E. Runway Length Analysis

This appendix describes the runway length analysis conducted for the Airport. Runway 7-25, the Airport's primary runway, has a length of 8,700 feet and the existing crosswind runway (Runway 12-30) has a length of 3,207 feet. A runway length analysis was conducted to determine if additional runway length is required to meet the needs of aircraft forecasted to operate at the Airport through the planning period. The analysis was conducted according to Federal Aviation Administration (FAA) guidance contained in Advisory Circular (AC) 150/5325-4B, *Runway Length Requirements for Airport Design*. The runway length analysis set forth in AC 150/5325-4B relates to both arrivals and departures, although departures typically require more runway length. Runway length requirements were determined separately for Runway 7-25 and Runway 12-30.

E.1 Primary Runway Length Requirements

According to AC 150/5325-4B, the design objective for the primary runway is to provide a runway length for all aircraft without causing operational weight restrictions. The methodology used to determine required runway lengths is based on the MTOW of the aircraft types to be evaluated, which are grouped into the following categories:

- **Small aircraft (MTOW of 12,500 pounds or less)** – Aircraft in this category range in size from ultralight aircraft to small turboprop aircraft. Within this category, aircraft are broken out by approach speeds (less than 30 knots, at least 30 knots but less than 50 knots, and more than 50 knots). Aircraft with approach speeds of more than 50 knots are further broken out by passenger seat capacity (less than 10 passenger seats and 10 or more passenger seats). Small aircraft with less than 10 passenger seats are further categorized into family groupings according to "percent of fleet" (i.e., 75 percent, 95 percent, and 100 percent). Each percent of fleet category is designed to pertain to a mix of increasingly larger/more capable aircraft.
- **Large aircraft (MTOW over 12,500 pounds, but less than 60,000 pounds)** – For purposes of runway length determinations, this category is exclusive to turbojet aircraft (e.g., business jets). Large aircraft are further categorized according to "percent of fleet" (i.e., 75 percent and 100 percent). Aircraft included in the 75 percent of fleet category include small and mid-size business jets, such as most Cessna Citations, Learjets, the Beech Jet 400A, and the Dassault Falcon 900. Aircraft included in the 100 percent of fleet category include larger business jets, such as the Citation X, Learjet 60, Dassault Falcon 2000, and the Bombardier 600 Challenger. Runway length recommendations for large aircraft are also based on a percent useful load factor (i.e., 60 percent useful load and 90 percent

useful load). Because of aircraft climb limitations, the runway length resulting from the 90 percent useful load calculations are considered by AC 150/5325-4B to approximate the limit of beneficial returns for the runway.

- **MTOW of 60,000 pounds or greater** – In addition to typical air carrier and regional/commuter aircraft, this weight category includes all regional jets regardless of their MTOW. Allthough many regional jets have a MTOW less than 60,000 pounds, the exception acknowledges the long range capability of regional jets and the necessity to offer these operators the flexiblity to interchange regional jet models according to passenger demand without suffering operating weight restrictions.

The majority of operations at the Airport are conducted by general aviation aircraft, including single- and multi-engine piston and turboprop aircraft, as well as business jets. To determine if Runway 7-25 has adequate runway length to accommodate these small and large aircraft (as defined above), the FAA's Airport Design computer program (Version 4.2D) was used. The computer program provides recommended runway length estimates (rather than specific requirements) for various groupings of aircraft corresponding to the MTOW categories described above. Inputs for the computer program include the Airport elevation (4,154 feet MSL), the mean daily maximum temperature of the hottest month (87.9 degrees Fahrenheit – see Section 2, Table 2-3), and the maximum difference in runway centerline elevation (8 feet for Runway 7-25).

Table E-1 presents the results of the runway length analysis for small and large aircraft using the Airport Design computer program. The results account for both takeoff and landing length. Based on the recommended runway lengths presented in Table E-1, Runway 7-25 (8,700 feet) should accommodate all small aircraft, 75 percent of large aircraft (business jets) at a useful load of 90 percent, and 100 percent of large aircraft at a useful load of 60 percent. However, it should be noted that these runway length recommendations are based on a mean daily maximum temperature of the hottest month, as well as with zero wind. Cooler temperatures and stronger headwinds reduce the required runway length for a given aircraft. In addition, the recommended runway lengths are for groups of aircraft and do not represent a required runway length for any specific aircraft. Consequently, even though Runway 7-25 may not accommodate 100 percent of business jets at 90 percent useful load as a group, this does not mean that at certain times a larger business jet operating at or near its MTOW cannot use the runway. Based on this analysis, no additional runway length for Runway 7-25 is recommended through the planning period to accommodate small general aviation aircraft or business jets.

