Appendix E
Airfield Safety Enhancement and Geometry Study - Runway and Taxiway Analysis

limit the applicable runway classifications to B-I for all but Runway 1L-19R until the parallel taxiway are improved to provide 240-feet of lateral separation between the taxiway centerline and the centerline of the runway that the taxiway serves versus the current 225 feet of lateral separation. The increased separation is necessary to fully conform to the design criteria set forth in Advisory Circular 150/5300.13a, change one for accommodation of aircraft in the B-II classification.

Table 7-3: Current and Future HWO Airport Classifications

FAA Classification	Runway 1L-19R		Runway 1R-19L		Runway 10R-28L		Runway 10L-28R	
	1L	19R	1R	19L	10R	28L	10L	28R
Airport Reference Code (ARC)	B-II(s)							
Design Aircraft	King Air B200/250							
Runway Design Code (RDC)	B-II(s)-VIS		B-II(s)-VIS		B-II(s)-5000		B-II(s)-5000	
Current Approach Reference Code (APRC)	B-II(s)-VIS	B-II(s)-VIS	B-I(s)-VIS	B-I(s)-VIS	B-I(s)-5000	B-I(s)-VIS	B-I(s)-VIS	B-I(s)-5000
Future APRC	Same	Same	B-II(s)-VIS	B-II(s)-VIS	B-II(s)-5000	B-II(s)-VIS	B-II(s)-VIS	B-II(s)-5000
Current Departure Reference Code (DPRC)	B-II	B-II	B-I	B-I	B-I	B-I	B-I	B-I
Future DPRC	Same	Same	B-II	B-II	B-II	B-II	B-II	B-II

Source: FAA AC 150/5300-13A, *Airport Design* and Kimley-Horn, Feb. 2016
(s) = small aircraft, 12,500 lbs. Maximum Takeoff Weight or less

7.3 Runway Analysis

The dominant feature on any airport is its runways. The pavement dimensions, the associated lighting and navigation aids, and the safety areas surrounding the runways determine what aircraft, and under what conditions those aircraft can be operated in a safe, efficient and regulatory compliant manor. The following evaluates the physical and operational characteristics of the runway system at HWO.

Runway Length

Providing an adequate length of runway helps ensure that aircraft regularly using an airport can operate safely within their performance characteristics and fly to their furthest non-stop destination with needed payload (i.e. fuel, passengers, and cargo). Alternatively, inadequate runway length limits the operational capability of the aircraft using an airport, including the types of aircraft and destinations served. Short runways can place restrictions on the allowable takeoff weight of the aircraft, which then reduces the amount of payload (passengers or goods) able to be carried.

FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*, provides guidance for calculating typical runway length needs at an airport. The guidance is focused on categories of airplanes with similar performance characteristics. The categories include:

- Small aircraft less than or equal to 12,500 lbs. Maximum Takeoff Weight (MTOW)
  - This category is further subdivided into groups that compose 95 percent and 100 percent of the aircraft fleet within this weight range.
  - Aircraft in this weight range that have 10 or more passenger seats are also grouped into a separate sub-category.
- Large aircraft weighing over 12,500 lbs. but less than 60,000 lbs. MTOW
- Large aircraft of more than 60,000 lbs. MTOW

As described previously, North Perry Airport is subject to a Broward County Ordinance that limits the MTOW of aircraft operating at HWO to 12,500 lbs. It is understood that this ordinance will remain in place throughout the planning horizon. Consistent with this, the Beechcraft King Air B200/250 has been defined as the critical design aircraft for HWO. The King Air B200/250 has a MTOW of 12,500 lbs. and can be configured with up to 13 passenger seats. Based on these items, and the guidance in FAA AC 150/5325-4B, the following analysis will identify runway length requirements for the King Air B200/250 and various other sub-categories of "small" aircraft

The FAA runway length guidance includes consideration of site specific factors such as temperature, airport elevation, effective runway gradient (takeoff only), and wet and slippery runways (landing turbojet-powered airplanes only). Landing length requirements are typically shorter than takeoff length requirements, even when adjusted for wet and slippery conditions, therefore, the desired runway length at HWO is driven by takeoff distance requirements. With consideration of the Airport elevation (8 feet above mean sea level or MSL), the mean maximum temperature of the hottest month in Hollywood Florida (91 degrees Fahrenheit), and the effective runway gradient (0-foot elevation difference), the FAA guidance recommends a runway length of 4,150 feet to accommodate the entire fleet of "small" aircraft that would include the King Air 200/250 design aircraft, as shown in **Table 7-4**. For aircraft with less than 10 passenger seats, the minimum runway length required is 3,100 feet for 95 percent of the fleet and 3,600 feet for 100 percent of the fleet assuming they operate at their maximum rated takeoff weight.

Runway 1L-19R is the longest north-south (N-S) runway at 3,350 feet and is lighted to accommodate both day and night operations. Runway 10R-28L is the longest east-west (E-W) runway at 3,255 feet, is lighted and provides non-precision instrument approach capability. These are therefore considered the main operational runways since the other two runways are shorter and unlighted. As indicated in **Table 7-4**, at these lengths, the main runways are deficient by 250 to 345 feet to accommodate 100 percent of the small aircraft fleet with less than 10 passenger seats and 800 to 895 feet deficient to accommodate those aircraft with more than 10 seats at their maximum allowable takeoff weight. The existing runway lengths do satisfy the minimum recommendation for 95 percent of the small aircraft fleet with less than 10 passenger seats.

Table 7-4: Runway Length Requirements per FAA Guidance (feet)

Passenger Seats	95% of Fleet	100% of Fleet	Deficiency N-S for 100% of the Fleet	Deficiency E-W for 100% of the Fleet
10 or more	n/a	4,150	800	895
Less than 10	3,100	3,600	250	345

Sources: FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design and* Kimley-Horn and Associates
Prepared: December 2015

Specific aircraft performance is also a key factor in evaluating runway length needs. Several aircraft models known to operate at HWO were identified from the same FAA Traffic Flow Management System (TFMSC) data used to develop the activity forecasts in **Section 5**. The runway requirements for these aircraft were calculated using the manufacturer flight planning manuals. Additionally, for on-demand charter aircraft operating under Federal Aviation Regulations (FAR) Part 135, an aircraft must be able to land within 60 percent of the available runway length at the primary destination airport. The aircraft must also be able to satisfy its' accelerate-stop distance requirements within 60 percent of the runway length. What this means is that for aircraft to directly fly charter operations to or from HWO, additional runway length would be needed. The required runway length calculations for these aircraft are provided in **Table 7-5**. Cells highlighted in red indicated deficiencies compared to the existing length of Runway 10R-28L (i.e. 3,255 feet).

