Pavement Classification Rating for Runways 18/36 and 12/30

Mason City Municipal Airport

PREPARED BY

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Introduction

As part of the update of the Iowa Airport Pavement Management System (APMS), Applied Pavement Technology, Inc. (APTech) determined the Pavement Classification Ratings (PCRs) for Runways 18/36 and 12/30 at Mason City Municipal Airport. In 2022, the Federal Aviation Administration (FAA) updated pavement strength reporting guidance to align with the International Civil Aviation Organization (ICAO). As part of that alignment process, reporting requirements are transitioning to PCRs from the previous reporting of Pavement Classification Numbers (PCNs) completed during previous APMS updates. When compared to an aircraft's Aircraft Classification Rating (ACR), the PCR provides a measure of a pavement's relative strength for supporting the applied loads of the aircraft. The process for determining PCRs is outlined in the FAA Advisory Circular 150/5335-5D, *Standardized Method of Reporting Airport Pavement Strength – PCR* and the corresponding FAARFIELD software (FAA 2022). FAARFIELD version 2.1 was used for the analysis (FAA 2023a).

Critical inputs for determining PCRs include the pavement cross section data, subgrade strength, and forecasted aircraft traffic. The pavements' cross sections were obtained through a review of historical records stored in the PAVER database. The subgrade strength and pavement layer properties determined during the 2018 PCN project were used. Required traffic data were derived by APTech from the FAA's Traffic Flow Management System Counts (TFMSC) obtained from the FAA Operations and Performance Data webpage. The overall operational volumes were obtained from Terminal Area Forecast data. These traffic data were then reviewed by the airport after which a 20-year traffic forecast was developed.

This report includes relevant information regarding the Pavement Condition Index (PCI) results, especially concerning load-related distress; an overview of the ACR–PCR system; required inputs for determining PCRs; and the PCR results for Runways 18/36 and 12/30 at Mason City Municipal Airport.

Pavement Condition Summary

APTech visually assessed the pavements at Mason City Municipal Airport in the fall of 2021 using the PCI procedure (APTech 2021). Detailed results of the condition assessment can be found in the Mason City Municipal Airport's individual APMS report or the web-based interactive APMS tool, IDEA (APTech 2023), available through a link on the Iowa Department of Transportation, Modal Transportation Bureau – Aviation (Iowa DOT) website.

Pavement condition data are not directly used in the structural analysis; however, the results should be considered when determining what PCR to publish. For example, a pavement exhibiting a significant amount of load-related distress provides a strong indication that the past traffic has exceeded the limits the structure can support. For asphalt-surfaced pavements, alligator cracking and rutting are considered load-related distresses.

For reference, table 1 summarizes the PCI, the percentage of the PCI deduct caused by load-related distress, and the specific load-related distress(es), if any, recorded during the most recent pavement inspection for Runways 18/36 and 12/30. The sections in the keel portions of both runways (the center 50 feet) experience most of the aircraft loading. Due to this, these sections were analyzed and are presented in this report. However, it should be noted that Sections 20A, 20B, 40, and 60 on Runway 18/36 and Sections 20 and 40 on Runway 12/30 comprise the outer 50 feet on either side of the keel and have similar construction to the corresponding keel sections.

Table 1. 2021 PCI results.

Branch	Section	Surface Type	LCD	2021 PCI	Percent Deduct due to Load-Related Distress	Load-Related Distress Observed
R12MC	10	AAC	5/3/2006	62	0	None
R12MC	30	AC	6/3/2005	62	0	None
R18MC	10A	AAC	6/4/2005	62	13	Rutting
R18MC	10B	AAC	6/4/2005	62	13	Rutting
R18MC	30	AAC	6/2/2005	62	0	None
R18MC	50	AAC	6/2/2005	64	0	None

Table Notes:

1. See figure 3 in the Mason City Municipal Airport Pavement Management Report or refer to the interactive APMS tool for the location of the branch and section.
2. Surface Type: AC = asphalt cement concrete; AAC = asphalt overlay on AC; PCC = portland cement concrete; APC = asphalt overlay on PCC.
3. LCD = last construction date.
4. Distress types are defined by ASTM D5340-20 (ASTM 2020).