As prescribed by AC 150/5325-4B, the methodology used to determine required runway length for aircraft with a MTOW greater than 60,000 pounds involves the use of Airport Planning Manuals (APMs) specific to a particular aircraft to derive appropriate takeoff and landing distances. At commercial service airports, aircraft with a MTOW greater than 60,000 pounds are typically associated with air carrier and regional/commuter passenger airline service.

Table E-1 Runway Length Analysis for Small and Large Aircraft

AIRPORT AND RUNWAY DATA	
Airport elevation	4,154 feet
Mean daily maximum temperature of the hottest month	87.9° F.
Maximum difference in runway centerline elevation	8 feet
Dry runways	
RUNWAY LENGTHS RECOMMENDED FOR AIRPORT DESIGN	
Small aircraft with approach speeds of less than 30 knots	420 feet
Small aircraft with approach speeds of less than 50 knots	1,130 feet
Small aircraft with less than 10 passenger seats	
75 percent of these small aircraft	4,040 feet
95 percent of these small aircraft	5,290 feet
100 percent of these small aircraft	5,610 feet
Small aircraft with 10 or more passenger seats	5,610 feet
Large aircraft with a MTOW of 60,000 pounds or less	
75 percent of these large aircraft at 60 percent useful load	6,270 feet
75 percent of these large aircraft at 90 percent useful load	8,680 feet
100 percent of these large aircraft at 60 percent useful load	8,350 feet
100 percent of these large aircraft at 90 percent useful load	9,940 feet

SOURCE: Federal Aviation Administration Airport Design computer program (Version 4.2D), January 2011, based on stated Airport and runway data inputs.
PREPARED BY: Ricondo & Associates, Inc., November 2011.

The following aircraft types are forecasted to operate scheduled passenger airline service at the Airport through the planning period, and were included in the runway length analysis:

- **Boeing MD-83** – Allegiant Air provided scheduled airline service at the Airport from June 2010 to January 2012 using MD-83 aircraft (ARC C-III). This aircraft has a MTOW of 160,000 pounds and is representative of the type of aircraft requiring the greatest runway length that could regularly use the Airport within the planning period to provide scheduled passenger air service. The engine type assumed in the analysis was the JT8D-219 engine.
- **Embraer EMB-120** – The EMB-120 turboprop is currently operated at the Airport by SkyWest Airlines and is forecasted to continue to be used through the planning period. While this aircraft has a MTOW of 26,433 pounds, the APM methodology was used in order to derive a more precise runway length requirement. Specific aircraft equipment assumed in the analysis as the extended range (ER) version with Pratt and Whitney PW 118A engines.

- **Bombardier CRJ-200** – As described in Section 3, it is anticipated that within the planning period, one or more daily regional/commuter airline flights currently operated by the EMB-210 could be replaced with one or more flights using a regional jet. The CRJ-200 LR (long range) regional jet is representative of the type of aircraft that could operate at the Airport in this capacity. The CRJ-200 has a MTOW of 53,000 pounds. However, as previously discussed, AC 150/5325-4B assumes that all regional jets are categorized as having a MTOW greater than 60,000 pounds and specifies that the APM methodology should be used when calculating runway length requirements for these aircraft in order to allow for airline flexibility in interchanging various regional jet models.

An analysis was conducted to determine if the existing length of Runway 7-25 (8,700 feet) is adequate for existing and forecasted operations of these aircraft. The analysis consisted of three steps and the results are presented in **Table E-2**.

Table E-2 Runway Length Analysis for Passenger Airline Aircraft

			ESTIMATED PERFORMANCE OPERATING ON RUNWAY 7-25 [1/]		
AIRCRAFT	MTOW	REQUIRED RUNWAY LENGTH AT MTOW	TOW	TOW AS PERCENTAGE OF MTOW	RANGE (NAUTICAL MILES) [2/]
Boeing MD-83 [3/]	160,000	11,000 feet	144,000	90%	1,600
Embraer EMB-120 ER [4/]	26,433	6,200 feet	26,433	100%	800
Bombardier CRJ-200 LR [5/]	53,000	9,200 feet	51,500	97%	1,350

Notes: MTOW = maximum takeoff weight; TOW = takeoff weight. Analyses for all aircraft types assume an airport elevation of 4,154 feet above mean sea level, a temperature of 86° Fahrenheit, a maximum difference in runway centerline elevation of 8 feet, and zero wind. Information presented in this table is for airport development planning purposes only and is not to be used for flight planning.

1/ The existing length of Runway 7-25 is 8,700 feet.

