Chapter 3
Location Modeling for Logistics Parks

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3.1 Background

Location theory is an extensive field with hundreds of published papers drawing upon disciplines as diverse as operations research, operations management, regional science, geography, economics, computer science and mathematics. Some recent and well-known references that survey the field are Hamacher and Drezner (2002), Current et al. (2004), Revelle and Eiselt (2005) and Eiselt and Marianov (2011). Yet, the discipline suffers from a paucity of publications that involve real-life applications, especially case studies. This paucity is noted in Current et al. (2004), which begins with the statement "Much of the literature on facility location modeling has not been directed to specific applications (that is, case studies)" and pointedly reinforced in Revelle and Eiselt (2005, p. 15) who state "…when it comes to applications, there appears to be a significant deficit, at least as compared to other, similar, fields." This is of particular concern since substantial inefficiencies can occur if facilities are located sub-optimally—for example, Rushton (1988, p. 101), illustrates this fact in an application involving the location of health clinics in India. Despite this paucity however, there are a few applications of facilities location models documented in the published literature from a variety of different disciplines and countries, as first noted in Eiselt (1992). For example, Rushton (1988) contains references on the use of location-allocation models in siting public-service facilities such as health clinics and schools, in the developing world.

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H. A. Eiselt, V. Marianov (eds.), *Applications of Location Analysis,* International Series in Operations Research & Management Science 232, DOI 10.1007/978-3-319-20282-2_3

This work extends the extant literature on location related case studies based on a project related to the location of a Logistics park in the southeastern region of North Carolina, USA. While a portion of this work draws upon that project, the primary objective of this case study is more than to simply to describe the location modeling process used in that application. Instead, the main objective is to distill lessons learned that can help guide future academic research in location theory. To that end, this case study begins with solving the problem at hand using a theoretical approach so that a contrast may be drawn with how the modeling was done in practice. In turn, that contrast forms the basis of the final section on conclusions and lessons learned.

The remaining case study is organized as follows. Sect. 3.2 gives the necessary background to the case study by providing the contextual framework of the project and an introduction to *NCSE*, detailing the socio-economic and infrastructural information that informed the research. The next two sections are devoted to modeling the location of a Logistics Park in *NCSE*. While Sect. 3.3 details how a "theoretical" modeling approach would have worked, Sect. 3.4 describes the actual approach used when conducting the study within a structured framework, referred to by its acronym, *SIRC*. Sect. 3.5 ends this work by describing the follow-up to the Seven Portals Study, lessons learned and recommendations for location scientists involved in modelling real-life location/site selection problems.

3.1.1 Background: Logistics Parks, Seven Portals Study and NC Southeast

A "Logistics Park" is defined as a "development concept in which distribution centers typically seen in a suburban area are built in a park like setting, created by landscaping" (Gardner, Kansas Official Website 2015). It is usually populated by warehouses, distribution centers and logistics-related companies/offices. In almost all cases, it is also an intermodal facility where truck trailers and containers are transferred between trucks and the railroad. The concept of Logistics Park has been applied and used in various international settings and may be referred to by other names such as Freight Village, Güterverkehrszentrum, Interporto etc. Many such facilities exist throughout the world and a few examples include Burlington Northern Logistics Park (Illinois, USA), large cargo airports such as Hong Kong and Memphis, Pinghu Logistics Park in Shenzen, China and Schipol Logistics Park in the Netherlands. In the last decade, academic research has begun to emerge in location theory around logistics parks; for instance, Lee et al. (2001) and Lee and Yang (2003) discuss models and strategies for the location of such facilities, whereas El Amrani (2007) investigates the impact of international Logistics Parks on supply chains of multinationals. To the best of our knowledge, however, this case study is the first that is based on an actual application related to Logistics Park location.

As to the history of why the state of North Carolina undertook planning for locating Logistics Parks, one needs to begin with the state-wide strategic plan for logistics (List et al. 2008). In order to implement the same, the North Carolina State

Legislature established the Governor's Logistics Task Force (*GLTF*) on December 7, 2009 and assigned this group seven tasks (see *GLTF*-Final Report 2012) which included the following:

- "Conduct a thorough inventory and evaluation of existing public and private transportation and commerce assets, including ports, inland ports, airports, highways, railroads, major distribution centers, and business and industrial parks.
- Report on the current system for moving goods and people, including the condition of the system, its overall performance, and its safety.
- Project future needs for the state's multi-modal transportation system and explore challenges and opportunities in meeting those needs.
- Explore innovative ideas in transportation and economic development that can help support the state's logistics capacity, including public private partnerships."

The final report from *GLTF* (*GLTF*-Final Report 2012) details the accomplishment of all its objectives, including the four listed above. In order to implement its charge, *GLTF* undertook some key studies, one of them being the "Seven Portals Study" (List and Foyle 2011), which was administered by the North Carolina Department of Transportation (*NCDOT*). The purpose of that study was to "describe ways in which North Carolina's transportation infrastructure investments can help with economic development and the creation of jobs" (List and Foyle 2011). The overall goal was investigating potential Logistics Parks throughout the state and identifying what infrastructure improvements are needed to support such a facility at that location. It was made clear that the study would not recommend specific sites above others but merely present facts about each to assist the North Carolina State Legislature make the final decisions. The final report of the Seven Portals Study by List and Foyle (2011) was based on smaller regional reports each of which focused on one specific region of North Carolina. This case study focuses on one such region, namely, North Carolina's Southeastern Region (*NCSE*) (see Fig. 3.1) and is drawn, in part, from the final report submitted for the same (Bhadury and Troy 2011).

For purposes of regional economic development, the North Carolina Department of Commerce (http://www.nccommerce.com/) has divided the state into seven distinct geographical regions, each with an established "Regional Partnership" agency to foster a collective approach to regional economic development; see http://www.thrivenc.com/ for a complete listing. North Carolina's Southeast Region, abbreviated as *NCSE*, (see Figs. 3.1 and 3.2) is one of these seven. The region is composed of 14 counties stretching from the Atlantic Ocean to Sandhills region of North Carolina. The region's 500,000 strong workforce, is employed in a diverse cross-section of workers engaged in agriculture, wood products, manufacturing, wholesale trades (i.e., distribution), construction, healthcare, government and the professions. Economically, *NCSE* is substantially diverse. Along with a strong agricultural, wood products and food processing sector supported by companies such as Smithfield Foods, International Paper Company and Campbell Soup, it is also home to high tech companies like GE Nuclear Energy, Pharmaceutical Product Development Company (*PPD*) and Corning.

Fig. 3.1 Relative position of *NCSE* in *Eastern* USA

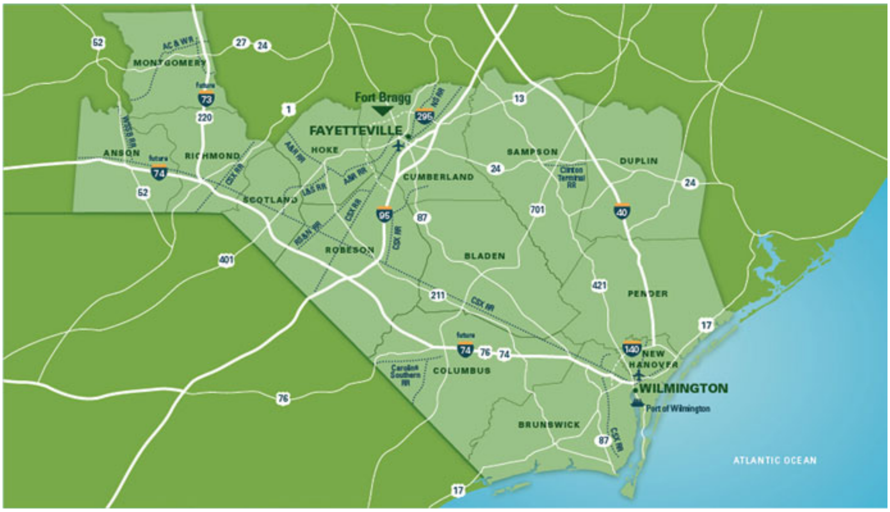

Fig. 3.2 North Carolina's *south east* region. (Source: http://www.ncse.org/)

