiction.

(109) I decided to use a uniform distance of twenty-five feet from center, for a total of fifty feet of right-of-way for all roads, a numerical value consistent with my experience as a land surveyor. While this figure does not represent the right-of-way for every road and street in every city, such a measurement is representative and provides the wider street corridors I was trying to create on the final map. Using the offset command again, I offset each centerline twenty-five feet in both directions.

(110) At this point, I needed to determine a width for each city BLOCK. BLOCKS serve as the organizational layer above PARCELS. Each block is comprised of multiple PARCELS. I determined that for the area inside the Glencoe city limits, a standard New York City block of 850 feet north and south by 265 feet east and west would be appropriate. Outside the Glencoe city limits, I used an area size of 850 feet north and south by 895 feet east and west. Street right-of-ways in both areas were set at 50 feet. The equation in Figure 13 explains the math:

Figure 12: Completed Centerline Drawing

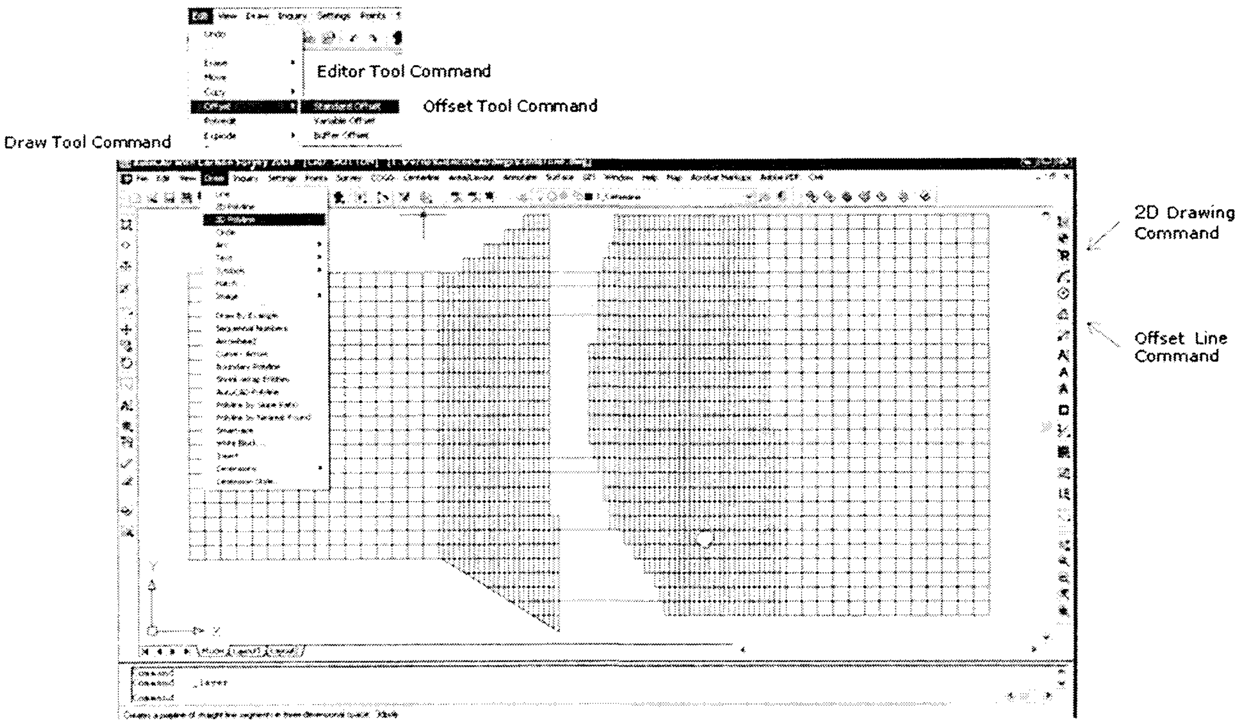


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Figure 13: City Block Equation

895 feet x 265 feet (1 city block) + 50 feet (1 street including right-of ways)= 1 complete BLOCK

(111) Once I determined the configuration of the BLOCKS, I designed the PARCELS layer. As I discussed earlier, the PARCELS layer is critical to the whole project because much of the population data of Glencoe will reside within the PARCEL layer. First, I determined acreage for each city BLOCK. A BLOCK contains 5.2 acres. Areas outside the city limits are not BLOCKS, but rather areas. Each of these areas contains 17.5 acres. I also established a minimum city parcel width of 50 feet wide, (850 feet divided by 50 equals 17 with no decimal remainder). I divided each block into seventeen parcels with a total acreage of 0.3 acres per parcel.

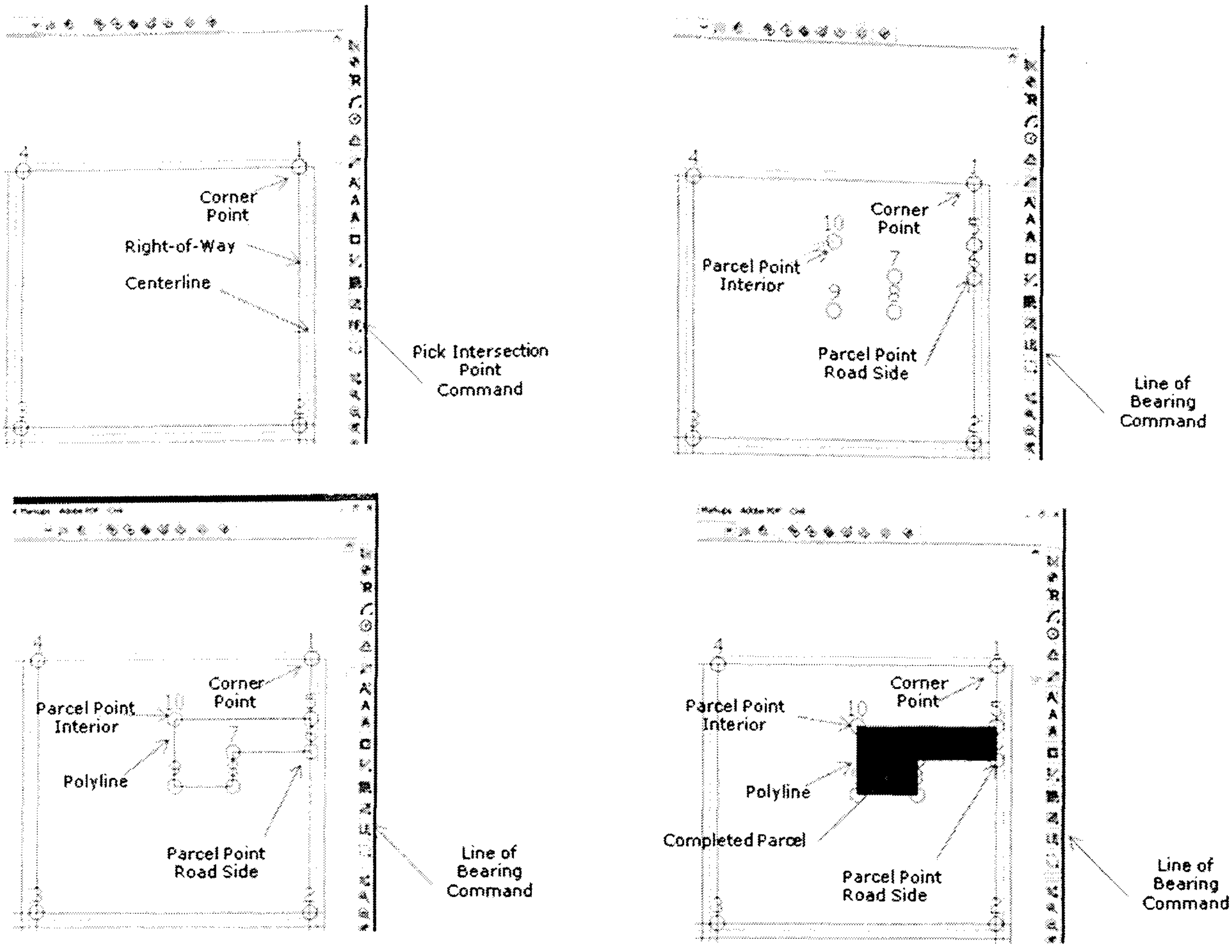
(112) Outside the city limits, the normal characteristics of suburban/rural land use made the process more complicated. Based on my land surveying experience, I applied examples of subdivisions that I had helped to survey. Since I had already determined that each area was going to have the same amount of acreage, the critical design issue was how many different ways I could divide 17.5 acres. Ultimately, I ended up with twelve different combinations. I turned each 17.5 acre area into its own subdivision, and applied one of the twelve patterns that I had created.

(113) To create the individual parcel patterns, I selected a point at each of the four corners of the BLOCK. Next, I created a new LAYER named PARCELS so that any drawing that I did would be in the proper layer. Then using the LINE OF BEARING COMMAND, I created points along the outside perimeter that equal the length of the specific parcel on the roadside. LINE OF BEARING works by selecting one point as a base, and from that point, a user can enter a bearing based on existing points, or a given measurement entered in degrees, minutes, and seconds. A bearing is simply the direction that one point is in relation to another point. A user may then enter the distance that the point is from the base point.

(114) With the exterior parcel points created, I next constructed the interior points. I accomplished this by again using the LINE OF BEARING COMMAND, selecting one of the newly created exterior corners, and placing the other three corners of the parcel at their appropriate bearing and distances. Next, using the CREATE POLYLINES command, I connected the points, making sure to CLOSE the line between the last point and the first point.

(115) The final step in this process turned the still hollow parcel into a polygon. I located the POLYGON toolbar in the ACAD submenu, placed it on my main toolbar, so I could use it continuously without having to use a pull-down menu and submenu. Then I selected one of my closed PARCELS, clicked on the POLYGON command, and completed the process. Figure 14 shows the step-by-step process in creating a polygon.

Figure 14: Step-by-step assembly of a PARCEL



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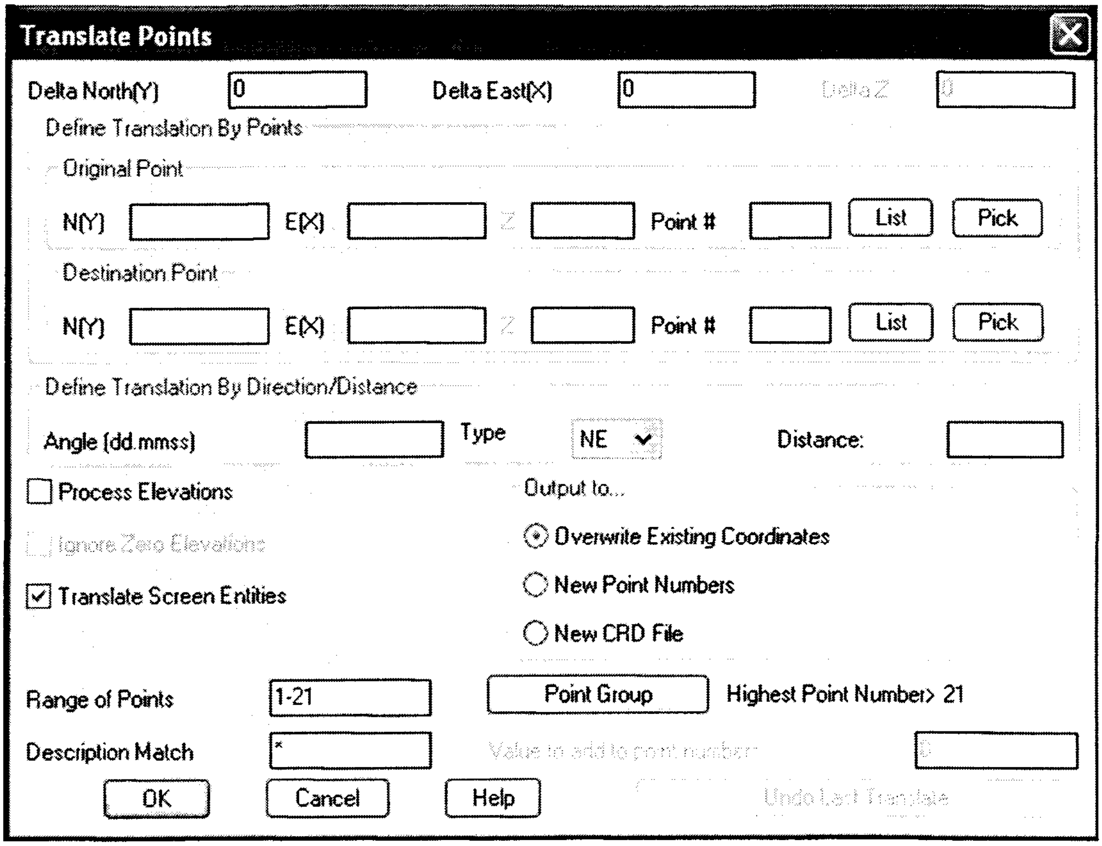
(116) I completed the remainder of the PARCELS in the same manner. With one area of PARCELS completed, I randomly selected one of the other twelve patterns I had created, and using the same process as above, created a different area of PARCELS. I repeated this same process until I had one complete row, which is fourteen blocks.

(117) Next, I used the COPY feature to create two copies of the first row. I used the ROTATE command to reverse one of the rows and set these copied rows off to the side. Remembering that alignment of the PARCELS was a critical issue, I wanted to ensure that I lined up the copied parcels with the existing blocks. AutoCAD© has a command for this specific purpose. I used the TRANSLATE POINTS command to place one point that I picked

at the corner of the copied PARCELS exactly on top of a picked point at the junction of the still empty CENTERLINE grid. By employing the TRANSLATE SCREEN ENTITIES command, the objects, in this case the copied PARCELS, aligned exactly with the picked point at the corner of the right-of-way. See Figure 15 for an example.

