

**Pavement Strength Analysis**  
**Prepared by Molzen Corbin**  
**September 2016**

The Santa Fe Municipal Airport was originally constructed in 1941. It was constructed by the military as a B-24 bomber training base. The airport construction probably proceeded from 1941 to about 1955 in order to complete all three runways and associated taxiways. Santa Fe County took over the airport in about 1948 as the war efforts declined.

Some of the existing runway surfaces are a part of that old, original construction. Some are not. These are described below.

In general, since 1989, several criteria have controlled pavement design. In the 1990s, the Gulfstream III (G-III) corporate jet seemed to control the equivalent design aircraft. This is a 68,700 lb dual wheel gear (DWG) aircraft. Business jets, such as the G-III, were frequent visitors to the airport, and pavement designs were for this aircraft. Pavements such as Runway 15-33, Taxiway D, the north apron, the far north apron, and the terminal ramp area were all designed to this standard.

In later years, 2000 to 2016, G-IV, G-V and Global Express aircraft have entered the market and have been included in the aircraft design fleet. The pavement design then was based on a 99,000 lb DWG aircraft. The pavements designed to this standard include Taxiway A, Taxiway C, the west half of the East Apron, and Taxiway F.

In 1991, the City of Santa Fe completed an Airport Master Plan which included a geotechnical investigation. This investigation provided boring logs of some 31 locations and provided CBR information. Specifically, the investigation found CBR values of 10, 16 and 20 and further commented that these values were significantly higher than expected for the soil classifications discovered. This information has been useful in pavement designs that followed.

In 2007 and 2013, the NMDOT Aviation Division completed a pavement condition index (PCI) survey of all New Mexico airport pavements, including SAF. This was a visual evaluation that rated cracking, raveling, and other visual disturbances. The value of the PCI is repeating the ratings periodically to see how the PCI diminishes over the years. Once a rating reaches 70, then immediate attention is needed. A dollar spent on pavement rehabilitation at a PCI of 70 will cost four to five dollars once the rating has degraded to a 20. The ratings at SAF showed the following:

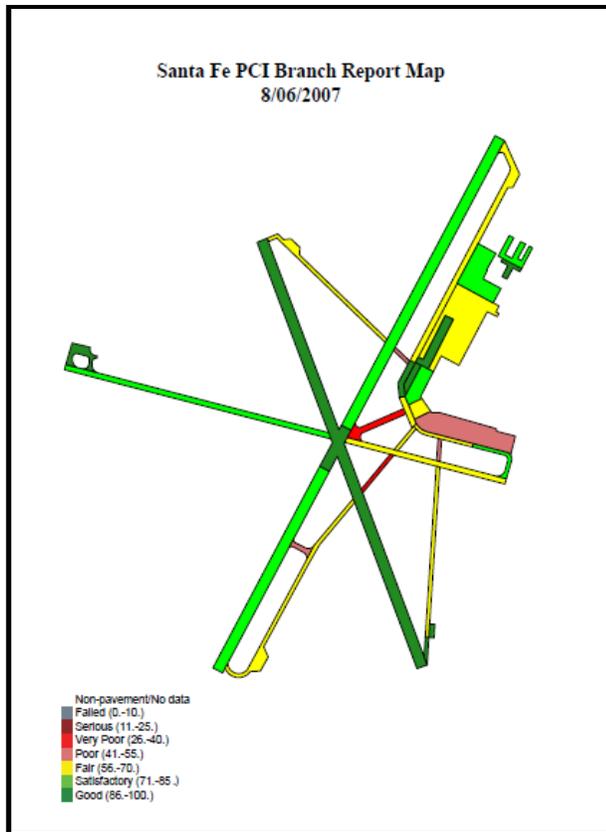
**Table 1  
PCI Results**

<b>Pavement</b>	<b>2007 PCI</b>	<b>2013 PCI</b>
Runway 2-20	71-85; 86-100 in midfield intx.	91-93 Coal Tar sealer placed in 2010
Runway 15-33	86-100	67-69
Runway 10-28	56-70 from 28 to Midfield; 71-85 Midfield to 10; Hammerhead 86-100	88; 41 from TW C to the midfield intersection. Hammerhead 69 Coal Tar Seal placed in 2010
Taxiway A	Mostly 56-70	92-100 Reconstructed in 2013
Taxiway C	56-70	92-93 Reconstructed in 2013
Taxiway D	56-70 from apron to 10-28; 26-40 from 10-28 to 15-33; 56-70 from 15-33 to south end	62 from apron to 15-33; 52 from 15-33 to the south end. Run-up apron 77
Taxiway E (now D1)	41-55	52
Taxiway F	26-40 Removed in 2014	79 from Apron to 15-33. Extension to the 10 approach was not complete
Taxiway G	41-55 from Apron to 2-20 (replaced in 2013); 56-70 to 15	49; Run-up apron 79
Taxiway J	Not rated	71
North Apron	56-70; one section 86-100	44-46
Far North Apron	71-85	54
East Apron Heavy	41-55	90 Reconstructed 2012
East Apron Light	41-55	84 Reconstructed 2012
Commercial Apron	71-85	72 (both asphalt and concrete)
A01SA-60	56-70	57
A01SA-50	56-70	20 (concrete)

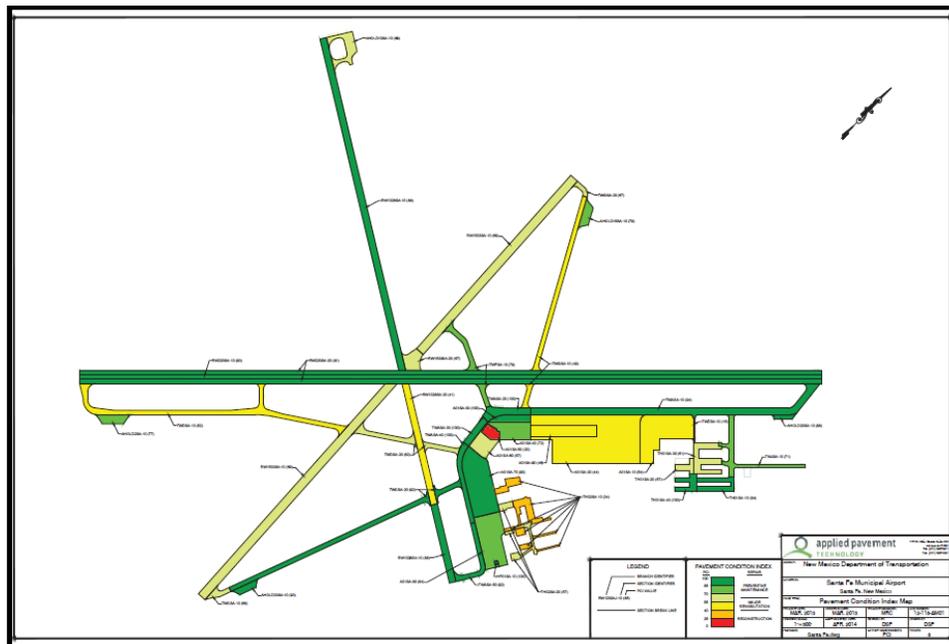
A01SA-60 does not have a common name, but was identified as such in the PCI report. It used to be concrete pavement, but the apron replacement in 1997 replaced this area with asphalt. The 2012 east apron reconstruction did not reach this section of asphalt between the east apron project and the concrete, hence the low rating.

A01SA-50 is a section of the concrete pavement and has a low PCI. Figures 1 and 2 below are color representations of the two PCI ratings.

The true value of the PCI ratings is in the additional data points. Having one PCI on a pavement is helpful, but to have PCI values taken every five years or so is beneficial in seeing how the PCI degrades over time. Figures 1 and 2 show the 2007 and 2013 ratings.



**Figure 1**  
**2007 PCI**



**Figure 2**  
**2013 PCI**

In 2014, the NMDOT Aviation Division went a step further and completed a project for non-destructive testing (NDT) and coring on all the State's airports, including SAF. The NDT testing was completed with a falling weight deflectometer (FWD) which was supplemented or calibrated on borings taken on the pavement. This report provided a pavement rating in terms of pounds, but also included a pavement condition number (PCN). FAA is moving towards using the PCN rating in lieu of an actual weight-with-wheel-gear rating. The resulting PCNs for SAF runways are shown in Table 2.