ACR–PCR Overview

ACR

According to FAA Advisory Circular 150/5335-5D (FAA 2022), the ACR is defined as a number that expresses the relative effect of an aircraft at a given weight on a pavement structure for a specified standard subgrade strength. The ACR can be calculated for any operating weight. Higher ACRs indicate an aircraft has a more severe effect on the pavement, while lower values indicate a less severe effect.

ACRs are reported by pavement type (rigid or flexible) and subgrade strength category (as defined later). Pavements with a portland cement concrete (PCC) layer are generally considered rigid, including those with an asphalt overlay on PCC (APC). Stronger subgrade support conditions (e.g., granular subgrade soils with higher elastic modulus values [E]) correspond to lower ACRs as compared to weaker subgrade support conditions. The ACR has a minimum value of 0 and no upper limit.

ACRs are determined for the analyzed aircraft for flexible or rigid pavements and the applicable subgrade strength category using the FAA's FAARFIELD software. The determined ACRs are for the specified aircraft weights. For a given aircraft, the ACRs will decrease as aircraft weight decreases. It is also worth noting that tire pressure influences ACRs. For example, given two aircraft with similar weights and gear configurations (for a specific pavement type and subgrade strength category), the aircraft with the lower tire pressure will have a lower ACR, indicating that its demand on a pavement is less than a similar aircraft with a higher tire pressure.

PCR

The PCR is assigned to a pavement and expresses the relative load-carrying capacity of that pavement in terms of allowable load for unrestricted operations based on the analyzed aircraft and pavement layer properties. The determined PCR is specific for the given conditions and should be recalculated if the aircraft types or volumes change significantly. As with the ACR, the PCR has a minimum value of 0 and has no upper limit. In addition to the numerical value, the PCR is reported with four codes, which represent the following categories:

- Pavement Type.
  - R = Rigid.
  - F = Flexible.
- Subgrade Strength Category.
  - A = High (E ≥ 21,756 psi).
  - B = Medium (14,504 psi ≤ E < 21,756 psi).
  - C = Low (8,702 psi ≤ E < 14,504).
  - D = Ultra Low (E ≤ 8,702 psi).
- Maximum Allowable Tire Pressure.
  - W = Unlimited (no pressure limit).
  - X = High (pressure limited to 254 psi).
  - Y = Medium (pressure limited to 181 psi).
  - Z = Low (pressure limited to 73 psi).
- Pavement Evaluation Method.
  - T = Technical Evaluation.
  - U = Using Aircraft Evaluation.

Note that the subgrade strength category is now based on the elastic modulus of the subgrade (rather than the California Bearing Ratio [CBR] and top-of-base k-value, as it was in the ACN-PCN system) and is now consistent for both flexible and rigid pavement types.

General Overload Guidance

For aircraft with an ACR that exceeds the recommended PCR, ICAO overload guidance can be referenced. Alternatively, the indicated aircraft may be able to safely use these facilities (following the ACR-PCR procedure) by operating at a reduced weight. If aircraft do not operate at their analyzed weights, then the PCR should be recalculated using the actual aircraft weights.

In general, aircraft with ACRs exceeding 10 percent of the reported PCR should be restricted to avoid potential damage to the pavement. It should be noted that this percentage increased from 5 to 10 percent for rigid pavement when compared to previous PCN guidance; it is unchanged for flexible pavement. Exceeding this recommendation may result in a reduced pavement life. Appendix C of FAA Advisory Circular 150/5335-5D (FAA 2022) presents the following guidance for pavement overloads (based on ICAO guidance):

- Occasional traffic by aircraft with an ACR not exceeding 10 percent above the reported PCR should not adversely affect the pavement (for flexible or rigid pavements).
- Annual overload traffic operations number should not exceed approximately 5 percent of the total annual aircraft traffic.
- Overloads should not normally be permitted on pavements already exhibiting signs of load-related distress, during periods of thaw following frost penetration, or when the strength of the pavement or its subgrade could be weakened by water.
- Airport owners should regularly inspect the pavement condition when overload operations are conducted. Periodically, the airport owner should review the criteria for overload operations. Excessive repetition of overloads can cause a significant reduction in pavement life or accelerate when a pavement will require major rehabilitation.

