Appendix S – Obstruction Evaluation & Airspace Analysis

South Deuel Wind Project

Invenergy

Deuel County, South Dakota

Obstruction Evaluation & Airspace Analysis

July 7, 2021

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Summary

Capitol Airspace conducted an obstruction evaluation and airspace analysis for the South Deuel wind project in Deuel County, South Dakota. The purpose for this analysis was to identify obstacle clearance surfaces established by the Federal Aviation Administration (FAA) that could limit the placement of 551, 591, and 640-foot above ground level (AGL) wind turbines. At the time of this analysis, wind turbine locations had not been identified. This analysis assessed height constraints overlying an approximately 71-square-mile study area (black outline, ***Figure 1***) to aid in identifying optimal wind turbine locations.

14 CFR Part 77.9 requires that that all structures exceeding 200 feet AGL be submitted to the FAA so that an aeronautical study can be conducted. The FAA's objective in conducting aeronautical studies is to ensure that proposed structures do not affect the safety of air navigation or the efficient utilization of navigable airspace by aircraft. The result of an aeronautical study is the issuance of a determination of 'hazard' or 'no hazard' that can be used by the proponent to obtain necessary local construction permits. It should be noted that the FAA has no control over land use in the United States and cannot enforce the findings of its studies.

The lowest obstacle clearance surfaces overlying the South Deuel wind project are 2,600 feet above mean sea level (AMSL) and are associated with instrument approach procedures. Proposed structures that exceed these surfaces would require an increase to instrument approach procedure minimum altitudes. If the FAA determines that this impact would affect as few as one operation per week, it could result in determinations of hazard. United States Geological Survey (USGS) elevation data indicates that these surfaces could limit 591 and 640-foot AGL wind turbines in the southwestern section of the defined study area. However, these surfaces should not limit 551-foot AGL wind turbines within the defined study area.

This study did not consider electromagnetic interference on FAA communication or surveillance radar systems. Impact on these systems can result in determinations of hazard regardless of the lack of impact on the physical airspace surfaces described in this report.

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Methodology

Capitol Airspace studied the proposed project based on location information provided by Invenergy. Using this information, Capitol Airspace generated graphical overlays to determine proximity to airports (***Figure 1***), published instrument procedures, enroute airways, FAA minimum vectoring altitude and minimum instrument flight rules (IFR) altitude charts, as well as military airspace and training routes.

Capitol Airspace evaluated all 14 CFR Part 77 imaginary surfaces, published instrument approach and departure procedures, visual flight rules operations, FAA minimum vectoring altitudes, minimum IFR altitudes, and enroute operations. All formulas, headings, altitudes, bearings and coordinates used during this study were derived from the following documents and data sources:

- 14 CFR Part 77 Safe, Efficient Use, and Preservation of the Navigable Airspace
- FAA Order 7400.2N Procedures for Handling Airspace Matters
- FAA Order 8260.3E United States Standard for Terminal Instrument Procedures
- FAA Order 8260.58B United States Standard for Performance Based Navigational (PBN) Instrument Procedure Design
- Technical Operations Evaluation Desk Guide for Obstruction Evaluation/Airport Airspace Analysis (1.5.1)
- United States Government Flight Information Publication, US Terminal Procedures
- National Airspace System Resource Aeronautical Data

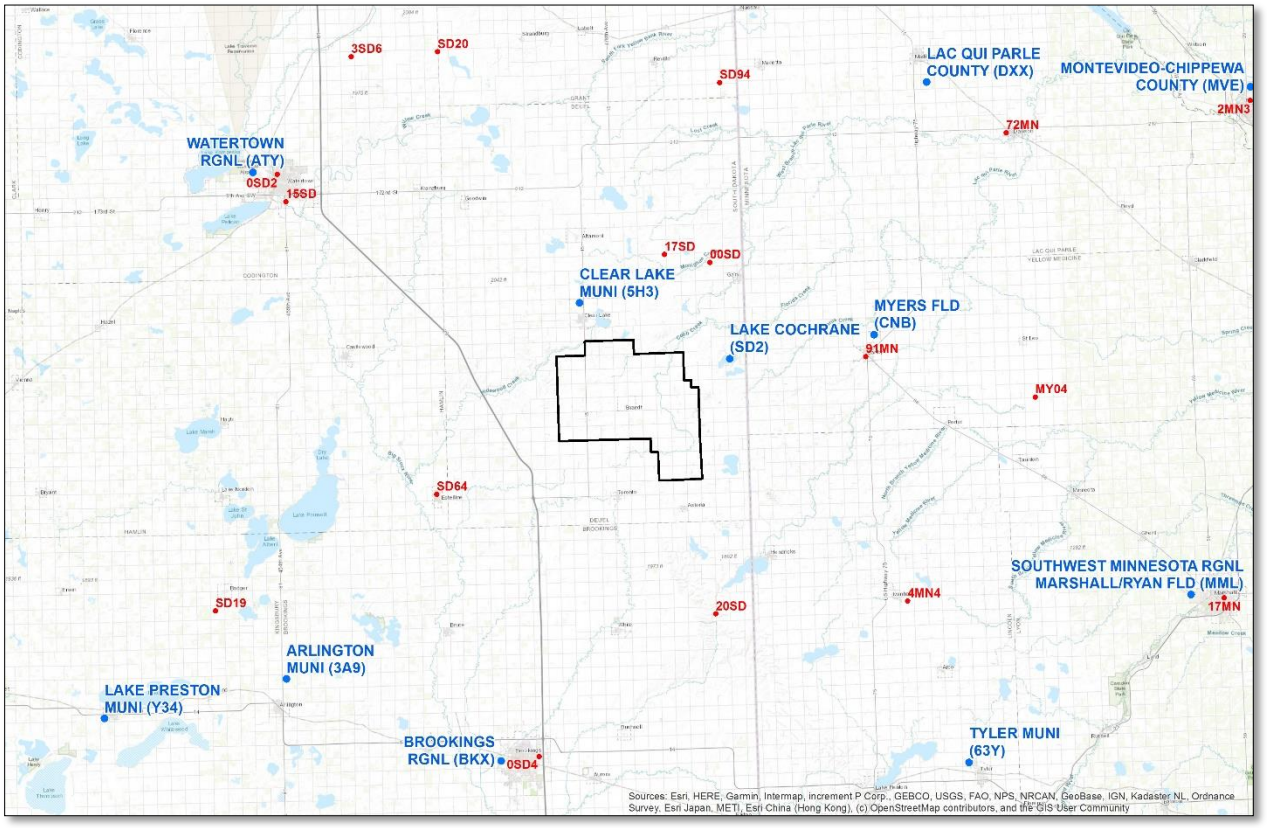

Figure 1: Public-use (blue) and private-use (red) airports in proximity to the South Deuel wind project

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Study Findings

14 CFR Part 77.17(a)(2) Obstruction Standard and 77.19/21/23 Imaginary Surfaces

The FAA uses level and sloping imaginary surfaces to determine if a proposed structure is an obstruction to air navigation. Structures that are identified as obstructions are then subject to a full aeronautical study and increased scrutiny. However, exceeding a Part 77 imaginary surface does not automatically result in the issuance of a determination of hazard. Proposed structures must have airspace impacts that constitute a substantial adverse effect in order to warrant the issuance of determinations of hazard.

14 CFR Part 77.17(a)(2) obstruction standards (dashed blue outline, ***Figure 2***) overlying the South Deuel wind project:

Lake Cochrane (SD2) [1]
77.17(a)(2): 1,939 to 2,338 feet AMSL

At 551, 591, and 640-feet AGL, proposed wind turbines in the eastern section of the study area (orange area, ***Figure 2***) will exceed this standard and will be identified as obstructions. Additionally, at all of the proposed heights, wind turbines will exceed 77.17(a)(1) – a height of 499 feet AGL at the site of the object – and will be identified as obstructions regardless of location.

