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## **Appendix D – Runway Protection Zone Analysis**

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# FAA GREAT LAKES REGION RUNWAY PROTECTION ZONE – ALTERNATIVE ANALYSIS

**Instructions:** Prior to completing this form, the RO/ADO staff must work with the Airport Sponsor to identify and document the full range of alternatives that could:

- 1) Avoid introducing the land use issue within the RPZ
- 2) Minimize the impact of the land use in the RPZ (i.e. routing a new roadway through the controlled activity area, move farther away from the runway end, etc.)
- 3) Mitigate risk to people and property on the ground (i.e. tunneling, depressing and/or protecting a roadway through the RPZ, implement operational measure to mitigate any risks, etc.)

<b>BACKGROUND</b>		
<b>1. AIRPORT:</b>  Ann Arbor Municipal Airport	<b>2. LOCATION (CITY, STATE):</b>  Ann Arbor, Michigan	<b>3. LOC ID:</b>  KARB
<b>4. EFFECTED RUNWAY:</b>  Runway 6/24	<b>5. APPROACH RPZ DIMENSION:</b> Runway 6 and Runway 24: LENGTH: 1,000 ft. INNER WIDTH: 500 ft. OUTER WIDTH: 700 ft. ACRES: 13.770 acres	<b>6. DEPARTURE RPZ DIMENSION:</b> Runway 6 and Runway 24: LENGTH: 1,000 ft. INNER WIDTH: 500 ft. OUTER WIDTH: 700 ft. ACRES: 13.770 acres
<b>7. DESIGN AIRCRAFT OF RUNWAY:</b>  FAA Traffic Flow Management System Counts data indicate that an Airport Reference Code (ARC) family grouping of turboprop B-II aircraft types are the most demanding classification that currently conduct greater than 500 annual operations at ARB.		
<b>8. DATE OF LATEST FAA SIGNED ALP:</b>  The last ALP for Ann Arbor Municipal Airport signed by the Michigan Aeronautics Commission was dated October 6, 2008.		
<b>9. TRIGGERING EVENT (i.e. what event caused the new or modified land use in the RPZ)</b>		
<input checked="" type="checkbox"/>	An airfield project (e.g. runway extension, runway shift)	
<input type="checkbox"/>	A change in the critical design aircraft which increases the RPZ dimensions	
<input type="checkbox"/>	A new or revised instrument approach procedure that increases the RPZ dimensions	
<input type="checkbox"/>	A local development proposal in the RPZ (either new or reconfigured)	
<input type="checkbox"/>	Other (please describe):	
<b>10. SELECT TYPE OF INCOMPATABLE LAND USE IN RPZ:</b>		
<input type="checkbox"/>	Buildings and structures (Examples include, but are not limited to: residences, schools, churches, hospitals or other medical care facilities, commercial/industrial buildings, etc.)	
<input type="checkbox"/>	Recreational land use (Examples include, but are not limited to: golf courses, sports fields, amusement parks, other places of public assembly, etc.)	
<input checked="" type="checkbox"/>	Transportation Facilities. (Examples include, but are not limited to: rail facilities (light or heavy, passenger or freight), public roads/highways, vehicular parking facilities)	
<input type="checkbox"/>	Fuel storage facilities (above and below ground)	
<input type="checkbox"/>	Hazardous material storage (above and below ground)	
<input type="checkbox"/>	Wastewater treatment facilities	
<input type="checkbox"/>	Above-ground utility infrastructure (i.e. electrical substations), including any type of solar panel installations.	
Does the Airport Sponsor own or control the area where the above incompatible land uses are located? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		

## ALTERNATIVES ANALYSIS

### 11. PROVIDE A DESCRIPTION OF EACH ALTERNATIVE INCLUDING A NARRATIVE DISCUSSION AND EXHIBITS OR FIGURES DEPICTING THE ALTERNATIVE:

The Ann Arbor Municipal Airport (ARB) is undergoing an effort to extend its primary runway, Runway 6/24, to meet the takeoff and landing distance requirements of the airport's critical aircraft that have increased in operations at ARB in recent years. The current configuration of the airport is shown in **Figure A**. Development options have been evaluated to define the recommended plan to provide additional length on Runway 6/24. The extension of Runway 6/24 also presents ARB with the opportunity to address HS 1, as shown on **Figure A**. HS 1 is an airport surface hot spot because hangars block the view from the airport traffic control tower (ATCT) to the intersection of Taxiway A and Taxiway A1. The proposed project is also a chance to correct the nonstandard designs of Taxiway A1 and Taxiway D, both of which offer direct access to the runway from their respective aprons.

FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*, was used to determine the runway length needed for the family grouping of B-II turboprop aircraft operating at ARB. Application of this AC found that 4,225 feet of runway length is needed to meet the runway length needs of B-II turboprop aircraft types; however, constraints surrounding ARB limit options to provide additional runway length. These constraints not only limit the ability to extend the runway but also opportunities to change its orientation within the footprint of the existing property boundary to provide the needed length. **Figure B** illustrates the constraints surrounding ARB.

The location of State Street and its intersection with Airport Drive are limiting factors at the end of Runway 24. The proximity of Ellsworth Road to the north and the location of businesses and the Pittsfield Township community center adjacent to this intersection create constraints. Options are limited to reroute State Street so that the runway could be extended in this direction. In addition, there is the potential for wetland impacts located off the end of Runway 24 east of State Street.

Hangars located north of Taxiway A limit the visibility from the ATCT to the intersection of Taxiway A1 and Taxiway A. An extension of the runway at the end of Runway 24 would not address the obstructed view from the ATCT. Any runway extension at the approach end of Runway 24 is not recommended due to these visibility concerns that could reduce safety.

While area is available at the end of Runway 6 for a runway extension, surrounding constraints limit how long of a length could be obtained. Primarily, Lohr Road to the west and the adjacent Stonebridge neighborhood limit how far the runway can be extended due to runway design surfaces and approach slope height clearance requirements.

This Runway Protection Zones (RPZ) analysis looks at six development options for lengthening Runway 6/24 and compares them to ARB's existing conditions (referred to as the No Build Alternative). This analysis assesses the effects that each alternative has on the RPZ at each runway end, as well as how well each alternative addresses HS 1.

The alternatives were evaluated for feasibility in terms of cost, constructability, and other factors. Exhibits depicting each build alternative are used as appropriate. Existing runway and taxiway configurations and designations are found on **Figure A**. The alternatives evaluated in this report are as follows.

#### No Build Alternative (3,505-foot Runway)

The No Build Alternative describes the existing conditions at ARB. Under this alternative, ARB would maintain its 3,505-foot runway in its current configuration. RPZs at both runway ends would remain in their current locations. This alternative is being documented to evaluate what would happen if no changes occurred to the existing length of Runway 6/24 to meet the demand of the family grouping of B-II turboprop aircraft types. No changes would occur to existing airside or landside infrastructure. This alternative is not a feasible option because it does not provide the runway length that is needed for the family grouping of B-II turboprop aircraft types operating at ARB.

#### Alternative #1: Extend 720 Feet at the Approach End of Runway 24 (4,225-foot Runway)

This alternative, shown in **Figure C**, involves constructing a 720-foot runway and taxiway additions at the approach end of Runway 24, resulting in a runway of 4,225 feet in length. Taxiway A would also be extended and Taxiway A1 would be shifted to the new Runway 24 threshold, which would eliminate direct access from the apron to the runway. Taxiway D would be realigned so that it has a standard 90-degree intersection with the runway and no direct access from the apron. Excess taxiway pavement associated with Taxiway D would be removed. No other changes to existing airfield infrastructure would occur.

With this proposed development action, State Street would need to be relocated around the Runway Safety Area (RSA) and Runway Object Free Area (ROFA), requiring that the existing roadbed of State Street, through these areas, be closed and removed. Two options for a relocated State Street are presented in **Figure C**. Control of land uses either through acquisition of property or an aviation easement would be needed for a portion of land not within the existing property boundary or within the relocated RPZ at the approach end of Runway 6/24.

#### Alternative #2: Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6 (4,225-foot Runway)

This alternative, shown in **Figure D**, involves extending Runway 6/24 by 720 feet at the approach end of Runway 6 to provide 4,225 feet of usable runway length. This alternative also proposes shifting Runway 6/24 150 feet to the southwest. An additional 150 feet of runway length would be constructed at the southwest end of Runway 6 and 150 feet of existing pavement would be removed at the Runway 24 end. The runway shift would provide clear visibility and line-of-sight for the ATCT to the relocated intersection of Taxiway A and connector Taxiway A1.

Taxiway D would also be relocated 150 feet to the southwest and changed so that the taxiway would intersect Runway 6/24 at a right angle. Unneeded pavement of existing Taxiway A1 and the 150 feet of existing runway pavement at the approach end of Runway 24 would be removed. Finally, the existing PAPI and FAA-owned REIL at the approach end of Runway 6 would be relocated to comply with the new runway threshold location.

#### Alternative #2A: Relocate State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)

Alternative 2A is the first of three alternatives that are similar in concept to Alternative 2 with the most substantial difference being the proposed relocation of State Street around the RPZ at the approach end of Runway 24. As shown in **Figure E**, Alternative 2A proposes the extension of Runway 6/24 by 720 feet at the approach end of Runway 6 and the shifting of the runway at the approach end of Runway 24

by 150 feet to provide 4,225 feet of usable runway length. With the shift in the runway, 150 feet of existing runway pavement would be removed at the approach end of Runway 24. Taxiway D would also be relocated 150 feet to the southwest and its alignment with the threshold of Runway 24 changed so that it intersects Runway 6/24 at a right angle. Pavement of the existing routing of Taxiway A1 would also be removed. Relocation of the PAPI and FAA-owned REIL at the approach end of Runway 6 to align with the shifted runway threshold is also proposed with this alternative.