Two sectors are of outstanding importance to overall economy of *NCSE* and deserve a special mention: military (Fort Bragg) and shipping (Port of Wilmington). As for the military sector, it is centered on Fort Bragg near Fayetteville. Established in 1918, Fort Bragg is now the largest US Army base by population in USA and includes 10 % of the US Army's active component forces. The base covers 161,047 acres and the military population comprises almost 60,000 officers and enlisted men and women with an additional 21,000 civilian workers employed directly by the army base. The *BRAC* (Base Realignment and Closure) process undertaken since 2005 by the US Department of Defense has contributed significantly to the growth of Fort Bragg. For example, European-based forces have been relocated to Fort Bragg. Additionally, several aircrafts are now located at Fort Bragg to form an Air Force Reserve/active duty associate unit as is Air Force Reserve Command operations and maintenance. Finally, *BRAC* has resulted in two major headquarters, Army Forces Command and Army Reserve Command to be located at Fort Bragg. With such a significant presence, it is no surprise that Fort Bragg and thus, the military sector, is a major economic driver in *NCSE*. The current annual payroll of Fort Bragg is estimated at $ 3.5 billion which generates a direct and indirect annual impact of approximately $ 10.9 billion in the immediate region (*NCSE* Regional Economic Profile 2013).

As for Port of Wilmington, it is North Carolina's sole container shipping port. The port is owned and operated by the North Carolina State Ports Authority (http://www.ncports.com) and offers terminal facilities serving container, bulk and break-bulk operations. The 42 ft navigational channel is complemented on the land side by available modern transit and warehouse facilities, state-of-the-art Panamax container cranes and support equipment, nine berths with 6768 ft. of wharf frontage and the latest in cargo management technology (North Carolina State Ports Authority 2015). Railroad service is provided by *CSX* Transportation which has daily service for boxcar, tanker and general cargo services. In order to facilitate the position of the port as a hub of international trade, it is a designated Foreign Trade Zone that is administered by North Carolina Department of Commerce. The port itself hosts almost 1 million sq. ft. of storage. The port has an annual traffic of over 2.1 million containers, which makes it smaller compared to the neighboring East Coast ports of Charleston, Savanah and Norfolk. Nonetheless, it provides container and bulk shipping to/from most world markets. Ocean carriers that call on the Port of Wilmington include major international shipping lines such as "K" Line America, Cosco Container Lines, Hanjin Shipping Company, Maersk Line and National Shipping Company of Saudi Arabia. As for the economic impact of the port and the shipping industry overall, Findley et al. (2014) estimate that this port has an annual economic impact of $ 12.9 billion and along with a smaller bulk port in Morehead City, supports 76,000 direct and indirect jobs.

Notwithstanding the above, the *NCSE* is a predominantly rural part of North Carolina, which suffers from significant unemployment and poverty issues. Figure 3.3 reveals that the region has few towns/counties that have a population above 1000. Also, as evident from Table 3.1, the region had an overall unemployment rate of 6.46 % as of December 2014 (above the state rate of 5.5 %) with 11 out of the 14 counties having a worse than state average unemployment rate. In particular, Scotland County, with a 10 % unemployment rate, was the 2nd highest in the state and has historically been in a similar position for a long while. With regards to family income, the picture is better balanced. As of end of fiscal year 2013-14, the average

Fig. 3.3 *NCSE*—towns over 1000, over 10,000 labeled

Table 3.1 *NCSE* counties at a glance. (Source: http://quickfacts.census.gov/, http://www.ncse.org/ and https://desncc.com/deshome)

County	Population (2014)	Median family income 2013-14 (US $)	Unemployment in Dec 2014 (%)
Anson county	26,948	34,659	6.6
Bladen county	35,190	42,473	8.1
Brunswick county	113,235	54,172	6.1
Columbus county	54,899	41,957	7.3
Cumberland county	344,167	55,675	6.3
Duplin county	58,710	33,172	6
Hoke county	46,265	49,400	5.7
Montgomery county	27,798	32,946	5.8
New Hanover county	196,320	65,219	5
Pender county	54,546	53,225	5.5
Richmond county	46,893	44,189	7
Robeson county	132,092	41,304	7.7
Sampson county	65,513	46,947	5.1
Scotland county	37,059	49,852	10.1
NCSE region (weighted average of 14 counties)		*51,091*	*6.46*
NC (overall)	*9,848,060*	*46,334*	*5.5*

Table 3.2 *NCSE's* employment profile (3rd quarter, 2012). (Source: http://www.ncse.org/)

Industry	Number of people employed in *NCSE* by the industry	Average weekly wages in the industry (in $)
Agriculture, forestry, fishing & hunting	6075	477.74
Mining	232	843.94
Utilities	2192	1576.91
Construction	15,764	713.37
Manufacturing	37,270	868.16
Wholesale trade	10,029	898.68
Retail trade	49,036	453.30
Transportation & warehousing	9910	786.35
Information	5068	841.25
Finance & insurance	7633	913.92
Real estate & rental & leasing	5210	648.31
Professional & technical services	14,642	1139.03
Management of companies & enterprises	2463	830.73
Administrative & waste services	19,126	513.31
Educational services	33,587	727.48
Health care & social assistance	61,993	760.62
Arts, entertainment & recreation	5557	333.21
Accommodation & food services	41,116	270.90
Other services except public administration	8360	483.12
Public administration	31,981	866.52

median family income was $ 51,091, which is higher than the state-wide average of $ 46,334. The $ 51,091 figure was buoyed primarily by the two urban centers in the region, Wilmington and Fayetteville, and the economic sectors around them. Overall, half of the region had a median family income below the state average. The distribution of the employment in this region across the various industry sectors and the median weekly wages in each are displayed in Table 3.2.

The region also has a strong logistical infrastructure for all modes of transportation. With regards to roadways, the bulk of this region is contained within a triangle of three major US interstates—Interstate 95, Interstate 40 and Interstate 73/74 and more importantly, the *NCDOT* has targeted these highways for improvement in the next decade. These three collectively make the region accessible to over half of the population of USA within one day's driving. Wilmington hosts North Carolina's only container shipping port, namely, the Port of Wilmington. The railroads in the region include both of USA's major freight carriers: *CSX* and Norfolk-Southern as well as several short-haul local lines such as Aberdeen & Rockfish, Carolina-Southern and Clinton Terminal Railroad. Finally, air service is provided at two primary airports: Wilmington and Fayetteville that offer connections via major American carriers such as Delta, US Airways, and American Eagle.

The regional economic development agency, known as North Carolina's Southeast (http://www.ncse.org/) has identified the following nine as the targeted industry clusters for future economic development of the region: advanced textiles, aviation and aerospace, biotechnology, building products, defense, distribution and logistics, energy, food processing and agri-industry, metalworking. As evident, critical to each of these is the presence of an efficient logistical infrastructure in the region including state of the art multi-modal Logistics Park with expeditious connection to the Port of Wilmington. This formed the basis for their desire to locate one in their region.

3.2 A Theoretical Approach to Determine the "Optimal" Location

In order to provide a contrast with how location decisions for Logistics Parks are made in practice as opposed to theory, we will begin with modeling the problem of locating a logistics park in *NCSE* as a traditional 1-median problem in location theory and analyze the results.

As is typical for any location model that seeks to determine the optimal location of a service facility, we have to begin by modeling the "consumers" of the services that would be provided by the logistics park. For that purpose, we represent *NCSE* as a collection of demand points on the two-dimensional Euclidean plane. With that, assume that there are N demand points located in *NCSE*, each of which is referenced as demand point i, where $i = 1,2,\ldots,N$. We assume here that each demand point represents an appropriately defined cluster of businesses or citizens of *NCSE* that are potential users of the services provided by a logistics park. It must be noted here that such aggregations essentially convert what is a location problem with continuous demand into one with discrete demand. In turn, that generates agglomeration errors that are well studied in location theory, see Francis et al. (2009) for a survey. Nonetheless, for purposes of illustration we will proceed with this demand agglomeration.