Table 7-5: Runway Length Requirements by Specific Aircraft (feet)

Aircraft	ARC	Maximum Takeoff Weight (lbs)	Maximum Landing Weight (lbs)	General Aircraft Operating Requirements				Part 135 Charter Landing/ASDA Requirements
				Takeoff Distance	Accelerate to Stop Distance[1]	Landing Distance		
						(dry)	(wet)	
Multi-Engine Piston								
Piper Seneca (PA-34-200)	A-I	4,200	4,000	1,740	2,280	1,390	n/a	3,800
Piper Navajo Chieftan (PA-31-350)	B-I	7,000	6,500	3,050	-	1,800	n/a	3,000
Beechcraft Baron (G58)	B-I	5,500	5,400	2,700	3,300	2,600	n/a	5,500
Turbo-Prop								
Super King Air B200	B-II	12,500	12,500	3,000	3,700	2,800 min	n/a	6,160
Pilatus PC12	B-II	10,450	9,921	2,650	3,100	2,280	n/a	5,170
Socata TBM 850	A-I	7,394	7,024	3,170	-	2,610	n/a	4,350
Jet								
Cessna Citation Mustang (510)	B-I	8,645	8,000	>3,110	-	>2,390	>2,750	4,580
Cessna Citation I (500)	B-I	11,850	11,350	3,690	-	2,365	2,720	4,530
Cessna Citation CJ1 (525)	B-I	10,700	9,900	4,280	-	2,715	3,125	5,210
Cessna Citation CJ2	B-II	12,500	11,525	3,980	-	3,125	3,595	5,990
Beechcraft Premier 1A	B-I	12,500	11,600	>3,790	-	>3,170	>3,645	6,075

Sources: Various Aircraft Manuals – Section 5 Performance Charts, Kimley Horn and Associates, 2016
Notes: Runway length calculations are based on maximum takeoff and maximum landing weights
Assumes dry runway conditions unless otherwise noted.
[1] Not all aircraft planning manuals provided accelerate-stop distance charts

As shown in the previous table, the existing runway lengths satisfy the general operating requirements for many of the aircraft that have, or would typically be expected to operate at HWO. For those aircraft operations highlighted by red cells, a reduction in takeoff or landing weight would be needed to bring the general aircraft performance capabilities within the range of the existing runway length. For the critical design aircraft, the King Air B200, the accelerate-stop distance requirement at MTOW results in an east-west runway deficiency of 445 feet (and a north-south deficiency of 350 feet) which is

approximately the same deficiency for the Cessna Citation I based at HWO. With the current maximum runway length of 3,350 feet, the King Air B200 is limited by its accelerated stop distance to a takeoff weight of 10,500 lbs. which represents a 50 percent useful load factor (i.e. payload and fuel). The Cessna Citation I is limited to approximately 11,100 lbs. for takeoff or 85 percent of its useful load.

It should be reiterated that the majority of aircraft currently based at and operating into HWO, are piston powered single and twin engine personal, business and training type aircraft (approximately 93 percent of total annual operations). While several models of single and twin engine turbo-prop and small jet aircraft are known to operate at HWO, these are estimated to account for less than 5.5 percent of the total annual operations at the Airport. It is these types of aircraft that would typically be used by Part 135 charter operators which can include FBOs that often strive to provide those services. As indicated in the preceding table, the Part 135 requirements limit the use of HWO for direct charter activity. These limitations do not, however, affect personal or corporate owners of those types of aircraft. As is evidenced by the FBO that operates the King Air B200 based at HWO, a charter operator can be located at HWO, they just have to perform their passenger carrying charter flights from another airport that meets the Part 135 requirements.

In summary, to satisfy the general operational requirements of the design aircraft and similar aircraft within the fleet of "small" general aviation airplanes, at maximum takeoff weight, a runway length between 3,700 and 4,150 feet would be needed. While this would satisfy the calculated operational needs of most of the aircraft identified in **Table 7-5**, including the based King Air B200 and Citation I, some of the identified jet aircraft would still experience some level of operational limitation. Part 135 charter operations would also remain substantially limited.

It should be noted that BCAD staff, in collaboration with some of the major airport tenants, have identified 4,000 feet as an operationally viable runway length that would satisfy most payload needs and corporate operating rules for many of HWO's tenants and anticipated transient aircraft operators. From a FBO and aircraft owner/operator perspective, this length is perceived to be consistent with the public general aviation needs in the southern Florida market. Alternative strategies to provide additional runway length at North Perry Airport will be evaluated in subsequent sections of this report.

Declared Distances

Ideally, a runway threshold is located at the beginning of the runway. As described previously, each runway threshold at HWO is displaced from the physical end of pavement and per FAA AC 150/5300-13A *Airport Design* requires the application of both an approach RPZ and a departure RPZ. It is understood that these thresholds are displaced for a variety of reasons including:

- Providing adequate 20:1 Threshold Siting Surface clearance over various buildings, towers, poles, roadways and trees that are in close proximity to the airfield
- Maintaining compatible land use within the FAA standard RPZ

With displaced thresholds, and depending on the direction of traffic flow, the entire length of runway pavement may not available for landing or takeoff. To support enhanced operational safety for turbine powered aircraft in situations like these, "Declared Distances" can be published, per FAA AC 150/5300-13 and as concurred upon by the FAA, that identify what distances are available for takeoff, landing and rejected-takeoff aircraft performance requirements. These distances may differ from the physical pavement length in order to meet FAA safety and separation standards such as RSA, ROFA, RPZ, and Threshold Siting and Departure Surfaces. These distances are "reduced" on paper only; no physical markings are indicated on the pavement.