In general, pavement overloads are expected to decrease pavement life but do not often cause immediate or catastrophic failures unless they are excessive.

PCR Analysis Inputs

Traffic, pavement cross section (thickness and material type), and subgrade data are used directly in FAARFIELD to calculate PCRs. In simplified terms, FAARFIELD uses these inputs to determine the critical aircraft within a traffic mix and adjusts the annual departures of the critical aircraft to achieve a Cumulative Damage Factor (CDF) equal to the maximum CDF of the aircraft mix. The maximum allowable gross weight of the critical aircraft to achieve a CDF of 1.0 is then determined, and the ACR of the critical aircraft at the maximum allowable weight is computed. FAARFIELD iterates these steps for all aircraft in the mix and presents the maximum ACR from this process as the PCR. The PCR should be associated with a “regularly using” aircraft to represent the pavement section. The FAA does not specify the threshold of the annual departures considered regular use; engineering judgment should be applied for seasonal or occasional use aircraft. Engineering judgment is also required to avoid overreporting pavement strength.

Pavement Cross Section

Pavement cross section information (layer thicknesses) and material types were obtained from historical construction records that were stored in the PAVER database. A summary of the relevant layer thickness information for the PCR analysis is presented in table 2.

Table 2. Pavement cross section used in the PCR analysis.

Branch	Section	Layer 1 Thickness, in	Layer 1 Material Type	Layer 2 Thickness, in	Layer 2 Material Type	Layer 3 Thickness, in	Layer 3 Material Type
R12MC	10	10.7	P-401	8	P-208	N/A	N/A
R12MC	30	6	P-401	8	P-208	24	P-154
R18MC	10A	8	P-401	8	P-208	24	P-154
R18MC	10B	14.1	P-401	8	P-208	N/A	N/A
R18MC	30	9.5	P-401	4.5	P-201	6	P-209
R18MC	50	8	P-401	6	P-201	N/A	N/A

Table Notes:

1. See figure 3 in the Mason City Municipal Airport Pavement Management Report or refer to the interactive APMS tool for the location of the branch and section.
2. Material Type: P-401 = asphalt concrete (flexible); P-501 = portland cement concrete (PCC, rigid); P-208 = aggregate base; P-201 = asphalt-treated base; P-154 = aggregate subbase.

Pavement and Subgrade Layer Inputs

FAARFIELD uses Layered Elastic Analysis (LEA) for modeling pavement structures for determining ACR and PCR. LEA is used as outlined in FAA Advisory Circular 150/5335-5D (FAA 2022). The updated analysis better aligns with the FAA’s current approach for airfield pavement design. In FAARFIELD, the user is allowed to input either subgrade modulus or CBR values for flexible pavement. The subgrade strength CBR of 6 percent was utilized during the 2018 project and was used again during this PCR analysis. Additionally, default FAARFIELD layer moduli were used during the analysis to represent the strength of the pavement layers.

Traffic

The characterization of traffic is an important part of the structural analysis of airport pavement facilities with inputs specifically including aircraft types, annual departure volumes, and weights. FAA pavement evaluation and design procedures only use departure data for the analysis because they generally have heavier loads due to larger fuel weight. The entire aircraft traffic mix associated with each facility is entered directly into FAARFIELD.

The traffic details were compiled by APTech. Information on the traffic mix, distribution, and future projections were determined using the FAA's TFMSC Instrument Flight Rules (IFR) flight data records (FAA 2023b). The results were provided to Mason City Municipal Airport staff members for review and comment, and adjustments were made at their request. This traffic represents an estimate of the projected 20-year average annual departures based on the traffic currently using the airport. This information is presented in table 3 along with the corresponding ACRs (as determined using FAARFIELD) for flexible pavement and the corresponding subgrade strength category.

Because PCR calculations are dependent on the aircraft using a facility, PCRs should be recalculated if the aircraft types, weights, or volumes change significantly. Additionally, inaccurate traffic can cause the PCR to be overestimated or underestimated.

Table 3. Traffic data.