Further, for each demand point i above, let (a_i,b_i) represent the abscissa and the ordinate respectively and let w_i represent the total demand for the services provided by the logistics park. Additionally, let $X = (a_X,b_X)$ represent any arbitrary point on this same plane. Then, the l_p distance between X and demand point is i, denoted by $d_p(X, i)$, is given by the following formula:

$$d_p(X,i) = \left[|a_x - a_i|^p + |b_X - b_i|^p\right]^{\frac{1}{p}} \tag{3.1}$$

Perhaps the most commonly used version of (1) above is when $p = 2$, i.e., L_2 distance, given by

$$d_2(X,i) = \sqrt{(a_X - a_i)^2 + (b_X - b_i)^2} \tag{3.2}$$

As is well known, the l_2 distance formula (2) shown above is also known as the Euclidean, or straight-line distance, which measures the length of the line segment connecting X and demand point i. This metric assumes that travel takes place along straight lines, and without barriers.

Another distance function that is used, albeit less commonly is the squared Euclidean distance given by

$$d^2(X, i) = (a_X - a_i)^2 + (b_X - b_i)^2 \tag{3.3}$$

The squared Euclidean distance metric (3) assumes that the disutility of travel increases quadratically. For example, the disutility of commuting is more costly for the 2nd mile than for the 1st mile, and more costly for the 10th mile than for the 9th. There are two reasons behind this assumption. First, people normally get increasing disutility from higher levels of a bad thing, such as work or pollution. Secondly, there is an increasing opportunity cost of an individual's time as more and more time is spent driving. It must also be mentioned that this metric is widely used by practitioners in selecting locations for distribution centers and warehouses.

Another commonly used distance metric is the l_1 metric when $p = 1$, also known as the Manhattan metric or the rectilinear distance metric. In this case, the distance between X and demand point i is given by:

$$d_1(X, i) = |a_X - a_i| + |b_X - b_i| \tag{3.4}$$

Two good sources of information for different kinds of l_p metrics and their implications in practice are Brimberg and Love (1995) and Burkey et al. (2011). As shown in Brimberg et al. (1994) and Fernández et al. (2002), variants of the l_p norm with intermediate values of p between 1 and 2 best predict road distances in real-world applications. This is why the analytical results in this section include those for $p = 1.5$.

Notwithstanding the definition of distance, the objective of locating a Logistics Park would obviously be to be as proximate to the users as possible. To that end, for any given l_p-metric, the 1-median of these of demand points is given by a point X^*, with the property that

$$\sum_{i=1}^{N} w_i d_p(X^*, i) \leq \sum_{i=1}^{N} w_i d_p(X, i) \text{ for all points } X \text{ in } NCSE \tag{3.5}$$

In other words, a logistics park located at X^* would be guaranteed to have the minimum possible total weighted average distance to all the customer demand points $i = 1, 2, \ldots, N$, where the weight of each point i is w_i and represents the total demand at that point. It is useful to note that when $p = 2$, i.e., in the case of the Euclidean metric, the 1-median is also referred to as the Fermat-Weber point, a classical problem in geometry going back to the seventeenth century.

As for computing the 1-median for a given set of points, the best known algorithm is given in Weiszfeld (1937), which has recently been translated into English (Weiszfeld and Plastria 2009). Numerous improvements to the original Weiszfeld algorithm have been proposed over time, see Plastria (2011) for a comprehensive update on them. Finally, we note that in the special case where the distance metric used is the Squared Euclidean Metric given in (3), the 1-median is referred to as the *center of mass* or *center of gravity*—we will use the former term. Determining the center of mass is straightforward, as it involves taking the weighted average of the coordinates of the demand points. However, it is important that one uses a rectangular projection of abscissa and ordinate coordinates rather than longitude and latitude (which are spherical coordinates).

With the backdrop above, it is clear that an analytical approach to locating a logistics park in *NCSE* would essentially determine the 1-median as the optimal location. The next questions then are: how do we define the appropriate clusters to aggregate demand and what distance metric (i.e., the value of p) do we use in the distance calculation formula in determination of the 1-median. Given that many such answers are possible, we provide below an analysis of how different solutions for the 1-median problem (5) may be obtained based on different answers to each of the two questions above. We refrain from prescribing one solution over another, but do present a rationale for why they differ from each other.

The first issue that needs to be resolved is a determination of where people live or work in *NCSE*, since that information is the foundation of all location modelling. There are many choices for the demand points. Two broad categories of choices are (*i*) choice of demander, and (*ii*) choice of scale. The simplest choice to use for the demanders would be to use several specific points if there are only a few relevant demand points, e.g., specific distribution centers or factories. Another common option (for small area studies) is to use the number of people at the location of their residences as the intensity and location of demand points. However, in the current case, it might make more sense to use the location (and size) of businesses in formulating the demand points.

Whether one uses locations of people or businesses, the coarsest practical scale for *NCSE* would be to use the 14 counties as the demand points. The drawback to doing this is that one must assume a single point to represent many demand points that are spread out over a large area, probably non-uniformly. When using people to represent the demanders, the finest practical scale is to use census blocks or block groups[1]. The block is the smallest unit of data released by the US Census Bureau. Typically, only population counts are released at this level, and at roughly 29,000 blocks per county in North Carolina[2], might be unnecessarily fine. Table 3.3 gives a breakdown of several intermediate scales that might be chosen, using North Carolina's numbers for reference.

When using businesses as the demand points, the finest practical scale for most analyses is to use business data aggregated at the zip code level. A convenient source of such data in the US is the economic census from the *BLS*. For each zip code, data are available on how many firms there are, how many total employees work in these firms, and the total payroll.

[1] Though some work on a small scale, such as for a single city or county could use individual addresses as demand nodes e.g., Qabaja and Bikdash (2014).

[2] https://www.census.gov/geo/maps-data/data/tallies/tractblock.html.

Table 3.3 Various scales for data for North Carolina

Type	Number	Average size (mi^2)
County	100	486.19
Zip code (or *ZCTA*)	1048	46.39
Tract	2195	22.15
Block group	6155	7.90
Block	288,987	0.17

In what follows, we will compare several different solutions for finding the 1-median of *NCSE*. As mentioned above, the key difference in each solution is a different answer to how the demand is being calculated and what distance metric is being used. As for distance metrics, we will show the solutions for four different distance measures: $p = 1$ (l_1 or Manhattan metric, given in (4)), $p = 1.5$, $p = 2$ (l_2 or Euclidean metric given in (2)) and the squared Euclidean metric described in (3). As for estimating the demand points $i = 1,2,\ldots, N$, we will also compare using two different weights: the number of people living in each zip code[3] in the 2010 census of the population and how many employees were recorded working at businesses in each zip code in the 2012 economic census. Because codes often cross county boundaries, zip codes were selected if their centroids fell within the set of counties under study (Fig. 3.4).

Fig. 3.4 Different solutions to the 1-median problem for *NCSE*

[3] Or *ZCTA* (Zip Code Tabulation Area), an approximation of zip code boundaries using census data.

The results from the computation of the 1-median as given in (5) are shown in Fig. 3.4 and the endings *EMP* and *POP* are for points using employment and population as the demand weights, respectively. Here, l_1, $l_{1.5}$, and l_2 represent the distance metric used, and *MEAN* denotes the center of mass.

These results lend themselves to some interesting observations. First, note that all of the solutions result in locations in northern Bladen County, whose county seat is Elizabethtown with a population of around 4000 people.

Second, we see that all of the measures using employees as the weights are to the southeast of their counterparts weighted on population, which may be explained as follows. There are only two major cities in this region of 14 counties: Fayetteville/Fort Bragg, and Wilmington. Of the two, Fayetteville/Fort Bragg has a much higher population represented in its zip codes (256,233 vs. 186,140), but the number of employees counted in the economic census is about the same (78,155 vs. 77,164). Despite this, the observed shift to the southeast is likely to be due to the fact that while Fort Bragg and surrounding *ZIP* codes have a large population, relatively few of those employees, who are primarily employed in the military sector, would be measured by the economic census[4]. Therefore, one can expect areas with large military bases, universities, or other categories of employer not considered to be "industries" in the economic census are likely to see sizeable variation in results based on whether population or employees are chosen as weights.