Figure 15: Translate Points Screen:



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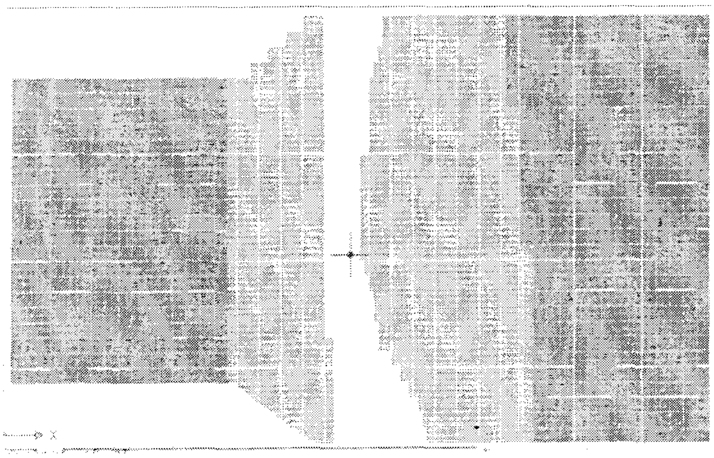
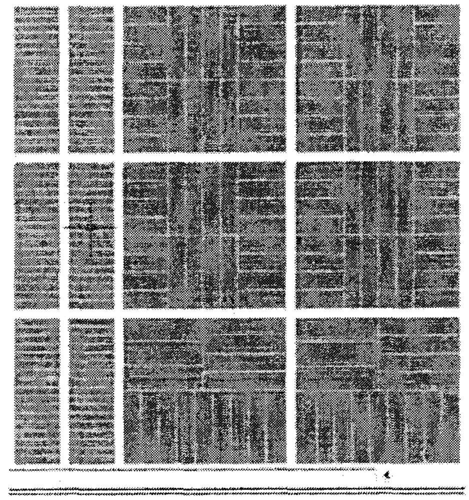
(118) Once the first row of the PARCELS block were properly aligned, I used one of the copied rows that I had set off to the side and again using the TRANSLATE POINTS command moved the copied PARCELS onto the next row of the CENTERLINE grid. With two complete rows, it became a matter of multiplication. Two rows became four, which became eight, then used six rows of the last section to finish filling in the side. I finished the layer by copying the whole side and TRANSLATING it to the other side of the city. The finished

PARCEL layer and a partial cutout showing the differences in the PARCEL sizes are shown in Figure 16.

Figure 16: Completed PARCEL layer and cutout showing different PARCEL sizes



Completed Parcel Layer Drawing



Parcel Layer drawing showing different parcel sizes

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(119) The detailed description that I provided in constructing the PARCELS layer is important because it provides the steps that I used in completing the other layers as well. As stated earlier, AutoCAD©, like ArcGIS© 9.2 uses a layer system, and I employed essentially the same steps as I constructed each individual layer. Table 8 shows a list of the remaining layers that I constructed using AutoCAD©.

Table 8: Glencoe Layers constructed in AutoCAD®

Layer Name	**Layer Purpose**
ALL LAYER	ALL LAYER is a complete drawing with all layers represented.
CENTERLINE	CENTERLINE LAYER is the base layer showing the centerlines of each street within the city of Glencoe.
NS RIGHT OF WAY	NS RIGHT-OF-WAY LAYER contains the 25-foot offsets from center that run north and south with the centerline of each road. Right-of-ways denote the ground that the city of Glencoe maintains ownership of for expansion and maintenance purposes.
EW RIGHT OF WAY	EW RIGHT-OF-WAY LAYER contains the 25-foot offsets from center that run east and west with the centerline of each road.
PARCELS	PARCELS LAYER shows the base property divisions within Glencoe. Each PARCEL is owned by an entity or individual within Perilo.
BLOCKS	BLOCKS LAYER is the grouping of PARCELS into pre-defined areas. It is used primarily for emergency response functions.

RESIDENTIAL ZONE	RESIDENTIAL ZONE LAYER contains parcels zoned for residential occupation. Planning and zoning are a key component in maintaining control over a community's development.
COMMERCIAL ZONE	COMMERCIAL ZONE LAYER contains parcels zoned for commercial use.
INDUSTRIAL ZONE	INDUSTRIAL ZONE LAYER contains parcels zoned for industrial use.
GOVERNMENTAL ZONE	GOVERNMENTAL ZONE LAYER contains parcels zoned to show property owned by one of the levels of government within the micro-nation of Perilo.
TRANSPORTATION ZONE	TRANSPORTATION ZONE LAYER contains parcels owned by the city transportation authority, such as the rail yards, the airport, and the city bus terminal and stops.
GLENCOE PARKS	GLENCOE PARKS LAYER contains parcels owned by the city of Glencoe and are zoned for park use.
GLENCOE LAKES	GLENCOE LAKES LAYER contains pre-drawn lakes that exist throughout the city.
MAJOR RIVERS	MAJOR RIVERS LAYER shows the major rivers that exist within the micro-nation of Perilo. The Glencoe River is a major river, but is contained within its own layer.
GLENCOE RIVER	GLENCOE RIVER LAYER shows the river that runs through the center of the city. It has its own layer to allow for more independent placement control of the river.
NORTHERN PROVINCE	NORTHERN PROVINCE LAYER shows the geographic borders of Perilo's northern provincial area.
NORTHWEST PROVINCE	NORTHWESTERN PROVINCE LAYER shows the geographic borders of Perilo's northwestern provincial area.
EASTERN PROVINCE	EASTERN PROVINCE LAYER shows the geographic borders of Perilo's eastern provincial area.
SOUTHWESTERN PROVINCE	SOUTHWESTERN PROVINCE LAYER shows the geographic borders of Perilo's southwestern provincial area.
PERILO	PERILO LAYER is the external border that encompasses the entire micro-nation of Perilo. Its purpose is to provide overall statistical data over the entire nation

(120) The next step involved a multiple-step process of converting each layer constructed in AutoCAD® into a format that the ArcGIS® 9.2 software can interpret. The result was a series of shapefiles (.SHP) that were readable by ArcGIS® 9.2. Once these files were converted, they could be placed on the ArcGIS® 9.2 map as individual layers that can be turned on or off depending on the needs of the user.

(121) To convert layers from AutoCAD® to ArcGIS® 9.2, I started with the ALL-LAYER DRAWING. Every file that I needed to convert was in this drawing. I started by performing a DRAWING CLEANUP operation on the ALL-LAYER Drawing. This process CONVERTS all segments and arcs to lines, removes excess and double lines, and removes empty layers.

Some layers will have contents even with no visible entities on the screen. These layers have no effect when the layer is converted and can be disregarded during the next steps. See Figures 17-18 for example screens.

Figure 17: Drawing Clean-Up Initial Screen

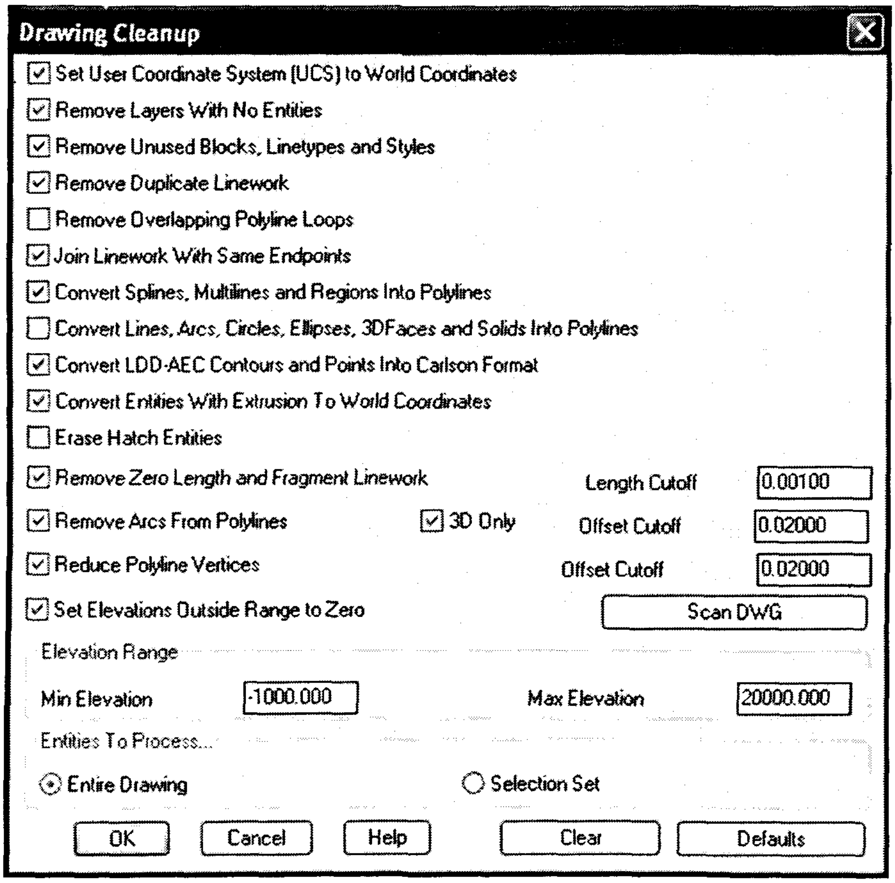

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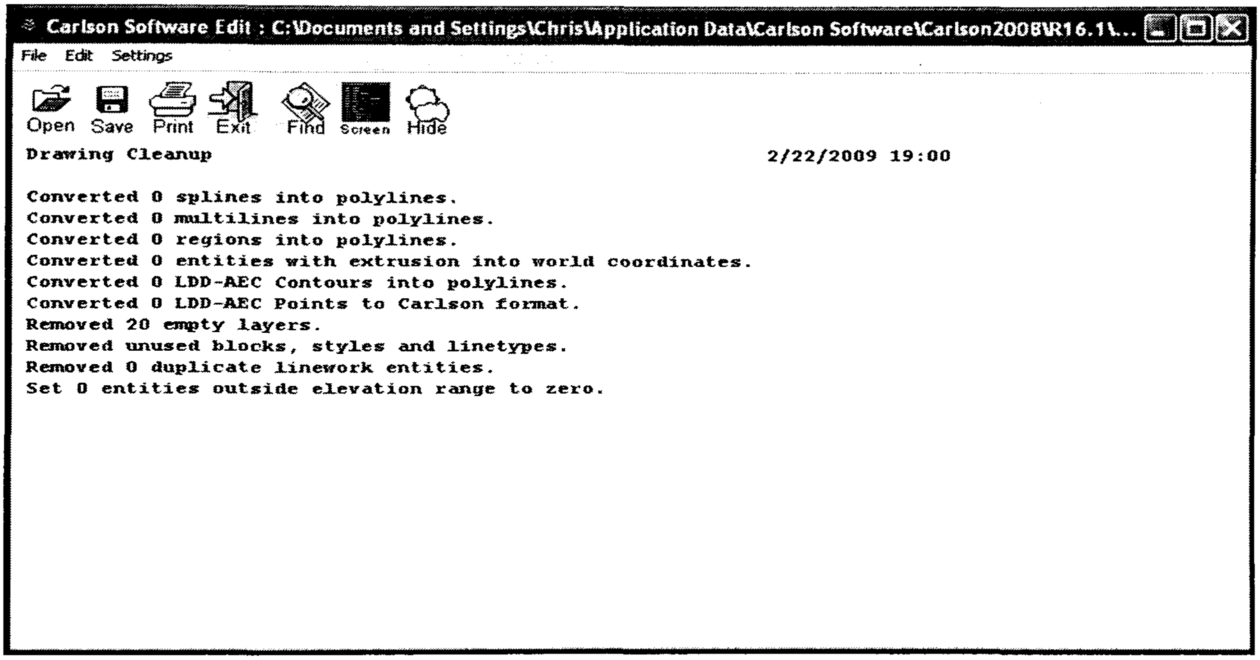
Figure 18: Drawing Clean-Up Final Screen



(122) Once the ALL-LAYER drawing was cleaned, I had twenty-two individual layers that required conversion to AutoCAD®. To accomplish this, the cleaned AutoCAD® files needed to be exported to ArcGIS® 9.2. This process takes eleven steps and much like the cleaning process is better shown by a table and a series of pictures. Once the process is completed for the twenty-two layers that were constructed, the vast majority of the remaining construction on the neutral-site GIS was done in ArcGIS® 9.2 To illustrate the example better, I have selected the PERILO drawing for export and conversion. It is important to note that while each of these processes seem both labor intensive and time consuming, the end result is a perfectly aligned neutral-site GIS. Table 9 gives a detailed description of the step-by-step process.