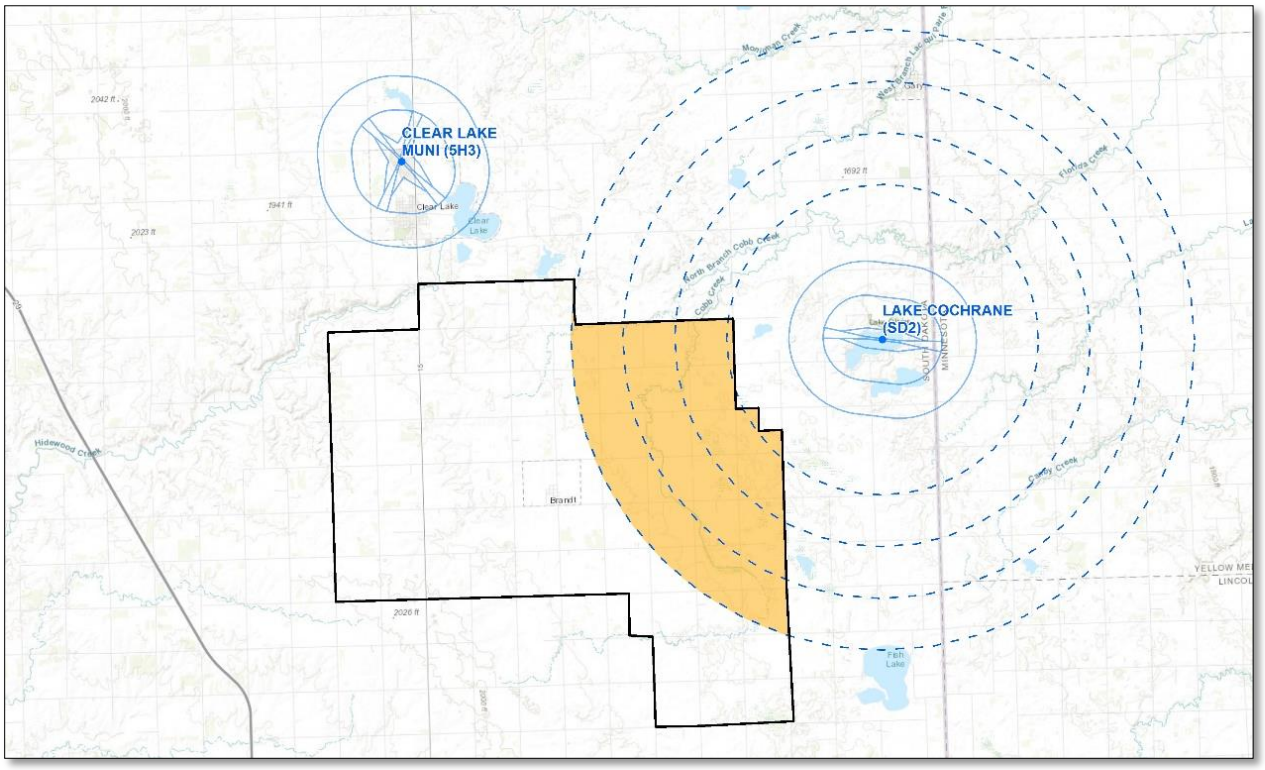

Figure 2: 77.17(a)(2) obstruction standard (dashed blue) and 77.19 imaginary surfaces (solid blue) in proximity to the South Deuel wind project

[1] Lake Cochrane (SD2) Is a seaplane base. Therefore, the FAA may choose not to apply the 14 CFR Part 77.17(a)(2) obstruction standard to this airport.

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Visual Flight Rules (VFR) Traffic Pattern Airspace

VFR traffic pattern airspace is used by pilots operating during visual meteorological conditions (VMC). The airspace dimensions are based upon the category of aircraft which, in turn, is based upon the approach speed of the aircraft. 14 CFR Part 77.17(a)(2) and 77.19 (as applied to a *visual* runway) imaginary surfaces establish the obstacle clearance surface heights within VFR traffic pattern airspace.

Clear Lake Municipal (5H3) VFR traffic pattern airspace overlies the South Deuel wind project. While the FAA may initially protect for up to Category D VFR traffic pattern airspace (shaded gray, ***Figure 3***), not all airports are likely to support a significant volume of Category D operations. As a result, the FAA will apply VFR traffic pattern airspace considering the airport's likely operations and runway physical characteristics (***Table 1***).

The likely VFR traffic pattern airspace (purple outline, ***Figure 3***) does not overlie the South Deuel wind project and should not limit 551, 591, or 640-foot AGL wind turbines within the defined study area.

Table 1: Runway physical characteristics and likely VFR traffic pattern application

	Status	Dimensions (Feet)	Weight Bearing Capacity (Pounds)	Surface Type	Potential VFR Traffic Pattern Category	Likely VFR Traffic Pattern Category
Clear Lake Municipal (5H3)[2]						
Runway 02/20	Existing	2,130 x 150	N/A	Turf	-	B
Runway 13/31	Existing	3,000 x 150	N/A	Turf	-	B

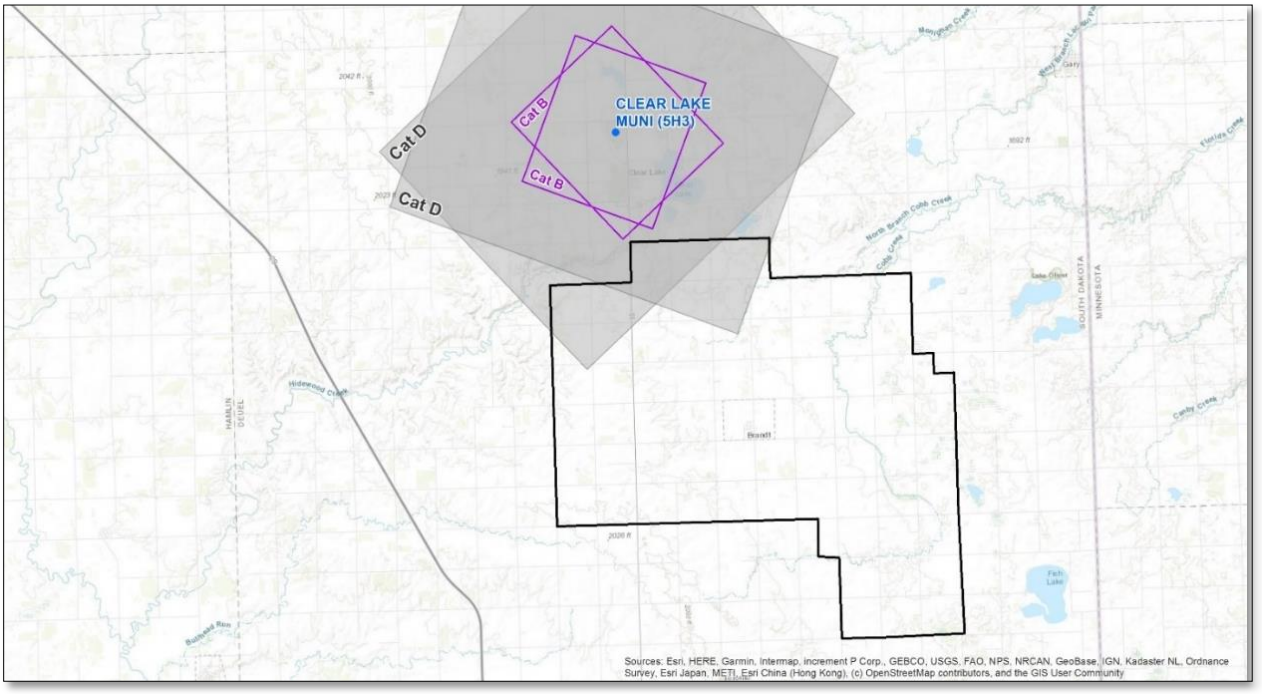

Figure 3: Clear Lake Municipal (5H3) VFR traffic pattern airspace and the South Deuel wind project

[2] Clear Lake Municipal (5H3) has a "plan on file" with the FAA to close. However, until this process is completed, the FAA will continue to protect Clear Lake Municipal (5H3) airspace.