2/ Range estimates are based on a full load of passengers and baggage and include reserve fuel for an additional 100 nautical miles. It should be noted that airline operational procedures may restrict the TOW of certain aircraft in certain conditions beyond the listed physical limitations of the aircraft. Such restrictions would affect the estimated range of a particular aircraft at a given TOW.

3/ Takeoff and range data for MD-83 with JT8D-219 engines derived from: McDonnell Douglas, *MD-80 Series Airplane Characteristics for Airport Planning*, 1990.

4/ Takeoff and range data for Embraer EMB-120 with PW 118A engines derived from: Embraer, *EMB120 Brasilia Airport Planning Manual*, October 30, 2000.

5/ Takeoff and range data for Bombardier CRJ-200 derived from: Bombardier, Inc., *Model CL-600-2B19 Series 100/200/440 Airport Planning Manual, Issue 7*, November 7, 2003.

SOURCE: Ricondo & Associates, Inc., January 2011, using the sources and assumptions noted above, in conjunction with Federal Aviation Administration, Advisory Circular 150/5325-4B, *Runway Length Requirements for Airport Design*, July 1, 2005.

PREPARED BY: Ricondo & Associates, Inc., November 2011.

The first step in the analysis was to determine if each aircraft could operate at its MTOW using Runway 7-25. This was accomplished using the methodology and assumptions specified in AC 150/5325-4B in conjunction with the applicable takeoff distance charts in the APM for each aircraft. The charts selected for use in this

analysis were based on a temperature of 86 degrees Fahrenheit,[1] zero wind, optimal flap configuration, and an airport altitude of 4,154 feet MSL. To account for differences in runway centerline elevation, a total of 80 feet was added to the derived runway length.[2] As depicted in Table E-2, of the three aircraft types, only the EMB-120 can take off from Runway 7-25 at its MTOW. With an available runway length of 8,700 feet, under the given conditions, it was estimated that the MD-83 can take off at a weight of approximately 144,000 pounds (90 percent of its MTOW) and that the CRJ-200 can take off at a weight of 51,500 pounds (97 percent of its MTOW).

The next step in the analysis was to estimate the approximate range (stage length) of each aircraft given its achievable takeoff weight (TOW) from Runway 7-25. The achievable TOW is the aircraft's operating empty weight plus a payload (or useful load), which consists of a combination of passengers, cargo, and fuel. For a given TOW, passengers/cargo could be sacrificed for fuel to achieve a greater range. The ranges presented in Table 4-5 assume that each aircraft carries a full load of passengers and baggage (i.e., 155 passengers in the MD-83, 30 passengers in the EMB-120, and 50 passengers in the CRJ-200). The ranges for each aircraft were derived using applicable range charts from the APMs.

The final step in the analysis was to determine if the achievable ranges for each of the aircraft are acceptable. Using U.S. Bureau of Transportation Statistics Passenger Origin and Destination (O&D) Survey data for calendar year 2009, the top 10 destination markets were derived for the Airport. These markets represent ultimate destinations for passengers. For example, although all passengers currently fly from TWF to Salt Lake City International Airport, most of those passengers connect to other flights in order to get to their final destination.

Table E-3 identifies the Airport's top 10 O&D markets, as well as the distance from TWF to each of those destinations. The ranges from TWF to each top 10 destination market were compared to the estimated achievable ranges for each of the aircraft as presented in Table E-2. Results indicate that both the MD-83 and CRJ-200 aircraft could potentially reach any of the top 10 destination markets from TWF using Runway 7-25 at its existing length, with a full load of passengers and baggage. Under similar conditions, the EMB-120 could potentially reach any of the top 10 destinations other than Dallas. According to the analysis, aircraft equivalent to the MD-83 and CRJ-200 could potentially connect passengers from the Airport to several other large hub airports throughout the country, such as Minneapolis-St Paul International Airport, Chicago O'Hare International Airport, and Hartsfield-Jackson Atlanta International Airport.

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1 The mean daily maximum temperature of the hottest month for the Airport is 87.9 degrees Fahrenheit. The APM takeoff distance charts available for each of the aircraft included in the analysis include separate charts for temperatures of 59 degrees Fahrenheit (Standard Day temperature) and 86 degrees Fahrenheit (Standard Day + 15 degrees Celsius). The charts that assume a temperature of 86 degrees Fahrenheit were used for this analysis. This is lower than the 87.9 degrees assumed for the Airport. However, in accordance with AC 150/5325-4B, it is acceptable to use an AMP chart if it is no more than 3 degrees Fahrenheit lower than the recorded value for the mean daily maximum temperature of the hottest month at the airport. In this case, the temperature difference is about 2 degrees Fahrenheit.