**Table 2**  
**PCN Ratings**

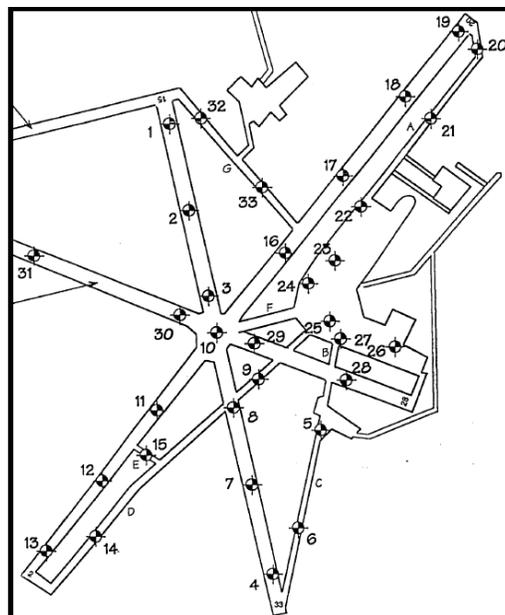
Runway	PCN	SWG Rating	DWG Rating	Design
2-20	46	116,000	134,000	Unknown
15-33	10	28,000	43,500	68,700 DWG
10-28	4	12,500		30,000 SWG

The taxiways and aprons were not included in this initial study. However, the study will include taxiways and aprons for SAF in the near future. Borings for SAF taxiways were taking place at SAF in the first week of July 2016, so those results will be available soon.

**Runway 2-20**

Runway 2-20 was originally constructed in the 1950s. While historical records do not indicate the original thickness, nor were any subsequent overlays completed, it is known that no significant changes have occurred to this runway since the inception of the AIP program in 1989.

The 1991 Airport Master Plan provided some useful information on the pavement section thickness. The location of the borings is shown in Figure 3 below and the log information is contained in Table 3 below.



**Figure 3**

## Runway 2-20 Borings in 1991

**Table 3**  
**Runway 2-20 Boring Logs**

<b>Boring</b>	<b>Asphalt</b>	<b>Base</b>	<b>Classification</b>
13	6	8	Silty Sand, SM
12	4.5	7	Sandy Clay, SC
11	10	10	Sandy Clay, SC
10	12	10	Clayey Sand, SC
16	12	8	Clayey Sand, SC
17	11	8	Silty Sand, SM
18	10	8	Clayey Sand, SC
19	8	8	Clayey Sand, SC

The 1991 geotechnical investigation provided recommendations for pavement rating. The report stated, “The pavement strength evaluation would indicate the pavement to be capable of supporting dual wheeled aircraft over 110,000 lb except at Boring No. 12, where the pavement thickness and soil type indicated the maximum aircraft to be 65,000 lb.”

It is apparent that the original construction of Runway 2-20 extended from the current 20 threshold to Taxiway E, now D-1. A 2,000-foot extension was added sometime later, from Taxiway E (now D-1) to the present Runway 2 threshold. This extension obviously did not receive the same pavement section thickness as the remainder of the runway.

Since 1990, two projects have been completed on Runway 2-20. One project, completed in 2005, used a Cutler process to mill ¾” to 1-1/2” of existing surface, reheat that material, add virgin material, and then lay down a new 1” porous friction course. This process essentially bought another 10 years of life for the pavement. Another project completed in 2011 was a simple application of a coal tar sealer on the runway surface to rejuvenate the oils in the surface.

In 2014, the PCI evaluation shows Runway 2-20 had a PCI of 71-85, with the midfield intersection being rated at 86-100. In 2013, the PCI rating was 91-93. The reason that the PCI actually increased was because of the presence of the coal tar sealer placed just prior to the 2013 rating. This treatment blackened the runway and rejuvenated the oil in the surface.

The PCN report provided a recommended pavement rating based on non-destructive testing of a 134,000 DWG aircraft and a 116,000 SWG aircraft. The PCN on the runway was determined to be 46. FAA is moving away from aircraft ratings and toward use of the PCN as an indication of pavement strength. Each individual aircraft has a corresponding Aircraft Classification Number (ACN). When the ACN is below the PCN, the aircraft can use the facility. With a PCN of 46, Runway 2-20 is capable of handling aircraft with an ACN less than 46. Some examples of ACNs are contained in Table 4 below.

**Table 4  
ACN Values**

<b>Aircraft</b>	<b>Weight</b>	<b>ACN</b>
Gulfstream III	70,200 DWG	23
Gulfstream IV	75,000 DWG	25
Gulfstream V	90,900 DWG	29
B737-700	155,000 DWG	42
B-737	174,700 DWG	50
B-757	271,000 DT	45
B-767	451,000 DT	79
CRJ	47,450 DWG	16
C-130	155,000 2S	32

**Runway 15-33**

Runway 15-33 is no longer a part of the historical, original pavement construction in the 1940s. In 2007, this runway was reconstructed. It was reduced in width from 150' to 100' and was repaved by pulverizing the existing pavement surface and base course, compacting that material in place and a new 4" asphalt surface was constructed as the final layer. Due to high oil prices at the time, the runway surface was grooved instead of placing a porous friction course layer.

