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FEASIBILITY OF AIR TRANSPORTATION:
THE CASE OF WATAUGA COUNTY, NORTH CAROLINA

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FEASIBILITY OF AIR TRANSPORTATION:
THE CASE OF WATAUGA COUNTY, NORTH CAROLINA

A Masters Thesis
Presented To
the Faculty of the Graduate School
Appalachian State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
James William Freeman

November, 1977

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ACKNOWLEDGMENTS

The author wishes to express his sincerest thanks to the following people, groups and agencies who gave of their time and effort in the compilation of the necessary data needed for this thesis work:

Robert Freeman	Watauga County Airport Commission
Ole Gade	Watauga County Commissioners
Robert Reiman	Watauga County Planning Department
Terry Epperson	Federal Aviation Administration
Harry McDonald	N.C. Department of Aeronautics
George Altman	Region D Council of Governments
John Brantley	
Thomas Rokoske	
Sara Freeman	
Jackie Blackburn	
Steve Holden	

ABSTRACT

Watauga County, a mountainous region in North Carolina is currently without a public airport. A small private airfield is located on a floodplain east of the town of Boone, and within a residential sector. It is unpaved and subjected to constant "weathering in." In addition, the airfield lacks even the most basic of navigational aids. The present County Commissioners and a number of private citizens would like to improve the airfield or construct a new public airport.

A preliminary study should be conducted to determine the practicality of locating a particular air transportation system in the area before thousands or millions of dollars are spent. Therefore, the research objective of the thesis was to determine the feasibility of an air transportation system for Watauga County. This was achieved by a parallel analysis of three sets of independent factors relevant to aeronautical activity: physical environment, socio-economic characteristics and economic development criteria. It is the major finding of this analysis that Watauga County has a need for a "General Utility" type airport, capable of supporting both civilian/business aircraft activity and limited charter service.

CHAPTER I

Introduction

Research Problem and Objectives

During the next twenty years, air transportation in the United States is expected to grow at a rapid pace.¹ In response to this expectation of growth and the accompanying need for additional facilities, the Federal Aviation Administration (F.A.A.) has designated specific areas on its National Airport System Plan which should have an air transportation system by the year 2000. One of the areas identified is Watauga County, North Carolina. During the 1960's and early 1970's, attempts at obtaining an airport for the county were unproductive. The causes of these fruitless attempts to date are found in two issues: a probable conflict of interest relating to the degree of authority to be granted the Airport Commission, and the lack of an in-depth air transportation system needs assessment for the county.² It is the objective of this study to determine the feasibility of an air transportation system for Watauga County.

Geography and Airport Location Analysis

The Federal Aviation Administration's publication, Airport Site Selection (no date), lists a number of geographic study elements necessary for airport location. Kenneth Sealy, in his book, The Geography of Air Transport (1966), examines these elements and relates them to

existing airports in Europe and the United States. Those factors considered crucial by Sealy are:

1. the technical requirements of aircraft and facilities,
2. the terrain and weather requirements of selected sites,
3. the economic requirements.

An additional factor considered by Edward Taaffe is the accessibility to and from the airport.³ Taaffe's studies on air passenger markets during the 1950's and 1960's showed that other transport modes are usually chosen by travelers when ground time to an airport equals or exceeds the actual flying time. In fact, it is as recent as 1971 that the F.A.A. began including airport user accessibility as a location factor to consider when planning new airports.⁴

Generally, most research in air transportation geography has been confined to air passenger markets and aircraft routes. These studies involved trends in air passenger traffic (Edward Taaffe), regional demands (William Stanley and Robert Bancom), and air transportation networks (Walter Wacht).⁵

Research Hypothesis and Procedures

A preliminary forecast will determine the practicality of locating a particular air transportation system in an area before thousands, or even millions, of dollars are spent. The F.A.A. has identified a number of forecast factors, while the Civil Aeronautics Board (C.A.B.) uses projection approaches similar to the F.A.A., but places greater value on a different set of variables. Bernard Schriever, in his study

of potential air transport markets, used a combination of C.A.B. and F.A.A. variables.⁶ Schriever's variables includes a profile of travelers with the greatest likelihood to journey by air.⁷ Comparing this feature with a population region, over a given period of time, provides an estimate of total market potential of the area.

This thesis will focus on three sets of independent factors relating to local air transportation analysis: physical aspects, social characteristics and economic development criteria. Study variables will be selected from these sets of factors; the findings derived from their analysis will subsequently be evaluated in terms of passenger market, airport design and applicable type of air transportation.

In view of the stated research objective and factors relevant to the analysis, the following major hypothesis will be assessed:

Watauga County's physical, social and economic environments can sustain an air transportation system.

Since the hypothesis is complex, it will be broken down into its component parts, and testing procedures applied accordingly.

Physical Environmental Aspects

Variables for the physical environment focus mainly on topographic and meteorological conditions. These factors have been identified by Kenneth Sealy and the F.A.A. as the most important elements affecting both air transportation and the location of airports. In Watauga County, the mountainous terrain offers difficulty, not only as the result of altitude, but also because rough relief and its influence on local weather conditions, as well as on the airport site location. Therefore, it is hypothesized that:

Airport sites are available and meteorological and topographic conditions of Watauga County will not adversely affect air transportation to a significant degree.

This hypothesis will be assessed in the following local manner:

Physiographic Aspects - Assessment of physiographic aspects will emphasize on relief, soil characteristics and drainage patterns. These variables are to be assessed through the use of topographic maps, air photographs and soil survey reports.⁸ Feasible site locations within the county, greater than 2,200 feet in length, will be mapped and evaluated as to their potential.⁹

Meteorological Aspects - Not only must local conditions in the proximity of sites be considered, but the variability of meteorological aspects of the county are a vital factor in determining the predicted usage of an air transport mode. Of particular concern are the variables: visibility, precipitation (particularly snowfall), wind, temperature and pressure. Changes in temperature and pressure both influence air density, which can be critical to aircraft performance at these higher altitudes. Information for these variables is to be obtained from Climatological Data, the monthly publication on North Carolina weather, The Weekly Series of Weather Maps by the United States Department of Commerce, local weather records dating from December, 1928, to present, and from interviews with local persons.

Socio-Economic Characteristics

Socio-Economic characteristics will be studied through the analysis of five variables: population size, age, education, occupation and median-income level. These variables have been used frequently in past

studies of potential air travelers.¹⁰ In Watauga County, a threshold level of these variables already exists for air transportation. This condition is likely to have resulted from the expansion of industries, the growth of recreation and tourist support services, improvement of wage levels, the increasing student enrollment at Appalachian State University, and the university's influence on median school years completed throughout the county.

It is hypothesized that:

Population size, age, education, occupation and median-income level, in combination, exceed the threshold level necessary for the introduction of an air transportation system into the County.

This will be researched by examining census data of the county and by reviewing existing studies such as Land Use Survey Analysis and Planning Recommendations for Boone, North Carolina, 1974, and Watauga County's Economic Development Study, 1977. An assessment of social conditions in Watauga County, in the context of standards derived in previous studies, will result in a forecast of potential air travelers.

Economic Development Criteria

Assessment of economic development criteria will focus on manufacturing industries, educational and recreational services, trade patterns and competitive transportation modes. Within each group, particular emphasis will be placed on these variables: distance to market, transportation costs and time costs. These variables frequently appear in locational analysis studies and are felt to be equally important in transportation studies.¹¹

Watauga County is presently serviced by automobile, truck and bus lines. Individuals and/or industries desiring to use the benefits of air transportation must travel by motor vehicle to reach the nearest airport with commercial service in Hickory. The Hickory airport is served only by Piedmont Airlines; connections have to be made to other major cities outside Piedmont's operating jurisdiction.

Therefore, it is hypothesized that:

Economic development factors favor an air transportation system in Watauga County.

This hypothesis will be assessed in terms of: (a) existing transportation usage and (b) potential air transportation usage. Graphs will be used to portray the physical distance and "time distance," showing how air transportation will be advantageous over existing modes. Information will be collected from manufacturing industries, recreational and tourist services, Region D Council of Governments, North Carolina Department of Transportation and the local planning agency.

Summary

The findings of this thesis research will provide the basis for determining whether or not air transportation is environmentally, socially and economically feasible in Watauga County. Should the results be positive, alternate air transportation systems, e.g., (1) an airport serving primarily as a feeder stop for air-taxi operations to a regional, air-carrier airport, (2) an airport providing access to the airways from a remote community or, (3) an airport serving a multipurpose role, will be assessed and recommendations made accordingly.

NOTES

¹Federal Aviation Administration, Aviation Demand and Airport Facility Requirement Forecasts for Air Transportation Hubs (Washington, D.C.: Department of Transportation, no date), p.1.

²Two issues as of September, 1976, were: (1) Appointment of new members to Airport Commission and (2) challenging the Airport Commission's right to condemn land.

³Edward Taaffe, "Trends in Airline Passenger Traffic: A Geographic Case Study," Annals of the Association of American Geographers, Volume 49 (1959), pp. 393-408.

⁴Federal Aviation Administration, "Airport Access Plans," Airport Master Plans (Washington, D.C.: Government Printing Office, 1971), pp. 57-63.

⁵Edward Taaffe, "The Urban Hierarchy: An Air Passenger Definition," Economic Geography, Volume 38 (1962), pp. 1-14.

William Stanley and Robert Bancom, "Some Spatial Components of Regional Air Service in the Southeast," Southeastern Geographer, Volume 12 (1972), pp. 145-154.

Walter Wacht, The Domestic Air Transportation Network in the United States (Chicago, Illinois: University of Chicago Press, 1974).

⁶Bernard Schriever, Air Transportation 1975 and Beyond: A Systems Approach (Cambridge, Massachusetts: MIT Press, 1968), pp. 37-58.

⁷Schriever used the variables: Trip length, income levels, occupation, age and trip purpose.

⁸The United States Department of Agriculture, Soil Conservation Service, Watauga County, North Carolina Soil Survey, 1944, will be used to study soil characteristics of each potential site.

⁹2,200 feet is the minimum runway length to be classified as a Basic Stage I Airport by F.A.A. criteria.

¹⁰John B. Lansing, "An Analysis of Interurban Air Travel," Quarterly Journal of Economics, Volume 75 (1961), pp. 87-95.

Bernard Schriever, Air Transportation 1975 and Beyond: A Systems Approach (Cambridge, Massachusetts: MIT Press 1968), pp. 66-68.

¹¹Brian Berry, Edgar Conkling and Michael Ray, The Geography of Economic Systems (New Jersey: Prentice-Hall, Inc., 1976).

CHAPTER II

ASPECTS OF THE PHYSICAL ENVIRONMENT

Introduction

The physical environment of Watauga County may constitute a possible limitation in airport site selection. Watauga County's mountainous terrain can be a hazard, not only as the result of altitude, but also because of rugged relief and its influence of local weather conditions. However, it is hypothesized that:

Airport sites are available and meteorological and topographic conditions of Watauga County will not adversely affect air transportation to a significant degree.

Variables assessed in evaluation of this hypothesis include: slope and altitude, soil characteristics, drainage patterns, visibility, precipitation, wind, temperature and atmospheric pressure.

Physiographic Aspects

The general land features of the county are those of a dissected plateau. Average elevation of the land surface and valleys are at an altitude from 3,000 to 3,700 feet, with higher mountain peaks rising above this to elevations in excess of 5,000 feet. Large tracts of open, level ground, with the exception of floodplain areas, are almost non-existent in the county.

Slope and Altitude

This influence of topography, especially the slope of the landscape, will mean a high construction cost of an airport--whatever its size. Two examples of the influence of topography on airport construction costs (in mountainous terrain similiar to Watauga County) are exemplified in Ashe and Jackson counties.¹ Both counties have small, paved single-runway airports on mountain ridges. At the present time, each of these comparable airports exceed a million dollars in development costs.

