Using GIS to Assist Location and Site Selection Decisions

Adriana Alicia Abramovich

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Committee:

James R. DeLisle

Manish Chalana

Terry Grissom

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Introduction

During the past four years, I have worked as a GIS (Geographic Information System) Analyst for the Community and Economic Development Department of the City of Renton and have developed a great interest for retail location analysis through my work in support of the Planning and Economic Development Division, This position has exposed me to assignments which have continuously required answering the following question: Where should a business be located and why?

Indeed, the nature of modern commerce and trade is becoming exceedingly complex and intricate. "One of the most important decisions a retailer can make is where to locate a retail outlet. Because convenience is so important to today's consumers, a retail store can prosper or fail solely based on its location. Recently, a changing retail environment is augmenting the location importance as retail economic groups develop multi-outlets chains or small stores."[1] Consequently governmental agencies and private firms are increasingly relying on GIS based analysis to locate and retain business, and also capture and maximize the return of new investments.

The general qualifications for determining a specific location include: site availability, land use and zoning designations, municipal code regulations, and

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[1] Mendez, A. B. Mendez and Themido, I.H. Multi-Outlet Retail Site Location Assessment. International Transactions in Operational Research. 2004, Vol. 11, 1-18

environmental restrictions. A key factor in business placement is finding the best and most financially stable location for a specific type of business use. This means examining the specific needs associated with the operation of varied uses, such as, hotels, offices, government offices, municipal or state agencies, restaurants, as well as, businesses that potentially have greater environmental impact, e.g., automobile oil change shops or dry cleaning stores. These are just a few examples of the challenges and considerations faced when proposing a business site location.

The focus of this paper covers one of the most powerful tools currently utilized to assist the location and site selection decisions which is the integration of location science and modeling with GIS. This approach reveals optimal solutions to companies or agencies as they seek to make business placement decisions to maximize their productivity and efficiency. The advent of geographic information systems (GIS) has enabled an explosion of interest in and ability to study the spatial patterns of behaviors. GIS not only makes it possible to store in digital form vast amounts of spatial data, it makes possible statistical analysis, modeling and visual display of geographic data. It provides a powerful new tool that has stimulated new and existing research using geographical concepts and data.

In business, there is the well-known question: "What are the three most important factors in retail?" The answer: "Location, Location, Location!"[2] Although there

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[2] Timmermans, Harry. Retail, Location and Consumer Spatial Choice Behavior in Applied Geography, A World Perspective edited by Bailly, Antoine and Gibson, Lay James. The GeoJournal Library. Klumer Academic Publishers. The Netherlands, 2004, 133-147.

are many factors that contribute to the success of a retail business or a multi-family housing venture, location is undeniable one of the dominant considerations. A good location helps to ensure success and a poor location usually dooms a business to failure. “The saying location, location, location, suggests that bad location decisions are difficult to compensate by other elements of the marketing mix such as pricing, merchandising and promotion. Space and location is the very core of geography; hence many geographical theories, results of spatial analysis and spatial methods are potentially relevant for better informed decisions in retailing”.[3] In fact, a primary need in retail business location is the capability to determine in advance the market potential for a retail outlet before committing to an investment in site expansion or a new building.

In location science, the integration of modeling and mapping with GIS allows the GIS Analyst to efficiently utilize data from varied sources to produce detailed models. These models can then assist with decisions for the best suitable alternative for future site location. This paper concentrates on how real life problems and decisions of business location can be supported through the use of this integrated approach. Some business site location decisions will continue to be made in an ad-hoc fashion, however, as our urban and commerce systems become more complex these ad hoc and “back-of-the-envelope” approaches might fail to capture all of the important complexities and, thus, fail to identifying the best alternative. Often, we have one or more commercial facilities in order to serve or operate in conjunction with the existing elements. This fact

[3] Ibid 2, 133

alone demands a greater concern for characterizing what exists, as well as locating variables such as disposable income or housing profile within the context of the service areas.

This paper introduces the historic background of site location analysis based on the founding fathers of location science. It begins with Pierre de Fermat that later inspired the solution to finding a central median location; then followed by Johann H. von Thunen theory,[4] who in 1826 proposed a model for evaluating agricultural patterns that analyzed land rent for agricultural commodities and by Walter Christallers' Central Place Theory[5] that involves the importance of proximity of goods and vendors, and the notion of threshold theory. The historic background on location theory describes the evolving approach over time and concludes with the accomplishments from the computational modeling era that integrates geographic information system as a key tool to assist in the location and site selection decisions.

The discussion of computer modeling describes how the availability of faster computers with greater data-processing capabilities now allows municipal agencies to deliver large scale computer models for public consideration and decision-making. This combined approach of public participation and modeling can now facilitate decisions for comprehensive land use planning by simultaneously considering housing and employment forecasts, as well as, other factors related to optimal land use.

[4] Von Thunen, J.H. Von Thunen Isolated State. UK. Oxford, Pergamon Press. 1966

[5] Christaller Walter, Central Places in Southern Germany. Translated by C. W. Baskin. Englewood Cliffs, New Jersey. Prentice-Hall. Originally published in German in 1933.

It is assumed that those interested in using GIS to assist in the location and site selection already have a basic knowledge in Geographic Information Systems theory. Therefore, this paper does not include an introduction to GIS nor to data acquisition and management. For those interested, there are many books available on these topics, particularly GIS in real estate. [6]

This paper dedicates a full chapter to trade area. Trade area is very important because "a primary need in retail location is the capability to estimate in advance the functional market area of a potential outlet before committing to a lease, investing in improvements or building a new facility". [7] It explores Grant Thrall's theory on trade and service area. Thrall, a professor of Geography at the University of Florida, has introduced technological advances for the process of market analysis for all industries, including retail. In *Urban Retailing in North America*, a thesis by David Major - alumni from the University of Washington 2007 Planning Program - describes that Thrall argues that there are two rules of thumb frequently used for deriving the geographic extend of a market area for a retailer, the radial distance approach and the drive time approach. Thrall explains in brief that the radial distance approach is an analytic tool that represents a trade area through a pattern of concentric circles inside other circles with varying radii in order to determine the location of customers relative to a primary trade area, using either ZIP code or census tract. The drive time approach

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[6] Castle Gilbert H. . GIS in Real Estate: Integrating, Analyzing and Presenting Locational Information. Appraisal Institute in association with Adams Business Media/GIS World. 1998. 131.

[7] Church, Richard L, Murray, Alan T. Location Analysis and GIS. John Wiley & Sons, Inc. Hoboken, New Jersey. 2009

builds off the radial distance method with driving times as the major determinant for locating a prospective store. The potential store location is thus selected based on distances that consumers must travel from home, work, school and other shopping venues. Chapter 2 on trade area concludes that for retailers of any size and scale, the drive time approach is a critical tool, not only for determining drive time from consumer homes, but also "calculating drive time between existing stores within the chain to maximize the trade area's coverage". [8]

Indeed, Thrall believes that in the changing dynamic of where people choose to live and shop in today's real estate market, the radial distance approach which uses a circular trade area may result in unnecessary errors in the trade area analysis for retailers of all scales. Circular trade area often does not take into account such factors as transportation networks or other factors that may influence population dispersion and customer geographic behavior, such as natural or manmade barriers and political jurisdictions. Due to the model of a trade area as concentric rings, the geometry of an expanding radius for a circle may dictate that in order to include an additional percentage of customers located in one particular area, that an equal area will need to be added to the trade area in another direction; however, this does not accommodate for the irregular dispersion of consumers within a given retailer polygon shape. Therefore, Thrall believes

[8] Major David, Urban Retailing in North America: An Analysis of the Opportunities and Challenges for Superstore Retailers in Urban Markets. University of Washington, Seattle. 2008. 14.

that retailers should use an irregular polygon shape approach that looks like an ameba as opposed to the traditional radial distance circles in the determination of trade areas.[9]

Chapter 2 not only covers Trade Area, it also explains how demographic characteristics are gathered throughout decennial Census and the American Community Survey (ACS). This chapter also describes how the gathering of demographics in general has now become relatively easy and inexpensive due to the availability of various data-collection sources through GIS web map applications tools. Concurrently clarifies how demographic data can be modeled with GIS software. This greatly benefits real estate developers who are interested in knowing prospective markets. This chapter also includes samples of demographics reports measured within rings of one, three and five miles and a report that uses 10 and 20 minutes of driving time measured from the same location.

The importance of estimating market potential is emphasized by Richard Church in related literature. He argues that "in fact, a primary need in retail location is the capability to estimate in advance the functional market area of a potential outlet before committing to a lease, investing in improvements or building a new facility". [10] Consequently, a variety of cases are presented within this paper to explain how to use GIS in site selection. Each case unfolds and is associated to a modeling pattern.

[9] Thrall, Grant. Business Geography and New Real Estate Market Analysis: Spatial Information Systems. England, Oxford University Press Inc. 2002. 88.

[10] Ibid 7, 82

Chapter 3 covers line based analysis along a network by illustrating the use of GIS in the decision making process of a case study of siting a path/corridor based on the amount of full-time employees along the path. Chapter 4 follows with an example of the approach of location based on characteristics of a specific area which involves the selection of multiple land parcels for acquisition. This strategy seeks industrial-zoned parcels equal or greater than seven acres with an improved land value of $500,000 or below. Chapter 5 concentrates on coverage based analysis that introduces multiple facilities and location-allocation model. Location is often considered the most important factor leading to the success of a business or public service. It presents a sample for fire stations with the objective to provide high quality service to the community. Given facilities such as fire stations that provide services and a set of demand points that consume them, the goal of location-allocation is to locate the facilities in a way that supplies the demand point most efficiently. As the same time, explains how location-allocation is considered a twofold problem that simultaneously locates facilities and allocated demand points to the facilities. Chapter 5 also explains how to work with the location-allocation feature class. It also takes the reader to the required steps for measuring Euclidian Distance and Euclidian Allocation. It analyze location-allocation of fire stations in the Renton area, including the location of current facilities, facility class (if that point represents a candidate, required site or even a competing facility), demand points (people or things requiring the services that those facilities provide), lines class (contains line features that connect demand points to the facilities they are allocated to) and point, line and polygon barriers that serve to temporarily restrict, add impedance to and scale impedance on parts of a network.

The description of each example of location analysis with GIS is presented with following matrix:

- Introduction and problem definition
- Modeling Application: GIS Analysis followed by a case study
- GIS Science
- Conclusion

The paper concludes with a discussion on the lessons learned from each case study, highlights what tools are available to real estate developers for location analysis and what does the future holds in location analysis with GIS.

Chapter 1: The Evolution of Business Location Theory

Locational analysis has grown to maturity over the last decades, evolving from its earliest roots to its current widespread use by a variety of interested parties including professionals in urban planning and real estate development.

Given the importance of the location decision, a number of analytical procedures have been developed for location analysis and site selection. “These constitute a distinct body of knowledge for both theoretical and practical perspectives.” They can be “traced to the practice of numerous entrepreneurs and managers who, based on their judgments and intuition, made location decisions for their firms. The wisdom underlying these decisions eventually was codified into rules of thumb and checklists which others could follow. These checklist included information necessary to evaluate the relative attractiveness of a site compared with other potential sites in the area. It listed various factors that are likely to impact on sales and cost at a site. The checklists were the first attempt to develop a systematic basis for site selection.” [11]

Three distinct stages of location theory emerged during the study of the literature on this topic. The early contributions to location theory stage were based on the study of geometrical and geographical factors; the second period or “Coming of Age” includes the development of assumptions and models that have proved fundamental to

[11] Gosh, Avijit, McLafferty Sara L. Location Strategies for Retail and Service Firms. Lexington Books. DC. Heath and Company/Lexington, Massachusetts/Toronto. 1987. 2

later research, and lastly, a third period of new models and applications, with most growth in the use of technology occurring after the 1960s. [12]

The period of early contributions includes theories from the seventeenth century, followed by the advances in the early twentieth century of Alfred Weber's work, and Walter Christaller and his theory of central place.

In the early literature on locational analysis, several works pointed to an approach of considering geometrical or geographical points located in a continuous plane. Actually, Pierre de Fermat (1601-1665), the father of calculus, presented a problem that stated: "given three points on the plane, find the fourth point such that the sum of the distances to the three given points is a minimum. This simple geometrically inspired problem dealt with finding a central median location". [13]

The concepts above were followed by Evangelista Torricelli (1608-1647), whom was credited with the geometrical construction needed to find such a spatial median or "Torricelli point".

in 1826, Johann H. von Thunen proposed a "model for evaluating agricultural patterns that analyzed land rent for agricultural commodities". [14] Land rent represents the difference between revenues obtained from the land and the cost of working that unit of land, and is the surplus left after all cost has been deducted.

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[12] H K Smith, G. Laporte and PR Harper. Location Analysis: Highlights of Growth to Maturity. School of Mathematics, University of Southampton. Technical Report.SO17 1BJ, UK

[13] Ibid 7, 4

[14] Ibid 4

However, it was not until the twentieth century, that Alfred Weber (1909) began the era of modern location analysis. The "Weber problem" is to locate the most efficient site for a factory assuming that transport cost are a function of Euclidian or straight line distances. Weber's analysis was the first to position a problem of industrial activity in terms of optimal placement. Weber's original work has been expanded over time in two problems domains: network along lines and surfaces or coverage in horizontal, round or inclined planes.

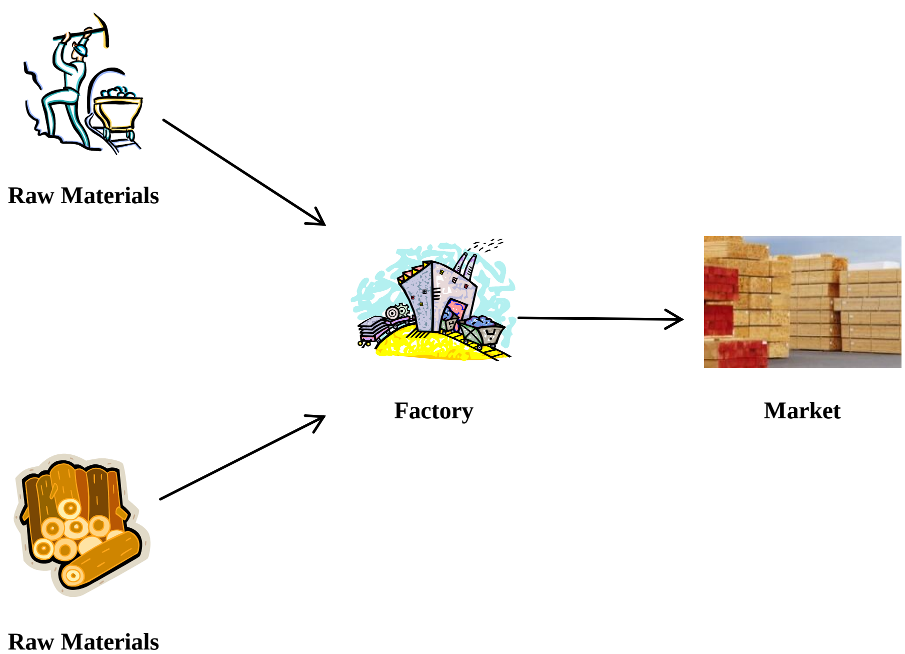

Figure 1.1 - Weber problem of locating the optimal placement for a factory to minimize costs.

Competitive location models in the early 1900s were also rooted in the work of Hotelling (1929)[15] who sought to determine the optimal location of two competing

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[15] Ralph M. Braid. The Optimal Locations of Branch Facilities and Main Facilities with Consumer Search. Journal of Regional Science. 1996. Vol. 36, Number 2, 217-234

vendors on a line segment. K.J Arrow and E. L. Lehmann explain in a biographical memoir of Harold Hotelling that he wrote six mayor papers on economics. One of them, published in a major journal, dealt with a topic that introduced spatial competition. He recognized that when establishments' area spatially separated, the cost to the consumer includes not only the price but also the transportation cost. As a result, he concluded that firms will tend to be concentrated in the middle. He noted that spatial differentiation was not only interesting in it, but could also be regarded as a metaphor for quality differentiation in products. Hotelling analysis indicates how two vendors would take part in competition for market share by setting prices with the purpose of maximizing profits.

"His method of analysis was to find the Nash equilibrium point of a two-stage game; in the first state the players locate themselves, in the second they choose prices". [16]

In 1933, Walter Christaller attempted to describe the location of the villages, town and cities of southern Germany. This work became the foundation of Central Place Theory. Christaller assumed that "given an unbounded fertile farming region, certain systematic and geometrical arrangement of retail centers would occur." He viewed the purchase of goods from retail centers as based on several properties. First, all goods have a range, which is the farthest distance that consumers are willing to travel to make a purchase. In the example of an expensive item that is purchased infrequently, e.g., refrigerator, the consumer is more likely willing to travel a greater distance for such a

[16] K. J. Arrow and E. L. Lehmann. Harold Hotelling 1895-1973: A Biographical Memoir. Published by the National Academies Press. Washington. DC. Volume 87, 5

purchase. In contrast, consumers are less likely to travel that far to purchase a low-cost item frequently needed, such as, bread.

Christaller also introduced the concept of threshold. The “threshold is the distance from a center at which the demand for a good is large enough to satisfy the requirements for a vendor to remain in business”. [17] “It is simple to see if the threshold of a good exceed the range of the good, at a given location, then that location is not profitable for offering that good. Christaller assumed that each customer would travel to the closest retail center offering the good of interest, as retailers of a given type were considered to be equal in all ways. He reasoned that excess profits occurred when the market range exceeded the threshold” [18] Christaller postulated that the ideal arrangements of centers offering the lowest ordered good would be points on a triangular lattice, carving out hexagonal market areas, where each customer buys a product at the closest center or village. The next highest center or town would be located among a subset of the lowest ordered centers. “Thus, he argued that a hierarchical arrangement existed where high ordered centers or city offer all goods that are offered by lower ordered centers. Each of higher ordered centers, therefore, formed hexagonal shaped market areas”. [19]

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[17] Christaller, Walter. Central Places in Southern Germany. Tranlation by C. W. Baskin. Englewood Cliffs, New Jersey. Prentice Hall. 1966

[18] Ibid 7

[19] Ibid, 2

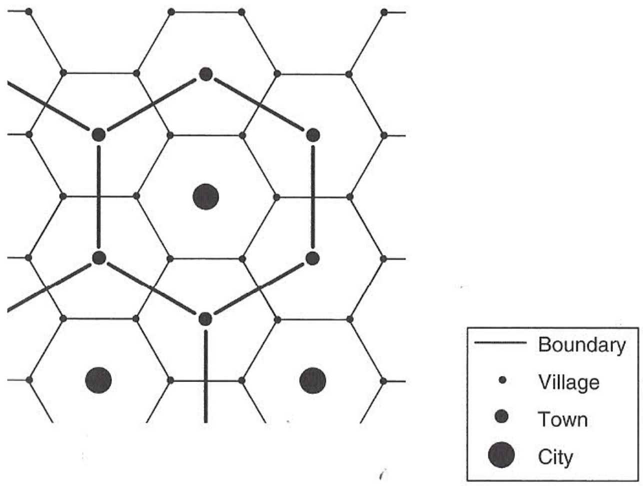

Figure 1. 2 Christaller's central place hierarchy

In the United States, the post-World War II years witnessed major changes in retail location patterns. A growing population, rising income levels, and the emergence of the suburbs presented retailers with new challenges. Department stores, mass merchandisers and supermarkets expanded rapidly, spreading from the central cities into shopping centers and free standing location in the suburbs. The rapid increase of outlets raised new concerns and gave rise to the need for a more systematic approach to location analysis. Checklists that were mostly oriented toward evaluating characteristics of urban sites were no longer adequate. Many retail firms sought the assistance of store-location analysts and a large or number of them opened in house location analysis departments around this time. "In Britain, during this same period, local governments, which played a much more active role in retail trade than in the U.S. counterparts, were instrumental in making formal location analysis studies an integral part of store location plans. A number of major studies on inter and intra-metropolitan spatial structures of retailing were initiated by the local agencies entrusted with overseeing the expansion of retail centers."[20] All in all, Weber, von Thunen, Hotelling and Christaller laid the basis for diverse areas of location research, retail competition, spatial layout and industrial location.

The first interaction models were gravity models, which assumed analogies between human behavior and Newtonian gravity laws. The basic gravity formulation - in which the movement of individuals between points is inversely proportional to the distance separating them - was applied by Converse in 1949 and Reilly in 1931 to analyze retail market areas. Later Huff (1964) [21] proposed an alternative model to overcome certain limitations of the Reilly-type approach. It turn out that there are many different spatial interactions models, but the underlying feature is that proximity or distance is a fundamental determinant of whether an individual (or area) will be a customer of a particular store.

It is only in the 1960s and 1970s when location modeling entered the period of coming to age. With the availability of computers power for processing and analyzing large amount of data, location science was able to address more complex scenarios. During this period, research focused on the geometrical arrangements reminiscent of Christaller's Central Place Hierarchy Theory, with locational analysis mainly devoted to

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[20] Ibid 11.

[21] Suárez-Vega Rafael, Santos-Peñate Dolores R., Dorta-González Pablo, Rodríguez-Díaz Manuel. A multi-criteria GIS based procedure to solve a network competitive location problem. Applied Geography, Volume 31, Issue 1, January 2011, Pages 282-291

the study of the: "classical p-median, p-centre, location-covering, simple plant location and quadratic assignment problems and their extensions. The discipline of regional science also took shape during this time, blending together location theory, economics and regional development. The leading proponents were Isard (1969) and Cooper (1963, 1964) who extended Weber's single-facility problem to address the allocation problem for multiple facility locations." [22] Maranzana (1964)[23] then moved the problem from continuous space to networks. In the 1970s, Toregas (1971)[24] formulated covering or coverage models. Coverage models provide a solution method for the location of facilities for emergency services to find the minimum number of points that cover all other network nodes within a specified distance. Church and ReVelle (1974) took the coverage problem an important step further to find the optimal locations for a given number of facilities, by maximizing the population covered within a specified service distance.

The problem of forecasting future sales becomes available at the same time. Examples are: Gibson and Pullen (1972) and Gonzales-Benito (2000) to name a few. This paper will give details on Huff model in chapter 2 to determine trade area and service area.

In the 1980s, the International Symposium on Location Decisions conference in Banff, Canada, brought together contributors from fields of operational

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[22] W. Isard. General Theory: Social, Political, Economic, and Regional, with Particular Reference to Decision-Making Analysis. MIT Press. Cambridge. Massachusetts. 1969.

[23] F.E. Maranzana. On the Location of Supply Points to Minimize Transport Cost. 261-270

[24] C. Toregas, R. Swain, C. ReVelle and L. Bergman. The Location of Emergency Service Facilities. 1363-1373

research, management science, economics, engineering and geography. This collaboration amongst different fields inspired the development of new models and applications for the theory of location. The availability of computers and machine readable data bases prompted the search for site selection methods that take advantage of the new tools.

A combination of location analysis with vehicle routing was also considered. It introduced the idea of minimizing the total travel time distance. Variations to this problem include whether a fleet of vehicles is homogeneous and whether there are multiple depots or a single depot to return to after delivering the merchandise.

In the analysis of location, demand is assumed to occur at nodes of a network. An interesting variation to this assumption is when demand is presented by flows of vehicles and pedestrian along transportation networks. For example, the main purpose of travel might be for reasons other than to obtain a service, such as commuting to work, yet the consumer might take advantage of the travel to seek an ATM machine, a gas station, or a drive thru hamburger place. This illustrates that many people may use a number of facilities during their commute to work which may include changes in their normal routes. When this class of problem presents, it is recommended to capture within the model the maximum amount of travelers, rather to utilize data related to minimal distances travelled. This type of consumer travel and purchase behavior requires modeling the probable travel origins and/or destinations.

The location and movement of vehicles within dynamically changing situations has led to another area of research. An example is the circulation pattern of an ambulance to be prepared for dispatch to serve potential patients, which refers to the shortest path problem on a network to reach a point.

In locating facilities that are considered environmental hazards, researchers have been concerned with both location of the facility and the determination of routes for disposal of harmful materials or substances. They have also developed models that take into consideration the location of noisy facilities, such as, airports. The public's desire for convenient connection of an airport to transportation routes must be weighed with the accompanying impacts of noise and pollution. In addition, the damage caused by hurricane Katrina and many other recent events of natural disasters have resulted in the implementation of an improved approach by the Federal Emergency and Management Administration (FEMA). This agency now uses a location-distribution model for disaster relief activities. FEMA has improved the location of sites for emergency centers and their services by adopting the following measures: locating the emergency center within areas of lower risk and re-location of medical staff from neighboring medical facilities.

In 1995, Verter and Dincer[25] reviewed models of production and distribution with a special focus on global supply chain management since global supply chain management has become a research topic of interest as multinational companies

[25] V. Verter and A. Dasci. The Plant Location and Flexible Technology Acquisition Problem. European Journal. 136. 366-382

seek to restructure and maximize efficiency of operations and transportation, which also takes into consideration account inventory levels and transportation costs.

Another trend relates to the logistics of consumer-to-supplier transactions. A typical example of the reverse flow of goods is the management of items returned by consumers for recycling. In these cases, the production networks are extended to take account of return flows from customers.

Location-allocation models provide an efficient, powerful technique for creating decision support systems for developing location strategies. Using the power of the computer, these models systematically evaluate a large number of potential store locations in order to find sites that maximize corporate goals such as market share or profits. In addition to determining optimal locations, the models simultaneously determine the allocation of consumers to the outlets, thus providing a basis for forecasting sales of individual outlets. While most early applications of location-allocation models dealt with public services, their use in retail site selection rapidly increased. The major advantage of location allocation models is their ability to systematically evaluate the impact of each store on the entire network of outlets in a market area. Most retail siting methods considered only the selection of single sites. In practice, however, retail chains locate several outlets in a market area either simultaneously or in sequence to achieve scale economies and market presence. The problem then is one of selecting store locations that optimize the performance of the firm’s network of outlets.

In conclusion, it is important to recognize that many location science problems must consider a realm of factors, including the need to characterize an application domain, complete with spatial data of road networks, population estimates, and demographic characteristics. It is through the modeling of this data that appropriate locations can be chosen for a range of uses, from retail stores to a biological reserve. Current locational research is reflected in its richness and complexity. There is a great interest and urgency to address locational problems such as: sustainable health facilities in developing countries, natural disaster planning, emergency response to man-made attacks, etc.

Indeed, applied geography has undergone remarkable changes in the last 20 years. Powerful new technologies have emerged that greatly improve the ability to collect, store, manage, view, analyze and utilize information regarding business location among other problems. These technologies include geographic information systems (GIS), global positioning systems (GPS), satellite base remote sensing and great variety of remarkable software. Geographic Information Science (GIScience) has given rise to an essentially multidisciplinary approach to applied problems. Likewise, as a recognition of this broadening field, the term GIScience is now being used to express many interests, not to the exclusion of GIS but in conjunction with GIS. This has stimulated a multidisciplinary approach to the solution of applied geographic problems. In fact, it is becoming more and more difficult for individual researchers to engage in a research project without some sort of interdisciplinary collaboration. For example, the solution of a facility location problem might require the cooperation of a modeler, GIS analysts in database management and graphics design, a remote sensing expert, an a spatial statistician.

For this reason, we can say that location theory from its early beginnings to the current period of new models and applications has greatly evolved, especially with the recent advances and availability of powerful computers, the access of data through web-based applications, and the access of researchers to more affordable GIS software. Both pure and applied location analysis have now converged into a more powerful location science that integrates location modeling with GIS. This location analysis which utilizes technological advances allows a variety of users from real estate developers to municipal planning agencies to draw upon sources of data to develop better approaches and location model representations. Thus, location science can help to minimize a variety of risks associated with the siting of varied uses, including financial and environmental risks, and maximize the benefits of location decisions and investments.

Chapter 2: Trade Area and Demographics

Retail forecasting includes several important components, including the delineation of the trade area. Trade area, also known as market area, is the geographical area containing customers or potential customers served by a business, service firm, or retailer. Modeling trade and service areas is an important task in making location decisions and is key to the success of any business. For example, in order to estimate the potential sales generation of a retail outlet, the spatial extent of the trade area must first be defined and subsequently one can determine the store's likely level of market penetration within that area. Information on residents and businesses within the trade area is valuable for a variety of applications including the following: obtaining a profile of potential customers, determining the spatial pattern of patronage, and planning advertising and sales promotion strategies. Thus, the trade area is a geographic area from which the store's sales originate. It is important to differentiate between a trade area and a service area. An attribute of a trade area is that customers generally travel to the business or store in order to seek the product or service. A service area can encompass the same geographic area as the trade area; however, the movement of commerce is that products and goods are delivered to customers within this area

The size of a retail trade area depends on a variety of factors. These factors include: facility type, size, and physical appeal of the facility the variety and price of merchandise and services offered; the characteristics of customers in the area; and the location of retail outlets of competing retail businesses. The size of a trade area for retail business may vary greatly even for a particular type of store. For example, the trade area size of a supermarket depends on whether the outlet is located in a rural or urban area. In highly urbanized areas, where consumers often walk to grocery stores and the level of competition is very high, supermarket trade areas may be less than a half-mile in radius. On the other hand, in rural areas, supermarket trade areas usually geographically extend much further, due to factors such as lower population density and fewer competing retail outlets. Trade areas of shopping centers are much larger in size than supermarket trade areas because in order to be profitable shopping centers must draw upon a larger consumer base. Due to the variety of products or services provided, consumers are willing to travel further to visit shopping centers. In general, the less frequently a good or service is purchased, the greater the distance consumers are willing to travel to buy it. Economic geographers refer to this distance as “range”[26] of a good or service. The range is a theoretical concept defining the maximum distance consumers are willing to travel to purchase a good or service. In the addition to the frequency of purchase, the range also depends on consumers’ incomes and their access to transportation. In general, the higher the level of consumer mobility, the greater is the range. The range of a good defines the maximum extent of the geographic trade area of a store selling that particular good. The distance that consumers actually travel may be less due to the availability of alternative sources of supply of that good. Consequently, the distance those consumers actually will travel to buy good decreases as the number of stores in the area offering that same good

[26] Ibid 7

increases. Competing retailers must consider several factors, including population density and consumer purchasing power, to determine the number of outlets that can be profitable within an area. Thus, the density of outlets in an area increases as the density of population and purchasing power rises. The geographic extend of the actual trade area of an outlet will tend to be smaller in highly populated areas, since consumers usually have more retail or service alternatives from which to choose.

After the type and nature of the retail operation has been appropriately identified and classified, the real estate developer and supporting staff then begin the market analysis for retail space by focusing on the geographic area from which customers are drawn to the retail site. The first step is to examine the physical and economic characteristics of the trade area in order "that proper boundaries can be ascertained as the constraints on satisfying demand can be identified."[27] The analyst needs to obtain economic, psychographic and demographic information about the population within the trade area, the extent of the good and services the population will demand, and lastly, what type of facilities and merchandising techniques are needed to capture and increase the demand.

Grant Thrall argues that there are two rules of thumb frequently used for deriving the geographic extent of a market area for a retailer: the radial distance approach and the drive time approach. Thrall explains in brief that the radial distance approach is

[27] Carn, Neil, Rabianski, Joseph, Racster, Ronald and Seldin, Mauri. Real Estate Market Analysis: Techniques and Applications. South-Western Thomson Learning. CT. 2001

an analytic tool that represents a trade area through a pattern of concentric circles inside other circles with varying radii in order to determine the location of customers relative to a primary trade area, using either ZIP code or census tract. The drive time approach builds off the radial distance method with driving times as the major determinant for locating a prospective store. The potential store location is thus selected based on distances that consumers must travel from home, work, school and other shopping venues. The drive time approach is a critical tool, not only for determining drive time from consumer homes, but also for "calculating drive time between existing stores within the chain to maximize the trade area's coverage".[28] Circular trade areas often do not take into account factors that influence consumer behavior, such as, transportation networks, or other factors that may influence population dispersion and customer geographic behavior, such as natural or manmade barriers, and political jurisdictions. Due to the model of a trade area as concentric rings, the geometry of an expanding radius for a circle may dictate that in order to include an additional percentage of customers located in one particular area, that an equal area will need to be added to the trade area in another direction; however, this does not accommodate for the irregular dispersion of consumers within a given retailer polygon shape. Therefore, Thrall believes that "retailers should use an irregular polygon shape approach that looks like an ameba as opposed to the

[28] Major David, Urban Retailing in North America: An Analysis of the Opportunities and Challenges for Superstore Retailers in Urban Markets. University of Washington, Seattle. 2008. 14.

traditional radial distance circles in the determination of trade areas."[29] Schmitz and Brett, in the book Real Estate Market Analysis, a case study approach, concur with this methodology. The authors state that "the most precise trade area definition will not be a uniform size or shape, nor will it extend equally in all directions. Yet, the analyst needs to take data availability and the cost of information collection into account when drawing a study area."

Although analysts have traditionally been forced to approximate market areas by using census tracts, zip codes, or county boundary because of data limitations, current geographic information systems technology and web mapping applications are providing greater options for market analysis to real estate decision makers. GIS is a combination of data, software, and geographic analysis that allows the creation of maps and sophisticated analysis. It has tremendous potential in business site location; it can be seen as a tool for managing, analyzing and visualizing geographic information. It help to identify where things happen or not, to explain what occurrences are associated with which places and reasons why, and then to use that knowledge for planning and management. With the proliferation and diversity of GIS applications it is not surprising that there are many definitions of GIS, each reflecting the distinction and perspective of different users' interests. Nevertheless, there is much shared ground and this leads to a commonly recognized view of GIS as a system of component tools used to capture, store, transform, analyze and display geographic data. Such tools are integrated into the off-the-

[29] Thrall, Grant. Business Geography and New Real Estate Market Analysis: Spatial Information Systems. England, Oxford University Press Inc. 2002. 88.

shelf desktop GIS software that includes ESRI's ArcGIS (www.esri.com), AutoDesk Map (www.autodesk.com), and MapInfo (www.mapinfo.com) among others. In addition to these commercial software, there are numerous free GIS software and open sources available such as GRASS GIS, Map-window (www.mapwindows.org), and Open Source GIS (www.opensourcegis.com).

The definition of GIS also raises the question: What are geographical data? Literally, these are data that describe processes, events or activities that take place on or near the surface of the earth in addition to where those processes, events or activities take place. The key characteristics of a geographic dataset are that it contains both attribute and location information. Attribute information is about the process, event or activity being measured. Location information is spatially related to the measured attribute or pertains to where the data was collected. There are several terms to describe the act of assigning location to attribute information, including georeferencing, geolocating and geocoding. Geocoding is the preferred term that I utilize as a GIS analyst.

Geocoding data, the act of assigning location to attribute data, is usually one of the first step towards the mapping and analysis of attribute information within a GIS.

GIS data can include a variety of attribute data, from real estate to population to transportation. Some specific examples of attribute data include: county property assessment files, geodemographics information, traffic volume counts and projections of absorption rates. Property assessment files include all of the properties characteristics used by property tax assessor to arrive at assessed values such as dimension of the parcel, current zoning designation, land value and improvements to the land value. Geodemographic information includes demographic census measures such as income, education, race, family composition, as well as, projections for the current and future year. Indeed, geodemographic "has come into use as a shorthand label for both the development and the application of area typologies neighborhood tapestry segmentation that has proved to be powerful discriminators of consumer behaviors and aid to market analysis. It is the analysis of people by where they live." [30] It is the suggestion that where you are, says something about who you are. Thus, that knowing where someone lives provides useful information about how that person lives. However, the relationship between places and people is neither one way nor solely the consequence of external factors. When people speak of their neighborhood or their community, they do so in a way that suggests an attachment to place." This implies that there is an interrelationship between people and places. Therefore, the physical, social and economic properties of an urban area in some way reflect the character, choices, preferences, ideals, affluence, and consumer lifestyles of past and present populations living in those settlements. They also are the consequence of governmental policies that control planning and housing. So there is a dynamic relationship between a resident population and its neighborhood. The style

[30] Harris Richard, Sleight Peter and Webber, Richard. Geodemographics, GIS and Neighborhood Targeting. John Wiley & Sons, Ltd. NJ. 2005

and character of urban area draws in certain population groups, perhaps by choice, perhaps by necessity. Those residents then further shape the evolution of the neighborhood. In conclusion, geodemographics is the analysis of people in relation to where they live. The knowledge of where people live, work and socialize is the location component. Data about what people do, where they live or work or socialize is the attribute information. The demand for Geodemographic data has led to a number of geographic data and software products that allow the analyst to differentiate a target population according to their neighborhood or specific urban area. Applications of these technologies can be pertain to diverse needs for data.