Representative Aircraft	Weight, lbs	Gear Type	Tire Pressure, psi	20-year Average Annual Departures for Runway 18-36	20-year Average Annual Departures for Runway 12-30	ACR for Flexible Pavement, Subgrade Category C
Piper Cherokee	2,150	S	43	1,500	1,500	8
Piper Navajo PA-31	6,536	S	66	3,750	3,750	22
Cessna CitationJet/CJ1	10,600	S	99	1,692	1,692	41
Cessna Excel/XLS	20,200	S	70	845	845	70
Learjet 75	21,500	D	201	507	507	57
Dassault Falcon/Mystère 20	28,660	D	138	10	10	75
Bombardier Challenger 300	38,850	D	208	68	68	114
Dassault Falcon 900	45,500	D	145	8	2	141
Bombardier CRJ-200	53,250	D	179	570	63	139
Gulfstream IV/G400	75,000	D	185	2	0	257
Gulfstream V/G500	90,900	D	188	3	0	296
Boeing 757-200	256,000	2D	183	1	0	337
Boeing Globemaster 3, C-17	585,000	2T	138	3	0	550

Table Notes:

1. Configuration of the main gear: S = single, 2S = single in tandem, D = dual, 2D = two duals in tandem, 3D = three duals in tandem, and 2T = two triples in tandem, as defined in FAA Order 5300.7, *Standard Naming Convention for Aircraft Landing Gear Configurations* (FAA 2005).

PCR Results

The ACR–PCR procedure is structured such that a pavement with a given PCR can support an aircraft that has an ACR equal to or less than the PCR. Likewise, the pavement cannot, according to the procedure, accept frequent loadings from an aircraft with an ACR exceeding the PCR. For evaluating the structural capacity of a pavement section, it can be misleading to only look at the PCR as the determination of whether the pavement is acceptable must also consider the traffic using that pavement. Another way of evaluating a given section is through the ACR/PCR ratio (with ACR representing the maximum ACR of the aircraft in the traffic mix), where a ratio less than one indicates that the aircraft in the analyzed traffic mix can use the pavement without restrictions.

The resulting PCRs based on the analyses performed using FAARFIELD, allowable gross loads for common gear configurations, and the ACR/PCR ratios are summarized in table 4. The corresponding gross load correlations were determined using FAARFIELD and guidance in FAA Advisory Circular 150/5335-5D (FAA 2022), which provides approximations based on general correlations, but are not specific to the analyzed aircraft.

Note the following when reviewing the ACR/PCR ratio:

- Green – structurally adequate: the ACR/PCR ratio is less than or equal to 1.0; the pavement section can support the maximum take-off weight (MTOW) of the selected aircraft without restrictions.
- Yellow – overload guidance applies: the ACR/PCR ratio is greater than 1.0 but less than 1.1; weight restrictions are recommended for certain aircraft in the traffic mix to avoid structural damage.
- Red – structurally inadequate: the ACR/PCR ratio is greater than 1.1; some aircraft in the current traffic mix should be limited from using the pavement section.

Table 4. PCR results and corresponding allowable aircraft weights.

Pavement Section	Allowable Gross Weight (S)	Allowable Gross Weight (D)	Allowable Gross Weight (2D)	Calculated PCR	Max ACR	Max ACR Aircraft	ACR/ PCR Ratio
Runway 12-30, Section 10	43,000 lbs	66,000 lbs	117,000 lbs	160/F/C/X/T	141	Dassault Falcon 900	0.88
Runway 12-30, Section 30	43,000 lbs	66,000 lbs	117,000 lbs	160/F/C/X/T	141	Dassault Falcon 900	0.88
Runway 18-36, Section 10A	120,000 lbs	223,000 lbs	329,000 lbs	610/F/C/X/T	550	Boeing Globemaster 3	0.90
Runway 18-36, Section 10B	120,000 lbs	223,000 lbs	329,000 lbs	610/F/C/X/T	550	Boeing Globemaster 3	0.90
Runway 18-36, Section 30	120,000 lbs	223,000 lbs	329,000 lbs	610/F/C/X/T	550	Boeing Globemaster 3	0.90
Runway 18-36, Section 50	120,000 lbs	223,000 lbs	329,000 lbs	610/F/C/X/T	550	Boeing Globemaster 3	0.90