Ideally, an area chosen for an airport should be naturally level land with a good drainage and free from all obstacles that may hamper the safe operation of aircraft. Since such a situation is unlikely to exist in the rugged topography of Watauga County, a chosen airport site must be modified to as safe a condition as possible. The objective is to reduce the effect of surface features on airplanes, primarily in the immediate vicinity of the landing strip--where the most crucial phase of flight takes place. Therefore, features such as relative relief and altitude, have a substantial affect on the siting and construction of an airport. At increasing altitudes, beginning at approximately 2000 feet above mean sea level, the fall-off in performance of some aircraft during take-off can mean a reduction in payload. Compensating for such a condition would mean constructing a runway longer than those found closer to sea level.

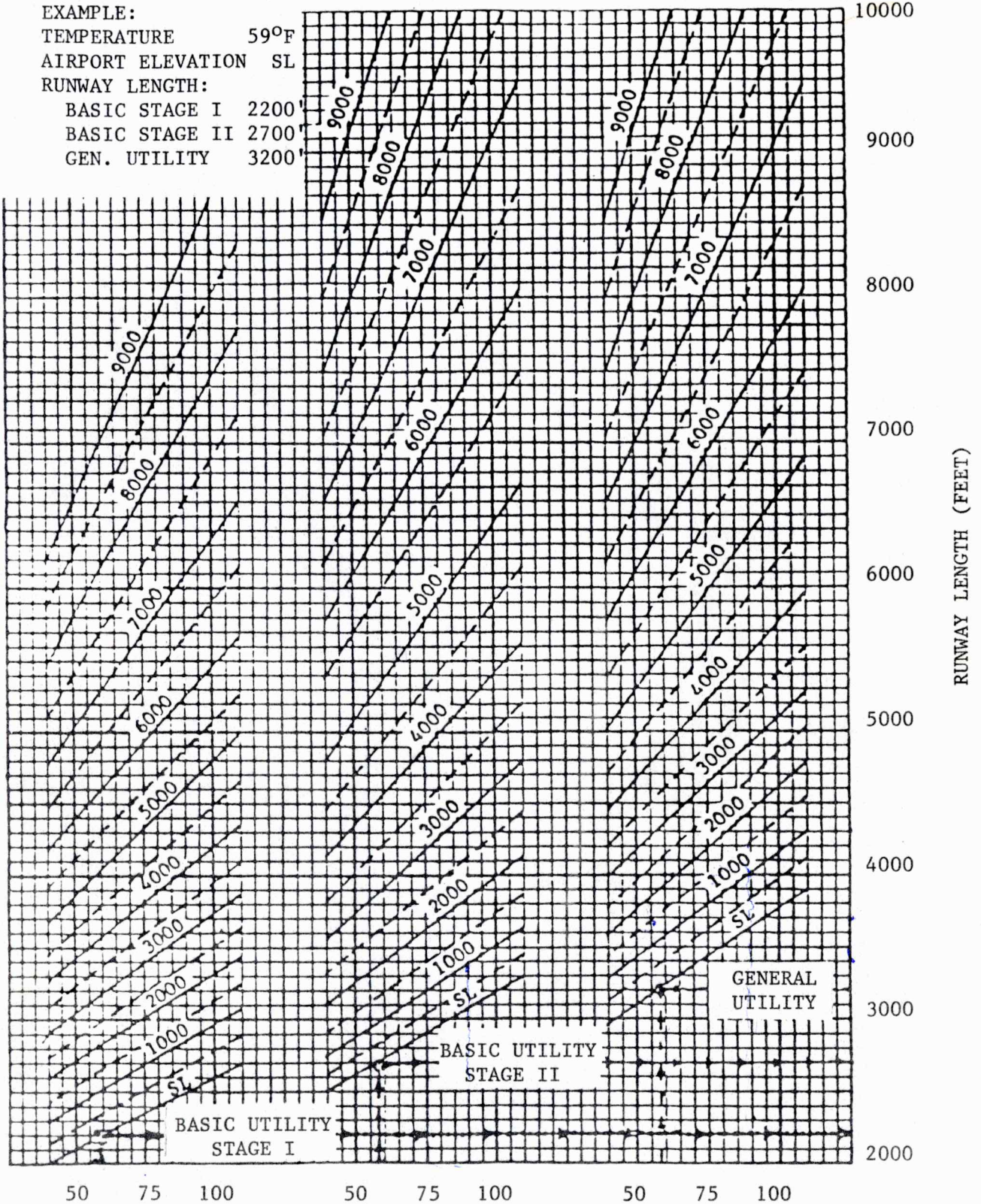
The F.A.A. has developed correction factors that take into account elevation and temperature conditions. The Agency's standard for runway length is an additional 7 percent per 1,000 feet of altitude, beginning at approximately 2,000 feet above mean sea level. This figure

Figure 1

RUNWAY LENGTH GRAPH

AIRPORT ELEVATION (FEET)

EXAMPLE:
 TEMPERATURE 59°F
 AIRPORT ELEVATION SL
 RUNWAY LENGTH:
 BASIC STAGE I 2200
 BASIC STAGE II 2700
 GEN. UTILITY 3200



NORMAL MAXIMUM TEMPERATURE (°F), HOTTEST MONTH OF YEAR

Source: F.A.A. Advisory Circular AC 150/5300-4B, "Runway Length Requirements and Capacity," p. 14.

is further corrected by a rate of .5 percent increase in runway length per 1 degree Fahrenheit when the expected temperature exceeds the standard atmospheric temperature of that elevation (see Figure 1).

Since the average elevation of Watauga County is more than 3,000 feet with further increases up to 5,000 feet, it means that any chosen site within the county will have to be increased in runway length corresponding to its elevation. Criteria, based on F.A.A. approved runway length, can be developed showing Watauga County's needed length per-thousand-foot intervals. This is done by first categorizing runway lengths into six groups, and then applying the F.A.A. correction standards. It is found that for Watauga County a minimum "Type-Six" runway has to be at least 2,508 feet long, at an elevation of 3,000 feet (see Table 1)--308 feet longer than a comparable runway on the Piedmont or coastal regions of North Carolina. At 4,000 feet altitude, the runway should be 2,662 feet long and at 5,000 feet altitude the required length is 2,816 feet. These figures are based only on elevation correction and do not take into account .5 percent per 1 degree Fahrenheit further increase when temperature exceeds the standard atmospheric temperature at that elevation. Further explanation of the additional .5 percent increase will be examined later in this chapter. It should be strongly emphasized that if a planned airport does not conform to F.A.A. correction standards, the airport will not be eligible to receive any federal funding.

Special care must be exercised in use of the Runway Length Graph, since at some locations it may be more appropriate to determine runway length by the specific type aircraft that will regularly use that

Table 1

CRITERIA USED FOR RUNWAY GROUPINGS

TYPE AIRPORT:	<u>Runway Length</u>						Regional Transport
	Basic Utility I	Basic Utility II	General Utility	General Utility	General Utility	Regional Transport	
Elevation	6	5	4	3	2	1	
	Feet	Feet	Feet	Feet	Feet	Feet	Feet
to 2,000 ft.	2,200	2,200-3,200	2,200-3,200	3,200-3,999	4,000-4,999	5,000	
3,000 ft.	2,508	3,648	3,648	4,559	5,699	5,700	
4,000 ft.	2,662	3,872	3,872	5,840	6,049	6,050	
5,000 ft.	2,816	4,096	4,096	5,119	6,399	6,400	
	Unpaved No Nav aids*	Unpaved No Nav aids	Paved Nighttime Nav aids	Paved Nighttime Nav aids	Paved Nighttime Nav aids All Weather	Paved Nighttime Nav aids All Weather	Paved Nighttime Nav aids All Weather

*Navigational Aids: Daytime - wind cone, segmented circle, tee, or tetrahedron

Nighttime - as for daytime plus unicom and runway lighting

All Weather - high intensity lighting, instrument landing system, tower

Source: Interviews with N.C. Department of Aeronautics and airport consultant firms.

airport. For example, some manufacturers of multi-engine airplanes suggest that pilots use the airplane's accelerate-stop distance in determining the length of runway available for take-off. This will increase the needed runway length over what the Runway Length Graph states. In order to compensate for this situation, the airport planner should consider what types of aircraft will most frequently use the facility in determining proposed runway length.²

Soils

The soils of Watauga County vary because of wide differences in the parent material, relief, and drainage, as well as some differences in climate, native vegetation and stage of soil development. Airport site location analysis demands careful evaluation--particularly of the nature of parent materials, degree of stoniness, relief, drainage, erodibility and present state of erosion, depth to bedrock color, consistency, texture and structure of various profile layers of the soil. Accurate identification and evaluation of soils at each tentative site must be completed before final site selection. The soil condition and availability of suitable construction materials at a site affects greatly the construction costs. For instance, grading costs are directly related to the difficulty of excavation and runway compaction.³

The use of good subgrade soils for runway compaction before paving will serve to distribute over greater areas the impact loads from constant taxi, take-off landing activities, thereby decreasing future paving maintenance costs and increasing runway life. Modification of poor subgrade soils are possible through the use of admixtures, such

as cement or lime, to produce the desired quality. However this method is usually expensive and may be overcome by borrowing a good subgrade soil locally.⁴

A local subsoil used in highway construction and having "the best engineering characteristics encountered in grading and excavating operations" is recommended by the F.A.A.⁵ Those better subsoils found in Watauga County and meeting F.A.A. standards are classified in the Ashe, Perkinsville and Tate associations.⁶ These associations are excessively drained; steep in slope with red, yellowish-brown loamy subsoils. They can be found mainly on mountain sides and footslopes. Quality subsoil can vary throughout the county because of grain-size, liquid limit and plasticity index.

Drainage

Rivers and creeks found within Watauga County are not of great length and many have originated as springs in higher elevations. Water volume carried by streams varies greatly throughout the year because of great variances in topography, which causes fluctuations in the ground water supply. Periods of flash flooding resulting from showery-type precipitation occur throughout the year. These frequent periods of unpredictable flooding would make airport development on floodplain areas impractical.

The site of the present private airport east of Boone is unacceptable for future development or expansion. The 2,845 foot sod runway lies in a floodplain area in close proximity to a residential district. Nine accidents within a ten-year period have resulted, primarily from

pilot error due to misjudgement of runway conditions--wet grass being a major adverse condition.

Water courses through any selected site are undesirable, and water should not be allowed to cross a runway or taxiway. Drainage structures to handle runoff to a nearby outlet must be planned.

A preliminary drainage investigation should be conducted to determine the limits of all drainage areas which may affect a feasible airport site.⁷ Tributary boundaries beyond the airport boundary ought to be included in the preliminary study. The maximum rainfall expected on the basis of one in every ten years is recommended by the F.A.A. for estimating runoff at feasible airport locations.

Meteorological Aspects

In Watauga County, the mountainous terrain is a hazard, because of its influence on local weather conditions. This close link between relief and weather conditions is important since it causes microclimatic differences in visibility, precipitation, wind, temperature and pressure. Although speaking, all elements of the weather are important, these aspects are more critical to aviation operations than others.

Weather records obtained at a Boone site, dating from December, 1928 to December, 1976, and a set of parallel records from a shorter period (1941-1976) at Blowing Rock (eight miles south of Boone), have been assessed for the purpose of this study. Even though these records suffer a deficiency in the quality of record keeping for the two areas, they are adequate for the purpose of this study. There is sparse data on visibility and an inconsistent twenty-year (1928-1948) wind-direction coverage.⁸

Visibility

Visibility is an important factor in any region and it is influenced by a number of different factors. Lack of adequate visibility for a pilot in mountain terrain can be due to fog, low cloud ceilings, heavy precipitation, haze, smoke, wind or temperature inversion layers. Such factors become a prime concern when landing or taking off at an airport. Even though most of these factors exist in level terrain, mountains are more prone to a higher incidence of temperature inversion, giving rise to fog and low clouds.

