RWDI

PHASE I TECHNICAL MEMORANDUM
FOR THE
ANCHORAGE AREA-WIDE
WIND SPEED STUDY
ANCHORAGE, ALASKA

Project Number: 98-362-4

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Submitted to: The Municipality of Anchorage

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1. INTRODUCTION AND BACKGROUND

The team of BBFM Engineers of Anchorage and Rowan Williams Davies & Irwin (RWDI) of Guelph, Ontario, Canada were retained by the Municipality of Anchorage to undertake a multi-phased study that involves the collection and analysis of available historic wind records for Anchorage. This technical memorandum is a report on the results of Phase 1 "Data Collection and Reliability Analysis," which involved the collection of wind data for available sites in the Anchorage area and a review of the extreme wind events at each site to determine the reliability of the data.

The Phase 2 portion of the study, entitled "Data Analysis and Development of Preliminary Wind Zones," will involve detailed analyses of the data to determine wind speeds for various recurrence intervals and is scheduled for completion by December 31, 1998. The Phase 2 analyses will include three-dimensional modelling of the wind field in the Anchorage area to enhance the understanding of complex spatial variations of a number of extreme wind events determined in Phase 1. A trial wind zone map for the 50-year return period winds will be produced at the end of Phase 2. Consideration for additional phases of this study is being given and may include a field monitoring program of new wind instrumentation sites. An analysis of updated wind data and a further refinement to a wind zone map are also being considered.

The overall goal of the complete study program is to develop a wind map for the Anchorage Building Service Area that is based on data collected from a variety of sources and which has a scientific and probabilistic basis. Up to this point, the wind design loads in Anchorage have been based on empirical data and the expertise of the local code review committees. The design wind speeds have not been based on a rigorous analysis. The goal of Phase 1 of the study is to collect the available wind data for Anchorage and to evaluate its reliability for further detailed analysis.

1.1 History of Design Wind Speeds for Anchorage

Prior to the 1982 Uniform Building Code (UBC), design wind loads were not tied to any given wind speed but were based on wind pressure zones. Under those codes, the Municipality of Anchorage (and the City of Anchorage prior to unification) required use of the 25 pound per square foot (psf) wind zone. When wind speeds and exposure factors, based on the ANSI A58 Standard (now the ASCE 7 Standard), were incorporated into the 1982 UBC, the code review committees selected a design wind speed of 100 miles per hour (mph) and a minimum exposure category of Exposure B. The selection of this wind speed was influenced by the large wind storm which occurred in 1982 and which caused significant damage, especially in South and East Anchorage. It resulted in higher wind design pressures than had been required previously. The design wind loads remained constant until the 1991 UBC.

In the 1991 UBC, the Exposure Categories B and C gust factors were adjusted slightly and new Exposure D factors were added. These new factors were larger than those required for Exposures B & C. In 1994, the local amendments to the UBC were modified, dropping the Exposure B minimum. The review committee realized that the amendment was not necessary since there was no Exposure category lower than category B.

For many years, most buildings in Anchorage were designed as if they were in an Exposure B area, even when they were not. Very few structures were designed using higher Exposure C factors and they were primarily in the area of the airport. Ironically, this is an area where experience suggests the wind speeds are lower than on the Hillside or along Muldoon, which were being designed for Exposure B. Approximately at the time of the adoption of the 1994 UBC, the Building Safety Division started requiring Exposure Categories C & D more often than previously had been the case. This resulted in significantly higher design wind pressures than had ever been required before. This affected residential construction more significantly than commercial construction due to the heavier shear walls and larger hold downs. As a result, there has been intense pressure on the Municipality of Anchorage to modify the design wind speed downward.

The Building Safety Department gathered the limited data that were available and presented it to the Structural Engineers Association of Alaska. Many of the members of that organization felt that the 100 mph wind speed was too high. Thus members of the Structural Code Review Committee that was examining the 1997 UBC suggested reducing the design wind speed. The committee examined the scant available wind data, drew on their experiences with wind in Anchorage, and developed a wind map. The only data available with statistical relevance were from the station at the International Airport. An analysis of the data indicated that a design wind speed of about 80 mph would be reasonable. However, in the committee's experience, lower wind speeds are to be expected at the airport. Thus, the map has three wind zones with design wind speeds varying from 80 mph along the coast to 100 mph along the mountains, with an area of 90 mph in between. The committee felt that this was a reasonable interim map until a more definitive analysis could be completed; hence, the purpose of undertaking this study.

2. PHASE 1: DATA COLLECTION AND RELIABILITY ANALYSIS

2.1 Background Information on Strong Winds at Anchorage

Strong winds at Anchorage tend to come from southerly directions during the summer months and northerly directions during the winter months[1]. The strongest winds in the area are the southeasterly down slope winds, descending the slopes of the Chugach Mountains, which lie to the east of Anchorage, and channelling through the Turnagain Arm, which lies to the southeast. These winds tend to affect the east side of Anchorage and are most common at elevations above 800 ft[2]. The two most severe wind storms in recent memory, those of April 1980 and December 1992, were associated with southeasterly winds[3]. Maximum gust speeds were estimated to be 134 mph (60 m/s) for the April 1980 storm, and were measured at 112 mph (50 m/s) during the December 1992 storm.