Table 9: Conversion of AutoCAD® Drawings to ArcGIS® 9.2 Layers

1.	In AutoCAD®, open the PERILO file which has just been cleaned.
2.	Select the MAP pull-down menu from the menu bar across the top of the drawing.
3.	In the MAP menu, select TOOLS. This will open a sub-menu. From the sub-menu, select EXPORT. See Figure 19 for an example.
4.	AutoCAD® will ask for a file name and tell it where to store the new shape file. The file name should be something that indicates what the file is.
5.	Once the file is named, the EXPORT command allows an AutoCAD® drawing (.DWG) file to be exported as a shape (.SHP) file. When export is selected from the TOOLS sub-menu, the EXPORT Screen appears. I have enlarged the two key sections of the screen in Figure 20a and Figure 20b.
6.	Using Figure 20a as an example, notice that the radio button is clicked to select POLYGON. If the drawing were line based, such as the CENTERLINE drawing file, the radio button adjacent to LINE would be selected. Additionally, notice that the SELECT LAYERS command is highlighted (it is the top button) and that the file 8_Perilo is in the LAYERS box. This indicates that the only layer that will be exported will be the 8_Perilo LAYER.
7.	Select OK at the bottom of the box. Depending on the size of the file, it may take a few seconds or a few minutes to export.
8.	From this point, the remainder of the process takes place in ArcGIS® 9.2. Open ArcGIS® 9.2 Catalog (its icon looks like a small file cabinet.)
9.	Click the Arc Toolbox icon (the icon is a red toolbox) at the top of the screen.
10.	Once the toolbox icon is selected, a window will open to the left of the main screen. In this window, select CONVERSION TOOLS, select the sub-menu TO SHAPE FILE, and the sub-menu FEATURE CLASS TO SHAPE FILE (multiple). See Figure 21 for an example.
11.	A dialog box will open and ask where information is coming from (INPUT FILE) and where the processed information should go (OUTPUT FILE). PERILO is the input file. In this example, the data will be stored in E:/Perilo/Glencoe. See Figure 22 for an example.
12.	Click OK. Check the box in the lower left hand corner to close the dialog box when the process is finished. PERILO is now a shape file (.SHP) in the Glencoe file.

Figure 19: Map Command with Sub-Menus

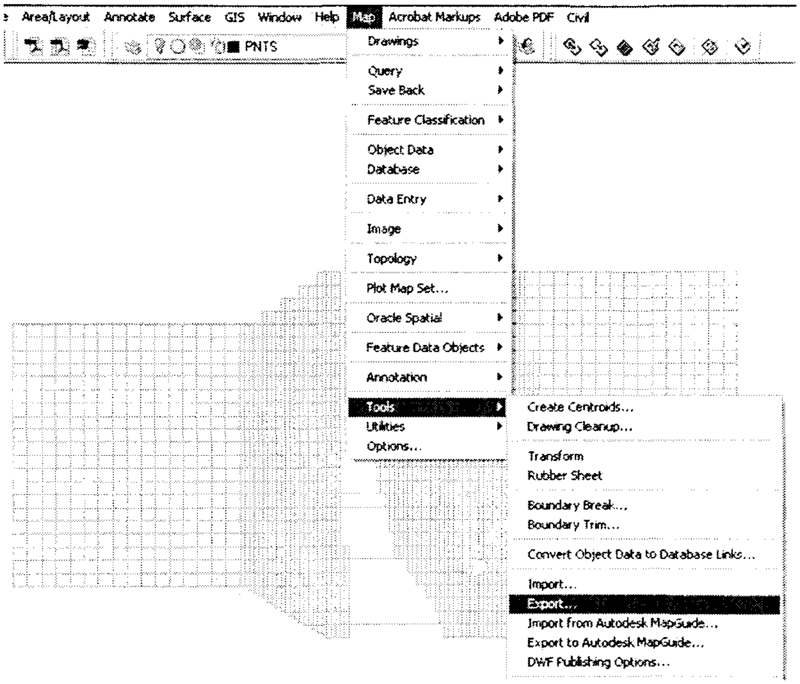


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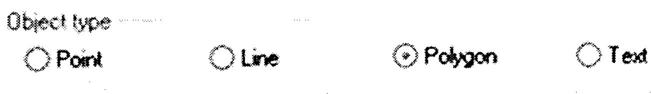
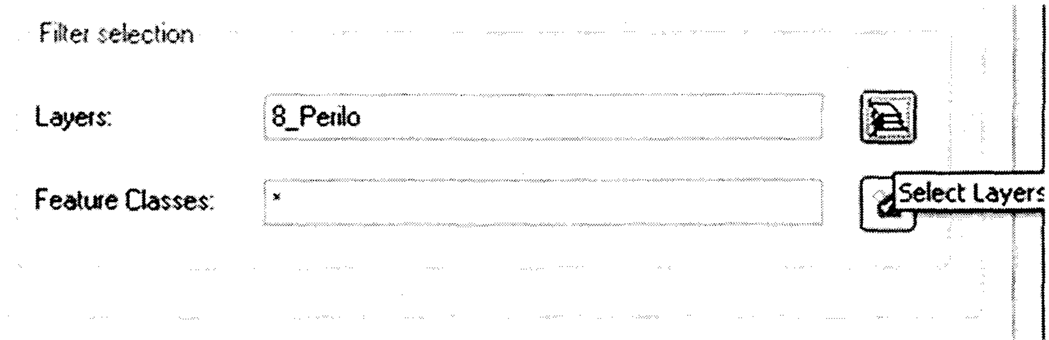
Figure 20a: AutoCAD® 3D Export Screen: Object Selection



Object Type Section

Figure 20b: AutoCAD® 3D Export Screen: Object Selection



Filter Selection/showing select layers command

Figure 21: Feature Class to Shape File Command

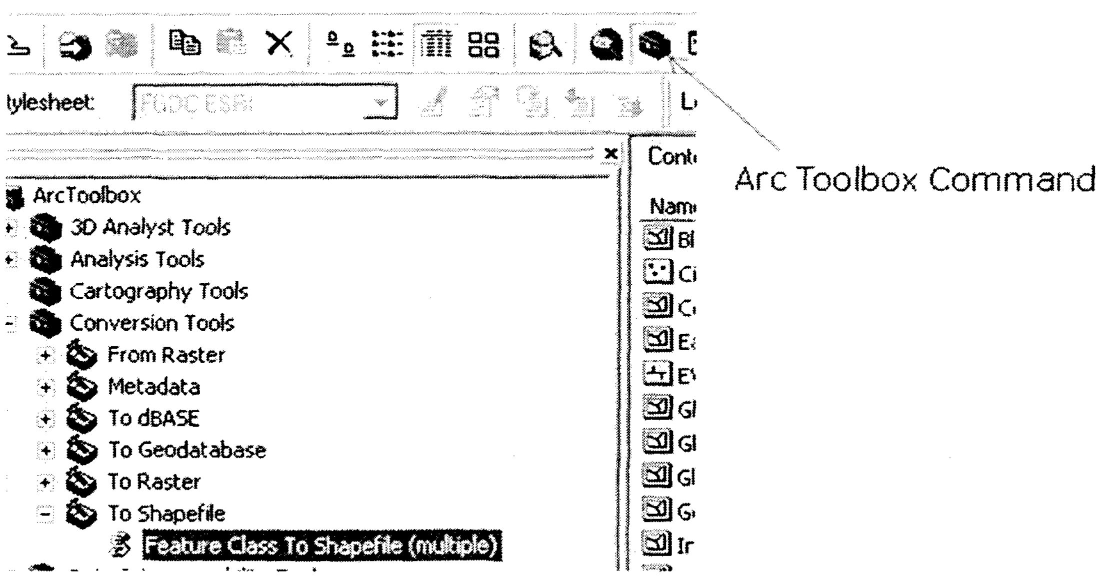
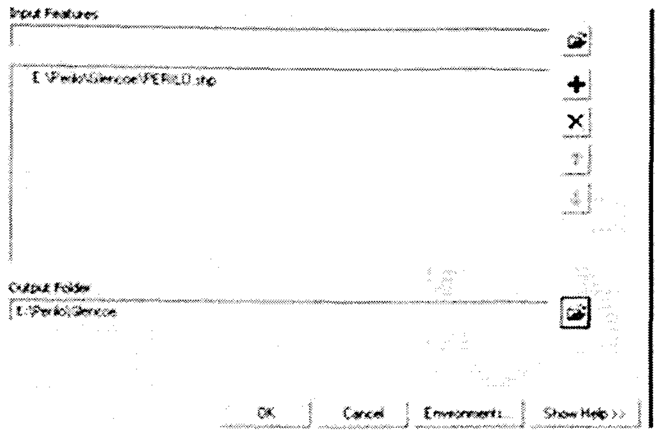


Figure 22: Feature Class to Shape File Dialog Box



(123) Once I completed the shapefile(.SHP) conversion, there are two other operations that I performed to make them usable by the Perilo GIS. The first is establishing a coordinate system. Each file that is assigned to the Perilo GIS must be assigned the same coordinate system.

(124) A map's coordinate system is essentially a "where in the world am I" file. Without this reference, a GIS may function and work, but it has no spatial reference to tie it down to anywhere else in the world. In other words, it is a piece of ground that is floating out in the middle of the globe somewhere. Establishing exactly where Perilo is located is an important part of the process.

(125) To establish the location, I used the steps in Table 10: XY Coordinates. As previously noted, each of the twenty-two files that I converted to shapefiles must have the same coordinates. For this example, I am using the CENTERLINE file.

Table 10: XY Coordinates

1.	From the E:/Perilo/Glencoe files (see Figure 23) right-click the CENTERLINE file.
2.	Select PROPERTIES. This will open up the SHAPEFILE PROPERTIES dialog box.
3.	Select the XY Coordinate System Tab from the top row of tabs. The coordinate system dialog box will open. Select PROJECTED COORDINATE SYSTEMS, UTM, WGS 1984, WGS 1984 UTM Zone 36N.prj. See figures 24a and 24 b for step-by-step procedures.

4.	Once a file has an assigned coordinate system, the file for that coordinate system will appear at the top of the shapefile property page. Repeat this process for all converted files.

Figure 23: Shapefile Properties Dialog Box

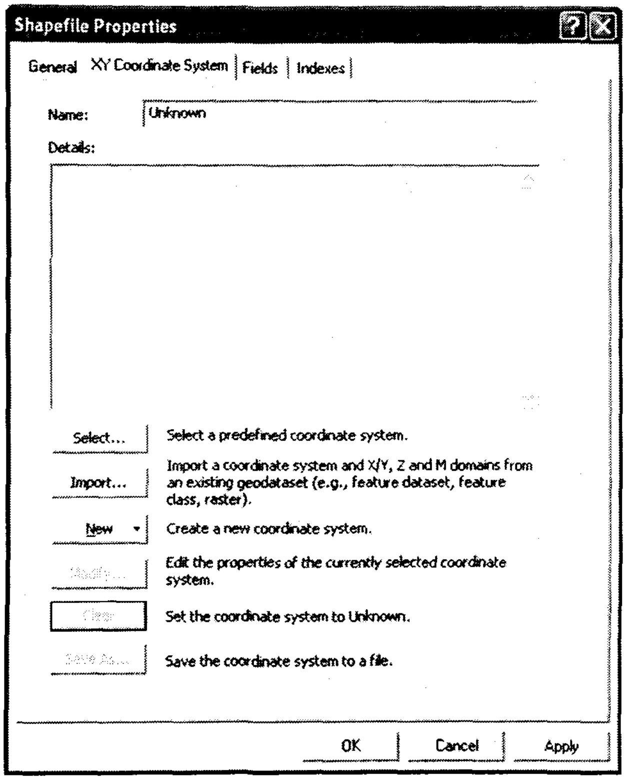


Figure 24a: Coordinate System Assignment

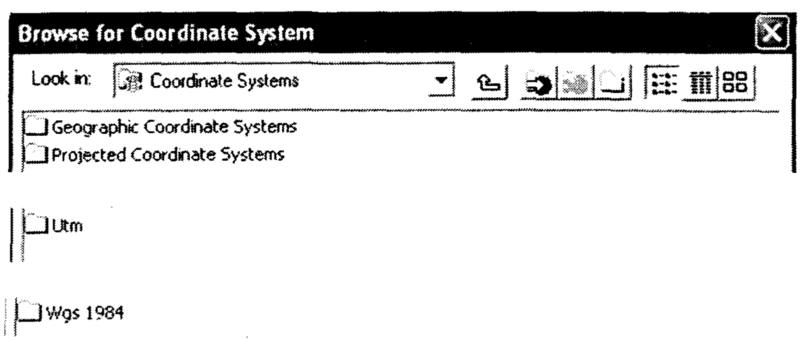
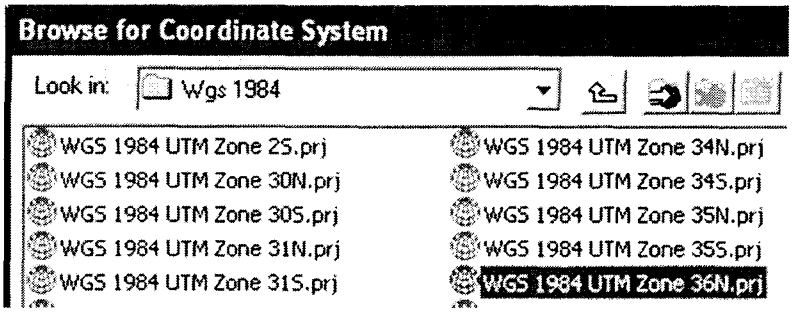


Figure 24b: Coordinate System Assignment: Continued



(126) Once I placed all LAYERS under one coordinate system, I started assigning FIELDS under SHAPEFILE properties. Fields are important for two reasons. First, they are the basis for the information ArcGIS© 9.2 will collect for a specific LAYER. For example, in the PARCEL layer, in a fully developed GIS, some of the information that is important would be the property owner's name, the property owner's address, and the deed book and page number where the deed to the property is filed in the local courthouse. When a LAYER is established, FIELDS to collect this information must be added to the LAYER.