An airport in Watauga County, sited where there is consistently poor visibility, may experience a decrease in the number of flight operations to a point where it can no longer economically support itself. This deficiency may lead to a considerable loss of income for those users who depend upon the airport to support their business operations. Two types of localities which should be avoided in this county are valleys and high mountain ridges.⁹ Valleys are prone to ground fog, which can linger for hours while the surrounding terrain is clear; low cloud ceilings will affect aircraft operations on the higher ridges more often than lower mountain ridges.

Precipitation

Heavy precipitation, such as rain or snow, can also decrease visibility to almost zero. If precipitation occurs at a freezing temperature, a runway may become icy or completely covered by snow, thus necessitating grounding aircraft and closing the airport at least until the runway is cleared and possibly until weather conditions improve.

The county's average annual distribution of precipitation is markedly uniform (see Table 2). The frequency of occurrence of measurable precipitation is about the same as near the North Carolina coast (an annual average of 53.2 inches), but the seasonal variation of precipitation for Watauga County is less than that of most eastern parts of the state. Summer rainfall in the county results from a complexity of factors including orographic, cyclonic, or convectional storms and varies considerably from locality to locality due to slope and exposure, while winter precipitation normally comes from large, eastward moving cyclonic storms. Snow may fall several times a month during November through March and yield three to ten times the amount collected elsewhere in the state.¹⁰

Precipitation data in airport planning should be assessed in terms of monthly amount and average number of occurrences. This is also true of poor visibility days. Table 3 shows the average number of precipitation days per month as calculated over a recent eleven-year period for Watauga County (1966-1976). According to the Department of Aeronautics in Raleigh, North Carolina, these averages would indicate the need for instrument navigational aids (NAVAIDS) at any proposed airport in Watauga County.¹¹

Temperature and Atmospheric Pressure

All aero-engines are sensitive to temperature change, which affects their efficiency. Specific site temperature, from an airport engineer's viewpoint, influences the design of a runway. Specifically affected is the runway's length. The hotter the temperature, the longer the runway should extend.¹² Another element which is calculated

Table 2

AVERAGE AND MAXIMUM MONTHLY TEMPERATURE AND PRECIPITATION CHARACTERISTICS,

WATAUGA COUNTY, N.C.

Month	Average		Temperature		Daily Maximum		Precipitation	
	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Inches	Centimeters
January	33.7	.9	42.9	6.1	3.69	9.37	3.69	9.37
February	34.7	1.5	44.9	7.2	4.26	10.82	4.26	10.82
March	40.7	4.8	51.5	10.8	5.06	12.85	5.06	12.85
April	50.9	10.5	62.6	16.9	4.34	11.02	4.34	11.02
May	59.0	15.0	70.3	21.3	4.25	10.80	4.25	10.80
June	65.6	18.7	76.5	24.7	4.44	11.28	4.44	11.28
July	68.2	20.1	78.2	25.7	5.66	14.38	5.66	14.38
August	67.6	19.8	78.0	25.6	4.90	12.45	4.90	12.45
September	61.2	16.2	72.3	22.4	4.65	11.81	4.65	11.81
October	52.2	11.2	64.3	17.9	3.97	10.08	3.97	10.08
November	42.0	5.6	52.9	11.6	4.04	10.26	4.04	10.26
December	34.8	1.6	45.1	7.3	3.92	9.96	3.92	9.96
Annual Average	50.9	10.5	61.6	16.4	53.18	135.08	53.18	135.08

Source: United States Department of Commerce, National Oceanic and Atmospheric Administration, Climatological Data, No. 81, Annual Summary (Washington, D.C.: Government Printing Office 1973). Data represents averages obtained from 1938 to 1972.

Table 3

AVERAGE MONTHLY PRECIPITATION OCCURANCE,
 WATAUGA COUNTY, N.C., 1966-1976.*

Month	Average Days of Precipitation
January	10.90
February	8.00
March	7.82
April	8.57
May	10.70
June	8.00
July	11.71
August	10.86
September	9.42
October	8.56
November	12.00
December	11.86

*The total number of days per month in which more than .25 inches of precipitation was recorded and divided by an 11-year period.

Source: Derived from local weather records.

along with temperature in order to determine runway length is atmospheric pressure. The combination of temperature and pressure create air density, which determines the lifting capacity of a wing. The lower the density, the lower the lift generated by a wing and the lower the engine power produced at a given speed. In order to maintain lift, the aircraft must fly faster, resulting in the need for greater runway length to enable the aircraft to take-off and land. This can be tested mathematically by use of engineering and aerodynamic formulas.

Based on an average daily maximum temperature of 79 degrees Fahrenheit (27 Celsius) and a site elevation of 3,500 feet (see Figure 1), a General Utility Airport (see Chapter 3) would need approximately a 4,900 foot runway.¹³

Wind

The design of an airport is usually determined by the orientation and number of runways. The single most important weather element influencing runway orientation is wind. Ideally, a runway should be orientated with the prevailing winds, since aircraft normally take-off and land into the prevailing wind. Wind conditions affect all aircraft in varying degrees. The smaller the aircraft, the more it is affected by wind, especially crosswinds. In a mountainous region, such as found in Northwest North Carolina, wind direction varies from locality to locality due to physiographic variation. Airport planners must, therefore, make a comprehensive and detailed wind analysis to determine runway orientation.

The most desirable runway is the one that has the largest wind coverage and minimum crosswind. "Wind Coverage is determined by percent

of time for which operations are considered safe due to acceptable crosswind components."¹⁴ The most comprehensive wind coverage for an airport is 95 percent. Included in the 95 percent coverage is a crosswind component of twelve miles per hour. Crosswind velocity of twelve miles per hour is the maximum allowed by the F.A.A.

A ten-year (or more) wind summary is preferred for use in determining runway orientation. If this cannot be obtained, then some lesser period may be used. However, with less than a three-year record, the F.A.A. may sponsor the construction of only one runway, and this will depend upon the quality of wind data gathered at close surrounding sites.

Wind velocity records, used in resolving crosswind components, must also be analyzed. These records must also cover a number of years, since the F.A.A. recognizes that a significant difference can exist between the wind velocity obtained from a ten-year record as opposed to that of a three-year record.

Wind direction for Watauga County was recorded at an approximate elevation of 3,400 feet, between the years of 1929 and 1948. Wind velocity has been recorded only since July, 1976, when the Geography Department at Appalachian State University began a continuous wind direction and velocity coverage. Table 4 shows the results of combining both of these sources to determine prevailing wind direction. Aligning a runway directly into the prevailing winds in Watauga County would produce a west-east configuration with 64.85 percent wind coverage. This does not account for additional crosswind coverage under 12 miles per hour. However, it would be feasible to align the runway in a

west-northwest and east-southeast direction in order to take additional advantage of the winds blowing from southeast and northwest. A 20-percent increase of wind coverage to 84.85 percent would be beneficial in terms of airport usage. A higher wind coverage percentage demands years of wind velocity data at the site and construction of a wind rose.¹⁵

Table 4

PREVALENT WIND DIRECTION, WATAUGA COUNTY, N.C.

1928 to 1948 and 1976 to 1977

Direction	Number of Observations	Percent	Cumulative Percentage
West	3061	53.19	53.19
Southeast	839	14.58	67.77
East	671	11.66	79.43
Northwest	422	7.33	86.76
Southwest	316	5.49	92.25
Calm	221	3.84	96.09
South	174	3.02	99.11
Northeast	44	.76	99.87
North	7	.01	99.88
Total	5755	99.86*	99.88*

*Does not total 100 due to rounding.

Source: Derived from local weather records.

Feasible Airport Site Locations for Watauga County

The F.A.A.'s general rule is that "nonair carrier airports planned to serve communities of less than 50,000 population should be located so that the majority of potential users are located within a 30-minute time contour."¹⁶ Prime driving time to this type airport is in the 15-through 20-minute contour. Added to this criteria, the North Carolina Department of Aeronautics stresses that all potential sites selected should have no present economic development, or minimal residential development at the most.

Based upon these guidelines and upon the topographic and meteorological criteria and analysis previously provided, it is found that in Watauga County four potential sites occur in the prime contour and one additional site within the 30-minute contour (see Figure 2).¹⁷ These sites are here designated by a relevant physical or other prominent feature, near which they are located. A brief discussion of each site follows:

1. Tweetsie Site (Blowing Rock Township) - Ridge of 3,600 feet in elevation with the potential of a 4,000-foot runway, located south of Tweetsie Railroad and north of Brown Branch Road off U.S. Highway 321. Possible disadvantages include the future development encroachment that may be brought on by the planned widening of 321. Also, it is uncertain that the runway can be aligned to take full advantage of the wind while still having an instrument approach capability, due to the proximity of Flat Top Mountain. Airport soil suitability is rated as good and estimated construction for elevation difference is 90 feet for a 4,000-foot runway.
2. Buck Ridge Site (Blue Ridge Township) - Ridge of 3,600 feet in elevation with the potential of a 5,000-foot runway, located at the end of Happy Valley, east of the Blue Ridge Parkway. The most promising of sites since no obstructions exist to hinder a parallel or to form v-shaped runways. Construction of two runways would allow better wind coverage and give the site the potential of being developed into a

POTENTIAL AIRPORT SITES IN WATAUGA COUNTY

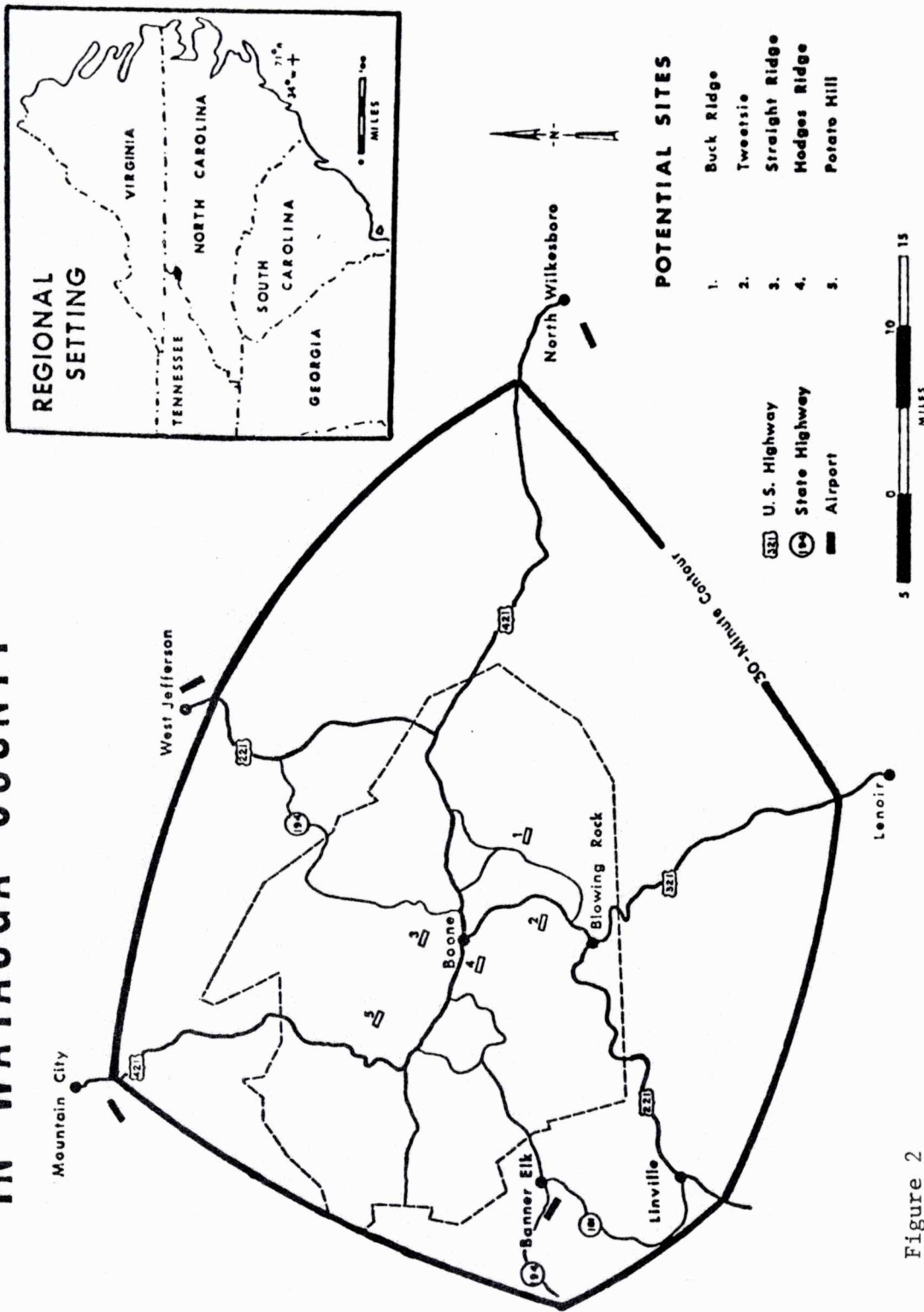


Figure 2

regional/transport airport, the criteria for which is discussed in Chapter 3. Airport soil suitability is rated as good, and estimated construction for elevation difference is 80 feet for a 5,000-foot runway.