If Declared Distances are not published, it may be assumed that the available landing length is equal to the runway length minus amount of displacement prior to the landing threshold. Additionally, if Declared Distances are not published, it can be assumed that the full pavement at the departure end of the runway is available for takeoff requirements. The following describes the four Declared Distances:

- Takeoff Run Available (TORA) – the length of runway available and suitable for satisfying takeoff distance requirements with consideration of the departure RPZ and TODA limitations. TORA cannot exceed the length of the runway.
- Takeoff Distance Available (TODA) – the TORA plus the length of any remaining runway, or established clearway, beyond the TORA that is available for satisfying takeoff distance requirements. Consideration must be given to any 40:1 instrument departure surface requirements (this is only applicable for designated instrument departure runways, not applicable at HWO).
- Accelerate-Stop Distance Available (ASDA) – the length of runway, plus any established stopway, declared available for satisfying accelerate-stop distance requirements for a rejected takeoff. RSA and ROFA requirements beyond the end of the ASDA must be considered.
- Landing Distance Available (LDA) – the length of runway available and suitable for satisfying landing distance requirements with consideration of threshold siting criteria, the approach RPZ, and the RSA and ROFA beyond both ends of the runway.

As of early 2016, there were no Declared Distances published for HWO. If the sponsor chose to publish Declared Distances, **Table 7-6** identifies what the Declared Distances for each runway would be based on the following assumptions:

- Current displaced thresholds are accurate and will be maintained in that location for the planning horizon
- Pilots are able to begin their departure from the end of pavement (EOP)
- Approach RPZs start 200 feet from the displaced threshold per FAA design standards
- Departure RPZs are co-located with the Approach RPZs to maintain consistent compatible land use (i.e. no residential uses).
- RPZ requirements are based on an Airport Reference Code B-II “small” aircraft with approach minimums of not less than one mile and dimensions of 250 feet x 1,000 feet x 450 feet.

By co-locating the Departure RPZs with the Approach RPZS, the TORA is effectively reduced by the distance of the displaced threshold on the opposing runway end. For example, the displaced threshold for Runway 19R is 350 feet which ensures the Runway 19R Approach RPZ is not over residential property, an incompatible land use. By placing the Runway 1L Departure RPZ in the same location as the Approach RPZ to maintain compatible land use, Runway 1L’s TORA is reduced by the same 350 feet. As the Departure RPZ does not affect the TODA, the TODA would be the same length as the runway pavement, 3,350 feet.

Table 7-6: Existing Declared Distances (feet)

Runway End	Pavement Length*	Displaced Threshold*	TORA [1]	TODA	ASDA	LDA
1L	3,350	350	3,000	3,350	3,350	3,000
19R	3,350	350	3,000	3,350	3,350	3,000
1R	3,260	185	3,150	3,260	3,260	3,075
19L	3,260	110	3,075	3,260	3,260	3,150
10L	3,240	181	3,180	3,240	3,240	3,059
28R	3,240	60	3,060	3,240	3,240	3,180
10R	3,255	255	3,045	3,255	3,255	3,000
28L	3,255	210	3,000	3,255	3,255	3,045

Sources: FAA AC 150/5300-13A *Airport Design*, Kimley-Horn and Associates Prepared: December 2015

* FAA Airports/Facility Directory, 10 Dec 2015 to 04 Feb 2016

Notes: [1] Approach and Departure RPZs are collocated, Departure RPZ controls TORA

Runway Width

The FAA design standards for runway width are described in FAA AC 150/5300-13A, *Airport Design* and are based on Runway Design Codes (RDC). For the North Perry RDCs identified in **Table 7-3** (i.e. B-II "small" aircraft with approach minimums of not less than one mile) the runway width standard is 75 feet. HWO meets this requirement as all four runways are 100 feet wide. While the existing runways are wider than the standard, this extra width does provide an added margin of safety for pilots, especially for the number of student pilots as well as low-time pilots, that may not yet be as proficient in their takeoff and landing skills. As there is a high level of training activity at HWO, this extra width provides added value to the flying public and users of the Airport. Based on guidance contained in AC 150/5300-13A, Appendix 2 "Wind Analysis", the 25 feet of extra pavement effectively provides additional crosswind tolerance. For these reasons, it is recommended that the 100-foot wide runways be maintained. It should also be noted that based on FAA standards, 100-foot wide runways can also support A/B-III aircraft or B-II aircraft with instrument minimums of less than ¾ mile (assuming all other standards and NAVAID requirements are met and they do not exceed the runway strength limit).

Runway Lighting, Marking and Visual NAVAIDs

Airports utilize a wide array of visual information systems to guide pilots while operating on the runways and maneuvering about the airfield. Appropriate runway lighting, pavement markings, and visual NAVAIDs can enhance operational safety in all weather conditions, especially during nighttime and low visibility conditions. Federal and state standards for airport marking and lighting are contained in FAA AC 150/5340-1L, *Standards for Airfield Markings* and Florida Administrative Code (FAC) Rule 14-60.007 *Airfield Standards for Licensed Airports.*[15]

Runways 1L-19R and 10R-28L are equipped with Medium Intensity Runway Lights (MIRLs), Runway End Identifier Lights (REILs), and Precision Approach Path Indicators (PAPIs) for both runway ends. Runways 1R-19L and 10L-28R have PAPIs on both runway ends, but no edge lights or REILs. FAA guidance

[15] Florida Administrative Code, www.flrules.org, accessed 6-13-16

requires runway edge lighting for non-precision runways if night instrument approach minima are to be established. An approach lighting system is recommended to support visibility minimums as low as ¾ mile and is required for minimums less than ¾ mile. HWO currently has a night-time straight-in instrument approaches from the west to Runway 10R and a straight-in instrument procedure to Runway 28R. These approaches can be used to facilitate a circle-to-land operation on all other runway ends as long as a visual fix has been achieved. For the existing instrument approach procedure on Runway 28R to be available for straight-in nighttime operations from the east, the installation of a LIRL or MIRL edge lighting system would be needed. As weather conditions favor approaches from the east, especially during IFR conditions, the lighting of Runway 10L-28R and installation of REILs on the 28R end should be programmed to improve overall utility of the airfield. While the other east-west runway already has edge lighting, it is understood that development of instrument approaches to Runway 28L is hindered by obstacles associated with off-airport structures east of the airfield – thus the eastern instrument approach was directed to Runway 28R. With the exception of Runway ends 28R and 10R, which have non-precision markings, all runway ends have basic markings indicating they support visual approaches only. According to the last FAA airfield inspection,[16] all of the markings are in good conditions and considered adequate at this time. Ongoing maintenance and upkeep will be needed throughout the planning horizon to keep these systems operating efficiently.

