Enclosure 2

(Ref. Technical Letter F500-L15-021)

MITRE

Center for Advanced
Aviation System Development

Nuevo Aeropuerto Internacional de la Ciudad de México

Assessment of International Civil Aviation Organization Annex 14 Obstacle Limitation Surfaces

Prepared for

Aeropuertos y Servicios Auxiliares

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Principal Acronyms and Abbreviations

AGL	Above Ground Level
AIP	Aeronautical Information Publication
ASA	Aeropuertos y Servicios Auxiliares
CAT	Category
CFR	Code of Federal Regulations
DGAC	Dirección General de Aeronáutica Civil
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
INT	Intersection
MITRE	The MITRE Corporation
MSL	Mean Sea Level
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México
NGA	National Geospatial-Intelligence Agency
OFZ	Obstacle Free Zone
OLS	Obstacle Limitation Surfaces
SARPs	Standards and Recommended Practices
TERPS	Terminal Instrument Procedures
U.S.	United States
UTM	Universal Transverse Mercator
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni Directional Range
WGS84	World Geodetic System 1984

1. Introduction

The MITRE Corporation (MITRE) works as an independent advisor to Aeropuertos y Servicios Auxiliares (ASA) on aeronautical matters pertaining to the Nuevo Aeropuerto Internacional de la Ciudad de México (NAICM). In this capacity, MITRE has analyzed various alternative runway configurations, and performed related analyses. One of MITRE's tasks is to analyze relevant obstacle limitation surfaces (defined below) in order to identify potential obstacles to air navigation in support of the development of instrument approach and departure procedures (refer to enclosure 1 to MITRE Technical Letter F500-L15-021 for details on MITRE's procedure design work for NAICM). That analysis is the subject of this report.

This report is organized as follows. Section 2 gives a brief outline of the role played by the International Civil Aviation Organization (ICAO) in airport safety. Section 3 describes the ICAO Obstacle Limitation Surfaces (OLS) that must be evaluated to ensure that critical areas at and near airports are kept free of obstacles that could adversely affect safety. Section 4 describes the NAICM runway configuration that was evaluated. Section 5 describes the methodology used in this analysis. Section 6 gives the results of the analysis. Section 7 provides closing remarks. Following that, the references used in the analysis are listed. Appendix A provides some information regarding the United States (U.S.) Federal Aviation Administration (FAA) process for conducting aeronautical studies. Finally, Appendix B provides some additional profile views of the Annex 14 OLS.

2. ICAO's Role in Airport Safety

The articles of the Convention on International Civil Aviation [1] were signed in Chicago, Illinois, U.S., on 7 December 1944. They established certain principles and arrangements for international civil aviation. The articles of this Convention, commonly referred to as the "Chicago Convention," provided the legal instrument necessary for the efficient and orderly development of international civil aviation. The Chicago Convention was signed by 52 States in December 1944. Ratification of the convention by 26 States occurred in April 1947. Today there are approximately 200 Contracting States to the Chicago Convention, making it one of the world's most widely accepted international legal instruments.

The Chicago Convention established ICAO, which became a specialized agency of the United Nations. The primary objectives of ICAO are to develop uniform principles and techniques of international air navigation and to foster the planning and development of international air transport.

The 96 articles of the Chicago Convention establish the privileges and restrictions of all Contracting States, provide for the adoption of international Standards and Recommended Practices (SARPs) regulating air navigation, recommend the installation of navigation facilities by Contracting States, and suggest the facilitation of air transport by the reduction of customs and immigration formalities.

Standards are specifications concerning physical characteristics, configurations, material, performance, personnel or procedures, where the uniform application of which is recognized as necessary for the safety or regularity of international air navigation and to which *Contracting States will conform* in accordance with the Chicago Convention. When a State is unable to comply with a standard, that State must notify ICAO of the noncompliance, called a difference. In addition to submitting differences, ICAO requires that States publish their differences through their Aeronautical Information Service when the notification of such differences is important to the safety of air navigation.