3. Straight Ridge Site (New River Township) - Ridge of 3,400 feet in elevation with the potential of a 5,000-foot runway, located west of Highway 194 and south of Howard Creek Road. Possible disadvantage is Howard Knob (4,420 feet) and Doe Ridge (4,200 feet) which may hinder instrument approaches. The site should only be considered for visual flying conditions. Airport soil suitability is fair, and estimated construction for elevation difference is 80 feet for a 5,000-foot runway.
4. Hodges Creek Ridge (Brushy Fork Township) - Ridge of 3,400 feet in elevation with the potential of a 4,500-foot runway, located south of Highway 105 behind the Ramada Inn. Possible disadvantages include the proximity of Watauga High School, and future development along Highway 105. Airport soil suitability is rated fair and estimated construction for elevation difference is 100 feet for a 4,500-foot runway.
5. Potato Hill Site (Meat Camp Township) - Rolling hill area of 3,920 feet in elevation with the potential of a 3,900-foot runway, located south of Potato Hill Lake and north of Wolf Ridge. Possible disadvantages include questionable instrument capabilities, high terrain in close proximity of site and travel distance and difficulty from Boone. Airport soil suitability is good and estimated construction for elevation difference is 50 feet for a 3,900-foot runway.

Summary

Topographic features are a limiting factor when locating an airport in Watauga County. Not only do the land features restrict the number of potential sites to five, but each site's runway length must be increased correspondingly to its elevation (see Figures 1 and 2). This influence of topography will mean a high construction cost of an airport whatever its size.

A close link exists between the County's relief and weather conditions. This causes microclimatic differences in visibility,

precipitation, wind, temperature and pressure. However, these climatic differences do not pose a serious threat to air transportation in Watauga County.

Therefore, it has been established from a study of the physical environment in Watauga County, that:

Airport sites are available, and meteorological and physiographic conditions at certain sites will not adversely affect air transportation in a significant degree.

A ranking, based upon the potential of each site to support a runway (including approach and land area) for an airport follows:

1. Buck Ridge Site (Blue Ridge Township)
 - Minimum Runway Length - 3,700 feet
 - Maximum Runway Length - 5,000 feet
 - Runway Width - 50 to 75 feet
 - Number of Runways - 2
 - Potential for Expansion - Yes
2. Tweetsie Site (Blowing Rock Township)
 - Minimum Runway Length - 3,700 feet
 - Maximum Runway Length - 4,000 feet
 - Runway Width - 50 to 60 feet
 - Number of Runways - 1
 - Potential for Expansion - No
3. Straight Ridge Site (New River Township)
 - Minimum Runway Length - 3,600 feet
 - Maximum Runway Length - 5,000 feet
 - Runway Width - 50 feet
 - Number of Runways - 1
 - Potential for Expansion - No
4. Hodges Creek Ridge (Brushy Fork Township)
 - Minimum Runway Length - 3,600 feet
 - Maximum Runway Length - 4,500 feet
 - Runway Width - 50 feet
 - Number of Runways - 1
 - Potential for Expansion - No
5. Potato Hill Site (Meat Camp Township)
 - Minimum Runway Length - 3,750 feet
 - Maximum Runway Length - 3,900 feet
 - Runway Width - 60 feet
 - Number of Runways - 1
 - Potential for Expansion - No

NOTES

¹The Ashe County airport was not completed as expected by the summer of 1976, due to unexpected costs and delays in grading off the ridge tops. Total cost as of summer, 1977, had reached 1.24 million dollars according to a member of Ashe County's Airport Commission. (Projected completion is Fall, 1977.)

The airport in Jackson County was completed as of last year. The airport, however, is experiencing erosion problems due to vegetation not being able to stabilize on steep cut slopes.

²Federal Aviation Administration, "Runway Length Requirements and Capacity," Advisory Circular on Utility Airports, Air Access to National Transportation, AC. No: 150/5300-4B, (Washington, D.C., 1975), p. 11.

³Ibid., p. 76.

⁴Ibid., pp. 75 - 76.

⁵Ibid., pp. 74 - 75.

⁶United States Department of Agriculture, Inventory and Evaluation, Soil and Water Resources, New River Township, Watauga County (U.S. Soil Conservation Service, 1973).

⁷Lecture notes from a North Carolina Airport Land Use Seminar, held at the McKinney Center, North Carolina State University, May, 1977.

⁸There were periods in which no wind direction was recorded. The longest consecutive non-recorded period was two weeks.

⁹According to the Watauga Democrat, during 1965 the F.A.A. approved two proposed valley airport sites for Watauga County, located in Valle Cruis and Happy Valley. As of 1969, the F.A.A. retracted its approval from those sites because of possible high incidence of valley fog.

¹⁰United States Department of Commerce, "Climatological Summary," Climatological Data, North Carolina (National Climatic Center, Asheville, North Carolina, 1971).

¹¹Interview with the North Carolina Department of Aeronautics, May, 1977.

¹²The maximum monthly temperature is used by airport engineers in order to determine runway length.

¹³A General Utility Type Airport of this size would serve all single and multi-engine aircraft up to corporate jets such as the Lear, Jet Star and Sabreliner 40-Series.

¹⁴Ibid., p. 7.

¹⁵A wind rose is a scaled graphical presentation of wind in terms of speed and direction. Concentric circles represent limits between speed group sectors. Radii for these groups should be accurately scaled to the representative speeds. Segments enclosed by the radial lines and concentric circles represent speed--direction combinations.

¹⁶Federal Aviation Administration, Airport Site Selection, AC No: 150/5060-2, (Washington, D.C.), p. 9.

¹⁷In order to determine potential sites in Watauga County for detailed analysis, the following procedure was used:

1. A comprehensive review of existing land use plans in the County.
2. Available wind data was studied to determine the desired runway orientation.
3. United States Geological Survey Maps (scale 1:24,000) were studied in order to select tentative sites and note the proximity of any major obstructions, topographic features, recreational areas and primary population distributions.
4. Each selected site was further studied with the use of existing aerial photographs, (1976, aerial photographs).
5. The Watauga County Soil Survey, 1944 was used to determine slope, drainage and soil characteristics.
6. Automobile driving time to each potential site from Boone's city limits and actual field inspection was conducted.
7. An aerial inspection of each selected site, which involved simulated approaches, was also conducted (June, 1977). However, due to a lack of weather recording instruments, the actual physical inspection of each site is incomplete.

CHAPTER III

SOCIO-ECONOMIC CHARACTERISTICS

Introduction

The collection of sociological variables for an area to be served by air transportation is needed to determine the feasibility, type and volume of aviation activity. Data such as population size, age, education, occupation and income level will assist in defining what is known as a "threshold level." In Watauga County, a threshold level of these variables may exist for air transportation because of the socio-economic growth of the County during the past ten years.

It is hypothesized that:

Population size, age, education, occupation and income levels, in combination, exceed the threshold level necessary for the introduction of an air transportation system into the county.

Population Characteristics

The size of an area's population and its rate of potential growth or decline are basic variables in determining the demand for air transportation services. These variables influence the level of airport growth in terms of incoming traffic from surrounding states, regions or cities, and traffic generated by the local population. Airport size and design is therefore based upon an area's population size ten (preferably twenty) years into the future. The North Carolina Department of

Aeronautics presently recognizes four airport types derived from population size. These airport types are:

1. Basic Utility Stage I
2. Basic Utility Stage II
3. General Utility
4. Regional/Transport

A brief discussion of each F.A.A. and State approved airport type follows:

1. Basic Utility Stage I - Geometric Criteria

Runway Length - 2,000 feet minimum
 Runway Width - 50 feet minimum, 75 feet maximum
 Taxiway Width - 20 feet minimum, 40 feet maximum
 Runway and Taxiway Slope - zero percent through 2 percent

Comments

This airport type is primarily intended to serve low-activity locations, small population communities, and remote recreational areas. Examples can be found in the North Carolina mountain counties of Alleghany, Graham, Clay and Swain.

2. Basic Utility Stage II

Runway Length - 2,500 feet minimum
 Runway Width - 60 feet minimum, 75 feet maximum
 Taxiway Width - 30 feet minimum, 40 feet maximum
 Runway and Taxiway Slope - zero percent through 2 percent

Comments

This airport type is primarily intended to serve medium-size population communities with a diversity of usage and potential for increased aviation activities. An example can be found in the North Carolina mountain county of Madison.

3. General Utility - Geometric Criteria

Runway Length - 3,000 feet minimum
 Runway Width - 75 feet minimum, 100 feet maximum
 Taxiway Width - 40 feet minimum, 40 feet maximum
 Runway and Taxiway Slope - zero percent through 2 percent

Comments

This airport type primarily serves communities located on the fringe of a metropolitan area or a relatively large remote community over 30,000 in population. Examples can be found in the North Carolina counties of Henderson, Haywood, Wilkes and Rutherford.

4. Regional/Transport Airport - Geometric Criteria

Runway Length - 4,500 feet minimum, expandable by 2,000 feet
 Runway Width - 100 feet minimum
 Taxiway Width - 50 feet minimum
 Runway and Taxiway Slope - zero percent through 2 percent

Comments

This airport type primarily serves communities over 50,000 in population. North Carolina examples include, Asheville, Buncombe County and Hickory, Caldwell County.

Size

Defining the airport type needed for region based only on population size is considered a preliminary step in the airport planning process. This assists in forming a general determination of a community's present aeronautical needs. However, a more important element to consider is the rate of population growth. A realistic population projection ten to twenty years into the future will better aid in specifying a region's airport type. Based upon this knowledge, an airport planner can form a tangible concept of airport size and needed land.

Population projections for North Carolina counties can be obtained from the State Department of Administration, Office of Business and Economic Research Services (OBSERS) and from local planning agencies. The OBSERS population projection for Watauga County predicts a population of 43,100 by the year 1990 (refer to Table 5). Township

areas increasing or decreasing correspondingly to the county's growth are shown in Table 6.

Table 5

POPULATION PROJECTIONS, WATAUGA COUNTY, N.C.

Year	Population
1970	23,404
1972	24,361
1980	30,325
1990	43,100

Source: Watauga County Development Study (1977) "OBSERS Series 'E' Projection - Division of Community Services," p. 9.