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Visual Flight Rules (VFR) Routes

During periods of marginal VMC – low cloud ceilings and one statute mile visibility – pilots often operate below the floor of controlled airspace. Operating under these weather conditions requires pilots to remain within one statute mile of recognizable landmarks such as roads, rivers, and railroad tracks. The FAA protects for known and regularly used VFR routes by limiting structure heights within two statute miles of these routes to no greater than 14 CFR Part 77.17(a)(1) – a height of 499 feet AGL at the site of the object.

The South Deuel wind project is located in proximity to rivers, highways, and transmission lines that could be used as VFR routes (***Figure 4***). There is no dataset that identifies VFR routes or their utilization. However, a traffic flow analysis can be conducted to assess historical radar flight track data and identify regularly used low-level routes.[3] If the FAA determines that VFR routes are flown regularly (as few as one operation per day), they could limit wind development in excess of 499 feet AGL and within two statute miles of these landmarks (hatched purple, ***Figure 4***).

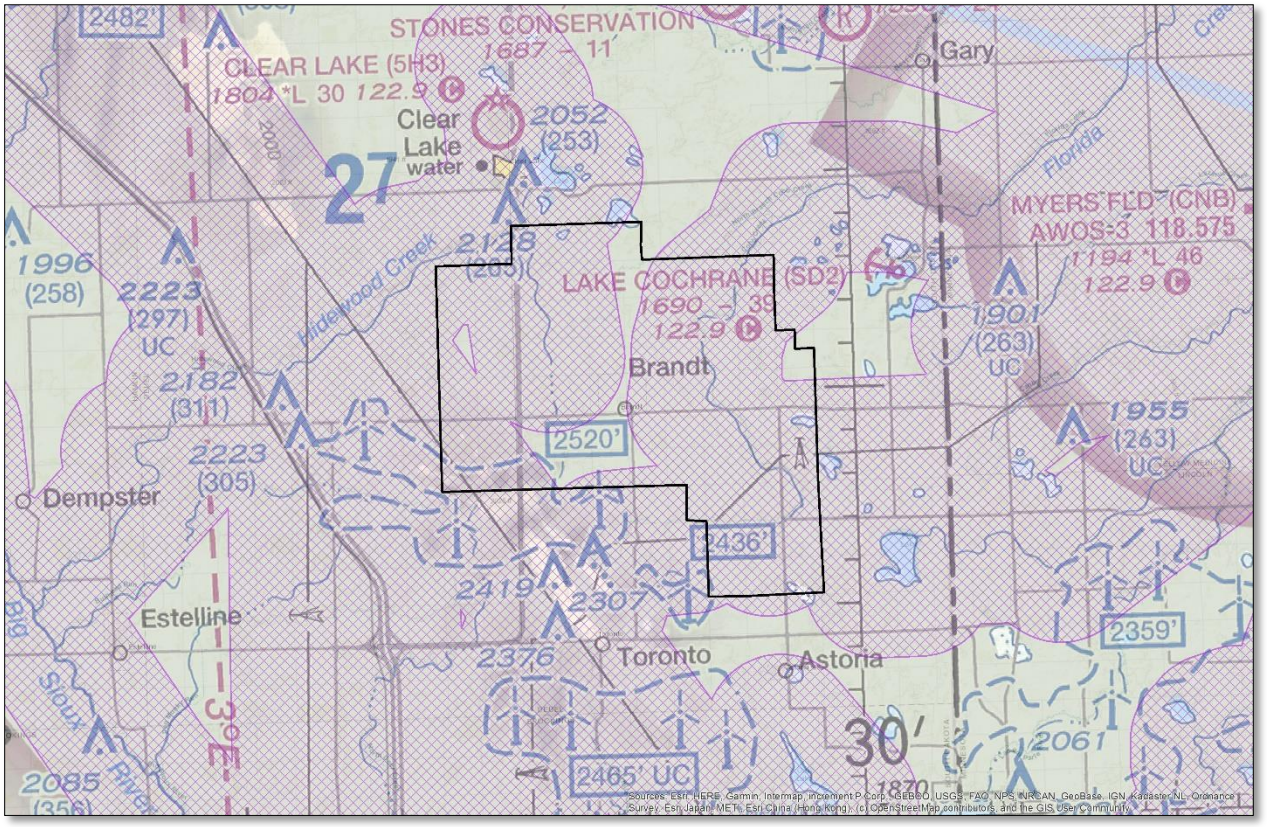

Figure 4: Potential VFR routes in proximity to the South Deuel wind project

[3] Radar coverage must be adequate to detect low level VFR flights.

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Instrument Departures

In order to ensure that aircraft departing during marginal weather conditions do not fly into terrain or obstacles, the FAA publishes instrument departure procedures that provide obstacle clearance to pilots as they transition between the terminal and enroute environments. These procedures contain specific routing and minimum climb gradients to ensure clearance from terrain and obstacles.

Proposed structures that exceed instrument departure procedure obstacle clearance surfaces would require an increase to instrument departure procedure minimum climb gradients. If the FAA determines that this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard.

Instrument departure procedure obstacle clearance surfaces (e.g., ***Figure 5***) are in excess of other, lower surfaces and should not limit 551, 591, or 640-foot AGL wind turbines within the defined study area.

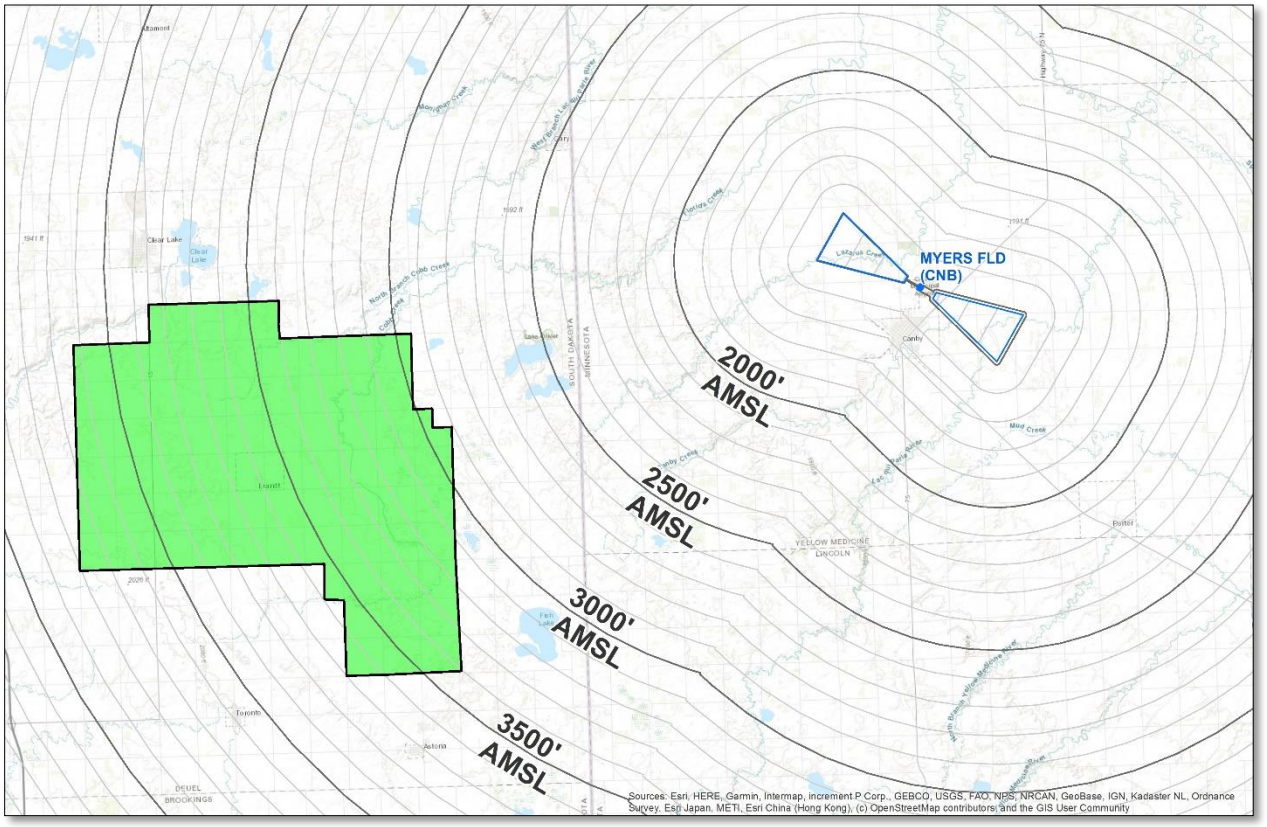

Figure 5: Myers Field (CNB) diverse departure procedure assessment

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Instrument Approaches

Pilots operating during periods of reduced visibility and low cloud ceilings rely on terrestrial and satellite based navigational aids (NAVAIDS) in order to navigate from one point to another and to locate runways. The FAA publishes instrument approach procedures that provide course guidance to on-board avionics that aid the pilot in locating the runway. Capitol Airspace assessed 15 published instrument approach procedures at five public-use airports in proximity to the South Deuel wind project: [4]