This project was designed for Gulfstream III aircraft, 68,700 lb DWG with approximately 1,500 annual departures. At the time, the only commercial service traffic was Beech 1900s flying to Denver. Therefore, the G-III design aircraft was deemed appropriate as this was the most demanding aircraft at SAF.

The 2007 PCI was 86-100. The 2013 PCI had reduced to 67-69.

The recent PCN has been published at 10, which relates to 28,000 lb SWG and 45,000 lb DWG. However, performance on this runway has been good with large jet traffic, no rutting or failures, only cracking along longitudinal and some transverse cracks.

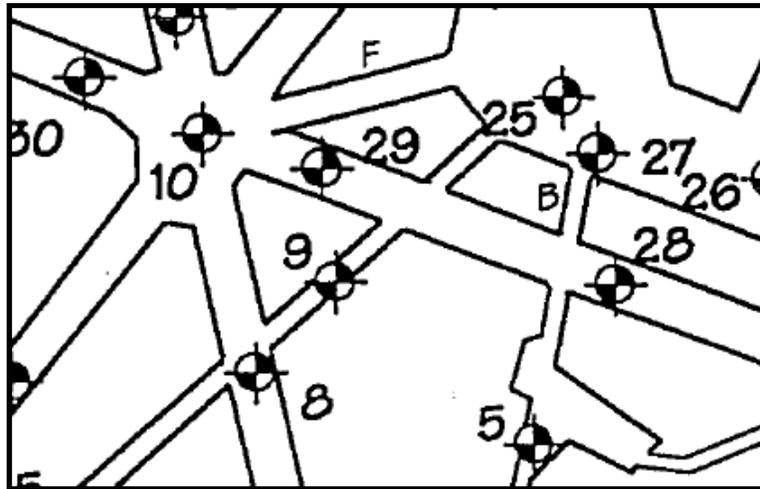
The pavement section included 4" of P-401 bituminous surface course, 6" of recycled asphalt and base course, and 8" of lime treated subgrade.

**Runway 10-28**

Generally speaking, the current condition of Runway 10-28 does not relate to the old, original construction in 1945; however, the portion of Runway 10-28 from Taxiway C to the midfield intersection is the old pavement section. In 1989, Runway 10-28 was closed from the midfield intersection to the west end. Weeds and grass had grown through pavement cracks. Runway 10-28 from the midfield intersection to the east end, approximately 2,900 feet in length, remained open.

In 2001, a grant was obtained to re-open this runway. FAA provided 90% of the funds of a \$1.8 million project to completely reconstruct the west half of the runway and a portion of the east half. Complete reconstruction of the east end, from the 28 threshold to Taxiway C, was also included. However, previous soil borings indicated that from the midfield intersection to Taxiway C had excessive asphalt

depth, approximately 10-12 inches. In order to save budget and in order to preserve this higher pavement strength, this section of runway was simply sealed with a porous friction course. The friction course was placed on the entire runway.



**Figure 4**  
**1991 Boring Report**

Boring 28 showed 3” of asphalt surface and 16” of aggregate base. Boring 29 showed 6.5” of asphalt surface and 8” of aggregate base. That is why this segment of pavement was left in place.

The design of this runway was for 1,200 annual departures of a 30,000 lb SWG aircraft. The pavement section was 2” of P-401 bituminous surface course, 8” of P-209 crushed aggregate base course, and 8” of P-154 subbase on prepared subgrade.

The 2007 PCI was 56-70 from 28 to the midfield intersection, 71-85 from the midfield intersection to 10, and the Hammerhead was 86-100. The 2013 PCI was 88, but 41 from Taxiway C to the midfield intersection, and the Hammerhead was 69.

A coal tar seal was placed on the entire runway in 2010.

The recent PCN report has stated that this runway should have a rating of 12,500 SWG as it has a PCN of only 4.