The current American Society of Civil Engineers (ASCE) Standard shows a 50-year peak gust speed of 100 mph (45 m/s) for Anchorage[4]. A previous version of the ASCE Standard showed a 50-year fastest-mile wind speed of approximately 80 mph (36 m/s)[5]. The Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska shows a 50-year sustained wind speed of approximately 65 mph (29 m/s)[2]. This reference also provides estimates of sustained wind speeds for other return periods, as follows:

Years	*2*	*5*	*10*	*25*	*50*	*100*	*200*	*1000*
Speed (mph)	38	45	50	58	65	72	80	103
Speed (m/s)	17	20	22	26	29	32	36	46

2.2 Available Wind Data for the Anchorage Area

Table 1 lists all of the currently available wind data sets for the Anchorage Area, as identified through discussions with the State Climatologist for Alaska, personnel at the National Climatic Data Center (NCDC) in Asheville, North Carolina and various other National Weather Service personnel. Most of the data for Anchorage International Airport, Elmendorf AFB and Merrill Field (Airport) were obtained in digital format from the NCDC. The annual fastest mile data for Anchorage International Airport were obtained from printed annual summaries (Meteorological Data for the Current Year) published by the NCDC. The data from the Portman Residence, which is a private weather station owned and operated by Mr. Carl Portman, were obtained in digital format directly from Mr. Portman.

Wind instruments are operated at various other locations in the Anchorage area, but documentation for long periods of record that would be suitable for statistical analysis has not been identified for any of these sites. These locations include the Rabbit Creek Fire Station, the Edmond Schuster residence at Glen Alps, Alaska Pacific University, Fort Richardson and various public schools. Apparently, some hard-copy records are available for the Rabbit Creek Fire Station and from Edmond Schuster, which may be of us in verifying some of the numerical modelling results during Phase 2 of this study. Fragmentary records may also be available for some of the schools. We will attempt to obtain these records during Phase 2.

Table 1: Currently Available Wind Data for Anchorage

Location	*Type of Wind Data*	*Period of Record*
Anchorage International Airport	Annual Fastest Mile	1953 to 1959, 1967 to 1979 (20 years)
	Daily Peak Gust	1954 to 1997 (43 years)
	Hourly 1-minute Averages	1953 to 1998 (44 years)
Elmendorf AFB	Daily Peak Gust	1949 to 1953, 1956 to 1958, 1961 to 1970 (18 years)
	Hourly 1-minute Averages	1941 to 1998 (55 years)
Merrill Field	Hourly 1-minute Averages	1945 to 1953, 1973 to 1998 (34 years)
Portman Residence, Upper DeArmoun Road	Daily Peak Gust	1984 to 1997 (14 years)

2.3 Spatial Distribution of the Available Data

The locations of the available sources of wind data are shown in Figure 1. The coverage of the Anchorage area is limited, with poor representation in populated areas to the east and southeast of downtown. As part of Phase II of this study, we have proposed to conduct 3-dimensional numerical modelling of selected storm events to gain better insight into the spatial distribution of the winds during severe storms. Phase III of the study involves installation of additional meteorological stations to enhance the spatial distribution of the wind observations. Given the limited spatial distribution of the currently available field data, the numerical modelling and field studies will undoubtedly play an important role in refining the wind zone map for Anchorage.

2.4 Relevance of the Various Types of Wind Speed Data

The fastest mile and peak gust data are most useful for predicting extreme wind speeds and both have been used previously for this purpose in the United States[6,7]. Hourly 1-minute averages are less useful, since they are more difficult to interpret. In statistical analysis, the hourly 1-minute values are often treated as equivalent to true 1-hour averages. The underlying assumption is that, while the hourly 1-minute readings and the true 1-hour averages can differ widely from each other hour to hour, they exhibit no systematic difference and the statistical distributions are approximately the same. In fact, it will be shown in Phase II of this study that the statistical distribution of the 1-minute readings differs systematically from that of true 1-hour averages in the tail of the distribution, at high wind speeds. This phenomenon becomes important in the prediction of extreme wind speeds.

In the present case, we have only one location with fastest mile wind data and only three with any peak gust data. At two of the sites (Elmendorf AFB and the Portman Residence), the peak gust data span a relatively limited number of years. On the other hand, we have hourly 1-minute averages for long periods of record at three sites. Fortunately, methods are available for making reasonably good use of the hourly 1-minute readings.

The Anchorage International Airport site has overlapping fastest-mile, peak gust and hourly 1-minute data, so that the statistical distributions can be compared, and scale factors can be determined that relate the distribution of the hourly 1-minute extremes to those of the fastest-mile and peak gust data. At the same time, it is possible to make theoretical estimates of the appropriate scale factors. In addition, the errors associated with using the hourly 1-minute readings can be minimized by using the parent distribution of the hourly readings instead of the extreme value distribution to predict extreme wind speeds. These methods will be discussed further in Phase II of this study.