Brookings Regional (BKX)
ILS or Localizer Approach to Runway 12
RNAV (GPS) Approach to Runway 12
RNAV (GPS) Approach to Runway 30

Lac Qui Parle County (DXX)
RNAV (GPS) Approach to Runway 14
RNAV (GPS) Approach to Runway 32

Myers Field- Canby Municipal (CNB)
RNAV (GPS) Approach to Runway 12
RNAV (GPS) Approach to Runway 30

Milbank Municipal (1D1)
RNAV (GPS) Approach to Runway 31

Watertown Regional (ATY)
ILS or Localizer Approach to Runway 35
RNAV (GPS) Approach to Runway 12
RNAV (GPS) Approach to Runway 17
RNAV (GPS) Approach to Runway 30
RNAV (GPS) Approach to Runway 35
Localizer Back Course Approach to Runway 17
VOR or TACAN Approach to Runway 17

Proposed structures that exceed instrument approach procedure obstacle clearance surfaces would require an increase to their minimum altitudes. Increases to these altitudes, especially critical *decision altitudes (DA)* and *minimum descent altitudes (MDA)*, can directly impact the efficiency of instrument approach procedures. If the FAA determines this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard. [5]

[4] Capitol Airspace assessed instrument approach procedures within 30 nautical miles (NM) of the study area. Although approach surfaces – including terminal arrival areas (TAA), feeder segments, and initial segments – from airports further than 30 NM may overlie the study area, the obstacle clearance surfaces present a lower risk to projects than the surfaces identified in this report. Therefore, height constraints associated with instrument approach surfaces for airports beyond 30 NM were not considered and are not included in the ***Composite Map***.

[5] Multiple minimum safe altitudes (MSA) overlie the study area. However, in accordance with FAA Order 7400.2N Paragraph 6-3-9(e)(5), minimum safe altitudes (MSA) are for emergency use only and cannot be used as the basis for determinations of hazard. Therefore, height constraints associated with MSAs were not considered and are not included in the ***Composite Map***.

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Milbank Municipal (1D1)

RNAV (GPS) Approach to Runway 31

The *30 NM to IYJER* straight-in terminal arrival area (TAA) minimum altitude is 3,600 feet AMSL. The obstacle clearance surface (hatched blue, ***Figure 6***) is 2,600 feet AMSL and is one of the lowest height constraints overlying the entire study area. USGS elevation data indicates that this surface could limit 591 and 640-foot AGL wind turbines in the southwestern section of the study area (orange and yellow areas, ***Figure 6***). However, it is possible that the FAA would increase the TAA minimum altitude to accommodate wind development up to 640 feet AGL. This mitigation option is subject to FAA approval.

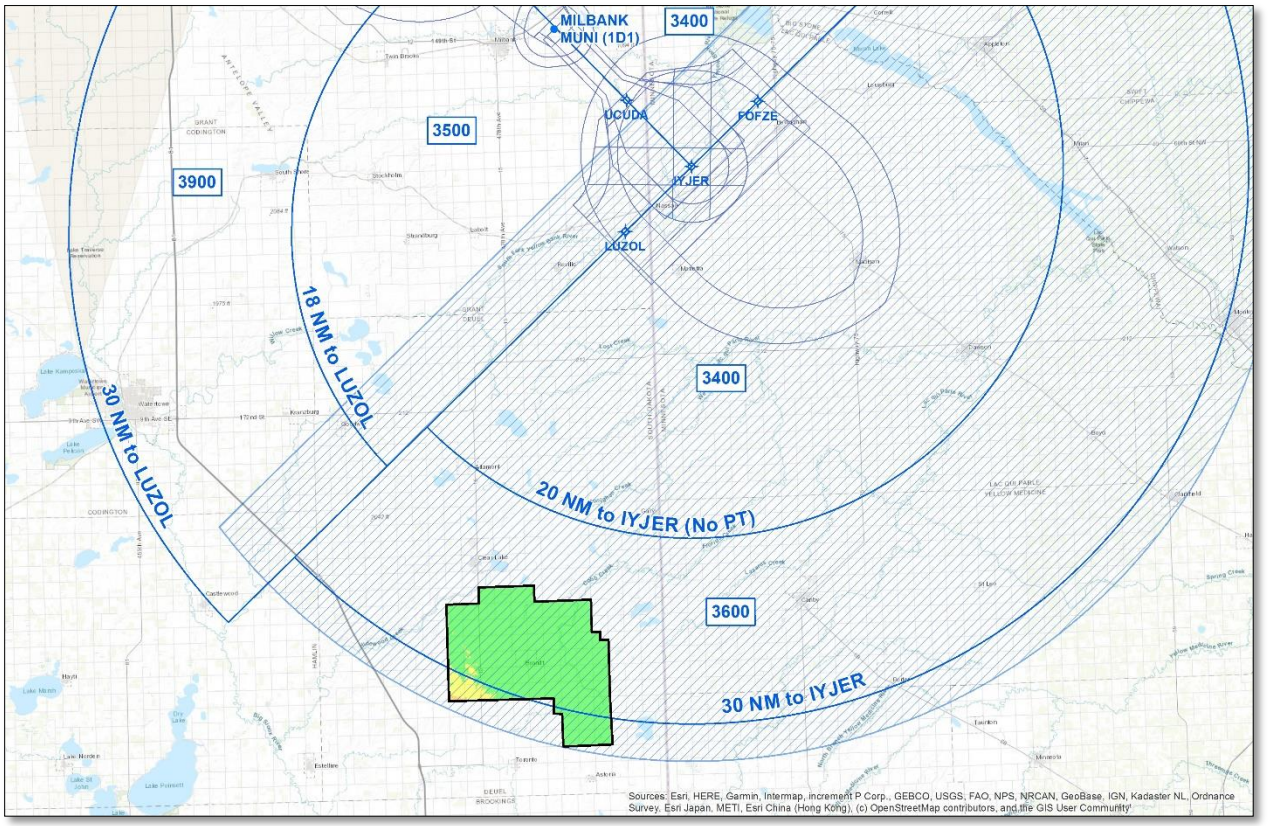

Figure 6: Milbank Municipal (1D1) RNAV (GPS) Approach to Runway 31 with 30 NM to IYJER straight-in TAA obstacle evaluation area (hatched blue)

Watertown Regional (ATY)

RNAV (GPS) Approach to Runway 12

The *DELDE* missed approach holding pattern minimum holding altitude (MHA) is 3,600 feet AMSL. The primary area obstacle clearance surface (inner purple outline, ***Figure 7***) is 2,600 feet AMSL and is one of the lowest height constraints overlying the northwestern section of the study area. However, USGS elevation data indicates this surface should not limit 551, 591, or 640-foot AGL wind turbines within the defined study area (green area, ***Figure 7***).