Pavement Strength and Condition

As described in **Sections 3.6** and **4.2**, the latest *Pavement Evaluation Report* for North Perry Airport (FDOT, June 2015) indicates that all four runways have a load bearing strength of 17,000 lbs. for a single-wheel landing gear configuration and are considered to be in "good" condition. As Airport operations are limited by Broward County ordinance to aircraft of 12,500 lbs. or less, the pavement strength is adequate for both current and anticipated operations. Based on the 2015 pavement conditions, and with ongoing scheduled maintenance, no major runway rehabilitation needs are anticipated throughout the planning horizon. Any new or extended runway pavements should be designed in accordance with the most current FAA guidance and industry practices to accommodate the critical design aircraft and also to a width consistent with that of the affiliated runway that any improvement is associated with.

Runway Safety Area and Object Free Area

Compared to the previous 2009 Master Plan and ALP, the Airport Reference Code (ARC) and RDC of the runways at HWO have changed from B-I "small" to B-II "small". Commensurately, the Runway Safety Area (RSA) standard will increase from 120 feet in width to 150 feet, and from 240 feet beyond the runway end to 300 feet. The Runway Object Free Area (ROFA) standard will also increase from 240 feet beyond the runway end to 300 feet, and from a width of 250 feet to 500 feet. There is ample space surrounding the runway system to meet these standards. The larger ROFAs are free of obstacles and due to the flat terrain, the RSA's appear to meet grade requirements. However, during any future runway pavement or lighting improvements, further evaluation of RSA compaction requirements may be needed.

Runway Separation

To ensure adequate distance is maintained between moving aircraft, the FAA has established separation standards between the runway and various components of an airfield. Like the RSAs and ROFAs, some of these standards (e.g. runway to taxiway and runway to aircraft parking) have increased

[16] FAA Airport 5010 Master Records, Inspection date 5/6/15, www.gcr1.com/5010web/ , accessed 6-4-16

commensurate with the change in ARC from B-I "small" to B-II "small". The current standards for a B-II "small" aircraft at HWO are shown in **Table 7-7**.

Table 7-7: Runway Separation Standards

Runway Centerline to:	B-I Small (feet)	B-II Small (feet)	B-II Small Standards Met
Parallel Runway Centerline (for simultaneous approaches)	VFR – 700 IFR – 5,000	VFR – 700 IFR – 5,000	VFR – Yes IFR - No
Holding Position	125	125	Yes
Parallel Taxiway/Taxilane Centerline	150	240	No[17]
Aircraft Parking Area	125	250	Yes

Sources: FAA AC 150/5300-13A *Airport Design* Prepared: Sept. 2016

With over 1,400 feet of separation between parallel runways, HWO meets the standard for aircraft to simultaneously approach parallel runways during VFR conditions. This separation distance does not, however, allow for simultaneous approaches during IFR conditions nor simultaneous departures during either VFR or IFR conditions.

The holding position, or hold lines, ensure aircraft on the adjacent taxiways are the proper distance from the runway centerline. HWO meets the standard with 125 feet hold lines. The aircraft parking areas are all more than 300 feet from runway centerlines, which exceeds the B-II "small" standard of 250 feet.

The standard separation between a runway centerline and the parallel taxiway centerline is 240 feet for B-II "small" aircraft; it was 225 for the previous B-I "small" aircraft classification. This separation standard is not met between the following parallel runway-taxiway combinations at HWO and should be addressed during future pavement rehabilitation projects or in the case of the proposed alignment of future Taxiway A, at the time of its construction:

- Taxiway B to Runway 1L-19R – 225 feet; 15 feet deficiency
- Taxiway D to Runway 1R-19L – 225 feet; 15 feet deficiency
- Taxiway N to Runway 10L-28R – 225 feet; 15 feet deficiency
- Taxiway L to Runway 10R-28L – 225 feet; 15 feet deficiency
- Taxiway A to Runway 1L-19R – Construct to a 240-foot separation

7.4 Taxiway Analysis

The configuration of the taxiway system influences how safely and efficiently aircraft are able to move between the various functional areas of an airport. Like the runway system, the FAA has developed design standards to guide the development of taxiway facilities. The following evaluates the physical and operational characteristics of the taxiway system at HWO.

Taxiway Geometry

FAA principles on taxiway geometry and design have been evolving. In 2007, the FAA issued Engineering Brief No. 75 "Incorporation of Runway Incursion Prevention into Taxiway and Apron Design." This led to AC 150/5300-13 Airport Design being updated in 2011, as Change 18, which included numerous

[17] Taxiways B,D,N and L maintain a separation of 225 feet

revisions to taxiway geometry and runway/taxiway interface concepts. That AC was subsequently further updated to the current 150/5300-13A (Change one) version in 2014 with refined guidance and an increased focus on mitigating runway incursions. Additionally, three airfield Hot Spots or areas where incidents have occurred or where the likelihood of an incident is considered to be high are designated on the existing airfield at HWO.

Comparison of the existing taxiway configuration at HWO to the current FAA geometric guidance and the location of the designated Hot Spots highlights several airfield intersections that are of concern. The following describes the current guidance and areas of concern, which are also identified in **Figure 7-1**. Where appropriate, mitigation recommendations are provided. For issue areas that may have multiple resolutions or are more complex in nature, an evaluation of alternative mitigation strategies or pavement re-configurations is provided in **Section 8** of this report.

- Three-Node Concept: Keep the geometry simple and reduce the number of taxiways intersecting at a single location. Present the pilot with no more than three choices in direction – ideally left, right and straight ahead.

  The intersection between Taxiways J, M and M3 results in five nodes which introduces more opportunity for pilot confusion and miscommunication. This is exacerbated by non-standard intersection angles, an acute angled exit from Runway 10R, and a wide expanse of pavement. It should also be noted that the 2015 *Pavement Evaluation Report* indicates that Taxiway J is in "very poor" condition. To simplify this intersection and maintain north-south cross-field traffic between Taxiways N and M, it is recommended that:

  - Taxiway J be replaced with a perpendicular cross-field taxiway located slightly east of the existing intersection,
  - Taxiways M3 and L3 be reconfigured as 90-degree exit taxiways, and
  - The angled exit from Runway 10R (which is a section of Taxiway J) be removed.