(127) To add FIELDS to a LAYER, I followed the instructions in Table 11. It is not critical that every field is added at the creation of a LAYER; FIELDS may be added at any time. I am discussing the add FIELDS procedures here because my experience during this study suggests it is easier to perform the process at this point.

Table 11: Add FIELDS to a LAYER

1.	From the E:/Perilo/Glencoe files within ArcCatalog right-click the CENTERLINE file.
2.	Select PROPERTIES. This will open up the SHAPEFILE PROPERTIES dialog box. Select the FIELDS tab. See Figure 25 for details.
3.	With the FIELDS tab selected, select a blank line under the last field name entered. Field Names may not have spaces between the words. If words need to be separated, use an UNDERSCORE between them.
4.	The DATA Type Field denotes what type of information that the FIELD will be permitted to accept. In most cases, if general information data is entered, TEXT will be sufficient. If numbers are the primary data, select LONG INTERGER or SHORT INTERGER depending on how much data will appear in the field. See Figure 26 for details.

Figure 25: Shapefile Properties/FIELDS

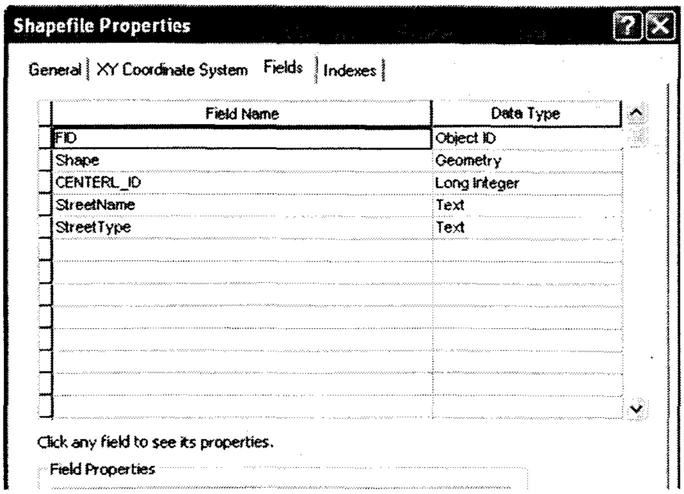
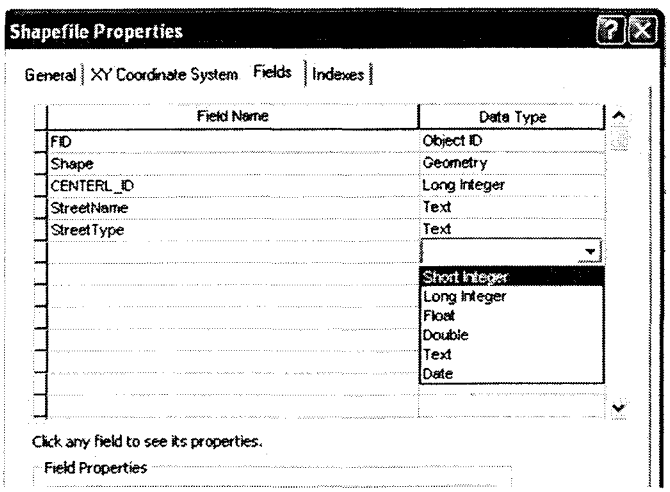


Figure 26: Shapefile Properties/FIELDS/DATA TYPE

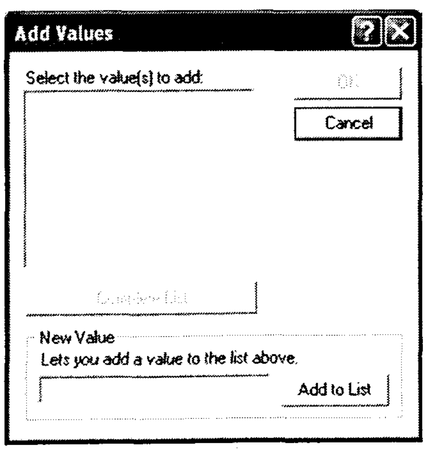


(128) The second reason that FIELDS are important is that they form the basis for a VALUE FIELD in a layer. As previously noted, a VALUE FIELD contains the specific information about a layer. This information may include the name or address of a building owner, or what planning and zoning applies to a given parcel.

(129) However, if information that is more detailed is required, then UNIQUE VALUES should be applied to a VALUE FIELD. For example, within Perilo, I created a LAYER called STRUCTURES. The STRUCTURES layer contains every building within Perilo, regardless of the type of building or its use. The question I had to resolve was how to separate the various types of buildings. Because emergency management is interested in both building usage and building population, segregating them using those two factors seemed to be the best approach. To do this, UNIQUE VALUES needed to be created. These UNIQUE VALUES allow for a specific type of structure to be created within the STRUCTURES layer. How to employ UNIQUE VALUES is discussed later in this paper, but it is important to understand exactly why these fields need to be in place at this time.

(130) UNIQUE VALUES may be inserted at two different phases of the construction. I used both while building Perilo. First, when I was initially establishing UNIQUE VALUES within a LAYER, I inserted randomly composed values into the blank ADD VALUE dialog box. See Figure 27 for an example of the dialog box.

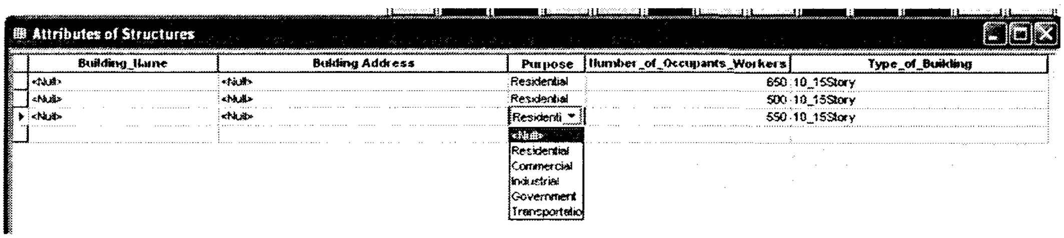
Figure 27: Blank ADD VALUE Dialog Box



(131) The second opportunity for adding UNIQUE VALUES occurs if the user wants to establish pull-down menus within a value field on the layers ATTRIBUTE TABLE (See Figure 28) for an example. The ATTRIBUTE TABLE is the table that holds all of the information

about a given layer through its established VALUE FIELDS. Pull-down menus allowed me to click on a VALUE FIELD, and instead of having to type the same information repeatedly, I could insert a pre-established value for that VALUE FIELD. Figure 28 shows an attribute table with an established pull-down menu.

Figure 28: Attributes Table with Pull-Down Menu



To create the pull-down menus in the VALUE FIELD, I had to establish a DOMAIN for that FIELD. Establishing DOMAINS is accomplished first in the properties menu of a specific geodatabase, and then in the properties menu of the LAYER itself. I have listed the steps in Table 12. It is only necessary to establish DOMAINS if a pull-down menu is desired for a field.

Table 12: Establishing a DOMAIN

1.	Locate the geodatabase where the DOMAIN is to be established. Right-click on the geodatabase. Select PROPERTIES. The geodatabase properties dialog box will open.
2.	Select DOMAINS from the tabs at the top of the geodatabase properties dialog box.
3.	Under the DOMAIN NAME column, in the first blank space available, type in the name of the DOMAIN that is being established. The name should relate to its purpose of establishment. For example, a Commercial Zone Domain could be entered as Comm_Zone. The domain name must be short and contain no spaces.
4.	The adjacent column is the description of the DOMAIN. It should be the longer version of what the DOMAIN column is.
5.	Under the DOMAIN Properties, set the Field Type to reflect what type of information that will appear in the FIELD. In most cases, if general information data is entered, TEXT will be sufficient. If numbers are the primary data, select LONG INTERGER or SHORT INTERGER, depending on how much data will appear in the field.
6.	Set the Domain Type to CODED VALUES. Set the SPLIT POLICY to Duplicate. The MERGE POLICY may remain at the DEFAULT VALUE. See Figure 29 for an example.
7.	The CODED VALUES is where the actual pull-down menu items are established. As before, enter short descriptors in the CODE Section and longer, complete descriptions in the DESCRIPTION section. See Figure 30.
8.	Once the CODED VALUES are set, select OK and close the dialog box.
9.	Go into the geodatabase where the DOMAIN exists, right-click on the LAYER that the

	DOMAIN was set up in, and select PROPERTIES. The FEATURE CLASS Properties dialog box will open.
10.	Select the FIELDS Tab.
11.	Select the FIELD Name. This will change the FIELD PROPERTIES box at the bottom of the FEATURE CLASS Properties dialog box.
12.	Select DOMAIN in the FIELD PROPERTIES box. A pull-down menu of the created domains will appear. Select the appropriate DOMAIN to assign it to that FIELD VALUE.
13.	Select APPLY AND OK. The dialog box will close. There is now an assigned domain to that FIELD VALUE. See Figure 31 for details.

Figure 29: Geodatabase Properties Dialog Box

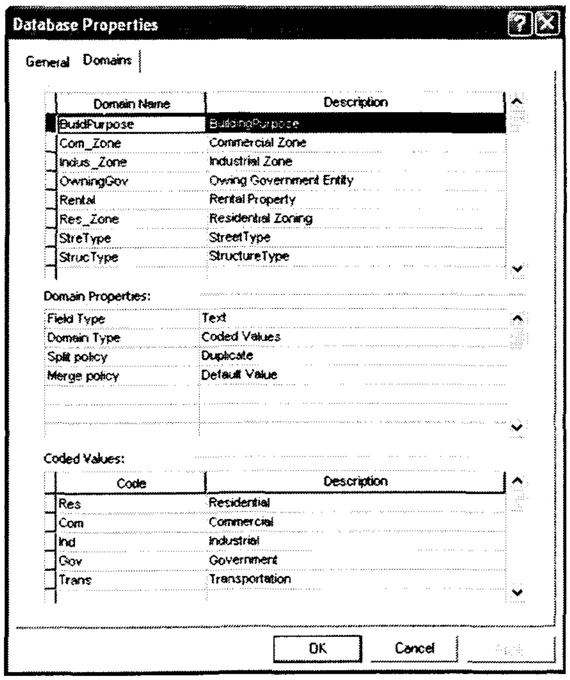


Figure 30: Geodatabase Properties Dialog Box/CODED VALUES

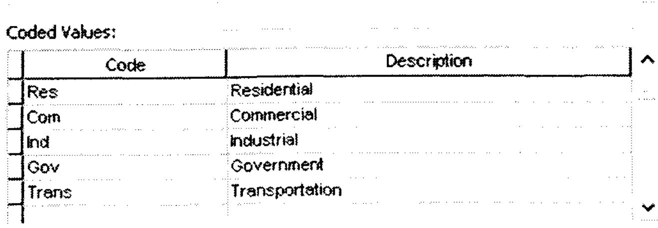
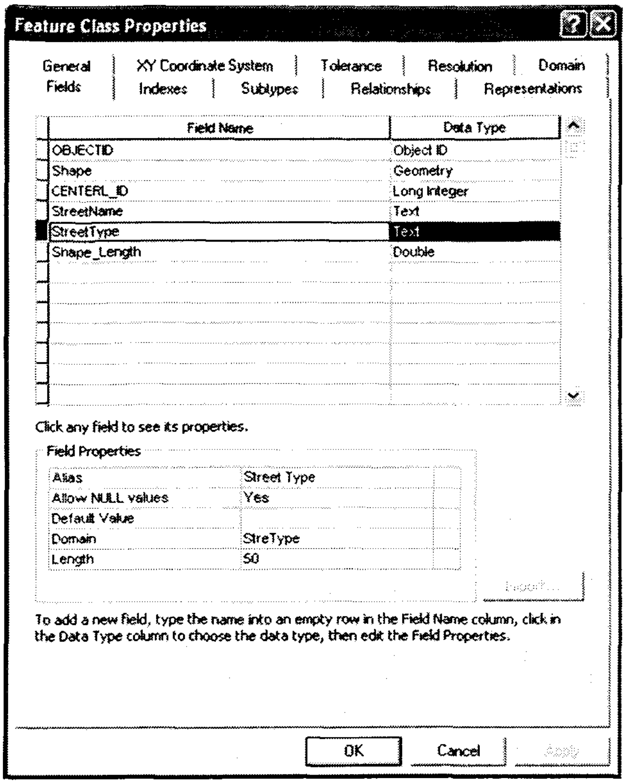


Figure 31: Feature Class Properties within the Geodatabase/DOMAINS



(132) At this point, the PERILO file is processed and can be used by the ArcGIS© 9.2 software. However, one item can't be overlooked. At the beginning of the process, a geodatabase (.MDB file) was created to hold all of the files that appear in the Perilo GIS. If it helps, think about this in the same way that you would think about a file cabinet. Most cabinets are designed to keep like items together in the same drawer. For example, bills and receipts might go in one drawer, while pictures might go in another. Keeping things scrambled in different drawers defeats the organizational purpose of having a filing system in the first place.

(133) ArcGIS© 9.2 organizes its electronic files using the same concept. By keeping like objects in the same place, in this instance, the PERILO.mdb, when ArcMAP is opened, it will know where to look for the files that it uses in its various layers. Otherwise, if the data is

not organized, the GIS will still work, but the user will have to choose which data folder the software needs to look in for specific files. Using the steps in Table 13, I placed these files into one geodatabase by exporting them from their original locations into a single geodatabase, in this case the PERILO.mdb.

Table 13: Export Files into a Geodatabase.