Other population projections for the town of Boone are significantly different from the OBSERS projection. The Water Resource Management Plan published by the Region "D" Council of Government's in 1974 projects a Boone population of 10,255 for 1980 and 12,519 for 1990. Changing the Watauga County total projected population accordingly will yield a substantially reduced count (population of 25,090 in 1980 and 28,033 in 1990) than what is found in the OBSERS projection. Conversely, one may expect the Boone suburban township of New River to increase dramatically rather than decrease in population over the next 15 years. It is equally likely that the Blue Ridge township projection is underestimated. Analyzing this information reveals the following:

1. A proposed airport for Watauga County should be of the

General Utility Type with the potential to expand. Estimated amount of acreage needed to satisfy this criteria is 200 acres.¹

2. Township areas showing possible high population growth rates should be avoided. If avoidance is impossible due to site availability, then strict airport site controls in the form of zoning, easements, purchase assurance, lack of public work projects, or non-issue of electrical and building permits should be implemented immediately. It is stressed that the final control of condemnation be used only after all previous methods have been tried without success.

Age Structure

Age structure is one of the most basic characteristics of a population. To an important degree, a person's age influences what he needs, buys, does and thinks. Absolute and relative proportions of a population found within the young, middle-aged, and old-age groups are notable determinants of that group's social and economic structure.² All aspects of community life, social attitudes, economic activities, political tendencies, military service and travel are affected by age composition.

In order to effectively plan for an air transportation system of a remote community as Watauga County, an age structure analysis is important. Of concern is the difference in the percentages of population within the younger, middle- and older-age groups. If a large portion of people in the study area are above 55 years old, then the likelihood for an air passenger market must be considered poor. However, other factors such as cargo transportation, recreational potential and retirees affording second homes should be strongly considered.

Table 6

POPULATION PROJECTIONS BY TOWNSHIPS
WATAUGA COUNTY, N.C.

Township	1970 (Actual)	1980	1990
Bald Mountain	363	342	330
Beaver Dam	847	714	589
Blowing Rock	1,321	1,400	1,563
Blue Ridge	898	951	1,084
Boone Town	8,754	15,400	27,586
Brushy Fork	2,345	3,188	4,444
Cove Creek	1,780	1,749	1,705
Elk	274	211	167
Laurel Creek	1,096	1,121	968
Meat Camp	1,274	1,206	1,132
New River	1,499	1,427	1,227
North Fork	231	197	163
Shawneehaw	390	315	248
Stony Fork	1,192	1,122	1,047
Watauga Township	1,139	992	857
	23,404	30,235	43,100

Source: Watauga County Development Study (1977) "OBSERS Series 'E' Projection - Division of Community Services," p. 8.

The greatest number of air travelers are under 35 years of age. However, those who have the greatest propensity to fly are between the ages 35 and 44.³ Above age 55, it is estimated that this group comprises only six percent of the total air travelers. Therefore, it is possible to use age distribution when planning future air passenger markets. If an air transportation system is going to depend upon air passengers for support, then it must be oriented to serve the predominate age group. This is also true in planning airport facilities to adequately handle possible air passengers. For instance, if the majority of the population is approximately 35 years of age, a community may want to consider a Basic Utility Stage II or a General Utility Airport with limited facilities. Restricting the physical size of the General Utility and Basic Utility Type II Airport will serve the present and future year needs of the 35-44 age sector without need to expand the facility. However, if the greatest percentage of population is approximately 25 years of age, then whatever airport facility is planned must include the option to expand. Primarily because this same 25-year age group is likely to fly more frequently ten years later and increase demand on the airport system.⁴

The age structure in Watauga County, as shown in Table 7 is based on 1970 U.S. Census figures. The County has a large percentage of its population between the 15-19 year (15.9 percent) and 20-24 year (16 percent) sectors. However, the size of these two groups is deceptive due to the inclusion of college age students attending Appalachian State University. College students for the most part leave the County upon graduation and are less likely contributors to an air passenger market because of cost factors. This is a factor which obviously must

Table 7

AGE STRUCTURE, WATAUGA COUNTY, N.C., 1970

Age Group	1970 Population	Percent of Total
0-4	1,581	6.8
5-9	1,687	7.2
10-14	1,759	7.5
15-19	3,714	15.9
20-24	3,742	16.0
25-29	1,479	6.3
30-34	1,130	4.8
35-39	1,092	4.7
40-44	1,097	4.7
45-49	1,163	5.0
50-54	973	4.2
55-59	973	4.2
60-64	843	3.6
65-69	705	3.0
70-74	518	2.2
75-79	417	1.8
80-84	187	.8
85 +	152	.6
Total	23,404	99.3*

Source: United States Population Census, 1970

*Does not total 100 due to rounding

be considered when assessing age structure in airport facility planning. However, college students may in the future use air transportation if the energy crisis becomes acute and/or air travel prices are competitive to the use of an automobile; especially since Watauga County is remote from large urban centers and depends solely upon the present highway system to service all of its transportation needs.

Education

Level of education attainment is an important element in population analysis. In addition, personal mobility, as well as recreation, social and cultural activities have been found related to educational attainment.

The educational quality of a population is not only related with the occupational structure of a labor force, but also with work quality. Also, a better educated labor force is more likely to be geographically mobile. Thus an air passenger market is in part generated by the geographic mobility brought on by what might be described as the indirect impact of education on air travel. This is indicated by the high numbers of professional, technical, managerial, and administrative people who tend to travel more frequently by air than persons of other occupations. Such people are more apt to have had some college training or hold college degrees.⁵

Every year a large number of high school graduates (62 percent in 1972) go on to higher education in order to better themselves.⁶ Therefore, it is possible to determine a potential air passenger market through the use of the number of high school graduates as a base index.

These graduates have increased their chances for earning a higher income and therefore classifying them as potential air passengers. The average percentage of North Carolina high school graduates who went on to higher education in 1972 was 58.1 percent. Of this percentage, 30.9 percent enrolled in senior colleges, 22.7 percent enrolled in junior colleges, community colleges and technical institutes, and 4.6 percent entered private trade, business and nursing schools.⁷

Table 8 shows school years completed by percent of population twenty-five years or older for Watauga County, North Carolina and the United States. In Watauga County all high school graduates (above 25 years of age) total 17.7 percent. This statistic lags behind North Carolina by 4.0 percentage points and the United States by 13.2 percentage points. This relatively low level of educational attainment, however, must be modified to include consideration of the much larger percentage of people under 25 that have completed high school in Watauga County than elsewhere, due to the large number of college students. However, the presence of Appalachian State University faculty, students and spouses in Watauga County increases the more highly educated sector to 12.2 percent, while the percentages for North Carolina and the United States is 8.4 and 10.6, respectively. In assessing these education characteristics, the indication emerges that the average resident of Watauga County would not utilize passenger air service.

This finding is supported by a 1971 survey by the College of Business at Appalachian State University of 180 landowner residents, in order to determine the amount of utilization of a passenger air service in Watauga County. Only 67, or 37 percent, of 180 landowners who

Table 8

SCHOOL YEARS COMPLETED BY PERCENT OF
POPULATION TWENTY-FIVE YEARS OR OLDER, 1970

	Watauga County*	North Carolina	United States
No School Years Completed	1.3	2.0	1.6
Elementary			
1 to 4 years	8.3	8.0	3.9
5 to 7 years	24.4	18.3	10.1
8 years	9.5	8.8	12.8
High School			
1 to 3 years	18.0	24.4	19.4
4 years	17.7	21.7	31.0
College			
1 to 3 years	8.8	8.4	10.6
4 years or more	12.2	8.4	10.6
Median School Years Completed	10.1	10.6	12.1

Source: United States Population Census, 1970

*Affected by the large number of college students in the unusual age structure.

returned the questionnaire indicated possible desire to use of passenger air service. This same survey was also conducted on 111 faculty and staff members of Appalachian State University, and resulted in 58 returns (52 percent) out of 111 who indicated possible usage.⁸

Neither segment of these two groups in Watauga County could solely support an air passenger market. However, a marginal air passenger market may exist when combining all those who indicated possible usage. The success of this passenger market would depend upon user frequency.

Occupation

Examining the occupation of the majority of a population in a region aids in forecasting aviation activity and airport type. Recognized by the Federal Aviation Administration, the Civil Aeronautics Board, and by most airport planning firms, are the three basic employment categories of primary, secondary and tertiary. The latter two of these tend to generate greater air transport activity than primary industries such as mining.

Secondary activity, as defined by Edgar C. Conkling, involves the changing of single materials, or the combining of different materials into more useful products, which can then be exported by truck, ship, train or aircraft.⁹ A region, in which the majority of its population is engaged in secondary activity, should consider planning and designing an airport to accommodate cargo-transport type planes. The use of these heavier planes would necessitate the construction for a

General Utility Airport in Watauga County to withstand up to 175,000 pounds gross weight.¹⁰

Areas of tertiary activity involve commercial output of services rather than goods. The lawyer, teacher, government worker and insurance adjustor are examples of persons in the tertiary sector of the labor force. These people usually carry on their business activities away from their home base and consider travel time heavily in accomplishing this business.

Plans for a Utility Airport, in regard to tertiary activity, would involve a runway stressed to withstand anywhere between 12,500 to 60,000 pounds gross weight.¹¹ (The F.A.A. recommends the construction of a runway of 60,000 pounds gross weight if there is to be heavy projected use by business or executive type jets such as Lear, Jet Star, Gulfstream, Jet Commander and Sabreliner.)

Historically, Watauga County has been a region orientated toward an agricultural economy. However, full time employment in farming-related activities declined drastically from 1965 to 1976, decreasing from 2,636 to 301 workers.¹² Altering this pattern has been the trend toward rapid urbanization and industrialization. Another explanation contributing to this change is land speculation for second home development, which has influenced the sale of marginal agricultural lands. In 1965, manufacturing employment constituted over half of the jobs in Watauga County (Table 9). From 1965 to 1976, however, the non-manufacturing sector expanded at three times the rate of the manufacturing sector.

Table 9

MANUFACTURING AND NON-MANUFACTURING EMPLOYMENT
WATAUGA COUNTY, 1965-1976

Employment	1965	1970	1972	1974	1976
Non-Manufacturing	1,214	4,200	5,700	6,950	5,591
Manufacturing	1,278	1,740	2,120	2,430	1,868
Total	2,492	6,460	7,820	9,380	7,459

Source: Watauga County Economic Development Study, 1977, "Manufacturing," p. 24.

In Watauga County, manufacturing is handicapped by a number of factors. Neither the labor force, transportation system, water and sewer capacity or topography will at present support the location of most large industrial plants in the County. Therefore, a Utility Airport to serve present and future secondary activity needs would not justify runway construction for heavy transport.

Income

Median income is the point in ranking of the distribution of the amount of earnings in which half the families have more and half the families have less. Knowledge of a region's median income aids in determining airport design and potential usage. However, the median income level should not be considered alone in determining airport design, but used along with the variables of population size, age, education and occupation.

A median income of \$7,500 (in 1969 dollars) is considered the minimum threshold level for potential air passenger travel. A \$10,000 plus level will include not only possible air passengers with the financial ability to travel more, but also will include a greater number of private aircraft owners.¹³

The higher the median income threshold, therefore, the more an airport planner must plan a proposed airport to suit the larger air traffic need. A lower income threshold would mean less airport facilities and acreage. Table 10 shows that median income in Watauga County in 1970 was \$6,149. This does not constitute a feasible income level market for air passenger travel. Therefore, designing a Utility Type airport should not involve a runway engineered for heavy transport, passenger terminal building, pedestrian walkways, baggage-handling systems, or large automobile parking areas.

Table 10

MEDIAN FAMILY INCOME, WATAUGA COUNTY AND
NORTH CAROLINA, 1970

	Watauga County	North Carolina
Total Number of Families	5,392	1,292,466
Median Income	\$6,149	\$7,774

Source: Land Use Survey Analysis and Planning Recommendations for Boone, N.C., 1974, "Economic Study of Boone," p. 41.