The U.S. Census Bureau provides the most important governmental data for demographic analysis due to its scope and the wealth of descriptive variables that are enumerated. Associated boundary information (census tract, census block group and census block) are produced to support and enable the collection of the census data, also facilitate subsequent analysis. Thus, the primary source of neighborhood information for the various GIS programs is typically the U.S. Census Bureau.

Big steps have been made to provide census data in easily accessible media, often with the specific intention of allowing the data to be effectively analyzed in a GIS.

In the United States, decennial censuses are taken every ten years to collect information about the people and housing. The 2010 Census asked ten of every person and housing unit in the United States. The information collected from this census included: age, Hispanic or Latino origin, household relationships, race, sex, tenure (whether the home is owned or rented), and vacancy characteristics. The following results from the 2010 Census are available in a number of datasets in American FactFinder at http://factfinder2.census.gov.

- 2010 Census Redistricting Data (Public Law 94-171) Summary File - used for congressional and state redistricting,
- 2010 Demographic Profile Data - 100-percent data asked of all people and about every housing unit 2010 Census Summary File 1 - counts and basic cross tabulations of information collected from all people and housing units,
- Summary File 2 (SF 2) - population and housing characteristics iterated for many detailed race and Hispanic or Latino categories, and American Indian and Alaska Native tribes - (to be released by April 2012).

Other decennial data sets include:

- 2010 Census Same-Sex Couple Households Summary File,
- American Indian and Alaska Native Summary File (AIANSF) - population and housing characteristics iterated for many detailed American Indian and Alaska Native tribes (released December 2012),
- Congressional District Summary File (to be released January 2013) and
- State Legislative District Summary File - (to be released June 2013).

The above information is available within a tables file format (excel, dbf, and csv). These data tables can then be joined to geographic units such as those utilized by the U.S. Census Bureau: census block, census block group or census tract. The data can subsequently be displayed in ArcMap for further analysis.

The U.S. Census Bureau changed the format and questions asked for the 2010 census of 2010 in contrast to the 2000 Census. All residents in 2010 were only asked ten questions whereas in previous years, a sample group had received a "long form" which had more detailed questions. ACS "is a nationwide survey designed to provide communities a fresh look at how they are changing. It is a critical element in the Census Bureau's decennial census program. The ACS collects information such as age, race, income, commute time to work, home value, veteran status, and other important data. ACS selects and collects information on about 3 million housing units. As with the 2010 decennial census, the information collected on individuals remains confidential."[31] Collecting data every year provides more up-to-date information throughout the decade about the U.S. population at the local community level.

The data collection method for the American Community Survey is through a survey of a sample population. Approximately three million housing unit addresses are selected annually, across every county in the nation. The collected data is then categorized at the following levels: national, state (including the District of Columbia), congressional districts, counties, and metropolitan and micropolitan statistical areas. The Puerto Rico Community Survey (PRCS) is the equivalent of the ACS for

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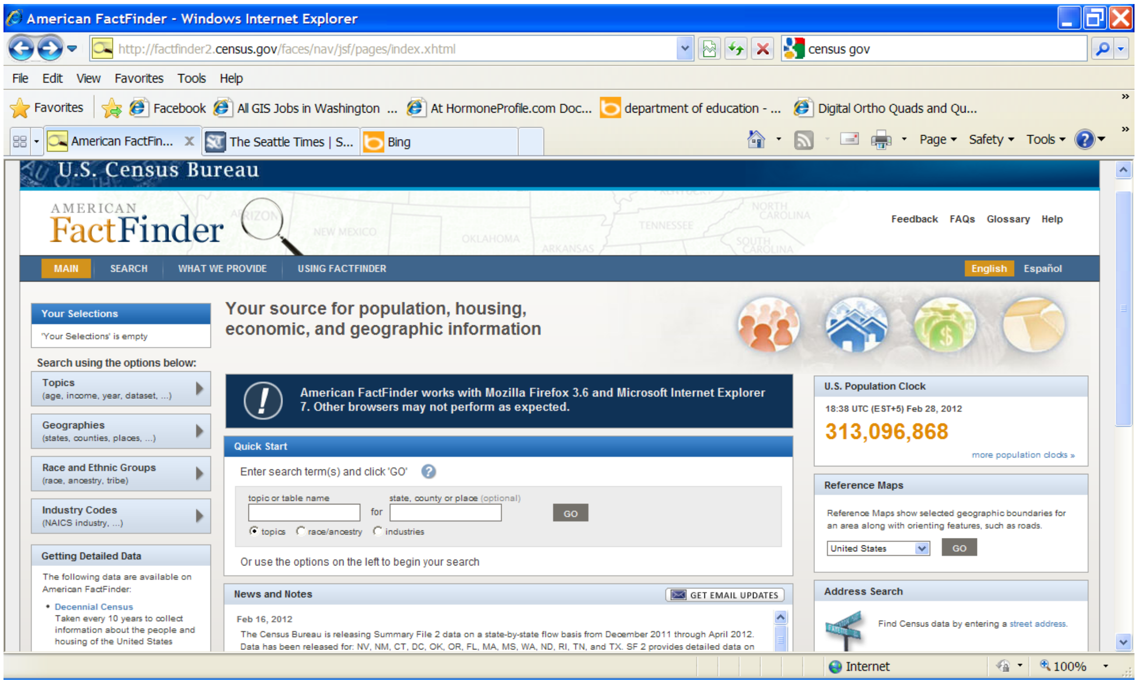
[31] US Census Bureau. American Community Survey. http://factfinder2.census.gov/faces/nav/jsf/pages/wc_acs.xhtml 2/1/2012

Puerto Rico, and began data collection in 2005. Data results from both the ACS and the PRCS are released together as a unified American Community Survey.

The new approach for delivering detailed demographic information in a timely fashion is through the American Community Survey (ACS) which is conducted annually, every three years or every five years. It depends on the total population size of the place. For geographic areas with larger populations, 65,000 or more, ACS produces annual estimates for all of the survey information. As mentioned previously, this information includes: age, race, income, commute time to work, home value, veteran status, and more. For geographic areas with smaller populations, between 20,000 and 64,999, the ACS produces estimates every three years. In 2010, the U.S. Census Bureau released the first estimates for smaller population areas which will subsequently be released every five years. These five-year estimates are based on ACS data collected from 2005 through 2009.

In 2006, the ACS made an important change to its data collection for population. The ACS sample was expanded to include the population living in group quarters. Group quarters include nursing homes, correctional facilities, military barracks, and college/university housing, and others.

As shown in figure 2.1, the U.S. Census Bureau provides a user friendly GIS portal that allows for the extraction of tables and displaying data on maps.



2.1 U.S. Census Bureau American FactFinder interface

The GIS portal of the U.S. Census Bureau attempts to provide information in a manner that is easy to access or extract, however, GIS users may still not find the information they are seeking or find it too cumbersome to locate or even to extract from their website. Consequently, and despite the progress in making census outputs available to users, obtaining, mapping and joining GIS data boundary files or even to other demographic data may still prove to be a time consuming process. To summarize, the census data themselves are not problem free. Complicating matters further, "the data can be in one of several different formats due to competing commercial offerings, and further non-commercial and governmental file types."[32] The task is made easier by GIS software from vendors such as ESRI or MapInfo. These software support the major formats directly, as well as, having the ability to import shapefiles from AutoCAD into ArcMap, and also join attributes collected and stored in an excel file format to a geographic unit with a common identifier. Another challenge to the manipulation and display of data involves projections, coordinate systems and even datum.

Due to such considerations and challenges noted above, commercial databases of census datasets have been intensely developed. These include population projections for non-census years, neighborhood tapestry segmentation, and consumer derived databases that describe the attributes of individuals or their household. This information is typically obtained from sources other than a census, including shopping surveys, share ownership data, consumer spending, unemployment data, etc. For example, the City of Renton used Claritas as a source for demographic data but then changed its source for demographic information, and now uses Business Analyst Online (BAO) from ESRI. As the GIS analyst for the City of Renton, it was important for me to show what were the advantages of utilizing BAO online over continuing with Claritas. Therefore, I researched ESRI methodology, especially how the data is collected and/or modeled. The features of BAO online are discussed below.

[32] Harris Richard, Sleight Peter and Webber, Richard. Geodemographics, GIS and Neighborhood Targeting. John Wiley & Sons, Ltd. NJ. 2005

The following graphics in figure 2.2 and 2.3 display the BAO interface. Figures 2.4 to 2.7 show how the web map application allows the user to set up preferences for functions such as the upload of your company or agency logo, or the receipt of the report in excel or pdf format to your email account.

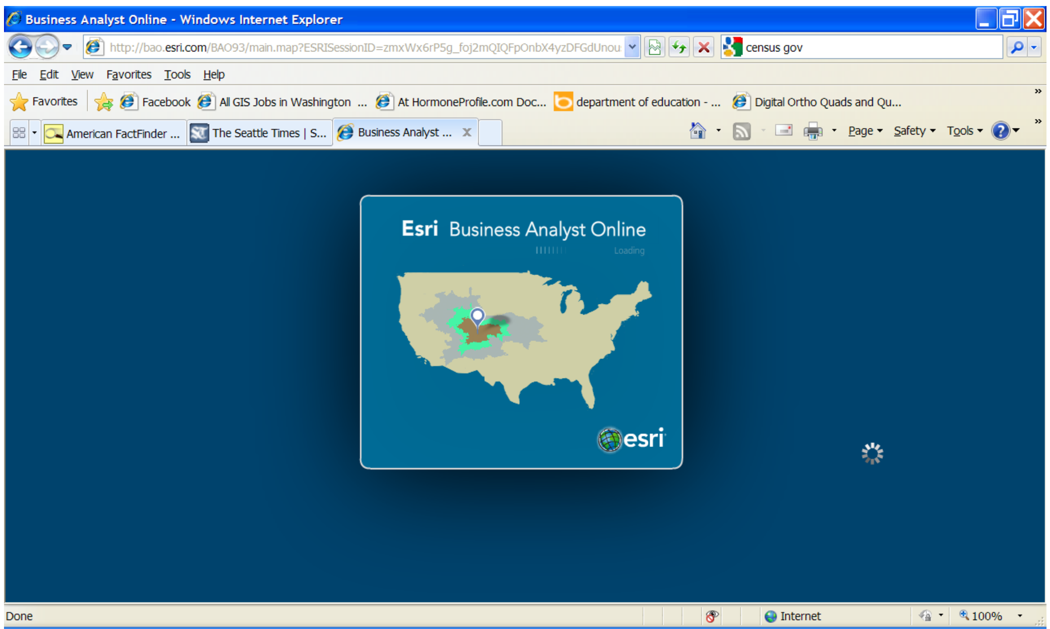


Figure 2.2 ESRI GIS portal to Business Analyst Online

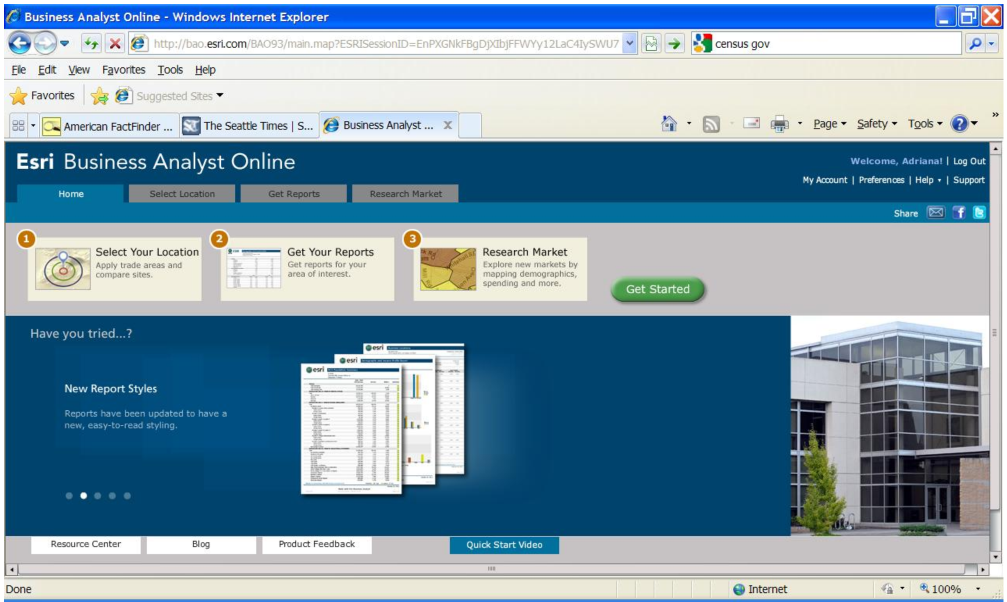


Figure 2.3 Business Analyst Online web map application with the display of the following tabs: home, select location, get report, and research market.

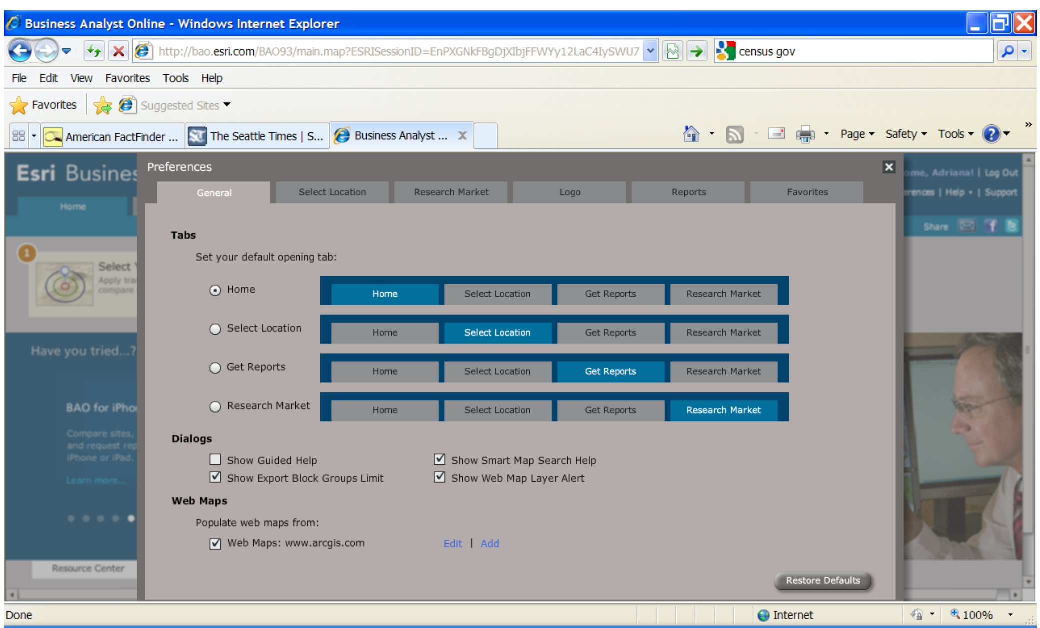


Figure 2.4 Set up general preferences

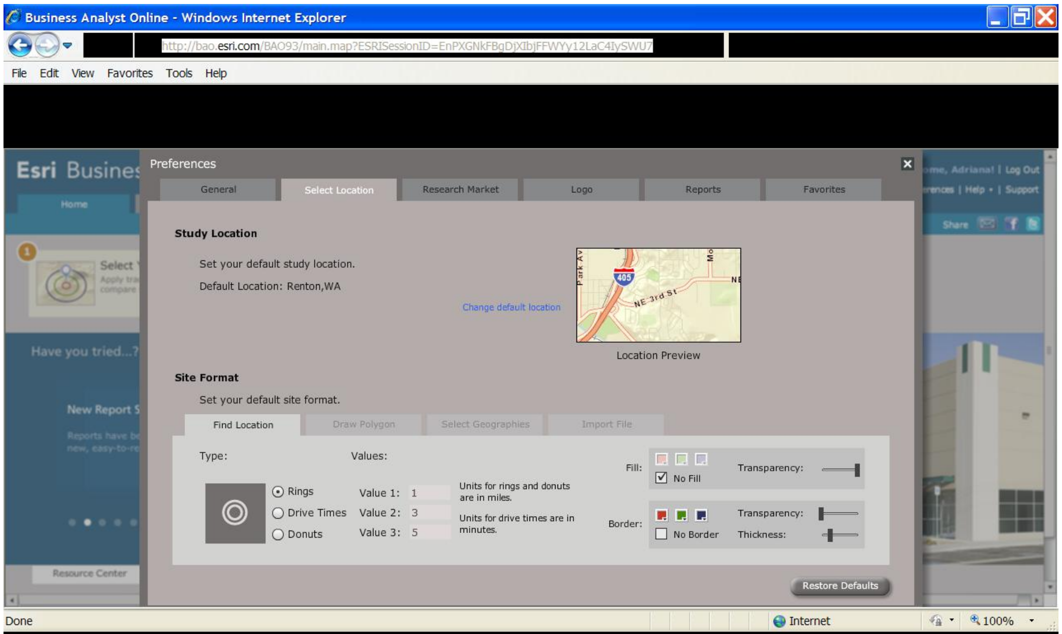


Figure 2.5 Set up select location preferences

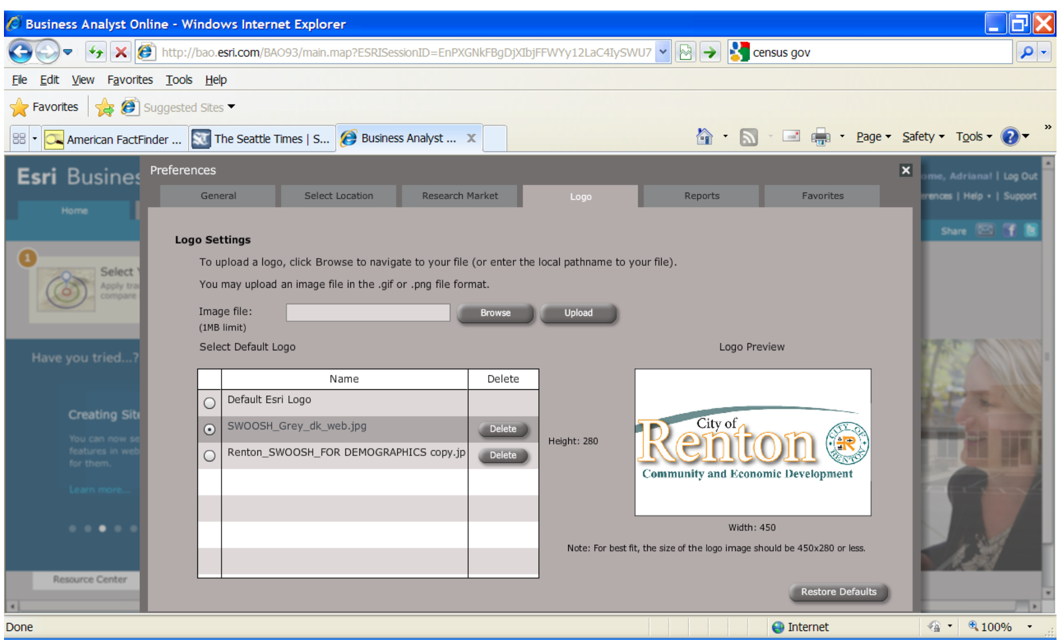


Figure 2.6 Set up and upload of your logo

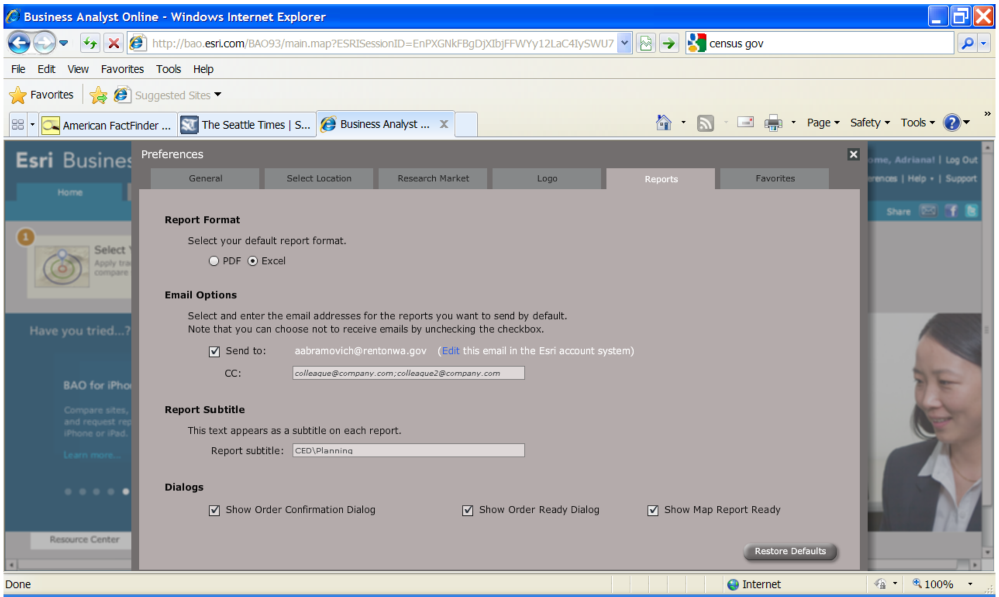


Figure 2.7 Set up report preference format (excel or pdf), email options and subtitles to appear in every report

Business Analyst Online (BAO) is a web-based solution that applies GIS technology to extensive demographic, consumer spending, and business data to deliver on-demand analysis, presentation-ready reports and maps. It is possible to select from a wide variety of existing reports or create custom reports to meet the user's marketing needs. Other features of BAO include analysis of current-year estimates and five-year projections of demographic data and extensive consumer spending and business data for the whole population of the United States. The program enables the user to generate reports and maps for study areas as granular as Census Block Groups, Census Tracts, or ZIP Codes. ESRI updates the data quarterly so that the GIS user has access to the most current and accurate data. Given that Business Analyst Online is hosted by ESRI, the subscriber need not to worry about data or technology updates because these are automatic. With Business Analyst Online, the analyst can identify trade areas, reveal untapped markets, evaluate sites as potential new store locations, and refine marketing messages

Below paragraphs show the recollection of facts applied into moving from Claritas to BAO.

In the case of population and household, ESRI methodology measures the current population in the United States by Census Block or Census Block Group**.** To model the annual change in number of households, ESRI utilizes three primary data sources:

- InfoBase database from Acxiom Corporation
- Residential delivery statistics from the U.S. Postal Service and
- Residential construction data from Hanley Wood Market Intelligence.

The U.S. Postal Service (USPS) publishes monthly counts of residential deliveries for every U.S. postal carrier route. This represents the most comprehensive and current information available for small geographic areas. USPS establishes carrier routes to enable efficient mail delivery. Carrier routes are redefined continually to incorporate real changes in the housing inventory and occupancy plus administrative changes in staffing and budgets of local post offices. The delivery statistics are later converted from postal carrier routes to census block groups. Due to overlaps, the delivery counts area is allocated across multiple block groups. It is possible to estimate the change in household numbers from the carrier route delivery statistic by linking carrier route to the census block groups.

Data on housing stock and occupancy is valuable for many applications, and often includes the following data: total housing units, occupancy, tenure, and home value. Total housing units are updated from the Census base by recorded changes in the housing inventory and estimated changes in occupancy rates since 1990, 2000 and 2010. Recorded change in the housing inventory is pulled from several data sources including: construction data from Hanley Wood Market Intelligence; building permits for permit issuing places and counties; Department of Housing and Urban Development data for new and demolished public housing and U.S. Census Bureau data for new manufactured homes placed by state. In Washington State, this information is collected by the Office of Financial Management from April to April.

To track new housing developments, ESRI gathers new and planned residential construction provided by Hanley Wood Market Intelligence. The database adds a unique component to the model strategy for producing accurate demographic forecasts. This database identifies individual construction projects, for instance, the exact location by latitude and longitude of a single-family home, townhome, or a condominium building. It also pinpoints the conversions of apartments into condominiums. The construction information includes:

- Total number of units planned.
- Inventory of units under construction, sold, and/or closed.

- Type of housing such as detached homes, townhomes, and condominiums.
- Target markets such as families, seniors, and empty nesters.

The database of new construction complements and corroborates the household numbers derived from the postal delivery statistics. More importantly, this information is incorporated into five-year forecasts for planned housing construction.

The data for tenure represents owner- and renter-occupied housing units. Together, these two components result in the sum total of households or total occupied housing units. Tenure forecasts is achieved utilizing a time series model based on data from the Housing Vacancy Survey from ACS then combined with the latest census data and with changes in housing occupancy obtained from the Current Population Survey from the U.S. Census Bureau. The model tracks the change in home values using the House Price Index (HPI) provided by the Office of Federal Housing Enterprise Oversight (OFHEO). Traditionally, OFHEO has combined loan data from purchases and refinancing to compute the House Price Index series which is released quarterly. . For refinanced loans, the appraised value of a home is used in lieu of the sales value to estimate the change in home prices. The model applies time series analysis to extrapolate housing data for both the short-term (current year) and long-range (five year forecast).

The employment tables display the civilian labor force and employed population by industry and occupation for the current the year and five year forecast. The civilian labor force includes the population aged 16 years and older who are classified as either employed or unemployed and excludes active duty Armed Forces personnel. The employed population includes persons who fit in either of the following two categories:

- Working during the reference week as a paid employee, self-employed, working on a farm, or as unpaid workers for 15 hours or more on a family farm or business.
- Temporarily absent from their job due to vacation, illness, bad weather, labor disputes, or other personal reasons, excluding layoffs. Total employment excludes volunteer workers and caretakers of home or family.

The unemployed population includes persons who were one of the following:

- Neither at work nor temporarily absent from a job.
- Seeking employment during the last four weeks.
- Available to accept employment.
- Waiting to return from a layoff.

BAO (Business Analyst Online) data also captures industry and occupation updates/temporal change from three federal statistical sources: the American Community Survey (ACS) () the Current Population Survey (CPS) () from the U.S. Census Bureau, and the Employment Projections program from the BLS (Bureau of Labor Statistics).[33] The updated data in national industry and occupation distributions are

[33] Bureau of Labor Statistics website at: http://www.bls.gov/lau/acsqa.htm 2/1/2012

derived from the three data sources listed above, thus providing evidence of trends at the national and state level.

To estimate income for all households the model takes into consideration data from several federal data sources including the Current Population Survey (CPS) and American Community Survey (ACS) personal and per capita income data, and the Census of Employment and Wages from the Bureau of Labor Statistics. The model correlates the characteristics of households at the geographical level of Census Block groups with data on changes in income levels. This stratification identifies several different patterns of change by household type that are then applied to forecast trends in income. Modeling links the current income change to all households with similar socioeconomic characteristics. Separate forecasts of the change in income by strata are aggregated to compose the income distributions.

Income data for households is obtained from the previous year, so 2011 income represents the income received in calendar year 2010. The model projection base is the income that was reported in Census 2010. Technically, 2010 income data represents income from 2009 because the U.S. Census Bureau tabulates income received in the last year before the decennial census. Similarly, the income for 2011 represents income received in 2010, expressed in 2010 dollars. Projections for 2015 are shown in 2014 dollars, assuming there will be a continuation of the current rate of inflation of 2.7 percent. Average and median income for 2010 and 2015 are calculated in the same way that the Census average and median income are computed. Medians are calculated from the distributions using linear or Pareto interpolation; averages, from aggregate household income.

After the base 2010 income tabulations are updated, the distributions are extended to provide additional data for the wealthiest households. The Pareto function is used to extend the upper interval of the income distributions from $200,000 or more to include the intervals $200,000–$249,999, $250,000–$499,999, and $500,000 or more. Finally, the results are calibrated to distinguish the changes in average household income. The same process is applied to median HH income.

A particularly useful feature of BAO is the availability of a Neighborhood Tapestry Segmentation system that classifies U.S. residential neighborhoods into 65 unique market segments based on socioeconomic and demographic characteristics. Tapestry Segmentation combines the traditional statistical methodology of cluster analysis with ESRI's latest data mining techniques to provide a robust and compelling segmentation of U.S. neighborhoods. The 65 market segments are combined to identify twelve life-mode summary groups based on lifestyle and life-stage and eleven urbanization summary groups based on geographic features and income. The Tapestry Segmentation Handbook offers complete details on each segment which includes preferences such as hobbies, cars, community involvement and purchasing preferences. ESRI's Tapestry Segmentation Area Profile compares the top tapestry segments in the study area, ranked by household percentage, to their national counterparts. The Community Tapestry is built on the ACORN (A Classification of Residential

Neighborhoods) system, a proven methodology that was introduced more than 20 years ago. "Tapestry combines cluster analysis, the traditional statistical methodology, with the latest data mining techniques to supply robust functionality for handling large amounts of Geodemographic data. Cluster analysis was also used to develop summary groups. Using the summary groups for analyses lets users work with fewer markets. By providing three methods—Life Mode, Urbanization, and Custom or Industry Specific—for dividing these 65 clusters into summary groups, Tapestry gives a broader view of U.S. neighborhoods."[34]

Understanding Summary Groups: The Life Mode method uses twelve summary groups based on lifestyle and life stage (figure 2.14). For example, as illustrated in the table below, Group L1–High Society consists of the seven most affluent clusters, whereas Group L5–Senior Styles includes the nine clusters with a high presence of seniors.

L1 High Society	**L7 High Hopes**
L2 Upscale Avenues	**L8 Global Roots**
L3 Metropolis	**L9 Family Portrait**
L4 Solo Acts	**L10 Traditional Living**
L5 Senior Styles	**L11 Factories & Farms**
L6 Scholars & Patriots	**L12 American Quilt**

Table 2.1 Life Mode summary groups

[34] Developing Community Trapestry. http://www.esri.com/news/arcuser/0104/tapestry.html 2/1/2012

The twelve summary groups used in the Urbanization method are based on geographic and physical features class and household income. These include population density, city size, location in or out of a metropolitan area, and inclusion in the economic and social center of a metropolitan area. For example, U1—Principal Urban Centers I, includes eight clusters that are concentrated in densely settled cities inside a major metropolitan area. Table 2.2 contains a list of the eleven summary groups defined in the Urbanization method. The notation 'I' or 'II' denotes relative affluence within the group.

U1 Principal Urban Centers I
U2 Principal Urban Centers II
U3 Metro Cities I
U4 Metro Cities II
U5 Urban Outskirts
U6 Urban Outskirts II
U7 Suburban Periphery I
U8 Suburban Periphery II
U9 Small Towns
U10 Rural I
U11 Rural II

Table 2.2 : Urbanization summary groups

The custom or industry specific method selects groups to provide a more focused application. Users can also define their own groups to capture the dynamics of

Tapestry for specific applications. For example, the 65 clusters could be grouped in rank order based on consumption rate from customer profiles and consumer surveys.

Why use clusters versus groups? Clusters will usually give users more differentiating power than summary groups. However, for analyzing a smaller number of markets, groups would be appropriate. Which grouping method to use depends on the application objective; for certain products or services, such as going to movies, the Urbanization method may more effectively distinguish consumption patterns than Life Mode groups. But for lifestyle or life stage related behavior, such as domestic travel, grouping by Life Mode would be more effective.

The generation of a neighborhood tapestry segmentation report with Business Analyst is relatively easy and takes very little time. There is an annual subscription cost; however, a user can pay for individual reports that are generated.