As noted, the major difference with Alternative 2A as compared with Alternative 2 is that State Street is proposed to be relocated around the shifted RPZ at the approach end of Runway 24. The relocated alignment of State Street would be routed around the east end of the RPZ and tie into Ellsworth Road east of its existing intersection. The portion of State Street would be closed within the boundary of the RPZ with cul-de-sacs installed on either side to provide access for local businesses. Acquisition of land to the east of State Street outside of the existing airport property boundary would be necessary under this alternative.

#### **Alternative #2B: Close State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)**

Alternative 2B is the second of three alternatives that are similar in concept to Alternative 2. The most significant difference with Alternative 2B is that State Street through the RPZ would be closed with no relocation planned as shown in **Figure F**. Alternative 2B also proposes the extension of Runway 6/24 by 720 feet at the approach end of Runway 6 and the shifting of the runway at the approach end of Runway 24 by 150 feet. Combined, this would provide 4,225 feet of usable runway length. Removal of 150 feet of existing runway pavement at the approach end of Runway 24 is also proposed with Alternative 2B. The relocation of Taxiway D 150 feet to the southwest and routing of Taxiway A1 to align with the relocated Runway 24 threshold is also proposed with existing taxiway pavements planned for removal. The PAPI and FAA-owned REIL at the approach end of Runway 6 would also be relocated to align with the shifted runway threshold with this alternative.

Alternative #2B proposes to close State Street with no planned relocation. Installation of cul-de-sacs is proposed on either side of the RPZ boundary so access to businesses are maintained along State Street to the north and south of the RPZ boundary.

#### **Alternative #2C: Use Displaced Threshold, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)**

The final of three alternatives similar in concept to Alternative 2 is Alternative 2C, which proposes the use of a displaced threshold to move State Street outside of the RPZ. With this alternative (as shown in **Figure G**), Runway 6/24 is again proposed to be extended 720 feet at the approach end of Runway 6 to provide 4,225 feet of physical runway length. This includes a 150-foot shift of the runway at the approach end of Runway 24 in which 150 feet of existing runway pavement would be removed. Again, as with the other Alternative 2 variations, this runway shift is intended to provide increased line-of-sight visibility for the ATCT to the intersection of Taxiway A and Taxiway A1. Other physical infrastructure improvements proposed with Alternative 2C are the relocation of Taxiway D and Taxiway A1 to align at 90-degree angles with the new Runway 24 threshold and the removal of existing taxiway pavement associated with these surfaces. The PAPI and FAA-owned REIL at the approach end of Runway 6 would also be relocated to align with the new runway threshold at the approach end of Runway 6. Finally, application of runway pavement markings to delineate boundaries associated with the relocated threshold would also be necessary with the implementation of this alternative.

With the use of a displaced threshold, the approach and departure RPZs at the approach end of Runway 24 would be shifted 600 feet to the southwest so that State Street would not be located within these RPZ boundaries. As a result, the following declared distance lengths would be available for takeoff and landing on Runway 6/24:

Declared Distance	Runway 6	Runway 24
TORA	3,625 feet	4,225 feet
TODA	3,625 feet	4,225 feet
ASDA	3,625 feet	4,225 feet
LDA	4,225 feet	3,625 feet

In summary, with the implementation of Alternative 2C, 4,225 feet of runway would be available for takeoff on Runway 24 and for landing on Runway 6 while 3,625 feet of runway would be available for landing on Runway 24 and takeoff on Runway 6.

#### **Alternative #3: Extend 360 Feet at both ends of Runway 6/24 (4,225-foot Runway)**

This alternative, shown in **Figure H**, involves constructing extensions on both ends of Runway 6/24. 4,225 feet of runway length would be provided with the construction of a 360-foot extension on each end of Runway 6/24. At the approach end of Runway 6 to the southwest, this would also require a 360-foot extension of Taxiway A as well as the construction of a new connector taxiway (Taxiway A4) to align with the new threshold at this end of the runway. Likewise, at the approach end of Runway 24, a 360-foot extension of Taxiway A to the northeast would occur to match the 360-foot extension of the runway at this end as well as a relocation of Taxiway A1. The routing of Taxiway D to the south of Runway 6/24 would also change to align this portion of taxiway to intersect Runway 6/24 at a right angle. Portions of the existing alignment of Taxiway A1 and Taxiway D, where they currently intersect Runway 6/24, would be removed for this new taxiway configuration.

As a result of this proposed airfield configuration, the PAPI and FAA-owned REIL at the approach end of Runway 6 would be relocated. With the runway extending to the northeast, State Street would also need to be relocated so its routing is located around the approach end of Runway 24 and its associated RSA and ROFA surfaces. Acquisition of land for the relocation of State Street or an easement within the relocated RPZ at the approach end of Runway 24 for portions outside of the existing airport property boundary are also needed with Alternative #3.

#### **12. PROVIDE FULL COST ESTIMATES ASSOCIATED WITH EACH ALTERNATIVE REGARDLESS OF POTENTIAL FUNDING SOURCES:**

The cost of each alternative was evaluated in 2021 dollars.

Alternative	Estimated Cost
No Build	\$0
#1 - Extend 720 Feet at the Approach End of Runway 24	\$10,898,000
#2 - Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6	\$3,097,000
#2A: Relocate State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast	\$6,396,000
#2B: Close State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast	\$3,237,000
#2C: Use Displaced Threshold, Shift Runway 150 Feet Southwest, and Extend 720 Feet N.E.	\$3,097,000*
#3 - Extend 360 Feet at both ends of Runway 6/24	\$9,918,000

\*A detailed cost breakdown was not prepared for Alternative 2C since the construction cost of this alternative would be the same as Alternative 2.

Detailed cost breakdowns for each build alternative can be found in **Appendix A** at the end of this document. Estimates include costs for mobilization, engineering, construction administration, permitting, pavement removal, site preparation, runway grooving, installation of runway and taxiway lights, signage, handholes, painting runway and taxiway markings, and restoration of the site.

For Alternative 1 and Alternative 2A, property acquisition and the relocation of State Street to avoid the shifted RSA contributed significantly to the cost of these options. Alternative 3, like Alternative 1 and Alternative 2A, also has property acquisition and State Street relocation costs. However, since Alternative 3 has a relatively shorter runway extension on Runway 24, the State Street relocation is less expensive, making the overall project slightly less costly than Alternative 1.

Alternative 2, Alternative 2B, and Alternative 2C are the least expensive construction options, largely because each avoids the property acquisition and State Street relocation costs by not extending any runway pavement to the northeast.

### **13. PROVIDE A PRACTICABILITY ASSESSMENT BASED ON THE FEASIBILITY OF THE ALTERNATIVE IN TERMS OF COST, CONSTRUCTABILITY AND OTHER FACTORS:**

Starting with the No Build Alternative, this section reviews the advantages and disadvantages of each alternative.

#### **No Build Alternative (3,505-foot Runway)**

The No Build option does not have an implementation cost making it technically the least expensive alternative, but it does not provide the runway length needed for the critical aircraft family grouping of B-II turboprop. Under this alternative, the existing runway would not be extended. In addition, hangars would still block the ATCT view of the intersection of Taxiway A and Taxiway A1. Taxiway D would continue to intersect the runway at less than an optimal 90-degree angle, hampering pilots' views of the runway and final approach. FAA AC 150/5300-13A, *Airport Design*, directs taxiways should intersect runways at right angles to provide the best visibility for pilots when entering the surface.

This alternative is not a prudent or feasible option and is only being documented for the purposes of comparison to the build alternatives described below. Retaining the existing length of Runway 6/24 at 3,505 feet does not provide 4,225 feet of runway length needed for the family grouping of B-II turboprop aircraft operating at ARB. Retention of the existing airfield configuration also does not allow ARB to address the taxiway geometry issue at the approach end of Runway 24 nor prevent direct access from the apron. Retention of the airfield in its existing configuration would not address these required design standards.

The intersection of Taxiway A and Taxiway A1 (identified as HS 1 on **Figure A**), is also a visibility concern on the airfield. In conversation with ARB officials, this intersection is not entirely visible from the ATCT. This is due to the location of hangars directly to the east of the ATCT which obstruct a clear view of this area of the airfield for air traffic controllers. Maintaining the existing configuration of the airfield would not improve this issue.

Should the existing configuration of the airfield be maintained, no changes to land uses within the RPZs would occur. Likewise, no off-airport impacts to roadways or on-airfield aircraft navigational instrumentation would be needed. While these are advantages, this development option does not address the need to provide 4,225 feet of runway length at ARB. Thus, this alternative is not recommended.

#### **Alternative #1: Extend 720 Feet at the Approach End of Runway 24 (4,225-foot Runway)**

Alternative 1 offers the advantage of providing 4,225 feet of runway length to meet the needs of B-II turboprop aircraft. The primary disadvantage with Alternative #1 is that relocation of State Street will be necessary to change the alignment of this road around the approach end of Runway 24 and its associated RSA & ROFA surfaces. The relocation of State Street will require property acquisition. With the extension of the runway to the northeast, the ATCT will continue to have line-of-sight to the relocated intersection of Taxiway A and Taxiway A1 blocked by hangars. Potential wetland impacts and the need to control land uses through an acquisition or easement within the portion of the relocated RPZ are also disadvantages to consider.

Preliminary investigations indicate that there are likely wetlands throughout the area east of State Street. Thus, both State Street alignment options have the potential to cause impacts to regulated wetlands.

#### **Alternative #2: Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6 (4,225-foot Runway)**

Alternative 2 offers many advantages. First, it provides 4,225 feet of needed runway length for B-II turboprop aircraft that currently operate at ARB without substantially changing existing on- and off-airport infrastructure. Alternative 2 also provides additional runway length entirely within the existing property boundary. Alternative 2 corrects the non-standard geometry of the intersections of Taxiway A1 and Taxiway D with Runway 6/24 so that pilot visibility is maximized and no direct access from the apron to the runway is allowed, increasing safety and situational awareness. Shifting the runway 150 feet to the southwest also eliminates the obstructed view from the ATCT so that air traffic controllers can view the intersection of Taxiway A and Taxiway A1.