### **Taxiway A**

This taxiway was completely reconstructed in 2012 to 2013, but in two phases. It was designed for 99,000 lb DWG aircraft. The first phase extended from the 20 threshold to the north edge of the Far North Apron. Taxiway C Reconstruction was included in this same project. This project was completed in 2012. Taxiway A Phase II included the remainder of Taxiway A from the northern edge of the far north apron, all the way around the apron to the Runway 28 threshold. It included some additional width in order to connect to the existing concrete apron. Taxiway A Phase II was completed in 2013.

The 2007 PCI was 56-70 and the 2013 PCI was 92-100. The PCI increased as a result of the new construction.

The typical section was 5" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-154 subbase (which was actually the pulverized asphalt and base course from the existing section), and 12" of subgrade preparation.

### **Taxiway B**

Taxiway B no longer exists. It used to be from the end of the 28 approach on to the apron, approximately 2,000 feet, but is now a part of Taxiway A

### **Taxiway C**

This taxiway was completely reconstructed in 2013 in the same project that reconstructed Taxiway A. It was designed for 99,000 lb DWG. In addition, construction required that an additional 2" of asphalt surface be placed due to surface texture and elevation problems. It has 7" of asphalt instead of the required 5" of asphalt, so this taxiway should be rated much higher in aircraft weight due to the additional asphalt.

The 2013 PCI was 56-70 and the 2013 PCI was increased to 96-100 as a result of the new construction.

The typical section is 7" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-154 subbase (which was actually the pulverized asphalt and base course from the existing section), and 12" of subgrade preparation.

### **Taxiway D**

This taxiway was completely reconstructed in 1998. It was designed for G-III aircraft at 68,700 lb DWG. The pavement sections were different on each side of Runway 15-33. From the Runway 2 threshold to 600 feet south of Runway 15-33, the pavement section consisted of 4" P-401 bituminous bourse, 6" crushed aggregate base course, 8" of P-155 lime treated subgrade, and 12" of subgrade preparation.

From 600 feet south of Runway 15-33 to the apron, the pavement consists of 4" P-401 bituminous surface course, 6" of cold millings taken from the entire taxiway pavement removal, and 8" P-209 crushed aggregate base course.

Taxiway E, now D-1, was a part of this project construction.

The 2007 PCI rating was 56-70 from the apron to 10-28; 26-40 from 10-28 to 15-33; 56-70 from 15-33 to south end. The 2013 PCI was 62 from apron to 15-33; 52 from 15-33 to the south end. The run-up apron showed a 77.

There has been at least one crack seal project done on Taxiway D since it was constructed. It is believed that a surface seal project has never been done on this pavement. In 2014, some pavement patches were completed along with the Taxiway F extension project to correct some severe rutting.

## Taxiway F

Taxiway F used to extend from the apron directly to the midfield intersection. In 2010, an AIP grant and an ARRA grant were secured to relocate this taxiway to remove the midfield intersection. It was moved north to extend from the apron to Runway 2-20, and then from Runway 2-20 to Runway 15-33. In 2014, a grant was executed to extend the taxiway from Runway 15-33, thence parallel to Runway 10-28 to the 10 threshold.

All of Taxiway F was designed for 99,000 lb DWG. The typical section is 5" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-154 subbase, and 12" subgrade preparation.

The 2007 PCI report is not applicable since the old taxiway was in place and the new taxiway was not. The 2013 PCI report shows a PCI of 79.

## Taxiway G

No work has been done on this taxiway since before 1989. Some crack seal and surface seal projects have been completed since 1989, but no significant improvements have been made.

The 2007 PCI showed a rating of 56-70. The 2013 PCI rating was a 49. The run-up apron on the 15 end shows a PCI of 79.

The pavement has shown no signs of failure, losing the crown or other anticipated catastrophic failure. It should be noted that the portion of Taxiway G from the apron to Runway 2-20 was included in the Taxiway A project of 2013. This segment has 5" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" of P-154 subbase (pulverized asphalt and base course from the removal), on 12" subgrade preparation and is designed to the 99,000 lb DWG design standard.

This pavement is a part of the original airport construction in the 1950s. The 1991 Airport Master Plan included a geotechnical investigation which contained soil borings of this taxiway. The locations of the borings are shown in Figure 5 below.