1.	In ArcCatalog© right-click PERILO files from E: /Perilo/Glencoe. From menu that will appear, select EXPORT. Export Perilo to geodatabase (single) See figure 32 for example.
2.	The Feature Class to Feature Class window will open. See Figure 33 for an example. Using the file folder icon located to the right of the INPUT FEATURES, select the PERILO.shp file.
3.	Use the file folder icon to select the file OUTPUT location. In this example, the PERILO file is going to the PERILO geodatabase (.mdb)
4.	The OUTPUT feature class is the name that will be assigned to the .shp file in the new geodatabase. The name can be anything and does not have to match the original file name. See Figure 33 for example.
5.	Press OK. Dialog box will open. When process is complete, dialog box will say "COMPLETE", or the box will close. New file is now in PERILO.mdb

Figure 32: Exporting PERILO Shapefiles to a Single Geodatabase

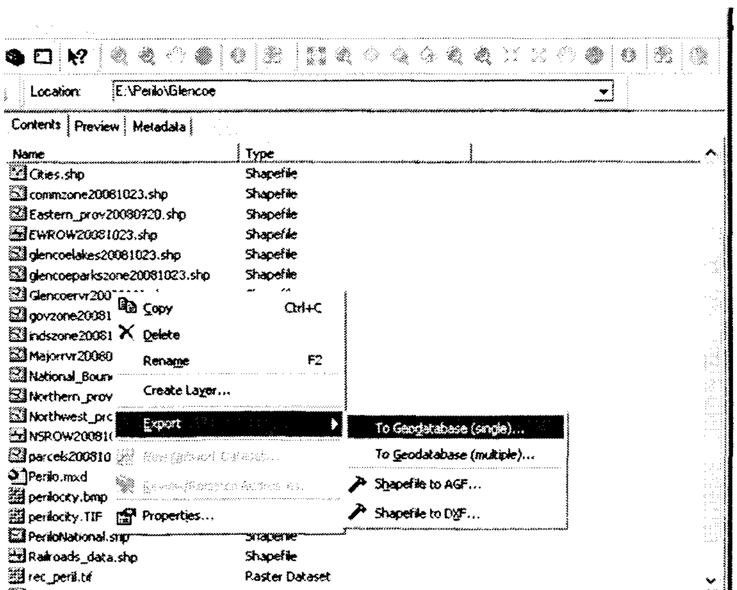
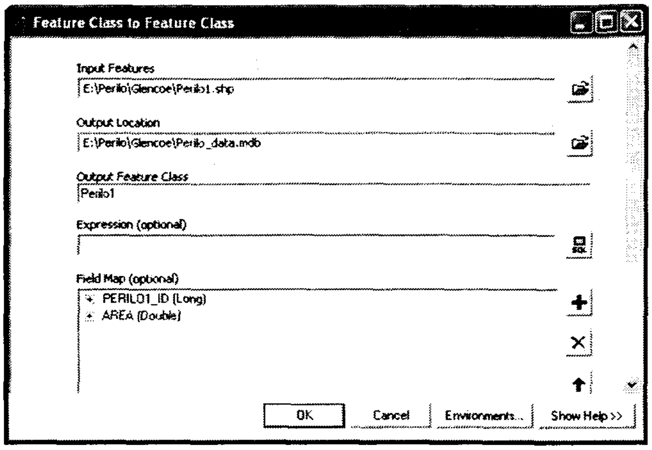


Figure 33: Shape (.shp) file to Geodatabase (.mdb) file



(134) Once I cleaned, converted, and exported the new files into a format that ArcGIS© 9.2 could read, I added them to the existing GIS. I have detailed this 5-step process in Table 11. With the new data added, the Perilo GIS is nearly complete.

Table 14: Add Data

1.	In ArcCatalog© select the ADD DATA command located on the STANDARD tool bar at the top of the screen. It is the black cross with the yellow background. The screen in Figure 34 will appear.
2.	Notice Figure 34 has the Perilio.mdb geodatabase highlighted. This is where the data that is being added is coming from. Double click the geodatabase.
3.	The screen in Figure 35 will appear. This is a list of all of the data that is stored in the Perilo geodatabase. From here, select the data that needs to be added to the Perilo GIS. If multiple data files need to be added, press the CTRL key and highlight the individual files.
4.	With all data selected, click the ADD key. This will add the information from the geodatabase to the active map. In Figure 36, the new data added is the Perilo National LAYER. It will appear at the very top of the table of contents.
5.	With the new LAYER added, it can be placed in the table of contents whenever it meets the needs of the GIS operator. Data that appears on the top of the table of contents will also be the top-most LAYER on the map and will draw over all of the other LAYERS. To move a LAYER down, left-click the layer name in the table of contents and drag it down or up depending on need.

Figure 34: ADD DATA Screen 1

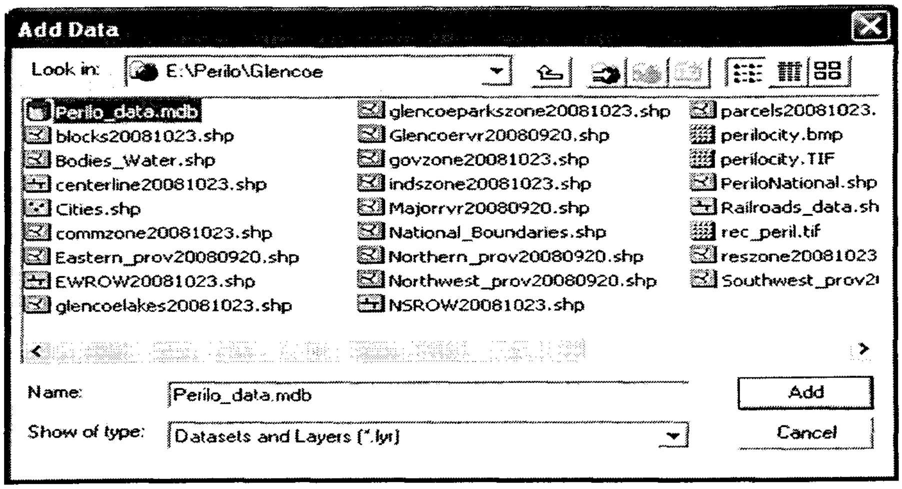


Figure 35: ADD DATA Dialog Box/PERILO Geodatabase

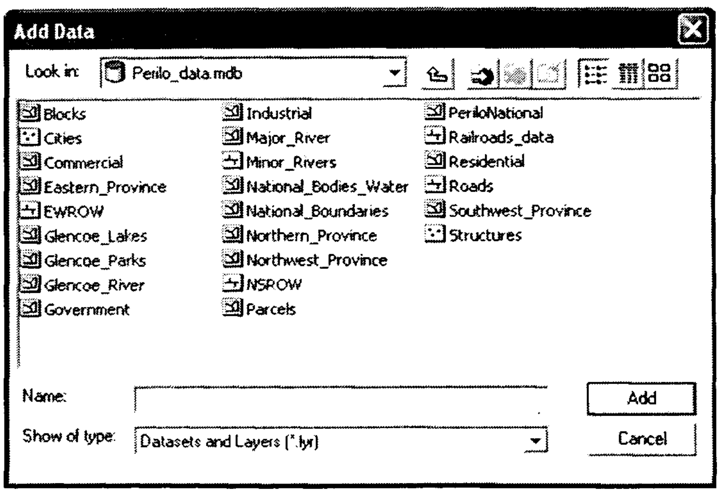


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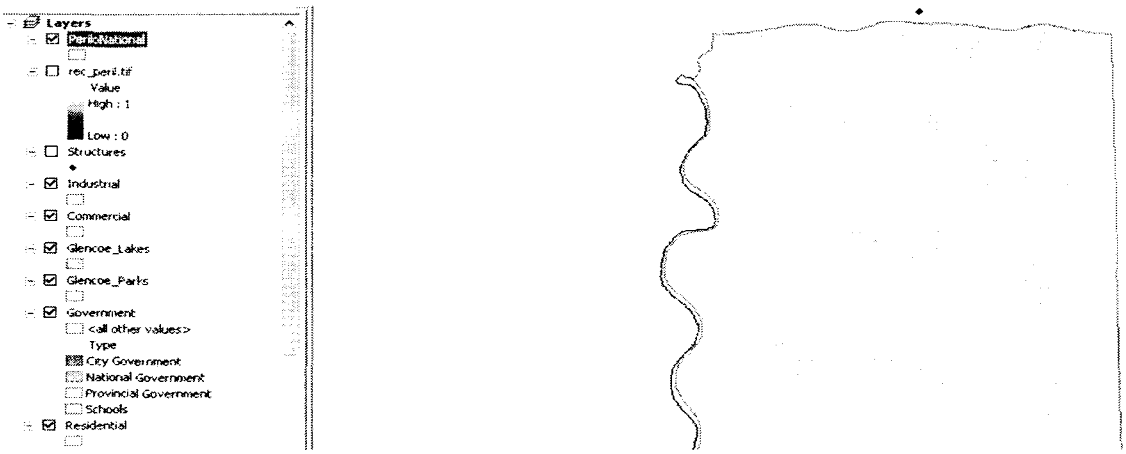
Figure 36: Perilo Map with New Data Added



(135) With all of my data added, I arranged my layer list so that the Provincial and National layers were shifted toward the bottom of the table of contents. The focus of the neutral-site GIS is the city of Glencoe; therefore, it was best to keep Glencoe and its many elements toward the top where they would be the most visible. The next steps involve dividing the layers themselves into more useful features that emergency management personnel will recognize.

(136) ArcGIS© 9.2 allows a GIS user not only to create a layer, but also to take each layer and break it down into individual classes. For example, the ROADS layer has several subcategories. Each subcategory represents a different type of road. Additionally, each subcategory has the option to be represented by a different symbol as well.

(137) Consider the various types of roads that potentially exist within a city. There are main roads that can extend several miles across an area. Feeder roads often branch out from these main roads, and might represent the majority of a traffic grid in the residential area. Interstate highways are a critical factor in moving people and commerce across the nation. All of these are road types that I used when constructing both Perilo and Glencoe.

(138) To establish the different classes of ROADS within the GIS, I first had to establish the values for each road that I intended to use. Notice in Figure 37 that in the pictured table of

contents, there are no values established for the ROADS layer except for <all other values>. This is a default value that ArcGIS© 9.2 creates for all layers within a GIS.

Figure 37: ArcGIS© 9.2 Table of Contents: ROADS

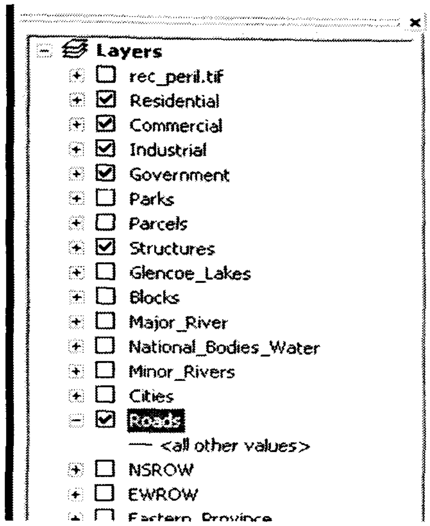
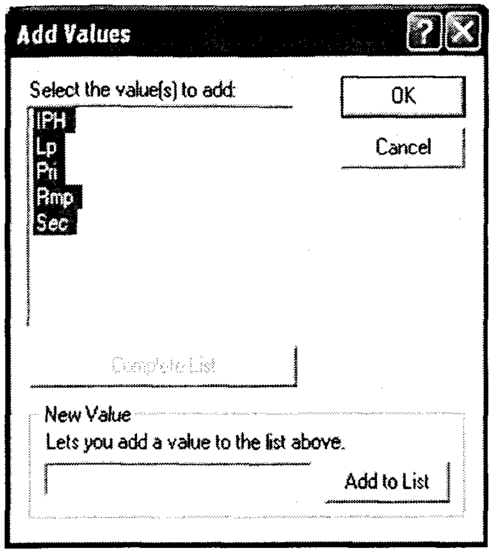


Table 15: Creating VALUES within a LAYER

1.	In the ArcGIS© 9.2 Table of Contents, right click on the layer that will have VALUES established. Select properties. This will open the Layers Property Dialog Box. Select the SYMBOLOGY tab.
2.	In the far left hand column of the Layers Property, under the CATEGORIES heading, select UNIQUE VALUES. This selection will change the VALUE FIELD area that is adjacent to the UNIQUE VALUES area of the dialog box.
3.	The value field is a pull-down menu. The values in this menu correspond to the same values that were established in the FIELDS tab in ArcCatalog. Select STREET TYPE in the value field.
4.	Select the ADD VALUES command. An ADD VALUES dialog box will open. See Figure 30.
5.	The VALUES that appear here were established in the DOMAIN that was created previously. Highlight them all, and select the ADD TO LIST command. If the desired value does not appear, return to the DOMAIN and add it there, so it will appear on the drop down menu.

Figure 38: Add Values Dialog Box



(139) With the individual types of roads now established in Perilo's GIS, I determined how the roads should appear on the map. With five different road types initially in use, it became important to differentiate between them. Using the UNIQUE VALUES feature located within the symbology tab ArcGIS© 9.2 allowed me to do this. These values use different symbols that I selected from the ArcGIS© 9.2 library to establish each type as different from another road type.