2.5 Instrumentation and Siting

Table 2 describes the historical locations, heights above grade and types of wind instrument at Anchorage International Airport and Figure 2 shows how the instrument location has changed over the years. Tables 3 and 4 and Figures 3 and 4 do the same for Elmendorf AFB and Merrill Field, respectively. The information in the tables was provided by the National Weather Service in Anchorage.

In addition to the information shown in the tables and figures, we made use of historical aerial photographs for each airport, and historical topographical maps of the Anchorage area. The photos and maps spanned the period from 1950 to the present day. This information enable us to assess the general exposure of the wind instrument site, as buildings, terrain or tree cover may influence the wind speed readings.

The anemometer at the Portman Residence is located at a height of approximately 38 ft above grade, 8 ft above the 30 ft high peak of a pitched roof. For most of the period of record, the instrument in use at the site was manufactured by Heathkit. Within the past few years, this instrument was replaced by two instruments, one manufactured by Davis Weather Inc. and the other by Texas Instruments.

Table 2: Anemometer History for Anchorage International Airport

Start Date	*Location*	*Height*	*Instrument*
12/26/51	Tower roof	62 ft above grade 10 ft above roof	F420B
10/30/53	North end of terminal (Concourse C)	41 ft above grade 19.5 ft above roof	F420C
3/2/61	300 ft west of intersection, Runway 6-24 / 13-31	22 ft above grade	F420C
1/17/64	750 ft north of intersection, Runway 6-24 / 13-31	22 ft above grade	F420C
7/27/72	100 ft east of Approach to Runway 6L	22 ft above grade	F420C
6/1/98	3675 ft west of Approach to Runway 6L	26 ft above grade	ASOS

Table 3: Anemometer History for Elmendorf AFB

Start Date	*Location*	*Height*	*Instrument*
03/41	Unknown	Unknown	Unknown
06/48	Unknown	Unknown	Selsyn
03/53	Atop hangar	45 ft above grade	AN/GMQ-1
04/56	same	80 ft above grade	Selsyn
10/58	same	80 ft above grade	AN/GMQ-1
02/61	400 ft south of touchdown point on Runway 05	13 ft above grade	AN/GMQ-11
01/71	Anemometer 1: just NW of intersection of Runway 5-23 and 13-33 Anemometer 2: just south of end of Runway 05	13 ft above grade	AN/GMQ-20
01/88	same	(1) 8 ft above grade (2) 20 ft above grade	same

Table 4: Anemometer History for Merrill Field

Start Date	*Location*	*Height*	*Instrument*
2/2/43	Unknown	11 ft above grade	Unknown
11/28/43	Unknown	17 ft above grade	Unknown
11/1/53	Unknown	75 ft above grade	Unknown
6/20/62	Unknown	56 ft above grade	Unknown
3/1/80	180 ft north of control tower	22 ft above grade	F420C
10/15/97	Unknown	20 ft above grade	ASOS

Further discussion on the siting of the wind instruments is provided in the following paragraphs.

Anchorage International Airport (Figure 2)

The wind instrument at this site has been well situated, with good exposure, throughout its history. Since 1961, it has been located among the runways. The exposure for hundreds of feet in all directions is open (ASCE Exposure C). During the 1950's, the instrument was located on a mast on the roof of the terminal building. At that time, the airport was relatively undeveloped and the exposure in all direction was comparable to that at the current instrument location. The height above grade of the instrument was approximately twice that of the terminal building and, as such, the instrument did not experience any significant building wake effects.

Elmendorf AFB (Figure 3)

The history of the anemometer position at Elmendorf AFB is not as well documented as that at Anchorage International Airport. This reduces the reliability of some of the wind speed data.

The instrument height and location prior to 1953 are unknown. Consequently, all readings taken prior to this time will not be of use to the present study. As a result, the number of useful years of data is reduced from 55 to 44.

For the period from 1953 to 1961, the instrument height above grade is known but the exact position is not. The instrument was located atop an unidentified hangar, and we have assumed that it was one of three large hangars located near the intersection of the two main runways. Personnel at the base agreed that this was the most likely location[8]. Based on this assumption, the exposure was open for several hundred feet in most directions, but was more like suburban terrain (ASCE Exposure B) for directions between south and west. In scaling the reported wind speeds to a standard open exposure and a standard height of 10m, therefore, it will be necessary to account for the directional variations in exposure during the 1953 to 1961 period.

From 1961 to 1971, the wind instrument was located near the end of one of the runways. The exposure was open for several hundred feet in all directions. Since 1971, the base has operated two wind instruments, one at each end of the main runway. The one at east end of the runway (i.e. at the end of Runway 23) is typically used only when Runway 05 experiences a tail wind (i.e., westerly winds)[9]. Since the prevailing directions for strong winds tend to be north and south, most of the wind readings of interest in the present study were likely recorded by the other instrument, located at the west end of the main runway (i.e., at the end of Runway 05). The exposure at both sites is open in all directions.