The steps for generating a neighborhood tapestry segmentation report are the following: select the location, choose the measure of distance of rings, donuts, or travel time followed by selecting the report from a list of prepackaged reports. The frames below show the steps of this process:

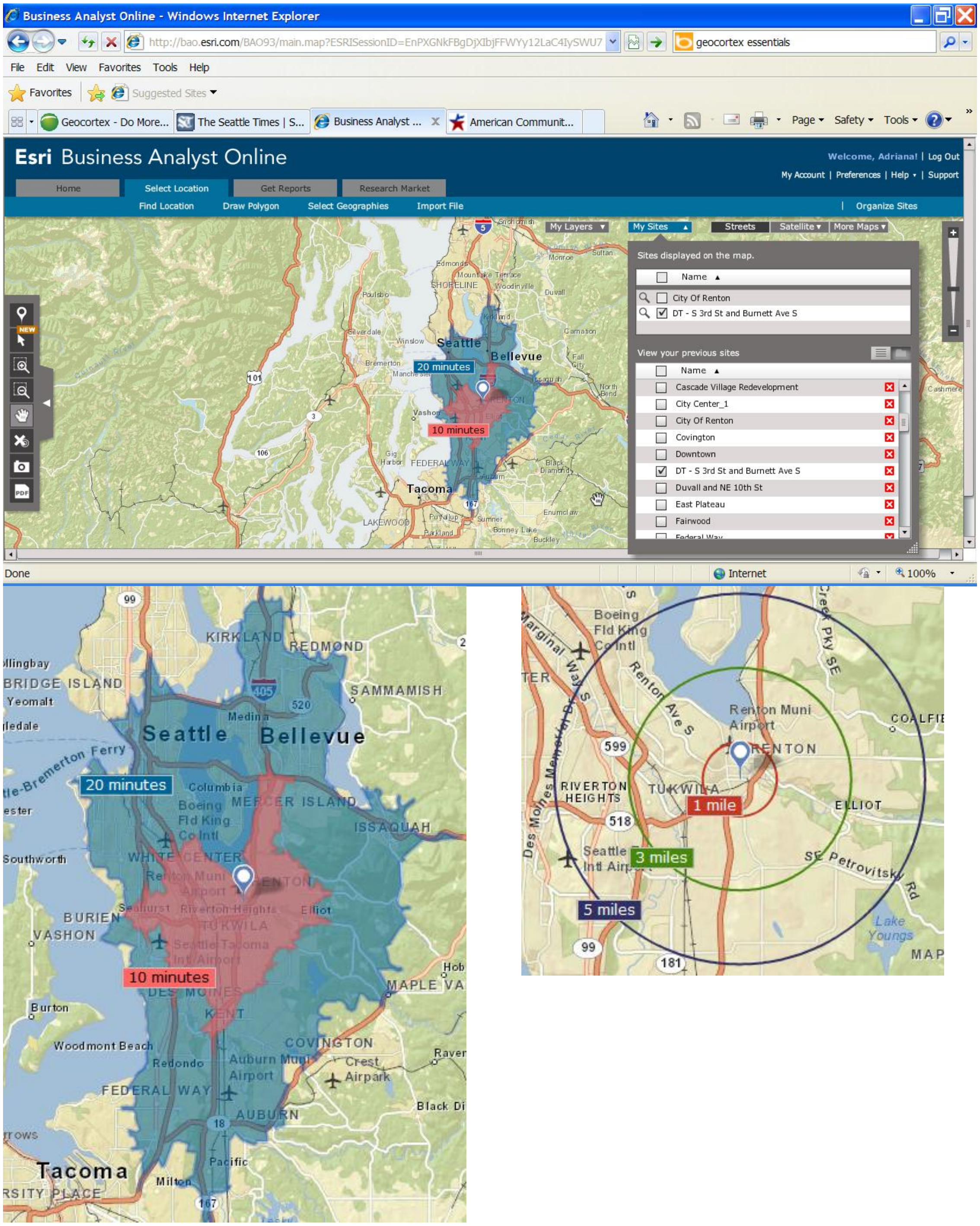


Figure 2.8 Select location and indicate concentric rings or driving time

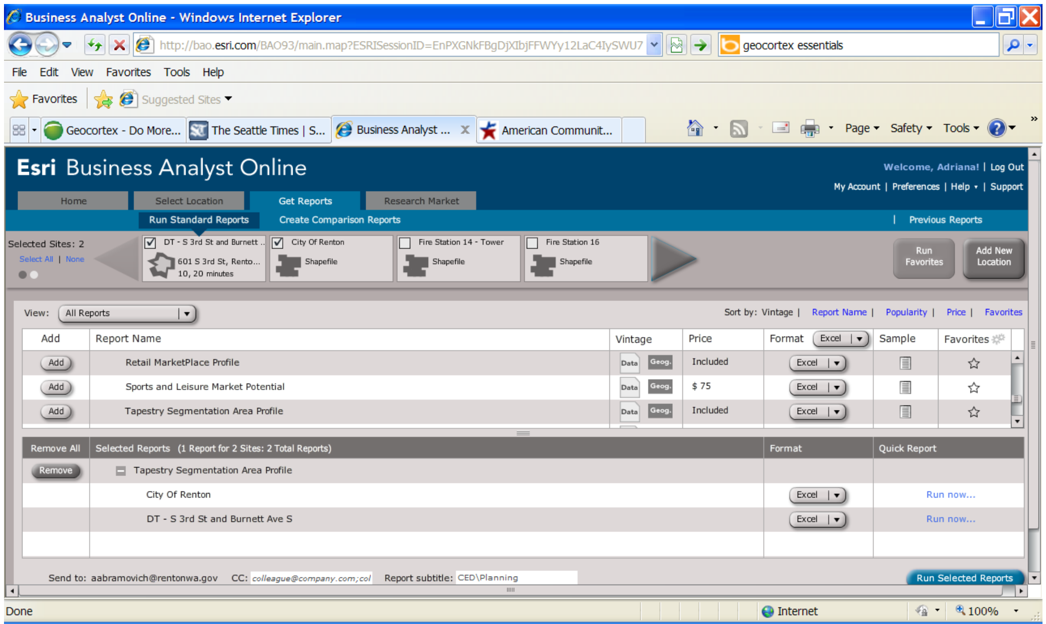


Figure 2.9 Select and run report

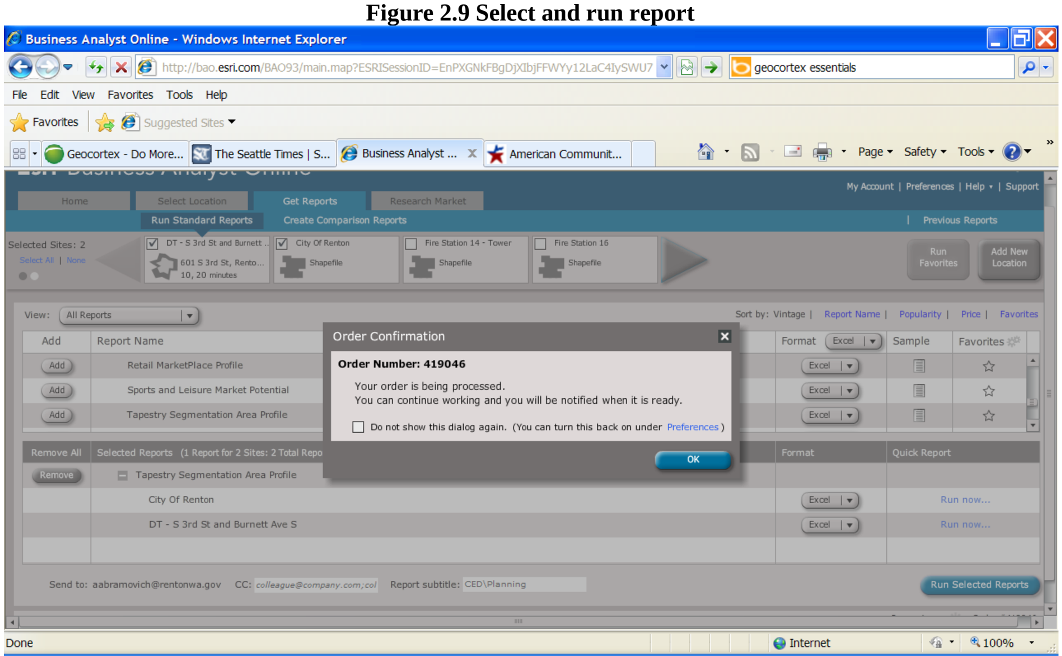


Figure 2.10 Await a few minutes, the order can be downloaded in excel or pdf file format

The tables below shows a neighborhood tapestry segmentation report measured driving time from the intersection of S. 3rd St and Burnett Ave S in downtown Renton,

A. It includes the top twenty tapestry segments in comparison with the national segments. s data is displayed in the following chart which displays the tapestry life mode groups and percentage of this life mode group within the neighborhood tapestry and the general U.S. ulation.

City of Renton
Community and Economic Development

Tapestry Segmentation Area Profile

DT - S 3rd St and Burnett Ave S
601 S 3rd St, Renton, WA 98057-2545
Drive Time: 10 minutes

Latitude: 47.47947
Longitude: -122.20918

Top Twenty Tapestry Segments

Tapestry descriptions can be her

		Households		U.S. Households		
			Cumulativ		Cumulative	
Rank	Tapestry Segment	Percent	Percent	Percent	Percent	Index
1	36. Old and Newcomers	12.5%	12.5%	1.9%	1.9%	643
2	24. Main Street, USA	11.2%	23.7%	2.6%	4.5%	434
3	28. Aspiring Young Families	9.1%	32.8%	2.4%	6.9%	384
4	39. Young and Restless	7.2%	39.9%	1.4%	8.3%	505
5	10. Pleasant-Ville	7.0%	47.0%	1.7%	10.0%	412
	Subtotal	**47.0%**		**10.0%**		
6	13. In Style	6.3%	53.2%	2.5%	12.5%	253
7	16. Enterprising Professionals	6.1%	59.3%	1.7%	14.2%	358
8	18. Cozy and Comfortable	6.1%	65.4%	2.8%	17.0%	215
9	52. Inner City Tenants	5.2%	70.6%	1.5%	18.5%	342
10	06. Sophisticated Squires	4.9%	75.4%	2.7%	21.3%	178
	Subtotal	**28.5%**		**11.3%**		
11	05. Wealthy Seaboard Suburbs	3.8%	79.2%	1.4%	22.6%	272
12	57. Simple Living	2.4%	81.5%	1.4%	24.0%	168
13	35. International Marketplace	2.1%	83.6%	1.3%	25.3%	162
14	17. Green Acres	2.1%	85.7%	3.2%	28.6%	64
15	12. Up and Coming Families	1.7%	87.4%	3.5%	32.1%	50
	Subtotal	**12.0%**		**10.8%**		
16	30. Retirement Communities	1.5%	89.0%	1.5%	33.5%	105
17	07. Exurbanites	1.4%	90.4%	2.5%	36.0%	56
18	14. Prosperous Empty Nesters	1.2%	91.6%	1.8%	37.9%	66
19	09. Urban Chic	1.1%	92.7%	1.3%	39.2%	85
20	04. Boomburbs	0.8%	93.5%	2.3%	41.5%	34
	Subtotal	**6.1%**		**9.4%**		
	Total	**93.5%**		**41.5%**		**225**

Figure 2.11 Top 20 Tapestry Segments inside trade area measured as 10 minute drive from the intersection of 3rd St and Burnett Blvd S in Downtown Renton

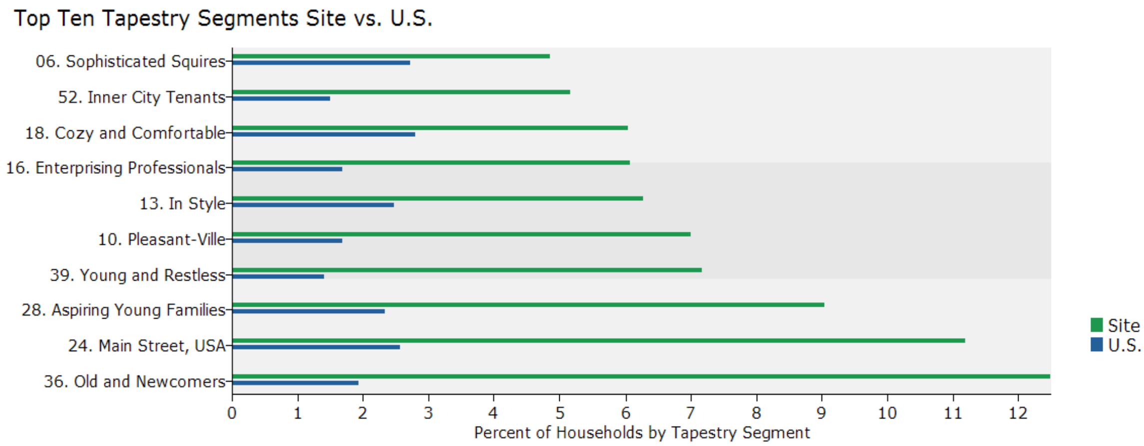


Figure 2.12 Chart showing percentage of households by tapestry segment inside 10 minute drive of a trade area measured from the intersection of 3rd St and Burnett Ave S in Downtown Renton

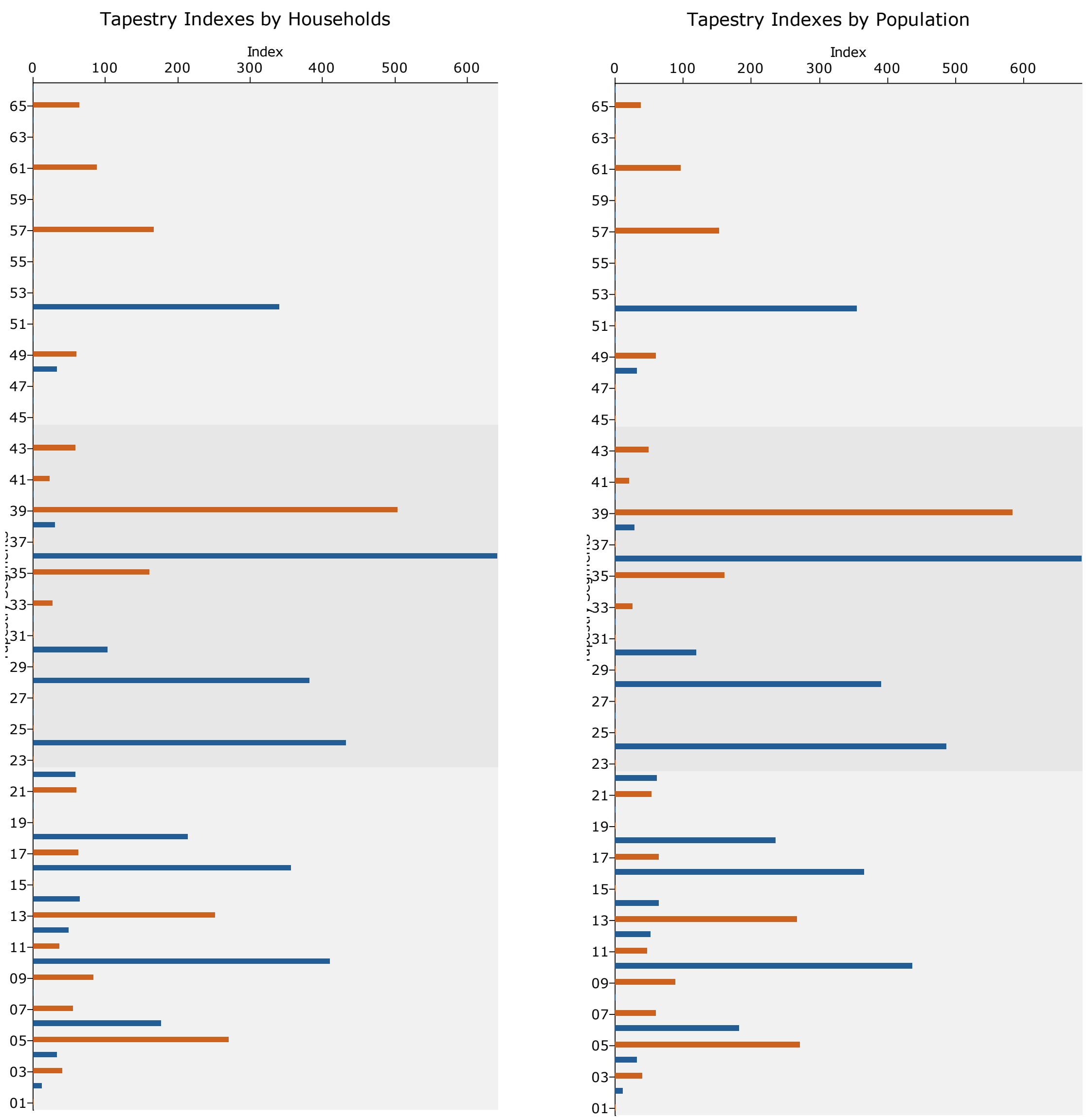


Figure 2.13 Tapestry index by household and by population. Y indicates tapestry segment measured inside 10 minute drive from the intersection of 3rd St and Burnett Blvd S in Downtown Renton

Tapestry LifeMode Groups	2010 Households		Index	2010 Population	
	Number	Percent		Number	Percent
Total:	86,905	100.0%		214,138	100.0%
L1. High Society	**10,094**	**11.6%**	**91**	**28,000**	**13.1%**
01 Top Rung	0	0.0%	0	0	0.0%
02 Suburban Splendor	197	0.2%	13	537	0.3%
03 Connoisseurs	510	0.6%	42	1,270	0.6%
04 Boomburbs	678	0.8%	34	1,925	0.9%
05 Wealthy Seaboard	3,263	3.8%	272	8,693	4.1%
06 Sophisticated Squires	4,223	4.9%	178	12,227	5.7%
07 Exurbanites	1,223	1.4%	56	3,348	1.6%
L2. Upscale Avenues	**25,088**	**28.9%**	**208**	64,338	30.0%
09 Urban Chic	983	1.1%	85	2,357	1.1%
10 Pleasant-Ville	6,091	7.0%	412	17,481	8.2%
11 Pacific Heights	205	0.2%	38	797	0.4%
13 In Style	5,466	6.3%	253	13,251	6.2%
16 Enterprising Professionals	5,285	6.1%	358	11,588	5.4%
17 Green Acres	1,798	2.1%	64	4,703	2.2%
18 Cozy and Comfortable	5,260	6.1%	215	14,161	6.6%
L3. Metropolis	**614**	**0.7%**	**13**	**1,339**	**0.6%**
20 City Lights	0	0.0%	0	0	0.0%
22 Metropolitans	614	0.7%	60	1,339	0.6%
45 City Strivers	0	0.0%	0	0	0.0%
51 Metro City Edge	0	0.0%	0	0	0.0%
54 Urban Rows	0	0.0%	0	0	0.0%
62 Modest Income Homes	0	0.0%	0	0	0.0%
L4. Solo Acts	**17,107**	**19.7%**	**289**	**35,778**	**16.7%**
08 Laptops and Lattes	0	0.0%	0	0	0.0%
23 Trendsetters	0	0.0%	0	0	0.0%
27 Metro Renters	0	0.0%	0	0	0.0%
36 Old and Newcomers	10,868	12.5%	643	22,167	10.4%
39 Young and Restless	6,239	7.2%	505	13,611	6.4%
L5. Senior Styles	**5,756**	**6.6%**	**54**	**11,293**	**5.3%**
14 Prosperous Empty Nesters	1,059	1.2%	66	2,385	1.1%
15 Silver and Gold	0	0.0%	0	0	0.0%
29 Rustbelt Retirees	0	0.0%	0	0	0.0%
30 Retirement Communities	1,321	1.5%	105	2,876	1.3%
43 The Elders	318	0.4%	60	433	0.2%
49 Senior Sun Seekers	644	0.7%	62	1,342	0.6%
50 Heartland Communities	0	0.0%	0	0	0.0%
57 Simple Living	2,047	2.4%	168	3,852	1.8%
65 Social Security Set	367	0.4%	65	405	0.2%
L6. Scholars & Patriots	**0**	**0.0%**	**0**	**0**	**0.0%**
40 Military Proximity	0	0.0%	0	0	0.0%
55 College Towns	0	0.0%	0	0	0.0%
63 Dorms to Diplomas	0	0.0%	0	0	0.0%

Data Note: This report identifies neighborhood segments in the area, and describes the socioeconomic quality of the immediate neighborhood. The index is a comparison o households or population in the area, by Tapestry segment, to the percent of households or population in the United States, by segment. An index of 100 is the US average.
Source: Esri

Tapestry LifeMode Groups	2010 Households			2010 Population	
	Number	Percent	Index	Number	Percent
Total:	86,905	100.0%		214,138	100.0%
L7. High Hopes	**8,384**	**9.6%**	**236**	**20,191**	**9.4%**
28 Aspiring Young Families	7,869	9.1%	384	19,050	8.9%
48 Great Expectations	515	0.6%	34	1,141	0.5%
L8. Global Roots	7,273	8.4%	102	19,095	**8.9%**
35 International Marketplace	1,828	2.1%	162	5,370	2.5%
38 Industrious Urban Fringe	425	0.5%	32	1,304	0.6%
44 Urban Melting Pot	0	0.0%	0	0	0.0%
47 Las Casas	0	0.0%	0	0	0.0%
52 Inner City Tenants	4,497	5.2%	342	10,878	5.1%
58 NeWest Residents	0	0.0%	0	0	0.0%
60 City Dimensions	0	0.0%	0	0	0.0%
61 High Rise Renters	523	0.6%	90	1,543	0.7%
L9. Family Portrait	**1,927**	**2.2%**	**28**	5,867	**2.7%**
12 Up and Coming Families	1,511	1.7%	50	4,520	2.1%
19 Milk and Cookies	0	0.0%	0	0	0.0%
21 Urban Villages	416	0.5%	62	1,347	0.6%
59 Southwestern Families	0	0.0%	0	0	0.0%
64 City Commons	0	0.0%	0	0	0.0%
L10. Traditional Living	**10,346**	**11.9%**	**137**	**27,502**	**12.8%**
24 Main Street, USA	9,738	11.2%	434	26,178	12.2%
32 Rustbelt Traditions	0	0.0%	0	0	0.0%
33 Midlife Junction	608	0.7%	28	1,324	0.6%
34 Family Foundations	0	0.0%	0	0	0.0%
L11. Factories & Farms	**0**	**0.0%**	**0**	**0**	**0.0%**
25 Salt of the Earth	0	0.0%	0	0	0.0%
37 Prairie Living	0	0.0%	0	0	0.0%
42 Southern Satellites	0	0.0%	0	0	0.0%
53 Home Town	0	0.0%	0	0	0.0%
56 Rural Bypasses	0	0.0%	0	0	0.0%
L12. American Quilt	**316**	**0.4%**	**4**	**735**	**0.3%**
26 Midland Crowd	0	0.0%	0	0	0.0%
31 Rural Resort Dwellers	0	0.0%	0	0	0.0%
41 Crossroads	316	0.4%	24	735	0.3%
46 Rooted Rural	0	0.0%	0	0	0.0%
66 Unclassified	0	0.0%	0	0	0.0%

Figure 2.14 Table showing tapestry life mode groups inside trade area measured as 10 minute drive from 3rd St and Burnett Blvd S in Downtown Renton

Businesses, government agencies, and nonprofit organizations use this information to better understand the markets they serve. Tapestry helps these organizations identify the best markets, discover how to reach them more effectively, and define the products and services preferred by consumers. An example is a retailer using neighborhood tapestry segmentation to discover the customer profile and shopping habits of consumers within a specific area. For instance, the retailer can then tailor sales promotions to fit each customer segment and their different shopping behavior, such as customers who prefer to shop online, those likely to respond to a customer loyalty promotion, and customers who always shop in the store.

A local government's homeland security department can utilize segmentation to determine the location of a community's vulnerable populations such as children under five years or the elderly in case of evacuation. Segmentation can also help local governments identify the types of existing community services such as child care so it is easy for employers to hire working mothers. Nonprofit organizations can use segmentation to profile current members, tailor targeted prospect messages, and define the services preferred by members. Reports generated for data needs such as these are available via Business Analyst Online at the following webpage: http://esri.bao.com

Trade areas portray different results if measured as 1-3-5 miles radii and compared to 10 and 20 minute-drive form the intersection of 3rd St and Burnett Ave S in downtown Renton (figure 2.15 and 2.16). Let’s take median household income as an example:

Median Household Income (Census 2010)		
1 mile	3 miles	5 miles
50,568	64,585	72,251

Median Household Income (Census 2010)	
10 minutes	20 minutes
65,373	69,682

Table 2.3 Comparing Median Household Income

If a company is aiming to sell a product for high income families, they might want to locate their business in a shopping area 5 miles or 20 minute drive from downtown Renton. If the company is catering to middle income families, they may want to stay inside the 1 mile radii from the same location.

City of Renton
Community and Economic Development

Market Profile

DT - S 3rd St and Burnett Ave S
601 S 3rd St, Renton, WA 98057-2545
Rings: 1, 3, 5 miles radii

CED\Planning
Latitude: 47.47947
Longitude: -122.20918

	1 mile	3 miles	5 miles
Population Summary			
2000 Total Population	10,049	85,909	206,724
2000 Group Quarters	126	413	1,035
2010 Total Population	10,937	96,662	234,299
2015 Total Population	11,573	102,876	250,031
2010-2015 Annual Rate	1.14%	1.25%	1.31%
Household Summary			
2000 Households	4,913	36,053	80,386
2000 Average Household Size	2.02	2.37	2.56
2010 Households	5,384	40,980	91,218
2010 Average Household Size	2.01	2.35	2.56
2015 Households	5,717	43,708	97,411
2015 Average Household Size	2.00	2.35	2.56
2010-2015 Annual Rate	1.21%	1.30%	1.32%
2000 Families	2,267	21,348	52,491
2000 Average Family Size	2.81	3.01	3.13
2010 Families	2,412	23,731	58,796
2010 Average Family Size	2.80	3.00	3.13
2015 Families	2,538	25,150	62,566
2015 Average Family Size	2.79	3.00	3.13
2010-2015 Annual Rate	1.02%	1.17%	1.25%
Housing Unit Summary			
2000 Housing Units	5,229	37,664	83,573
Owner Occupied Housing Units	30.4%	53.1%	60.3%
Renter Occupied Housing Units	63.8%	42.6%	35.8%
Vacant Housing Units	5.8%	4.3%	3.8%
2010 Housing Units	5,936	44,001	97,270
Owner Occupied Housing Units	31.1%	51.7%	58.5%
Renter Occupied Housing Units	59.6%	41.5%	35.3%
Vacant Housing Units	9.3%	6.9%	6.2%
2015 Housing Units	6,304	46,868	103,730
Owner Occupied Housing Units	31.9%	51.9%	58.9%
Renter Occupied Housing Units	58.8%	41.4%	35.0%
Vacant Housing Units	9.3%	6.7%	6.1%
Median Household Income			
2000	$36,337	$47,050	$51,079
2010	$50,568	$64,585	$72,251
2015	$60,742	$77,241	$83,405
Median Home Value			
2000	$155,766	$167,969	$181,442
2010	$228,205	$248,450	$275,132
2015	$288,636	$308,803	$341,594
Per Capita Income			
2000	$22,020	$23,820	$25,052
2010	$30,612	$32,349	$33,146
2015	$36,796	$37,526	$38,561
Median Age			
2000	35.6	34.9	35.4
2010	37.7	37.0	37.6
2015	37.7	37.0	37.8

Data Note: Household population includes persons not residing in group quarters. Average Household Size is the household population divided by total households. Persons in families include the householder and persons related to the householder by birth, marriage, or adoption. Per Capita Income represents the income received by all persons aged 15 years and over divided by the total population. Detail may not sum to totals due to rounding.

Source: U.S. Bureau of the Census, 2000 Census of Population and Housing. Esri forecasts for 2010 and 2015.

Figure 2.15 Market Profile 1-3-5 miles radii measured from the intersection of 3rd St and Burnett Blvd S in Downtown Renton

City of Renton
Community and Economic Development

Market Profile

DT - S 3rd St and Burnett Ave S
601 S 3rd St, Renton, WA 98057-2545
Drive Time: 10, 20 minutes

CED\Planning
Latitude: 47.47947
Longitude: -122.20918

	0 - 10 minutes	0 - 20 minutes
Population Summary		
2000 Total Population	191,002	981,752
2000 Group Quarters	1,009	21,400
2010 Total Population	214,139	1,088,521
2015 Total Population	227,676	1,151,671
2010-2015 Annual Rate	1.23%	1.13%
Household Summary		
2000 Households	77,461	407,648
2000 Average Household Size	2.45	2.36
2010 Households	86,905	455,096
2010 Average Household Size	2.45	2.34
2015 Households	92,457	483,203
2015 Average Household Size	2.45	2.33
2010-2015 Annual Rate	1.25%	1.21%
2000 Families	47,756	233,197
2000 Average Family Size	3.07	3.04
2010 Families	52,852	254,312
2010 Average Family Size	3.07	3.04
2015 Families	56,024	267,997
2015 Average Family Size	3.07	3.04
2010-2015 Annual Rate	1.17%	1.05%
Housing Unit Summary		
2000 Housing Units	80,904	427,163
Owner Occupied Housing Units	54.0%	52.6%
Renter Occupied Housing Units	41.7%	42.8%
Vacant Housing Units	4.3%	4.6%
2010 Housing Units	93,298	491,537
Owner Occupied Housing Units	52.8%	50.4%
Renter Occupied Housing Units	40.4%	42.2%
Vacant Housing Units	6.9%	7.4%
2015 Housing Units	99,132	521,879
Owner Occupied Housing Units	53.2%	50.3%
Renter Occupied Housing Units	40.1%	42.3%
Vacant Housing Units	6.7%	7.4%
Median Household Income		
2000	$47,077	$49,635
2010	$65,373	$69,862
2015	$78,228	$82,945
Median Home Value		
2000	$172,623	$204,256
2010	$258,812	$319,600
2015	$322,023	$392,505
Per Capita Income		
2000	$23,830	$28,485
2010	$31,677	$37,108
2015	$36,850	$43,734
Median Age		
2000	35.0	35.5
2010	36.8	37.4
2015	36.8	37.5

Data Note: Household population includes persons not residing in group quarters. Average Household Size is the household population divided by total households. Persons in families include the householder and persons related to the householder by birth, marriage, or adoption. Per Capita Income represents the income received by all persons aged 15 years and over divided by the total population. Detail may not sum to totals due to rounding.

Source: U.S. Bureau of the Census, 2000 Census of Population and Housing. Esri forecasts for 2010 and 2015.

Figure 2.16 Market Profile 10 and 20 minute-drive measured from the intersection of 3rd St and Burnett Blvd S in Downtown Renton

Conclusion

Within this chapter, I have reviewed Trade Area theory and methods for identifying and delineating a trade area. I discussed the implications of two different approaches proposed by Grant Thrall of delineating the geographic extent of a market area: radial distance and drive time approach. This approach has many practical applications, including siting a new facility and determining market penetration.

Secondly, I introduced the terminology and concepts of geographic datasets which include attribute and location information. Geocoding is discussed as one of the tasks in the GIS analysis and mapping processes for assigning a location to attribute data. Also explained the importance of Geodemographics which is the process that relates people characteristics and behavior with the places they reside.

Given that GIS requires a variety of data in order to produce maps or demographic analysis, I cited various sources of data, with the principal source being the U.S. Census Bureau. I listed the types of information provided by the decennial census, and also the annual data available through the American Community Survey which samples three million households across the nation.

The process of collecting, managing and analyzing demographic information on urban areas can be time-consuming and difficult. Recognizing this situation and the market opportunity it presents, a number of GIS software and data vendors have begun offering more joined-up solutions, making the process of acquiring, handling and visualizing demographic data much easier.

I reviewed and discussed the benefits of Business Analyst Online (BAO), a GIS product from ESRI, which is a web-based solution that applies GIS technology to extensive demographic, consumer spending, and business data. This web map application utilizes geodemographics which is the analysis of people based on a statistical classification of the area in which they live. The geodemographics approach has been found by many to be a useful aid for guiding decision-making and the management of geographical information.

A common choice of data to define the similarity or difference in demographics between geographical areas is the national census statistics from the U.S. Census Bureau. Such classification has been bedrock of a rapidly growing industry that has its origins in urban geography and sociology. Present applications include survey design, retail planning, direct marketing, media analysis, as well as other strategic marketing, planning and decision-making by both the public and private sector.

I examined the usefulness of neighborhood tapestry segmentation.

Tapestry classification can be used to look for geographical patterns in various socio-economic, behavioral, outlook in life, attitude or consumer datasets. In summary, there are various options for seeking and utilizing attribute and location data. GIS analysis can be applied to a variety of scenarios. Within this chapter, I discussed the utility and process of GIS for site selection of a business. The site selection process must be trusted by both the business developers or managers and the GIS analyst working within an organization or municipality. Whichever method is preferred, using GIS has proved to be a superior method to manage the process of the site selection for the business world.

Chapter 3: Line Based Analysis

Introduction and Problem Definition

In the decision of where to locate a facility, it is important to consider transportation networks and other infrastructure, for instance, pipeline networks. The requirements for the facility may then be constrained to specific points or intersections, with few locations meeting the needs criteria of that particular new business.

Companies that seek to minimize their transportation costs are therefore very careful to build delivery centers in the right location. FedEx serves as a model of a business that strives for efficient transportation of goods while minimizing these costs. Their practice is to have regional warehouses that serve as distribution centers to collect and sort packages. The packages destined for delivery to customers in the east side of Seattle are received at the warehouse located in Issaquah while those packages destined for South King County are received at the warehouse located in Fife, thus, minimizing travel time and reducing costs.

Case Study: Development Regulations along Pipeline Corridor

When new development expands into areas with existing transmission pipelines, there is a need for regulations to minimize potential conflicts between pipelines and development. Federal and state regulations attempt to ensure pipeline safety by regulating the design, operation and maintenance of pipelines. However, local government has the authority to implement land use regulations to minimize the likelihood of accidental damage to pipelines from construction activities. Pipeline damage or failure could potentially result in the risk of injury to both general and vulnerable populations, as well as, to important emergency facilities. That is the case of Renton *docket 78-planning near pipelines* that required the GIS analyst to take into consideration the Municipal Research and Services Center of Washington (MRSC) model setback ordinance for a transmission pipeline. [35]

The application of the model required the acquisition of current data in a shapefile or feature class format followed by the geoprocessing of a 50-foot or 500 foot buffer setback measured from the edge of hazardous liquid, gas pipelines and most structures. For highly populated facilities - especially those with vulnerable populations, such as, schools, hospitals, arenas, day care centers, and emergency services - the analysis required the geoprocessing of a buffer of a 500-foot setback from the edge of the pipeline so the resulting change in the Municipal Code of the City of Renton balanced the need for public safety through promotion of careful development near pipelines to reduce the likelihood of damage to such facilities. The goal was also to avoid needlessly complicating development regulations or becoming too onerous for applicants seeking permits. Thus, these code changes fulfill MRSC requirements and protect public health, safety and welfare and are consistent with the Growth Management Act, King County planning policies, and the City of Renton Comprehensive Plan. Figure 3.1 below shows a map that features the 500-foot buffer measured from the pipeline network that intersects

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[35] Model Setback Ordinance for Transmission Pipelines. http://www.mrsc.org/subjects/pubsafe/pipesetbackord.aspx 1/6/2012

existing schools, and hospitals and thus indicates constraints for any future development along the pipeline path.

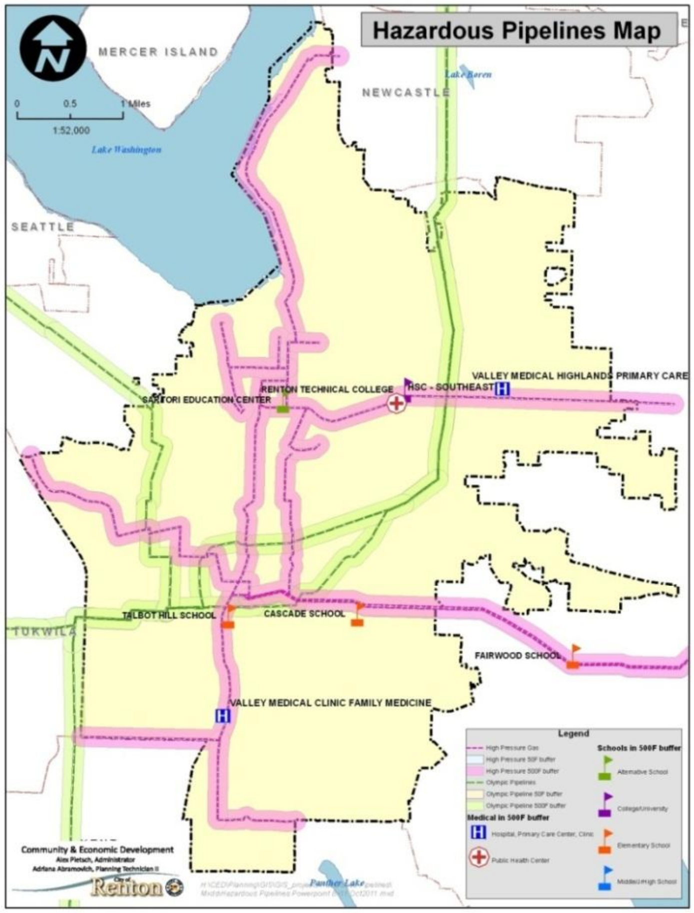


Figure 3.1 Docket #78 - Planning Near Hazardous Pipelines Map

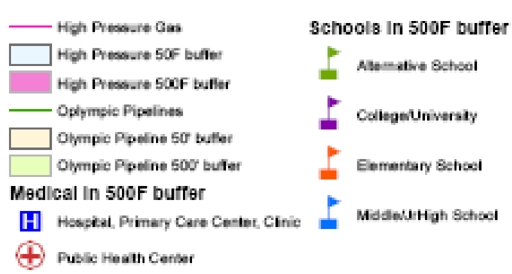


Figure 3.2 Legend Hazardous Pipeline Map

Case Study: Metro King County Proposed Rapid Ride Line F and Proposed Extension to the Landing in Renton

In line-based facility location, the emphasis might be on either a path or a corridor. In a technical sense, a path and a corridor can be viewed as representing different contexts from the perspective that a path suggest in many instances, the sitting of the facility on an existing network. Often this network is composed of streets and road segments and intersections. In contrast, a corridor is typically less confined and more open in terms of being able to be routed almost anywhere on the landscape in theory. Perhaps, a good characterization would be that a path oriented situation is likely restricted to a defined network, whereas a corridor application is likely continuous, capable to be directed throughout any part of a region.

The location selection for a linear-based facility must take into consideration various factors. An example of GIS analysis that takes into consideration associated data along a line is the selection of alternative routes for public transportation. Factors requiring consideration include: zoning restrictions, land use regulations, public population to be served along the route, and even natural obstacles such as rivers or cliffs. Locating the best transportation route often involves public participation, public review, and interaction of interest groups.