Table 16: Creating UNIQUE VALUES within a LAYER

1.	In the ArcGIS© 9.2 Table of Contents, right click on the layer that will have UNIQUE VALUES established. Select properties. The Layers Property Dialog Box will open. See Figure 39. Select the SYMBOLOGY tab.
2.	In the far left hand column of the Layers Property, under the CATEGORIES heading, select UNIQUE VALUES. This selection will change the VALUE FIELD area that is adjacent to the UNIQUE VALUES area of the dialog box.
3.	The value field is a pull-down menu. The values in this menu correspond to the same values that were established in the FIELDS tab in ARC catalog. Select STREET TYPE in the value field.
4.	Right click on the symbol adjacent to the abbreviation under the HEADINGS column. The SYMBOL SELECTOR will open a dialog box that allows a user to select which symbol to use to represent that specific UNIQUE VALUE. Figure 40 provides an example. In my example, the symbol for a major highway is assigned.
5.	Complete the same steps for all UNIQUE VALUES established under a LAYER. Once the steps are completed, each one of these UNIQUE VALUES will appear in the VALUES list

	with its new symbol in the LAYER VALUES dialog box. See Figure 41 for an example. Click APPLY and then OK. The new SYMBOLS and UNIQUE VALUES will appear in the table of contents.

Figure 39: Initial Layer Dialog Properties Box

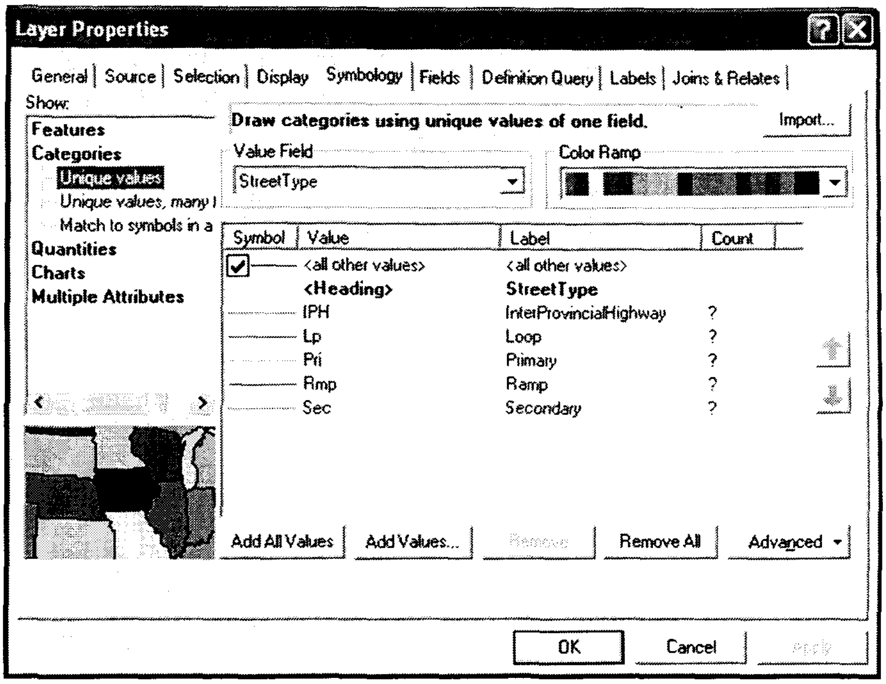


Figure 40: Symbol Selector Dialog Box

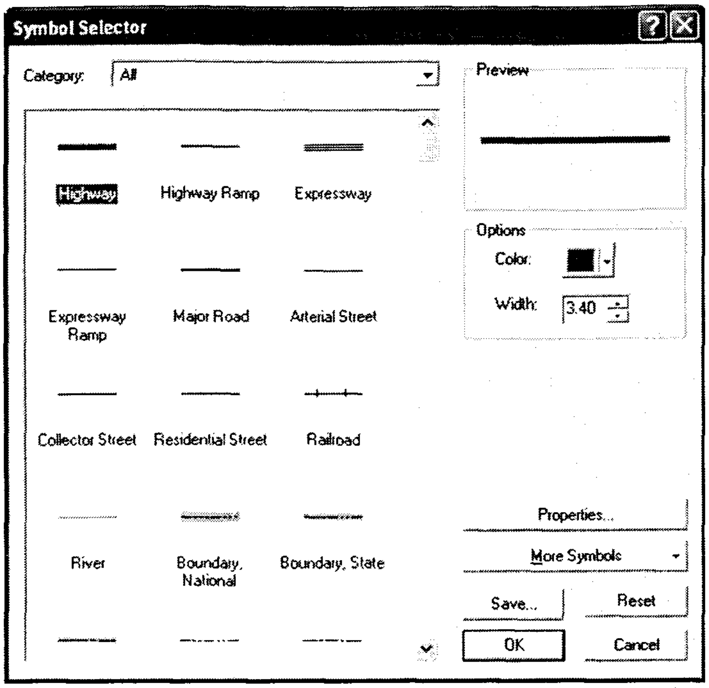
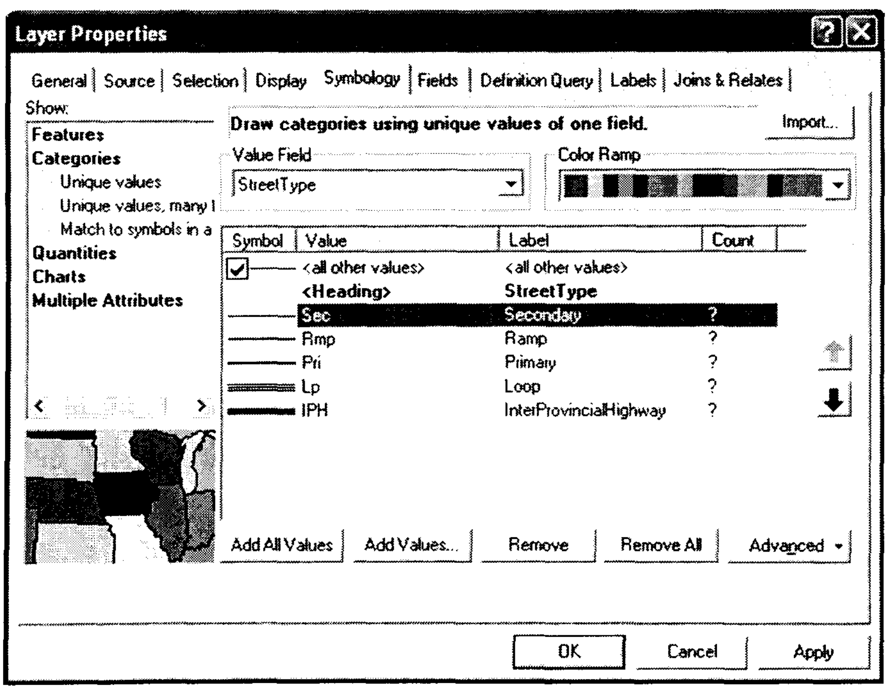


Figure 41: LAYER VALUES Dialog Box with Completed Symbols



(140) With the ROADS layer and the UNIQUE VALUES that I assigned to it completed, finishing the remaining layers posed no significant challenges. I followed the exact same steps in Tables 15 and 16 to create VALUES and UNIQUE VALUES for each layer. Table 17 details the individual VALUES and UNIQUE VALUES that exist within the Perilo GIS.

Table 17: Perilo GIS LAYERS and VALUES

Layer	**Values**
Residential	Low Residential, Medium Residential, High Residential
Commercial	Low Commercial, Medium Commercial, High Commercial
Industrial	Low Industrial, Medium Industrial, High Industrial
Governmental	Board of Education, City Government, Provincial Government, National Government
Roads	Inter Provincial Highways, Provincial Highways, Expressways (City Loop), Primary Roads, Secondary Roads, Ramp Accessways
Structures	1-9 Story Building, 10-15 Story Building, 16-20 Story Building, 20+ Story Building, Church, Condominium, Duplex, Elementary Schools, Middle Schools, High Schools, Emergency Operations Center, Fire Department Headquarters, Fire Department Substations, Hospitals, Junior College, Major Industrial Complex, Police Headquarters, Police Precinct, Single Family Home, Small Industrial Complex, University

(141) One of the decisions I made when I was establishing VALUES related to land use, such as low residential or medium commercial, was to simplify the zoning. Ordinarily, a city would have multiple zones for each type of land use. These zones are largely dependent on the needs of the city, the types of businesses that they are trying to attract and the tax structure that is in place. However, the purpose of the neutral-site GIS was not to provide training on city planning, but instead to focus on emergency management uses. Therefore, I opted to provide a basic outline of Glencoe's planning and zoning, recognizing that emergency personnel will focus on the emergency planning process.

(142) The last item that I completed in Perilo's GIS was to establish a limited population. There were several reasons why I opted not to attempt to put a full population base within Glencoe. First, as previously mentioned, there are over 40,000 parcels of ground within Glencoe. In theory, each one of those parcels should have an owner, whether it is an individual owner, or a corporation. However, the level of effort required is not currently

justified by the simulation's use. The option exists to provide a more detailed population base if the development of scenario requires it and the resources are available to complete the process.

(143) Regardless of the need for a full population base within Perilo, some initial population needed to be placed within the GIS. As I discussed in the sample and population section, the population is simulated. They will largely reside in the 23,398 residential parcels. However, I also needed to account for the period of time when the population is somewhere other than a residential PARCEL. To meet this need, I created the STRUCTURES LAYER within Perilo.

(144) For the purposes of this project, I decided to detail only the capability to create structures. The procedures for doing this are shown in Table 14. It is also important to note three things. First, the process does not change, regardless of the type of structure that is placed on a zoned parcel. Second, STRUCTURES appear on top of one of the five different layers: RESIDENTIAL, COMMERCIAL, INDUSTRIAL, GOVERNMENT, and TRANSPORTATION. The STRUCTURES layer acts independently. It can be independently controlled, regardless of what the status of the underlying layer is. Third, before placing STRUCTURES on one of the five different layers, I found it best to establish the zone of the individual PARCEL within each of the five different layers. The zones were the UNIQUE VALUES that I created earlier within each of the layers.

(145) For example, if I am placing an apartment building within the RESIDENTIAL LAYER, how I had zoned the specific PARCEL within the RESIDENTIAL LAYER would determine what size building (and therefore the number of occupants) I would place there. If I wanted a large 20+story building STRUCTURE on a parcel, it would be zoned as HEAVY RESIDENTIAL. On the other hand, if I chose to place a single-family home STRUCTURE on a RESIDENTIAL PARCEL, then I would have zoned it LIGHT RESIDENTIAL. The same procedures apply to each of the other five layers as well.

Table 18: Placing Structures on a LAYER

1.	With the ArcMAP© function of ArcGIS© 9.2 open, use the ZOOM Command (the magnifying glass with the plus symbol on it) to zoom into a specific LAYER PARCEL.
2.	Place ArcMAP© into EDITOR mode: click on the EDITOR command and open up the sub-menu. Select START EDITING.
3.	Under the TASK menu, select CREATE NEW FEATURE.
4.	Under the TARGET menu, select STRUCTURES.
5.	Select the SKETCH TOOL from the toolbar (it is shaped like a PENCIL).
6.	With the SKETCH TOOL selected, place the cursor wherever the new structure is to be placed. It will likely be near the road. Driveway access is not a layer on the map at this time. The building will appear as a blue dot with a red X because its attributes have not been defined yet. See Figure 42 for an example.
7.	Select the EDITOR TOOL (it is the black arrow with adjacent to the SKETCH TOOL).
8.	Right click the undefined building. Select ATTRIBUTES. The ATTRIBUTES sub-menu will appear. See Figure 43 for an example.
9.	From the ATTRIBUTES sub-menu, all of the specific information about the building can be set. In the example in Figure 44, the building has been set as a 10-15 story building, with a RESIDENTIAL purpose, containing 500 people. To change an individual value, click it and change the value using the pull-down menu or type in a value.

Figure 42: Add STRUCTURE

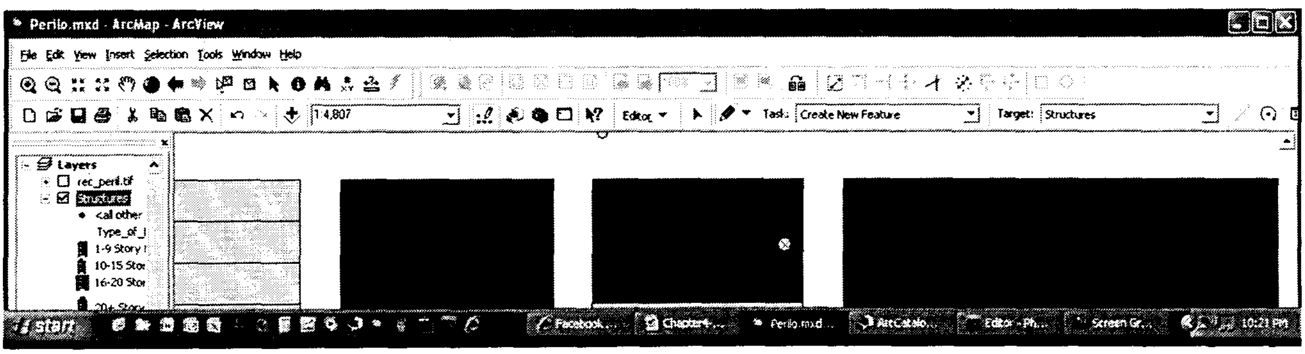


Figure 43: ATTRIBUTES Sub-Menu.