Merrill Field (Figure 4)

As at Elmendorf AFB, the early history of the wind instrument at Merrill Field is not well documented. Prior to 1980, the location is unknown. Given the relatively large height above grade from 1953 to 1980, however, it is likely that the instrument was located atop a building at that time. We have assumed that it was located on the former control tower. Based on this assumption the exposure was open for most directions, but was more like suburban terrain (ASCE Exposure B) for directions between north and east.

For the period prior to 1953, the wind instrument was at lower height (17 ft above grade) and we assume that it was in the open among the runways.

The current location is near the intersection of the two runways. The exposure in all directions is open for several hundred feet. The control tower is only about 180 ft to the south, and may have a small effect on the anemometer readings during southerly winds.

Portman Residence

The Portman Residence is on Upper DeArmoun Road near the intersection with Canyon Road. This location is near the mouth of the Rabbit Creek canyon, on the northeast slope of the canyon. The elevation is approximately 1300 ft above sea level and the terrain rises to the northeast, toward the Glen Alps area. The instrument is 8 ft above the roof of the house and approximately 38 ft above local grade. The house is surrounded by low lying deciduous trees and bushes, generally varying from 5 to 15 feet tall. There are several taller conifers that are fairly widely spaced. The exposure corresponds most closely to ASCE Exposure B.

Impact of Instrument Type on Peak Gust Data

The type of wind instrument used is relevant to the peak gust data. Differing response characteristics can cause two wind instruments to report a different peak speed for the same gust. In analysing peak gust speeds from National Weather Service sites for the ASCE code, Peterka and Shahid (1998)[6] assumed that the effective duration for all reported peak gusts was 2 to 3 seconds. Their assumption was based on comments provided by personnel at the National Climatic Data Centre, with no supporting documentation[10]. Apparently, the Atmospheric Environment Service in Canada similarly indicates an effective gust duration of 2 to 3 seconds for its wind instruments, also with no supporting documentation[11].

In recent years, the National Weather Service has been switching from manual to automated surface observing systems (ASOS). ASOS systems were implemented at Anchorage International Airport and Merrill Field in 1998 and 1997, respectively. The peak gusts recorded by these systems are 5-second averages. To date, it appears that the ASOS systems tend to record lower peak gusts than the previous gust recorders[9,12]. This is evidence that the effective duration of gusts recorded prior to installation of the ASOS systems is significantly less than 5 seconds.

RWDI has made several attempts to obtain information on the response characteristics of the wind recording systems used in Anchorage with no success to date. Should information prove to be unavailable, the 2 to 3 second assumption will be used for all wind instruments, which is in line with the assumption used in developing the current ASCE 7 Standard wind map.

Heathkit, the company that supplied the wind instrument used by Carl Portman for most of his 14 years of record, is no longer in business, and performance specifications are not available. Mr. Portman indicated his belief that the Heathkit reported speeds that are a few miles per hour higher than his current wind instruments, one of which is manufactured by Davis Weather Instruments, and one of which is manufactured by Texas Instruments[13]. It is therefore possible that the Portman data err slightly on the high side.

2.6 Missing and Erroneous Data

Anchorage International Airport

The data for Anchorage International Airport are the most complete of any of the available data sets. A total of 383,563 valid hourly 1-minute readings are available for a 44 year period, representing an average of approximately 8700, out of a possible 8766 readings per year (i.e., little or no missing data). Daily peak gusts are available with scarcely any missing values for a 43 year period. The fastest mile record, however, is much more limited, covering only 20 years. The fastest mile speeds have not been recorded since 1979, and there is a period of missing data during the 1960's.

Figure 5 shows a plot of the annual maximum fastest mile, hourly 1-minute average and peak gust speeds at Anchorage International Airport. The wind speeds have not yet been corrected for any changes in instrument height and exposure over the years, which will be done in Phase II of this study. The three data sets show reasonably consistent year-to-year trends. For the most part, the fastest mile data lie directly over the hourly 1-minute data. This is not terribly surprising, since both are applicable to an averaging time on the order of 1 minute. In most years, the annual maximum hourly 1-minute reading and the annual fastest mile reading occurred during the same storm event. The annual peak gust, however, was sometimes associated with a different storm.

The annual maximum fastest mile speeds and hourly 1-minute averages are generally in the range from 25 mph to 60 mph. The peak gusts are generally in the range from 40 mph to 75 mph. The maximum reported peak gust in 1965 was over 100 mph and was significantly higher than any other reported value. This value, which was logged for October 26, 1965, is considered to be erroneous (the peak gust recorded at Elmendorf AFB on the same date was only 9 mph) and is likely the result of data entry error. This reading will be deleted from the record.

Hourly readings were printed and examined for all days on which one or more readings exceeded 40 mph. As a result of this examination, three erroneous strong wind readings were identified. All three readings occurred in 1965 and were isolated readings with light or moderate wind speeds reported for all other hours on the same day. In each case, the reported peak gust speed for the day was lower than the reported hourly reading in question. The three erroneous hourly readings will be deleted from the record.