An illustration of choosing a network is the Metro King County proposal to add a new bus route known as Rapid Ride F Line to operate between Burien, SeaTac, Tukwila and Renton starting in fall 2013. King County Metro expects to place in service, “eye-catching red and yellow buses that will pull up and stop every 10 to 15 minutes, seven days a week which will generate a fastest and easiest line to travel. The stations will have electronic signs showing when the next bus will arrive and will allow ORCA card readers to pay before boarding the bus. Stations and stops will be placed where most riders gather, at easy walking distance. The buses will have low floor for easy boarding, free Wi-Fi, and security features. As buses approach intersections, they will send signals to traffic lights that will hold green lights longer or switch red lights to green faster to improve the time of the ride.”[36] Metro is considering several different routing options for the F line as it travels between Burien and Renton. The path between Burien and Tukwila train station has been set. However, after Rapid Ride F bus leaves Tukwila train station, there are three alternative routing options. A closer look to the inset shown as figure 3.5 depicts the three alternative routes from the Tukwila Station to South Renton Park and Ride. They are options A, B, and C. King County Metro has also proposed two alternative routes from the South Renton Park and Ride to the Landing shopping area across from the Boeing 737 plant. Figure 3.6 and 3.7 are showing the proposed extension to the Landing known as Option A–Landing and Option B-Landing. The three options from the Tukwila Station (A, B and C) combined with two proposed extensions to the Landing shopping area have generated six possible routes. The stops are yet to be determined and they will be based on the surveys to prospective bus-riders. Nonetheless,

[36] King County Metro website: http://www.kingcounty.gov/transportation/kcdot/MetroTransit/RapidRide/FLine.aspx 1/22/2012

consensus has been reached for the path between Burien and Tukwila and the Tukwila train station. During the decision process, King County Metro conducted online surveys in English and Spanish and an open-house at Renton City Hall on January 26, 2012. [37] The results of the public participation have not yet been made public. The decision-making team conjoined by King County Metro and Renton's transportation Division will assess the results from the survey as well as the GIS analysis results provided by the City of Renton Planning Division. One of the fundamentals for the Landing extension is the number of full-time employees that could be served along each alternative route.

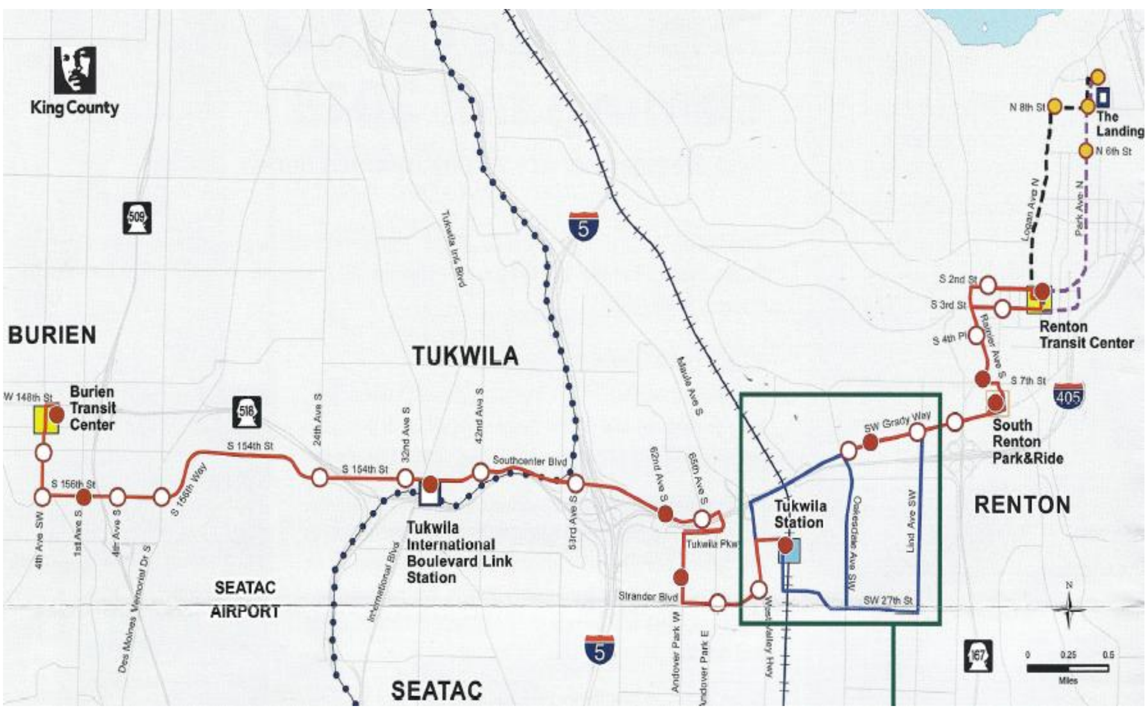


Figure 3.3 King County Metro Map – RapidRide F Line proposed routing and stops

[37] Public involvement, take an online survey. http://www.surveymk.com/s/RapidRideFLineRouting 1/22/2012

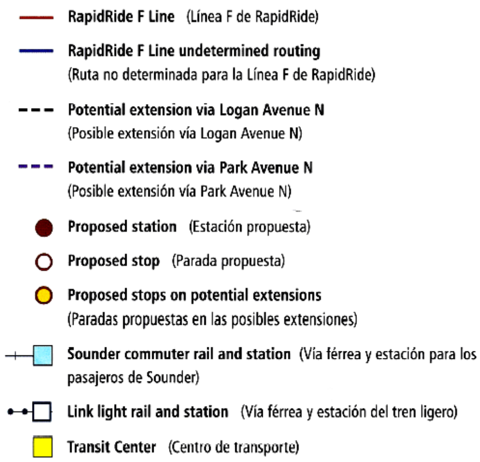


Figure 3.4 Map Legend

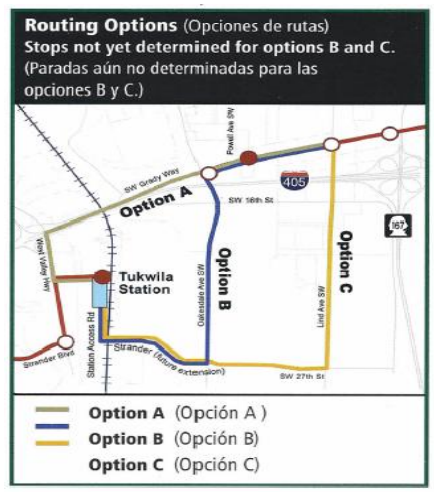


Figure 3.5 Routing Options A, B and C

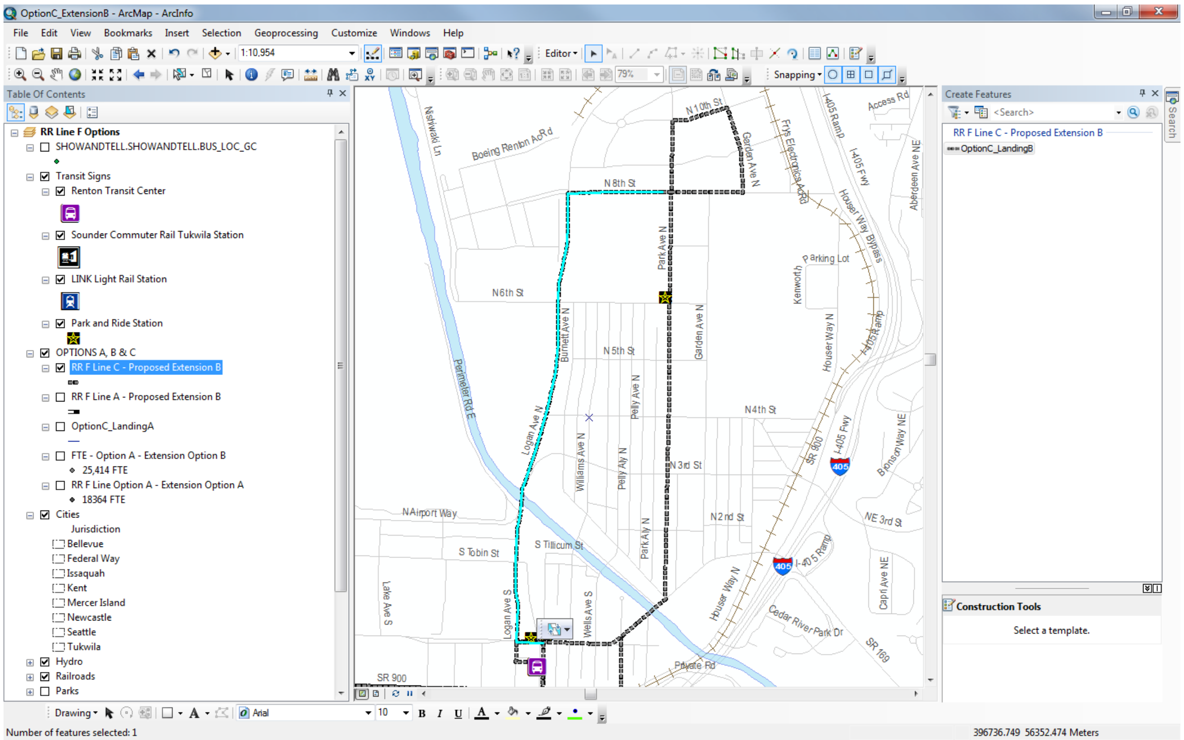


Figure 3.6 Proposed Extension Option A (along Logan Ave N) and Proposed Extension B (Along Park Ave)

Modeling Representation: GIS Analysis

In building the model to help the selection of the best route, the analyst used Model Builder. Model builder within the toolbox of ArcGIS Desktop Version 10, ESRI software, is an application that allows the creation, editing and management of models in order to evaluate different options. The model is then saved and repeated for analysis of each combination of routes.

The following describes the steps used to graphically depict the six alternative routing options for the King County Metro proposal for the Rapid Ride F line. The analyst mapped each route presented in figure 3.5 as options A, B and C with the two proposed routes to the Landing shopping area shown in figure 3.6. The two latter routes are designated as Landing A which passes along Logan Ave N and Landing B which runs along Park Ave. To build the GIS model, the analyst used the ESRI model builder tool described in the steps below. The final table shows the results of the analysis delivered to Metro King County and Renton's transportation division for further evaluation.

1. Merge the routing options (A, B and C) to the proposed extension options to the Landing shopping area (Extension A-Landing and Extension B-Landing).
    a. Option A merged to extension to the Landing A
    b. Option A merged to extension to the Landing B
    c. Option B merged to extension to the Landing A
    d. Option B merged to extension to the Landing B
    e. Option C merged to extension to the Landing A
    f. Option C merged to extension to the Landing B

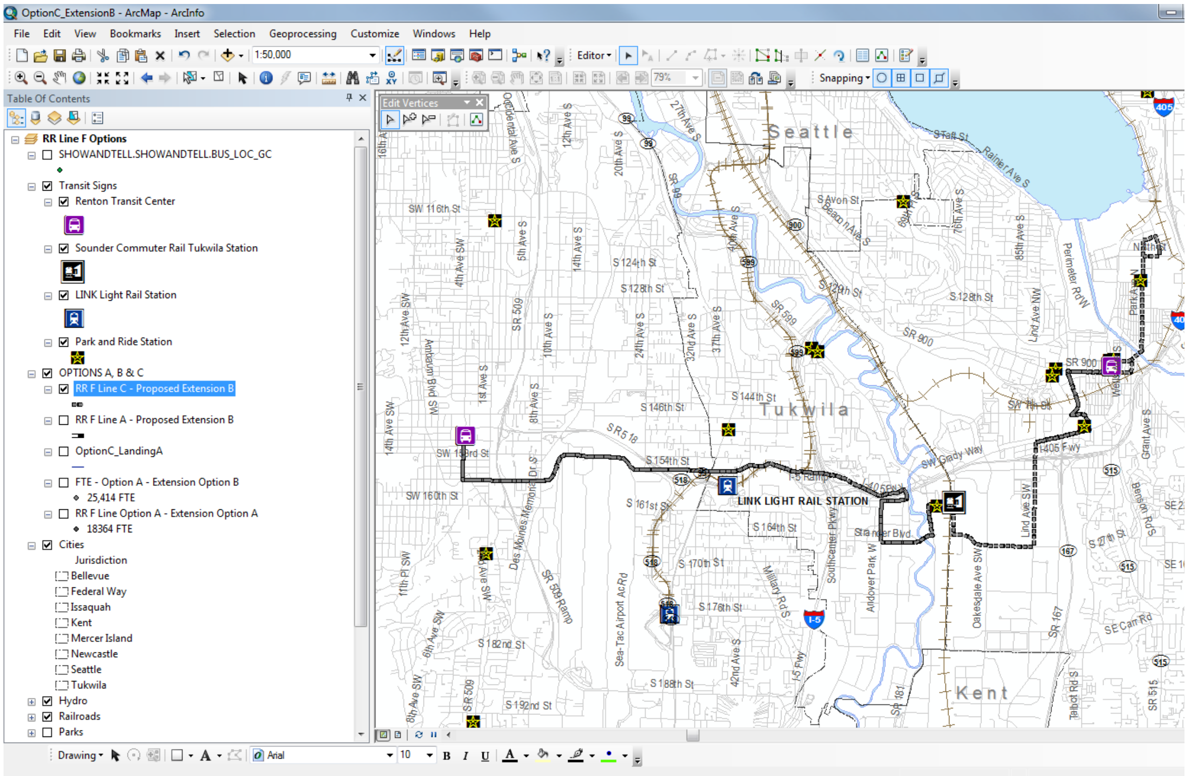


Fig 3.7 Feature class showing Option C to South Renton Park and Ride merged to Option B proposed extension to the Landing along Park Ave.

2. Use the geoprocessing tool to trace a 0.25 mile buffer for each itinerary.

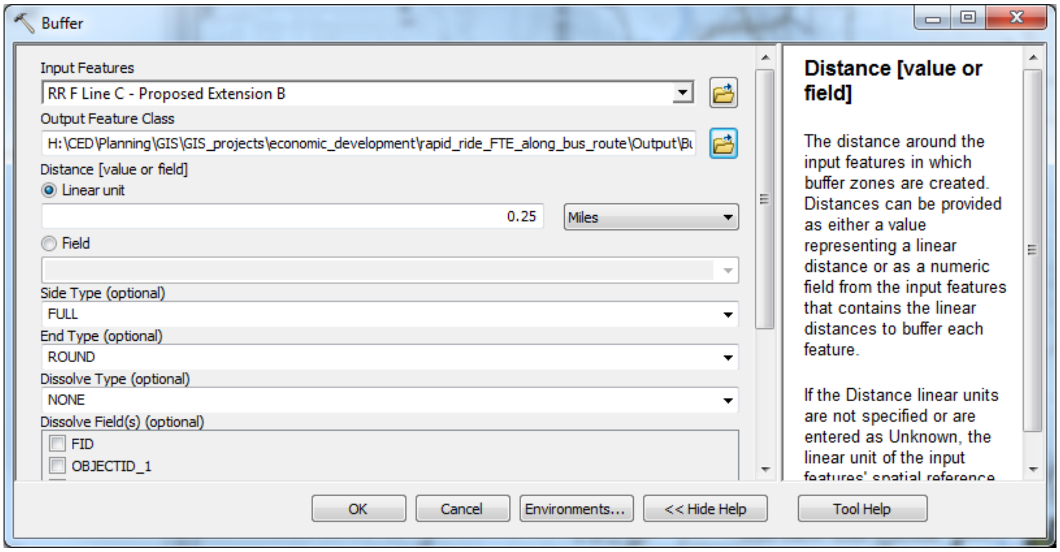
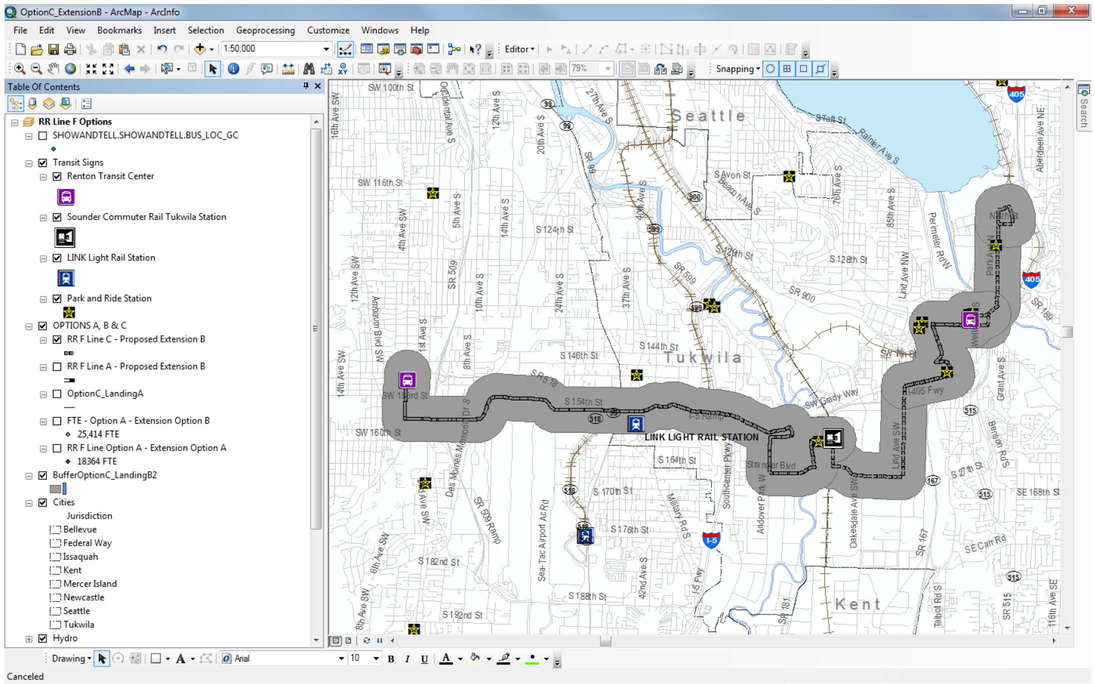


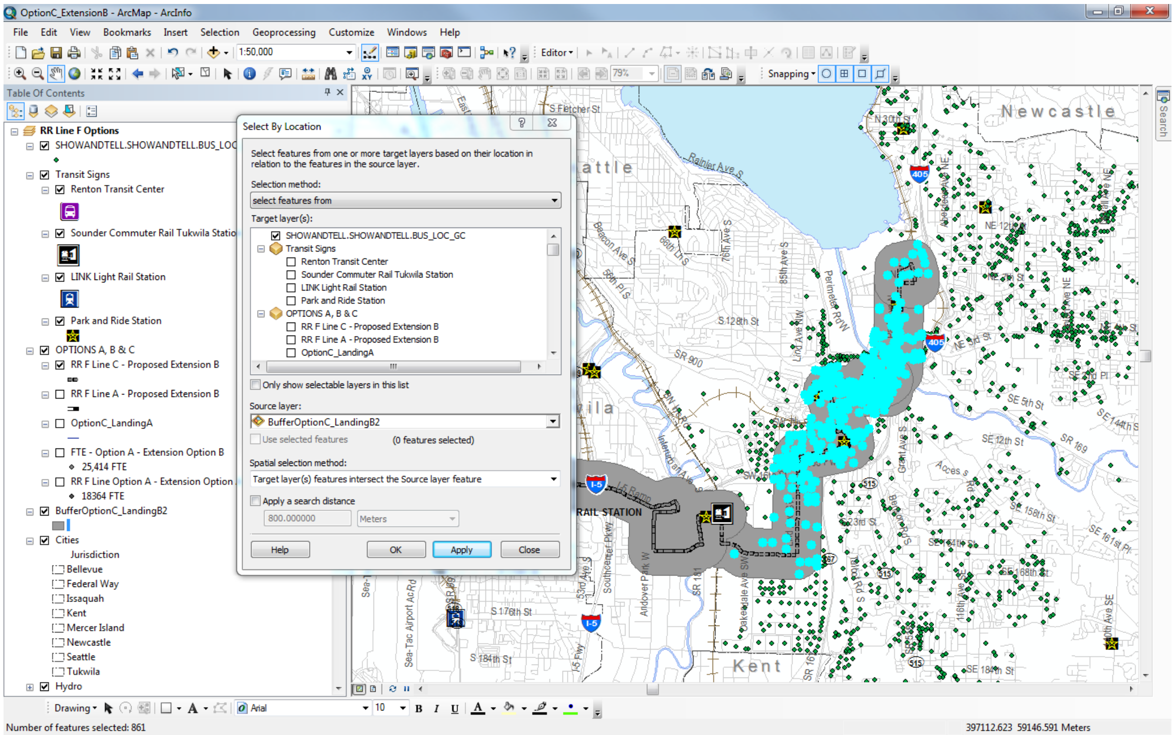
Figure 3.8 Snapshot of geoprocessing buffer tool with 0.25 mile distance

3. Add the 0.25 mile buffer to the map. Each route option depicts a slightly different buffer, because it measures the buffer from a different combination of routes. The following steps below show the graphic representation of the combination of Option C for the RapidRide F Line along with the proposed Extension B to the Landing.



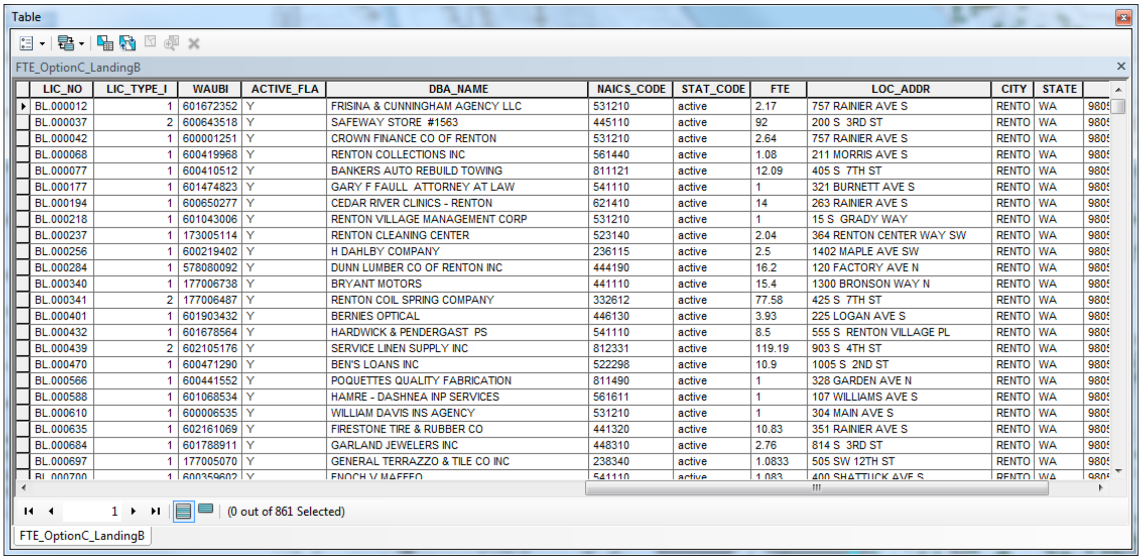
3.9 Screen snapshot showing extend of the buffer and location of light rail station, park and ride parking lots, and Tukwila train station

4. Select all of the business licenses within the boundary of the 0.25 mile buffer.



3.10 Screen snapshot showing the selection of Business Licenses inside the buffer

5. Export all of the selected businesses located inside of the buffer and save the output as a new feature class.

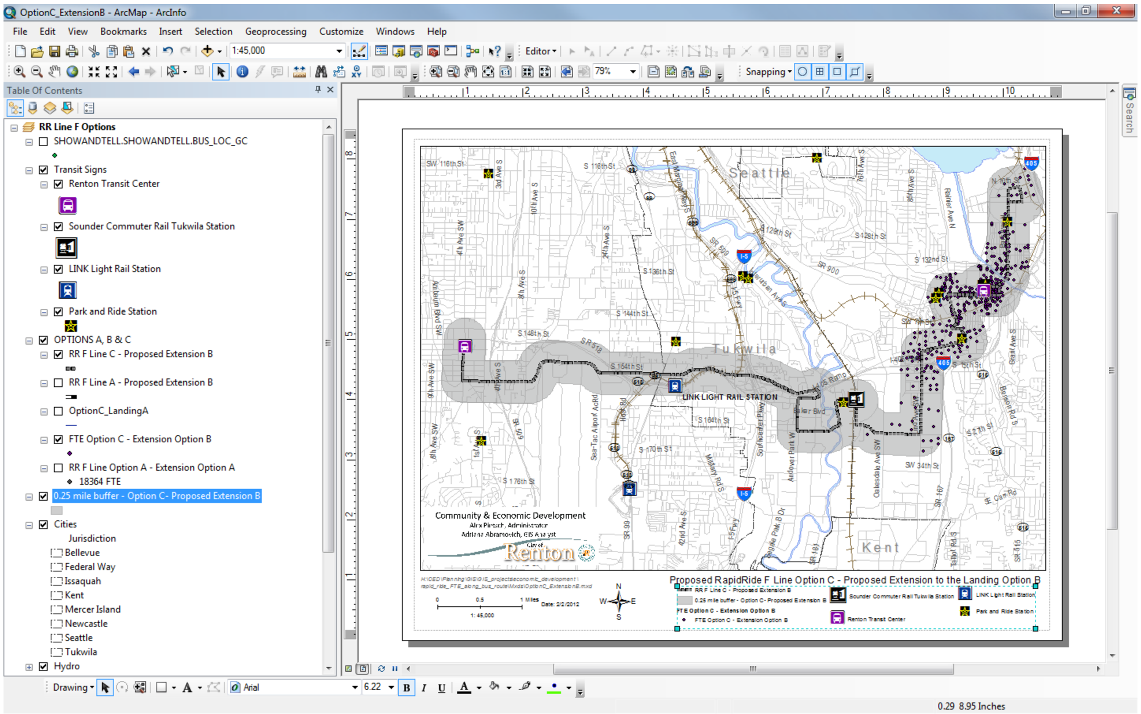


LIC_NO	LIC_TYPE_I	WAUBI	ACTIVE_FLA	DBA_NAME	NAICS_CODE	STAT_CODE	FTE	LOC_ADDR	CITY	STATE	
BL.000012	1	601672352	Y	FRISINA & CUNNINGHAM AGENCY LLC	531210	active	2.17	757 RAINIER AVE S	RENTO	WA	980
BL.000037	2	600643518	Y	SAFEWAY STORE #1563	445110	active	92	200 S 3RD ST	RENTO	WA	980
BL.000042	1	600001251	Y	CROWN FINANCE CO OF RENTON	531210	active	2.64	757 RAINIER AVE S	RENTO	WA	980
BL.000068	1	600419968	Y	RENTON COLLECTIONS INC	561440	active	1.08	211 MORRIS AVE S	RENTO	WA	980
BL.000077	1	600410512	Y	BANKERS AUTO REBUILD TOWING	811121	active	12.09	405 S 7TH ST	RENTO	WA	980
BL.000177	1	601474823	Y	GARY F FAULL ATTORNEY AT LAW	541110	active	1	321 BURNETT AVE S	RENTO	WA	980
BL.000194	1	600650277	Y	CEDAR RIVER CLINICS - RENTON	621410	active	14	263 RAINIER AVE S	RENTO	WA	980
BL.000218	1	601043006	Y	RENTON VILLAGE MANAGEMENT CORP	531210	active	1	15 S GRADY WAY	RENTO	WA	980
BL.000237	1	173005114	Y	RENTON CLEANING CENTER	523140	active	2.04	364 RENTON CENTER WAY SW	RENTO	WA	980
BL.000256	1	600219402	Y	H DAHLBY COMPANY	236115	active	2.5	1402 MAPLE AVE SW	RENTO	WA	980
BL.000284	1	578080092	Y	DUNN LUMBER CO OF RENTON INC	444190	active	16.2	120 FACTORY AVE N	RENTO	WA	980
BL.000340	1	177006738	Y	BRYANT MOTORS	441110	active	15.4	1300 BRONSON WAY N	RENTO	WA	980
BL.000341	2	177006487	Y	RENTON COIL SPRING COMPANY	332612	active	77.58	425 S 7TH ST	RENTO	WA	980
BL.000401	1	601903432	Y	BERNIES OPTICAL	446130	active	3.93	225 LOGAN AVE S	RENTO	WA	980
BL.000432	1	601678564	Y	HARDWICK & PENDERGAST PS	541110	active	8.5	555 S RENTON VILLAGE PL	RENTO	WA	980
BL.000439	2	602105176	Y	SERVICE LINEN SUPPLY INC	812331	active	119.19	903 S 4TH ST	RENTO	WA	980
BL.000470	1	600471290	Y	BEN'S LOANS INC	522298	active	10.9	1005 S 2ND ST	RENTO	WA	980
BL.000566	1	600441552	Y	POQUETTES QUALITY FABRICATION	811490	active	1	328 GARDEN AVE N	RENTO	WA	980
BL.000588	1	601068534	Y	HAMRE - DASHNEA INP SERVICES	561611	active	1	107 WILLIAMS AVE S	RENTO	WA	980
BL.000610	1	600006535	Y	WILLIAM DAVIS INS AGENCY	531210	active	1	304 MAIN AVE S	RENTO	WA	980
BL.000635	1	602161069	Y	FIRESTONE TIRE & RUBBER CO	441320	active	10.83	351 RAINIER AVE S	RENTO	WA	980
BL.000684	1	601788911	Y	GARLAND JEWELERS INC	448310	active	2.76	814 S 3RD ST	RENTO	WA	980
BL.000697	1	177005070	Y	GENERAL TERRAZZO & TILE CO INC	238340	active	1.0833	505 SW 12TH ST	RENTO	WA	980
BL.000700	1	600359602	Y	ENOCH V MAFFEO	541110	active	1.083	400 SHATTUCK AVE S	RENTO	WA	980

3.11 Table showing business name, national industry code, and total of full time employees (FTE) field per business license

6. Then look for the field that represents the total of full time employees per business license. Sum the total number of full time employees per routing option and save as a new output.

7. Add the database file to the table of content (left side of the screen) so that it appears on the map and within the map legend. Insert the legend to reflect the results and save the map as a pdf file.



3.12 Export final map as pdf file

The table below shows the projected ridership of full-time employees per route combination. Option C combined with extension B to the Landing shows the highest potential ridership of the six proposed route options.

OPTION	EXTENSION	NUMBER OF FULL TIME EMPLOYEES
Option A	Extension A	23.451
Option A	Extension B	25,414
Option B	Extension A	24,661
Option B	Extension B	25,866
Option C	Extension A	26,411
Option C	**Extension B**	**27,871**

Table 3.1 Table showing number of full time employees per combination of routes

GIS-Science

The two case examples presented in this chapter, the development restrictions along Renton pipeline network and the proposed RapidRide F line in the City of Renton, involve corridor routing which reflects the problem of continuous space siting. In *Location Analysis and GIS*, Church and Murray explain that "often the approach taken is to transform a problem from a field view of geographic space to a discrete, network representation." Consequently, "considerable work involves defining the network and deriving attributes associated with the network. GIS and associated functionality is essential in this process." [38] They also suggest that the selection of the best route or corridor can be accomplished by following below analytical steps:

1. Decide what data is the most meaningful in terms of routing, and collect the data for the analysis. Select the most appropriate GIS layers. The most meaningful components include gathering appropriate data to support the routing of the corridor with layers that can influence the outcome such as:
    i. Topography and Slopes (maybe the words 'slopes' is adequate, you choose)
    ii. Land use designation (residential, industrial, commercial)
    iii. Presence of significant buildings (historic buildings, hospitals or schools)

[38] Ibid 2, 167

iv. Environmental constraints, such as, designation of Type 1 conservation areas (for rivers, lakes, and some creeks) which indicate the presence of endangered species.

v. Transportation elements (existing roads, pipelines, transmission lines)

vi. Land ownership, geocoded addressed of business and/or taxpayers

2. Define a network of possible transitions across the landscape.

3. Utilize the appropriate model; to identify the route which meets the desired criteria, e.g., least vehicular impact, lowest cost, or serves the highest amount of employees along the corridor.

4. Analyze the data to compare the alternative routes or corridors.

All of the above steps are achievable with the extension ArcGIS Network Analyst built into to ESRI software. This extension facilitates the following mapping tasks to perform a network-based spatial analysis: routing, fleet routing, travel directions, closest facility, service area, and location-allocation. When using the ArcGIS Network Analyst extension, the analyst can dynamically model realistic network conditions, including one-way streets, turn restrictions, speed limits, and variable travel speeds based on traffic. Thus, an analyst can easily build networks from GIS data by using a sophisticated network data model."[39]

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[39] ESRI web page ArcGIS Network Analyst. Overview.
http://www.esri.com/software/arcgis/extensions/networkanalyst/index.html. 1/20/2012

The two examples detailed above did not require the use of this extension due to routes that had already been pre-established, for the pipeline location and the Metro King County bus routes. Nonetheless, the network analyst extension has valuable uses as shown in online demonstrations on the ESRI website at http://www.esri.com/software/arcgis/extensions/networkanalyst/key-features.html as well as in Chapter 5 of this paper. The website provides examples of how to use this extension for routing (multi-point routing, time window supported on stops and traveling salesperson), vehicle routing problems (time windows, driver breaks, vehicle capacities and order quantities as in FedEx delivery trucks), and service area [40] (in case of complex polygon generation or allocation across networks).

The GIS analyst can now benefit from the features and capabilities of the ArcGIS Network Analyst extension for analysis of network-based location allocation. Examples include the following abilities:

a.) discover the shortest and most efficient routes for a fleet of vehicles that travels to multiple destinations,

b.) establishment of time windows to schedule when vehicles should arrive to a location; and

c.) determine optimal locations for multiple facilities.

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[40] ArcGIS Network Analyst Key Features. Service Areas: View Demo http://www.esri.com/software/arcgis/extensions/networkanalyst/key-features.html. 01/13/2012

The analyst is thus able to y perform a location-allocation analysis and define service areas based on travel time or distance, create a network using existing GIS data, and generate a matrix of network travel costs from each origin to all destinations.

In most cases, above steps are also preceded by a suitability analysis that usually takes into consideration accessibility, association or even environmental components. A suitability analysis is a process of systematically identifying or rating potential locations with respect to a particular use. A facility refers to any such possible endeavor that needs a location and that could be represented by a point, a line, or polygon-based objects. The terms identifying and rating indicate that suitability could be measured in absolute or relative terms. Suitability analysis is also used on the next chapter on area based analysis to select appropriated zoned parcels with the purpose of selecting underdeveloped land for a trucking company seeking to move to Renton. When selecting feasible sites, the analyst studies certain minimal requirements concerning land, access and infrastructure for the best path location including population density, how accessible a stop is to the neighbors, or even if a bus stop can be reached by foot along a sidewalk and so on.

Conclusion

In this chapter, I introduced the concept of location selection along a line or path on established network. It has been shown that the facility might be either a path or a corridor. In underlying this problem, there is the assumption that a network of nodes and arcs exist, or the path can be derived by connecting the starting location with the destination point. I presented two cases of line location based analysis along a network with associated data that have influenced the final decision on regulating future development or in choosing the bus route to serve a greater ridership based on the numbers of full-time employees. This chapter also discussed the capabilities of network analyst, an extension of ArcGIS software. To show how this extension tool can be used, I pointed the reader to online demonstrations on the ESRI webpage which can address the following problems: vehicle routing, closest facility and driving directions.

This chapter also mentioned suitability analysis, which is the process of systematically identifying feasible, potential site/facility location either in relative or absolute terms. With a set of feasible sites, it is then possible to explore issues of performance and service provision, such as the extension of the bus line.

The aim of this chapter was to illustrate important fundamentals on line/ network location selection, and what GIS tools and extensions are available to planners, developers and the GIS community.