This shift in the runway and extension to the southwest to provide the needed runway length of 4,225 also shifts the RPZ at the approach end of Runway 24 so that it is entirely located within property owned by municipal jurisdictions (City of Ann Arbor and Washtenaw County Road Commission), eliminating the need for private land acquisition. Through an easement with the Washtenaw County Road Commission, land use would be controlled within this area. One minor disadvantage is the need to relocate the PAPI and FAA-owned REILs at the approach end of Runway 6. State Street also remains within the RPZ off of Runway 24 with the distance of the street to the boundary of the inner width of the RPZ increasing from 358 feet to 440 feet.

Few environmental concerns or potential impacts are associated with Alternative 2. There are two regulated wetlands and a constructed agricultural drainage ditch off the end of Runway 6. Preliminary design indicates that both regulated wetlands can be avoided with no impacts expected. The RSA and ROFA of Runway 6 will intersect a constructed agricultural ditch, however, it flows inside an existing culvert at this location, so ditch impacts are not expected. There is one regulated wetland complex in the vicinity of Runway 24 and the relocated Taxiway D. Initial analysis indicates that the construction of Taxiway D can be designed to avoid impacts to this wetland.

#### **Alternative #2A: Relocate State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)**

Alternative 2A is the first of three development options similar to Alternative 2 that proposes off-airfield changes along with the on-airfield infrastructure layout proposed by Alternative 2. Alternative 2A offers the advantage of providing 4,225 feet of runway length to meet the needs of B-II turboprop aircraft; however, as with Alternative 1, the primary disadvantage is the relocation of State Street resulting in considerable impacts to traffic patterns in the area. State Street is a primary north-south traffic artery in the Ann Arbor area that begins in downtown Ann Arbor and runs adjacent to the University of Michigan campus. State Street provides a primary access route to the community for those that live south of Ann Arbor proper.

Relocation of State Street, as proposed by Alternative 2A, would interrupt the traffic flow of this road by requiring thru traffic to make a series of turns using Ellsworth Road to travel around the airport. This would create traffic congestion on Ellsworth Road and is an impact not likely desired by the larger community. Implementation of Alternative 2A would also require the acquisition of property east of State Street outside of the existing airport property boundary for the relocation of the road. This contributes to the increased cost to implement this alternative and may delay the project schedule because of the coordination needed to acquire the property. In addition, potential wetlands located to the east of State Street could be impacted with the relocated road with the implementation of this alternative.

Due to potential traffic flow impacts, cost, and possible environmental impacts, Alternative 2A is not recommended for implementation.

#### **Alternative #2B: Close State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)**

Alternative 2B is the second of three development options similar in concept to Alternative 2 that continues the review of off-airfield changes with the on-airfield development proposed by Alternative 2. Alternative 2B continues to offer the advantage of providing 4,225 feet of runway length to meet the needs of B-II turboprop aircraft; however, the primary disadvantage with Alternative 2B is that State Street would be closed within the boundary of the RPZ with no relocation of the road planned. This alternative would significantly impact traffic patterns in the area as compared with Alternative 2A since State Street is a primary north-south traffic artery in Ann Arbor, connecting downtown Ann Arbor and the University of Michigan with areas to the south. Implementation of Alternative 2B would remove this route and result in considerable traffic changes throughout the Ann Arbor community. This alternative would require traffic traveling on State Street between Ann Arbor and areas to south to use other roads not necessarily designed for heavy traffic use.

Alternative 2B is not recommended for implementation due to significant impacts to traffic patterns.

#### **Alternative #2C: Use Displaced Threshold, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast (4,225-foot Runway)**

Alternative 2C is the third of three alternatives similar in concept to Alternative 2; however, Alternative 2C has no off-airfield infrastructure changes similar to Alternative 2 and shares the same implementation costs. With the use of a displaced threshold, 4,225 feet of runway length for B-II turboprop aircraft would only be provided for takeoff on Runway 24 and landing on Runway 6. When landing on Runway 24 and taking off on Runway 6, only 3,625 feet of runway length would be available. While 4,225 feet of runway would be provided in certain instances, the use of a displaced threshold does not fully meet the intent of providing runway length for the critical aircraft. While this option does remove State Street from the RPZ without creating social-economic impacts due to traffic pattern changes, it is not recommended since it does not fully meet the purpose and need of providing 4,225 feet of runway length for takeoff and landing in both directions on Runway 6/24 for the critical aircraft.

Although this alternative (along with the other two development options similar in concept to Alternative 2) focused on potential RPZ improvements at the approach end of Runway 24, consideration was also given if the runway could be shifted further to the southwest at the approach end of Runway 6 to provide 4,225 feet of runway length and limit impacts to State Street within the RPZ. It was found that any further shift of the runway to the southwest from what is being proposed in Alternative 2 may have unacceptable consequences.

Shifting the runway to the southwest may introduce new obstructions to aircraft operations. Shifting the runway any further may also result in impacts to potential wetland areas located near the property boundary of the airport. From a project design perspective, any further shift of the runway to the southwest may result in Lohr Road and potential residential properties to the west being located within the new RPZ. Shifting the runway threshold further to the southwest may also increase the potential for noise impacts since the runway would be closer to residential homes located on this side of the airport. It was determined that any further shift of the runway to the southwest would not be a feasible alternative given the potential of additional environmental, noise, and other socio-economic impacts expected.

#### **Alternative #3: Extend 360 Feet at both ends of Runway 6/24 (4,225-foot Runway)**

Alternative #3 offers the primary advantage of providing 4,225 feet of runway length to meet the needs of turboprop aircraft users. However, Alternative #3 has many disadvantages. First, and most significantly, State Street would need to be relocated around the extended runway and would require land acquisition. The acquisition of land or an easement within a portion of the relocated RPZ at the approach end of Runway 24 is another disadvantage to consider. Although the alignments of the intersections of Taxiway A1 and Taxiway D with Runway 6/24 are improved so that they intersect at right angles and no longer have direct access from the apron, the relocation of the intersection of Taxiway A and Taxiway A1 to the northeast does not allow air traffic controllers in the ATCT to view this area clearly, further complicating the current line-of-sight issue. Finally, the PAPI and FAA-owned REILs at the approach end of Runway 6 would need to be relocated.

Environmental impacts can be expected with the 360-foot extension to the northeast as regulated wetlands are found throughout the area east of State Street in the Runway 24 approach. As with Alternative #1, it is likely that both State Street alignment options would impact

regulated wetlands. There are few environmental concerns or potential impacts associated with the extension of Runway 6 to the southwest. Although two regulated wetlands and a constructed agricultural drainage ditch were previously delineated off the end of Runway 6, these resources are well outside the area of construction and would not be impacted by the 360-foot extension.

#### **14. DESCRIBE THE PREFERRED ALTERNATIVE THAT WOULD MEET THE PROJECT PURPOSE AND NEED WHILE MINIMIZING RISK ASSOCIATED WITH THE LOCATION WITHIN THE RPZ:**

The table below compares several key issues for each of the six alternatives and no build option. The table shows that only the build alternatives meet the project purpose of providing 4,225 feet of runway length that is needed for turboprop aircraft operating at ARB. Alternative 2 also provides the most safety benefits with the least number of impacts to the surrounding environment and local community.

Alternative	Cost (millions of \$)	Runway Length	Land Acquisition / Easement Requirements	ATCT Visibility of TWY A/A1	Taxiway D Nonstandard Geometry	Wetland Impacts
No Build	None	3,505 feet	Land for RPZ control	Blocked	Not fixed	No
#1 – Extend 720 Feet at the Approach End of Runway 24	\$10.9	4,225 feet	Land for State Street relocation Land for RPZ control	Blocked	Fixed	Yes
#2 – Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6	\$3.1	4,225 feet	None	Clear	Fixed	No
#2A – Relocate State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast	\$6.4	4,225 feet	Land for State Street relocation Land for RPZ control	Clear	Fixed	Yes
#2B – Close State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast	\$3.2	4,225 feet	Land for RPZ control over closed road right-of-way	Clear	Fixed	No
#2C – Use Displaced Threshold, Shift Runway 150 Feet Southwest, and Extend 720 Feet N.E.	\$3.1	4,225 feet (t/o 24, land 6); 3,625 feet (t/o 6, land 24)	None	Clear	Fixed	No
#3 – Extend 360 Feet at both ends of Runway 6/24	\$9.9	4,225 feet	Land for State Street relocation Land for RPZ control	Blocked	Fixed	Yes

In comparison to the other alternatives, Alternative 2 is the preferred action to provide the recommended runway length for ARB and address other airfield infrastructure needs with the fewest expected impacts to on- and off-airport infrastructure, the environment, and the surrounding community. With the 150-foot shift of the runway to the southwest, Alternative 2 avoids the need to close and/or relocate State Street.

The runway shift will be accomplished by moving both the Runway 6 and Runway 24 thresholds 150 feet to the southwest, along with shifting associated navigational equipment. Also, Alternative 2 does not require ARB to seek the acquisition of land or easements to further protect incompatible land uses within the RPZs.

Alternative 2 offers the additional benefits of allowing Taxiway D and Taxiway A1 to intersect Runway 6/24 at a right angle, thus meeting design standards identified in FAA AC 150/5300-13A, *Airport Design*. Alternative 2 also improves the safety of the airfield by shifting Runway 6/24 150 feet to the southwest so that the intersection of Taxiway A and Taxiway A1 can be viewed unobstructed by air traffic controllers in the ATCT, thus alleviating the HS 1 issue. Alternative #2 is the only option that adequately addresses this safety issue.

Alternative 2 is also the best option for minimizing the impact of existing and future land uses within the RPZ. With 0.028 acres, or 0.2 percent of the existing RPZ located on private property, this alternative shifts the RPZ at the approach end of Runway 24 entirely onto land owned by municipal authorities (City of Ann Arbor and Washtenaw County Road Commission) so that all land within the RPZs can be controlled by these municipal agencies. Through use of an easement with the Washtenaw County Road Commission, ARB can control how the land within the RPZs is used.

Thus, to provide 4,225 feet of runway length at ARB to meet the needs of similar grouping of turboprop aircraft types, implementation of Alternative #2 is the recommended development action.