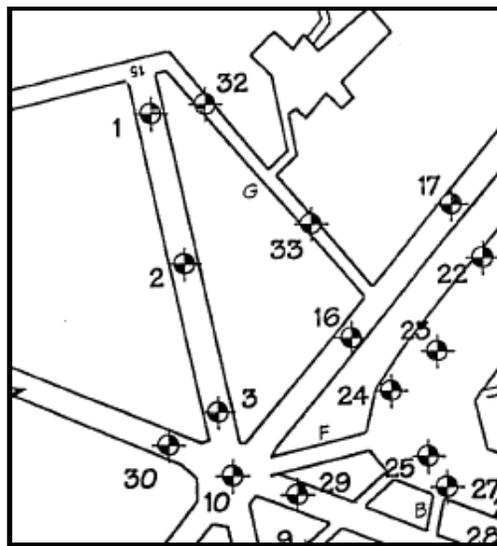


Figure 5  
Taxiway G Borings

Boring log 32 showed 6" of asphalt concrete, 8" of base course on top of Sandy Clay, CL subgrade. Boring log 33 showed 5" of asphalt concrete, 8" of base course on top of Clayey Sand, SC subgrade.

This taxiway is in need of total reconstruction and is on the airport ACIP in the near future. However, other projects have taken priority over this pavement for now.

### **Taxiway J**

Taxiway J was constructed with Runway 15-33 in 2007 as a separate bid project, as development pressure increased at the airport. From Taxiway A to the east, where the taxiway makes a 90 degree turn, was designed for 99,000 lb DWG for Investair, the first hangar to be constructed. It was intended to be for a G-IV, but only a Challenger is stored there currently. The n/w segment is light aircraft, 30,000 lb SWG.

The design called for 4" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-154 subbase on 6" subgrade preparation, from Taxiway A to the 90 degree turn. After the turn, the pavement is for light aircraft, 2" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-154 subbase, on 6" P-152 subgrade preparation.

The 2013 PCI report showed this pavement condition as a 71. While now 10 years old, this pavement has not received any sort of crack or surface seal treatment as maintenance.

### **North Apron and Far North Apron.**

These have two separate names as they were constructed in separate projects and in different years. The north apron was some 14 acres of parking apron constructed in 1991 as AIP grant #1 out of 41 grants to date. This area used to be filled with taxilanes and hangars, but in 1990, the first two AIP grants were obtained, one to eliminate the lease and relocate the hangars, and the other to construct the 14 acre apron. There was an existing apron in this area, and that apron was not disturbed or reconstructed. It was left in place and the new apron was simply constructed around the existing apron. It is delineated in the figure below.

The far north apron was a part of the 1998 Taxiway D project as an additive alternate. It was not awarded due to lack of funds, but was re-bid the following year in 1999.

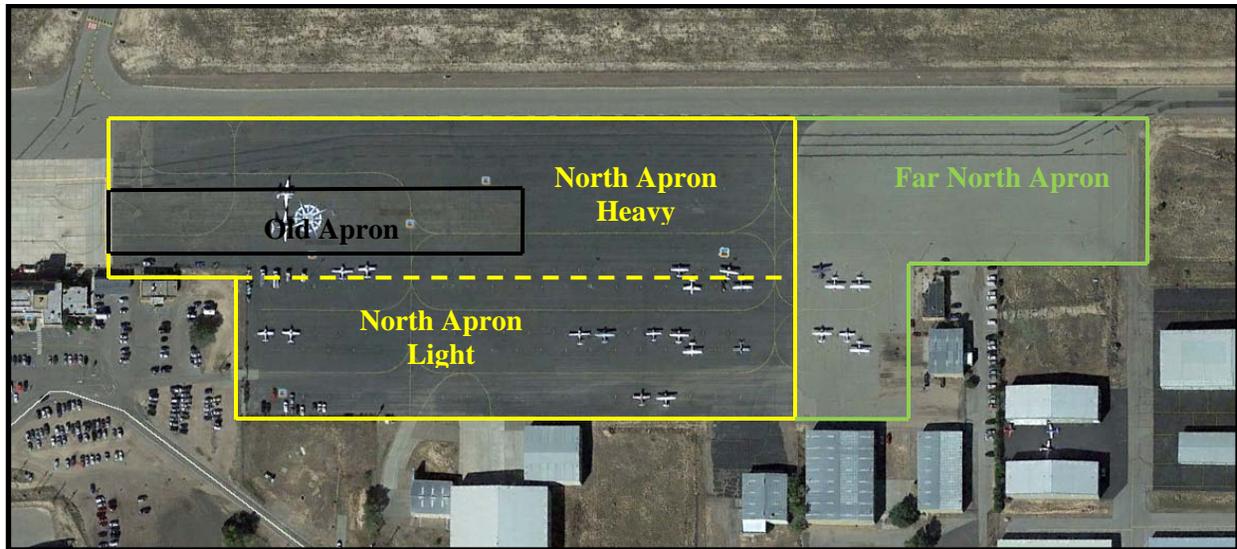
The north apron has two separate sections: a heavy aircraft section and a light aircraft section. The heavy section was designed for G-III aircraft, while the light section was designed for 30,000 lb SWG. Both are at the end of their design life but have performed very well over 26 years. Surface seal and crack seal have extended the pavement life well. There have been at least one surface seal and two crack seal projects since the pavement was constructed.