RNAV (GPS) Approach to Runway 30

The *DELDE* hold-in-lieu of procedure turn MHA is 3,600 feet AMSL. The primary area obstacle clearance surface (inner purple outline, ***Figure 7***) is 2,600 feet AMSL and is one of the lowest height constraints overlying the northwestern section of the study area. However, USGS elevation data indicates this surface should not limit 551, 591, or 640-foot AGL wind turbines within the defined study area (green area, ***Figure 7***).

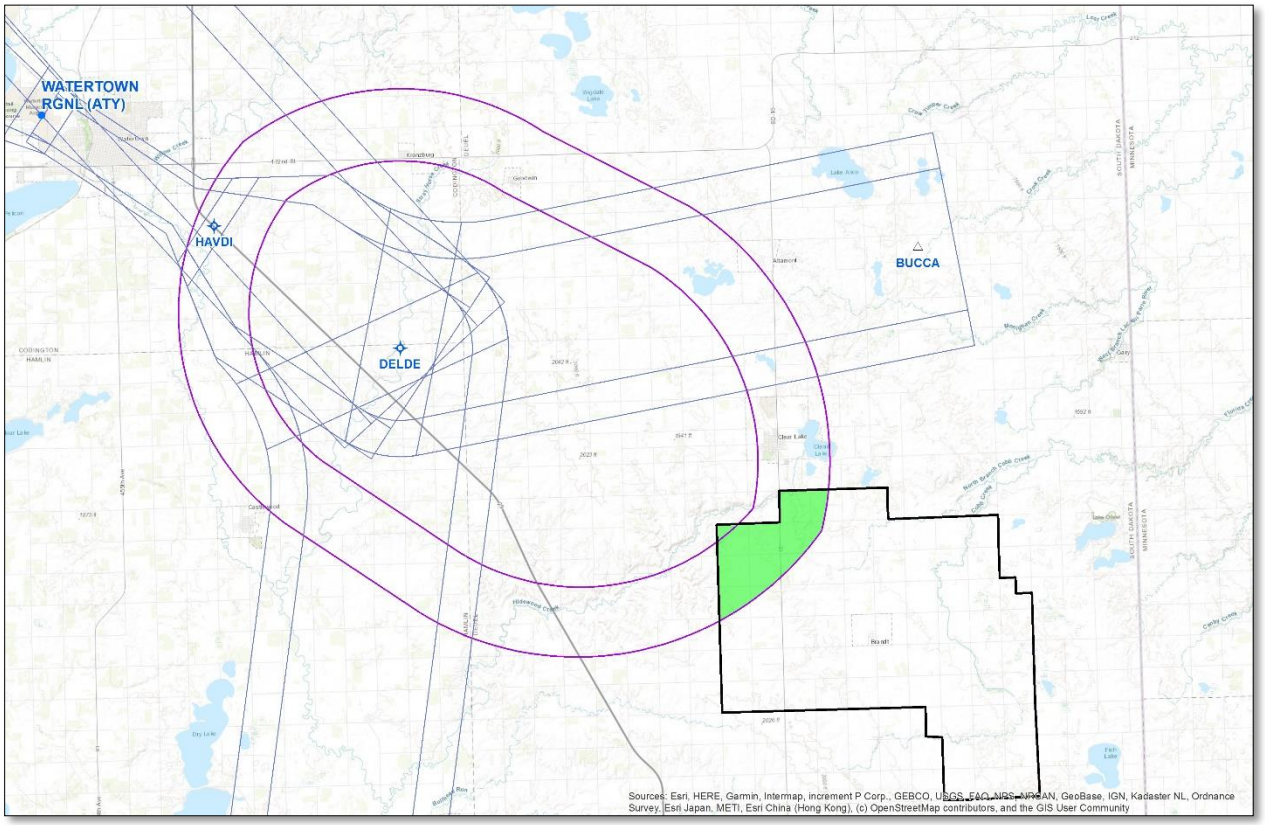

Figure 7: Watertown Regional (ATY) RNAV (GPS) Approach to Runway 30

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Enroute Airways

Enroute airways provide pilots a means of navigation when flying from airport to airport and are defined by radials between VHF omni-directional ranges (VORs). The FAA publishes minimum altitudes for airways to ensure clearance from obstacles and terrain. The FAA requires that each airway have a minimum obstacle clearance of 1,000 feet in non-mountainous areas and normally 2,000 feet in mountainous areas.

Proposed structures that exceed enroute airway obstacle clearance surfaces would require an increase to their minimum obstruction clearance altitudes (MOCA) and/or minimum enroute altitudes (MEA). If the FAA determines that this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard.

Low altitude enroute airway obstacle clearance surfaces (e.g., ***Figure 8***) do not overlie the South Deuel wind project and should not limit 551, 591, or 640-foot AGL wind turbines within the defined study area.

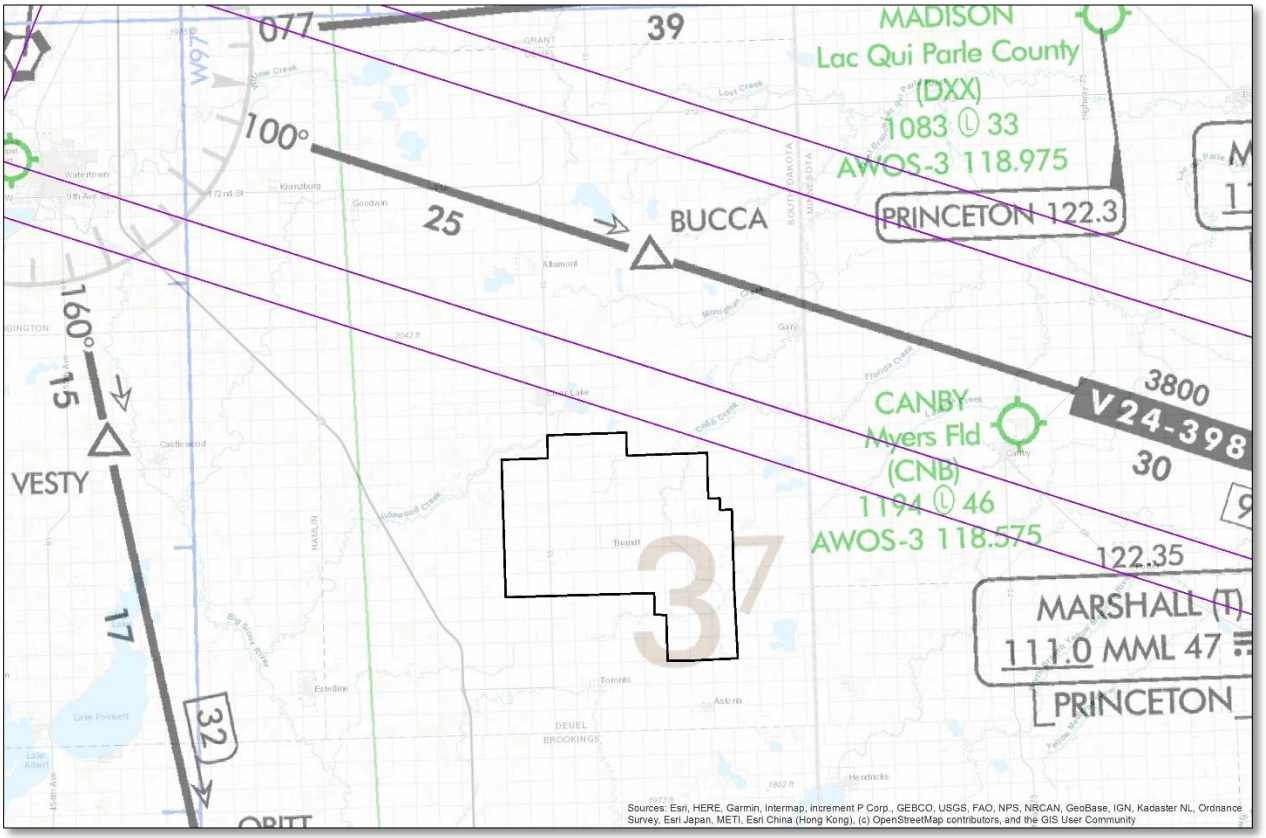

Figure 8: Low altitude enroute chart L-12 with V24-398 obstacle evaluation areas (purple)

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Minimum Vectoring/IFR Altitudes

The FAA publishes minimum vectoring altitude (MVA) and minimum instrument flight rules (IFR) altitude (MIA) charts that define sectors with the lowest altitudes at which air traffic controllers can issue radar vectors to aircraft based on obstacle clearance. The FAA requires that sectors have a minimum obstacle clearance of 1,000 feet in non-mountainous areas and normally 2,000 feet in mountainous areas.