Elmendorf AFB

A total of 469,014 valid hourly 1-minute readings are available for Elmendorf AFB, spanning a 55 year period and representing an average of approximately 8500 readings per year (i.e., a nearly complete data set). The daily peak gust data, on the other hand, are incomplete. Only 7 full years of gust data, and another 11 years with between 1 and 6 months of missing data, are available. Fastest mile data are not available.

Figure 6 shows a plot of the annual maxima for Elmendorf AFB. As at Anchorage International Airport, the maximum hourly 1-minute readings are in the 25 mph to 60 mph range, and the peak gusts are in the 40 mph to 75 mph range, except for one highly suspect peak gust in excess of 200 mph, recorded for 1951. This reading is considered to be a data entry error.

Hourly readings were printed and examined for all days on which one or more readings exceed 40 mph. Three erroneous strong wind readings were identified, one in 1946, one in 1974 and one in 1983. In all cases, the reading in question was an isolated reading, with reported speeds for all other hours of the same day being light or moderate. Daily peak gust speeds corresponding to these dates were not available for Elmendorf, but were available for Anchorage International for the 1974 and 1983 dates. In both cases, the reported peak gust was 20 mph or less. The three bad readings will be deleted from the hourly records.

Merrill Field and the Portman Residence

A total of 281,544 valid hourly 1-minute readings are available for a 34 year period at Merrill Field, representing an average of approximately 8300 readings per year. As at Elmendorf AFB, this is a nearly complete data set. No peak gust or fastest mile data are available. At the Carl Portman Residence, a complete set of 14 years of daily peak gust speeds is available.

The annual maxima for Merrill Field and the Portman Residence are shown in Figure 7. The annual maximum hourly 1-minute readings for Merrill Field appear to be generally larger in magnitude than comparable data for Anchorage International and Elmendorf AFB, ranging between about 30 mph and 65 mph. However, when hourly readings on days with one or more readings exceeding 40 mph were examined, over 30 erroneous strong wind readings were identified. One or more of these readings occurred in almost every year of record. A typical example is January 27, 1992, on which an isolated hourly reading of 54 mph occurred, while the peak gust for that date reported at Anchorage International Airport was only 14 mph and that reported at the Portman Residence was less than 15 mph. The identified bad readings will be deleted from the records.

The annual peak gusts measured at the Portman Residence are in the 60 mph to 110 mph range, and are generally much higher than the annual peak gusts recorded at Anchorage International and Elmendorf AFB. This arises from the fact that the Portman Residence is located in the Rabbit Creek canyon which is known to experience particularly severe winds.

2.7 The Big Storms of 1980 and 1992

It is interesting to note that the wind storms of 1 April 1980 and 1 December 1992, which have been discussed in the published literature, did not produce unusually strong winds at either Anchorage International Airport, Elmendorf AFB or Merrill Field. Apparently, the more extreme wind speeds were limited to areas of higher elevation to the east and southeast of Anchorage.

During the storm of 1 April 1980, the maximum gust speed at Anchorage International was only 43 mph (19 m/s) and the recorded hourly 1-minute wind speeds did not exceed 23 mph (10 m/s). Somewhat higher hourly 1-minute wind speeds were recorded at Elmendorf AFB, reaching as high as 30 mph (13 m/s). At Merrill Field, a 1-minute speed of 45 mph (20 m/s) was recorded during one hour, but for the rest of the day, the speed remained below 23 mph (10 m/s). These speeds are all well below the gust speed of 134 mph (60 m/s) that was estimated to occur in the hills to the southeast.

During the storm of 1 December 1992, the maximum gust at Anchorage International was 55 mph (25 m/s) and the hourly 1-minute speeds ranged up to 29 mph (13 m/s). At Elmendorf AFB and Merrill Field, the hourly 1-minute readings ranged up to 32 mph (14 m/s) and 29 mph (13 m/s), respectively. At the Portman Residence in the Rabbit Creek area, on the other hand, a maximum gust speed of 109 mph (49 m/s) was recorded.

The April 1980 and December 1992 storms were associated with southeasterly Chinook winds descending the Chugach mountains and accelerating through the Turnagain Arm. The Airports have experienced more severe events associated with northerly winds. A recent example is the storm on 3 March, 1989, which produced a maximum gust speed of 75 mph (33 m/s) and hourly 1-minute readings up to 51 mph (23 m/s) at Anchorage International Airport. This storm did not have a big impact in the hills to southeast, with a reported maximum gust speed of only 28 mph (12 m/s) at the Portman Residence.

These examples provide a good illustration of the two wind storm regimes that affect different parts of the Anchorage area. It will be important for the numerical modelling in Phase 2 of this study to examine both types of wind storms.

2.8 Phase 1 Conclusions

To date, four sites having long-term wind records have been identified in the Anchorage area: Anchorage International Airport; Elmendorf AFB; Merrill Field; and the Portman Residence on Upper DeArmoun.