Chapter 4: Area Based Analysis

Introduction and problem definition

A fundamental geographic planning problem involves the selection and acquisition of land for a specific use. The following are examples of circumstances where land procurement is necessary: a site for a large warehouse; the development of multi-family housing; offices and office park; and park lands for a reserve to protect endangered species. In land procurement, there are many criteria that are important to the developer. Some of the most important criteria include cost of the parcels and compatibility with the expected use and zoning regulations. Some resources available to the purchaser include the public information provided by the county assessor, such as, the parcels' attribute data found at the King County Assessor webpage. The table below shows the following tax parcel account record description including land value, improvements to the land value, and levy code. All of this data is free to the public at the King County GIS Portal and is available for use as tables or in shapefiles format. [41]

[41] King County Assessor data is public data. It is available through the King County GIS Portal at: http://www.kingcounty.gov/operations/GIS/GISData/GISDataDistribution.aspx 01/13/2012

Tax Account Receivable Record Description

Notes: AcctNbr, ReceivableType, BillYr made up the unique key.
The file is not in any particular sequence.

Record Count: Approximately 9,648,570

Field Name	Format	Length	Look Up	Description
AcctNbr	character	12		
ReceivableType	character	1		
BillYr	number	4		
OmitYr	number	4		
LevyCode	number	4		
ApprLandVal	number	9		
ApprImpsVal	number	9		
NewDollar	number	9		
LandVal	number	9		

Figure 4.1 Tax Account Receivable Record Description

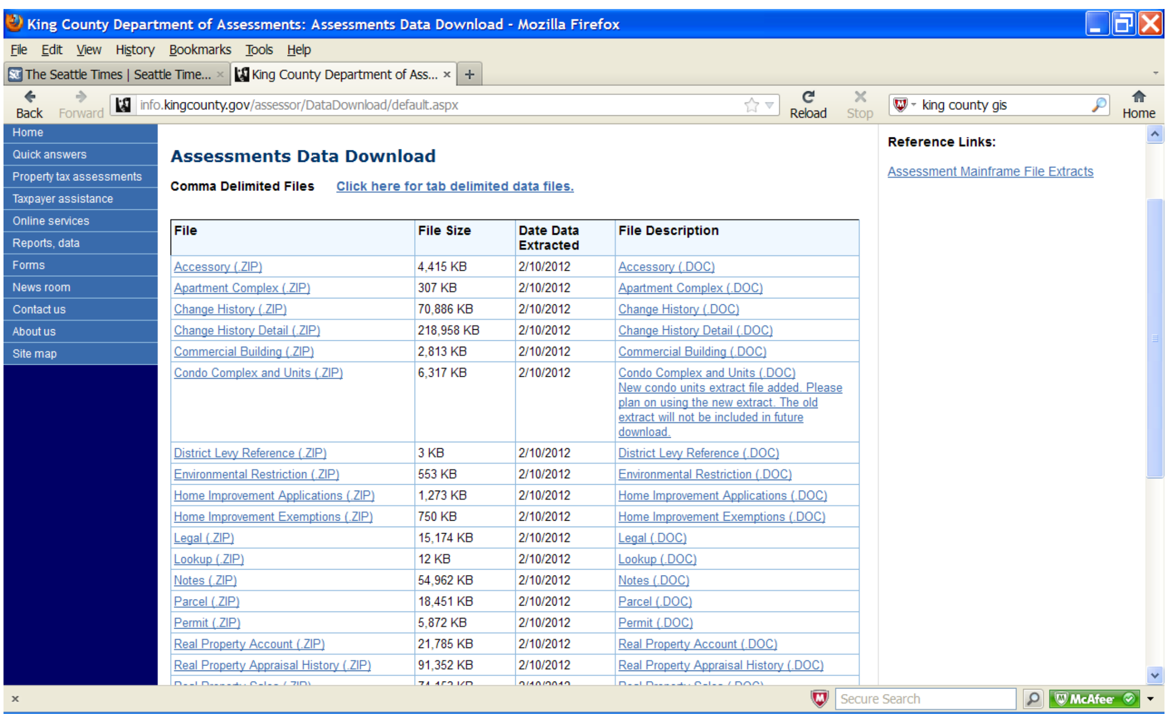

Figure 4.2 King County GIS Portal Screen Shot – KC Assessor Parcel Data interface

In area based business site selection, there are a limited number of parcels for potentially locating a facility which meet certain important criteria. The goal is to select a parcel that fits the developer's budget, compatibility of the proposed project with the current land use designations, and accessibility to transportation networks and transit. The developer might also wish to undertake its project in a municipality that offers an accelerated permitting process in order to reduce the upfront costs. Market potential is also another important consideration that influences the location of a business. A thorough study of the prospective market is key in the decision whether to open a new store and its prospective location. In fact, when potential customers and demand are not equally distributed within a specific area, factors such as distance to the origination point such as homes or place of work must be considered due to their influence upon market potential. Because shopping behavior is distance sensitive and potential customers and demand is not equally distributed across space, market potential is location sensitive.

In the selection of the best next site, many businesses relay on municipal economic development teams for property data research and/or GIS analysis. These teams main goal is the creation of an environment that supports business development, nurture entrepreneurial spirit and foster successful partnerships. The biggest cities on the west side of Washington State have some sort of Economic Development division. In addition, in 2001, they formed what is known as eCityGov alliance. The cities come together to form an "inter-local agency with a mission of providing web-based services to their constituents."[42] In 2011, the eCityGov Alliance finally launched a new regional mapping service NWMaps.net. This new web portal provides interactive GIS mapping and property data for public use. It places parcel information at the fingertips of citizens and businesses. The site includes zoning and property information, parks and trail information, and basic demographics among others but omits information on available commercial property.

The City of Renton counts with a special team to support prospective investors, developers, and business owners. The city not only has launched one of the best GIS portals in the region (http://rentonwa.gov/government/default.aspx?id=29886) but also offers GIS analysis support to all those companies interested in moving to Renton which helps the process of determining the best site location.

The following two cases highlight the considerations involved in area based site selection for a proposed project. The first case involves a trucking company seeking to relocate from Seattle to Renton. This company requested assistance from the Economic Development division of the City of Renton to locate a suitable site. According to the owner of the trucking company, the ideal site would have an area of approximately 8 to 10 acres in order to accommodate 50 - 70 trucks, preferably with a small warehouse on site. However, they are ready to build if necessary.

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[42] About eCityGov http://www.ecitygov.net/about/default.aspx 01/12/2012

The Economic Development division requested the GIS analyst to select parcels that met the following criteria: zoned as industrial land, 7 acres or greater, and with an improved value equal or less than $ 500,000. They were very impressed with the report on availability of land but this is a still pending project. At the time or writing this paper, the trucking company was working on their final decision with a real estate broker and an architectural firm. It may take another year to complete the site planning process, but the availability of GIS analysis services has shortened the decision-making process.

The second case highlights the site selection process for the expansion of the Federal Aviation Administration (FAA). This project is considered a high priority retention and expansion project for the City of Renton.

On December 15, 2009, the United States General Services Administration (GSA) and the Federal Aviation Administration (FAA) placed a notice of solicitation for class A office space. The proposed lease term is for 20 years with expected occupancy in September of 2014. The solicitation highlighted that they seek "518,865 rentable square feet, yielding 451,186 square feet of office and related space along with on-site parking for 1600 vehicles"[43] in a specific geographic area that comprises Renton, Tukwila, Kent, SeaTac and Des Moines. Other site criteria include: a 20 ft. security setback, amenities such as childcare center and play yard in a separate building to the main building within a half mile, a location outside of the 100 year

[43] US General Services Administration, US Government seeks leased office space in Renton, Tukwila, Kent, SeaTac, and Des Moines, WA. Solicitation Number PWA2176. https://www.fbo.gov/?s=opportunity&mode=form&id=8ab719e9b035f7db67d3882a90a9ae5f&tab=core&_cview=0 12/22/2009

floodplain; multiple bus lines within one-half mile; transit and road connections to the nearest Sound Transit train station; and a contiguous site that is not divided by a public road. The proposed structure(s) is planned to be a single or multiple buildings seeking the gold certification level through the Leadership in Energy and Environmental Design (LEED) program.

The retention of the FAA in Renton would ultimately result in a regional consolidation for the Northwest mountain region including Alaska and Oregon. This project has the potential to generate approximately 2,000 high-wage jobs for the City of Renton and neighboring communities, which represents a significant gain, in addition to the anticipated construction jobs for the project.[44] Thus, the retention and expansion of the current offices of the FAA is crucial for Renton. The current FAA office is located inside Renton's boundary and it is currently the fourth largest employer in Renton.[45] Therefore, a main concern for city officials is not to lose the approximately 1,600 high-wage jobs to another city.

As far the timeline and the process, the first step included letters of interest for 9 properties from a total of 16 properties in the running and presented to the FAA. The letter of interest included marketing points highlighting each of the

[44] Stiles, Mark. FAA may need a new building. Daily Journal of Commerce. http://www.djc.com/news/re/12014834.html 02/10/2010

[45] Radford, Dean. Renton's fourth-largest employer, the FAA, looking for new headquarters' site. Renton Reporter. http://www.rentonreporter.com/news/87174867.html 03/09/2010

properties.[46] Indeed, having 9 options in Renton, positions the city very well. Des Moines meanwhile has an 88-acre site owned by the Port of Seattle called the Des Moines Creek business Park. SeaTac has four potential sites close to public transit lines. The city staff has met with each property owner and potential developers to discuss zoning code requirements for the project and possible public improvements needed to win the contract. If any of the sites makes the FAA's shortlist, the city of SeaTac will discuss potential infrastructure improvements such as more streetlights, sidewalks, city officials said. "The City of SeaTac has 4 viable locations that fit all of the FAA's initial requirements, most importantly those related to transportation options for FAA staff and visitors said Todd Cutts, interim manager in a press conference published by the Business Report newspaper. Three Tukwila property owners meanwhile have contacted the FAA, said Derek Speck, economic development administrator for the city of Tukwila. "It is an absolute plum. We would love to have it in Tukwila" Speck said. "We will do everything we can" but they kept the developers names as confidential." The city of Kent is teaming up with Hines and Mortenson Construction in pitching a 15.5-acre site in the southwest corner of downtown Kent that includes 10 acres owned by the city, said economic development manager Kurt Hanson. He also stated that "the city investments during the last 15 years have made it a viable choice for the FAA to locate its regional offices".[47]

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[46] Ibid 5

47 Fickes, Andrew. FAA reviews sites for regional office. The Business Reporter. Volume 7- #5. May 2010. 1-5

The FAA and the General Services Administration have also conducted site tours on the properties during the past couple months. Ross Buffington, a GSA spokesman, said the FAA and GSA plan to issue solicitations for offers to qualified applicants in late May or early June, and much of the detailed procurement process is kept confidential, he said.

Nevertheless, the GIS analysis has proven that just a few properties comply with most of the requirements. They are: the adjacent parcels to the current FAA office location, the Ford Motor property, Longacres office park, Regal East valley and/or Triton Tower's contiguous land.

Modeling Representation: GIS Analysis

Case Study: Trucking Company is seeking to move to Renton, Selection of Underdeveloped Industrial Land

The following describes the GIS analysis provided by the City of Renton to assist in locating available and appropriate parcels for the proposed business activities of a trucking company. The necessary data for this analysis was already stored and maintained in the Renton GIS server. Figure 4.3 shows the selection of all parcels contained in areas zoned as industrial (heavy, medium and light industrial). To determine the assessed value of the parcels, the parcel layer was then joined to parcels Tax Account Receivable Record Description by their common ID or PIN (Parcel Identification Number). The geoprocessing (shown on figure 4.4) included a query of all parcels with an improved value of less than or equal to $500,000. From the previous choice, the analyst selected only parcels (figure 4.5) of seven acres or greater.

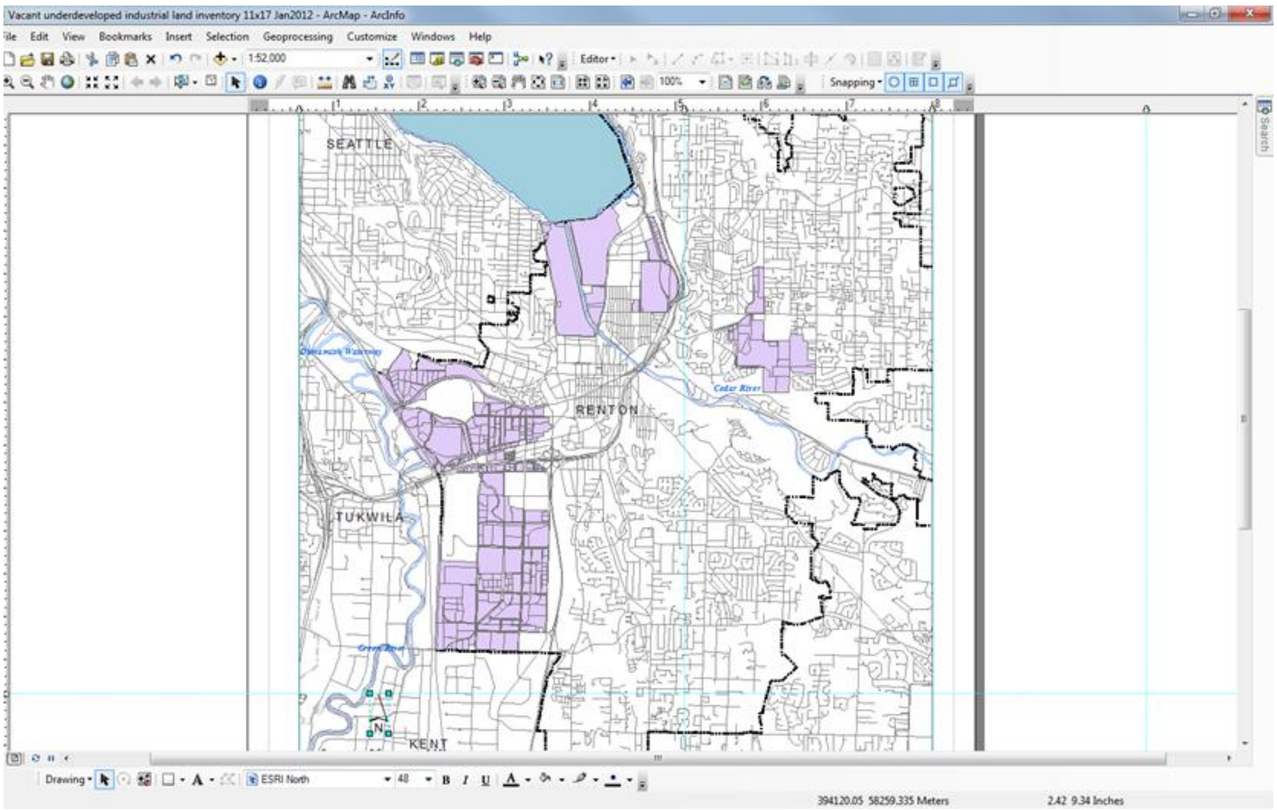

Figure 4.3 Intersect parcel feature class with zoning, then query parcels zoned as light, medium or heavy industrial

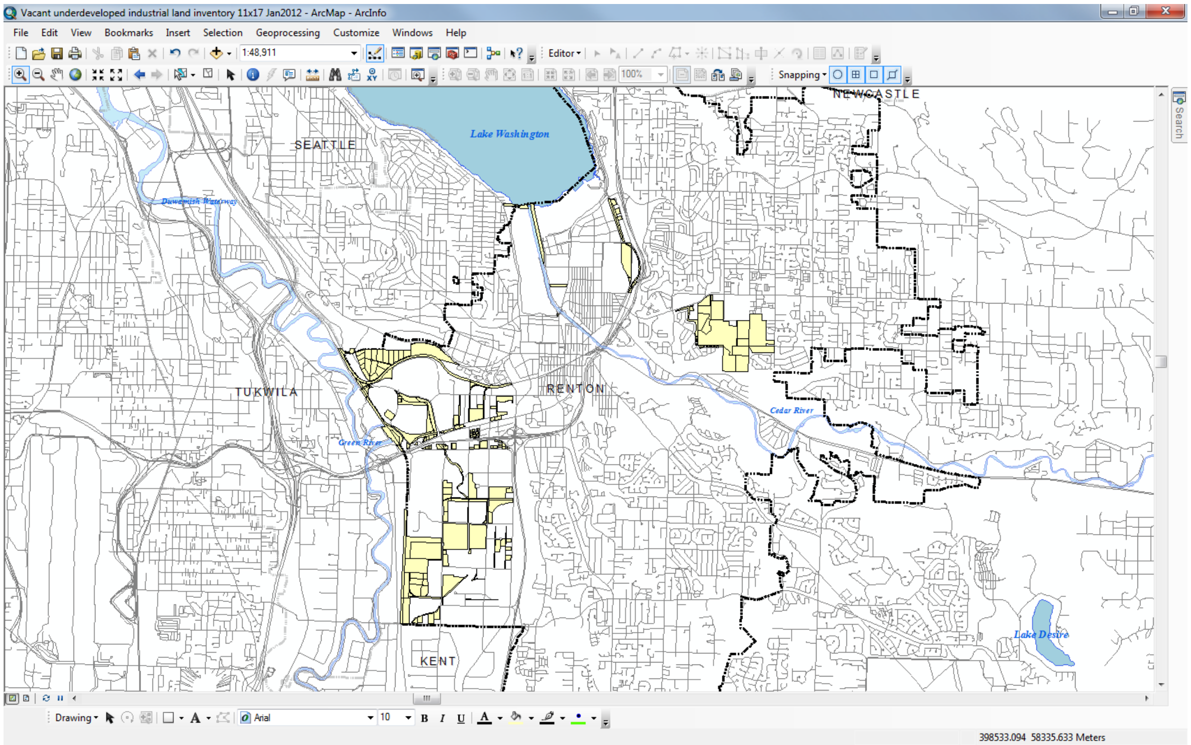

Figure 4.4 Select parcels with improved land value less than or equal to $500,000

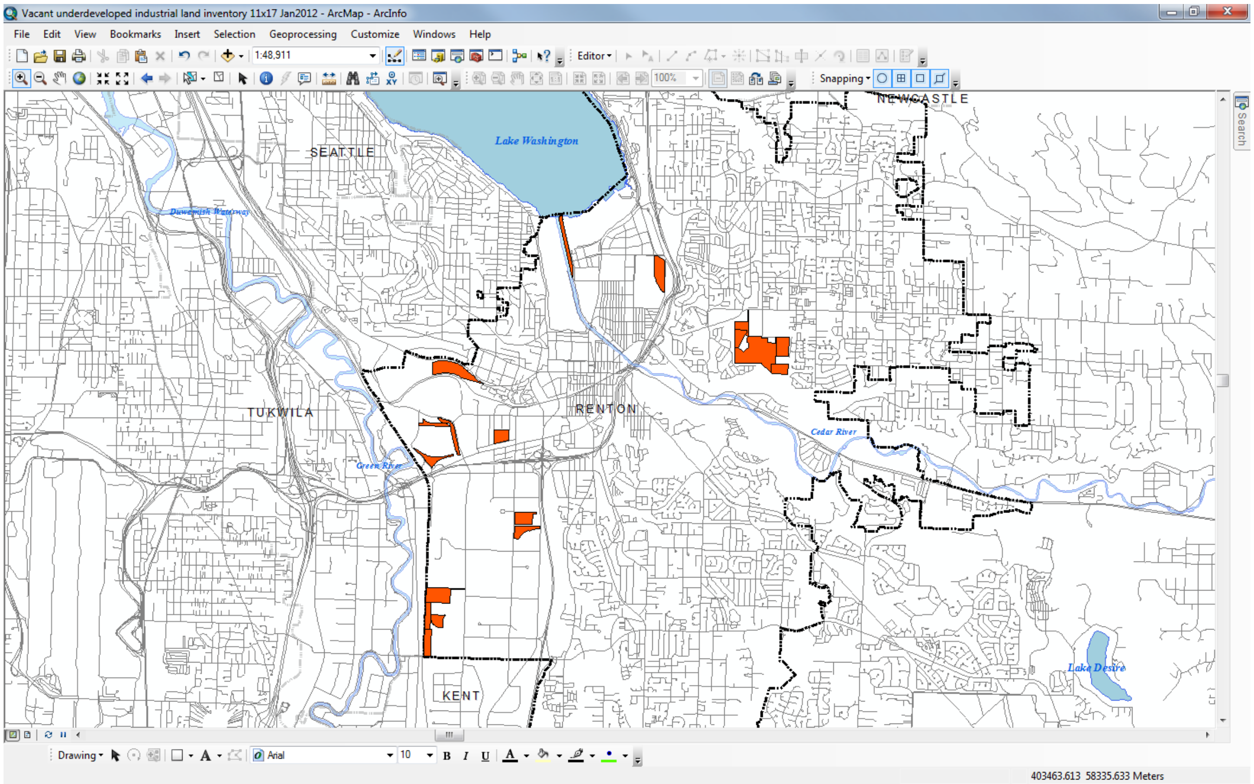

Figure 4.5 From previous query select those parcels with acreage equal to or greater than 7 acres

Case Study: Federal Aviation Administration-Office Opportunities

The following describes the GIS analysis provided by the City of Renton to assist in locating available and appropriate parcels for the proposed expansion of the FAA. Some of the data used for the pre-solicitation of leased office for the FAA, was already stored and maintained in the Renton GIS server. Features classes for bus lines, railroads, train stations and also transportation-related points such as, park & ride lots and bus stops points, were acquired from King County GIS office.

The map shown on figure 4.6 required the following steps:

1. Select available properties for sale with space for 520,000 square feet.

2. With a different symbology, show Renton transit center, Sounder commuter rail Tukwila station, Link light rail station and all Park and Ride lots.

3. Differentiate by color:

   a) all bus lines that connect to the Sounder commuter rail Tukwila station,
   b) all bus lines that connect to Renton transit center,
   c) all bus lines that connect to Link rail station,
   d) all bus lines that connect to Sounder commuter rail Kent station,
   e) all other bus lines and
   f) proposed Rapid Ride F Line extension to the Landing shopping area through Park Ave N.

4. Use the geoprocessing tool and build a 0.5 mile buffer applied to selected properties.

The city contacted property owners and come up with 9 potential sites for the FAA retention/expansion list of properties (Figure 4.6).

i. Adjacent parcels to the current location of the FAA building property
ii. Hawk’s Landing property
iii. Longacres Office Park property
iv. Regal East Valley property
v. Sound Ford property
vi. Southport property

vii. Stoneway property

viii. Sunset Bluff property and

ix. Triton Towers.

5. Prepare a map specific to each potential site (as shown on figure 4.8, for the Triton Towers property) which shows the transit access for the proposed FAA office. This map can then be attached to the letter of intention.

These competing sites will be further evaluated by the governmental agency to decide on the best location to build the new offices of the FAA.

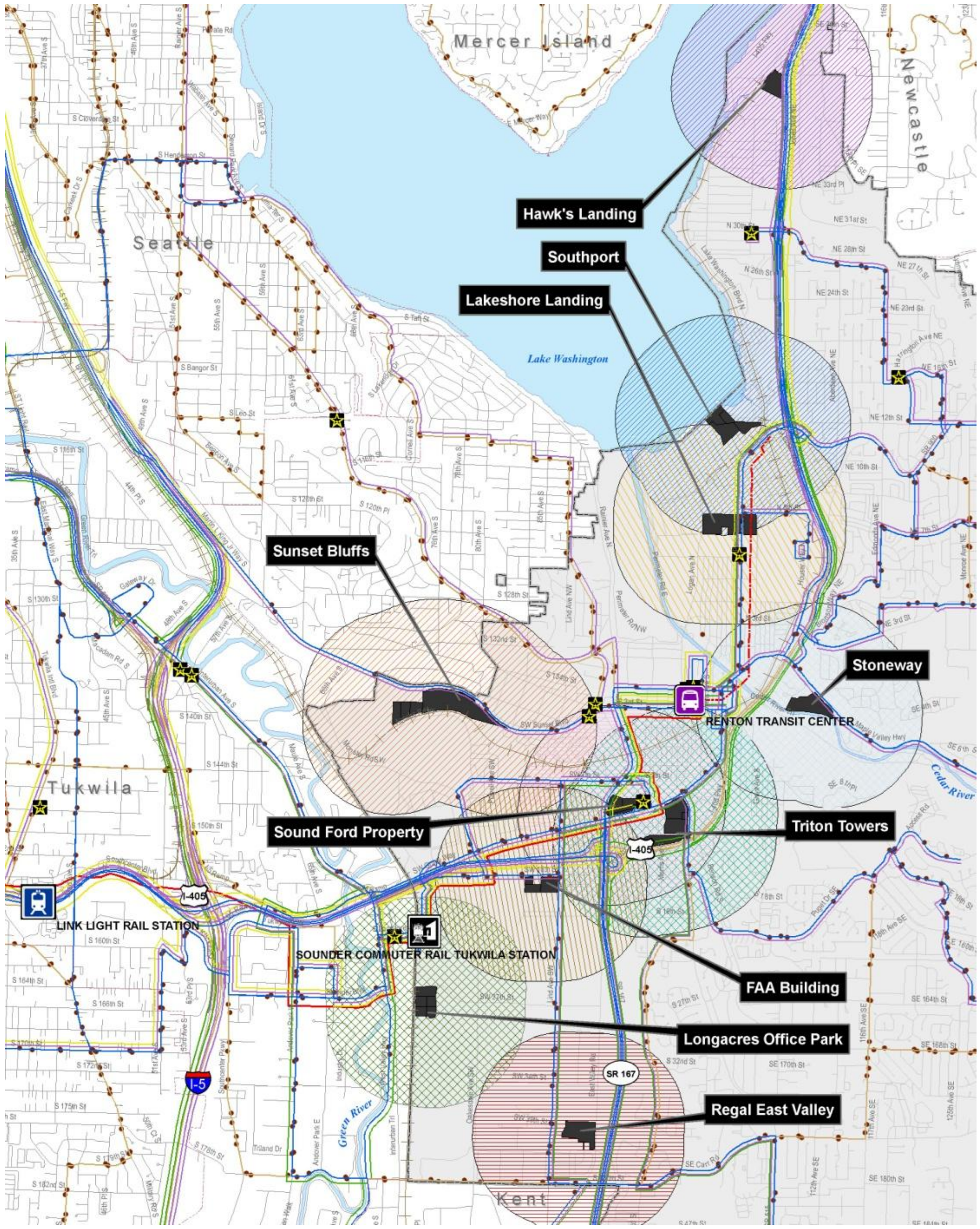

Figure 4.6 Map showing FAA office opportunities, 0.5 mile buffer, bus lines, bus stops, train stations, and connection to main transportation hubs.

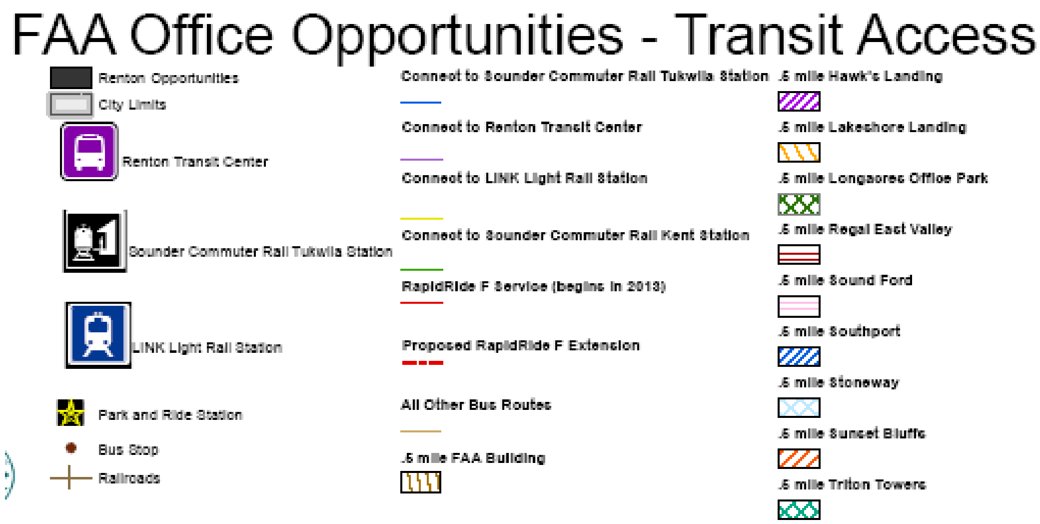

Figure 4.7 Map legend

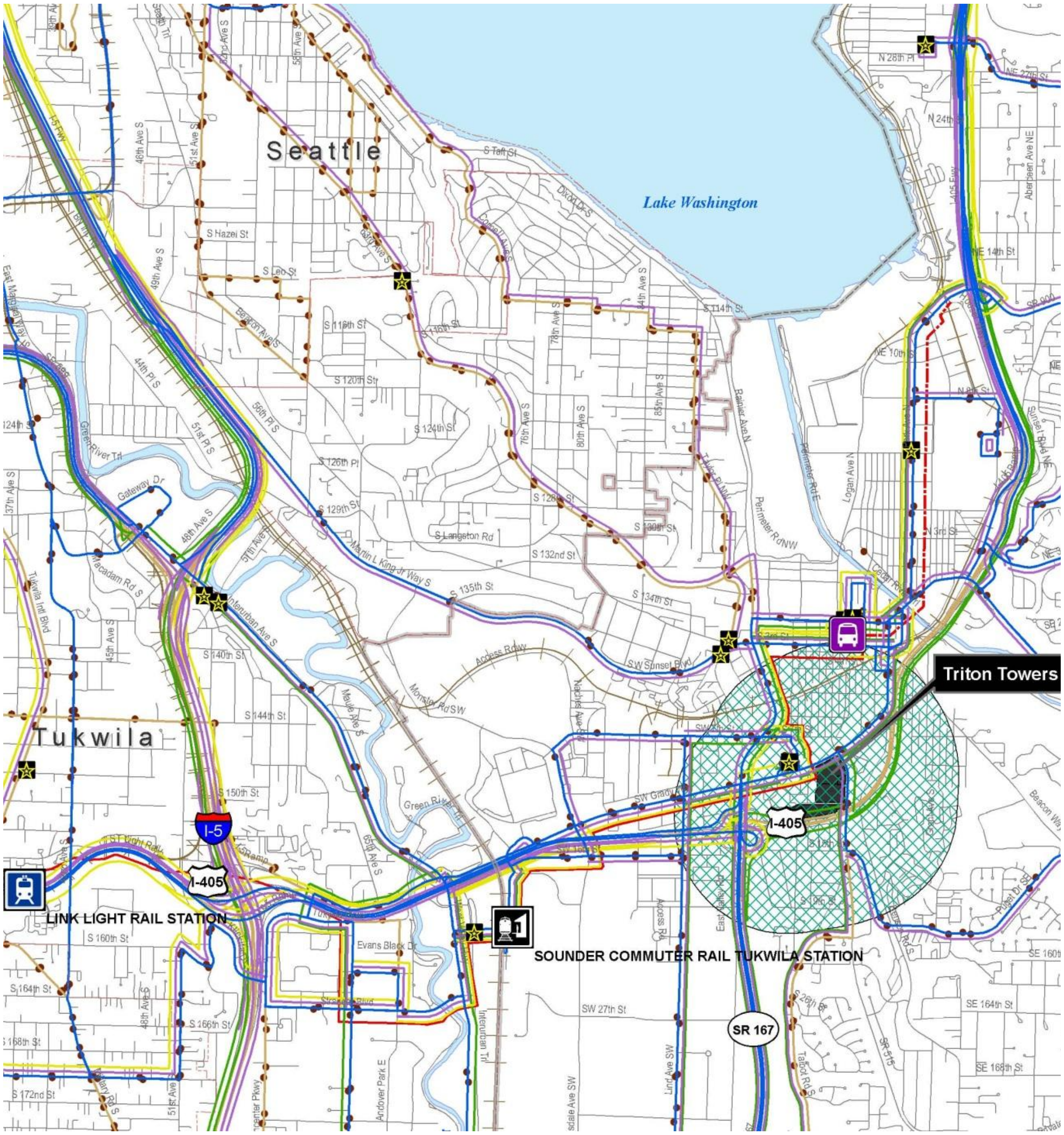

Figure 4.8 Map showing Triton Towers property, 0.5 mile buffer, and lines that represent connections by bus to the Link, Sounder Tukwila station and Kent Station

GIS Science

Since parcels are geographically located, the data related to the area based selection of a potential site for a business will largely be based on spatial factors. GIS can be relied upon to conduct the essential analysis through map algebra operations identifying appropriate land for procurement. One approach is to take into consideration the attributes of the parcel. In the case of the trucking company case study, the following land attributes were considered: acreage, zoning area, land use, and assessed improved value to the land.

Important criteria for the proposed FAA office expansion included: contiguity and adjacency, the walkability of the area, and connections to transportation hubs. Contiguity and adjacency refers to assembling contiguous parcels with similar attributes, such as, the same owner or zoning characteristics to benefit demanding square footage for office use. Walkability is a measure of the effectiveness of community design in promoting walking distance as alternative to driving cars to reach shopping, the office, schools and other common destinations. Thus, walkability measured by half-mile buffer was an important item to introduce to the GIS analysis for the FAA project.

The last step of the analysis for the proposed site of the FAA offices included connectivity to transportation hubs, an important factor for the FAA. Figures 4.6 and 4.8 are showing transportation networks, including direct connections, walkability to transportation hubs as well as to bus stops and park and ride lots. So given this context, the analyst began by reviewing contiguous parcels with similar attributes to ensemble a combination of lots, then followed by half mile walkability buffer and ending with connections to transportation hubs.

Conclusion

In this chapter, I introduced the concept of area based business location and selection. Although the GIS analysis has been completed for both of the case studies presented, there has been no resulting final site selection for either of them. The trucking company site selection is still in the early stage and the many considerations of the office expansion for the Federal Aviation Administration have yet to be resolved. For the FAA project, the neighboring cities of Des Moines, Tukwila, Kent, and SeaTac, have also offered potential sites, however, the GIS analysis performed by the City of Renton revealed the greatest number of potential sites. There are very good indications for a favorable result that will benefit the City of Renton. Indeed, spatial analysis is the problem solving aspect of GIS. The tools seems very basic – buffers, overlays, selections- but when combined in a particular sequence they can reveal thing about the data that can’t be seen in a spreadsheet or a chart. In both case studies there was no need to acquire or to create new data. The GIS analyst made exiting data say new things. The key was to know the tools well and design the right sequences to bring the big picture into view. By utilizing the capabilities of GIS to show transportation systems, parcel characteristics such as zoning or size, the City of Renton was able to place itself in a positive position as the site for the FAA office expansion.

Equally important is CoStar Group report of November 16, 2011 that states that Federal Partners acquired 200,000 square feet of federally leased office for $ 35 million, where FAA offices are currently located. "The offering garnered broad investor interest given the quality of the assets as well as the rapidly improving Seattle economy. Particular interest came from investors who were conversant with the nuance of GSA tenancy and were attracted to this particular deal by the opportunity to renew and retain the FAA occupancy on the long term basis." [48]

[48] Sumner Justin, CoStar Group News: Regional. FAA Bldg Trades for $ 35M. Federal Partners Acquires 200,000 SF Federally Leased Office in Renton http://www.costar.com/news/article/FAA-Bldg_Trades-for-$35M/133681 11/16/2011

Chapter 5: Coverage Analysis

Introduction and Problem Definition

The purpose of covering models, also known as coverage models, is to evaluate and choose locations that provide service coverage to possible users or consumers within a specific distance or travel time constraint. Such coverage is important in situations where access plays a critical role in use of the service. When covering location-allocation models were developed, they were mostly used for location of public sector emergency services or fixed facilities, such as schools or fire stations. This model can also be utilized for other applications. In the case of a chain of stores, it is important to assess the level of service provided by a network of outlets over a region or trade area. Thus, techniques of covering models can be used to evaluate any network of retail stores "where the objective involves the trade-off between the potential for utilization and the cost of providing the service."[49] When the whole network of facilities is evaluated simultaneously, the analyst can turn to location-allocation techniques. The techniques of coverage models can be tailored to a wide variety of situations, but fundamentally they are designed to allocate a given spatial distribution of demand to a specific number of service facilities, e.g., fire stations and retail outlets.