The north apron heavy section was designed for G-III aircraft. The section is comprised of 4" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, 8" P-208 base course, on 6" of subgrade preparation. It is believed that the 8" P-154 subbase was actually constructed with the P-209 crushed aggregate base course.

The light apron section is comprised of 2" P-401 bituminous surface course, 8" P-209 crushed aggregate base course, on 6" of subgrade preparation. The section has performed well over the 20+ years of service. FBOs continue to park heavier aircraft on this light aircraft section and no problems have resulted.

Constructed in 1991, the 2007 PCI rating was 46-71. Amazingly, the portion of the north apron which was not touched (shown as “Old Apron” in the figure below), as it was the original construction, has a PCI rating of 86-100. The 2013 PCI rating was 44-46. While the PCI is low, the apron is performing well. There is cracking, but there are no subgrade failures, potholes, or other major concerns at this time.

The far north apron was constructed later, in 1999. It has the heavy rated pavement section, similar to the north apron. The section is comprised of 4” P-401 bituminous surface course, 8” P-209 crushed aggregate base course, 8” P-208 base course, on 6” of subgrade preparation. It was designed for G-III aircraft, or 68,700 lb DWG.



**Figure 6**  
**North Apron Sections**

### **East Apron**

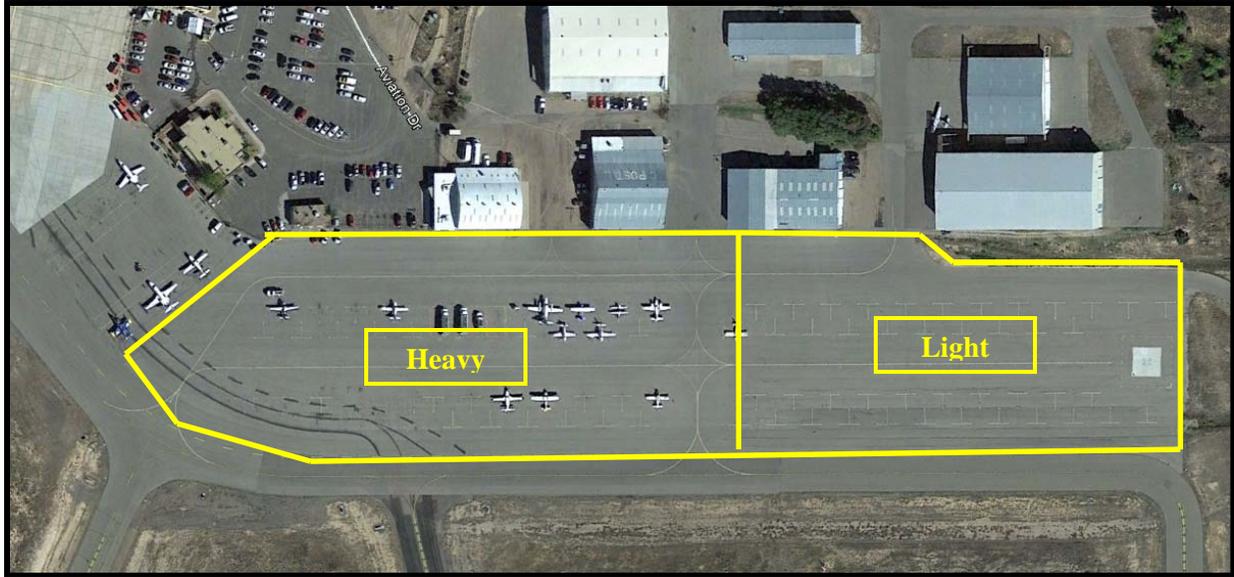
The East Apron has two different typical sections: a heavy and a light aircraft section. The heavy aircraft section includes a typical section of 4” P-401 bituminous surface course, 8” P-209 crushed aggregate base course, and 8” P-154 subbase, placed on 12” of subgrade preparation. It is the asphalt apron closest to the concrete pavement.