#### **15. IDENTIFY ALL FEDERAL, STATE AND LOCAL TRANSPORTATION AGENCIES INVOLVED OR INTERESTED IN THE ISSUE:**

Coordination has occurred with the following federal, state, and local transportation agencies as a part of this RPZ analysis:

- Federal Aviation Administration, Great Lakes Region Airports Division
- Michigan Department of Transportation, Office of Aeronautics
- City of Ann Arbor
- Washtenaw County Road Commission

**16. PROVIDE AN ANALYSIS OF THE SPECIFIC PORTION(S) AND PERCENTAGES OF THE RPZ AFFECTED, DRAWING A CLEAR DISTINCTION BETWEEN THE CENTRAL PORTION OF THE RPZ VERSUS THE CONTROLLED ACTIVITY AREA, AND CLEARLY DELINEATING THE DISTANCE FROM THE RUNWAY END AND RUNWAY LANDING THRESHOLD.**

The future RPZs at each end of Runway 6/24 as illustrated in Alternative 2 are contained within municipal boundaries, resulting in the desired level of RPZ control by ARB. The future approach RPZ for Runway 24 has 640 feet of State Street within its boundary. The two-lane road and its shoulders occupy approximately 28,700 square feet of the future RPZ, or 4.8 percent of the area of the RPZ. The road penetrates the future RPZ on the north side approximately 610 feet from the inner width of the future RPZ and penetrates on the south side of the future RPZ approximately 440 feet from the inner width. Most of the road is in the central portion of the future RPZ. Approximately 21,200 sq. ft. of the road is in the central portion of the future RPZ, which comprises 3.9 percent of the central portion area. The remainder of the road, 7,500 sq. ft., is in the controlled activity area and takes up 14.3 percent of that area. The road is close to being perpendicular to the extended runway centerline and the closest it approaches the proposed runway threshold is approximately 700 feet. While slightly larger, the dimensions of the footprint of State Street within the future RPZ do not change significantly from the footprint of State Street within the existing RPZ. Currently, State Street occupies 650 linear feet within the RPZ at a total area of 0.75 acres (32,670 square feet) and takes up 5.4 percent of the total RPZ area. At its closest point, State Street is currently 358 feet from the boundary of the inner width of the existing RPZ at the approach end of Runway 24.

**17. PROVIDE AN ANALYSIS OF (AND ISSUES AFFECTING) SPONSOR CONTROL OF THE LAND WITHIN THE RPZ.**

The airport and City of Ann Arbor can control the land use under the proposed RPZ of the preferred alternative (Alternative 2). See **Figure D**. While the airport does not own State Street, which cuts through the RPZ at the approach end of Runway 24, the city owns the lots on each side of the road and therefore controls development along the road in the RPZ. The Washtenaw County Road Commission owns the right of way for State Street and has the appropriate authority to control land use in the RPZ, so ARB would need to coordinate with this organization. This coordination could also include the installation of signs on State Street to notify and restrict drivers from parking or stopping within the boundary of the RPZ. Ultimately, the installation of such signs will be at the discretion of the Washtenaw County Road Commission. Coordination between the City and the County is encouraged to develop an appropriate signage plan.

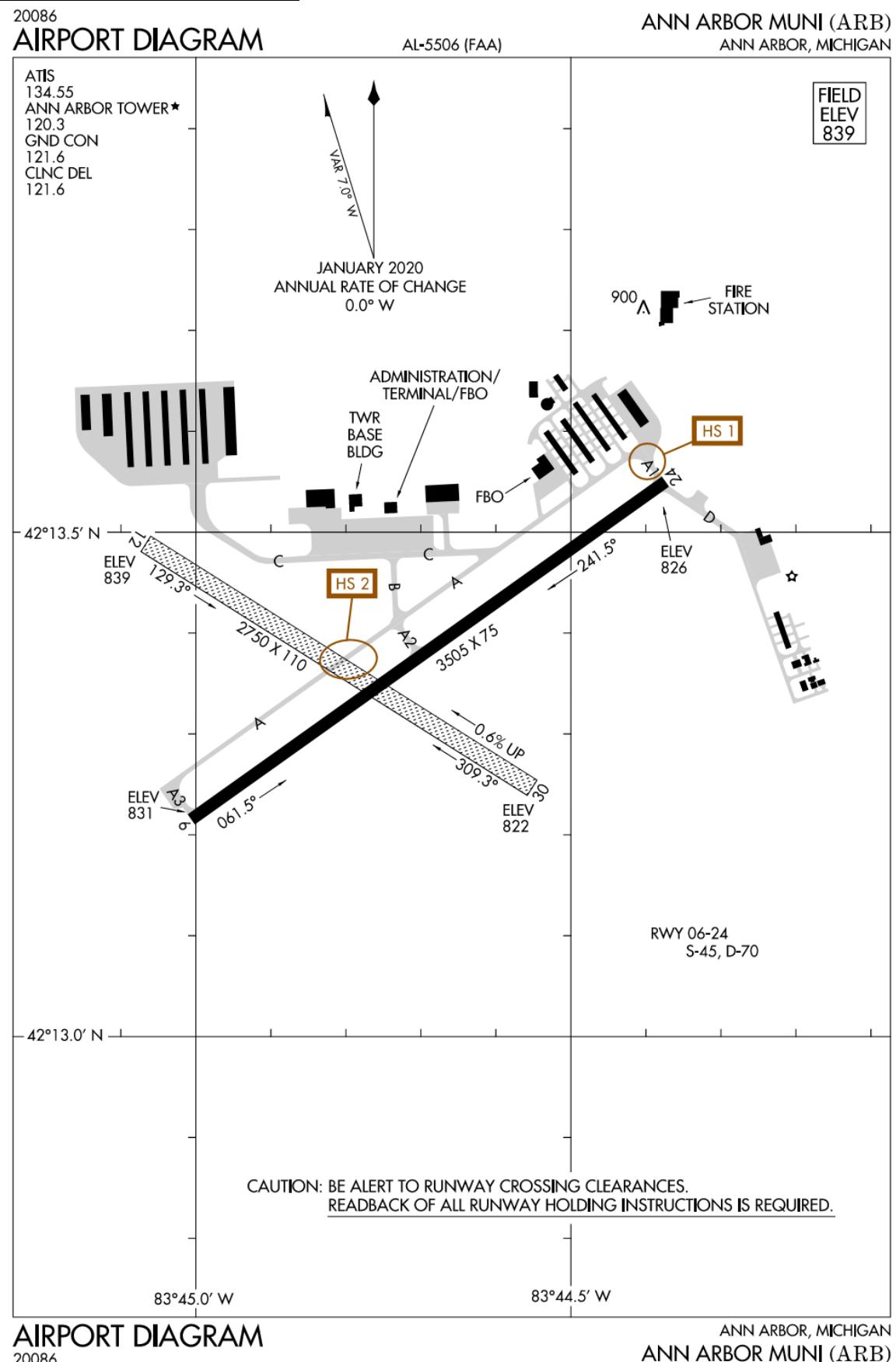
If the airport remains a B-II and its instrument approaches maintain visibility minimums of one mile, no additional land is needed to keep control of the future RPZs under the preferred alternative.

**18. ANY OTHER RELEVANT FACTORS FOR HEADQUARTERS CONSIDERATION:**

All runway length determinations were conducted in accordance with guidance published in FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*. Runway length calculations by on-demand charter operators, govern by Part 135 requirements, may require greater safety margins, resulting in increased runway lengths. Providing 4,225 feet of runway length as recommended by Alternative 2 allows Part 135 operators increased length in calculating runway length needs based on operational factors such as payload, fuel load, and intended destination as well as environmental factors such as temperature, precipitation, and presence of contaminants (water, ice, snow) on the runway.

19. SIGNATURE OF ORIGINATOR 	20. PRINTED NAME OF ORIGINATOR Matthew Kulhanek	21. DATE January 11, 2022
22. ORIGINATOR'S TITLE Airport Manager	23. TELEPHONE (734) 794-6312	24. E-MAIL mjkulhanek@a2gov.org