- Intersection Angles: Design 90 degree turns wherever possible – they provide the best visibility to the left and right for a pilot. In other situations, and where necessary, standard angles of 30, 45, 60 and degrees are preferred. Acute angled taxiway exits enhance runway utilization but should not be used as runway entrance or crossing points. A right angled turn at the end of a parallel taxiway is a clear indication of approaching a runway. Non-standard angles are found at numerous intersections including:

  - Taxiway B and B1. This area is exacerbated by an acute angled exit from Runway 1L and a wide expanse of pavement entering the North Apron. It is recommended that the acute angled exit be replaced by a standard 90-degree exit taxiway and the wide apron connector be reduced to standard width.
  - Taxiway B and R. Taxiway R is an original piece of the Airport's "wagon wheel" configuration which also provides an acute angled exit from Runway 19R. Taxiway R is characterized by a wide expanse of pavement to provide south turns from Taxiway R on to Taxiway B. ATC tower and BCAD staff have indicated that the hold apron along Taxiway R is not regularly utilized. The 2015 Pavement Evaluation Report indicates that Taxiway R is in "fair" condition but is at the point where significant repair action is needed. It is recommended that Taxiway R and the unused hold apron be removed. It is further recommended that angled exit from Runway 19R be replaced by a standard 90-degree exit.

- Taxiway R and M1. This taxiway intersection is at a runway crossing point that also functions as an acute angled exit from Runway 28L. As described previously, it is recommended that Taxiway R be removed which would remedy this situation and allow Taxiway M1 to remain in place as a standard 90-degree exit with no loss of exit capacity.
- Taxiway L at L1, D, E, L2, and L3. These five connectors provide access from the South Apron and the FBO Apron to Taxiway L. They are all at non-standard angles and all continue past Taxiway L providing direct access to Runway 10R-28L. It is recommended that these five connectors be replaced with three 90-degree connectors that are offset from any continuation directly to the runway.
- Taxiway J and M3. Taxiway M3 intersects with both Taxiway J and Runway 10R-19L at non-standard angles. As described previously it is recommended that Taxiway J be removed and that Taxiways M3, and its continuation on to L3, be reconfigured as a standard 90-degree exit.
- Taxiway J and N. This intersection is at a non-standard angle crossing Taxiway J and the magnetic compass rose which continues on to the non-standard angled entrance to the Runway 28R threshold. The previously recommended replacement of Taxiway J with a perpendicular (i.e. 90-degree) cross-field taxiway, along with developing a standard 90-degree entrance/exit to Runway 28R, would mitigate this area of concern. The addition of a hold apron and preservation of the compass rose is also recommended.
- Extension of Taxiway L beyond the Runway 28L EOP. This taxiway provides access from the southeast T-hangar complex to Taxiway L and the entrance/exit to Runway 28L. It is at a non-standard angle and non-standard width that contributes to a wide expanse of pavement in this location. This area of concern is further complicated by the connector to the South Apron which provide direct access to Runway 28L through an extra-wide runway entrance/exit. It is recommended that the South Apron connector be relocated to the west and the wide entrance to Runway 28L be reconfigured as a standard entrance/exit. While this would simplify the entire intersection, the Taxiway L extension would still be a non-standard configuration as a function of its location relative to the Runway 28 entrance. Alternatively, access to Taxiway L from the southeast T-hangar area could be routed through the South Apron to the relocated connector but this would place traffic on an already very active apron.

- Wide Expanses of Pavement: Wide pavements, should be avoided as they require placement of signs far from a pilot's eye and reduce the conspicuity of other visual clues. Under low visibility conditions, or due to a pilot focus on the centerline, signs can more easily be missed. This is especially critical at runway entrance points. Where wide expanses of pavement are unavoidable, such as a crossover taxiway providing a 180 degree onto a parallel taxiway, avoid direct access to a runway.

  The entrance/exit taxiways to Runways 10R, 28L, 28R, 1L, 19R and 19L are approximately 100 feet wide. With a 240-foot runway to taxiway separation for B-II aircraft, the standard entrance/exit taxiway would be approximately 44 feet wide expanding to approximately 60 feet to accommodate turning fillets. This results in over 40 feet of excess pavement. It is understood that pilots were using these extra-wide entrances to by-pass holding aircraft. These entrances do not provide sufficient space nor were they marked for such maneuvers. There is evidence on the field that taxiway centerline markings were shifted to the center of the

pavement to mitigate pilots "squeezing by" another aircraft. This re-marking however, led to non-standard intersections angles and the wide expanses of pavement still remain. At each of these runway ends, it is recommended that the excess pavement be removed and standard width entrance/exit taxiways be developed. Additionally, to provide by-pass capability it is recommended that either hold aprons or properly spaced by-pass taxiways (with grass islands between them) be provided. Potential configurations of hold aprons and by-pass taxiways will be evaluated in **Section 8** of this report. The previously recommended removal of Taxiways J and R, and the reconfiguration of Taxiway B1 would mitigate the other intersections with wide expanses of pavement. This will enhance situational awareness by helping pilots maintain proper alignment on the taxiway centerlines and providing better cockpit views of signage, lighting and other aircraft traffic.

- Runway Crossings: Limiting the number of runway crossings reduces the potential for human error and aircraft incident and reduces workload for both pilots and ATC control.

  With dual intersecting runways and aviation facilities in all quadrants of the airfield, runway crossings at HWO are unavoidable. Many of the existing crossings are continuations of parallel taxiways that provide the most direct access to the various runway ends, such as is the case with both Hot Spot 1 and 3 and to a lesser extent Hot Spot 3. The ATC tower is operational from 7:00am to 9:00pm (local time) and during that time ground circulation is under ATC control. The extensive taxiway system provides both ATC and pilots with numerous options for circulating aircraft about the airfield. When winds distinctly favor operations in the north-south or east-west direction, only one set of parallel runways would be operational thereby lessening the concern of crossing the non-operational runways. It is during times of calm wind or when the ATC tower is closed that the uncontrolled crossing of runways becomes more of a concern. Considering that HWO supports a large amount of flight training operations for student and low-time pilots, there is a heightened potential for inadvertently crossing an active runway such as indicated by Hot Spot 1 and Hot Spot 3. It should be noted that runway guard lights (i.e. "wig-wags" which are flashing yellow warning lights) were installed at the intersection of Taxiways E and L to minimize the potential for inadvertent runway crossings of Runway 1R/19L in this area. Reconfiguration of the exit from the South Apron to Taxiway L nearest to Taxiway E will also significantly mitigate issues triggering the designation of this area as Hot Spot 3 on the airport

  In combination with the mitigation of "High Energy Intersections" (see below), shifting the location of some of these crossings would introduce taxiway turning movements, thereby increasing pilot interaction/situational awareness and reducing the potential for taxiing past a hold marking and crossing a runway without clearance. The tradeoff, however, is some level of increase in taxi times along certain routes.