Table Notes:

1. See figure 3 in the Mason City Municipal Airport Pavement Management Report or refer to the interactive APMS tool for the location of the branch and section.
2. Corresponding allowable gross weights for Single (S), Dual (D), and Double Dual (2D) gears are determined using FAARFIELD and guidance in Appendix E of FAA Advisory Circular 150/5335-5D, which provides approximations based on general correlations but are not specific to the analyzed aircraft.
3. The recommended PCR for reporting to avoid overloading is limited to not exceed 10 percent of the maximum ACR for all sections presented in this table. If the fleet mix changes, the PCR should be recalculated.

Generally, a single PCR is published for a runway, and the structural capacity is often limited by the weakest area of the runway (as traffic, especially for heavier aircraft, often require the use of the entire length of the facility). As such, the recommendation provided herein for the value to publish for the runway PCR is based on the weakest area of the runway.

Runways 18/36 and 12/30 have sufficient structural capacity for the analyzed traffic. APTech recommends reporting a PCR of 610F/C/X/T for Runway 18/36 and 160/F/C/X/T for Runway 12/30. It should be noted that the pavement capacity of both runways exceeds the demand of the current traffic as listed in table 3. As suggested in FAA Advisory Circular 150/5335-5D (FAA 2022), to avoid reporting PCRs that are excessively greater than the ACRs of the aircraft in the analyzed traffic mix, the PCR has been limited based on ACRs of the traffic using the facility. Both runways may be able to support heavier aircraft, but specific aircraft would have to be analyzed in the traffic mix to verify. Load-related distress in the form of rutting was observed during the most recent PCI inspection on Runway 18/36 Sections 10A and 10B. These pavements should be monitored for future deterioration.

The PCR of Runway 12/30 is based on Dassault Falcon 900 as the critical aircraft. It should be noted, the 2018 PCN analysis included the Gulfstream IV and Gulfstream V aircraft in the traffic mix and resulted in higher structural capacity rating (the analysis is based on the anticipated traffic). Based on the initial calculations, Runway 12/30 can still support these aircraft. However, current guidance is to limit the PCR reporting based on the ACR of the critical aircraft (Dassault Falcon 900), and the ACRs of the Gulfstream IV and Gulfstream V aircraft currently exceed the proposed PCR.

In general, aircraft with ACRs less than the PCR can operate unrestricted, and aircraft with ACRs greater than the PCRs for the analyzed facilities may be able to safely use these pavements by following the ACR–PCR procedure and operating at a reduced weight. Some infrequent overloads are allowed in accordance with the general overload guidance, which is presented within this report. Aircraft operators are required to obtain permission to use a runway when their aircraft's ACR exceeds the published PCR. These operators are often aware of their aircraft's ACR for their intended operating weight.

Additionally, pavement overloads are expected to decrease pavement life but do not often cause immediate or catastrophic failures unless they are excessive. While the FAA's pavement structural capacity approach is conservative, decision-makers should be aware of the effect and risks of operating these aircraft based on the PCR analysis results where overload operations are conducted.

Summary

APTech determined the PCRs for Runways 18/36 and 12/30 at Mason City Municipal Airport. The assessment included reviewing available pavement construction records and aircraft traffic data and subsequently analyzing these data to determine the pavement's structural capacity.

An overview of the ACR-PCR system, inputs used for PCR calculations (including pavement layer thicknesses, material types, subgrade modulus, and traffic), and PCR results are documented in this report. The PCRs presented within this report were calculated using the FAA's technical evaluation method for determining PCRs, as described in FAA Advisory Circular 150/5335-5D (FAA 2022) and using the corresponding FAARFIELD software.

The PCR recommended for publication for Runway 18/36 at Mason City Municipal Airport is 610/F/D/X/T and for Runway 12/30 is 160/F/C/XT. The analysis indicates both runways are structurally adequate for the analyzed aircraft. Load-related distresses were observed during the most recent PCI inspection on Runway 18/36 Sections 10A and 10B. These pavements should be monitored for future deterioration.