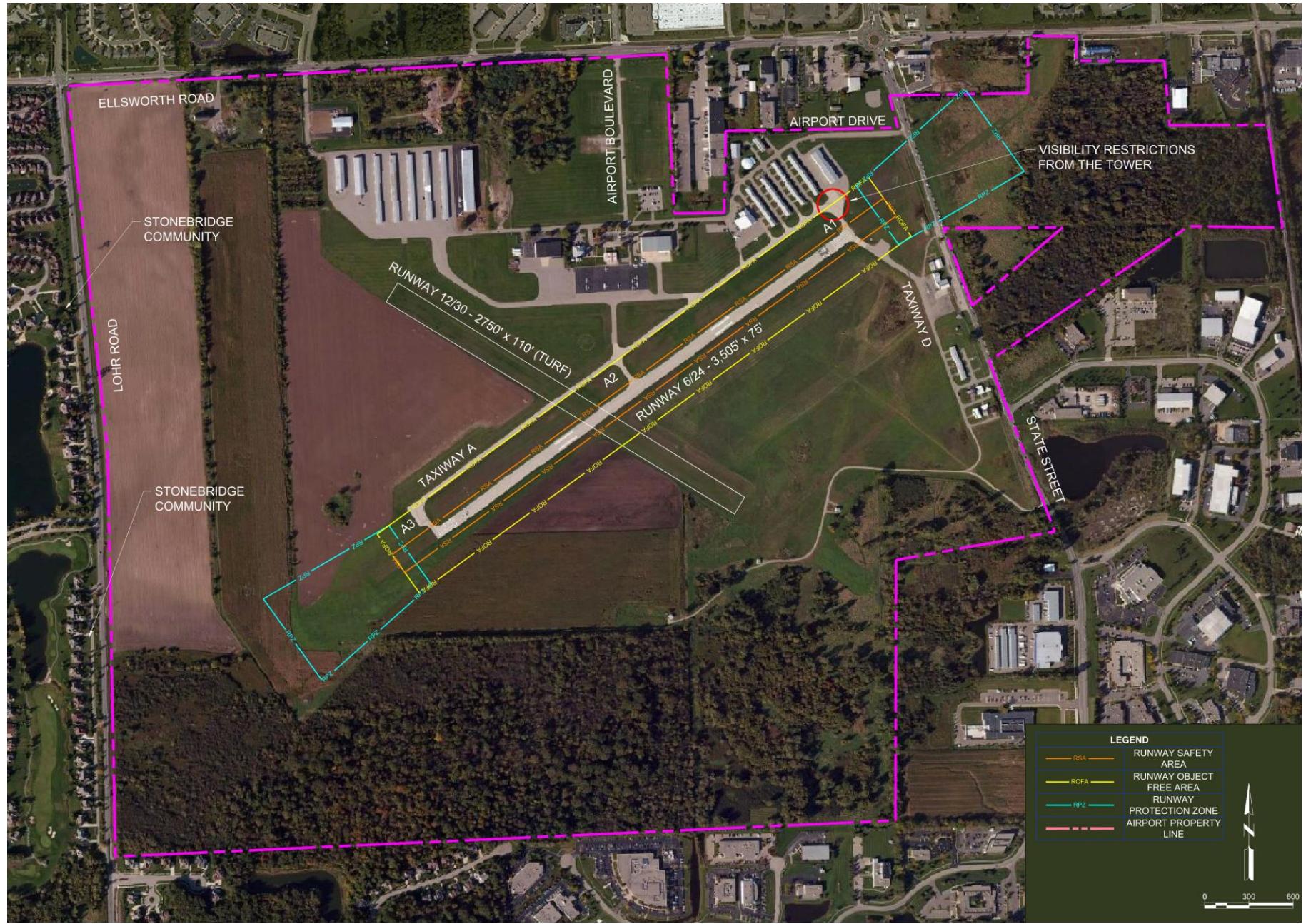
**Figure A – Existing Airfield Configuration**



**AIRPORT DIAGRAM**  
20086

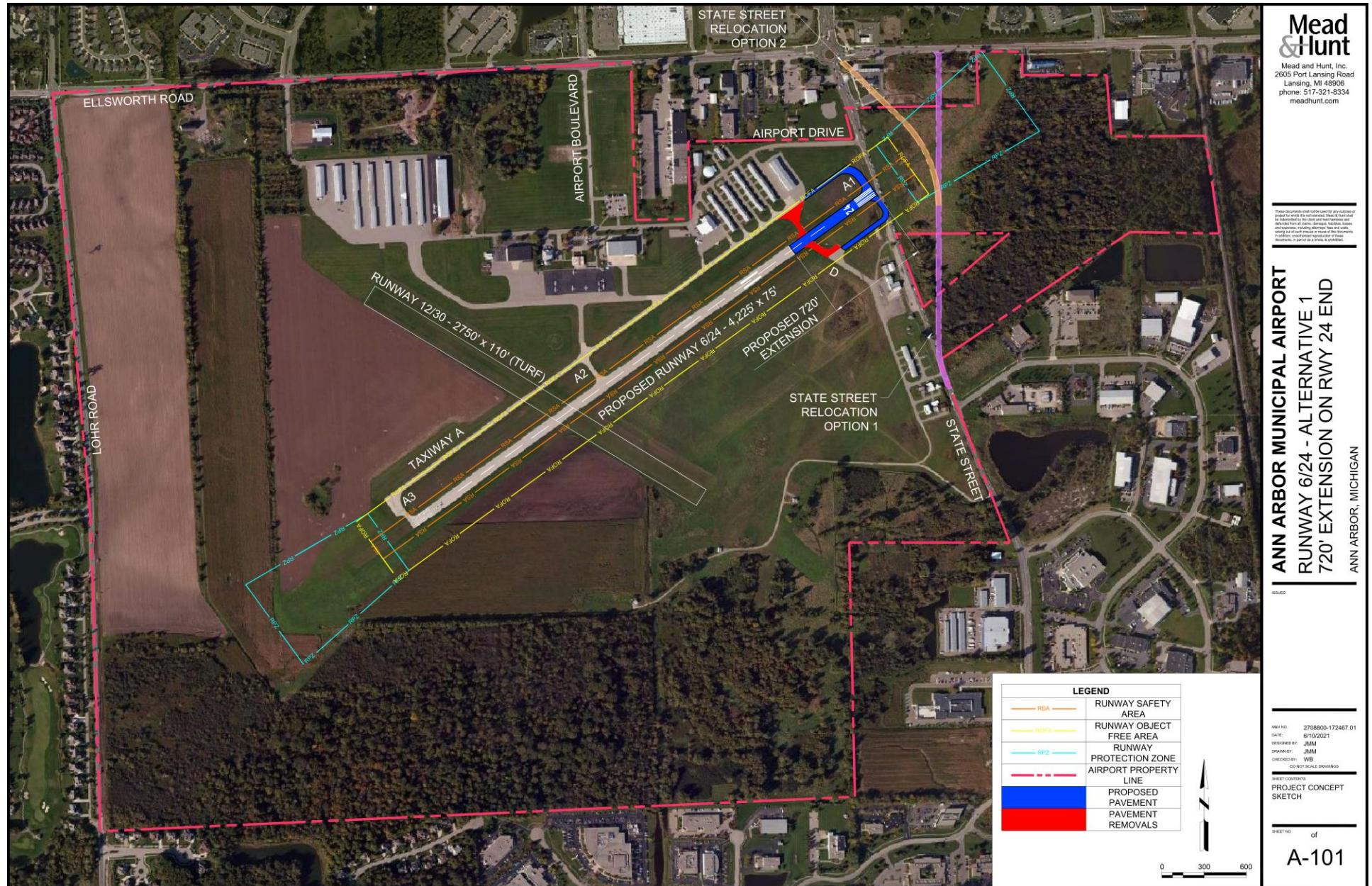
ANN ARBOR, MICHIGAN  
ANN ARBOR MUNI (ARB)

**Figure B – Location of Physical Constraints**



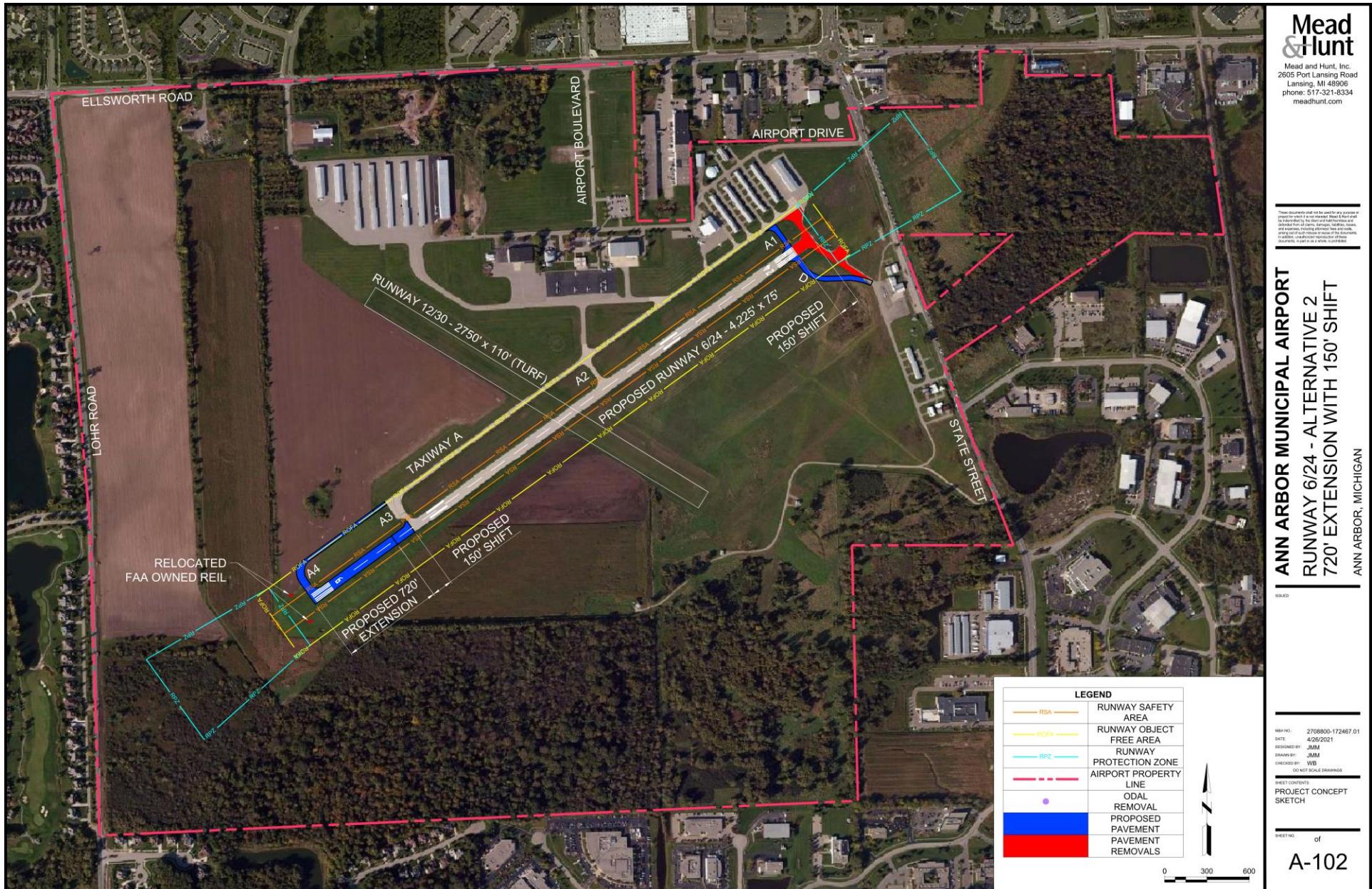
Source: Mead & Hunt (2020)