2 AC 150/5325-4B specifies that for aircraft with a MTOW greater than 12,500 pounds, the derived runway length for takeoff must be increased by 10 feet per foot difference in centerline elevations between the high and low points of the runway centerline elevations. The maximum difference in runway centerline elevation on Runway 7-25 is 8 feet.

Table E-3 Top 10 Destination Markets From Twin Falls

DESTINATION MARKET/CITY [1/]	ASSOCIATED AIRPORT (CODE)	DISTANCE FROM TWF (NAUTICAL MILES)
Phoenix, AZ	Phoenix Sky Harbor International Airport (PHX)	555
Salt Lake City, UT	Salt Lake City International Airport (SLC)	152
Las Vegas, NV	McCarran International Airport (LAS)	385
San Diego, CA	San Diego International Airport (SAN)	598
Denver, CO	Denver International Airport (DEN)	471
Los Angeles, CA	Los Angeles International Airport (LAX)	544
Seattle, SEA	Seattle-Tacoma International Airport (SEA)	447
Dallas, TX	Dallas/Fort Worth International Airport (DFW)	1,007
Orange County, CA	John Wayne-Orange County Airport (SNA)	551
Ontario, CA	Ontario International Airport (ONT)	526

Notes:

1/ Top destination markets were derived from an analysis of Bureau of Transportation Statistics (BTS) Passenger Origin and Destination Survey data for calendar year 2009.

2/ The associated airport represents the primary airport serving each destination market/city.

3/ The distance from TWF to each destination market/airport was obtained from the Great Circle Mapper (http://gc.kls2.com, accessed January 6, 2011) and represents the direct distance between the two airports. The actual flying distance between TWF and each airport depends on the specific route flown, which may not be the shortest/most direct route.

SOURCE: Ricondo & Associates, Inc., January 2011, based on the sources noted in footnotes 1 through 3.
PREPARED BY: Ricondo & Associates, Inc., November 2011.

While the EMB-120 or CRJ-200 may not be used to serve many of these destinations directly, these aircraft (along with the MD-83) are representative of a variety of aircraft that could potentially operate from the Airport on an infrequent/nonscheduled basis (i.e., charters, BLM firefighting, etc.).

Based on this analysis, aircraft with a MTOW of more than 60,000 pounds, including all aircraft types forecasted to use the Airport in support of regular passenger airline service, can use Runway 7-25 at its existing length without incurring operational restrictions that would limit the ability of the aircraft to serve a reasonable list of destination markets from TWF. Therefore, no additional length to runway 7-25 is recommended during the planning period.

The 2003 Master Plan Update noted that a 1,300-foot westward extension of Runway 7-25 was shown on an ALP approved by the FAA as part of the Airport's 1988 Master Plan Update. This extension (to 10,000 feet) was carried through the 2003 Master Plan Update. To quantitatively evaluate the feasibility of such an extension, using the assumptions and methodologies documented in this subsection, it was estimated that the MD-83 aircraft (carrying a full load of passengers and baggage) could achieve a range of approximately 2,000 nautical miles. This range would potentially be sufficient to reach destinations along the East Coast. However, based on an analysis of destination market data, regular use (500 annual operations or scheduled

airline service) of an aircraft between TWF and airports on the East Coast is unlikely during the planning period. In addition, the aviation activity forecast does not suggest regular use of aircraft requiring a runway longer than 8,700 feet without incurring significant operational limitations. Therefore, an extension of Runway 7-25 to 10,000 feet is not recommended in this Master Plan Update. It is noted that the existing layout of Runway 7-25 with respect to roadways and equipment (such as the localizer off the approach end of Runway 7) has been developed to accommodate future extension of the runway. It is recommended that future development of the Airport should account for the potential future extension of the runway so as not to limit the long-term utility of the Airport.

Crosswind Runway Length Requirements

AC 150/5325-4B recommends that the length of a crosswind runway be determined based on the lower crosswind capable aircraft using the primary runway. The Airport's crosswind runway (Runway 12-30) is primarily used by small general aviation aircraft (ARC A-I and B-I) either for more convenient access to/from the primary general aviation area on the Airport during calm wind conditions, or in wind conditions that are unfavorable for the use of Runway 7-25.

Based on the analysis of the runway length required for small aircraft with less than 10 passenger seats, presented in Table 4-4, a runway length of approximately 4,040 feet is recommended to accommodate 75 percent of these aircraft. However, the "75 percent" group of aircraft includes a variety of unspecified propeller driven aircraft, including both single- and multi-engine aircraft of varying sizes. Since Runway 12-30 is primarily used by small single-engine aircraft, AC 150/5325-4B allows for the use of individual aircraft flight manuals to determine appropriate runway lengths for the aircraft to be accommodated.