Recommended Practices are specifications concerning physical characteristics, configuration, material, performance, personnel or procedures, where the uniform application of which are recognized as desirable in the interest of safety, regularity, or efficiency of international air navigation. *Contracting States will endeavor to conform* to Recommended Practices in accordance with the Convention.

The technical provisions of ICAO are published in 19 Annexes that are listed below. There are a number of supporting documents to the Annexes, which are not listed below, but are referred to in applicable sections of this assessment.

Annex 1: *Personnel Licensing*
Annex 2: *Rules of the Air*
Annex 3: *Meteorological Service for International Air Navigation*
Annex 4: *Aeronautical Charts*
Annex 5: *Units of Measurement to be used in Air and Ground Operations*
Annex 6: *Operation of Aircraft*
Annex 7: *Aircraft Nationality and Registration Marks*
Annex 8: *Airworthiness of Aircraft*
Annex 9: *Facilitation*
Annex 10: *Aeronautical Telecommunications*
Annex 11: *Air Traffic Services*
Annex 12: *Search and Rescue*
Annex 13: *Aircraft Accident and Incident Investigation*
Annex 14: *Aerodromes*
Annex 15: *Aeronautical Information Services*
Annex 16: *Environmental Protection*
Annex 17: *Security*
Annex 18: *The Safe Transport of Dangerous Goods by Air*
Annex 19: *Safety Management*

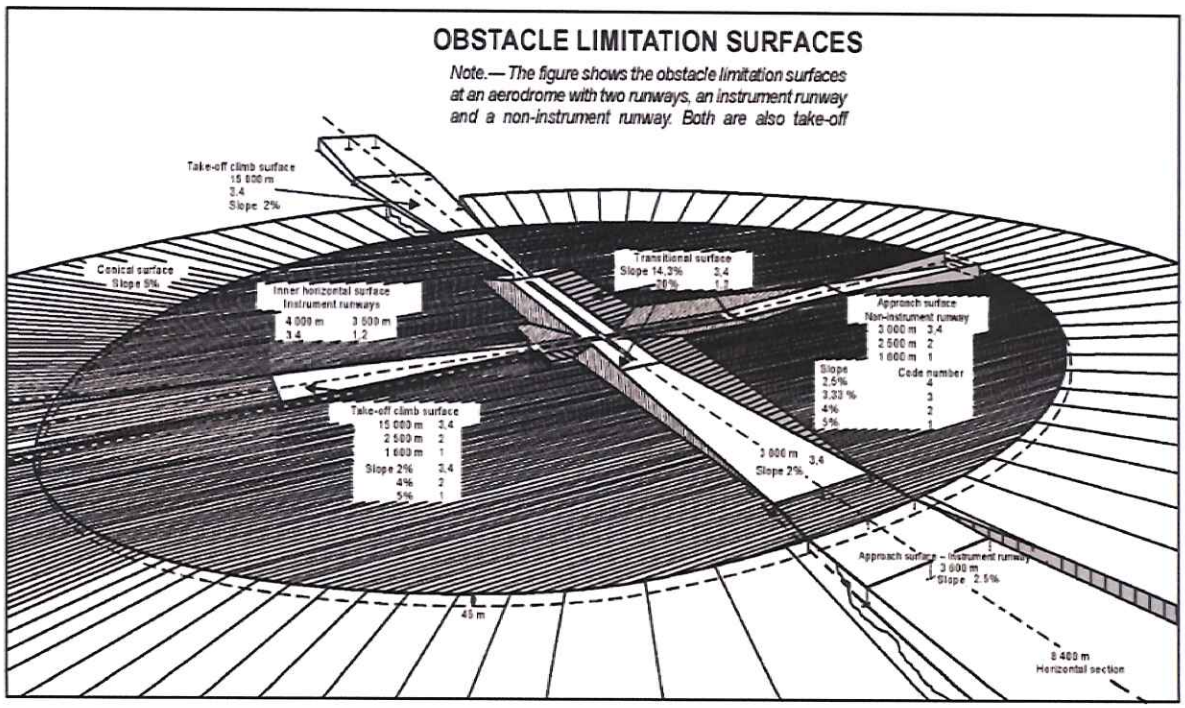
In addition to ICAO SARPs, MITRE also reviewed *Circular Obligatoria: Requisitos para Regular la Construcción, Modificación y Operación de los Aeródromos Civiles* [2], which complies with the specifications contained in Annex 14.