**Figure C – Alternative #1: Extend 720 Feet at the Approach End of Runway 24 (4,225-foot Runway)**



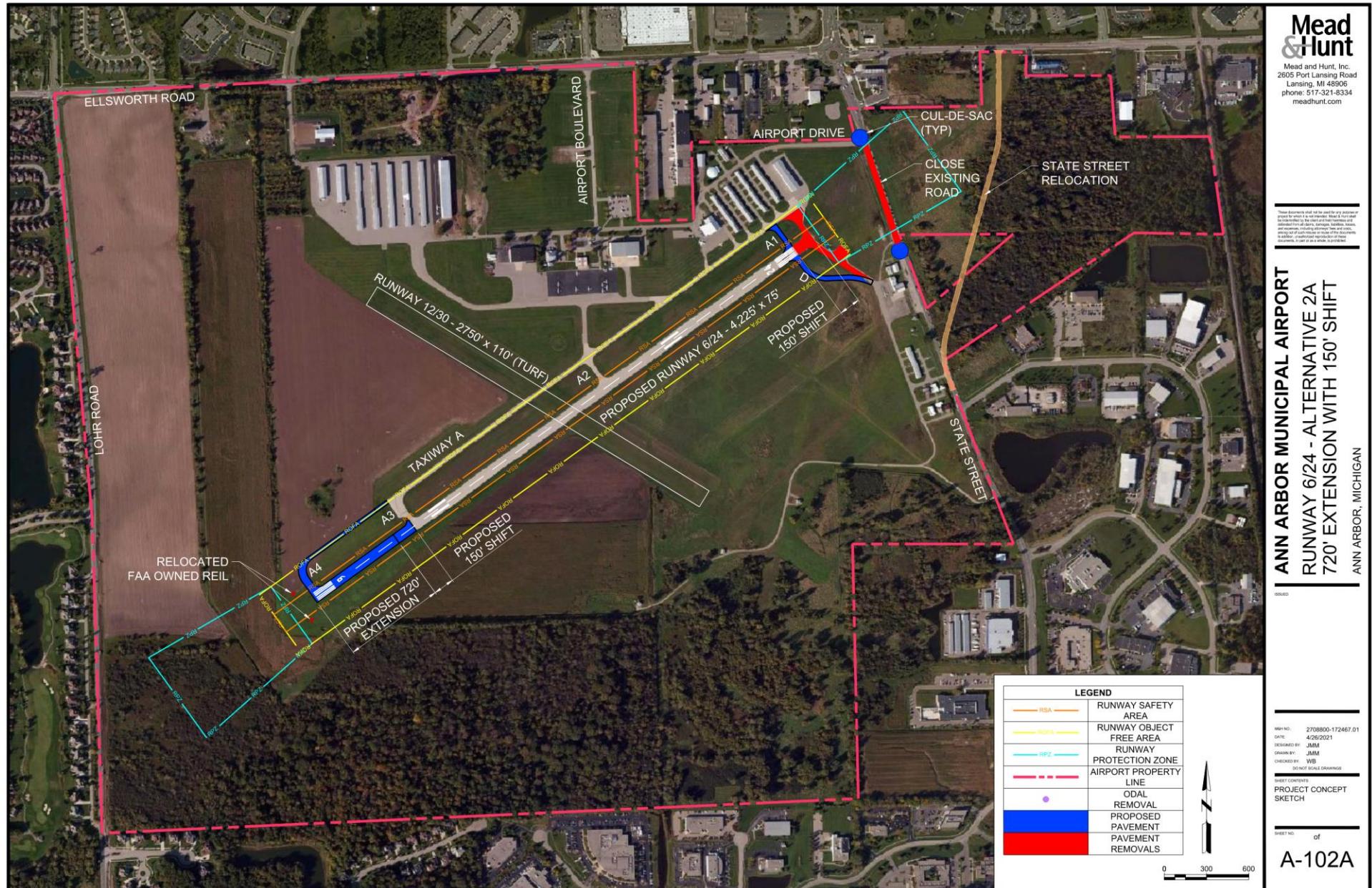
Source: Mead & Hunt (2021)

Figure D – Alternative #2: Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6 (4,225-foot Runway)



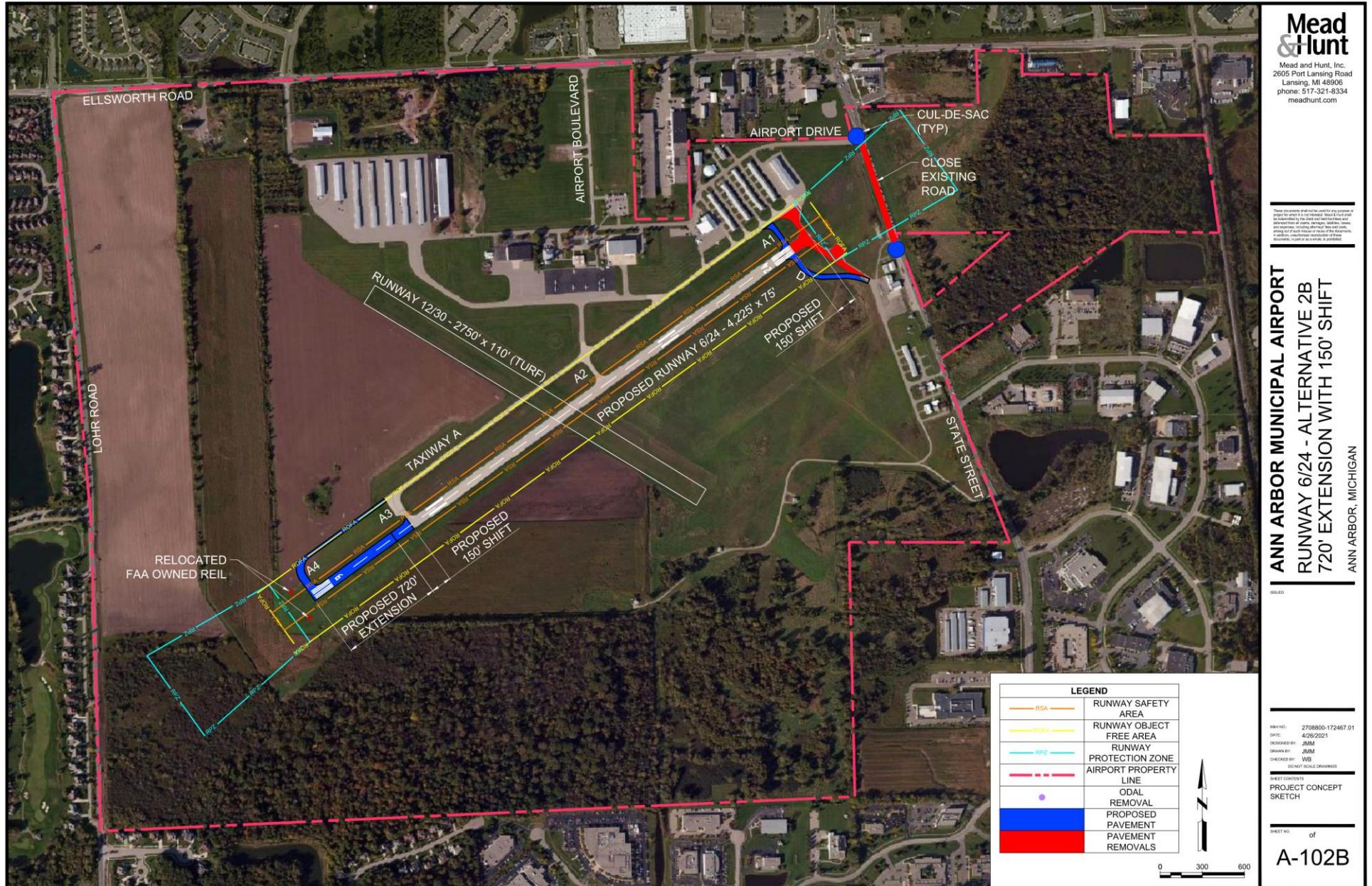
Source: Mead & Hunt (2021)

Figure E – Alternative #2A: Relocate State Street, Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6



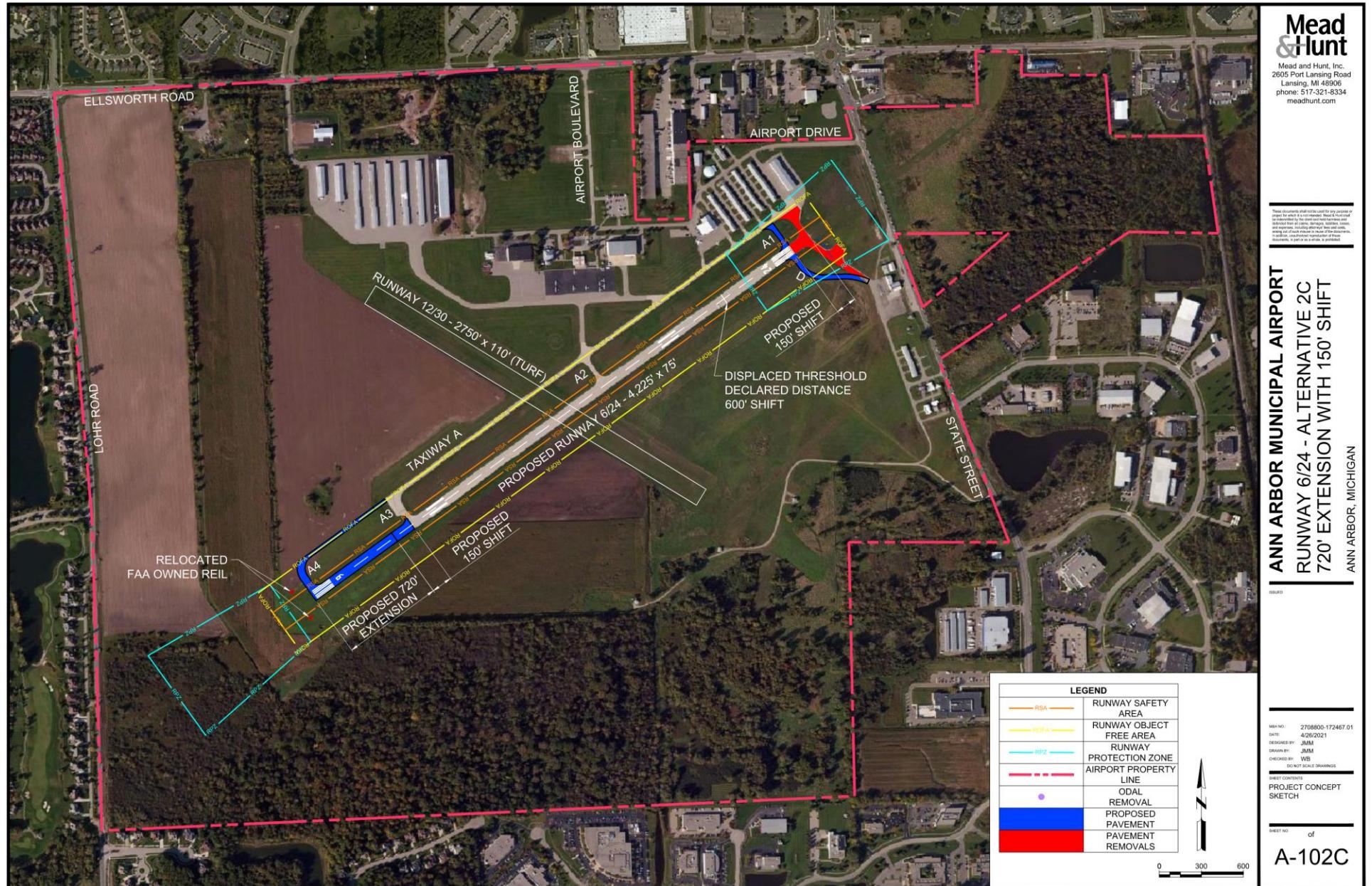
Source: Mead & Hunt (2021)