The wind data set for Anchorage International Airport is excellent, with over forty years of hourly readings, over forty years of peak gust data and twenty years of fastest mile data. The siting of the wind instrument is well documented throughout the period of record, and only a few bad wind readings were identified in the digital data.

Elmendorf AFB has an excellent set of hourly wind readings spanning over 50 years, with only a few identified bad readings. The available peak gust data are limited, spanning only seven full years and eleven additional years with up to 6 months of missing data. Fastest mile data are not available. The siting of the instrument is poorly documented for the period prior to 1971, and this reduces the reliability of readings taken during that period.

Merrill Field has a fairly complete set of hourly wind readings spanning a 34 year period. However, a relatively large number of erroneous strong wind readings has been identified (over 30). This suggests that the data from Merrill Field are somewhat less reliable than those from Anchorage International Airport and Elmendorf AFB. Peak gust and fastest mile readings are not available for this site. The siting of the wind instrument is not well documented prior to 1980.

Carl Portman (Portman Residence) appears to have reliable daily peak gust data, but the period of record is somewhat limited (14 years), which means that the statistical sampling error associated with the predicted 50-year wind speed will be relatively large. Nevertheless, the Portman data are extremely valuable, since they represent the only source of long-term wind information for the east side of Anchorage, in the foothills of the Chugach Mountain range.

Given the limited spatial distribution of the available wind data, the three-dimensional wind field modelling and field monitoring programs included in Phases 2 and 3 of this study will be important tools in refining a wind zone map for Anchorage. During the numerical modelling, it will be important to examine the two principle types of wind storms in the study area: (i) the storms associated with northerly winds, which tend to produce their greatest impact in the western part of Anchorage; and (ii) the storms associated with southeasterly Chinook winds, which tend to produce their greatest impact in elevated terrain to the east and southeast of downtown.

3. PHASE 2: DATA ANALYSIS AND DEVELOPMENT OF PRELIMINARY WIND ZONES

This portion of the study is currently in progress and is expected to be completed by November 30, 1998.

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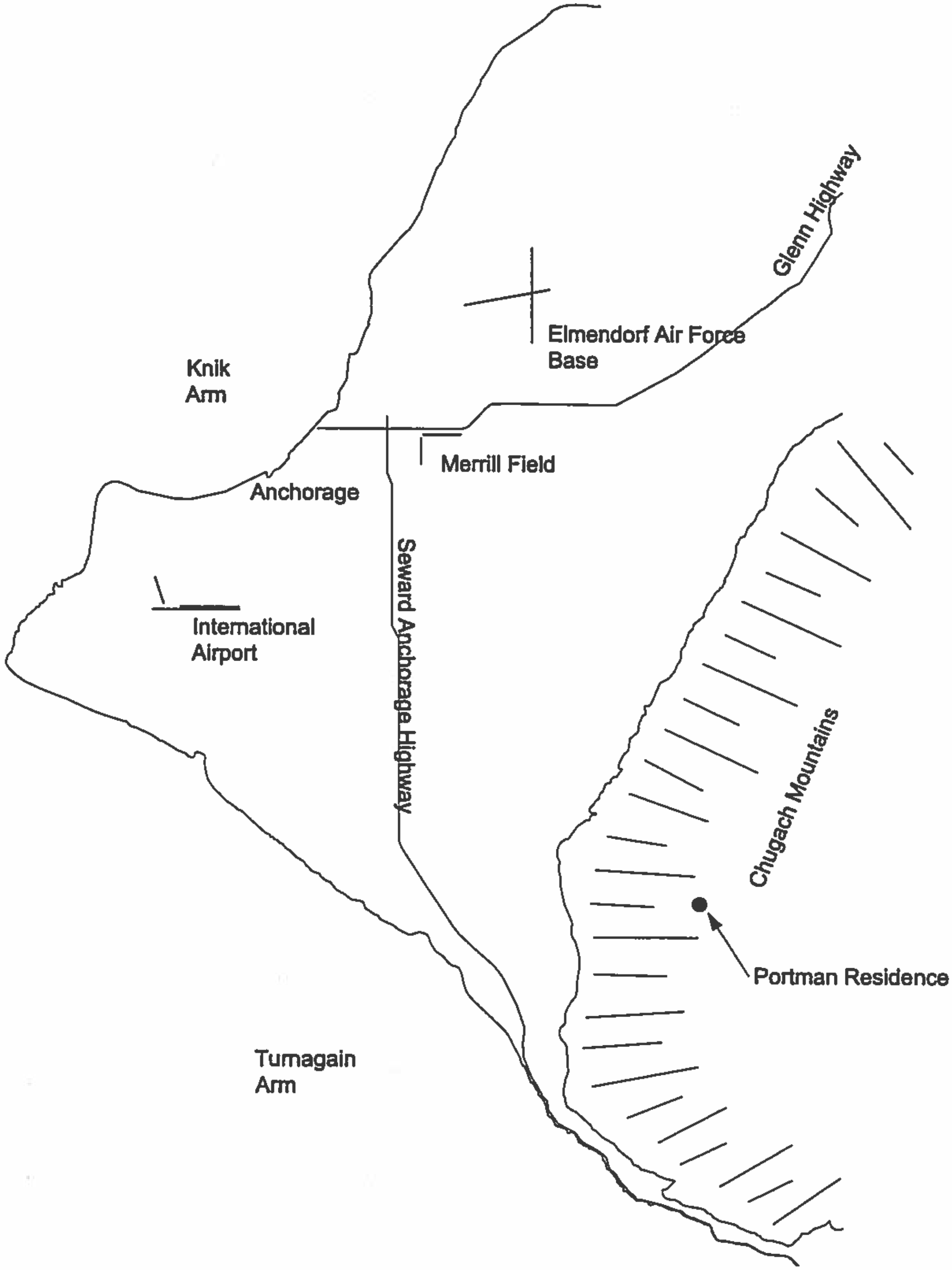