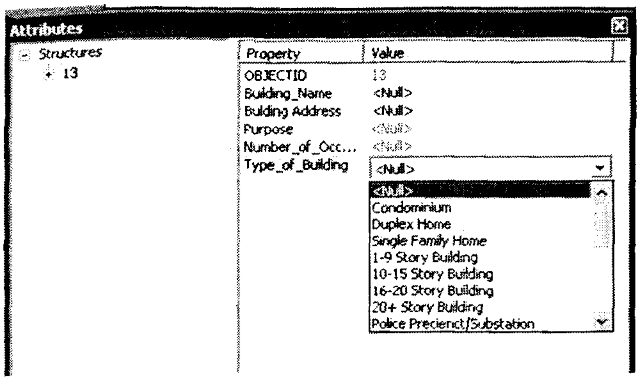
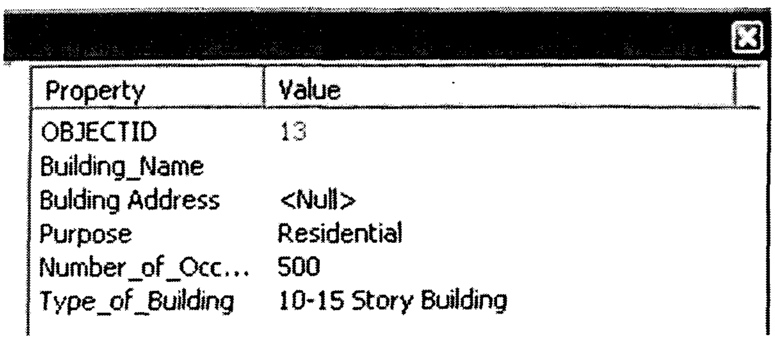


Figure 44: ATTRIBUTES Sub-Menu with Completed Information.



(146) The last task I accomplished was to assign the PARCEL LAYER to a zone. Refer to Figure 35 for the status of the PARCEL before assignment. The individual parcel is not designated into a zone, so it appears as an <all other values> in the RESIDENTIAL LAYER. Only after I assigned it a specific zone does the color change indicating the assignment. Completing the task was similar to placing a building on a PARCEL with minor adjustments in the steps. See Table 19 for specific instructions.

Table 19: Changing <all other values> to a Specific Zone

1.	With the ArcMAP© function of ArcGIS© 9.2 open, use the ZOOM Command (the magnifying glass with the plus symbol on it) to zoom into a specific POPULATION LAYER PARCEL.
2.	Place ArcMAP© into EDITOR mode. To accomplish this, click on the EDITOR command and open up the sub-menu. Select START EDITING.
3.	Under the TASK menu, select CREATE NEW FEATURE.
4.	Under the TARGET menu, select RESIDENTIAL. See Figure 45 for an example.
5.	Select the EDITOR TOOL (it is the black arrow with adjacent to the SKETCH TOOL).
6.	Right click the undefined POPULATION LAYER PARCEL. Select ATTRIBUTES. The ATTRIBUTES sub-menu will appear. See Figure 46 for an example.
7.	From the ATTRIBUTES sub-menu, all of the specific information about the <all other values> POPULATION LAYER PARCEL can be set. The pull-down menus that were created as UNIQUE Values are also available in this menu. In the Perilo example, the UNDEFINED PARCEL has been set as MEDIUM RESIDENTIAL. To change an individual value, click it and change the value using the pull-down menu or type in a value. See figure 47 for details.

Figure 45: <all other values> with STRUCTURE

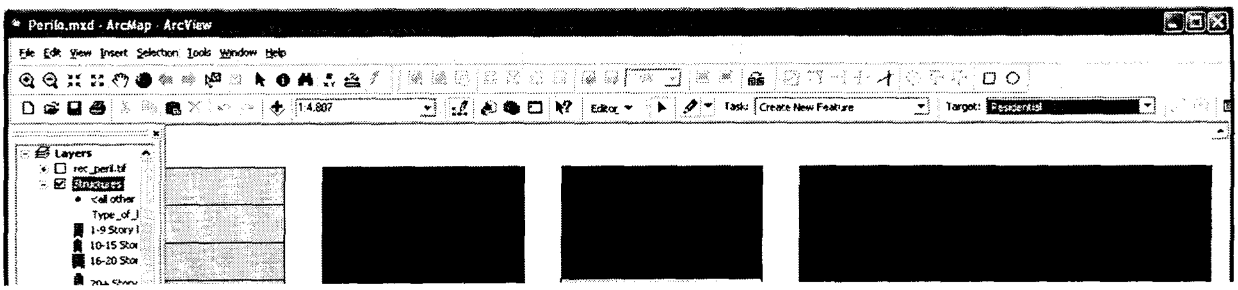


Figure 46: ATTRIBUTES Sub-Menu <all other values> PARCEL

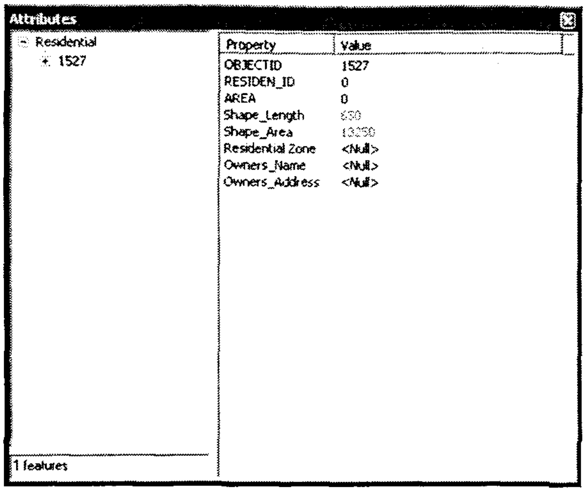
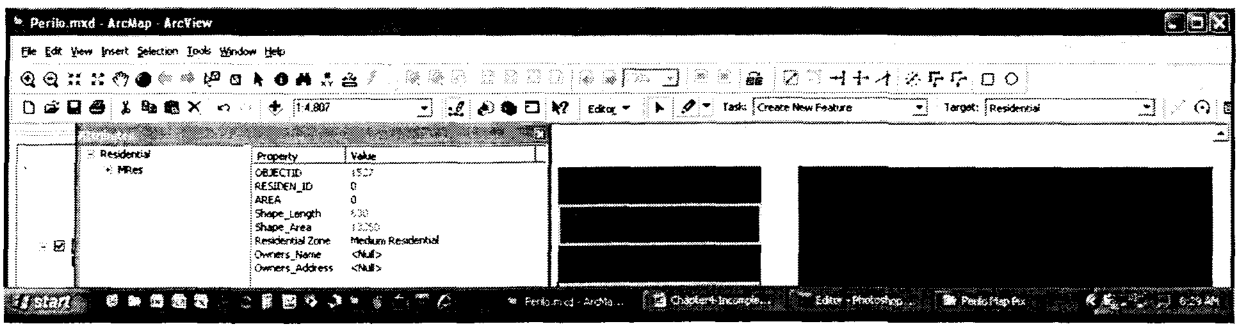


Figure 47: Zoned MEDIUM RESIDENTAL with STRUCTURE

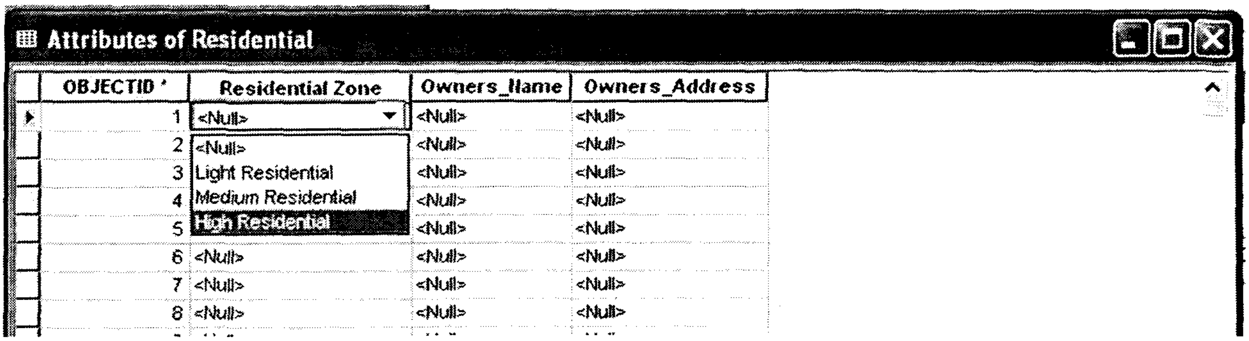


(147) It is also possible to set the ATTRIBUTES for a LAYER using the ATTRIBUTE table. The table contains all of the attribute information for that LAYER. Similar to the ATTRIBUTES sub-menu that is pictured in Figure 41, the pull-down menus that were created as UNIQUE VALUES are also available in the ATTRIBUTE TABLE.

Table 20: Changing Data Through an ATTRIBUTE TABLE

1.	Place ArcMAP© into EDITOR mode. Click on the EDITOR command and open up the sub-menu. Select START EDITING.
2.	Select the LAYER that needs to be modified by right clicking on the LAYER name into the ArcMAP© table of contents. A sub-menu will open. Select OPEN ATTRIBUTE TABLE.
3.	Change the desired value by clicking in the box of the value and activating the pull-down menu or by typing the information into the now blank space.
4.	Close the ATTRIBUTE Table. Save changes.

Figure 48: ATTRIBUTE TABLE with Pull-Down Menu



(148) One of the decisions that I made early in the neutral-site development was the shape and size of the PARCELS. In a normal city, parcels would not be as perfectly aligned and even at the property boundary as they appear in Glencoe. They also would not be over two acres in size as many of the non-city limit parcels are. As a land surveyors' assistant, I spend an extensive amount of time looking at parcels of actual cities and counties. The design of this neutral-GIS is an anomaly, but not one that I felt would make any difference in terms of the training value provided by the Perilo neutral-site GIS. Parcel shapes will not affect flood zones or damage caused by an earthquake. The layout of the PARCELS was done for convenience. There was no reason to figure out how to jigsaw 15,000 parcels into the non-city limits area. Initially I tried to create irregular shapes for the 15,000 parcels outside the city, but had little success in completing this in an expeditious manner.

(149) The directions I have provided here are to the best of my knowledge how ArcGIS© 9.2 and AutoCAD 3D© work. With program updates and software changes, much of what I

wrote in my paper could be very different in just a few years. The intent was to detail how Perilo was constructed and clearly demonstrate the steps involved.

ANALYSIS AND CONCLUSIONS

SUMMARY OF RESULTS

(150) My study examined one basic question: is it possible to develop a neutral-site GIS that addresses information needs useful for the training of emergency management personnel? The processes and procedures I have described in this paper suggest that the development of such a product is indeed possible. However, such a hypothesis comes with one caveat: Development is better suited as an undertaking by a team of individuals with a diverse knowledge of GIS software packages, computer aided drawing (CAD) fundamentals, city design, and emergency management principles. What I completed here is only a first step in what will be a long process that could lead to a working system suitable for distribution.

(151) The greatest strength of the site's neutrality is the wide latitude given to the specific training concerns of a diverse group of emergency personnel. The city of Glencoe, Republic of Perilo, could exist virtually anywhere on the planet. The design is flexible enough to address a variety of emergency and disaster scenarios ranging from routine to the catastrophic (Drabek and Hoetmer 1991). By not keying on a specific location, the neutral-site has the ability to provide a variety of training not normally considered by a site-specific GIS. Inclement weather phenomena, earthquakes, fires, or industrial accidents are scenarios that present programming and testing options.

(151) My subordinate research question directly asked what the specific steps were required to complete the research, development, and construction of the Perilo neutral-site GIS. Each process took several steps which I briefly discuss in the following sections:

- What are the functions of a GIS? The process involved with gaining a working knowledge concerning the basic operation of a GIS through review of the literature, completion of software specific training, and experimentation.

- What is the process involved in developing the neutral-site GIS concept? To develop the concept, I integrated my understanding of spatial relationships developed through experiences on surveying crews over the last ten years with existing literature defining what a city is. Such knowledge aided me in my understanding of the elements in the physical construction of a community.
- How did the construction of the national and provincial maps of Perilo as described in the results section occur? The construction provided a test bed for the eventual development of the last phase. These efforts were accomplished using both AutoCAD 3D© by Autodesk with a Carlson© overlay program and ArcGIS© 9.2.
- What were the processes involved with the construction of Glencoe? To complete the construction of Glencoe, I needed to develop a base map, multiple layers, a population base, and the associated map. I accomplished these requirements using both AutoCAD 3D© by Autodesk with a Carlson© overlay program and ArcGIS© 9.2.

LESSONS LEARNED

(152) During the course of this study, I identified three key concerns which may assist others who undertake such a process:

- Individuals approaching this process should have a good understanding of the relationships between spatial objects, land use, and population bases. Although my experience in land surveying was critical to me, such a knowledge base is obtainable in a variety of ways. Literature review, professional course development, and observation of a live GIS in use would be valuable in this effort.
- Training is a key component. The software is not intuitive, the understanding of how it works, and the functions it performs are vital to the overall process. Because there are a variety of products and constant evolution of technology, expect that the software that is available today could function in a different manner tomorrow.

- Future GIS operators and city planners need a clear understanding of the expectations from such a product before the process begins. The expectations will change as the project develops (as they did in my case), but having a series of goals allowed rapid transition when difficulties arose.

IMPLICATIONS OF THE STUDY (RECOMMENDATIONS)

(153) Information management is one of the most critical aspects of emergency response (Drabek and Hoetmer 1991). Yet, it often appears that information management is also one of the most overlooked aspects as well. During crisis management, there is a perception that it is less complicated to act upon known information instead of waiting for a complete picture. In my fifteen years of personal experience as an emergency manager, I have worked for supervisors who did not want to wait for the picture to develop fully. Looking back, I can understand that such supervisors did not have the information resources in the field that today help provide up-to-date information.