3. ICAO Obstacle Limitation Surfaces

A key element of the consideration of safety is the application of SARPs contained in ICAO Annex 14 [3], in particular, the evaluation of the ICAO Annex 14 OLS, described in this section.

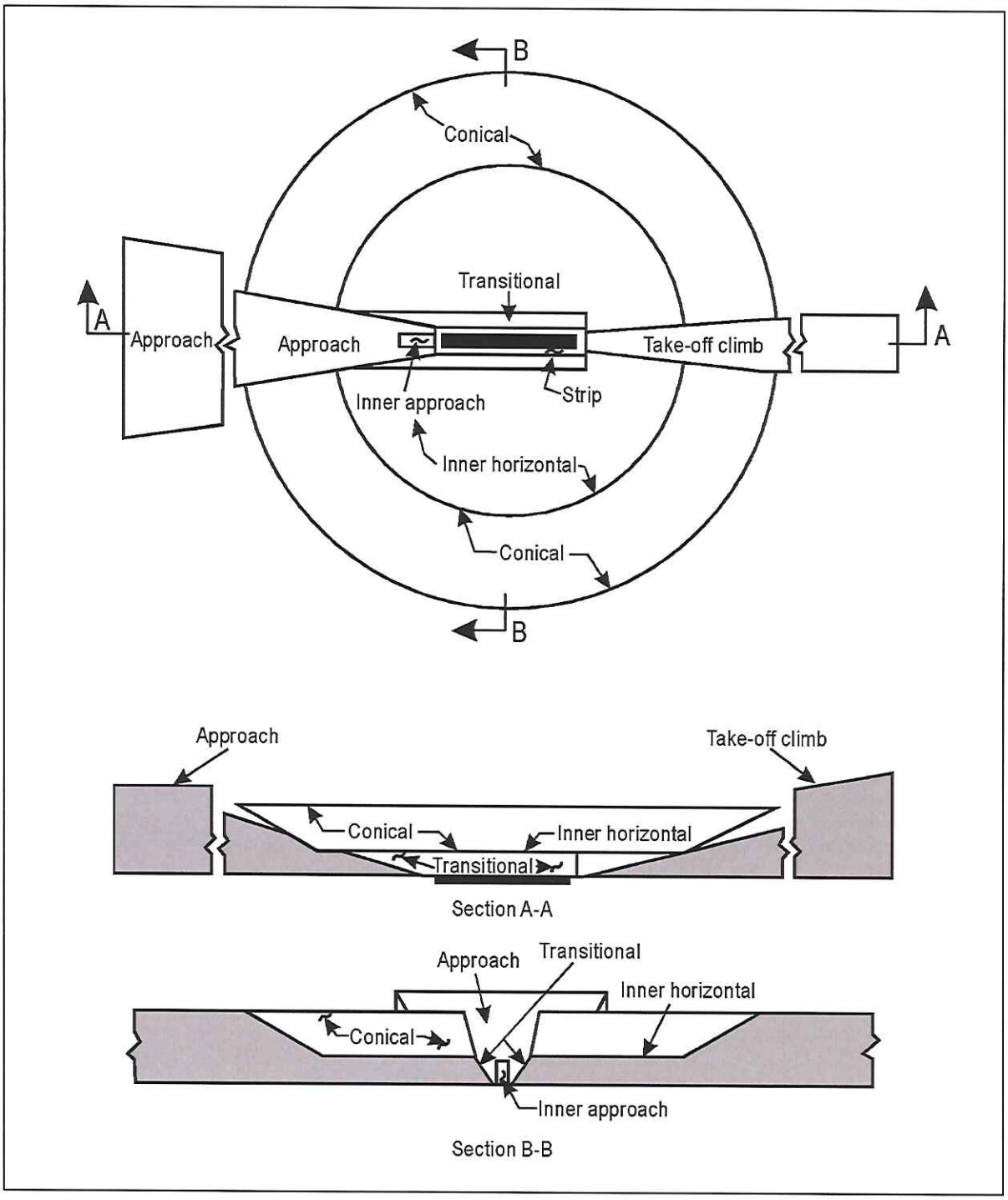
ICAO has established OLS around and over airports to be used for identifying obstacles to air navigation and preventing the development of obstacles that could adversely impact aircraft operations (see Figures 1 and 2). These surfaces define the limits of obstacle heights on and around the airport. Ideally, obstacles should not be allowed to penetrate these surfaces, to minimize dangers to aircraft either during a visual approach or during the visual segment of an instrument approach. Obstacles that do penetrate these surfaces should, as far as practicable, be removed. If an object cannot be removed, an aeronautical study should be conducted, to determine if the object would impact air navigation and significantly affect the regularity of operations. Examples of potential measures to alleviate the impact of an obstacle penetration (depending on the outcome of an aeronautical study) include removing the obstacle, marking and lighting it, publishing the location of the obstacle in the Aeronautical Information Publication (AIP), permanently displacing the threshold, limiting the use of the runway to certain types of approaches (e.g., instrument approaches), and restricting the type of traffic that may use the runway. Displacing the threshold, however, will result in a reduction of available landing distance. Consideration should be given to the operational impact of any threshold displacement on aircraft operations.