The amount of total population that is located within the immediate vicinity of service facilities or retail outlets is an important factor in determining the level

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49 Ghosh, Avijit and McLafferty Sara L. Location Strategies for Retail and Service Firms.Lexinton Books. D. C. Heath and Company/Lexington, Massachusetts/Toronto. 1987

of service provided. . In designing a network of retail outlets, the objective should also be to find locations that maximize the number of people within a specified maximum distance or travel time constraint.

Public sector facilities such as schools, hospitals, libraries, fire stations and emergency response service centers, seek to provide high quality service to the community in a cost-effective manner, which includes choosing a location to help achieve this objective. The goal of location-allocation is to locate the facilities in a way that supplies the demand point most efficiently. It is a twofold and interactive process that simultaneously seeks facility locations facilities and the allocated demand point to the facilities.

The primary responsibility of a fire department is the delivery of fire and rescue services to the public. The delivery of these services normally originates from fire stations located throughout the area to be protected. To provide effective service, firefighters must respond in a minimum amount of time after the incident has been reported to the emergency call center or 911. The decision of where to locate fire stations must therefore take into consideration the importance of response time to fire or medical emergencies and flashover. Time is a critical element since fire growth can expand very quickly. All fires go through the same stages of growth; however, one particular stage called “flashover” emerges as very significant because it marks a critical change in conditions at the scene of a fire. “Fire growth is exponential; that is, fire doubles itself every second of free burn that is allowed." [50] Thus, response time greatly matters for preventing a fire from reaching the stage of flashover and the greater potential for loss of life and damage to property.

In addition to response time, Fire Departments must also take into consideration other factors which determine their service delivery. These factors include the following: a.) dispatch time which is the amount of time that it takes to receive and process an emergency call; b). turnout time which refers to the time from when units acknowledge notification of the emergency; c.) response time measures when units are in route to the emergency; d.) access time measures the time from the fire truck to access to the fire or emergency, including any barriers that are present; and e.) setup time which is the time that takes to prepare response equipment, e.g., connect the hose and position ladders.

Incident trend analysis can provide supporting data for important decisions related to fire prevention or staffing requirements. Incidents can be queried based on incident type, cause, time, units assigned, or other variables contained in the attribute data. For example, a firefighter could request to map arson fires that occurred after sundown on weekends. Using GIS, an analyst can question the records stored in the database then can place points on a map that match the query.

When citizens are in need of an ambulance, they trust it will come to their rescue almost instantly. As a consequence the response time depends on the distance

[50] ESRI White Paper, GIS for Fire Station Locations and Response Protocol. January 2007.

between the location where the ambulance is stationed and the patient. The problem is to assign the best location to a fire stations or emergency response center so that they can reach the greatest number of people within their service area in the most time-efficient manner. Response time can be mapped by utilizing a fire station layer and street layer. A street layer is often represented in the GIS as a series of lines that intersect on the map. Each street line segment contains attribute information such as road type, distance, and travel speed for that part of the segment expressed in miles per hour. This model follows what Church and Murray describe as "prescriptive service area"[51] that given a set of product sources (fire station) and set of destinations (each neighbor address), the analyst can identify the most efficient way to allocate supply (fire service) at sources to satisfy demand at destinations. This generic problem definition specifies that sources are typically the point location that provides the service and destinations are those locations to which the service is provided such as addresses in the neighboring area. Allocation of service to supply the demand of emergency and fire services delineates the fire station service area. This relays somewhat to equivalent problem of assessing the trade area for a store.

The following maps show how GIS can be used to map fire station locations and service areas.

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[51] Church, Richard L and Murray Alan T. Business Site Selection, Location Analysis and GIS. John Wiley & Sons, Inc. Hoboken, New Jersey. 2009

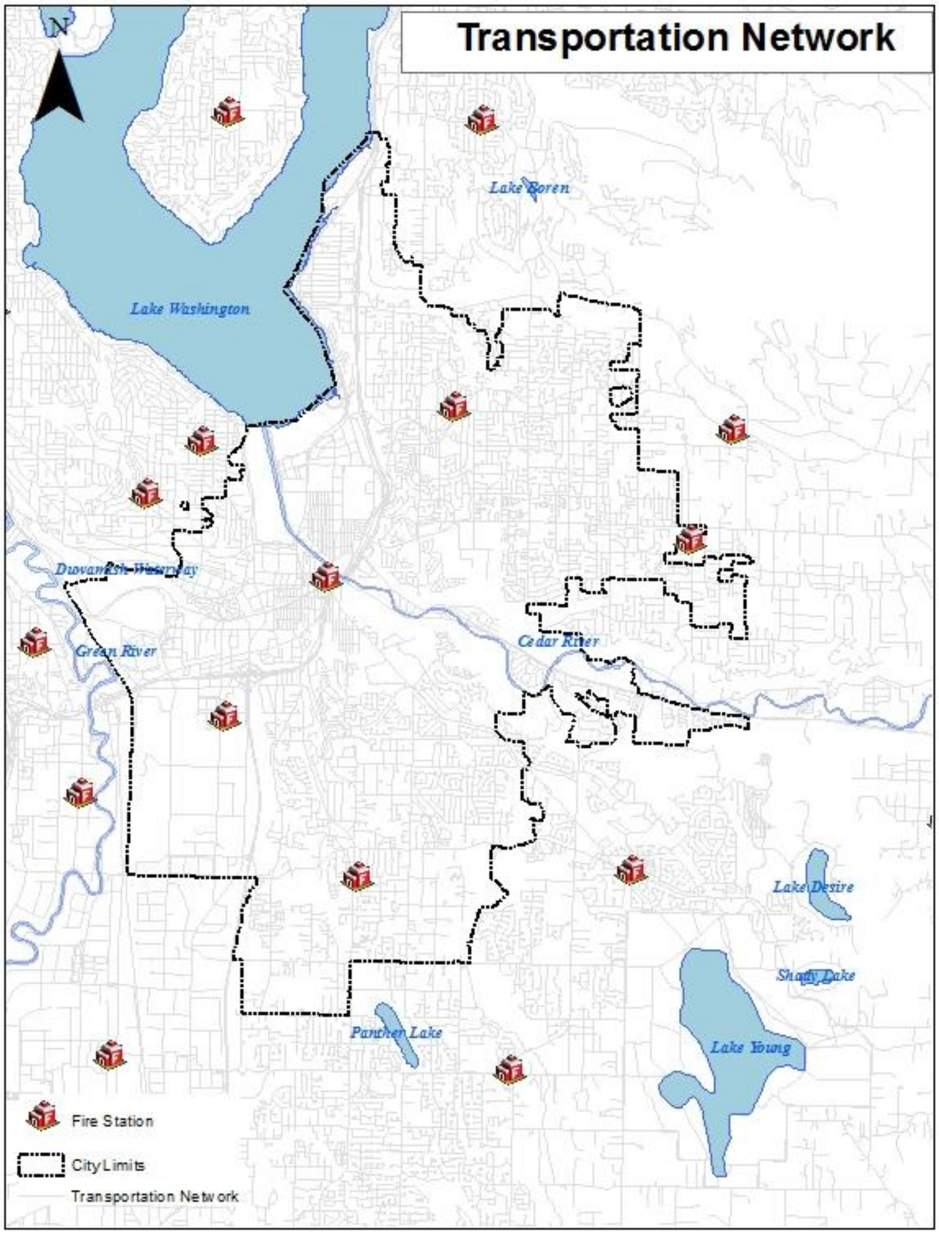


Figure 5.1 Map showing street centerlines and location of fire stations

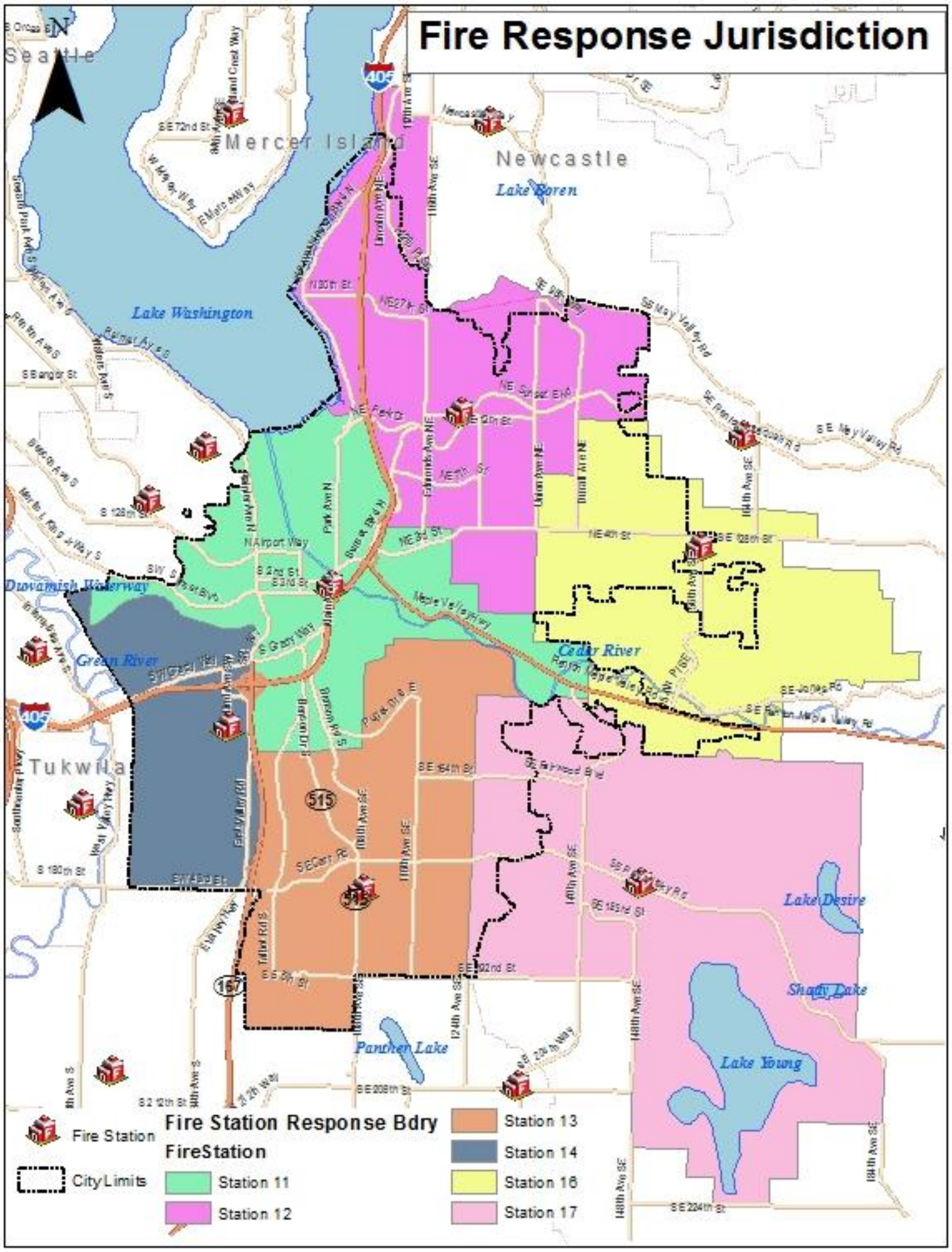


Figure 5.2 Map showing fire jurisdictions per fire station and main arterials

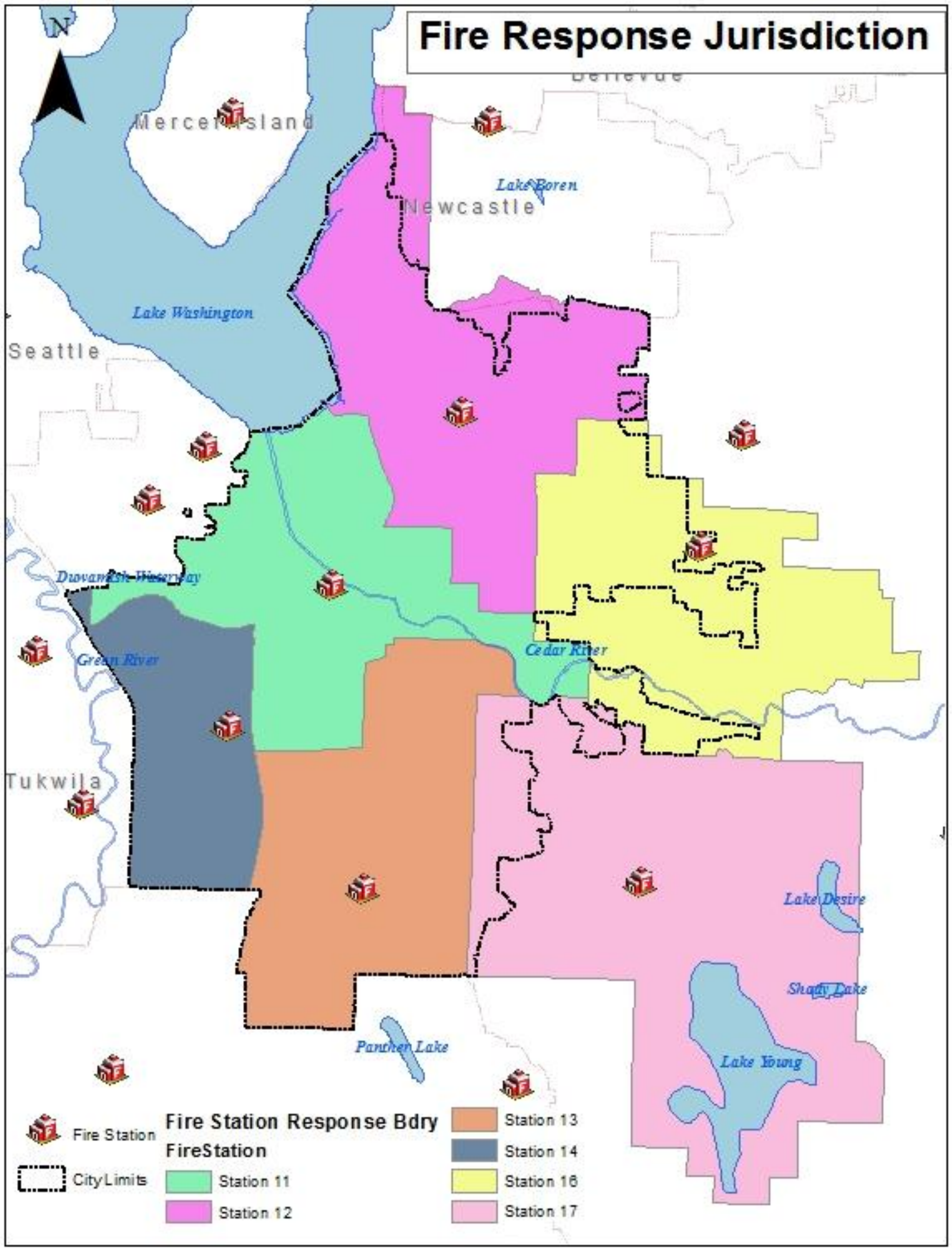


Figure 5.3 Map showing fire response jurisdiction per fire station without arterials and city boundary

Modeling Representation: GIS Analysis

Case Study: Emergency Management Fire Station Location

The street network and fire station layers allow the analyst to perform network analysis. The result will be displayed by an irregular polygon around the fire stations that illustrates where the fire truck could travel in any single direction.

This covering modeling was used for the analysis of 2011 response data also to find out if a new fire station was needed. In ArcMap, I displayed the locations of all the fire calls, including those located outside of city boundary. (Figure 5.5)

A first step began with data gathering from the City of Renton Fire Department. In this instance, the data table did not provide the full address, therefore, as the GIS analyst, I used string operations function to concatenate cells on in the excel file. The concatenation of the fields required writing a script for two or more text fields with a space in between as follows: [textField1] & " " & [textField2].

The next step involved geocoding full addresses for all fire responses for the Year 2011.

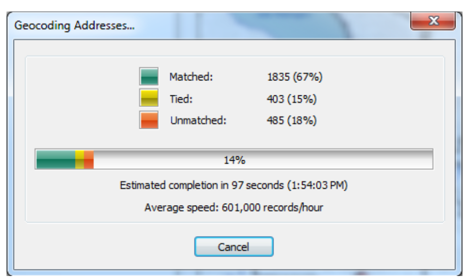


Figure 5.4 Geocoding Fire Responses

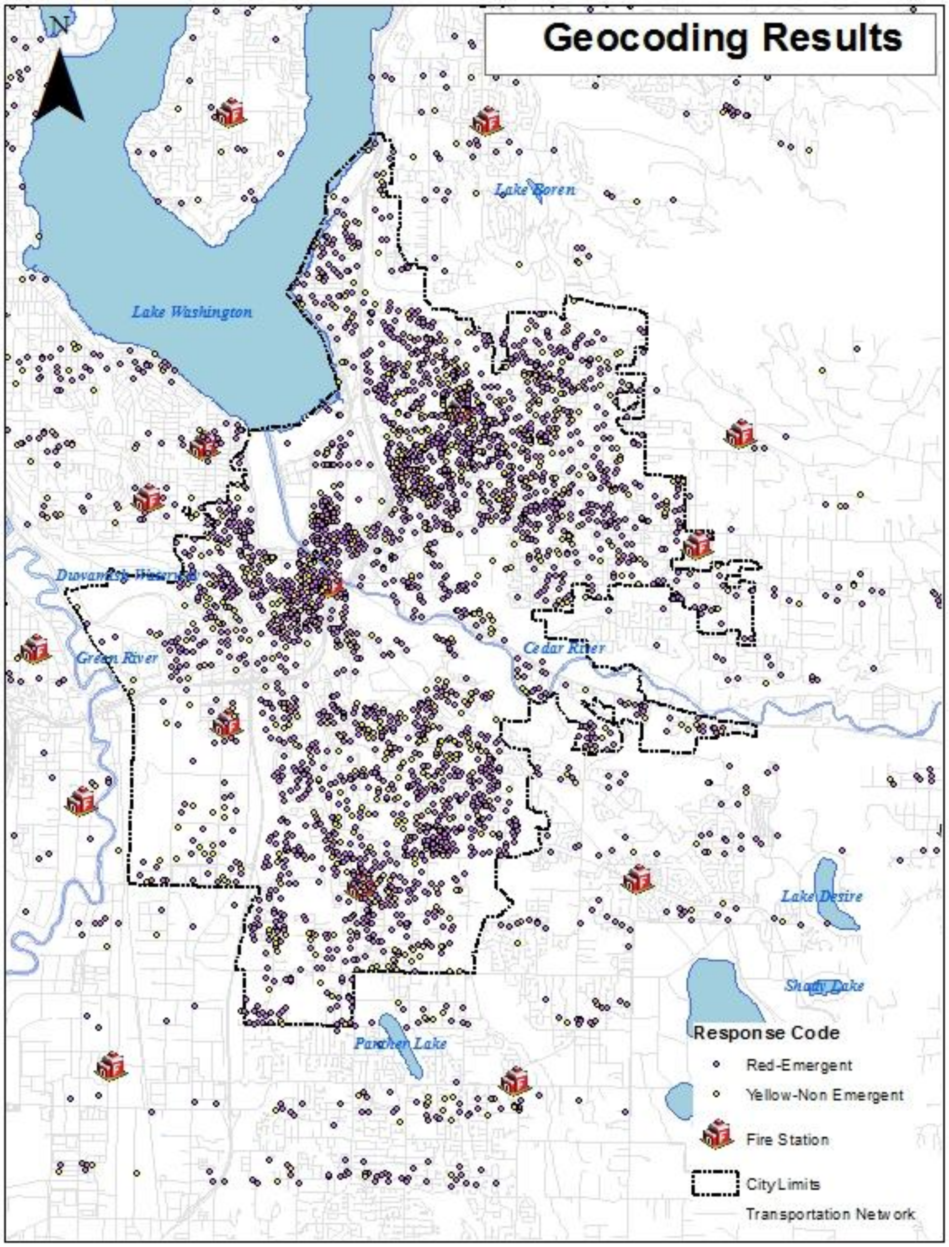


Figure 5.5 Map showing street centerlines and geocoded addresses

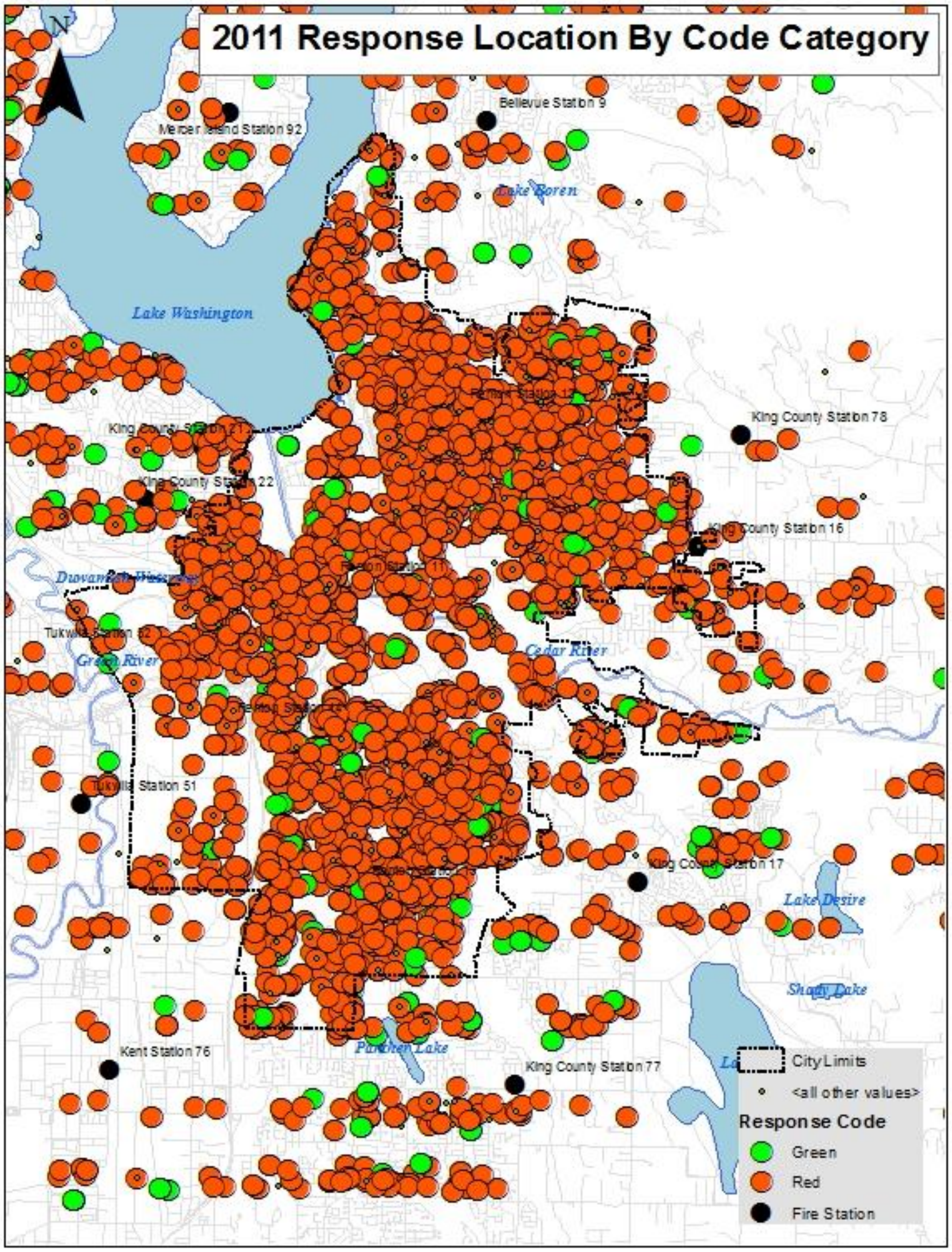


Figure 5.6 Map showing geocoded results by response code: red=emergency, green=medical

The process of locating the “nearest features” from input features is called “near features”. “Near distance” is the analytical step to determine the distance between the input and nearest features. An example is the analysis of fire station location and response events to determine if responders were traveling too far .. Figures 5.7 and 5.8 are graphical representations of near distance and how this is measured.. Each entry can be depicted as a point, polyline, polygon or multipoint. There can be one or more entries of near features, such as the geocoded fire and medical responses incidents for 2011. When multiple entries of near future are specified, a new field NEAR_FID is added to the input table to store the path of the sources feature class (feature class is a combined GIS word, it is similar to a shapefile but resides in the GIS server. The word has been included in the glossary) that contains the nearest feature. The near distance tool generates a new table that shows the distance between the fire station and the near point. The distance has been reported in a table identifying which station is closest; the feature stored as NEAR_FID (figure 5.7) for the fire station table was transferred from the fire station feature class to the geocoding results table and shown on the map as a legend. Figure 5.8 shows which fire station responded to the fire or medical incident.

Incident_T	Miles	NEAR_FID	NEAR_DIST
2 Gas leak (natural gas or LPG)	0	1	21095.56265
2 Gas leak (natural gas or LPG)	0	1	21095.56265
1 EMS call, excluding vehicle accident with inju	0	1	21084.65497
11 EMS Call, Medical	0	1	21084.65497
11 EMS Call, Medical	0	1	21084.65497
11 EMS Call, Medical	0	1	21084.65497
11 EMS Call, Medical	0	1	21084.65497
1 EMS call, excluding vehicle accident with inju	0	1	21047.45369
1 EMS call, excluding vehicle accident with inju	0	1	21047.45369
1 EMS call, excluding vehicle accident with inju	0	1	21022.40811
1 Heat from short circuit (wiring), defective/wo	0	1	20971.96960
1 Heat from short circuit (wiring), defective/wo	0	1	20971.96960
1 Heat from short circuit (wiring), defective/wo	0	1	20971.96960
1 EMS call, excluding vehicle accident with inju	0	1	20917.48532
1 EMS call, excluding vehicle accident with inju	0	1	20917.48532
1 EMS call, excluding vehicle accident with inju	0	1	20917.48532
1 EMS call, excluding vehicle accident with inju	0	1	20917.48532
1 EMS call, excluding vehicle accident with inju	0	1	20917.48532
11 EMS Call, Medical	0	1	20904.21975
11 EMS Call, Medical	0	1	20904.21975
11 EMS Call, Medical	0	1	20904.21975
11 EMS Call, Medical	0	1	20904.21975
11 EMS Call, Medical	0	1	20904.21975
11 EMS Call, Medical	0	6	20774.24472
1 EMS call, excluding vehicle accident with inju	0	6	20750.60423
1 EMS call, excluding vehicle accident with inju	0	1	20731.80124
1 EMS call, excluding vehicle accident with inju	0	1	20731.80124
6 CO detector activation due to malfunction	0	6	20723.56171
10 EMS Call, Other Accident/Trauma	0	6	20723.56171
1 EMS call, excluding vehicle accident with inju	0	6	20719.12920
1 Lock-out	0	1	20685.32692
0 Good intent call, other	0	1	20676.08008
0 Good intent call, other	0	1	20676.08008
11 EMS Call, Medical	0	6	20662.25756

Figure 5.7 Near distance table that measures the distance in feet

from the fire station to fire and medical 2011 incidents

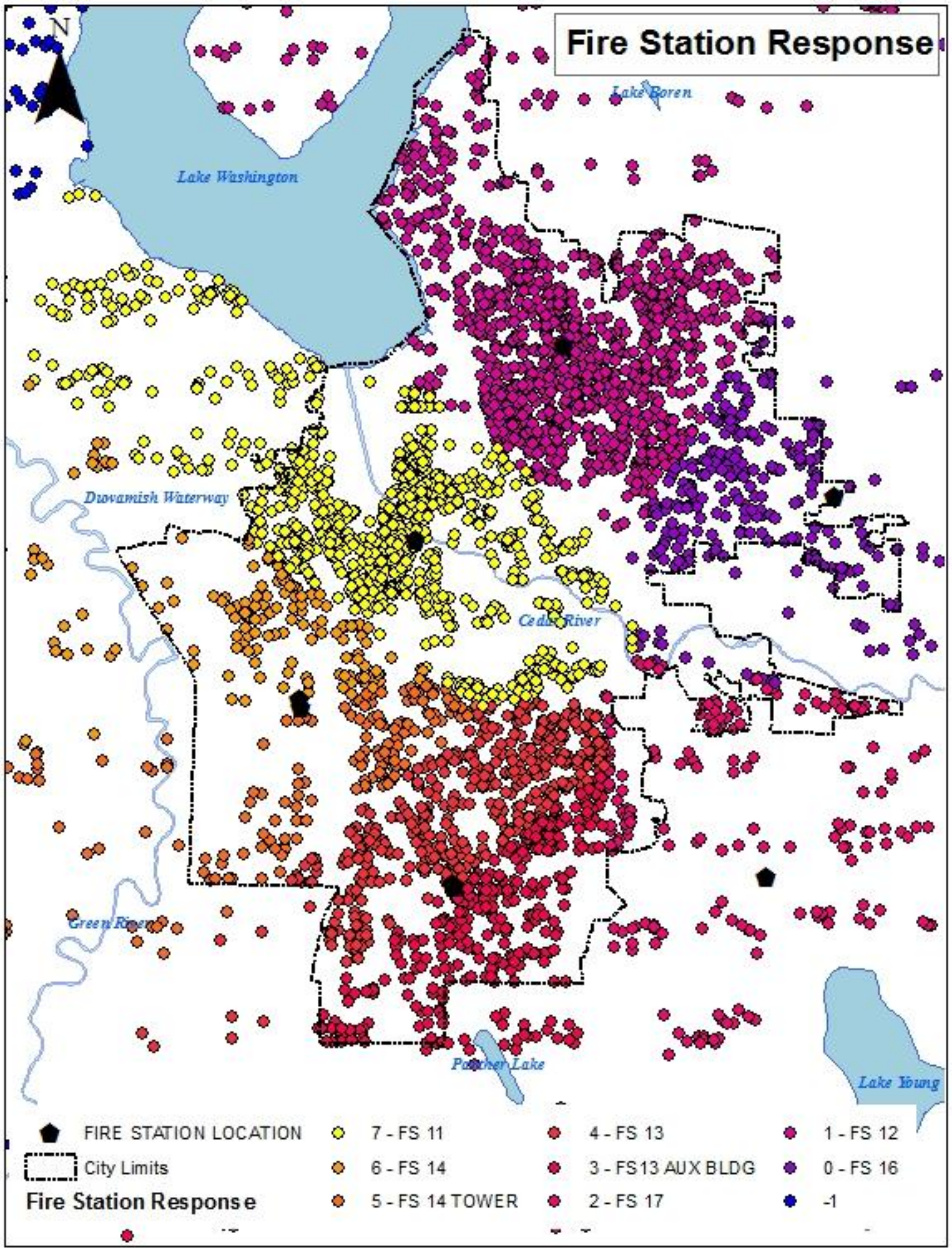


Figure 5.8 Map showing what fire station responded to the fire or medical incident (what year?) Keep title of map on the same page as map.

Near distance applies the famous Pythagorean formula also known as Euclidian distance or the ordinary distance between two points. It is important to differentiate between the concepts of Euclidian distance, direction, and allocation. Euclidian distance gives the distance from each cell in raster to the closest source, e.g., the distance to the closest town Euclidian direction refers to the direction from each cell to the closest source, such as, the direction to the closest town. Lastly, Euclidian allocation identifies the cells that are to be allocated to a source based on closest proximity, thus, used to calculate what the closest town is. The Euclidian distance is calculated from the center of the source cell to the center of each of the surrounding cell. Conceptually, the Euclidian algorithm works as follows: for each cell, the distance to each source cell is determined by calculating the hypotenuse. This calculation determines the shortest distance. The figures below demonstrate parameters that were entered in the Euclidian distance tool to result in a maximum distance of 21,120 feet or four miles.

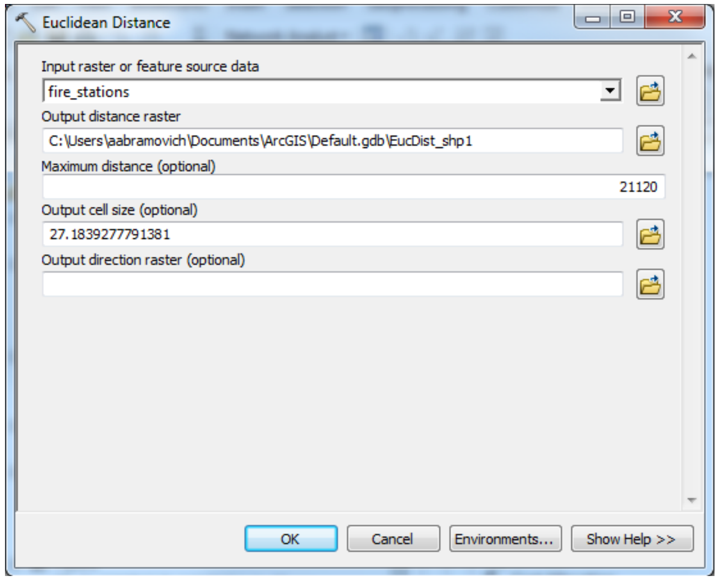


Figure 5.9 Euclidian Distance tool with input of maximum distance of 21,120 feet

The map in figure 5.10 shows the Euclidian direction raster output that contains the azimuth direction for each cell to the nearest source. The Euclidian distance tool has some limitations because it maps a straight line, however, it may not be possible to travel in a straight line to a specific location. The distance tool doesn't take into consideration the presence of obstacles such as rivers or slopes, and the possible route to avoid these obstacles. To more accurately calculate distance, the analyst can use the analysis of cost distance. This temporary layer can be shown as concentric circles (similar to a bull's eye) with color hues representing the distance from the different fire stations. Locations with a close proximity to both stations will get a high value and those further away will get a lower value.

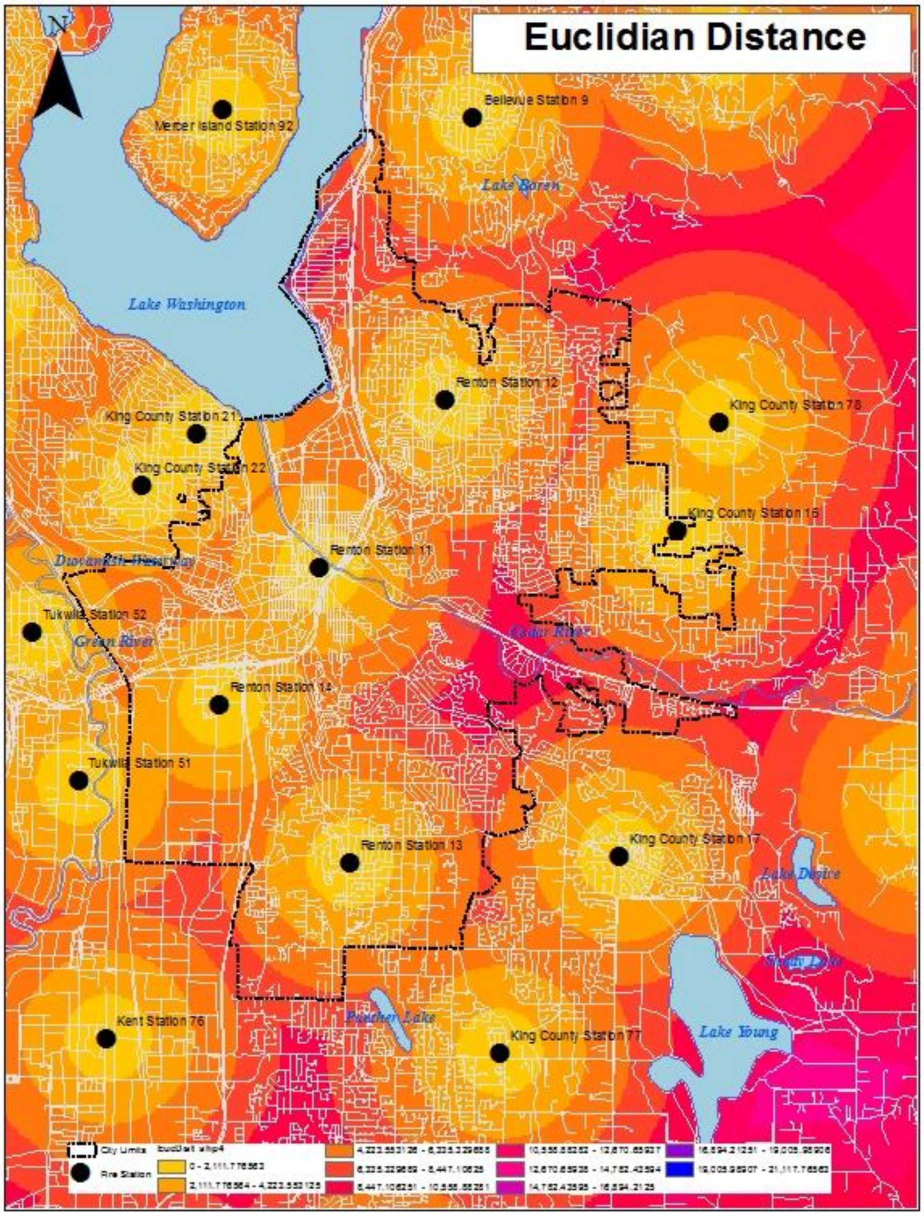


Figure 5.10 Map showing Euclidian Distance from all fire stations in the region.