Wind Study	True North	Drawn by: SKM	Figure: 1
		Approx. Scale: 1"=15 000'	RWDI
Anchorage Area-Wide Wind Speed Study - Anchorage, Alaska	Job No. 98-362	Date Revised: July 22,1998	

A - 1972-present
B - 1964-1972
C - 1961-1964
D - 1953-1961

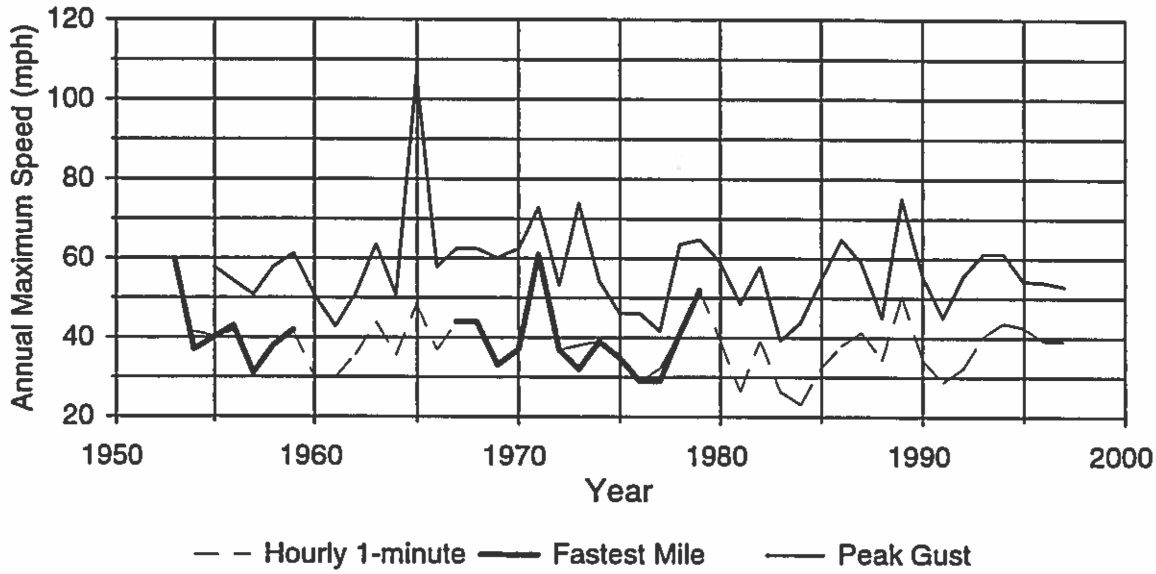
Historical Anemometer Locations at Anchorage International Airport **Photo Courtesy of Aeromap U.S. Inc.** Anchorage Area-Wide Wind Speed Study - Anchorage, Alaska	True North Job No. 98-362	Figure No. 2 Scale: N.T.S. Date: July 22, 1998	RWDI