Figure F – Alternative #2B: Close State Street, Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6



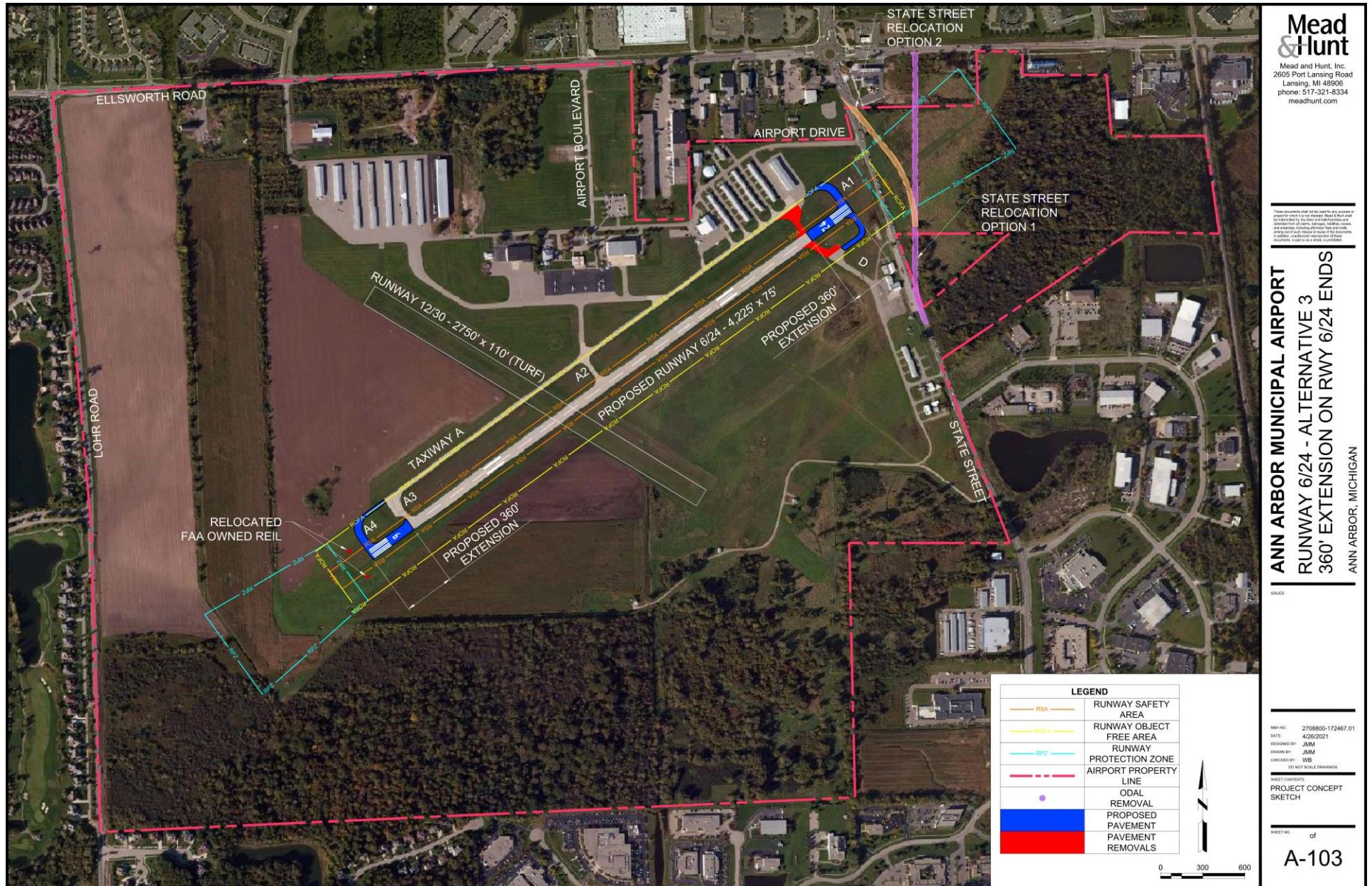
Source: Mead & Hunt (2021)

**Figure G – Alternative #2C: Use Displaced Threshold, Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6**



Source: Mead & Hunt (2021)

Figure H – Alternative #3: Extend 360 Feet at both ends of Runway 6/24 (4,225-foot Runway)



Source: Mead & Hunt (2021)

## **Appendix A**

### **Cost Estimates for Ann Arbor Municipal Airport Runway 6/24 Extension Alternatives**

**Table A-1: Alternative #1 – Extend 720 Feet at the Approach End of Runway 24**

#### **ENGINEERING COST ESTIMATE**

PROJECT: Extend Runway 6-24 Alternative 1  
 LOCATION: ANN ARBOR MUNICIPAL AIRPORT  
 CITY: ANN ARBOR, MI  
 DATE: 6/10/2021  
 PREPARED BY: SCT

FINAL DESIGN  
 PROJECT PROGRAMMING  
 FEASIBILITY STUDY  
 STATE PLANNING  
 BASED ON 2021 DOLLARS

WORK DESCRIPTION: Extend Runway 24 (720')

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ITEM COST
MOBILIZATION AND GENERAL CONDITIONS	LS	1	\$ 500,000.00	\$ 500,000.00
SAFETY AND SECURITY	LS	1	\$ 150,000.00	\$ 150,000.00
PERMITS	DLR	10000	\$ 1.00	\$ 10,000.00
PAVEMENT REMOVAL	SYD	5200	\$ 5.00	\$ 26,000.00
EXCAVATION 36"	CYD	12000	\$ 12.00	\$ 144,000.00
P-154 SUBBASE	CYD	6500	\$ 17.50	\$ 113,750.00
P-209 AGGREGATE BASE COURSE	CYD	4500	\$ 50.00	\$ 225,000.00
P-401 BITUMINOUS AGGREGATE PAVEMENT	TON	4500	\$ 105.00	\$ 472,500.00
RUNWAY GROOVING	SFT	57600	\$ 2.50	\$ 144,000.00
MIRL/MITL	EA	45	\$ 1,400.00	\$ 63,000.00
CABLE/CONDUIT/DUCT	LFT	6000	\$ 12.00	\$ 72,000.00
SIGNS	EA	4	\$ 4,000.00	\$ 16,000.00
HANDHOLES	EA	4	\$ 5,000.00	\$ 20,000.00
MARKING REMOVAL	SFT	41000	\$ 3.00	\$ 123,000.00
MARKING	SFT	12980	\$ 0.50	\$ 6,490.00
FENCE	LFT	2500	\$ 35.00	\$ 87,500.00
RESTORATION	ACRE	5	\$ 5,000.00	\$ 25,000.00
ROAD RELOCATION	LANE MILE	2	\$ 1,500,000.00	\$ 3,000,000.00
PROPERTY ACQUISITION	LS	1	\$ 3,000,000.00	\$ 3,000,000.00
CONTINGENCY (20%)				\$ 1,639,648.00
ENGINEERING (7%)				\$ 436,652.16
CONSTRUCTION ADMINISTRATION (10%)				\$ 623,788.80
TOTAL				\$ 10,898,328.96

Source: Mead & Hunt (2021)

**Table A-2: Alternative #2 – Shift Runway 150 Feet Southwest and Extend 720 Feet at the Approach End of Runway 6**

ENGINEERING COST ESTIMATE

PROJECT: Extend Runway 6-24 Alternative 2  
 LOCATION: ANN ARBOR MUNICIPAL AIRPORT  FINAL DESIGN  
 CITY: ANN ARBOR, MI  PROJECT PROGRAMMING  
 DATE: 5/19/2021  FEASIBILITY STUDY  
 PREPARED BY: SCT  STATE PLANNING  
 BASED ON 2021 DOLLARS

WORK DESCRIPTION: Extend Runway 6 (870') Shorten Runway 24 (150')