The dimensions and slopes of the Annex 14 OLS are shown in Table 1 (approach runways) and Table 2 (take-off runways).



Source: ICAO Annex 14

Figure 1. ICAO Annex 14 OLS (3-Dimensional View)



Source: ICAO Annex 14

Figure 2. ICAO Annex 14 OLS (Plan and Profile View)

Table 1. Dimensions and Slopes of ICAO Annex 14 OLS: Approach Runways

APPROACH RUNWAYS

	RUNWAY CLASSIFICATION									
	Non-instrument Code number				Non-precision approach Code number			Precision approach category I Code number		Precision approach category II or III Code number
Surface and dimensions[a]	1	2	3	4	1,2	3	4	1,2	3,4	3,4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35 m	55 m	75 m	100 m	60 m	75 m	100 m	60 m	100 m	100 m
INNER HORIZONTAL										
Height	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m
Radius	2 000 m	2 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m
INNER APPROACH										
Width	—	—	—	—	—	—	—	90 m	120 m[c]	120 m[c]
Distance from threshold	—	—	—	—	—	—	—	60 m	60 m	60 m
Length	—	—	—	—	—	—	—	900 m	900 m	900 m
Slope								2.5%	2%	2%
APPROACH										
Length of inner edge	60 m	80 m	150 m	150 m	150 m	300 m	300 m	150 m	300 m	300 m
Distance from threshold	30 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section										
Length	1 600 m	2 500 m	3 000 m	3 000 m	2 500 m	3 000 m	3 000 m	3 000 m	3 000 m	3 000 m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2.5%	2%	2%
Second section										
Length	—	—	—	—	—	3 600 m[b]	3 600 m[b]	12 000 m	3 600 m[b]	3 600 m[b]
Slope	—	—	—	—	—	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	—	—	—	—	—	8 400 m[b]	8 400 m[b]	—	8 400 m[b]	8 400 m[b]
Total length	—	—	—	—	—	15 000 m	15 000 m	15 000 m	15 000 m	15 000 m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	—	—	—	—	—	—	—	40%	33.3%	33.3%
BALKED LANDING SURFACE										
Length of inner edge	—	—	—	—	—	—	—	90 m	120 m[c]	120 m[c]
Distance from threshold	—	—	—	—	—	—	—	c	1 800 m[d]	1 800 m[d]
Divergence (each side)	—	—	—	—	—	—	—	10%	10%	10%
Slope	—	—	—	—	—	—	—	4%	3.33%	3.33%

a. All dimensions are measured horizontally unless specified otherwise.
b. Variable length (see 4.2.9 or 4.2.17).
c. Distance to the end of strip.
d. Or end of runway whichever is less.
e. Where the code letter is F (Column (3) of Table 1-1), the width is increased to 155 m. For information on code letter F aeroplanes equipped with digital avionics that provide steering commands to maintain an established track during the go-around manoeuvre, see Circular 301 — *New Larger Aeroplanes — Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study*.