Corresponding to the low-median income level in Watauga County is the number of people who own private aircraft within the county. The Civilian Aircraft Census, 1975, records ten owners registering aircraft in the county. This low number for a county with an estimated population of 29,000 may not only be from the lack of residents who can fly and afford a plane, but possibly from the inadequacy of the present sod airport facility. However, a recent survey (summer 1977) by the Airport Commission resulted in letters from twenty-three aircraft owners who would extensively use and/or base their aircraft in Watauga County, if an adequate paved runway facility existed.¹⁴

Assessment of Air Transportation

Based on Watauga County's Social Characteristics

The variables of population size, age, education, occupation and income levels were studied separately for their potential to support an airport and/or air passenger market. Those variables which do not presently constitute a threshold level for air transportation in Watauga County are occupation, education and median income levels. The only variable which supports both an airport and possible air passenger market for the county is population size.

The research hypothesis can be supported only in part. Greater support might be found if more precise figures concerning the contribution of Appalachian State University students to the census statistics were available.

A finding of particular importance is the population growth. If the population reaches between 35,000 and 40,000 by 1990 then Watauga

county will be on the verge of qualifying for a Regional/Transport Type airport according to present F.A.A. and North Carolina airport standards. It is the author's contention that along with this growth will be increased education and median income levels, above the threshold level to support air transportation in the county.

Assessment of the county's social conditions in total reveals that an air passenger market does not presently exist, and that any proposed airport should be planned to satisfy only general aviation need. Any proposed airport should be constructed in the General Utility class with limited facilities, but have the potential to expand its boundaries and facilities, if warranted.

Land use planning may be used effectively to preserve a potential site and minimize future environmental conflicts between an airport and community. County or regional planners ought to use this control to protect those limited airport sites located in townships with high population growth rates. This is especially true of the Blue Ridge township where the only potential Regional/Transport Airport site exists in Watauga County (see Figures 3 and 4). All other sites can only accommodate a General Utility type airport due to topographic restrictions.

AIRPORT SITES LOCATED IN TOWNSHIPS

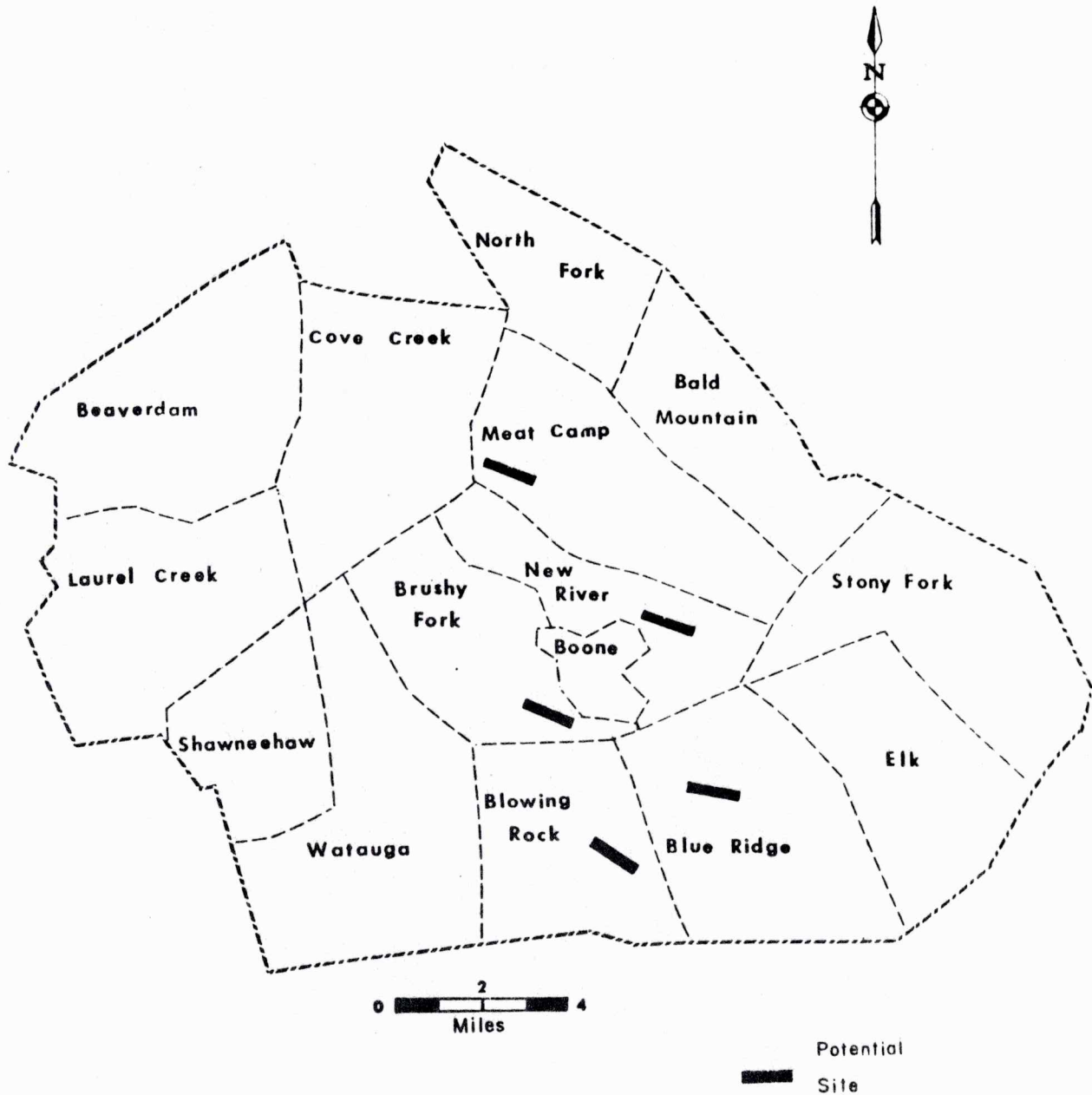
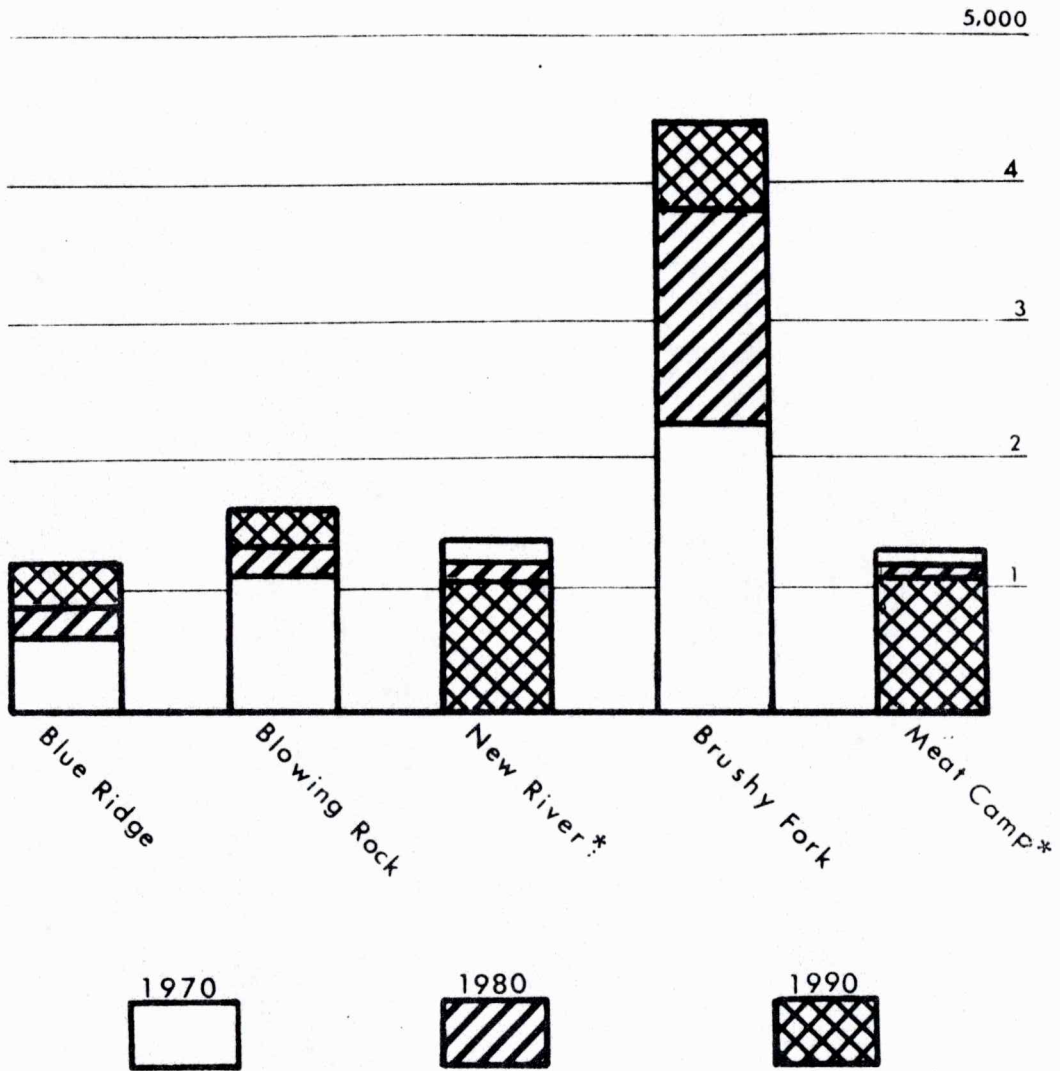


Figure 3

POPULATION PROJECTIONS

Airport Site Townships



*The New River and Meat Camp Townships show a population decline by the year 1990.

Figure 4

NOTES

¹Estimated acreage is based upon a strip of land approximately 9,000 feet long by 1,000 feet wide.

²Glenn Trewartha, "Age Structure," A Geography of Population: World Patterns (New York: Wiley and Sons, Inc., 1969), p. 117.

³Bernard Schriever, Air Transportation 1975 and Beyond: A Systems Approach (Cambridge, Massachusetts: MIT Press, 1968), p. 67.

⁴Ibid., p. 67.

⁵Ibid., pp. 58 - 59.

⁶James Clay, Douglas Orr and Alfred Stuart, "Services and Amenities," North Carolina Atlas Portrait of a Changing Southern State (North Carolina University Press: Chapel Hill, 1975), pp. 252-253.

⁷Ibid., p. 253.

⁸Robert Lewis and Sampter Langston, "A Forecast of Passenger Utilization," A Forecast of Utilization of an Air Service in Watauga and Avery Counties (Appalachian State University, College of Business: mimeographed, 1971), p. 6.

⁹Richard S. Thoman, Edgar C. Conkling and Maurice H. Yeates, The Geography of Economic Activity (New York: McGraw Hill Book Company, 1968), p. 5.

¹⁰Federal Aviation Administration, Airport Design Standards - General Aviation Airports - Basic and General Transport, AC NO: 150/5300-6 (Washington, D.C., 1969), p. 3.

¹¹Ibid., p. 3.

¹²Interview with Mr. James Abernathy of the Watauga County Planning Department, June, 1977.

¹³Bernard Schriever, Air Transportation 1975 and Beyond: A Systems Approach (Cambridge, Massachusetts: MIT Press, 1968), pp. 66 - 67.

¹⁴These letters of documentation indicated the type of aircraft owned, the "N" registration number, present based location, and the number of anticipated landings per month in Watauga County.

CHAPTER IV

ECONOMIC DEVELOPMENT CRITERIA

Introduction

Economic assessment of a region is necessary to determine an air transportation system's potential need. Principal contributors to the present economic conditions in Watauga County include: manufacturing, educational and recreational sectors. Implementation of an air transportation system could be beneficial to these industries and contribute to the overall economic growth of the county. In terms of economic growth, the benefits generated by air transport systems can be expressed as:

1. Direct The airport is an employment center using local labor.
2. Indirect a) Airport activities require local goods and services.
 b) There are passenger related activities such as taxicab, and convention or visitor generated business.
 c) The multiplier effect - The initial suppliers of goods and services must purchase goods and services demanded by airport activities.
3. Other Certain kinds of manufacturing industries regard air service availability as a major locational criteria (examples include Burlington Mills and Boling Chain Company)¹

It is therefore hypothesized that:

Factors characterizing economic development favor an air transportation system in Watauga County.