- Taxiway Crossings in the Center Third, or "High Energy" Section of a Runway: These are taxiway intersections that cross the middle third of a runway. Runway intersections/crossings should be limited to the outer third of runways where pilots have more options to maneuver and avoid potential collisions.

  There are high energy intersections on each of the four runways at HWO. These are formed by the parallel Taxiways P, N, D, E and A. Hot Spot 1 is associated with the runway crossings of Taxiways D and P. As described previously, removing or relocating these intersections will decrease the potential for inadvertent runway crossings but increase taxi times along some routes. As this is a fairly complex issue, potential mitigation alternatives will be evaluated in **Section 8** of this report.

- Direct Runway Access: Taxiways should not lead directly from an apron to a runway without requiring a turn. These situations can lead to confusion where a pilot would be expecting to encounter a parallel taxiway but inadvertently enters a runway.

  Taxiways B1, D, E, L1, L2, L3, P2 and the taxiway to the County Mosquito Control facility all provide direct access from an aircraft parking apron to a runway. In conjunction with remedying the non-standards angles described previously, relocating and realigning these apron connectors will introduce turns onto the parallel taxiways prior to entering a runway, thereby increasing pilot situational awareness and decreasing the potential for runway incursion.

- Aligned Taxiways: Entrance taxiways whose centerlines coincide with (i.e. directly aligned with) a runway's centerline are essentially "prohibited" by the FAA. These situations have often occurred when a runway end has been relocated without the construction of a new entrance taxiway. This places taxing aircraft in direct line with aircraft that are landing or taking off. The FAA recommends that existing aligned taxiways be removed.

  The intersection of Runways 1L and 10R, in conjunction with the displaced thresholds and non-standard entrance of Taxiway L to Runway 1L, have created aligned taxiways to both runway ends. As described previously, the potential for confusion and miscommunication between pilots and ATC is exacerbated by the radio nomenclature for "Runway 0 1 Left" and "Runway 1 0 Right". The FAA has designated this area as Hot Spot 1 and ATC tower staff has indicated this as their greatest area of operational concern. There are several potential mitigation alternatives for this area of concern which will be evaluated in **Section 8** of this report.

- Dual-Use Pavements: Runways used as taxiways, or taxiways used as runways, can lead to confusion. A runway should always be clearly identified as a runway and only a runway.

  For HWO, the Aligned Taxiways at the intersection of Runways 1L and 10R are also considered dual-use pavements. This could lead to pilots utilizing the wrong runway end or continuing to taxi along a runway thinking it is a taxiway.

- High-Speed Exit Taxiways: Exit taxiways that form an acute angle with the runway centerline (typically 30 degrees) are commonly referred to as high-speed exit taxiways. Their purpose is to enhance airport capacity by allowing aircraft exiting the runway to continue onto the parallel taxiway more rapidly than if a 90-degree exit were provided. This, in turn, clears the runway for another operation sooner. The high-speed taxiways should only be used as an exit from a runway, not as an entrance, and not as a runway crossing point. These exit taxiways should also not provide access directly to another runway. According to FAA guidance, high-speed exits are typically only utilized at airport that support aircraft in approach categories C and above (i.e. 121 knots and above).

  Taxiways B1, R, and J are part of the airport's original "wagon wheel" circular taxiway that now effectively provides two acute-angled or high-speed exits for Runway 10R-28L and two for Runway 1l-19R. These are currently the two main lighted runways at HWO. Complicating matters is that Taxiway B1 provides direct access to the North Apron, Taxiway R intersects with the runway at M1, and Taxiway J intersects with M and M3. While these exits do provide some level of enhanced throughput capacity for the runways, due to the compounding geometry concerns and the aged pavement conditions, it is recommended that these high-speed exits be removed or reconfigured as standard 90-degree exit taxiways.