The light aircraft section has a typical section of 2” P-401 bituminous surface course, 8” P-209 crushed aggregate base course, and 8” P-154 subbase, placed on 6” of P-155 lime treated subgrade and 12” of subgrade preparation. It is farther east on the apron area.

The delineations of this project are shown in Figure 7 below.

It was constructed in two phases, under the same construction contract but with two phases of funding. It was completed in 2010. Some crack sealing has taken place on the eastern portions of this apron, but more is needed.

The 2007 PCI is not applicable. The 2013 PCI rating showed a PCI of 90 for the heavy section.



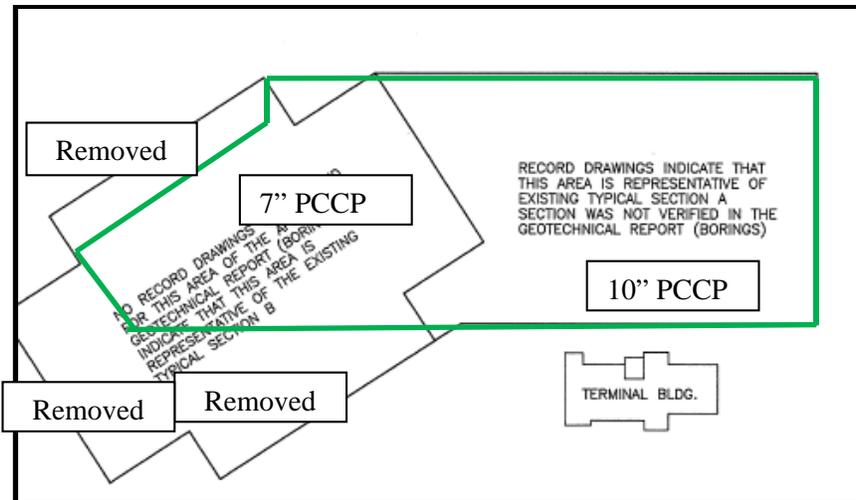
**Figure 7**  
**East Apron Sections**

### **Commercial Apron**

Ideally, the commercial area is the concrete pavement in front of the terminal. There is insufficient area for the future of parking in front of the terminal for commercial service parking. Nevertheless, parking spaces for three ERJ-145s have been provided.

This concrete pavement is of unknown strength or thickness. The concrete was originally constructed in 1955 or so. A project to replace some of the concrete panels was accomplished in 1995 or so. At that time, the concrete pavement was tested and showed some 7,000 psi of compressive strength.

A project was completed in 1992 to remove and replace some concrete panels and to remove much of the eastern portion of the concrete ramp. Record drawings show that the concrete pavement was between 7" and 10" in thickness. A diagram from this 1992 project was included in the construction drawings and is represented in Figure 8 below. Typical Section A, as noted below, was the 10" concrete, and Typical Section B indicated only 7" of concrete pavement.



**Figure 8**  
**PCCP Thickness**

The green lines are the limits of the PCCP in place as of now.

### Conclusions

The ERJ-145s dominate the climate at SAF. However, they are not the design aircraft. SAF realizes many operations of G-III, G-IV, G-V and G-VI aircraft now. In addition, the Global Express is a frequent user of the pavement.

The ERJ-145s are being phased out and they will be replaced by 75 passenger aircraft. That could be the ERJ-175, or the Q-400. The airport would like to accommodate the A-319 and even 737s in the future.

Ideally, the airport should design pavements, especially Runway 2-20, Taxiway A, and Taxiway D, to accommodate a 155,000 DWG aircraft. Runway 15-33 should be designed the same, to be used as a backup facility. This would accommodate all aircraft, including commercial service and potential chartered jets, to the local casinos.

Two constraints to this pavement design are the lack of stabilized base and the need to have FAA agree to the critical design aircraft.

According to FAA design criteria, jet aircraft over 100,000 lbs require a stabilized base and there is essentially none at SAF. Runway 2-20 has excessive asphalt depth and the pavement design program can be tailored to convert excess asphalt depth to a stabilized base. Other pavements on the airfield cannot.

The next issue will be to convince FAA that there are, or could be, 500 annual operations of a heavier aircraft, such as a A-319, based upon letters, meetings or actual data that such an aircraft will use the airport.