This hypothesis will be assessed in terms of: (1) existing transportation usage and (2) potential air transportation usage for industries now located in the study region.

Manufacturing Industries

A primary concern in conducting industrial transportation studies is to determine the most suitable transport mode(s) for individual industrial use. A method commonly used is called a "transport determinant study" and involves commodity values, shipment size, distance/time relations, and form of transport.² Watauga County's four major manufacturing industries: Thomas, Ramo, Woolridge, Incorporated (T.R.W.), Vermont American Corporation, Blue Ridge Shoe Company and Shadowline Company, will be assessed accordingly.

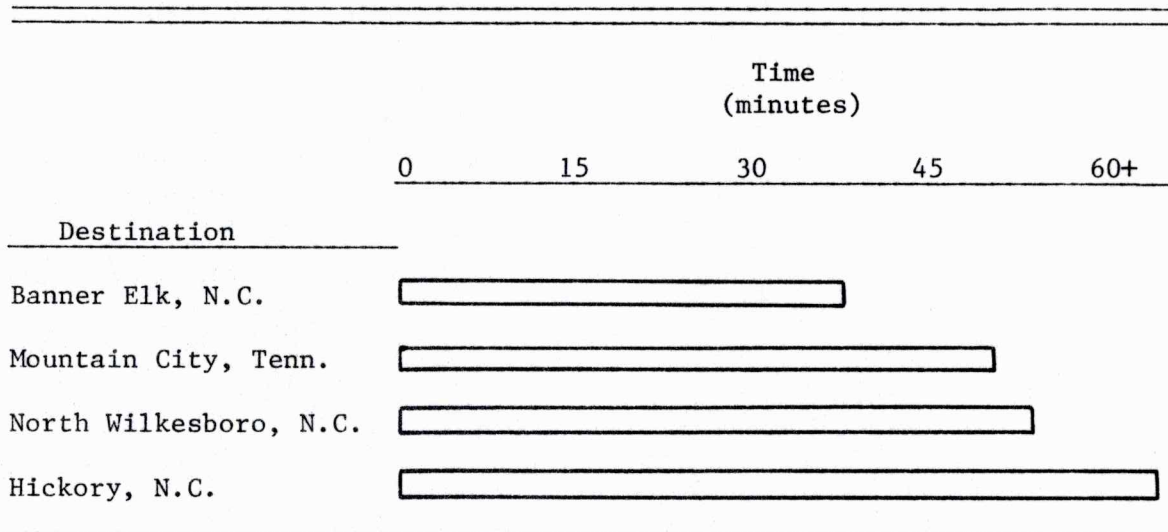
Thomas, Ramo, Woolridge, Incorporated

The main products produced by T.R.W. are an assortment of small resistors, and power wire-wound resistors. Resistor sizes are normally small and a large number may be crated together for shipping. These products are transported throughout the United States or to other T.R.W., Inc. plants for installation in other products. Unit costs are high even though resistors are used in a number of high demand items, such as computers, radios and aviation instruments. There is enough produced that transport savings time is not an important location factor. T.R.W., Inc., therefore, is able to locate in regions served by a highway system and does not have to depend on the availability of other transportation modes.³

However, there are occasions where the least possible travel time is essential for T.R.W. administrative officials. At these appropriate times, officials usually fly a chartered aircraft out of North Wilkesboro or Hickory, North Carolina, or out of Mountain City, Tennessee. Only the airport at Hickory, North Carolina, has scheduled commercial flights. Approximate automobile driving times to each airport destination are found in Figure 4.

Figure 4

AVERAGE AUTOMOBILE DRIVING TIME FROM BOONE TO
FOUR NEARBY AIRPORTS



Source: Driving time estimates made by the author "within the 55 M.P.H. speed limit." Time may vary due to amount of traffic present on the highway and weather conditions.

Vermont American Corporation

The main products of Vermont American are saber saw blades, circular saw blades, hand hack saw blades, band saw blades and chisels.

These tools are usually crated together and transported by truck throughout the southeast. Occasionally a specific blade or a number of blades and chisels are needed quickly by a user or a dealer. At such time, Vermont American delivers the products to their destinations in a company plane, a twin engine Piper Navaho.

Presently, the company is bringing officials, workers and visitors to the Boone plant two or three times a week. Their commuting pattern is from a corporate office in Louisville, Kentucky, and scattered small community plants in the southeast. The company plane cannot use the present Boone sod strip due to aircraft weight; for safety reasons, their pilots also refuse to use the Banner Elk airport. Currently, Vermont American's company plane is using the Hickory, North Carolina, or Mountain City, Tennessee, airport for their Boone operations.⁴

Blue Ridge Shoe Company

The main products of Blue Ridge Shoe industry are men's dress and work welt shoes, which are transported by truck to surrounding regions. Demand is not great enough to seek a faster form of transport. (Unit costs are lower than the products of T.R.W., Inc. and Vermont American Corporation and thus Blue Ridge Shoe Company is less likely to need air transport service.)

Approximately once or twice a month, Blue Ridge administrative officials do have a need to use air transportation. Usually, they fly out of Hickory, North Carolina, or Tri-Cities Airport (Johnson City-Kingsport-Bristol) in Tennessee. The industry owns a multi-engine

aircraft, which seldom serves the Boone plant. However, the plane is extensively utilized at Blue Ridge Shoe's scattered plant operations throughout the North Carolina coastal region.⁵

Shadowline Company

The main product of Shadowline is ladies nightwear. Cost per commodity item is low and "time demand" is not great. Thousands of units can be packaged, boxed and transported in a single truck.

Due to Shadowline's small number and small scale of plant operations, administrative officials rarely use air transportation. Furthermore, this Boone industry does not foresee a need for air transportation in its long range plans.⁶

Educational Services

Appalachian State University has contributed much to economic growth in Watauga County. This has been accomplished over the years through the University's expansion of facilities, faculty, staff and student enrollment. Business sectors of the economy directly benefiting from Appalachian State University's growth are retail trade, service and construction. However, according to unofficial estimates the University's enrollment should peak at around 9,200 students by the 1980-81 academic year.⁷ Further growth is unlikely due to the inability of the Boone area to provide additional water, sewer, housing and land. Lack of proposed additional improvements in the transportation system will also inhibit growth.

The primary transportation modes presently used by the university are state-owned or private automobiles and university vans and buses. When the shortest travel time is essential for sports or business, air transportation facilities are used at Hickory, North Carolina, Winston-Salem, North Carolina, or Tri-Cities Airport in Tennessee. Occasionally, school officials have chartered private flights out of North Wilkesboro and out of the sod strip near Boone.

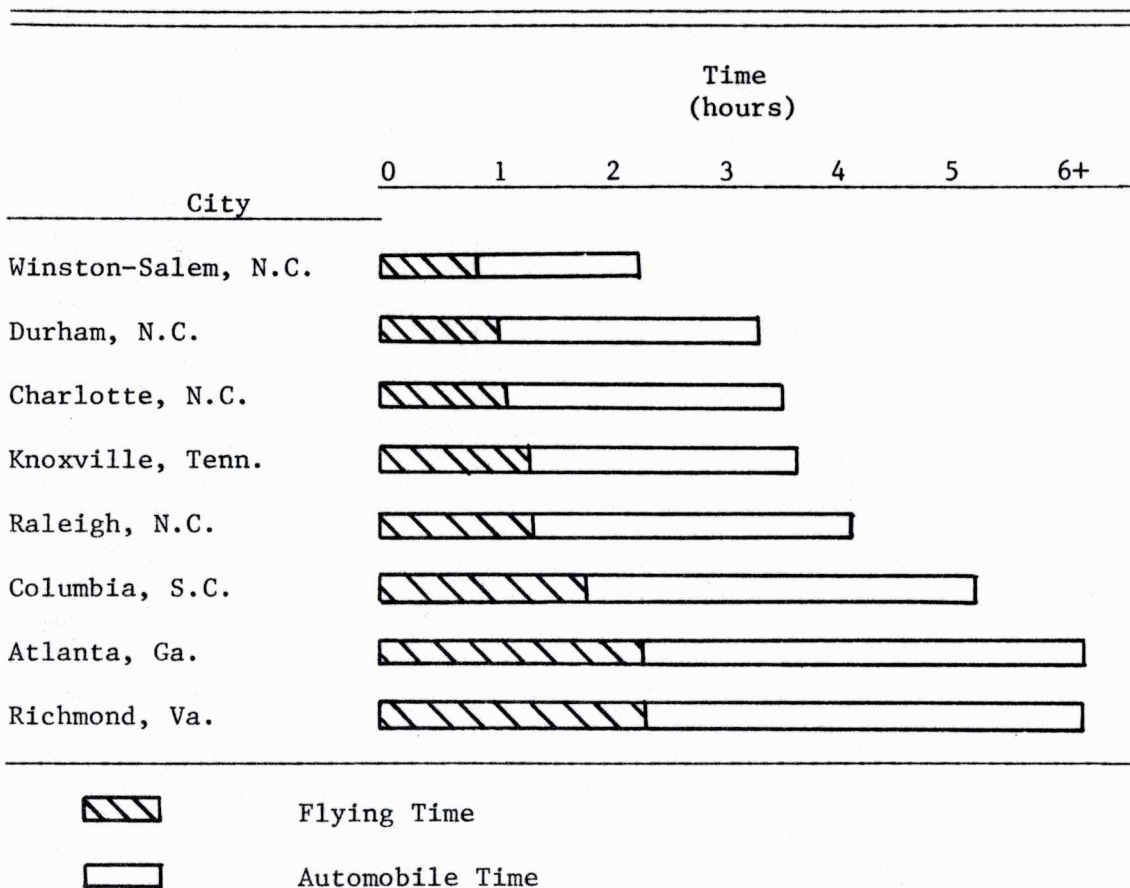
It is difficult to make an exact assessment of the amount of use the University would make of an air transportation system, but it is likely to be considerable. As a member institution of the University of North Carolina, a large amount of University business is transacted in Chapel Hill. Various members of the University staff make several visits per week to the General Administration offices for meetings. In addition, Appalachian State University is an agency of the State of North Carolina, and therefore has considerable business in Raleigh. By plane, travel time to and from these destinations can be considerably less (see Figure 4).

The university is also a member of the Southern Conference in athletics and currently fields 20 intercollegiate teams. On a regular basis, University teams travel to Huntington, West Virginia; Charleston, South Carolina; Richmond, Virginia; Chattanooga, Tennessee; and Greenville, North Carolina. Teams from these universities also travel approximately five to eight hours to play in Boone. In addition to conference members, the school's teams compete against many other colleges in nearby or adjacent states. During the 1976-77 school year, the basketball team and individual athletes representing Appalachian State

University flew to their respective competition in one or more of the following states: Maryland, Florida, Georgia, Indiana, Alabama, as well as, internationally, to Scotland.

Figure 5

APPROXIMATE FLYING/DRIVING TIMES FROM BOONE,
NORTH CAROLINA TO NEARBY MAJOR CITIES



Source: Flying times were based on interviews from local pilots flying general aviation propeller type aircraft; driving times are estimates based on road distances and existing speed limits.

The Appalachian Center for Continuing Education attracts conference participants from every state in the Union. Most visitors

come from the eastern seaboard but conferees have come from every state. The Center attracts governmental, business and educational leaders for a variety of seminars, conferences and meetings.⁸

Though no precise figures are available, the Director of the Center has indicated that conferences have been lost due to the low number of motel rooms available and to inadequate transportation. Many conference members do not want to travel long distances by automobile. Because of insurance liability problems, the Center no longer operates a bus shuttle service but advises conferees to use cabs or rental car services from and to nearby commercial airports.