Proposed structures that exceed MVA/MIA sector obstacle clearance surfaces would require an increase to the altitudes usable by air traffic control for vectoring aircraft. If the FAA determines that this impact would affect as few as one operation per week, it could result in determinations of hazard.

Minneapolis (ZMP) Air Route Traffic Control Center (ARTCC)

Sector PFSD01 (ZMP_TAV_2020)

The MIA is 3,600 feet AMSL. The obstacle clearance surface (hatched blue, ***Figure 9***) is 2,649 feet AMSL and is in excess of other, lower surfaces. However, USGS elevation data indicates that this surface could still limit 640-foot AGL wind turbines in the southwestern corner of the study area (yellow area within yellow box, ***Figure 9***).

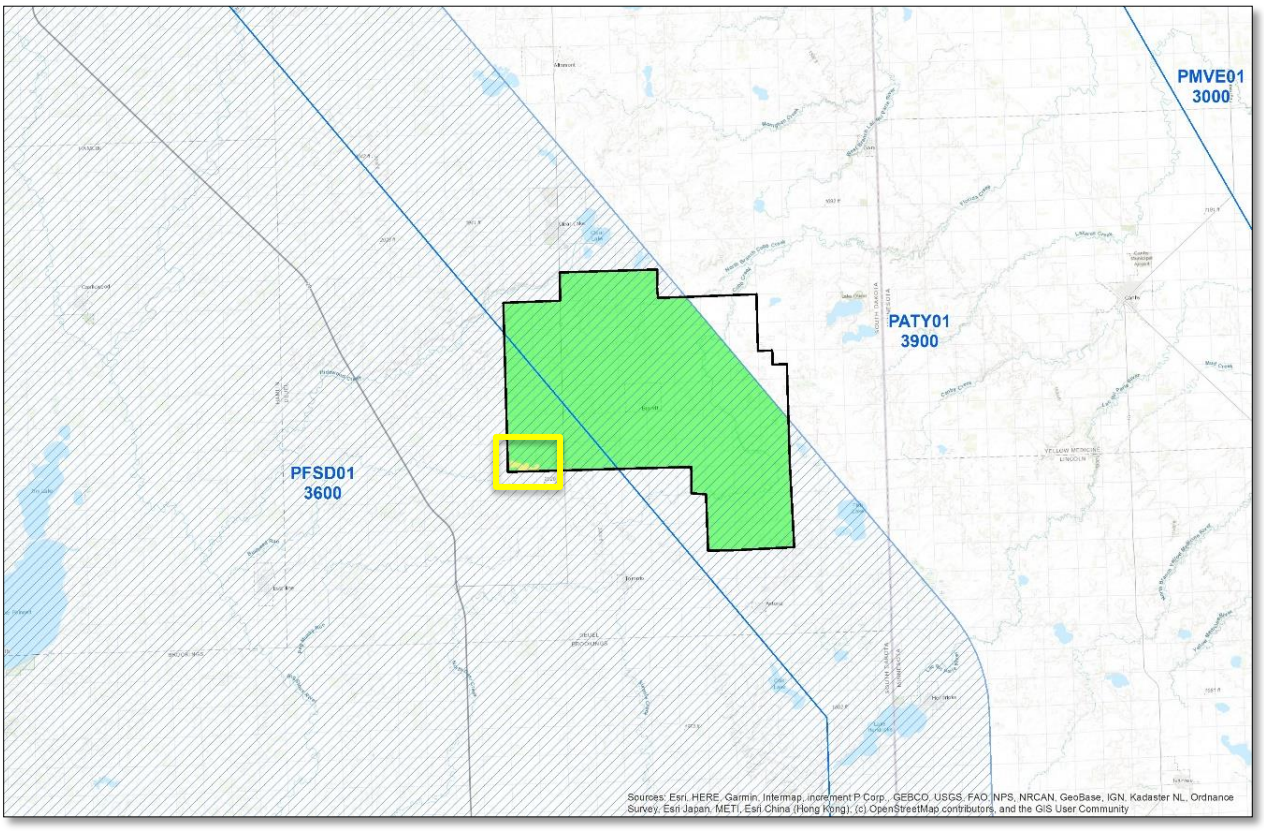

Figure 9: Minneapolis (ZMP) ARTCC MIA sectors (blue) with Sector PFSD01 obstacle evaluation area (hatched blue)

Terminal and Enroute Navigational Aids

The FAA has established protection areas in order to identify proposed structures that may have a physical and/or electromagnetic effect on navigational aids (NAVAIDs). The protection area dimensions vary based on the proposed structure type as well as the NAVAID type. Proposed structures within these areas may interfere with NAVAID services and will require further review by FAA Technical Operations. If further review determines that proposed structures would have a significant physical and/or electromagnetic effect on NAVAIDs, it could result in determinations of hazard.

NAVAID protection areas do not overlie the South Deuel wind project (***Figure 10***). As a result, it is unlikely that proposed wind turbines would have a physical or electromagnetic effect on terminal or enroute NAVAIDs.

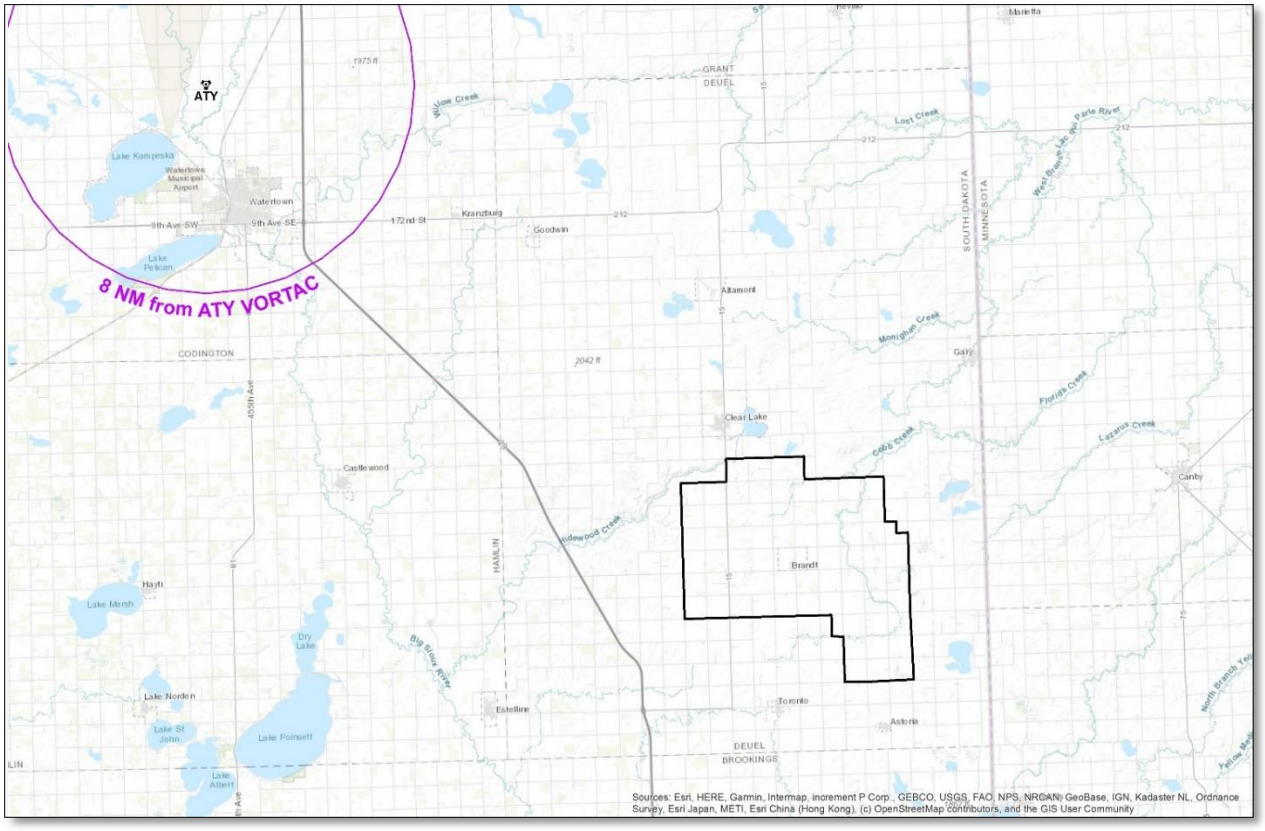

Figure 10: Watertown (ATY) VORTAC protection area and the South Deuel wind project