A third interesting observation is that the centers of mass (labeled *MEANPOP* and *MEANEMP* in Fig. 3.4) are to the southeast of the 1-median obtained using l_1, $l_{1.5}$, and l_2 distance measures. The difference comes from the underlying objective of the two types of measures. While with the l_1, $l_{1.5}$, and l_2 we minimize the sum of the weighted distances, the center of mass minimizes the sum of squared distance. This means that points farther away will have a larger influence on the center of mass, because the square of a large distance becomes much larger than the sum of many medium-sized distances. Thus the distant lying sparsely populated regions of *NCSE* have tended to "pull" the center of mass in their direction.

Finally, note from Fig. 3.4 that all the solutions to the 1-median problem for l_1, $l_{1.5}$, and l_2 metrics in *NCSE* occur in an area that is largely agricultural land, and not in the middle of cities or towns. Also, several state highways (seen labeled with numbered ovals in Fig. 3.4) run nearby many of these locations, also with fairly convenient access to federal and interstate highways. This makes these sites well-suited for the location of a logistics park. Despite the same, Sect. 3.4 will make evident that none of the initial candidate sites selected in the actual implementation of the project were even proximate to the location indicated in Fig. 3.4. This discrepancy, in turn, is behind one of the key conclusion of this chapter that analytical results are, at best, only a small part of location modelling in practice. Other factors, be they social, economic or political, are usually much more important in influencing final outcomes.

[4] The economic census covers businesses of all sizes, but excludes most government-owned industries. Also excluded are schools (primary through university, including private schools), agriculture, and religious organizations (see http://www.census.gov/econ/census/help/naics_other_classification_systems/codes_not_covered.html for a complete list).

3.3 Location in Practice: Site Selection Process and Analysis

This section presents a synopsis of the actual approach taken in modelling the site selection process for a Logistics Park in *NCSE* and is based in large part on Bhadury and Troy (2011). The process followed may be structured formally within a framework that we introduce here and refer to by its acronym *SIRC*, which stands for the following steps that need to be executed in their prescribed order.

*Step 1 S*ituational analysis of the region where the logistics park will be located.

*Step 2 I*nitial selection of candidate sites for locating the logistics park in the region.

*Step 3 R*eadiness assessment for each of the candidate sites selected in Step 2 above. Such assessment should include current infrastructure, desired infrastructure for peak performance of the logistics park and the gap between the two.

*Step 4 C*ompetitive summary of the candidate sites, stating strengths and weaknesses of each. This step is obviously based on the data collected in the prior three steps.

While the *SIRC* framework is general enough to be used for any real-life location modeling problem, the remaining portion of this section is devoted to illustrating its implementation in the context of the current application.

3.3.1 Step 1 of SIRC: *S**ituational Analysis*

The application of this first step of *SIRC* comprised of collecting social and economic information about *NCSE* that is relevant to a public works project such as the location of a logistics park. Such information comprised of population, employment, labor wages and their trends. Information was also gleaned about the industry clusters that were targeted for development by the regional economic development agency. Besides studying published reports, 14 interviews were held with 34 selected industry leaders, economic development officials, public officials and senior management from the existing logistical facilities such as Port of Wilmington, Wilmington International Airport, Fayetteville Airport, Laurinburg-Maxton Airport and International Logistics Park to name a few. The objective of these interviews was to collect background information and assess the current and anticipated logistical needs of the region and their views on the Logistics Park in *NCSE*. The results from this first step of Situational Assessment forms the basis of most of the information presented in Sect. 3.2 above.

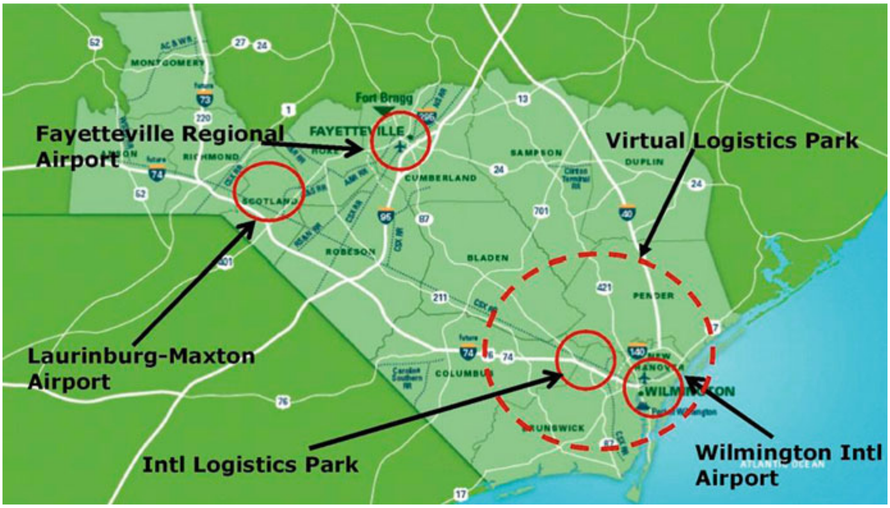

Fig. 3.5 Initial candidate sites

3.3.2 Step 2 of SIRC: I*nitial Selection of Candidate Sites*

The next step in the location modelling process is to select initial candidate sites for location. In this case, this was done on the basis of the data collected in the first step and an analysis of all available sites across the *NCSE*. The criteria used for the selection were sites proximate to highway, rail, and air access and having at least 400–500 acres of developable land to accommodate the needs of the companies that were expected to locate in the logistics park. Additionally, the opinions and ideas of the local economic and political leaders, as gleaned from the interviews, weighed heavily on the decision making process. Based on all the above, four sites were finally selected as candidate sites for locating a logistics park[5] and as depicted in Fig. 3.5, they were as follows: Laurinburg-Maxton Airport (*MEB*); Fayetteville Regional Airport (*FAY*); International Logistics Park of NC (*ILP*) and Wilmington International Airport (*ILM*). Additionally, as a result of numerous interviews and research conducted to evaluate the four designated sites, the research team added a fifth possible site, a "virtual logistics park" for the Greater Wilmington Area. A brief overview of each site is presented below.

[5] An analytical approach to the modelling would have selected all sites in *NCSE* that matched the criteria being used, consider this entire set as initial candidates for location and determine the optimal location of the logistics park by solving the for the 1-median of this resulting discrete location problem. Nonetheless, other factors (preferences of interviewees, need for economic development in economically depressed counties, need to promote sites that were already developed etc.) prevailed and contributed to only the above four sites from this set being selected as candidate sites in Step 2 of the *SIRC* process.