(154) GIS has the ability to provide this information. All phases of the comprehensive emergency management cycle (mitigation, preparedness, response, and recovery) would benefit significantly from the visual representations that a GIS would offer. Additionally, the personnel that any neutral-site GIS helped train would be better prepared to use a GIS in both emergency operation center applications and in field response work.

AREAS FOR FURTHER STUDY

(155) My research focused on the processes and procedures for the research, development, and construction of a neutral-site GIS. Future research might well examine the effectiveness of the neutral-site GIS provide training in providing training to the target audience. My focus was on a target audience comprised of professional emergency management personnel with limited or no GIS experience.

(156) A broader research question is whether the development of software and tools that do not require the extensive training that I undertook for this project would provide broader opportunities to use this type of neutral-site in a wider application of public service

applications. The continued rise of costs and the decline of tax revenues, combined with staffing constraints suggest that simulation should be a priority for future training needs. If it is possible to establish that a neutral-site GIS works for emergency planning, it seems reasonable to suggest that such a system has a much broader range of applications.

Works Cited

Author's Note: Internet addresses for electronic sources cited in this paper were accurate at the time of preparation of the paper in its final form. Material on internet sites changes rapidly, and locations may contain different material from that available to the author at the time of writing or may no longer be active.

Antal, John F.; "Combat Team; The Captain's War: An Interactive Exercise in Company-Level Command in Battle

Bagnall Norma H.; "On Shaky Ground: The New Madrid Earthquakes of 1811-1812.;" University of Missouri Press; [Book]; Columbia, Missouri, United States of America; 1996; Page 57.

Ballard, Timothy, Pate, Jason, et. al.; "Chronology of Aum Shinrikyo's CBW Activities,". Monterey Weapons of Mass Destruction Geodatabase.; [website]; Monterey Institute for International Studies.; Monterey, California, United States of America, 2001-03-15. Location: http://cns.miis.edu/pubs/reports/pdfs/aum_chrn.pdf; accessed on 2009-03-13.

Browne, Mark J and Hoyt, Robert E.; "The Demand for Flood Insurance: Empirical Evidence.;" Journal of Risk and Uncertainty.; [Journal]; Kluwer Academic Publishers; Norwell, Massachusetts, United States of America; Volume 20 Issue 3; 2000; Pages 291-306.

Castel, S. and Otte, E. [Editors]; "Conflict and Cooperation Related to International Water Resources: Historical Perspectives; Selected Papers of the International Water History Association's Conference on the Role of Water in History and Development.;" United Nations Educational, Scientific, and Cultural Organization [Conference Paper]; Bergen, Norway; 2001; Page 27.

Daniel, Glyn E.; "The First Civilizations: The Archaeology of their Origins.;" Phoenix Press; [Book]; London, England; The Orion Publishing Group Limited; 1968; Page 12.

Davis, Mike; "Ecology of Fear: Los Angeles and the Imagination of Disaster.;" Metropolitan Books; [Book]; New York, New York, United States of America; Henry Holt and Company; 1998

Drabek, Thomas E.; and Hoetmer, Gerard; *Emergency Management: Principles and Practice for Local Government*; [book]; Washington, District of Columbia, United States of America; International City Management Association; 1991

Denzin, Norman K.; "Interpretive Interactionism.;" SAGE Publications; [book]; Thousand Oaks, California, United States of America; October 2001; Page 107.

Downton, Mary W., Miller-Barnard J. Zoe, and Pielke, Roger A. "Reanalysis of U.S. National Weather Service Flood Loss Database.;" Natural Hazards Review; [Journal]; American Society of Civil Engineers; Reston, Virginia, United States of America; Volume 6; Issue 1; Pages 13-22.

Foresman, T.W.; "GIS Early Years and the Threads of Evolution.;" The History of Geographic Information Systems: Perspectives from the Pioneers.; Foresman, T.W. Editor, Pearson Education; [Book], Upper Saddle River, New Jersey, United States of America; 1997-11; Pages 181-198.

Gerckens, Lawrence C.; "Historical Development of American City Planning.;" The Practice of Local Government and Planning.; International City Management Association;[Book]; Washington, District of Columbia, United States of America; 1979.

Green, Walter G. III; "A Study of Core Functions in Emergency Management as Reflected in Training Requirements for Professional Certification.;"Universal Publishers [Book]; Boca Raton, Florida, United States of America; 1999.

Greenlee, D.D and Guptill, S. C.; "GIS Development in the Department of the Interior.;" The History of Geographic Information Systems: Perspectives from the Pioneers.; Foresman, T.W. Editor, Pearson Education; [Book], Upper Saddle River, New Jersey, United States of America; 1997-11; Pages 181-198.

Godschalk, David R., Beatley, Timothy; "Natural Hazard Mitigation. Recasting Disaster Policy and Planning.;" Island Publishing; [Book]; Washington, District of Columbia, United States of America; 1999.

Haddow, George D. and Bullock, Jane A.; "Introduction to Emergency Management.;" Butterworth and Heinman; [Book]; Burlington, Massachusetts, United States of America; Elsevier Science; 2008.

Hamermesh, Daniel S. and Frazis, Harley "Data Watch: The American Time Survey.;" The Journal of Economic Perspectives; [Journal]; American Economic Association; Nashville, Tennessee, United States of America; Volume 19; Number 1; Pages 221-232.

Hogan, David E. and Burstein, Jonathan L.;"Disaster Medicine." Lippincott Williams and Wilkins; [Book]; Philadelphia, Pennsylvania, United States of America; Wolters Kluwer Group; 2007; Second Edition; Page 214.

Holloway, Immy; "Basic Concepts for Qualitative Research.;" John Wiley and Sons Incorporated; [Book]; Malden, Massachusetts, United States of America; First Edition; 1997.

Johnston Arch C. and Schweig Eugene S.; "The Enigma of the New Madrid Earthquakes of 1811-1812.;" Annual Review of Earth and Planetary Sciences; [Journal]; Annual Reviews; Palo Alto, California, United States of America; Volume 24; 1996-05; Pages 339-384.

Kahn, Matthew E.; "The Death Toll From Natural Disasters: The Role of Income, Geography, and Institutions.;" The Review of Economics and Statistics; [Journal]; Harvard University Kennedy School of Government; Cambridge, Massachusetts, United States of America; Massachusetts Institute of Technology Press; Volume 87, Number 2; 2005-05 Pages 271-284.

Kunreuther, Howard; "Mitigating Disaster Losses Through Insurance.;" Journal of Risk and Uncertainty.; [Journal]; Kluwer Academic Publishers; Norwell, Massachusetts, United States of America; Issue 2-3 Volume 12; 1996-03; Pages 171-187.

Lee, Allan S.; "A Scientific Methodology for MIS Case Studies.;" MIS Quarterly and the Society for Information Management"; [Journal]; University of Minnesota; Minneapolis, Minnesota, United States of America; Volume 13; Issue 1; Page 33-50.

Littlejohn, David; "Defending the Reich.;" James R. Bender Publishing; [Book]; San Jose, California, United States of America; First Edition; 2007.

McCarthy, Kevin, Peterson D.J. ,Sastry, Narayan, and Pollard Michael, "The Repopulation of New Orleans after Hurricane Katrina; [Technical Report]; RAND Gulf States Policy Institute; Jackson, Mississippi; United States of America; RAND Corporation, Santa Monica, California, United States of America; 2006.

McLoughlin, David; "A Framework for Integrated Emergency Management.;" .;" Public Administration Review; [Journal]; Wiley-Blackwell; Volume 45; Special Issue; Oxford, United Kingdom, 1985-01, Pages 165-172.

Milner-Gulland E.J., Shea, K.; "Competing Harvesting Strategies in a Simulated Population Under Uncertainty." Animal Conservation; [Journal]; Wiley-Blackwell; Volume 4; Issue 2; Oxford, United Kingdom, 2001, Pages 157-167.

National Weather Service GIS Data Portal; National Oceanic and Atmospheric Administration; [website]; National Weather Service.; Silver Springs, Maryland, United States of America; 2008-05-30. Location: http://www.weather.gov/gis/; accessed on 2009-05-12.

O'Looney, John; "Beyond Maps GIS and Decision Making in Local Government.;" Environmental Systems Research Institute (ESRI) Press [Book]; Redlands, California, United States of America; 2002.

Pal, Akhilesh, Graettinger, Andrew J.; "Emergency Evacuation Based On Geographic Information System Data.;" [Conference Paper]; 82nd Annual Meeting of the Transportation Research Board; Washington, District of Columbia, United States of America, 2003-01-12

Petak, William J.; "Emergency Management: A Challenge for Public Administration.;" Public Administration Review; [Journal]; Wiley-Blackwell; Volume 45; Special Issue; Oxford, United Kingdom, 1985-01, Pages 3-7.

Plevin, Liam; "State Farm Won't Cover Properties in Florida.;" The Wall Street Journal Online; United States Edition; New York City, New York, United States of America.; Dow Jones and Company; 2009-01-28; Accessed on 2009-03-13 at http://onlinewsj.com/article/SB123310332431722147.html

Ryan, John and Dunford, George; "Micro Nations, The Lonely Planet Guide to Home-Made Nations.; " Lonely Planet Publications Pty Ltd [Book]; Footscray, Victoria, Australia; 2006; Page 4-5.

Sellers, Thomas A. and Weaver, Todd, W., "Environmental Factors Can Confound Identification of a Major Gene Effect: Results From a Segregation Analysis of a Simulated

Population of Lung Cancer Families.;" Genetic Epidemiology; [Journal]; Wiley-Blackwell; Volume 15; Issue 3; Hoboken, New Jersey, United States of America; Pages 251-262

Starr, Paul; "Seductions of Sim: Policy as a Simulation Game.;" The American Prospect.; [Journal]; Danvers, Massachusetts, United States of America; Volume 17; 1994-03-21

Stier, Daniel D. and Goodman, Richard A., "Mutual Aid Agreements: Essential Legal Tools for Public Health Preparedness and Response.;" American Journal of Public Health; [Journal]; American Public Health Association; Volume 97; Supplement Number 1; Washington, District of Columbia, United States of America; Pages S62-S68.

Speheger, Douglas A., Doswell, Charles A III, and Stump, Gregory J.; "The Tornadoes of 3 May 1999: Event Verification in Central Oklahoma and Related Issues.;" Weather and Forecasting; [Journal]; American Meteorological Society; Boston. Massachusetts, United States of America; Volume 17; Issue 3; Pages 362-381.

Turner, Barry A.; "Causes of Disaster: Sloppy Management.;" British Journal of Management; [Journal]; London, England, John Wiley and Sons Limited; Volume 5; 1994; Pages 215-219.

Tomlinson, Roger; "The Canada Geographic Information System.;" The History of Geographic Information Systems: Perspectives from the Pioneers.; Foresman, T.W. Editor, Pearson Education; [Book], Upper Saddle River, New Jersey, United States of America; 1997-11; Pages 21-32.

Tomlinson, Roger; "Thinking About GIS. Geographic Information System Planning For Managers.;" Environmental Systems Research Institute (ESRI) Press [Book]; Redlands, California, United States of America; 2007.

Waugh, William L. and Tierney, Kathleen J.; [Editors] "Emergency Management; Principles and Practice for Local Government; Second Edition."; International City/County Management Association [Book]; Washington, District of Columbia, United States of America; 2007. Page 32-33

Wilson, Edward and Oldfield, Mark; "2002 World Series Earthquake?;" State of California Department of Conversation News Release 2002-45.; [Internet Site]; Sacramento, California, United States of America; 2002; Release Number 45. Accessed on 20090228 at http://www.conservation.ca.gov/index/news/2002%20News%20Releases/Pages/NR2002-45%20World%20Series%20Earthquake.aspx

Wilson Richard C.; "The Loma Prieta Quake, What One City Learned" International City/County Management Association; [Book]; Washington, District of Columbia, United States of America; 1991; Page 16.

Winkler, Allan M.; "A 40-Year History of Civil Defense.;" Bulletin of the Atomic Scientists; Bulletin of the Atomic Scientists [Journal]; Chicago, Illinois, United States of America; 1984-06; Volume 40; Issue 6; Pages 16-22.

Winter, Glyn; "A Comparative Discussion of the Notion of Validity in Quantitative and Qualitative Research.;" Nova Southeastern University; [Journal]; Fort Lauderdale, Florida; United States of America; Volume 4, Number 4, 2000/03.

Yin, Robert K.; "Case Study Research Designs and Methods.;" Sage Publications Incorporated [Book]; Thousand Oaks, California, United States of America; Sage Publications Limited; 2003; Page 5.

Yoffee, Norman; "The Collapse of Ancient States and Civilizations.;" The University of Arizona Press [Book]; Tucson, Arizona, United States of America.; The Arizona Board of Regents; 1988; Pages 44-68.

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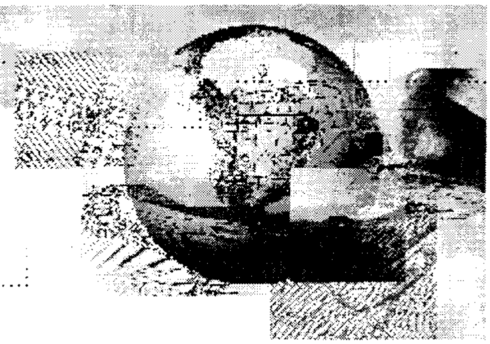

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