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Military Airspace and Training Routes

Although the FAA does not consider impact on military airspace or training routes, they will notify the military of proposed structures within these segments of airspace. Impact on these segments of airspace can result in military objections to the proposed development. If the planned development area is on federal land, impact on military airspace or training routes may result in the denial of permits by the Bureau of Land Management.

Military airspace and training routes do not overlie the South Deuel wind project (***Figure 11***). Therefore, these segments of airspace should not result in military objections to proposed wind development.

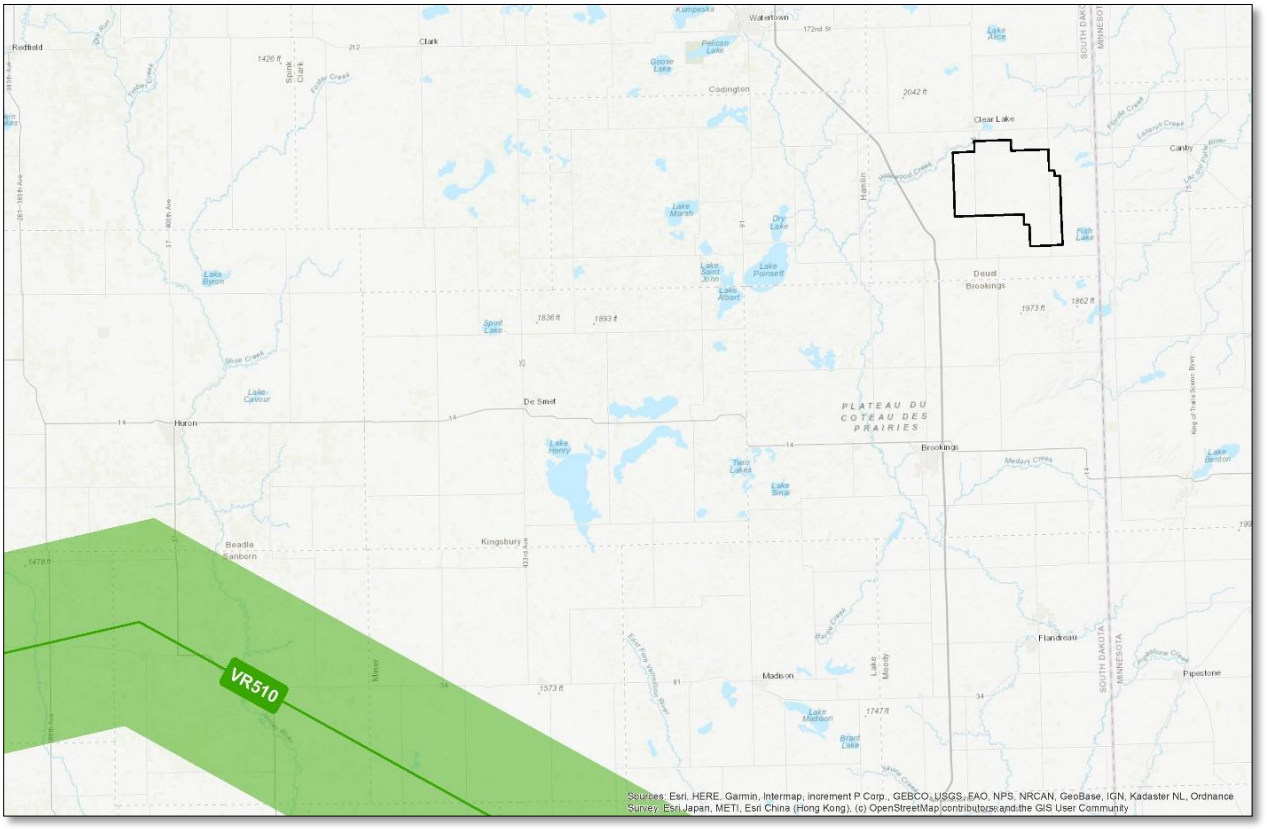

Figure 11: Military training routes in proximity to the South Deuel wind project

Conclusion

At 551, 591, and 640 feet AGL, wind turbines in the eastern section of the study area will exceed the Lake Cochrane Airport (SD2) 14 CFR Part 77.17(a)(2) obstruction standard (***Figure 2***) and will be identified as obstructions. Additionally, at 551, 591 and 640 feet AGL, proposed wind turbines will exceed 14 CFR Part 77.17(a)(1) – a height of 499 feet above ground level at the site of the object – and will be identified as obstructions regardless of their location. However, exceeding these standards does not automatically result in the issuance of a determination of hazard. Proposed structures must have airspace impacts that constitute a substantial adverse effect in order to warrant the issuance of determinations of hazard.

The lowest obstacle clearance surfaces overlying the South Deuel wind project are 2,600 feet AMSL (***Figure 12***) and are associated with instrument approach procedures. USGS elevation data indicates that these surfaces could limit 591 and 640-foot AGL wind turbines in the southwestern section of the study area (orange and yellow areas, ***Figure 13***).

At 591 and 640 feet AGL, proposed wind turbines in the southwestern section of the study area (orange and yellow areas, ***Figure 6***) will require an increase to a Milbank Municipal (1D1) RNAV (GPS) Approach to Runway 31 TAA minimum altitude. However, the FAA may be willing to increase this altitude to accommodate wind development up to 640 feet AGL. This mitigation option is subject to FAA approval.

At 640 feet AGL, proposed wind turbines in the southwestern corner of the study area (yellow area, ***Figure 9***) will require an increase to the Minneapolis (ZMP) ARTCC Sector PFSD01 MIA. If the FAA determines that this impact would affect as few as one radar vectoring operation per week, it could result in determinations of hazard.

The AGL Clearance Map (***Figure 13***) is based on USGS National Elevation Dataset (NED) 1/3 Arc Second data which has a vertical accuracy of 1.89 meters root-mean-square error (RMSE). Therefore, the AGL Clearance Map should only be used for general planning purposes and not exact structure siting. In order to avoid determinations of hazard, proposed structure heights should adhere to the height constraints depicted in the Composite Map (***Figure 12***).

If you have any questions regarding the findings of this study, please contact ***James Scott*** or ***Marie Ramos*** at (703) 256-2485.