1. *Laurinburg-Maxton Airport (MEB):* The Laurinburg-Maxton Airport (see http://www.lmairport.com) is a small airport that is located in a rural region that borders Scotland and Robeson counties and is operated by the Laurinburg-Maxton Airport Commission that reports to the governing bodies of the cities of Laurinburg and Maxton. No commercial flights operate at *MEB* and its chief current use is for military training. Among the features of this small airport are a 6500-foot lighted runway, equipped with high-intensity lights, new *LED* taxiway edge lights, signage and pavement marking and a new and full *ILS* (instrument landing system). It also serves as the last landing site for many planes that are targeted to be decommissioned. *MEB* offers significant opportunity for development as a result of the availability of developable land, adequate and improving roads, and ready access to most infrastructural needs. In addition, as a direct result of its location, *MEB* can serve as a link to the Port of Charleston making it an attractive site as a distribution center for both North and South Carolina as well. However, the airport currently lacks a strategic plan and facilities need major costly improvement and while there are immediate plans and funds available to improve two of the three runways, the improvements do not fill all the needs and requirements to make *MEB* truly competitive. In addition, the area has access to national railroads operated by *CSX* but to take full advantage of these resources costly rail connections are needed. Finally, while most infrastructure is available at the *MEB* site, much of it needs substantial upgrades and retrofitting.
2. *Fayetteville Regional Airport (FAY):* Fayetteville Regional Airport (http://www.flyfay.com/) is located in Cumberland County and is operated by an airport director for the City of Fayetteville. The primary advantage of this as a possible site for a logistics park is proximity to potential demand given the industrial presence around Fayetteville and the growing military sector in Fort Bragg. The site is geographically well located with regards to US interstates. It has access to *CSX*, Norfolk Southern and short line railroads; while these connections are not on the airport site, they are all located within the City of Fayetteville. The area is also in close proximity to major interstate highways, the Port of Wilmington, Research Triangle Park, recreational facilities and developable land including shovel ready sites. In addition, and perhaps most significantly, it is located near an expanding military facility of Fort Bragg.
3. *International Logistics Park (ILP):* The International Logistics Park of North Carolina (http://brunswickedc.com/sites-buildings/available-sites/international-logistics-park-of-nc) is built on the Columbus/Brunswick County line on US 74/76 just 15 miles from the Port of Wilmington. This is important because the Port of Wilmington promotes the "At Port" site location model whereby facilities (e.g., warehouses, distribution centers) located within 20 miles of the port enjoy the same state, regional, local and port tax incentives as those located within the port premises and a lower rate from trucking companies. *ILP* is a joint venture between Brunswick and Columbus Counties, and has an undeveloped 1100 acre park that hopes to capitalize upon the "at port" site location promoted by the Port of Wilmington. The most significant attribute of *ILP* is the vast amount of developable land that includes shovel ready sites where utilities, gas, water electricity and sewer are readily available. Further, the existing roads and

planned road projects make *ILP* accessible, especially to the Port of Wilmington and Wilmington International Airport. Although *ILP* lacks a rail connection, located directly across the street is the site of another large industrial park, the Mid-Atlantic Logistics Center, that has *CSX* rail access.

4. *Wilmington International Airport (ILM)***:** The Wilmington International Airport (http://www.flyilm.com/) is located in New Hanover County and serves southeast North Carolina. The airport, located off I-40 and I-140, is operated by the New Hanover County Airport Authority. Although underutilized, it is a full-service airport that offers commercial, cargo and general aviation facilities and a state of the art Federal Inspection Services (*FIS*) facility. Runways are adequate and expandable to meet demand. Shovel ready industrial sites that meet the Port of Wilmington's "at port" location criteria are available at the airport and larger tracks of developable land are located nearby in Pender, Brunswick and Columbus Counties. The existing basic infrastructure (communications, water, sewer and power) at *ILM* may be classified as being of average quality. The airport also has at-site rail service with an indirect link to the Port of Wilmington. In addition, the high quality of life in the area provides the ability to attract highly skilled workers. However, a weakness for *ILM*, like the nearby International Logistics Park, is its risk exposure to the future viability of the Port of Wilmington.
5. *A "Virtual Logistics Park" for the Greater Wilmington Area:* The final assessment of the research team was an innovative idea that, to the best of knowledge of the authors, has never before been mentioned in the location modeling literature. This was to create a "virtual logistics park" from the Greater Wilmington area that comprises of all logistics assets of the region and is coordinated by a central organization to work synergistically as a unified and coherent institution. These assets include: Port of Wilmington, *ILM*, *ILP* discussed above but also two additional industrial parks in this region, namely, Mid-Atlantic Logistics Center and the Pender Commerce Park all of which are within 30 miles of each other. There are numerous reasons in support for this idea. First, geographical proximity puts all of these existing industrial parks within the requirement to be considered "at port" with regards to the Port of Wilmington. Second, the "virtual logistics park" collectively has all modes of transportation—shipping (Port of Wilmington); air freight (*ILM*), rail (*CSX* rail access at *ILM*, Port of Wilmington as well as Mid-Atlantic Logistics Center) and abundant trucking services. Additionally, developable land parcels of all sizes, many shovel-ready, are found in the metro area and/or *ILP* and the Greater Wilmington area has excellent utilities infrastructure (communications, water, sewer and power) to accommodate growth. Therefore, all that would be needed to create a "virtual logistics park" would be some minor infrastructure needs and for the area's political and economic leaders to work together and cooperatively in creating an umbrella organization to administer this park as one coherent entity. And it is this last condition that engenders the most important challenge involved with the "virtual logistics park," namely, the practical difficulties involved in initiating such an entity that brings all these disparate organizations under one umbrella and thereafter, getting them to work cooperatively towards common regional goals rather than individual ones.

3.3.3 Step 3 of **SIRC: R*eadiness Assessment of Candidate Sites***

This step is the heart of the location modeling process espoused by the *SIRC* framework. As implied in the title, this step was devoted to conducting an in-depth assessment of each of the five candidate sites mentioned in Step 2 above and on the basis of the same, develop a comprehensive summary of the site's logistical assets, shortcomings and an estimate of what improvements would be needed to locate a regional logistics park at that site and time and cost estimates of the same. After reviewing existing practitioner literature and speaking to local economic developers, it became clear that for each site, the research team would have to focus on all infrastructure within a 10 and 60 miles radius since those would be the most heavily impacted areas if a logistics park was located at the site. In order to assess the local workforce available to work at companies expected to operate within the logistics park, existing commuter data for the state indicated that examining the workforce qualifications within a 30 min drive time from each site would provide the best information. Finally, it was important to study and assess the facilities available at the site itself. As an example of this portion of the location modeling, see Fig. 3.6 for an example of the 60 miles radius area examined for the *FAY* site. Also, Fig. 3.7 shows the 30 mile radius that comprises the "virtual logistics park."

After examining the areas mentioned above, three tables were produced for each site. The first table, labeled the "assessment matrix" presented an overall summary of the readiness of each site. The second table, labeled "site summary" presented detailed information on existing infrastructure such as roads, airports etc. at each site and the improvements to them that would be needed in order to locate a logistics park at the site. The third and final table was based on the first two and summarized the strengths, weaknesses and recommendations for each site. See Tables 3.4, 3.5 and 3.6 for examples of what was produced for the *FAY* site.

This was followed by a narrative explaining the basis for the information presented in the three tables. For example, the narrative accompanying the assessment of the *FAY* site was as follows (see Bhadury and Troy 2011):

"The Fayetteville Regional Airport (*FAY*) is located in Cumberland County and is operated by an Airport Director for the City of Fayetteville. Cumberland County is a Tier 2 county and has an unemployment rate of 9.2 % (November 2010) and is home to an increasingly important military base, Ft. Bragg. . . . "Proximity" is the key word needed to understand the Fayetteville Regional Airport area and its potential as a 'logistics village.' Fayetteville is located half-way between Miami and Maine. It is on I-95 and 30 min away from I-40. Although not at the airport, the area has rail access on *CSX* and *NS* as well as a local short line railway. It is near the Port of Wilmington, Research Triangle Park and recreational facilities at the ocean and near the Pinehurst resorts. In addition, and perhaps most significantly, it is in very near the expanding Ft. Bragg. Airport facilities are in good condition with a 6500 ft. runway that could be expanded to 8500 ft. The airport has several parcels of land available for development and adjoining land in private hands could be developed as well. Furthermore, additional industrial land is available in the immediate area. Some of