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ITEM COST
MOBILIZATION AND GENERAL CONDITIONS	LS	1	\$ 240,000.00	\$ 240,000.00
SAFETY AND SECURITY	LS	1	\$ 120,000.00	\$ 120,000.00
PERMITS	DLR	10000	\$ 1.00	\$ 10,000.00
PAVEMENT REMOVAL	SYD	5500	\$ 5.00	\$ 27,500.00
EXCAVATION 36"	CYD	15000	\$ 12.00	\$ 180,000.00
P-154 SUBBASE	CYD	7500	\$ 17.50	\$ 131,250.00
P-209 AGGREGATE BASE COURSE	CYD	5000	\$ 50.00	\$ 250,000.00
P-401 BITUMINOUS AGGREGATE PAVEMENT	TON	5500	\$ 105.00	\$ 577,500.00
RUNWAY GROOVING	SFT	69600	\$ 2.50	\$ 174,000.00
MIRL/MITL	EA	48	\$ 1,400.00	\$ 67,200.00
RELOCATE FAA REIL	SET	1	\$ 75,000.00	\$ 75,000.00
RELOCATE PAPI	SET	1	\$ 50,000.00	\$ 50,000.00
CABLE/CONDUIT/DUCT	LFT	8000	\$ 12.00	\$ 96,000.00
SIGNS	EA	3	\$ 4,000.00	\$ 12,000.00
HANDHOLES	EA	6	\$ 5,000.00	\$ 30,000.00
MARKING REMOVAL	SFT	41000	\$ 3.00	\$ 123,000.00
MARKING	SFT	14380	\$ 0.50	\$ 7,190.00
RESTORATION	ACRE	7	\$ 5,000.00	\$ 35,000.00
CONTINGENCY (20%)				\$ 441,128.00
ENGINEERING (7%)				\$ 185,273.76
CONSTRUCTION ADMINISTRATION (10%)				\$ 264,676.80
TOTAL				\$ 3,096,718.56

Source: Mead & Hunt (2021)

**Table A-3: Alternative #2A – Relocate State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast**

ENGINEERING COST ESTIMATE

PROJECT: Extend Runway 6-24 Alternative 2A  
 LOCATION: ANN ARBOR MUNICIPAL AIRPORT  
 CITY: ANN ARBOR, MI  
 DATE: 12/10/2021  
 PREPARED BY: SCT

FINAL DESIGN  
 PROJECT PROGRAMMING  
 FEASIBILITY STUDY  
 STATE PLANNING

BASED ON 2021 DOLLARS

WORK DESCRIPTION: Extend Runway 6 (870') Shorten Runway 24 (150'), Relocate State Street

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ITEM COST
MOBILIZATION AND GENERAL CONDITIONS	LS	1	\$ 240,000.00	\$ 240,000.00
SAFETY AND SECURITY	LS	1	\$ 120,000.00	\$ 120,000.00
PERMITS	DLR	10000	\$ 1.00	\$ 10,000.00
PAVEMENT REMOVAL	SYD	5500	\$ 5.00	\$ 27,500.00
EXCAVATION 36"	CYD	15000	\$ 12.00	\$ 180,000.00
P-154 SUBBASE	CYD	7500	\$ 17.50	\$ 131,250.00
P-209 AGGREGATE BASE COURSE	CYD	5000	\$ 50.00	\$ 250,000.00
P-401 BITUMINOUS AGGREGATE PAVEMENT	TON	5500	\$ 105.00	\$ 577,500.00
RUNWAY GROOVING	SFT	69600	\$ 2.50	\$ 174,000.00
MIRL/MITL	EA	48	\$ 1,400.00	\$ 67,200.00
RELOCATE FAA REIL	SET	1	\$ 75,000.00	\$ 75,000.00
RELOCATE PAPI	SET	1	\$ 50,000.00	\$ 50,000.00
CABLE/CONDUIT/DUCT	LFT	8000	\$ 12.00	\$ 96,000.00
SIGNS	EA	3	\$ 4,000.00	\$ 12,000.00
HANDHOLES	EA	6	\$ 5,000.00	\$ 30,000.00
MARKING REMOVAL	SFT	41000	\$ 3.00	\$ 123,000.00
MARKING	SFT	14380	\$ 0.50	\$ 7,190.00
RESTORATION	ACRE	7	\$ 5,000.00	\$ 35,000.00
ROAD RELOCATION	LANE MILE	1.5	\$ 1,500,000.00	\$ 2,250,000.00
TURN AROUND	EACH	2	\$ 50,000.00	\$ 100,000.00
CONTINGENCY (20%)				\$ 911,128.00
ENGINEERING (7%)				\$ 382,673.76
CONSTRUCTION ADMINISTRATION (10%)				\$ 546,676.80
TOTAL				\$ 6,396,118.56

**Table A-4: Alternative #2B: Close State Street, Shift Runway 150 Feet Southwest, and Extend 720 Feet Northeast**

## ENGINEERING COST ESTIMATE

PROJECT: Extend Runway 6-24 Alternative 2B  
 LOCATION: ANN ARBOR MUNICIPAL AIRPORT  
 CITY: ANN ARBOR, MI  
 DATE: 12/10/2021  
 PREPARED BY: SCT

FINAL DESIGN  
 PROJECT PROGRAMMING  
 FEASIBILITY STUDY  
 STATE PLANNING  
 BASED ON 2021 DOLLARS

WORK DESCRIPTION: Extend Runway 6 (870') Shorten Runway 24 (150'), Close State Street

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ITEM COST
MOBILIZATION AND GENERAL CONDITIONS	LS	1	\$ 240,000.00	\$ 240,000.00
SAFETY AND SECURITY	LS	1	\$ 120,000.00	\$ 120,000.00
PERMITS	DLR	10000	\$ 1.00	\$ 10,000.00
PAVEMENT REMOVAL	SYD	5500	\$ 5.00	\$ 27,500.00
EXCAVATION 36"	CYD	15000	\$ 12.00	\$ 180,000.00
P-154 SUBBASE	CYD	7500	\$ 17.50	\$ 131,250.00
P-209 AGGREGATE BASE COURSE	CYD	5000	\$ 50.00	\$ 250,000.00
P-401 BITUMINOUS AGGREGATE PAVEMENT	TON	5500	\$ 105.00	\$ 577,500.00
RUNWAY GROOVING	SFT	69600	\$ 2.50	\$ 174,000.00
MIRL/MITL	EA	48	\$ 1,400.00	\$ 67,200.00
RELOCATE FAA REIL	SET	1	\$ 75,000.00	\$ 75,000.00
RELOCATE PAPI	SET	1	\$ 50,000.00	\$ 50,000.00
CABLE/CONDUIT/DUCT	LFT	8000	\$ 12.00	\$ 96,000.00
SIGNS	EA	3	\$ 4,000.00	\$ 12,000.00
HANDHOLES	EA	6	\$ 5,000.00	\$ 30,000.00
MARKING REMOVAL	SFT	41000	\$ 3.00	\$ 123,000.00
MARKING	SFT	14380	\$ 0.50	\$ 7,190.00
RESTORATION	ACRE	7	\$ 5,000.00	\$ 35,000.00
TURN AROUND	EACH	2	\$ 50,000.00	\$ 100,000.00
CONTINGENCY (20%)				\$ 461,128.00
ENGINEERING (7%)				\$ 193,673.76
CONSTRUCTION ADMINISTRATION (10%)				\$ 276,676.80
TOTAL				\$ 3,237,118.56

**Table A-5: Alternative #3 – Extend 360 Feet at both ends of Runway 6/24**

## ENGINEERING COST ESTIMATE

PROJECT: Extend Runway 6-24 Alternative 3  
 LOCATION: ANN ARBOR MUNICIPAL AIRPORT  
 CITY: ANN ARBOR, MI  
 DATE: 5/19/2021  
 PREPARED BY: SCT

FINAL DESIGN  
 PROJECT PROGRAMMING  
 FEASIBILITY STUDY  
 STATE PLANNING

BASED ON 2021 DOLLARS

WORK DESCRIPTION: Extend Runway (360') Extend Runway 24 (360')

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ITEM COST
MOBILIZATION AND GENERAL CONDITIONS	LS	1	\$ 500,000.00	\$ 500,000.00
SAFETY AND SECURITY	LS	1	\$ 150,000.00	\$ 150,000.00
PERMITS	DLR	10000	\$ 1.00	\$ 10,000.00
PAVEMENT REMOVAL	SYD	5200	\$ 5.00	\$ 26,000.00
EXCAVATION 36"	CYD	12000	\$ 12.00	\$ 144,000.00
P-154 SUBBASE	CYD	6000	\$ 17.50	\$ 105,000.00
P-209 AGGREGATE BASE COURSE	CYD	4000	\$ 50.00	\$ 200,000.00
P-401 BITUMINOUS AGGREGATE PAVEMENT	TON	4500	\$ 105.00	\$ 472,500.00
RUNWAY GROOVING	SFT	57600	\$ 2.50	\$ 144,000.00
MIRL/MITL	EA	40	\$ 1,400.00	\$ 56,000.00
RELOCATE FAA REIL	SET	1	\$ 75,000.00	\$ 75,000.00
RELOCATE PAPI	SET	1	\$ 50,000.00	\$ 50,000.00
CABLE/CONDUIT/DUCT	LFT	5000	\$ 12.00	\$ 60,000.00
SIGNS	EA	3	\$ 4,000.00	\$ 12,000.00
HANDHOLES	EA	6	\$ 5,000.00	\$ 30,000.00
MARKING REMOVAL	SFT	41000	\$ 3.00	\$ 123,000.00
MARKING	SFT	12000	\$ 0.50	\$ 6,000.00
FENCE	LFT	1750	\$ 35.00	\$ 61,250.00
RESTORATION	ACRE	5	\$ 5,000.00	\$ 25,000.00
ROAD RELOCATION	LANE MILE	1.5	\$ 1,500,000.00	\$ 2,250,000.00
PROPERTY ACQUISITION	LS	1	\$ 3,000,000.00	\$ 3,000,000.00
CONTINGENCY (20%)				\$ 1,499,950.00
ENGINEERING (7%)				\$ 377,979.00
CONSTRUCTION ADMINISTRATION (10%)				\$ 539,970.00
TOTAL				\$ 9,917,649.00

Source: Mead &amp; Hunt (2021)