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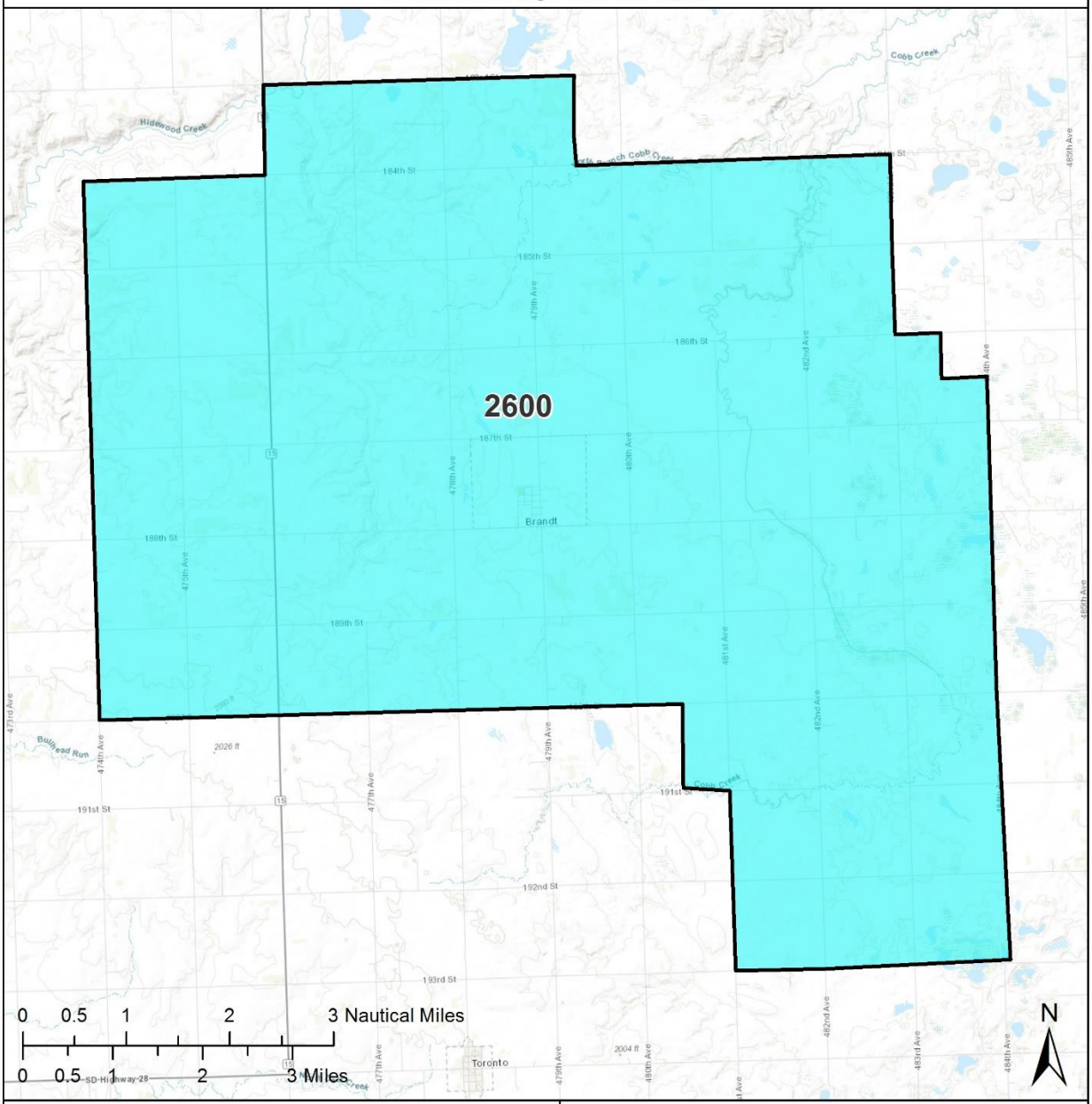
Proposed structures that exceed 14 CFR Part 77.17(a)(1) - a height of 499 feet AGL at the site of the object - will be identified as obstructions regardless of location.



Obstacle Clearance Surface

Height - AMSL Feet

2,600

All heights are above mean sea level (AMSL)

South Deuel Wind Project
Composite Height Constraint Map

Plot Date:
6 July 2021

Coordinate System:
NAD 1983 UTM Zone 14N

Marie Ramos

Figure 12

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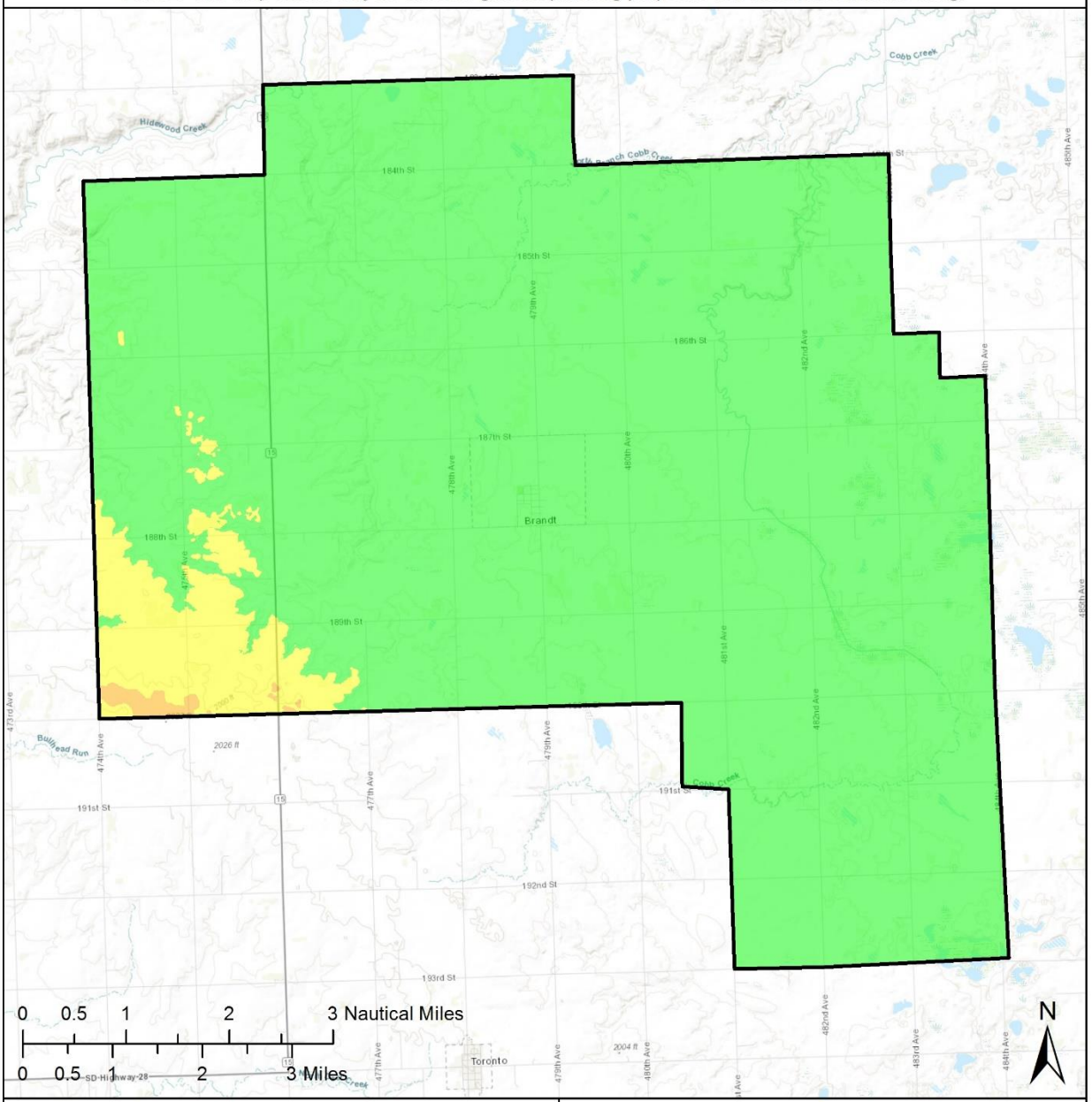
The USGS 1/3 Arc Second Digital Elevation Model (DEM) data used to create this map has a vertical accuracy of 1.89 meters RMSE. This map should only be used for general planning purposes and not exact structure siting.



Clearance

Height - AGL Feet

- < 551
- ≥ 551 < 591
- ≥ 591 < 640
- ≥ 640

South Deuel Wind Project
Above Ground Level (AGL) Clearance Map

Plot Date:
6 July 2021

Figure 13

Coordinate System:
NAD 1983 UTM Zone 14N

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