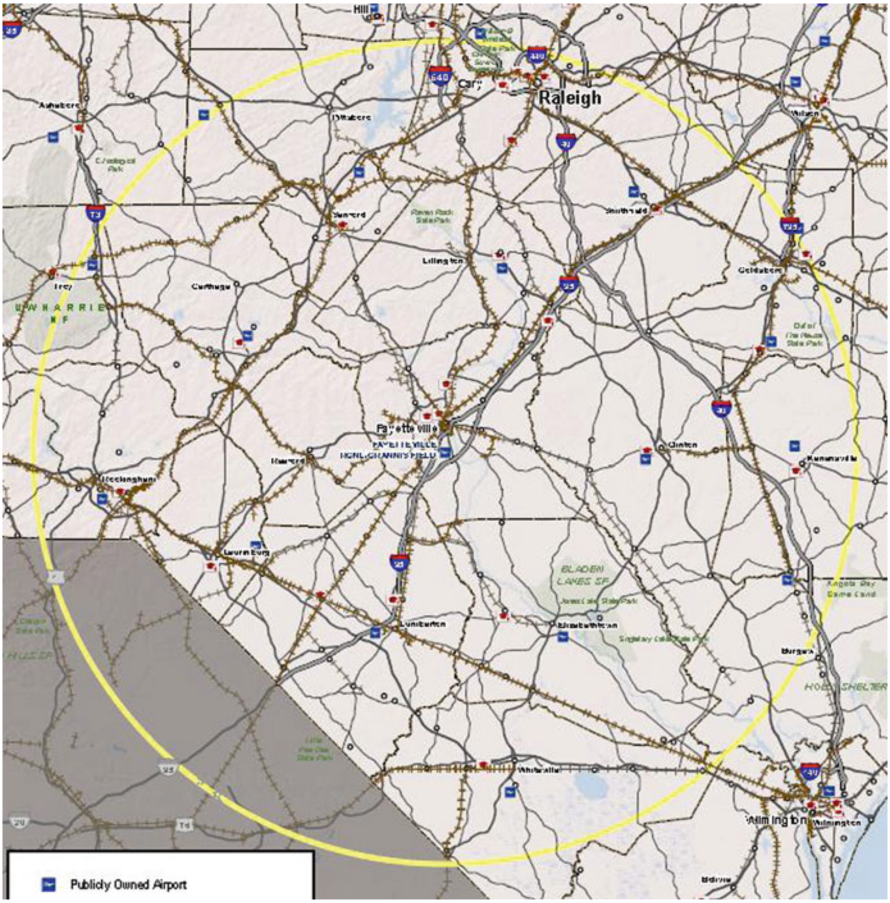

Fig. 3.6 60 mile radius for the *FAY* site. (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

the land is 'shovel ready.' Access from the airport to I-95 is excellent. To reach its potential as a 'logistics village,' *FAY* would have to develop cargo facilities. It is currently considered a 'truck' market. Water and sewer issues at the airport would need to be addressed and should include a pumping station for sewer service. To help make some of this happen, the Airport Plan and the Fayetteville Area Plan should be coordinated to maximize the economic development benefits of the airport."

Given the novelty of the idea of creating a "virtual logistics park", see Table 3.7 and Table 3.8 for the assessment matrix and for the strengths, weaknesses and recommendations regarding the same.

Based on Table 3.7 and Table 3.8, the narrative assessment for the "virtual logistics park" was presented as below (Bhadury and Troy 2011).

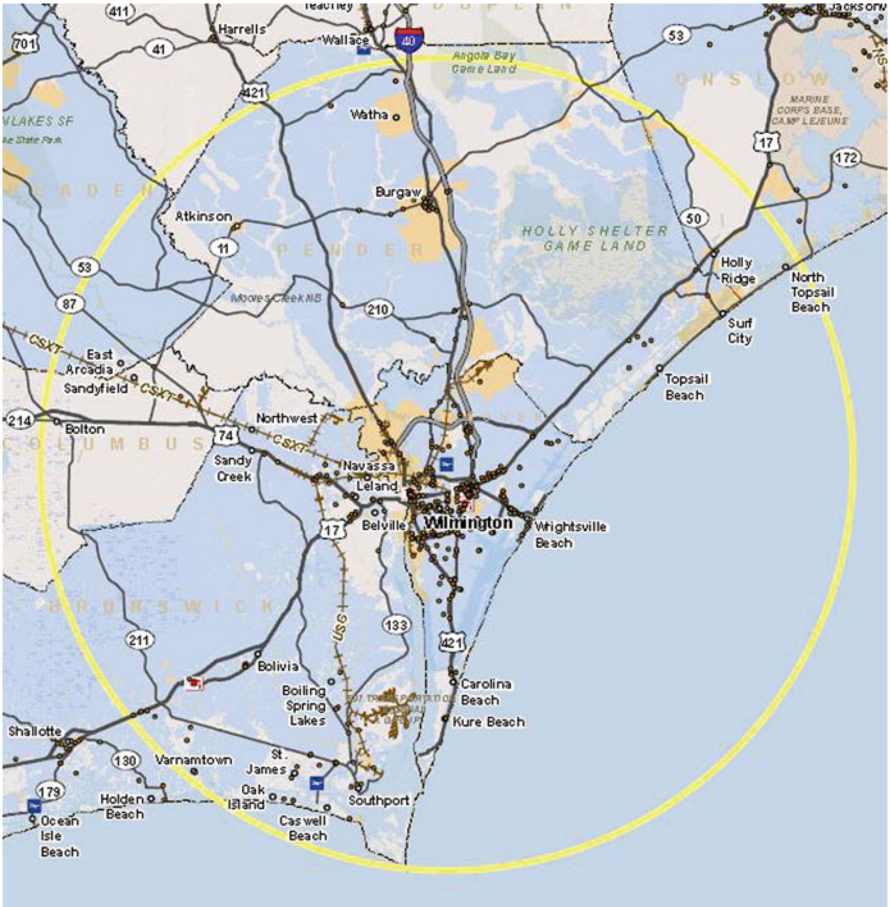

Fig. 3.7 30 mile radius for the "virtual logistics park". (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

"…the Greater Wilmington Area is strategically positioned to capitalize upon the area's logistics assets and establish a 'virtual logistics park.' A 'virtual logistics park' for the Greater Wilmington Area would not only incorporate two sites under consideration in this study, the International Logistics Park and Wilmington International Airport but also the Port of Wilmington, Pender Commerce Park and the Mid-Atlantic Logistics Center. In fact, the 'virtual logistics park' would include all of the logistics assets within a 30 mile radius of Wilmington International Airport. While all components of a 'virtual logistics park' are not located in one spot in the metro area, they are all in close enough proximity to each other to satisfy the 'at port' logistics model criteria for the Port of Wilmington. This is a significant factor that will serve as a strong foundation for developing logistics assets in the Greater Wilmington Area.

Table 3.4 Assessment matrix for *FAY* Site. (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

Measure	Fayetteville regional airport (*FAY*) area
Facility type[a]	Commercial and general aviation
Target industries	Defense/homeland security; distribution; aerospace; general manufacturing
Speed of implementation	5–10 years
Infrastructure—transport	
Highway	Very good
Rail	Not at site but good connections in metro area
Air	
Existing runways	Two-only one *FAA* supported Lengths: 7712’ & 4800’ ILS Category 1 capability
Can runways be extended?	Yes, at a cost
Maritime (ship/barge)	92 miles to port of wilmington; fayetteville is accessible by barge via cape fear but not currently operational
Infrastructure—other	
communications	Very good
Power	Adequate
Water	Improvements needed
Sewer	Improvements needed-pumping station
Land available (acreage)	Some existing sites available at airport, improvements needed for other sites
Labor force	
Availability	Yes, including skilled labor
Education programs to support local industry	Yes
Specialty criteria[b]	Fayetteville economic development seeking *FTZ*; no cargo facilities

[a] *Facility* type major business practice at this location (intermodal facility, warehouse, distribution center, light manufacturing, and so forth)
[b] *Specialty criteria* foreign trade zone, customs, high-security, and so forth

The ‘virtual logistics park’ should be established, developed and coordinated by area leaders through the creation of a central ‘facilitation’ board. . . . The combined logistics assets of a ‘virtual logistics park’ far outweigh the value of Wilmington International Airport and the International Logistics Park when evaluated separately. . . . Most significantly, for the short-term, the ‘virtual logistics park’ is essentially ready to begin operation without additional major investments as the infrastructure already exists to support this effort. In fact, only two things are immediately needed to support the creation of a ‘virtual logistics park,’ the establishment of a coordinating board and a lighted intersection at the entrance to *ILP* and the Mid-Atlantic Logistics Park.”