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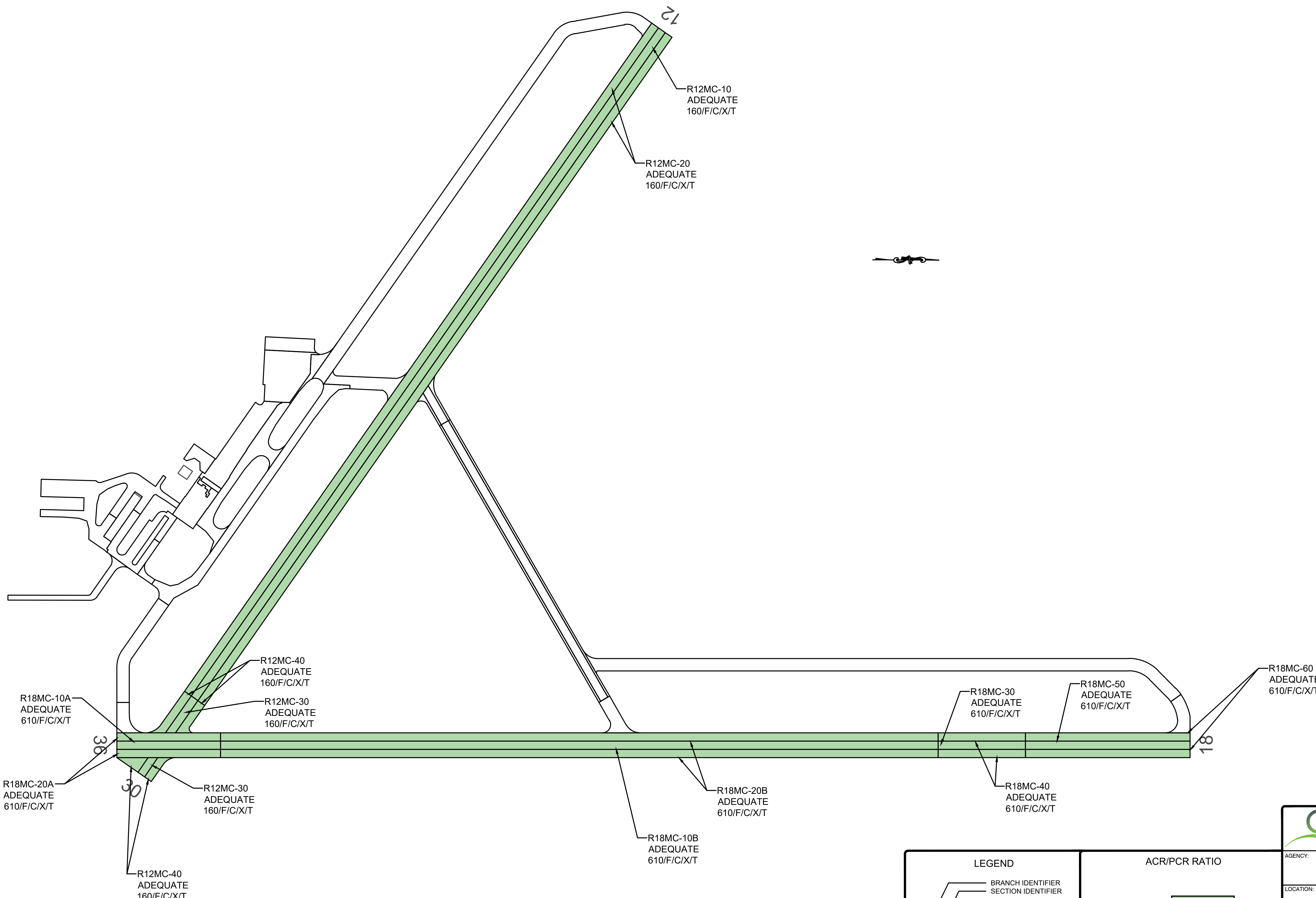

LEGEND

BRANCH IDENTIFIER
SECTION IDENTIFIER
R1028SV-10C

SECTION BREAK LINE

ACR/PCR RATIO

ADEQUATE	RATIO ≤ 1
OVERLOAD GUIDANCE	1 < RATIO < 1.1
INADEQUATE	RATIO ≥ 1.1

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