A - 1971-present
B - 1961-1971
C - 1953-1961

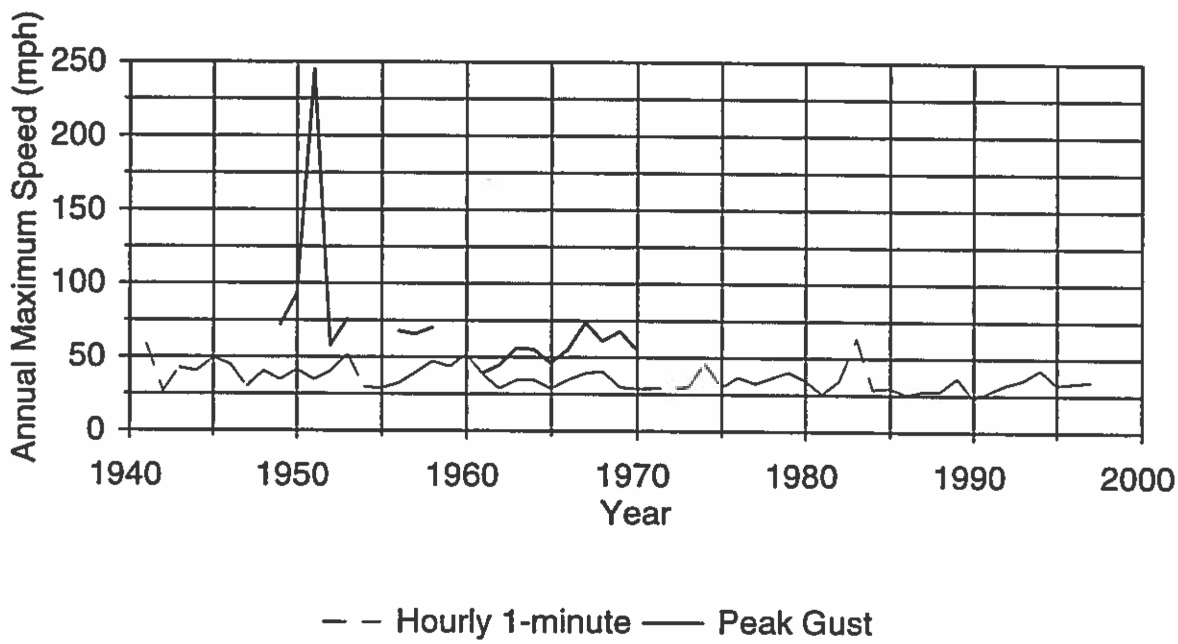
Historical Anemometer Locations at Elmendorf AFB	True North	Figure No. 3	RWDI
Photo Courtesy of Aeromap U.S. Inc.		Scale: N.T.S.	
Anchorage Area-Wide Wind Speed Study - Anchorage, Alaska	Job No. 98-362	Date: July 22, 1998	

A - 1971-present
B - 1953-1980

Historical Anemometer Locations at Merrill Field	True North	Figure No. 4	RWDI
Photo Courtesy of Aeromap U.S. Inc.		Scale: N.T.S.	
Anchorage Area-Wide Wind Speed Study - Anchorage, Alaska	Job No. 98-362	Date: July 22, 1998	



Recorded Annual Maximum Wind Speeds for Anchorage International Airport	Figure No. 5	RWDI
Anchorage Area-Wide Wind Speed Study - Anchorage, AK — Job No. 98-362	Date: July 27, 1998	



Recorded Annual Maximum Wind Speeds for Elmerdorf AFB

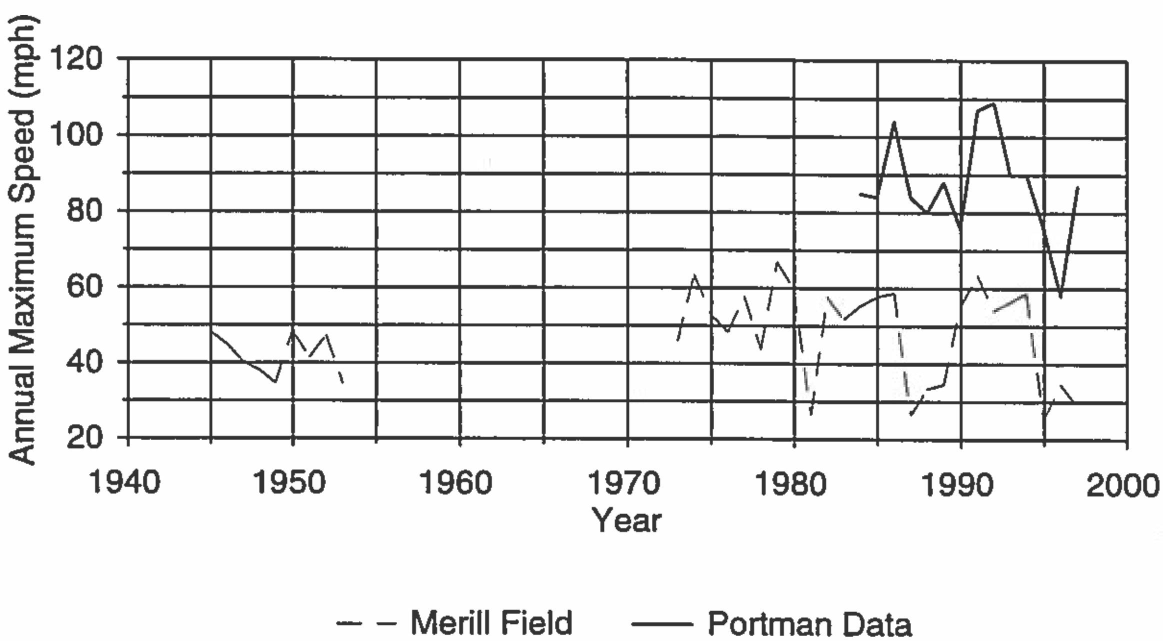
Anchorage Area-Wide Wind Speed Study - Anchorage, AK

Job No. 98-362

Figure No. 6

Date: July 27, 1998

RWDI



Recorded Annual Maximum Wind Speeds at Merrill Field and the Portman Residence

Anchorage Area-Wide Wind Speed Study - Anchorage, AK

Job No. 98-362

Figure No. 7

Date: July 27, 1998

RWDI