Table 3.5 Site summary for *FAY. (*Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

Facility	Current status	Improvements needed
Roads	Adequate plus	See roads recommendations
Airports	Central location, halfway between Maine and Miami Moderate commercial and general aviation facility (no cargo facility) One FAA supported runway which can only handle narrow body aircraft. Cash flow positive but limits growth (debt free)	Runway/taxiway upgrades needed (see water/sewer) Cargo facility required Additional sources for capital improvements
Railroads	Inadequate at *FAY* but good metro access; *FAY* 5–8 miles from main line	Spur required if cargo issue is resolved; costly
Ports	92 miles to port of Wilmington with adequate highway	
Shovel ready sites	Moderate airport sites available in NW corner with additional private tracts available	Water and sewer improvements needed for development of existing property
Workforce	Better than adequate skilled labor & technical labor available (military discharges around 6000 per year)	Needs to be promoted for recruitment of industry to area
Transport servicing	Trucking facilities are plentiful	
Communication	Good to very good	
Power	Adequate, owned by city	
Water/sewer Water/sewer (continued)	Adequate, presuming "no growth"	Pumping station at *FAY* for additional sewer capacity No sewer facilities on Southside of airport Taxiways need remediation for water problems Overall improvements needed for future growth
Specialty criteria	Applying for *FTZ*, location undetermined	

3.3.4 Step 4 of SIRC: C*omparative Summary of Candidate Sites*

This is the final step in the *SIRC* framework and is made necessary by the fact that in most real-life location problems, the decision makers do not ask for a single prescriptive recommendation, opting instead to be presented with alternate solutions with rationale for each so that they can make the final decision. Therefore, after completion of the individual assessments for each of the five candidate sites

Table 3.6 Strengths, weaknesses, and Recommendations for *FAY* Site. (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

Strengths	Weaknesses	Recommendations
Proximity (highways, Ft. Bragg, recreation, port, *RTP*, etc.) Ft. Bragg expansion will stimulate airport growth (commercial/industrial, general aviation, and military related traffic) Military outsourcing leads to airport growth potential (hangers, runways, land sites) Better than adequate skilled and technical labor available (around 6000 military discharged per year) Roads are better than adequate in all directions	No cargo facility No at site rail connection Port 92 miles away Only one *FAA* supported runway that can handle narrow body aircraft Additional capital sources are not currently available No updated fayetteville area plan and airport plan not tied to economic development driven issues Water and sewer issues need to be addressed Limited number of large parcels of land for growth Expansion of runways will be expensive	See that city and economic development proactively recruit a champion, military is a good candidate to spur growth and provide dollars for logistics village at airport. Update Fayetteville area plan and coordinate with airport plan in order to promote economic development at *FAY* Correct water and sewer issues to maximize growth potential

in Sect. 3.4.3 above, a comparative summary was drawn up for all the five sites. This summary ensured that it did not recommend one site over another. Instead, it attempted to compare the relative strengths and weaknesses of each site so that the ultimate decisions makers (*NCDOT* and North Carolina State Legislature) could choose the final location for the logistics park.

The first part of the comparative summary was to enlist the common characteristics of all five sites studied. Some examples were as follows (Bhadury and Troy 2011):

- "The area shares an excellent network of existing roads including interstates, limited access highways and four-lane highways. Also, completion of planned road construction for improvement of the regional highway infrastructure will further enhance area transportation and provide a stronger foundation for a distribution and logistics based cluster for *NCSE*.
- While not excellent, the region generally has good access to railroads, *CSX*, Norfolk Southern and numerous short line connections. Improvements such as the establishment of an intermodal rail/truck facility in or near the *NCSE* region that has a direct rail link from the Port of Wilmington and the reestablishment of some preserved rail corridors could improve the attractiveness of the area to industry especially for supply chain based companies.
- The region has a strong agricultural and food processing base. Additionally, the growing military presence in the Fayetteville area and the Port of Wilmington are regional assets and are critical components for economic development in *NCSE*."

Thereafter, an added narrative was devoted to comparing the site specific resources and infrastructure needs. Specific topics addressed were: highway infrastructure,

Table 3.7 Assessment matrix for the "virtual logistics park" for the greater Wilmington area. (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

Measure	Virtual logistics park
Facility type[a]	Airport, trucking, rail, port, logistics and distribution, warehousing center, and manufacturing
Target industries	See *ILM*, *ILP* and *NCSEs* targeted clusters
Speed of implementation	Immediate
Infrastructure—transport	
Highway	Good to very good and improving (see "cape fear commutes 2035: transportation plan")
Rail	Available with limitations
Air	*ILM*
Existing runways	Two at *ILM* Lengths: 8000' & 7004' ILS category 1 capability
Can runways be extended?	Yes, at a cost
Maritime (ship/barge)	Port of Wilmington
Infrastructure—other	
Communications	Good to excellent
Power	Adequate
Water	Adequate, but secondary water source needed. Overall area has future water concerns
Sewer	Septic and traditional available
Land available (acreage)	Excellent- numerous shovel ready of all sizes
Labor force	
Availability	Overall excellent- some skills training may be needed
Education programs to support local industry	Yes
Specialty criteria[b]	ILM has full-service customs *FIS* facility; area meets "at port" logistics model; inactive *FTZ* at port could be reactivated and sub-zones established as needed at other "virtual logistics village" sites

[a] *Facility type* major business practice at this location (intermodal facility, warehouse, distribution center, light manufacturing, and so forth)
[b] *Specialty Criteria* foreign trade zone, customs, high-security, and so forth

railroads, air connections, utilities (including broadband), availability of developable land, labor force availability and specialty criteria (such as the need to establish free trade zones at sites other than the Port of Wilmington).

Two examples of such narratives from the report (Bhadury and Troy 2011) are presented below. The first is for the highway infrastructure at these sites and the second focusses on the amount of developable land available.

Table 3.8 Strengths, weaknesses, and recommendations: "virtual logistics park" for the greater Wilmington area. (Source: http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2010-34-3southeastregionreport.pdf)

	Strengths	Weaknesses	Recommendations
"Virtual logistics village" for the greater Wilmington area	All transportation modes Adequate infrastructure Shovel ready sites International trade (Port of Wilmington) Major industrial parks including: international logistics park, Mid-Atlantic logistics center, pender commerce park	Absence of strong coordination Highway and rail access ("the last mile") Risk exposure to future viability of the Port of Wilmington	Enhance coordination with a "facilitation" group (e.g., similar to Aerotropolis Leadership Board for PTI) Capitalize on "At Port" logistics model Improve highway and rail access Continue to invest in maritime activities

"Highways: In general, all five sites have good road access and planned improvements will only make access easier. When I-74 is complete to the Piedmont Triad and beyond, *NCSE* access to the Midwest will improve as truck traffic will be able to bypass the congested Raleigh area. This is especially true for the International Logistics Park (*ILP*), the Wilmington International Airport (*ILM),* the 'virtual logistics village' and the Laurinburg-Maxton Airport (*MEB*) sites. For these same sites, The Monroe Bypass, along with the completion of I-74 to Rockingham, and completion of I-140 in the Wilmington area will provide better access to the Charlotte market and beyond. Key to the near term success of the *ILP* is a full lighted intersection at the entrance to the Mid-Atlantic Logistics Center and *ILP*. In the future the state should also consider building a full interchange at the intersection of Highway 87 and US 74 that would provide links via access roads to not only *ILP* but the Mid-Atlantic Logistics Center and allow the removal of the interim lighted intersection. While the Port of Wilmington by itself is not a targeted site, it is part of the 'virtual logistics village' and this site will benefit significantly from all road projects and will help the Port to implement its 'at-port' logistics model and become more globally competitive. Planned road projects for the Fayetteville area will slightly enhance traffic around the Fayetteville Regional Airport (*FAY*); however, overall, *FAY* already has excellent immediate access to I-95 and access to I-40 is just 30 min away via I-95."