Recreational Services

Recreation-oriented developments such as Hound Ears Resort, Beech Mountain, Mill Ridge Resort and various golf courses have assumed an important role in Watauga County's economy. Directly benefiting from recreation developments are the employment sectors in construction, real estate, service activities and recreational investment and consulting firms.

Much of the recreation industry in Watauga County is large scale land and second homes development. The North Carolina Public Interest Research Group in a report entitled The Impact of the Recreational Development in the North Carolina Mountains (April, 1975), surveyed land ownership and recreational development trends in the County from 1968 to 1975. Some of the trends pertinent to this study were:

1. a 26 percent increase in non-local land ownership during the period,
2. most land was purchased by out-of-state owners,
3. most recreational land development was large scale, with an average tract of 1,000 acres,
4. recreation development proceeded at a rate three times that of the rest of the state.

Introducing an air transportation system will bolster these trends. Developers of Hound Ears Resort and Grandfather Golf and Country Club state that an airport facility is desired by many second home owners. For instance, according to developers of Grandfather Golf and Country Club, "there are at least fifty people owning homes at Grandfather Golf and Country Club and Grandfather Mountain Lake who either own their own planes or work with companies with planes, and there is a constant need by these people for a better nearby airport. These are planes that have instruments for use in all-weather, night or day airports and are too large for Beech Mountain Airport."⁹ Furthermore, realtors (such as Frontier Reality Homes) have stated some sales have been lost from prospective second home owners due to the lack of adequate transportation facilities, including a local airport. It is felt by these developers that construction of an airport in Watauga County will mean an added attraction to second home owners and companies who own aircraft.

A large number of people from all over the United States have been known to use Watauga County's summer and winter recreational facilities. Currently, these people travel here by automobile or charter bus. The potential for a seasonal air passenger market comprised of

these visitors is obvious, especially for those traveling hundreds of miles one way to reach Watauga County. A study done by the Civil Aeronautics Board in 1972 discloses the relationship between distance and size of the air passenger market.¹⁰ (See Table 11)

Table 11

POTENTIAL AIR PASSENGER USAGE IN THE UNITED STATES
COMPARED TO AUTOMOBILE USAGE

One Way Trip Miles	Percent Of Total Travelers	Percent By Automobile	Percent By Air Carrier
100 - 199	42.9	95.8	1.2
200 - 299	20.8	92.3	4.9
300 - 399	10.3	87.9	9.7
400 - 499	5.7	80.6	17.0
500 - 999	10.9	71.8	24.4
1000 and Over	9.2	50.9	45.7

Source: U.S. Airline Industry, An Overview of Present State of Development (Sept, 1974) p. 7.

This table shows that as trip length increases to over 1,000 miles, the air passenger market increases while automobile usage decreases.¹¹ In the 500 to 1,000 mile increment, air passengers accounted for 24.4 percent of the total market. It would seem that because of the speed advantage of the airplane, the air passenger market could gain an even greater percentage, especially since the automobile usually requires more than one day to accomplish the trip while the airplane

takes between one and a half to two and a half hours to complete.

Reasons why the air passenger market does not gain a greater percentage here appears to include:

1. lack of points of destination or origin suitable to the traveler,
2. cost to the traveler,
3. personal preference of the automobile or some other transport mode (rail or boat).

In the increments under 500 miles, the air passenger market has trouble in capturing most of the total market. Most airlines must have approximately 20 percent per year of the total travel market before considering year around air passenger service.

It is possible, when applying these findings to recreational visitors, that a potential air passenger market will exist. This market for Watauga County, would be primarily composed of recreational visitors throughout the year and depend upon tourist trends.

Assessment of Air Transportation Potential

Based on Development Criteria

The principal contributors to Watauga County's present economic condition were studied separately as to how each could benefit from an air transportation system. Both the educational and recreational sectors can benefit from the travel time saving offered by air transportation. T.R.W., Inc., Blue Ridge Shoe, and Shadowline, of the manufacturing sector, will not benefit in time savings or product shipment costs. These three industries will only utilize air transportation on

rare occasions by administrative officials. Vermont American is the only industry extensively using air transportation for both administrative/cargo purposes, and foresees an increased future demand.

Thus, the only major air passenger market is that potentially generated by the educational and recreational sectors of the economy. The parameter of this market is dependent upon tourist trends and on the stability of the economy. However, the year around seasonal passenger market in Watauga County may be economically feasible for airline companies such as Piedmont Airlines to service. It would be possible for an airline company to operate a seasonal year around shuttle service or charter flights to Watauga County at little or no economic loss, provided an adequate airport facility existed to accommodate shuttle type aircraft. Existence of such an airport may be an important factor in attracting new industries to the county.

NOTES

¹General Aviation Manufacturer Association, "New Industry, New Jobs, New Money," How To Land And Keep An Airport In Your Community, (1976), p. 1.

²Richard M. Highsmith, Jr., and Ray M. Northan, "Determinants Of Transport Cost," World Economic Activities: A Geographic Analysis (New York: Harcourt, Brace and World, Inc., 1968), pp. 436-438.

³Interview with Mr. Allen Kauses, the general manager at T.R.W., Incorporated - IRC Resistor Division, June, 1977.

⁴Interview with Mr. John West, Vermont American Corporation plant official, June, 1977.

⁵Interview with Mr. William Dixon, Blue Ridge Shoe Company plant official, June, 1977.

⁶Interview with Shadowline Company plant official, June, 1977.

⁷Interview with Mr. David Smith, Registrar, Appalachian State University, June, 1977.

⁸Interview with Mr. Robert Snead, Vice-Chancellor For Development, Appalachian State University, July, 1977.

⁹A letter addressed to the Watauga County Airport Commission from the Developers of Godfather Golf and Country Club's president, Mr. Hugh Morton, explained the recreational need for an airport facility in the County, June, 1977.

¹⁰United States Department of Transportation, Office of Aviation Policy, "Customer Identification And Development," United States Airline Industry An Overview of Present State of Development, (Washington, D.C.: Government Printing Office, September, 1974), pp. 7-14.

¹¹"Percent by Air Carrier" is the percentage of air passengers who flew on an airplane.

CHAPTER V

CONCLUSIONS

Summary

The major research objective of this thesis, feasibility of an air transportation system for Watauga County has been achieved by the parallel analysis of three sets of independent factors: aspects of the physical environment, socio-economic characteristics and economic development criteria. Study variables were selected from these sets of factors and evaluated in terms of passenger market, airport design and applicable type of air transportation.

The physical environment affects an aircraft in the vicinity of the airport and during the actual transit. These factors are important to an air transportation system, and were assessed in the context of federal guidelines and recommendations (Chapter II).

Air transportation problems encountered in Watauga County are chiefly those connected with local topography and elevation. Based on barriers imposed by the physical environment, no more than five potential airport sites exist in the County (see page 24). These sites are located on sparsely populated ridge tops that are aligned into the prevailing winds (a west-northwest and east-southeast configuration). Developing an airport on a ridge decreases the number of possible obstructions and also decreases the incidence of ground fog.

In Chapter III, socio-economic characteristics were examined to determine whether the "threshold level" needed to support an airport and/or air passenger market in Watauga County exists. The variables assessed included: population, age, education, occupation and median income level. Looking at the total picture, it is clear that an adequate air passenger market does not exist at the present time. However, the size of the present population and the rate of population growth supports both an airport and the potential for an air passenger market.

These findings suggest that any proposed airport should be constructed in the General Utility class with limited facilities. However, due to the present population growth rate, such an airport must have room for expansion when warranted in the future.

Principal contributors to the present economic condition in Watauga County were studied in terms of their potential benefit from an air transportation system (Chapter IV). Both the educational and recreational sectors will benefit in some degree from the travel time savings offered by air transportation. In spite of the great number of university students, it is presently felt that no more than a few can or will take advantage of air transport. Since a number of different seasonal activities exist in Watauga County, a year round air passenger market is possible from the recreational sector. Those recreational participants who would be most likely to contribute to an air passenger market are retirees, second home owners and developers. The manufacturing plants of T.R.W., Inc., Blue Ridge Shoe and Shadowline will not benefit in time savings or product shipment costs. Only Vermont American Corporation is presently

using air transportation for both administrative/cargo purposes, and foresees an increased future demand.

In addition there may be an infrequent air transport usage by other county residents. However, the total market is presently not large enough to require numerous daily flights into and out of the region. Small shuttle type aircraft flying once or twice a day, or every other day should satisfy this air passenger demand.

Therefore, in view of the stated research objective and results from this analysis, it is the conclusion of this thesis that-Watauga County's physical, social and economic environments can sustain an air transportation system--provided this system is limited to a General Utility class.

Recommendations

It is the contention of the author that Watauga County should not have to depend solely upon the highway transportation system to serve all of its socio-economic needs. The local Council of Governments, (Region "D"), also recognizes this situation and is presently in the process of exploring the possibility for a rail system to service the region. The results of this thesis will justify a limited air transportation system in Watauga County. Those socio-economic characteristics supporting the development of air transportation are particularly population size and population growth rate, with somewhat weaker support offered by the industrial, educational and recreational sectors of the county.

This thesis finds that potential aeronautical activity generated by Watauga County warrants an air transport system that incorporates

both general aviation propeller and business/executive jet aircraft. Other air transport types, such as short take-off and landing aircraft (STOL), and helicopters are either in the experimental stages or are costly to operate and therefore not feasible to assess here.¹ Also, there is not projected a need for large air transport aircraft (comparable to the Boeing 727), since neither the large year round air passenger market nor the potential airport site for such a scale operation exists in Watauga County. Small charter or shuttle-type aircraft having the capability to take-off and land on a General Utility class runway will satisfy the air passenger need in Watauga County.

Therefore, it is recommended that Watauga County develop an airport in the Federal Aviation Administration's (F.A.A.) "General Utility" category within the next five to ten years. Development of an airport within a five to ten year time span is important, since as indicated by Chapter II, only a few possible airport sites exist. The most promising of these sites, Buck Ridge, (see Chapter II) is located in an area of rapid population growth. Increased residential or urban development on any site will decrease the probability of obtaining needed airport acreage. Thus, to protect this and other potential sites, the Watauga County Planning Board must implement appropriate land use controls immediately.

Proposed facilities of a "General Utility" class serving general aviation and business/executive jet aircraft in Watauga County would be along the following lines:

1. A single paved runway having the capability to withstand at least 12,500 pounds gross weight.

2. The dimensions of the runway should be between 4,000 to 5,000 feet long by 75 feet wide with the capability to extend runway length between 500 to 1,000 feet.²
3. A 40-foot wide taxiway parallel to the runway.
4. Paved aircraft parking apron at least 300 feet wide by 300 feet long.
5. Runway and taxiway lighting plus an airport rotating beacon, visual approach slope indicator (VASI) and possible runway end identifier lights (REIL).
6. Small terminal building, hanger, underground fuel tank storage and pumping facilities.
7. Nondirectional radio beacon or other aerial navigations facility providing instrument approach capability is feasible for the airport.

The total amount of acreage needed for construction and proper airport zoning for such a facility would be between 200 and 300 acres--depending on the selected site. According to F.A.A. criteria, an airport's immediate surrounding area must be zoned from encroaching residential and urban development.³

Development of a different type of air transportation system or the construction of an airport facility other than that outlined here does not appear to be warranted for Watauga County. In addition, it is felt that prolonged delays in implementing these recommendations may remove Watauga County even further from the opportunity to developing a viable air transportation system.

NOTES

¹A study conducted by the Civil Aeronautics Board in 1972 showed that the operating cost for helicopter service as 20.1 cents per available seat-mile as compared with 3.9 cents per available seat mile for turbo-prop aircraft service.

²The Runway Length Graph (see Figure 1) shows that a "General Utility" runway for Watauga County will be between 4,000 to 5,000 feet long. Exact length depends upon the elevation of the selected airport site.

³Federal Aviation Administration, Model Airport Hazard Zoning Ordinance, AC NO: 150/5190-3A (Washington D.C., 1972).

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