The darker color shades indicate areas with lesser fire service coverage

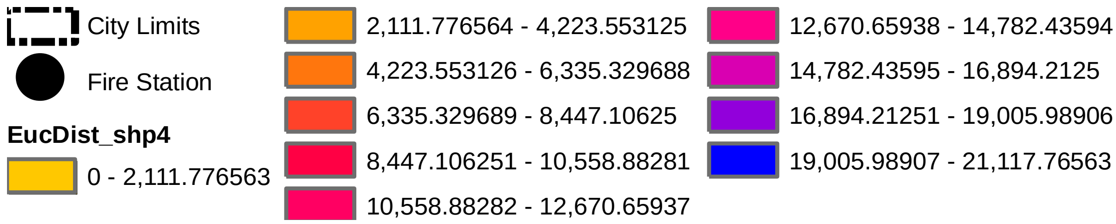


Figure 5.11 Euclidian Distance legend shows range of distances expressed in feet from a fire station

This model is based in Huff gravity model that solves the planar problem which considered Euclidian distances and each point in the plane as also a potential location for a new facility or best location.

With Euclidian allocation the analyst can measure the maximum distance of service coverage designated for each fire station. When the input is a feature class, the source locations are converted internally to a raster before performing the Euclidian analysis. The resolution of the raster was controlled with a 200 cell size parameter. For the purpose of consistency, the analyst used the same parameter as used for Euclidian distance of 21,120 feet. Figure 5.12 shows the parameters assigned to measure Euclidian allocation. The source data are the fire stations locations (shown as points) with the distance of 21,120 feet denoting the maximum ideal distance between a fire station and potential emergency or fire incidents. The cell size represents at which the output raster will be created.

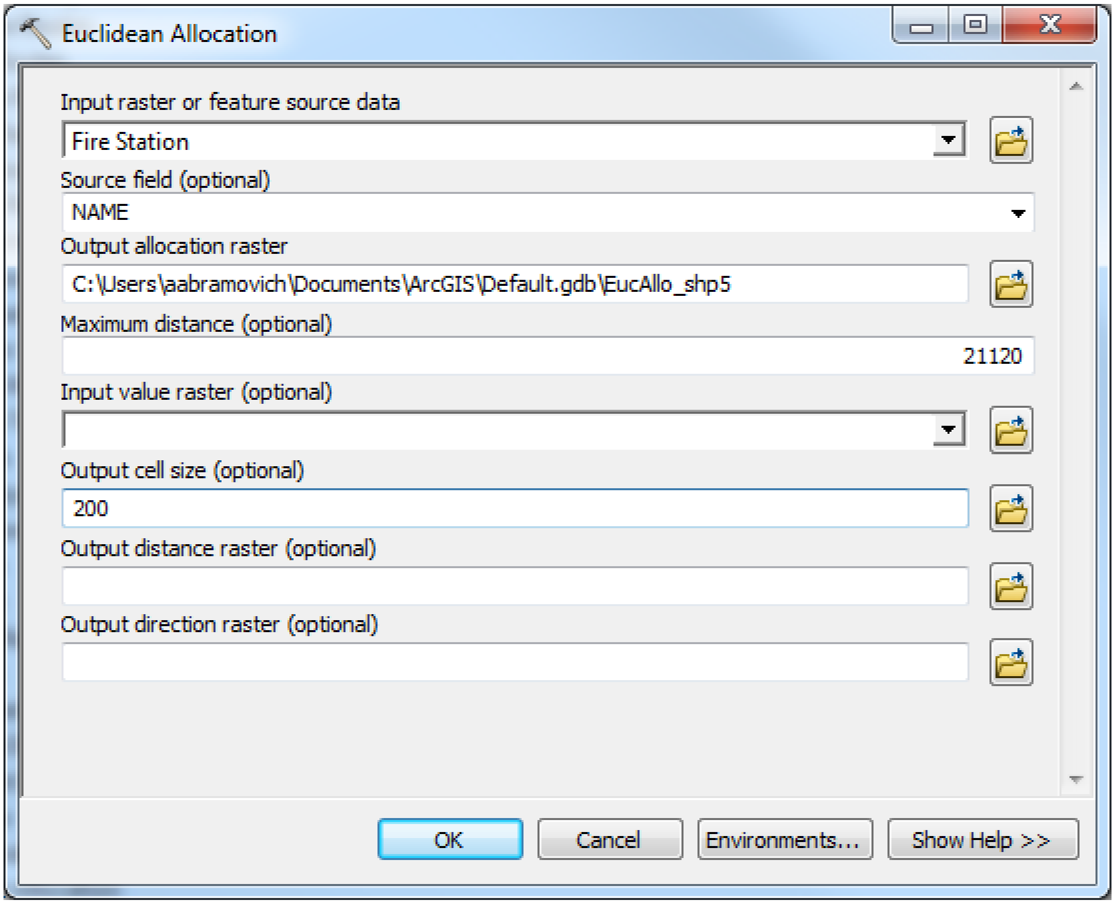


Figure 5.12 Euclidian allocation tool

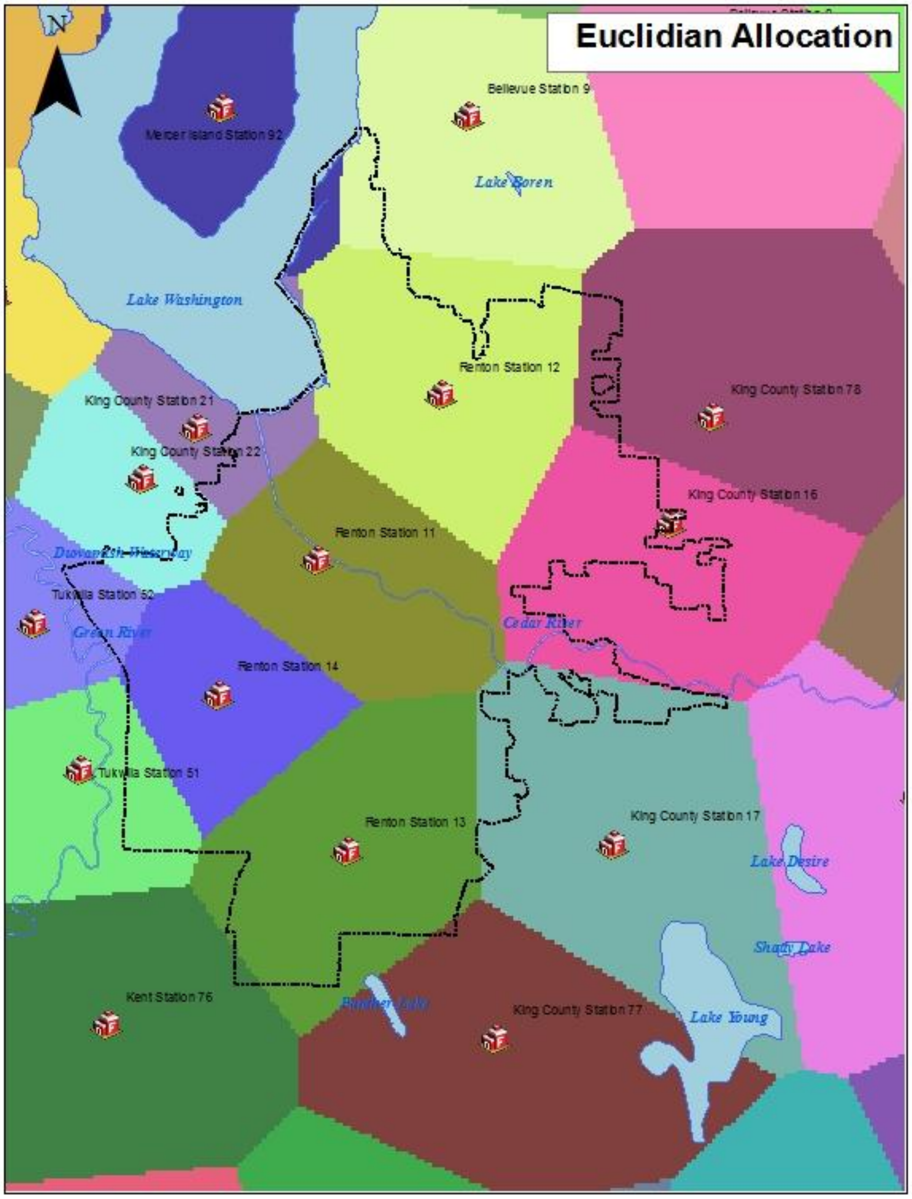


Figure 5.13 Map showing Euclidian Allocation

Euclidian allocation is therefore a very useful analytical tool. This type of analysis can be performed on a single fire station or simultaneously on all fire stations to analyze gaps in service coverage. In 5.13, the analyst mapped all of the fire stations both within and just outside of the city boundary.

Any analysis using straight line to measure distance has an inherent flaw when dealing with street grids or other types of networks. The distance measurements may cross an area that the network doesn't go (this statement is unclear, can you explain it more clearly? Esp what you mean by 'network') . The solution is to use Network Analyst to calculate the cost along the network. This analysis can be accomplished in ArcMap or ArcCatalog both integrated programs of ArcGIS Desktop. The following steps show how to calculate cost along the network:

- Turn on the Network Analyst tool;
- Add a new field to the street network feature class and name it MINUTES;
- Add the following script using the field calculator: Shape _Length / ((speedlimit * 5280)/60). The result is the time in minutes that it takes to traverse each line segment. If the street network doesn't include speed limit for each segment, you can use the street type as surrogate by assigning all major streets a faster travel time and assigning residential streets a slower travel time to due to their slower travel speed.

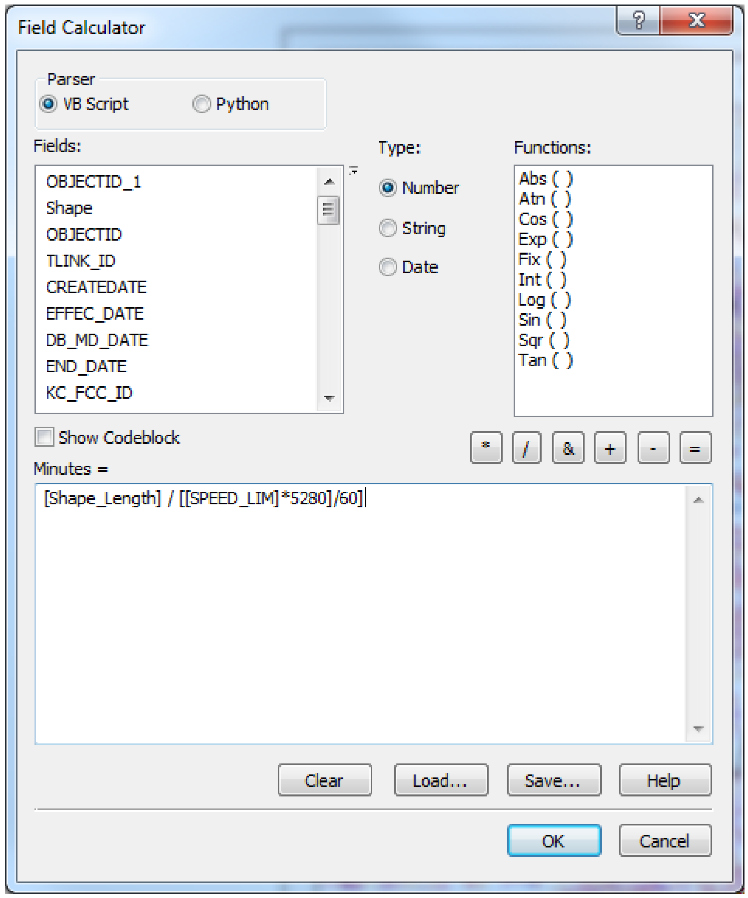


Figure 5.14 Script showing how to calculate how many minutes it takes to traverse each line segment

- Use the build entire network button command; when prompted to the full extend, then click yes.

This network will now let you do several types of network analysis including finding the nearest facility, an origin destination cost matrix and service area. The closest facility function is similar to the near point script used earlier, except that it measures travel distance along the road network instead of a straight line. So it is possible to map a service area based upon travel time, for instance, four, six or eight minutes. The steps are very similar to those followed with near distance or distance allocation tools. In the situation that an analyst does not have access to a full license of ArcGIS desktop with costly extensions such as Spatial Analyst and Network Analyst, then it is possible to use Business Analyst Online (BOA) as an alternative tool. It is important to note that Business Analyst Online has some limitations, such as, it can only show driving times. It can also overlap as shown on Chapter 2: Trade Area and Demographics. In BAO, the analyst can add shapefiles to the web map application such as the location of the fire stations. (Figure 5.15) During the explanation of geodemographics in Chapter 2, it was noted that BAO includes three tabs where the analyst can choose on the travel time from a location point.

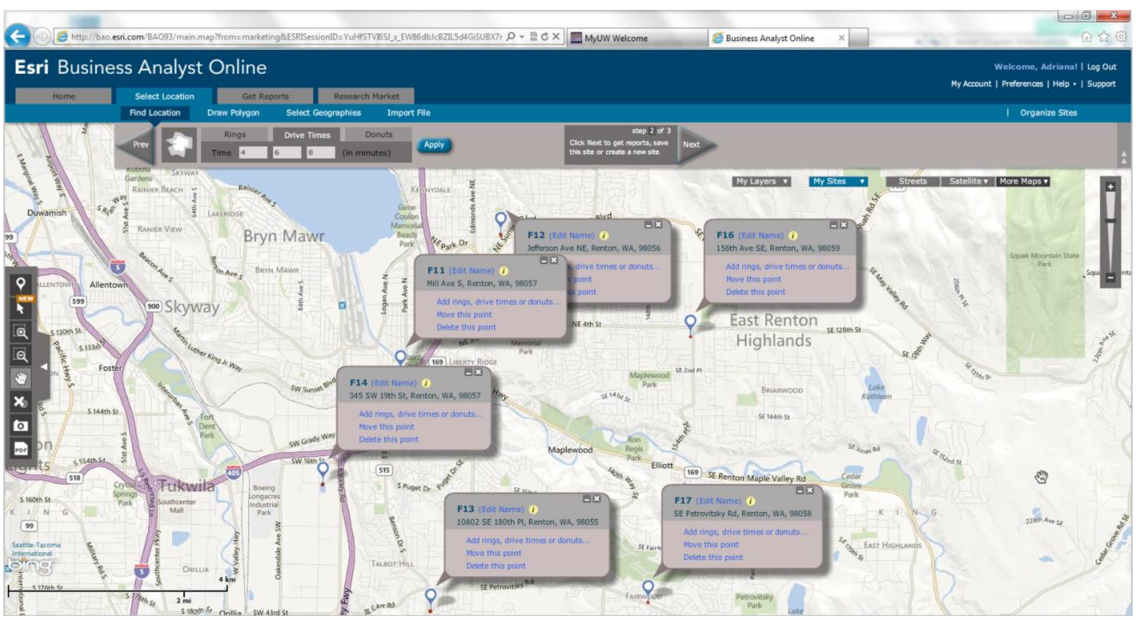


Figure 5.15 Map showing fire station labels with BAO

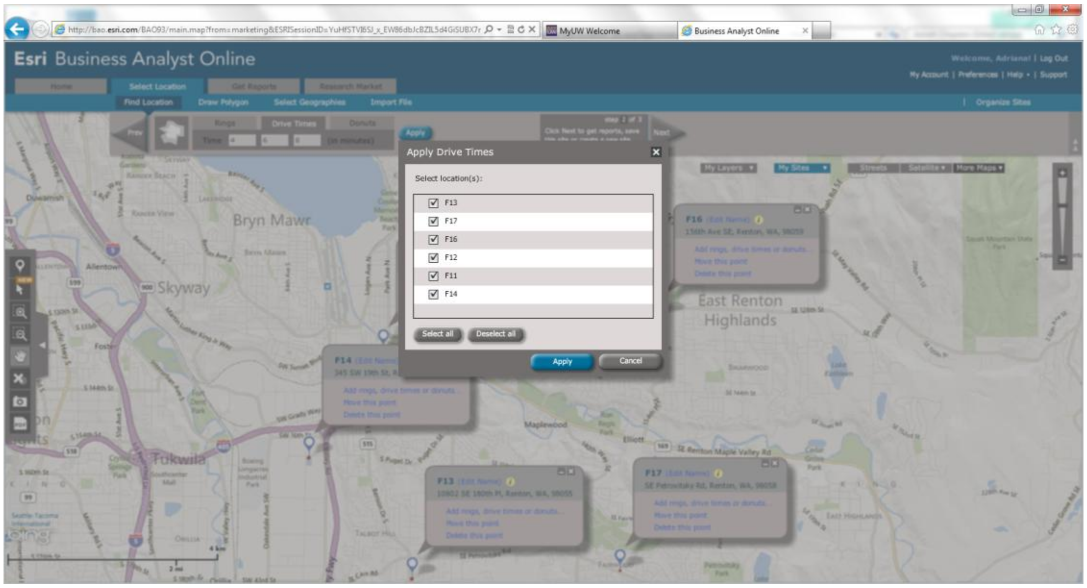


Figure 5.16 Screenshot showing location of fire stations and the set-up of driving time response to 4, 6 and 8 minutes

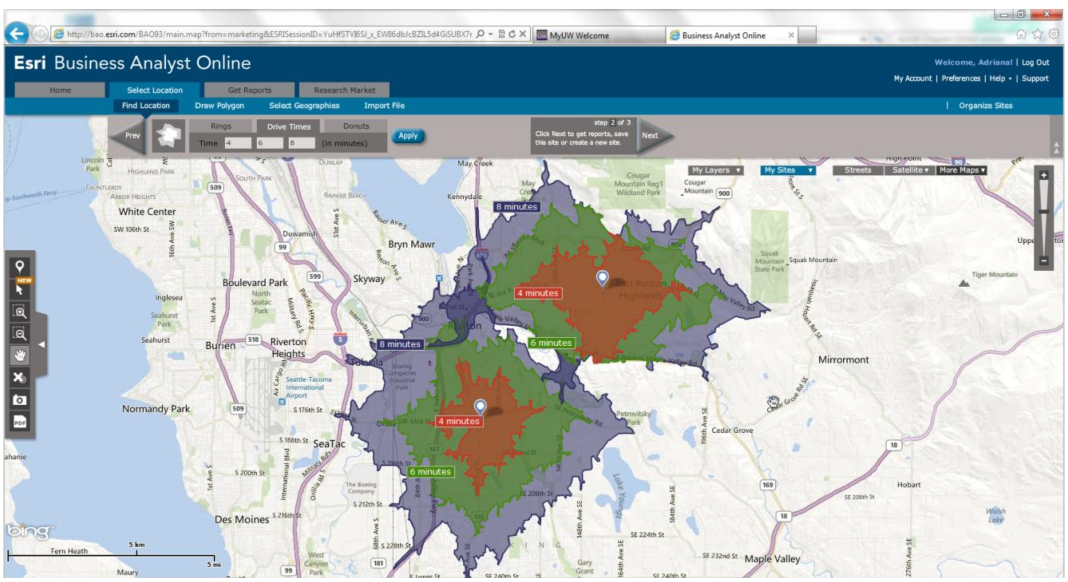


Figure 5.17 Map showing 4, 6 and 8 minutes time response for Fire Station 13 (to the north) and Fire Station 18 (to the south). The darker shade represents an overlap in service coverage between the two fire stations.

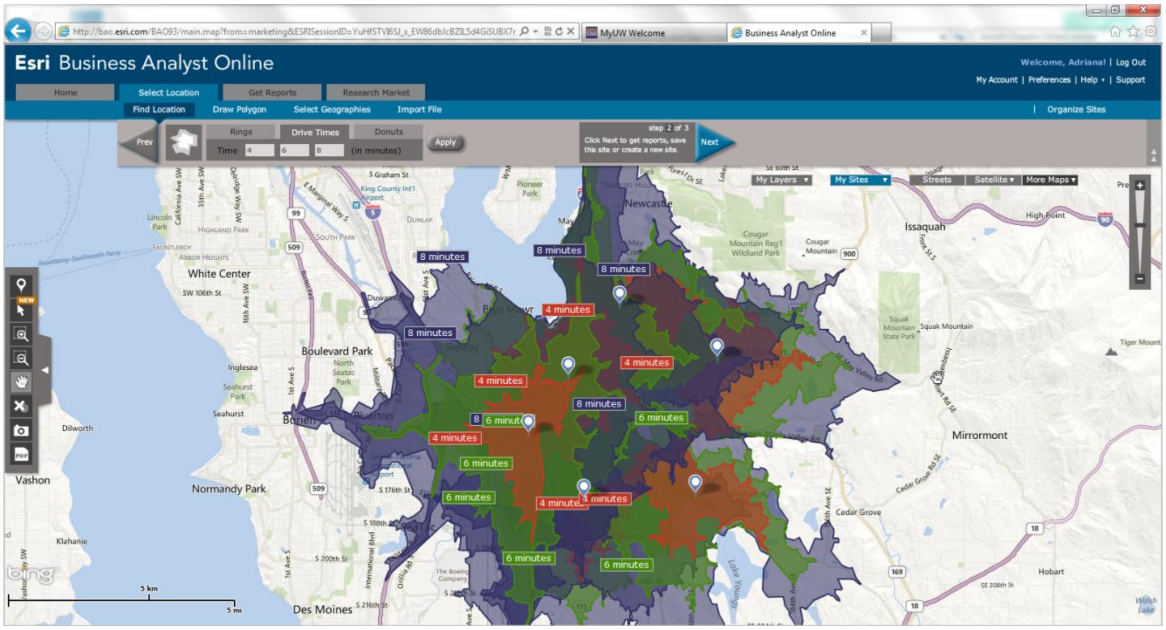


Figure 5.18 Screenshot response time of 4, 6 and 8 minutes for all fire stations. Darker shades show overlapping emergency service coverage

What is the recommended analytical process and programs that can be utilized by a company or agency use to select locations to avoid overlapping service areas?

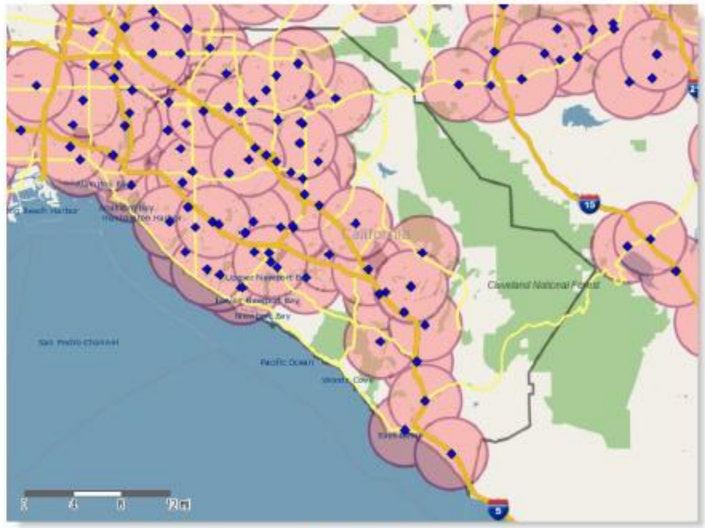
Case Study: Alteryx Advanced Spatial Analytics for Successful Retail Growth

Andy Verostek, Market Planning Analyst for Del Taco, the second largest Mexican restaurant chain in the country, was helpful in responding to this challenge. The Del Taco restaurant business has 528 current locations in sixteen states with most growth focused in the following locations: Southern California, Salt Lake City, Dallas, Denver and Orlando. During a meeting, Mr. Verostek was asked about his daily challenges. He responded with this list:

- Manage a spatial database of those franchise territories that have been sold;

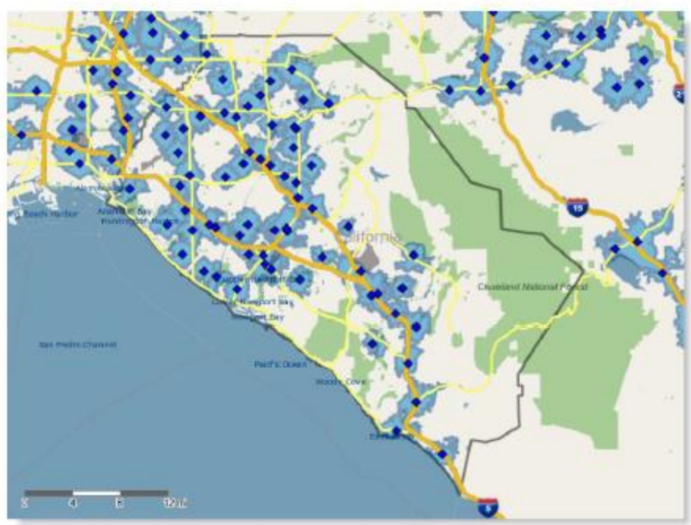
- Create a knowledge base of demographics/psychographic (measuring consumer behavior in a selected geography) on the store network;
- Report on the economic viability of proposed locations; and
- Explore new ways to access information.

The analysis provided by Mr. Verostek for Del Taco includes examining each trade area to identify low and high performers and to ascertain any patterns. The results are then tested against common knowledge with the process repeated again. He explained that trade area definition is “critical to their mission. Del Taco doesn’t use concentric circles because it is the less efficient. Drive time still can have double counting of data”. Standard drive time to designate a trade area can still lead to possible overlap which then can lead to over counting demographic information and result in a skewed analysis. Analysts at Del Taco prefer Alterix, an application which allows them to draw non-overlaying queries in a second.



Concentric circles – least efficient

Figure 5.19 Overlap of concentric circles



Drive time – still can have double counting of data

Figure 5.20 Less overlay with driving time

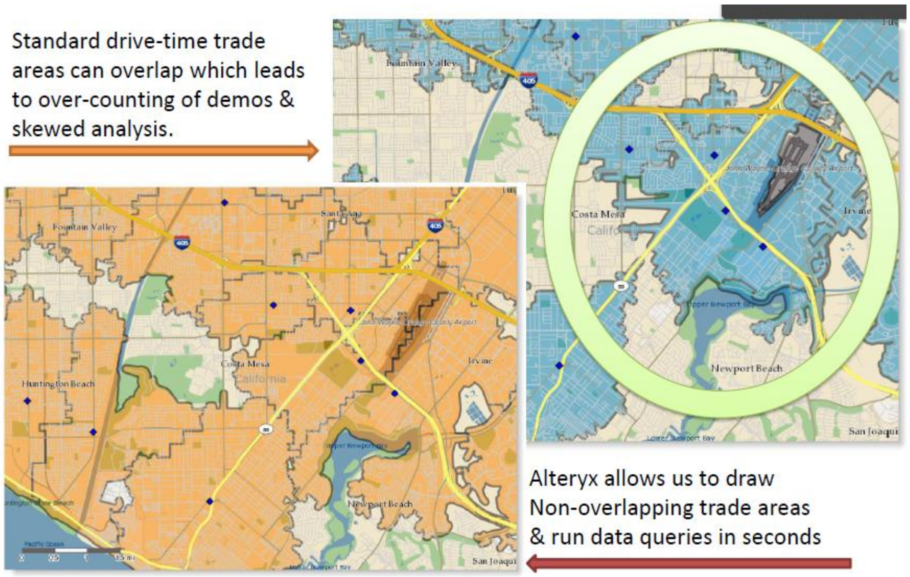


Figure 5.21 Alteryx allow better analysis of the population

Avoidance of overlapping drive time trade areas is the foundation of regression analytics. Once established, they allow accuracy in creating: proxy consumer profiles, distance decay models, cannibalization models and market optimization models. The spatial regression analysis yields more refined demographic data of the population within the trade area. Thus, it is possible to differentiate between different populations, e.g., daytime (employee) population, residential population, and seasonal or tourist population.

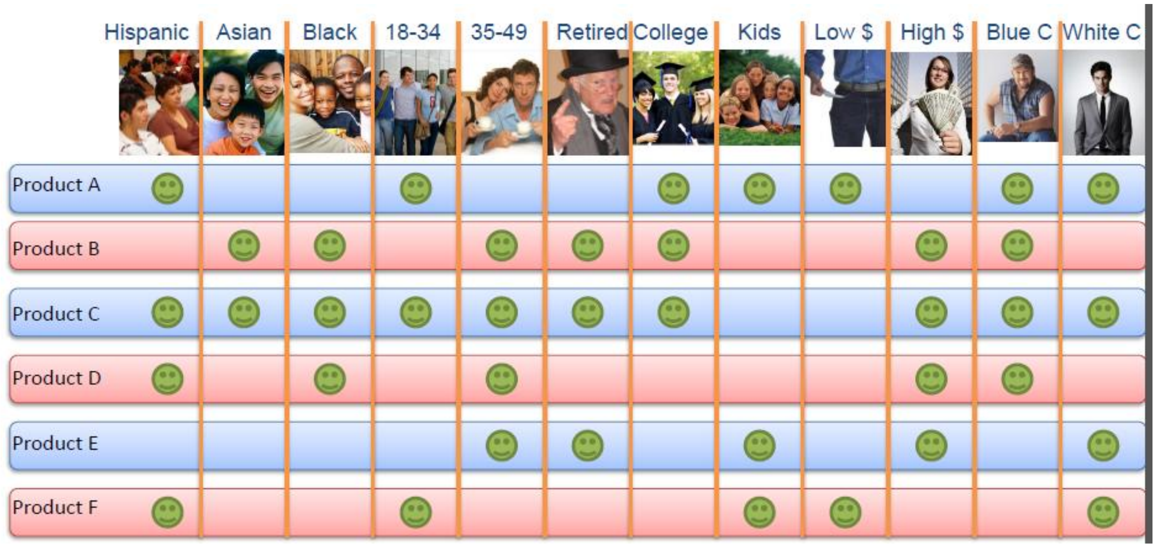


Figure 5.22 Diagram - Product appeal comparison via spatial regression

Although analysis of demographic data is important, especially for siting retail or services, there is valuable information that can be obtained from field visits. Mr. Verostek of Del Taco explained that they start with population density (figure 5.23), followed by median household income, and then look for shopping center areas where customers react to the brand. Although this analysis provides insight into factors affecting the demand for their restaurants, the marketing analysts at Del Taco follow up with onsite visits. Whereas the analysis gives information, the field visit confirms the information.

Population Density:

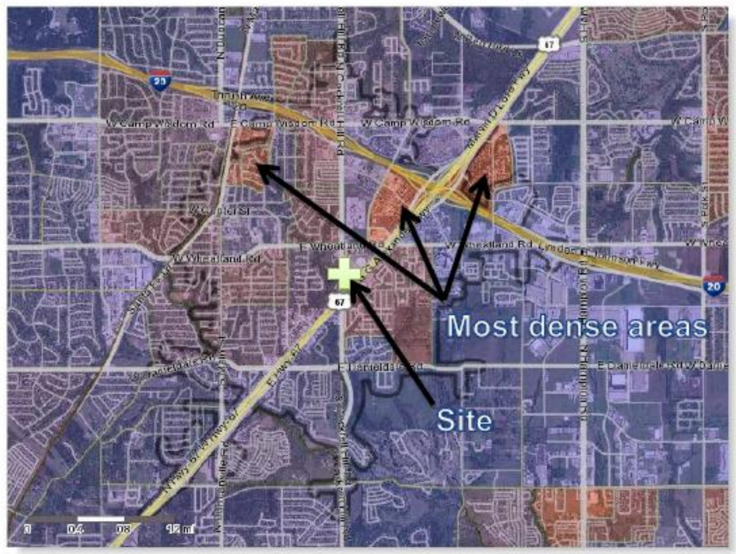


Figure 5.22 Step 1: Population density analysis

Population Density:

Figure 5.23 Identification of low and middle to upper income households

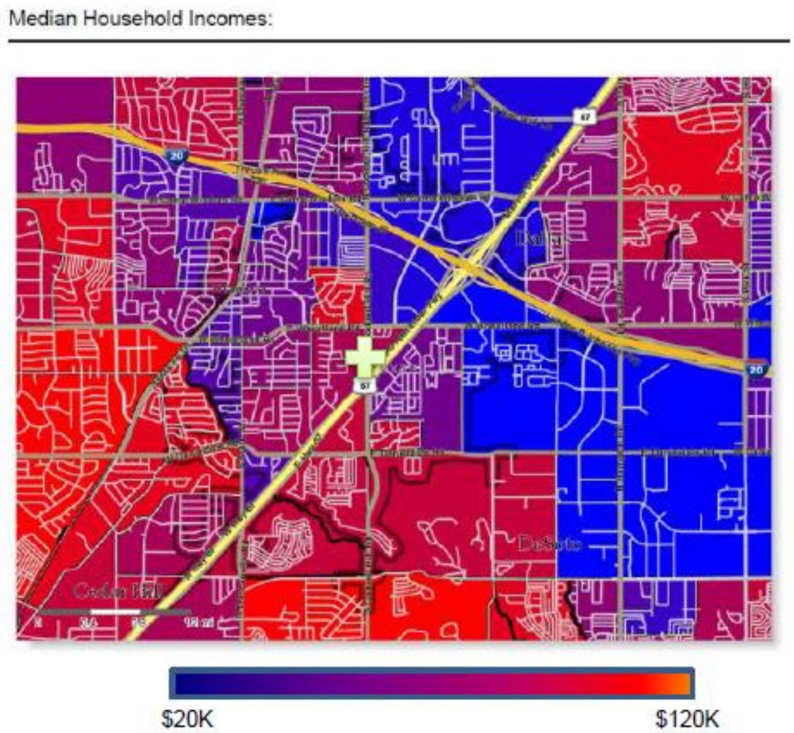


Figure 5.24 Median Household Income per census block group

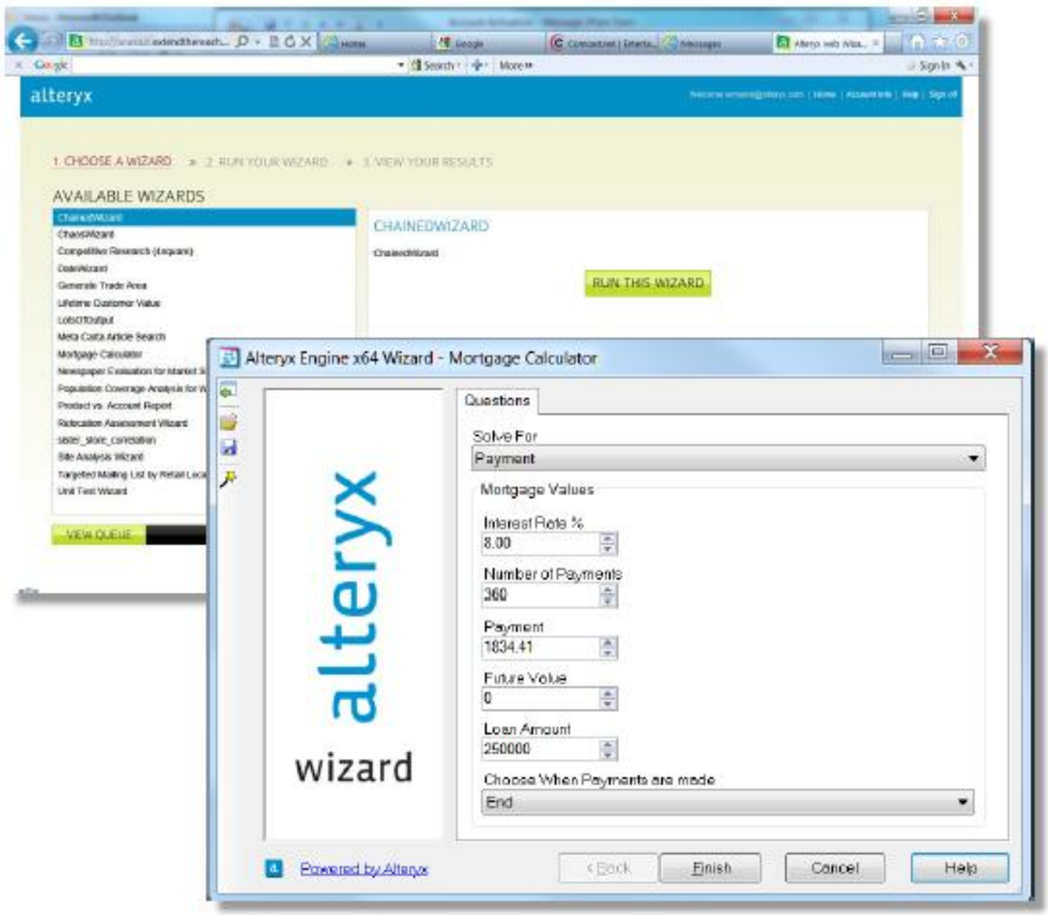


Figure 5.25 Alteryx interface

Del Taco has chosen Alteryx to run their business process, which has the benefit of providing access to a wide range of data for many locations.. Another benefit of Alterix is that this program doesn't require programming expertise in SQL, C++ or C#. The demographic data is stored and gets prepackaged in the cloud which optimizes business processes with real time business intelligence. It is data driven and has reusable report designs. The application includes a couple of wizards that responds to the company's needs. Mainly, it allows the parameterization of business processes for flexibility and reuse. Another source of data utilized by Del Taco is the third party vendor called PopStats which provides real time demographic data from that is updated three times per year. The appeal of this product is that it uses comparison via spatial regression analysis and also includes macros for repeatable processes to be crated for greater efficiency.