"Developable land: each of the five possible sites studied for a 'logistics village' has land available for development. Similar to the Global TransPark, *MEB* has land available to meet almost any need. Some of that land is already shovel ready and located in a certified industrial site fronting the future I-74. The *ILP* has 1100 acres available and, immediately across the street from *ILP*, the Mid-Atlantic Logistics Center has an additional 1100 acres with rail access. *FAY* has some parcels immediately available but infrastructural improvements would be needed to build on other existing parcels. Additional land is also available near the airport. *ILM* has around 150 acres available at site and other possible sites adjoin the airport. If the 'virtual

Table 3.9 Comparative summary for all candidate sites

Site	Strengths	Weaknesses	Needs
Laurinburg-Maxton airport (*MEB*)	Significant capacity for expansion Proximity to Ft. bragg and camp McCall	Facilities require significant costly improvements Lack of strategic plan for airport	Needs champion (private/government)
Fayetteville airport (*FAY*)	"Proximity" Ft. bragg expansion Adequate labor available	Lack of capital sources for infrastructure improvement Disconnect between airport plan and economic development	Proactively recruit a champion (military?) Update Fayetteville area plan and coordinate with airport plan Correct water and sewer issues
International Logistics Park (*ILP*)	Abundance of shovel ready sites Meets "at port" criteria Tier 1 (economically disadvantaged) county status makes it eligible for tax incentive support from state and local governments	Risk exposure to future viability of the Port of Wilmington	Planned road projects (full intersection) Cooperate with Mid-Atlantic logistics center Leverage regional logistics assets
Wilmington international airport (*ILM*)	Modern full-service (*FIS*) airport Shovel ready industr*ial* sites Quality of life	Risk exposure to future viability of Port of Wilmington	Leverage regional logistics assets Utilize professional skills of local retirees
"Virtual logistics park" in the greater Wilmington area	All the strengths of regional logistics assets including *ILP* and *ILM* above	Risk exposure to future viability of Port of Wilmington	Form a coordinating board that can leverage regional logistics assets in creating this "virtual" organization

logistics village' is considered significant, developable land is available at *ILP*, the Mid-Atlantic Logistics Center, and Pender Commerce Park and at or adjacent to *ILM*. A large percentage of this land is shovel ready and meets the criteria for the Port of Wilmington's 'at port' logistics model."

The complete comparative summary is available in Bhadury and Troy (2011); key points from that are captured in Table 3.9.

3.4 Epilogue and Conclusions

This final and most important section of the case study will first describe the epilogue of events after the completion of the Seven Portals Study. Thereafter, conclusions are presented on the lessons learned from the study as well as its implications for future research in location theory.

After the completion of the research, the key findings were presented in early 2011 to Governor's Logistics Task Force (*GLTF*) in the form of the final report Bhadury and Troy (2011). That report became a part of the final report submitted by the lead research team of the Seven Portals Study project, see List and Foyle (2011). In turn, List and Foyle (2011) became an integral part of the report submitted by *GLTF*, namely, the *GLTF* Final Report (2012). However, in 2012, all recommendations from prior studies undertaken by *NCDOT*, including the Seven Portals Study, were placed on hold, and *NCDOT* announced that it would substantially change the way transportation infrastructure in North Carolina was financed. Subsequently, *NCDOT* announced a new method for evaluating infrastructure projects such as the ones recommended in the Seven Portals Study. This new method is referred to as *Strategic Transportation Investments* and a description of the same is available at http://www.ncdot.gov/strategictransportationinvestments/. As of the end of 2014, no logistics park had been located by *NCDOT* anywhere in the state directly as a result of the Seven Portals Study. Nonetheless, smaller recommendations from the study were implemented; for example, cold storage facilities were added at the Port of Wilmington in order to facilitate exports of agricultural products.

There are numerous lessons to be learned by location theorists from an actual application such as the one described in this chapter. Three key lessons are as follows:

1. *Most Problems Involve Location of a Single Facility:* In most cases in real life, site location problems consider the location of only one facility. In case multiple facilities are involved, the decision-makers usually divide the area to be served into smaller regions and focus primarily on locating one facility in each of them, much like the original Seven Portals Study was broken up into smaller, regional ones, each involving the location of one logistics park in a specific region of the state.
2. *Most Problems Have Multiple, often Conflicting, Objectives:* In real life location problems, decision-makers have multiple objectives, some of which are not even quantifiable. This makes it almost impossible to determine an optimal location. In fact, the fuzziness of some of the objectives, as for example, the objective to stimulate economic development through location of logistics parks in the case of the Seven Portals Study, make it questionable if an optimal location can even be defined that is acceptable to all decision makers. For example, whereas minimizing travel distance might attract the location of a facility towards the demand centers (usually high population urban centers), governments locating public facilities also have a tendency to consider sites in high unemployment areas (usually sparsely populated rural areas) so as to stimulate economic development. Therefore it is important that in the analysis, researchers stick to evaluating strengths and weaknesses of candidate sites with regards to the various objectives of the decision-makers rather than being prescriptive and recommending one particular site.

3. *Rigorous Scientific Analysis is a Small Part of The Modeling Process*[6]: When locating public facilities, especially large and expensive facilities such as logistics parks, theoretical analysis such as the one presented in Sect. 3.3, is at best a small part of the actual location modeling process. In fact, as is evident from this chapter, the 1-median locations determined by the analytical process of Sect. 3.3 and as presented in Fig. 3.4 are not even proximate to any of the initial candidate sites selected by the research team (Fig. 3.5) on the basis of the Situational Analysis step of *SIRC*. This exemplifies that site selection of public facilities in practice mostly involves factors other than analytical ones. Public facilities such as logistics parks are viewed by the citizenry as job creators as well as a nuisance (causing congestion, pollution etc.). As a result, public perception, as reflected directly by the citizenry, as well as through their elected leaders and/or special interest groups and the clout that these have in the decision-making process have a far larger bearing on the modeling process in practice than does the mathematical analysis presented in Sect. 3.3.

The import of lessons 2 and 3 is an important guideline for location theorists who are called upon to perform location modelling of public facilities. The guideline is that in Step 1 of the *SIRC* framework (namely, situational analysis), researchers must first identify all stakeholders involved and make sure that all necessary background information is collected about them. Such background research should involve a study of the socio-economic profile of the region as well as their future trends, as we presented in Sect. 3.2. In addition to this in-depth study of the region being considered for location, it is also important for researchers to get to know the important social, economic and political figures in the region and interview them to find out their expectations from the facility being located as well as the process that ought to be used in determining the location. That is why the research team conducted 14 interviews with 34 different people in *NCSE* as a part of completing the Situational Analysis for this project. Not only does this create the information that forms the bedrock of the subsequent steps (Steps 2–4 of the *SIRC* framework), but also lends credibility to the work being done which, in turn, lays the groundwork for the eventual acceptance by stakeholders of the findings and conclusions of the research project.

These lessons presented above also lead to two important recommendations about future research in location theory and we conclude this case study with the same. The first of these points to the importance of single-facility location models. While multi-facility location models are theoretically much richer than single facility location models, more research needs to be focused on the latter. The primary source of complexity in real life location models comes not from having to locate multiple facilities but from having to locate one with numerous, often conflicting and non-quantifiable, objectives. Thus, it is our recommendation that more work

[6] A member of the research team succinctly stated this principle as " *Location in practice is 80 % politics and 20 % science*".

needs to be done on multi-objective, single facility location models where some of the objectives are allowed to be fuzzy and/or qualitative. By nature, such models will need to combine quantitative analysis with qualitative research and should add to the richness of extant literature in location theory.

The second observation about future academic research stresses the importance of exploring alternate optimal and near-optimal solutions in location models. As mentioned above under lessons learned, it is difficult to define "optimality" with a high degree of precision for most real life location problems. As a result, decision-makers look not for a single prescriptive recommendation but a range of alternate recommendations that do "well enough" on most objectives. In the language of optimization, this implies that research in location theory should focus on efficient ways to generate alternate optimal locations as well as near-optimal solutions to complex, multi-objective problems. The goal of location modeling in practice is to then present the best of these alternate and near-optimal solutions to the decision-makers along with strengths and weaknesses of each to enable them to make final decisions.

Acknowledgment This work draws, in part, upon the experiences of the first and the third author in the implementation of the Seven Portals Study project. That project was supported by *NCDOT*, which is gratefully acknowledged.

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http://www.springer.com/978-3-319-20281-5

Applications of Location Analysis
Eiselt, H.A.; Marianov, V. (Eds.)
2015, XIII, 437 p., Hardcover
ISBN: 978-3-319-20281-5