Figure 7-1: Taxiway Geometry Concerns at HWO

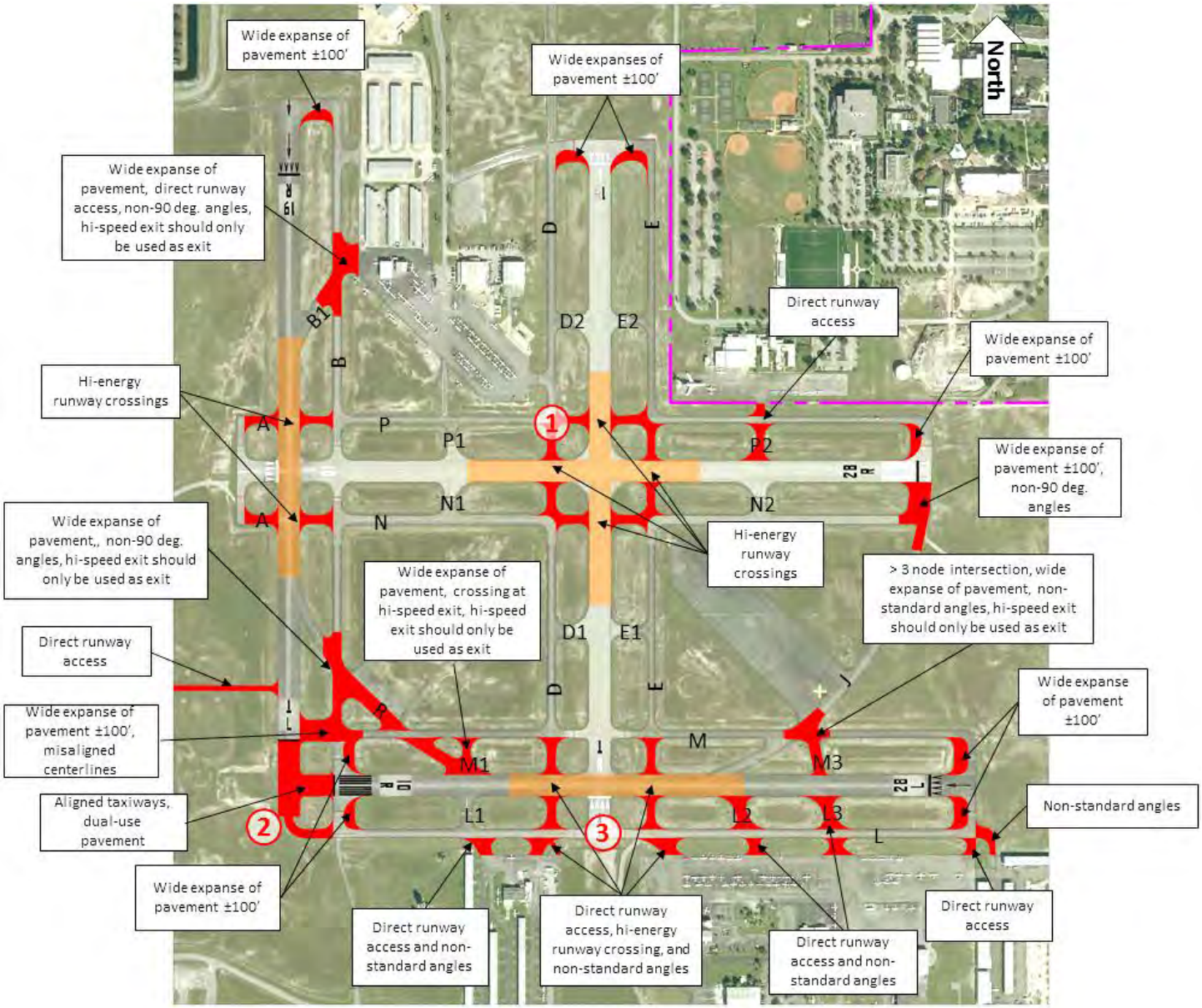

Image Source: BCAD, 2015 Aerial

Prepared: Kimley-Horn, 2016

Taxiway Dimensions and Separation Standards

Similar to runway design standards, FAA AC 150/5300-13A identifies dimensional standards for taxiways and taxiway-related separations that are intended to provide adequate operational clearance between aircraft and other fixed or moveable objects. These standards are based on both the ADG and the TDG

of the aircraft intended to use the facilities. The design aircraft of HWO, the King Air B200, is ADG II and TDG 2. Based on the characteristics and design standards discussed in **Section 4.3** and shown in **Table 7-8**, the Airport meets the B-II taxiway design standards including TSA, TOFA, separation, pavement width, and centerline turn radius. Parallel Taxiways B, D, L, N and Taxiways R and J are all greater than the 35-foot standard. Consistent with the benefit of the additional runway width described previously, the extra taxiway width provides an added margin of safety for pilots, especially student and low-time pilots that may not yet be proficient in their taxiing skills. As there is a high level of training activity at HWO, this extra width provides value to the users of the Airport. For the lighted taxiways, this also provides less opportunity for aircraft to damage the edge lighting fixtures. The 2015 *Pavement Evaluation Report* indicates that the parallel taxiways are in "good" condition and will not require substantial repair for several years to come. Based on these items, it is recommended that the extra pavement be maintained until such time as funding decisions for major rehabilitation warrant a reevaluation of maintaining the existing width. The replacement of Taxiway J and future development of Taxiway A however, should be designed to a minimum of the 35-foot standard.

Table 7-8: Taxiway Design Standards

FAA Design Standard (in feet) For ADG II and TDG 2	
Taxiway Safety Area (TSA)	79
Taxiway Object Free Area (TOFA)	131
Taxiway Wingtip Clearance	26
Taxiway Width	35
Taxiway Edge Safety Margin	7.5
Taxiway Shoulder Width	15
Taxiway Centerline to Parallel Taxiway/Taxilane Centerline	105
Taxiway Centerline to Fixed or Moveable Object	65.5
Taxiway Centerline Turn Radius	75

Source: FAA AC 150/5300.13A *Airport Design*

One area of the airfield that warranted a little extra evaluation was the separation distance between the South Apron connector and the adjacent taxiway/taxilane near the Runway 28L end as shown in **Figure 7-2**. The separation distance is approximately 96 feet between centerlines. The taxiway-to-taxiway standard is 105 feet. The taxilane-to-taxilane standard is 97 feet. Assuming the T-hangars being supported by the eastern taxiway/taxilane have a maximum hangar door width of 46 feet, application of the FAA wingtip clearance standard (i.e. 26 feet) between an ADG II taxiway and an ADG I taxiway would result in a required centerline separation distance of 88.5 feet. As discussed previously, it was recommended that this apron connector be shifted westward so as not to provide direct access from the South Apron to Runway 10R-28L. With this in mind, the relocation of the connector would eliminate any concern of separation between these two taxiways. In the interim, the existing 96 feet appears suitable to accommodate the aircraft operating in these two aircraft storage areas.