The following describes the analytical process possible in utilizing the Alterix program. From a database file with more than one hundred thousand records, Alterix filters and isolates one product code, spatially associated with non-overlapping trade area polygons. A multiple join tool merges both data streams together based on a common field name. The “a sequence” of filter tools organize the trade area by concentration of each demographic variable into six categories, with the number range of one equal to significantly above average and six equal to significantly below average. The summary tool then crunches the sales data.

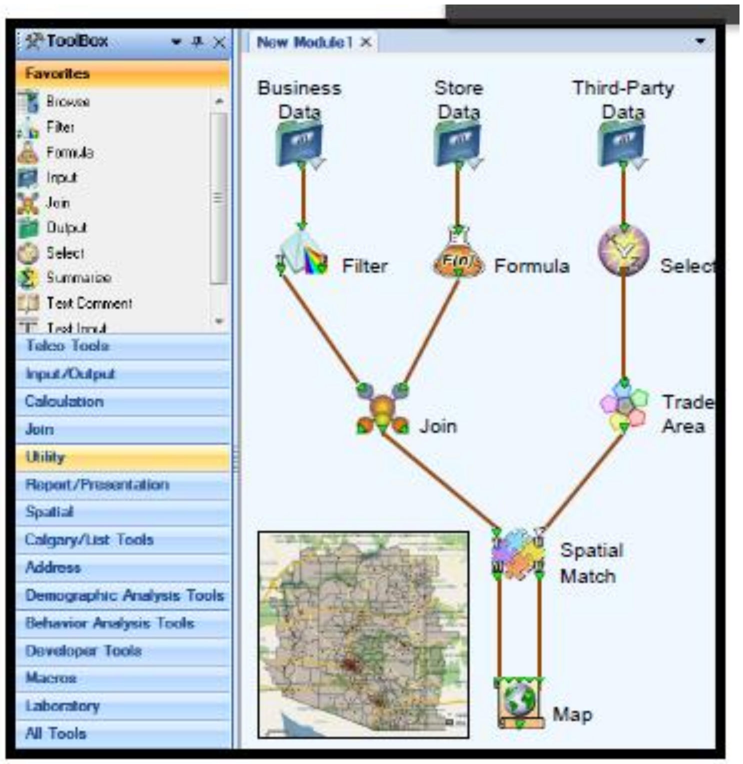


Figure 5.26 Modules are aggregation of tools

The process is repeated across dozens of variables. The results are then exported into any format; from excel tables to ESRI files or even pdf files. The data is layered on top of Google earth which has a customized interface that can depict most big box and chain stores in the country. Each store is represented with their own logo. While much of this information is already in Google Earth, the functionality of having each retail concept individually layered and labeled has broad applications. Additional layers include: trade area polygons, trade area demographics, field organization and franchisee territories. The following capabilities of the PopStats can been useful to a variety of businesses:

- Identification of the customer demographics for top performing stores. This can allow a comparison of the demographics for every researched site with the ideal location model according to age, income, employment, lifestyle, and more (Need to limit quotes from Del Taco or else it looks like you are promoting their business)Creating information-rich site maps and charts which can graphically display complex data, including up to 400 data points. This can facilitate analysis of the pros and cons of each potential location also gaining greater confidence from lower level decision makers. Since adding PopStats products to its market research, Del Taco's management team has found that the research can trump gut feeling. "Every prospective site is pre-screened with this technology so that our real estate team, corporate executives, and franchise owners have unbiased data on each location before they spend a dime. Recently, we looked at a site that on the surface looked great, but when I applied the data, the customer mix in the trade area was off base," Verostek said.
- Improving business success for franchisees with thorough analysis and careful site selection. "Sometimes franchisees will come to us with locations in mind, so we use our market research to evaluate their locations' pros and cons," explained Verostek. "They are usually impressed with the sophisticated insight and appreciate being able to evaluate sites for the best possible success."

From the interview process with Mr. Verostek of Del Taco, I learned that using spatial statistics allows for analyzing relationships and what happens when assigning variables to geographic areas. I found the analytical process of Alterix to be very similar to Business Analyst, the most expensive ArcGIS Desktop extension.

GIS Science

Coverage calculation for points is fairly forthright given that a point is either covered or is not. Establishing a maximum distance or travel time can then answer the question of how much service coverage can be provided with a limited number of facilities, such as fire stations.

The discovery of what is within traveling range of a feature can help define the area served by a facility. Traveling range is measured using distance time or travel cost. An analyst can evaluate what is within a set distance travel range of a feature class. This allows observing events in an area or discovering the area served by a facility of the features affected by an activity.

It is important to distinguish if you are measuring using travel distance or travel costs. Travel distance is the distance between two points and can be measured over a geometric network, such as streets measuring. Thus, locating specific points (facilities, events, etc.) nearby can be based on a set of distances or upon travel costs to or from a feature class, for example, a fire truck traveling from the fire station to a fire. Nearness doesn't have to always be measured using distance. You can also measure distance by using travel costs. Travel costs can include travel time and operating costs for vehicles. Time is one of the most common costs; it takes longer for a customer to get to a store through heavy traffic. Other costs include the operating cost per mile, for instance, the operating costs for a delivery FedEx truck. When mapping a feature the analyst can choose whether to use travel distance or travel cost. Mapping travel costs gives a more precise measure of what is nearby than mapping distance, but requires more data preparation and processing.

Knowing the kind of output desired will help choose the most appropriate method for analysis. It depends if you need a list, a count or a summary. Once the analyst identifies which features are near a source, it is possible to generate a list of features, a count or a summary statistic based on a feature class attribute. An example of a list of features is the parcel identification number and addresses of each lot within the radius of an ongoing project. Examples of a simple count include the total number of calls to emergency services or 911 within a mile of a fire station over a period of time or the numbers of calls by type of incident (fire, medical, police, gas leak). Sometimes the attribute information you have about map features is not organized the way you want—for instance, you have population data by county when you want it by state. By summarizing the data in a table, you can derive various summary statistics—including the count, average, minimum, and maximum values—and get exactly the information you want. ArcMap creates a new table containing the summary statistics. You can then join this table to the attribute table of a layer so you can symbolize, label, or query the layer's features based on their values for the summary statistics. Another example of a summary is the total amount of acres of land within an area zoned as RMF (residential multifamily), or the search for the average or the mean square footage of buildings within three minutes of each fire station.

For distance or cost, the analyst should specify the source locations and a distance or travel cost along each linear feature. The GIS finds which segments of the network are within the distance or cost. After that, the analyst can use the area covered by these segments to find the surroundings features near each source.

The question arises of how to select features within a specific distance. The answer is similar to creating a buffer.by using a selection tool to find what is within a certain area.. The analyst can specify the distance from the source and then GIS selects the surrounding features within that specified distance. For example, all addresses along center lines of the three- minute drive network. Therefore, an emergency team or firefighters have data of the total population that resides within a three-minute drive from their fire stations for whom they will provide service. A spider diagram is an alternative method to show the line between each location and its nearest source. Source location in networks is often known as centers as they usually represent centers to or from which people, goods, or services travel. If a location is near two or more sources, the geoprocessing command draws a line to each. The analyst can draw the lines in different colors to make it easy to see which locations area associated with each source. Spider diagrams are especially useful for comparing the varying patterns between several sources features, such as, distance and direction locations from a source. These diagrams can also display which source features have more locations points nearby compared to other source features.

Within all these approaches, GIS can calculate the distance based on a straight line or Euclidian distance using simple geometry. For mapping distance between features, the analyst can gather information, such as the distance to the nearest hospital from certain areas for an emergency helicopter landing; or the locations of all fire hydrants within 1,000 feet of a burning building.

When the input source data is a feature class, the source locations are converted internally to a raster before performing the Euclidean analysis. The resolution of the raster can be controlled with the output cell size parameter. The maximum distance is specified in the same map units as the input source data. The network analysis classes have attributes that specify the inputs and outputs for a given location-allocation problem. A facility in a location-allocation analysis is a point feature that represents a potential or required site, but it might also represent a competing facility. Competing facilities or services have overlapping coverage of a geographic area. In the case of emergency services, this is not entirely negative, although much overlap of services is financially costly and is not the most effective use of services. In the example of retail locations, there is a desire to avoid overlapping coverage of competing facilities in order to maximize their consumer base and market. The location-allocation solver chooses the best location for potential facilities in order to allocate demand to in the most efficient way according to premises set by response protocol.

Demand points class is typically a location that represents the people that require the service that a fire station or a business provides. For example, an earlier model for locating fire stations only required emergency response within four minutes to the person or business requiring assistance. However, the analyst needs to take into consideration mitigating factors, such as, an area with a high percentage of an elderly population, which might then require a faster response time of two minutes versus four minutes. The line class is an output only network analysis class and therefore contains line features that are generated by the solver during the solve operation. It contains line features that connect demand points to the facilities to which they are allocated. If a demand point is allocated to more than one facility, it has one line for each facility to which it is allocated. If a demand is not allocated to any facility, it won't have any corresponding lines. When the network analysis layer was created, the barrier classes were empty. They were populated only when objects were added into them. In the layer properties, I selected to maximize coverage so all emergency services arrive at all demand points within the specified response time.

Conclusion

In Chapter 5, I introduced the utility of location-allocation models which can be used for locating a variety of facilities and services, including fire stations and retail. I presented covering models based on the maximal distance to a point, travel time and network analysis. This chapter shows maps and steps that were used to analyze the service coverage of fire stations within and adjacent to the City of Renton, WA. This chapter also included an introduction on the use of ArcGIS tools and its extensions, such as, Spatial Analyst and Network Analyst.

Lastly, I provided a set of lessons learned from a market analyst working for the Del Taco restaurant chain. I reviewed the utility of software, including Alteryx and PopStats, which were utilized by the analysts of Del Taco to seek demographic information and identify potential restaurant sites. Additionally, I introduced a web-map application tool developed by Alteryx that resides in the cloud. I concluded that this tool has similarities to Business Analyst Online, and that spatial regression can be used in the selection of the perfect location.

Conclusion: Lessons learned and what the future holds

Location decisions have a major impact on the success of a store or emergency management agency. The saying, “location, location, location” emphasizes the importance of this decision. It can be very difficult to compensate for poor location decisions through various marketing practices such as pricing, merchandising or promotion. Space and location are the very core of the field of geography. Geographical theories, spatial methods, and spatial analysis results provide important tools for making informed decisions where to locate a business or facilities providing emergency services.

Given the importance of the location decisions, a number of analytical procedures have been developed for location analysis and site selection. The origin of location research can be traced to the practices of numerous entrepreneurs and managers who made location decisions based on their intuition and judgment. The wisdom underlying these decisions eventually was codified into rules of thumb. While subjective judgments and managerial experience for site selection continues to be important, the science of location decisions has evolved to a greater reliance on systematic and objective bases for location decision making. The result is the current array of techniques that focuses upon on finding optimal sites and even sales forecasting. To forecast sales or predict the success of a retail business or agency, the geographic area from which the outlet is likely to draw most its customers must first be delineated. The projected success is determined by the size and population characteristics of the trade area. Information on trade area size and demographic composition is also useful for obtaining a profile of potential customers.

The development of spatial interaction models for retail, and sales forecasting owes its origin to the work of David Huff. The Huff's model provided for the first time an approach that made it possible to look at the complex interactions within the total system of retail trade area in a potential market. Huff was the first to suggest that a trade area should be viewed as continuous and probabilistic rather than the simple nonoverlapping areas proposed by the earlier "gravity" formulations or the nearest center hypothesis of central place theory formulated by Christaller.

Trade and service area models can play an important role in location analysis. This approach should be limited to the addition of only a single facility or perhaps the closing of a single facility. Unfortunately, this type of analysis and location decision making is frequently used in practice to make decisions for several new facilities, since an optimal multisite pattern must be selected simultaneously rather than indepently, one at a time. If a change in more than one facility is desired, then the application of models designed for siting multiple facilities should be relied on.

Concurrently, the field of location-allocation modeling has grown into a well-established discipline. Location models provide an efficient, powerful technique for creating decision support systems for developing location strategies. Using the power of the computer, these models systematically evaluate a larger number of potential locations in order to find the best fit. While most early applications of location-allocation models dealt with public services, their use in retail site selection has increased rapidly.

Location is central to how people are organized and relate to their world. As information based society, we value systems and services that can provide data about the location of people, objects, and phenomena. The existing information systems reflect this, as most of the contents in databases are linked to location or geographic components.

In addition to contributions to the real estate industry such as retail organizations, real estate developers, and consultants, geographers have made important contributions to planning policy. It is the interest of developers and city planners to choose locations for businesses that take advantage of existing transportation systems. The business wants to assure that customers can arrive to their store and the urban planner wants to facilitate best use of transportation systems. An assessment of market potential is a key issue for the decision to open a new store or locate the next fire station. Market potential is both distance and location sensitive because potential customers and demand for services are not equally distributed across space.

Within this paper, I provide analysis of the following location models: a) line/network based; b) area-based and c) coverage-based. This paper is not able to discuss all classes of models in location theory due to the number that exists.

For the line-based analysis, I introduced the selection of a bus route based on total numbers of full time employees. With the example of locating a pipeline, I explained the implications of a network location for the adoption of new planning policy which also addressed public safety. These two line-based analyses have data associated to a linear location that have influenced the final decision on regulating future development or in choosing a bus route to serve the greatest ridership based on the number of full-time employees. It has been shown that the line based facility might be a path or a corridor, effectively a route between one location and another. The task is to identify a path through the network connecting an origin location to a destination location. Path and corridor are important problem contexts, often tied to GIS because of the ease with which a suitability and cost data layer can be derived.

In the area-based analysis, I shifted the study to the selection of the optimal location for a truck company and a federal agency. In employing spatial analysis with GIS, I addressed these problems using very basic geoprocessing tools such as selection, intersect, buffers, and overlays. When these tools are combined in a particular sequence, they can reveal more about the data. In both of these case studies there was no need to acquire or to create new data, because, as the GIS analyst I was able to extrapolate needed information from the existing data. This chapter illustrates how to incorporate spatial and topological properties, like contiguity. It is challenging and require greater mathematical sophistication and the explicit use of GIS.

In the coverage based analysis chapter, I introduced the usefulness of location-allocation models which can be used for locating a variety of facilities and services, including fire stations and retail. I presented covering models based on the maximal distance to a point, travel time and network analysis. The fire station example included an introduction on the use of ArcGIS tools and its extensions, such as, Spatial Analyst and Network Analyst. Covering models require rich, detailed geographic data to work from, especially when attempting to identify feasible sites, demand areas and derive coverage. GIS provides an ideal framework to support location planning and analysis where coverage standards are a feature of the model.

Throughout this paper, I have introduced new terminology such as geodemographics. As the name implies, geodemographics is the coupling of information recording location (the geo) with attribute data, such as demographic data. It refers to the analysis of people based on a statistical classification of the area in which they live. The classification aims to capture and differentiate between the important socio-economic dimensions of urban areas of varying geographical sizes: Census Tract, Census Block Groups or Census Block. The topic of geodemographics then led to discuss neighborhood tapestry and its importance for neighborhood retail targeting.

Since there are overwhelming number of geographic data and software products catering to those wishing to differentiate target populations according to the neighborhoods in which those populations live, I presented Business Analyst Online, a user-friendly tool that is readily available to real estate developers, business and planning agencies.

In every case study, my modeling tool of preference was extracted from the toolbox of ESRI Desktop version 10 software. I described how to use GIS to capture, store, transform, analyze and display geographic data. A geographic dataset contains both attribute and location information; the act of georeferencing adds geography to the data. A common georeference/geocode permits tables of data to be related and jointly manipulated. GIS functions connected with geodemographics allows the investigation of population characteristics through aggregation, overlay and point-in polygon analysis.

Along this process, I’ve learned that:

a) Most location models area defined in terms of spatial type of feature (e.g., point, line or area), by metrics (e.g., covering, cost) as well as by the number of amenities/buildings that need to be located. (e.g., one or multiple sites) ;
b) When presented with a specific type of problem, above classification can be used to find the proper model and the principal intent.
c) There are a range of location models classes. Not only classes, but within a class there are numerous varieties and extensions to the model.
d) This thesis doesn’t cover every model; it only covers models that aim to solve the following problems. They are:

Purpose	**Model**
• To locate one or multiple stores in order to minimize competing locations:	Median
• To locate a route or corridor across a territory or along a street network:	Line-based
• To maximize coverage given by serving locations (e.g., fire stations) or minimize cost in order to cover all demand:	Coverage-based
• To acquire land for same proposed use	Area-based
• To locate one or more stores in order to downgrade competitors market share:	Competitive
• To locate a route (e.g., public bus line extension to the Landing in Renton) along with access sites along the route to optimize service and capture largest amount of ridership.	Combined route and access

On my research, I've also found many other representative models to solve problems. However, I didn't have examples from my daily work to introduce a new model class.

There are problems that I expect to explore with the application of class models that allow: a) to locate a facility system that has defined level that are interrelated (e.g., UW Neighborhood Medicine clinics and hospital chain in the region) which requires the use of a hierarchical model class; b) to locate facilities in order to capture customers flow, where flow is based on travel patterns of potential customers that requires the use of flow capturing model class; c) select sites in order to protect endangered species as the Shoreline Master Program does in the State of Washington as well as many others.

It is unquestionable that the future of location science lies at the relation between GIS, modeling and an application field like business site selection. Products like Google earth or ESRI GIS viewer based on Microsoft Silverlight technology, cell phones with navigation capability can bring a rich variety of data to our fingerprints. Location based services is exploding not only through the use of cell phones but also with the introduction to the market of inexpensive tablets which are providing greater access to business data for customers. This means that in the future, consumers will no longer need to spot a business or go to the phone book to find out about a potential store or professional service. Indeed, an out of sight location now can be viewed in a navigation/mapping application and the prospective customer can be directed to that store. It also has been proved that companies such as Amazon have been able to expand their effective market are by selling over the Internet. Other business make sales over the Internet having their customers pick it up at their stores such as J. C Penny, Macy's and Nordstrom. Companies are very aware of this shift in doing business and are working toward the integration of business site selection models that contemplate potential of sales over the Internet. This is impacting banks with online banking, restaurants that allow online ordering of food; medical services that deliver test results, etc. There is so much potential to take greater advantage of GIS representation and functionality in problem solution that in fact I expect that many more model classes will be developed to be more efficient in the solution of these problems.

It is therefore rewarding to apply the capabilities of GIS models and the presented location theories and models to real-life examples. This leads to a greater potential of success in the delivery of services and economic success of businesses, while in my case, also helping a city planning department to achieve goals of efficient use of resources and transportation networks.

Glossary

Absolute accuracy - the degree to which the position of an object on a map conforms to its correct location on earth according to an accepted coordinate system.

Accessibility- An aggregate measure of the degree of ease with which a place, person, or thing can be physically accessed, depending on one or more given factors, e.g., slope, traffic, and distance.

Address - A designation of the location of a building, consisting of numerical and text elements such as a street number, street name, and city arranged in a particular format.

Address data - Data that contains address information used for geocoding. Address data may consist of one individual address or a table containing many addresses.

Address data format - The arrangement of address information in a database, most often consisting of such address elements as house number, street direction, street name, street type, city, and postal code.

Address data model - The rules of a geodatabase designed specifically to accommodate address-related material, such as streets, zones, ranges, and so forth. These rules define the address elements, their attribute values, and the relationships between them. An address data model facilitates address data storage.

Address locator - A dataset in ArcGIS that stores the address attributes, associated indexes, and rules that define the process for translating non spatial descriptions of places, such as street addresses, into spatial data that can be displayed as features on a map. An address locator contains a snapshot of the reference data used for geocoding, and parameters for standardizing addresses, searching for match locations, and creating output. Address locator files have a .loc file extension.

Address locator property - A parameter in an address locator that defines the process of geocoding.

Algorithm - A mathematical procedure used to solve problems with a series of steps. Algorithms are usually encoded as a sequence of computer commands.

Allocation - In network analysis, the process of assigning entities or edges and junctions to features until the feature's capacity or limit of impedance or progress is reached. For example, streets may be assigned to the most accessible fire station within a six-minute radius, or students may be assigned to the nearest school until it is full.

Analysis - A systematic examination of a problem or complex entity in order to provide new information from what is already known

Application - The use of a GIS to solve problems, to automate tasks, or generate information within a specific field of interest. For example, a common agricultural application of GIS is determining fertilization requirements based on field maps of soil chemistry and previous crop yields.

ArcGIS Online - A set of web-based maps, globes and other data and services created by ESRI (Environmental Systems Research Institute) for use by ArcGIS products and GIS applications on the Internet.

ArcWeb Services - ESRI-hosted Web services that include map data and on-demand geospatial capabilities needed to add real-time locations, addresses, points of interest, dynamic maps, and routing directions to Web and wireless applications.

Area -A closed, two-dimensional shape defined by its boundary or by a contiguous set of raster cells.

Attribute - Nonspatial information about a geographic feature in a GIS, usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station

Attribute data -Tabular or textual data describing the geographic characteristics of features.

Availability - The degree of ease with which a dataset or other object may be found or obtained.

Basemap - A map depicting background reference information such as landforms, roads, landmarks, and political boundaries, onto which other thematic information is placed. A basemap is used for locational reference and often includes a geodetic control network as part of its structure.

Best route -The route of least obstacle or interruption between two or more locations, taking into account various factors including connectivity and travel restrictions such as one-way streets and rush-hour traffic

Block Group - A unit of U.S. census geography that is a combination of census blocks. A block group is the smallest unit for which the U.S. Census Bureau reports a full range of demographic statistics. A block group is a subdivision of a census tract and includes approximately 700 residents.

Boundary - A line separating adjacent political entities, such as countries or districts; adjacent tracts of privately-owned land, such as parcels; or adjacent geographic zones, such as ecosystems. A boundary is a line that may or may not follow physical features, such as rivers, mountains, or walls.

Capacity - In location-allocation, the maximum number of people or units that a center can service, contain, or have assigned to it.

Census Block - The smallest geographic unit for which the U.S. Census Bureau tabulates decennial census data. Many blocks correspond to city blocks bounded by streets. In rural areas a census block may include several square miles with boundaries other than streets.

Census geography -Any one of various types of precisely defined geographic areas used by the U.S. Census Bureau to collect and aggregate data. The largest unit of area is the entire United States, while the smallest unit is a census block.

Census Tract - A statistical subdivision of a county that can include 2,500 to 8,000 residents, however, it generally includes approximately 4,000residents. A census tract is designed to encompass a population with relatively uniform in economic status, living conditions, and demographic characteristics. Tract boundaries normally follow physical features but may also follow administrative boundaries or other nonphysical features. A census tract is a combination of census block groups.

Data – Any collection of facts, statistics, and items of information which are arranged in a particular format; often, the basic elements of information that can be produced, stored, or processed by a computer.

Data integrity - The degree to which the data in a database is accurate and consistent according to data model and data type.

Data Model - A data model in software engineering is an abstract model that describes how data is represented and accessed. Data models formally define data elements and relationships among data elements for a domain of interest. Data model explicitly determines the meaning of data, which in this case is known as structured data (as opposed to unstructured data, for example an image, a binary file or a natural language text, where the meaning has to be elaborated). Typical applications of data models include: database models, design of information systems, and enabling exchange of data. Usually data models are specified in a data modeling language.

Database - A database is an integrated collection of logically related records or files that is organized so that the data can be easily accessed, managed, and updated for a variety of applications. Databases are classified according to content: bibliographic, full-text, numeric, and images. The data in a database is organized according to a database model. The model that is most commonly used today is the relational model. Other models such as the hierarchical model and the network model use a more explicit representation of relationships.

Defined study area - A study area with a defined boundary, such as a city.

Definition query - In ArcMap, a request that examines feature or tabular attributes based on user-selected criteria and displays only those features or records that satisfy the criteria.

Distribution - The frequency or amount at which an object, entity, or event or occurs within a given area. Measuring the distribution of a set of features allows calculating a characteristic of the distribution, such as its center, compactness, or orientation. The value can be used to truck changes in the distribution or to compare distributions of different features.

Donut - A method of defining the rings in an analysis so that the values inside the rings are exclusive. The donut only takes into consideration the values inside of the donut. For example, in an analysis with three donut rings and 10 households in each, the total number of households for each ring would be 10.

Extension - In ArcGIS, this is an optional software module that adds specialized tools and functionality to ArcGIS Desktop. Examples of ArcGIS extensions include: ArcGIS Network Analyst, ArcGIS Street Map, and ArcGIS Business Analyst.

Facility - In ArcGIS Network Analyst, a network location used in closest facility and service area analyses.

Feature - In GIS, a feature is an entity with a geographic location, typically describable by points, lines, arcs, or polygons. Roads, bodies of water and cadastral information are examples of feature data. Features are usually labeled.

Feature attribute table - A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In raster datasets, each row of an attribute table corresponds to a certain zone of cells having the same value. Attribute tables are often joined or related to spatial data layers and the attribute values they contain can be used to find, query, and symbolize features or raster cells.

Geocoding is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or zip codes (postal codes). With geographic coordinates the features can be mapped and entered into Geographic Information Systems, or the coordinates can be embedded into media such as digital photographs via geotagging. Reverse geocoding is the opposite: finding an associated textual location such as a street address, from geographic coordinates.

Geodatabase - A database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference system, attributes, and behavioral rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others. Geodatabases can be stored in Oracle, Microsoft Access, Microsoft SQL Server, and PostgreSQL relational database management systems, or in a system of files, such as a file geodatabase

Geoprocessing - A GIS operation used to manipulate GIS data. A typical geoprocessing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geoprocessing operations include:

geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion.

Geographic Information System (GIS) is a group of procedures that provide data input, storage and retrieval, mapping and spatial analysis for both spatial and attribute data to support the decision making activities of the organization.

GIS - Acronym for geographic information system. **GIScience** - Abbreviation for geographic information science. Considered as the field that research and studies the theory and concepts of GIS. It seeks to establish a theoretical basis for the technology and use of GIS. It also studies how concepts from cognitive science and information science might apply to GIS, and investigate how GIS interacts with society.

Gravity model – It is a model that assumes that the influence of phenomena or populations on each other varies inversely with the distance between them.

Hierarchy - A type of network attribute for a network element in a network dataset. Hierarchy can be used during network analysis to assign priority to a network element. For example, in a transportation network dataset, a "road class" hierarchy can be assigned to edges to favor major roads instead of local streets.

Identifier - A unique character string or numeric value associated with a particular object. Two features classes can be joined when they have a common identifier. The most common identifier for parcel is the Parcel Identification Number or PIN.

Integration -A high degree of interconnection between two or more programs or datasets, in which they share a common schema, ontology, semantic approach, or method that allows information to be passed between them without being fully processed.

Internet - The global network of computers that communicate through common protocols, such as TCP/IP.

Interoperability - The capability of components or systems to exchange data with other components or systems, or to perform in multiple environments. In GIS, interoperability is required for a GIS user using software from one vendor to study data compiled with GIS software from a different provider.

Interpolation - The estimation of surface values at unsampled points based on known surface values of surrounding points. Interpolation can be used to estimate elevation, rainfall, temperature, chemical dispersion, or other spatially-based phenomena. Interpolation is commonly a raster operation, but it can also be done in a vector environment using a TIN (Triangulated Irregular Network) surface model. There are several well-known interpolation techniques, including spline and kriging.

Intersect - A geometric integration of spatial datasets that preserves features or portions of features that fall within areas common to all input datasets.

Intersection - The point where two lines cross. In geocoding, this often refers to the cross point of two or more streets.

Joining -Appending the fields of one table to those of another through an attribute or field common to both tables. A join is usually used to attach more attributes to the attribute table of a geographic layer.

Kriging - An interpolation technique in which the surrounding measured values are weighted to derive a predicted value for an unmeasured location. Weights are based on the distance between the measured points, the prediction locations, and the overall spatial arrangement among the measured points. Kriging is unique among the interpolation methods in that it provides an easy method for characterizing the variance, or the precision, of predictions. Kriging is based on regionalized variable theory, which assumes that the spatial variation in the data being modeled is homogeneous across the surface. That is, the same pattern of variation can be observed at all locations on the surface. Kriging was named for the South African mining engineer Danie G. Krige (1919-).

Layer - The visual representation of a geographic dataset in any digital map environment. Conceptually, a layer is a slice or stratum of the geographic reality in a particular area, and is more or less equivalent to a legend item on a paper map. On a road map, for example, roads, national parks, political boundaries, and rivers might be considered different layers.

Layer file - In ArcGIS, a file with a .layer extension that stores the path to a source dataset and other layer properties, including symbology.

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Map query - A statement or logical expression that selects geographic features based on location or spatial relationship. For example, a spatial query might discover which points are contained within a polygon or set of polygons; find features within a specified distance of a feature; or find features that are adjacent to each other.

Matrix – An arrangement of data in rows and/or columns and usually organized by numbers. In computer science, a two-dimensional array is called a matrix.

Model - A model is a pattern, plan, representation (especially in miniature), or description designed to show the main object or workings of an object, system, or concept. Model may also refer to a: a) data model, a description of the structure of a database; b) mathematical model, an abstract model that uses mathematical language, or c) geoprocessing script created using ModelBuilder, a visual programming language included as part of ArcGIS Desktop Network which can display an interconnected set of points and lines that represent possible routes from one location to another. For geometric networks, this consists of edge features, junction features, and the connectivity between them. For network datasets, this consists of edge, junction, and turn elements and the connectivity between them. For example, an interconnected set of lines representing a city streets layer is a network.

Network analysis - Any method of solving network problems such as travel time, rate of flow, or capacity, using network connectivity.

Network analysis class - In ArcGIS Network Analyst, a feature class or table containing network analysis objects that is stored within a network analysis layer. Network Analyst solvers read input from, and write output to, network analysis classes.

Network analysis layer - A composite layer that contains the properties and network analysis classes used in the analysis of a network problem, and the results of the analysis.

Network analysis object - In ArcGIS Network Analyst, a feature or row in a network analysis class. Network analysis objects are used as input and written as output during network analysis. A network location is a specific type of network analysis object that has a defined position on a network dataset.

Origin - A fixed reference point in a coordinate system from which all other points are calculated, usually represented by the coordinates (0,0) in a planar coordinate system and (0,0,0) in a three-dimensional system. The center of a projection is not always its origin.

Origin-destination cost matrix - In ArcGIS Network Analyst, a type of network analysis that computes a table containing the total impedance or progress from each origin to each destination displayed in ascending order according to travel time.

Output data - Data that is the result of a geoprocessing steps using GIS software.

Parcel PIN - Acronym for parcel identification number. In Survey Analyst - Cadastral Editor, a unique identifier for a parcel. The format of an identifier is defined by the government's organization, and may contain numerical values, alpha characters, or both.

Parcel type - A classification for parcels, used to provide additional information about them and how they must be treated for least squares adjustment. Standard parcels, blocks, and easements are all examples of parcel types.

Path - The connecting lines, arcs, or edges that join an origin to a destination.

Process - One process, or multiple processes connected together, creates a model.

Query - A request to select features or records from a database. A query is often written as a statement or logical expression.

Shape -The characteristic appearance or visible form of a geographic object as represented on a map. A GIS uses points, lines, and polygons to represent the shapes of geographic objects.

Shapefile - A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

Shared boundary - A boundary common to two features. For example, in a parcel database, adjacent parcels share a boundary. Another example is a parcel that shares a boundary on one side with a river. The segment of the river that coincides with the parcel boundary shares the same coordinates as the parcel boundary

Store market analysis - A type of business analysis that uses mostly data about a store or stores, rather than about customers. Examples include ring studies and analyses of equal competition areas and drive-time areas.

Study area -The geographic area treated in an analysis.

Suitability analysis – is a process of systematically identifying or rating potential location with respect to a particular use.

Syntax -The structural rules for using statements in a command or programming language.

Traveling salesperson problem - A Hamiltonian circuit problem in which a salesperson must find the most efficient way to visit a series of stops, then return to the starting location. In the original version of the problem, each stop may be visited only once.

Web Map Server specification - A set of interface specifications that provides uniform access by Web clients to maps rendered by map servers on the Internet.

Web page - A page of information stored on a Web site and viewed in a Web browser. Web pages may contain text, graphics, animations, forms for data entry, and links to other Web pages.

Web portal - A Web resource that provides access to a broad array of related resources and services.

Zoning - The application of local government regulations that permit certain land uses within geographic areas under the government’s jurisdiction. Zoning regulations typically set a broad category of land use permissible in an area, such as residential, commercial, agricultural, or industrial. Zoning regulations can also set constraints on building construction within areas, which may affect factors such as the maximum height of structures, minimum setbacks from property lines, the amount of parking that must be provided, or the density of housing.

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