Using the Pilot Operating Handbooks (POHs) for a representative list of aircraft that may use Runway 12-30, an analysis was conducted to determine if the existing length of the runway (3,224 feet) is sufficient to safely accommodate takeoff and landing operations of these aircraft. Inputs for this analysis included the airport elevation (4,154 feet) and a mean daily maximum temperature of the hottest month of 87.9 degrees Fahrenheit.[3] Pursuant to AC 150/5325-4B, no adjustments to takeoff lengths due to differences in runway centerline elevations are required for aircraft with a MTOW less than 12,500 pounds. **Table E-4** presents the results of this analysis.

As depicted in Table E-4, each of the representative aircraft have takeoff and landing runway length requirements less than 3,224 feet, given the stated conditions and assumptions included in the analysis. The existing fleet mix that currently uses Runway 12-30 is not expected to change significantly through the forecast period. Therefore, it is reasonable to conclude that the existing length of Runway 12-30 is appropriate given its role as a crosswind runway for small general aviation aircraft. No extension of Runway 12-30 is recommended in this Master Plan Update.

[3] Tables/charts included in most POHs for small general aviation aircraft allow for the determination of takeoff/landing distances based on a number of temperature increments. For this analysis, POH tables with a temperature of 30 degrees Celsius (86 degrees Fahrenheit) were used.

Table E-4 General Aviation Aircraft Takeoff and Landing Distances

				TAKEOFF DISTANCE (FEET) [1/]		LANDING DISTANCE (FEET)	
AIRCRAFT	MODEL YEAR	SPECIFICATIONS	MTOW	GROUND ROLL	TOTAL OVER 50-FOOT OBSTACLE [2/]	GROUND ROLL	TOTAL OVER 50-FOOT OBSTACLE
Cessna 152 [3/]	1978	Single-engine piston	1,670	1,190	2,250	580	1,370
Cessna 172P [4/]	1982	Single-engine piston	2,400	1,490	2,850	670	1,480
Cessna 182P [5/]	1976	Single-engine piston	2,950	1,140	2,250	730	1,580
Cessna 208 [6/]	1998	Single-engine turboprop	8,000	1,650	2,860	880	1,880
Piper Warrior [7/]	1974	Single-engine piston	2,325	N/A	2,200	750	1,250
Piper Seneca [8/]	1973	Multi-engine piston	4,200	1,500	2,300	860	1,500

Notes: MTOW = maximum takeoff weight; N/A = not available. Analyses for all aircraft types assume an airport elevation of 4,154 feet above mean sea level and a temperature of 86° Fahrenheit, and zero wind. Information presented in this table is for airport development planning purposes only and is not to be used for flight planning.

1/ Takeoff distance is based on short field operating procedures, which include optimal flap setting and full throttle prior to brake release.

2/ While an aircraft may become airborne after the ground roll, it is preferable (from a piloting standpoint) to assume that the required runway equals the total takeoff distance to clear a 50-foot obstacle at the end of the runway. If no such obstacle exists at the end of the runway, this required length becomes a conservative length for added safety.

3/ Takeoff and landing distances for Cessna 152 derived from: Cessna Aircraft Company, *Pilot's Operating Handbook, 1978 Model 152*, 1977.

4/ Takeoff and landing distances for Cessna 172P derived from: Cessna Aircraft Company, *Information Manual, 1982 Model 172P*, 1995.

5/ Takeoff and landing distances for Cessna 182P derived from: Cessna Aircraft Company, *Pilot's Operating Handbook, 1976 Model 182P*, 1976.

6/ Takeoff and landing distances for Cessna 208 derived from: Cessna Aircraft Company, *Pilot's Operating Handbook, 1998 Model 208 With PT6A-114A (675 SHP) Engine*, April 1, 1998; Revision 6, October 30, 2002.

7/ Takeoff and landing distances for Piper Warrior derived from: Piper Aircraft Corporation, *Cherokee Warrior Information Manual, PA-28-151*, July 1973.

8/ Takeoff and landing distances for Piper Warrior derived from: Piper Aircraft Corporation, *Airplane Flight Manual for Seneca, PA-34-200* May 14, 1973.

SOURCE: Ricondo & Associates, Inc., January 2011, using the sources and assumptions noted above, in conjunction with Federal Aviation Administration, Advisory Circular 150/5325-4B*, Runway Length Requirements for Airport Design*, July 1, 2005.

PREPARED BY: Ricondo & Associates, Inc., November 2011.