Figure 7-2: Taxiway J Centerline Separation

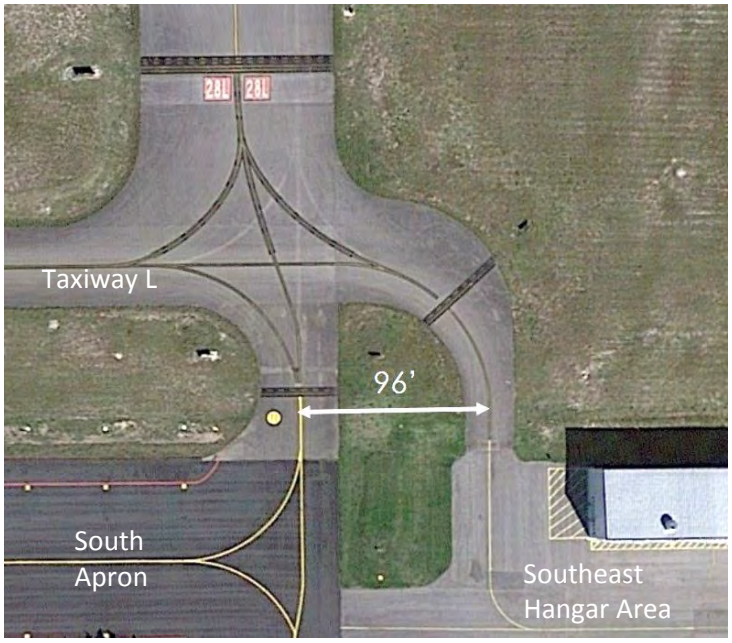

Image Source: Google Earth, 2016

As described previously, Taxiways B, D, L, and N do not meet the runway-to-taxiway centerline separation standard by 15 feet. Shifting the taxiway centerlines further away from the runways will also cause a shift in the associated TSAs and TOFAs. With a 15-foot shift in the taxiway centerline, plus half of the standard TOFA distance, the new TOFA would extend 80.5 feet from existing taxiway centerline. Select objects for the relocated Taxiways B and D would be within the TOFA, as shown in **Figure 7-3**. The one grass tie-down east of Taxiway B would need to be relocated. Pavement surrounding the aircraft fueling facility west of Taxiway D could remain, however care should be exercised to ensure that other equipment does not remain stored within the limits of the TOFA.

Figure 7-3: Taxiways B and D

Image Source: Google Earth, 2016

Taxiway Lighting

Taxiway edge lights illuminate taxi routes and define the lateral limits of taxiway pavement. For airports to operate effectively during nighttime and low visibility conditions, taxiway edge lighting is recommended – particularly for runways that provide nighttime instrument approaches. According to the FAA Order 5100.38D *Airport Improvement Program Handbook*, federal funding for taxiway lighting is only eligible if the taxiway is associated with a lighted runway. The majority of taxiways at HWO are lighted with the recommended Medium-Intensity Taxiway Lights (MITLs). These lighted taxiways provide circulation to all currently developed areas of the Airport. Taxiways A, N, N1, N2, and J are not lighted and only the southern portion of Taxiway E is lighted.

As there are alternate lighted taxi routes, Taxiway N and the replacement to Taxiway J are not essential to have edge lighting. During any new or rehabilitated taxiway design, consideration should be given to at least installing the light bases and conduits if lighting may be desired in the future. Lighting of the northern portion of Taxiway E is also not a priority as Runway 1R-19L is currently unlit and the airport property boundary east of the taxiway precludes aeronautical development in this area. If the instrument approach to Runway 28R is upgraded to support nighttime operations, lighting of Taxiway N (particularly the western half) is recommended.

7.5 Summary of Airfield Facility Requirements

With the change in critical design aircraft from the King Air F90 (B-I) to the King Air B200 (B-II) there are several FAA design standards that require improvements to the airfield facilities at HWO. Current FAA guidance also indicates there are several airfield geometric improvements that would enhance operational safety and minimize the potential runway incursion. The preceding analyses identified several of the improvements needed to meet those standards and accommodate the current and anticipated levels of aviation activity and use needs. The following summarizes these recommendations.

- Runway Length – extend one of the east-west runways to provide operational lengths of 3,700 feet to 4,150 feet. Alternatives to achieve this will be evaluated in **Section 8** of this report.
- Runway to Taxiway Separation – shift parallel Taxiways B, D, L and N further from the runway centerline by 15 feet to meet B-II aircraft standards.
- Pursue the installation of edge lighting on Runway 10L-28R and the establishment of instrument night minimums to Runway 28. The lighting of Taxiways A, N, N1 and N2 may also be warranted at that time.
- Preserve the ability to develop a full-parallel Taxiway A to the west of Runway 1L-19R with a separation distance of 240 feet from the runway. This improvement has been depicted on the FAA approved ALP since at least the 1996 version. It has not yet been implemented as there has not been sufficient west side aeronautical development that would require it. Since banner towing operations occur in the turf areas to the northwest of the Runway 10L threshold, the southern portion of Taxiway A could be constructed first without impacting the banner operation. Future development in the northwest quadrant of the Airport, and completion of the northern portion of Taxiway A, would require moving or modification of banner towing operations.
- Taxiway Geometry – to simplify the overall configuration, enhance pilot's situational awareness and reduce the potential for runway incursion:
  - Reconfigure the intersection between Runways 1L and 10R and eliminate the aligned taxiways and dual-use pavement. There are several potential mitigation alternatives for this area of concern which are evaluated in **Section 8** of this report.
  - Replace Taxiway J with a perpendicular cross-field taxiway located slightly east of the existing intersection.
  - Reconfigure Taxiways M3 and L3 as 90-degree exit taxiways.
  - Remove the angled exit from Runway 10R (which is a section of Taxiway J).
  - Reconfigure Taxiway B1 from an acute-angle to a standard 90-degree exit taxiway; separate it from the associated apron connector, and reduce the width of the connector to a standard configuration.
  - Remove Taxiway R and the associated hold apron, replace the angled exit from Runway 19R with a standard 90-degree exit.
  - Remove two of the five apron connectors south of Taxiway L (i.e. L1, D, E, L2, L3) and reconfigure the remaining three as standard 90-degree connectors that are offset from any continuation directly to the runway.
  - Reconfigure Taxiway L2 north of Taxiway L as a standard 90-degree exit taxiway.
  - Reconfigure Taxiways L3 and M3, north of Taxiway L, as standard 90-degree exit taxiways and maintain offset from the replacement Taxiway J.
  - Reconfigure the entrance taxiway between Taxiway N and the Runway 28R EOP as a standard 90-degree entrance/exit, add a hold apron and relocate the compass rose.
  - Reduce the wide expanses of pavement at the entrance/exit taxiways to Runways 10R, 28L, 1L, 19R and 19L and provide either a by-pass taxiway with adequate group II aircraft separation or a hold apron. Potential configurations of hold aprons and by-pass taxiways will be evaluated in **Section 8** of this report apron.

- Reduce, reconfigure, relocate or enhance the runway crossings in the high-energy (i.e. middle third) section of the runways. Potential mitigation alternatives will be evaluated in **Section 8** of this report.
- Relocate Taxiway P2 and reconfigure the taxiway to the County Mosquito Control facility to eliminate direct apron-to-runway access.