Source: ICAO Annex 14

Table 2. Dimensions and Slopes of ICAO Annex 14 OLS: Take-off Runways

RUNWAYS MEANT FOR TAKE-OFF

Surface and dimensions[a] (1)	Code number 1 (2)	2 (3)	3 or 4 (4)
TAKE-OFF CLIMB			
Length of inner edge	60 m	80 m	180 m
Distance from runway end[b]	30 m	60 m	60 m
Divergence (each side)	10%	10%	12.5%
Final width	380 m	580 m	1 200 m 1 800 m[c]
Length	1 600 m	2 500 m	15 000 m
Slope	5%	4%	2%[d]

a. All dimensions are measured horizontally unless specified otherwise.
b. The take-off climb surface starts at the end of the clearway if the clearway length exceeds the specified distance.
c. 1 800 m when the intended track includes changes of heading greater than 15° for operations conducted in IMC, VMC by night.
d. See 4.2.24 and 4.2.26.

Source: ICAO Annex 14

Note that NAICM was evaluated consistent with ICAO aerodrome reference code 4F, per the definition given in ICAO Annex 14 [3]. Furthermore, each of the runways at NAICM was evaluated as Category (CAT) I precision approach. However, the OLS that must be established for CAT II/III precision approaches (i.e., the Inner Approach, Inner Transitional, and Balked Landing Surfaces) were also evaluated since those procedures are being considered by authorities for NAICM.

3.1 Conical Surface

The Conical Surface (along with the Inner Horizontal Surface) protects airspace for visual circling prior to landing. Visual circling is a maneuver used to align the aircraft with the runway for landing when a straight-in landing from an instrument approach is not feasible. The Conical Surface slopes upwards and outwards from the periphery of the Inner Horizontal Surface (defined below). The slope of the Conical Surface is measured in a vertical plane perpendicular to the periphery of the Inner Horizontal Surface. For NAICM, a slope of 5% (20:1) was applied.

The limits of the Conical Surface are the following:

- A lower edge coincident with the periphery of the Inner Horizontal Surface; and
- An upper edge located at a specified height above the Inner Horizontal Surface. For NAICM, a height of 100 m was used.

3.2 Inner Horizontal Surface

The purpose of the Inner Horizontal Surface (along with the Conical Surface) is to protect airspace for visual circling prior to landing. The Inner Horizontal Surface is located in a horizontal plane above an aerodrome and its environs. The height of the Inner Horizontal Surface is measured above an elevation datum established for such purpose. The radius or outer limits of the Inner Horizontal Surface is measured from a reference point or points established for such purpose. Guidance on determining the elevation datum and the extent of the Inner Horizontal Surface is contained in the Airport Services Manual (Doc 9137), Part 6 [4]. For NAICM, a height of 45 m, an elevation datum of 2223 m Mean Sea Level (MSL), and a radius of 4000 m were used.

3.3 Approach Surface

The Approach Surface defines the volume of airspace that should be kept free of obstacles in order to protect an aircraft in the final phase of landing. The Approach Surface is an inclined plane or combination of planes preceding the threshold, and composed of the following:

- An inner edge of specified length, horizontal and perpendicular to the extended centerline of the runway and located at a specified distance before the threshold;
- Two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the extended centerline of the runway;
- An outer edge parallel to the inner edge.

The above surfaces are varied when lateral offset, offset, or curved approaches are utilized, specifically, two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the extended centerline of the lateral offset, offset or curved ground track. The elevation of the inner edge is equal to the elevation of the midpoint of the threshold. The slope of the Approach Surface is measured in the vertical plane containing the centerline of the runway (and continues to contain the centerline of any lateral offset or curved ground track).

For NAICM, each Annex 14 Approach Surface has a slope of 2% (50:1) for the first 3000 m, and then the slope increases to 2.5% (40:1) until it intersects either a horizontal plane 150 m above the threshold elevation or the horizontal plane passing through the top of any object that governs the obstacle clearance limit, whichever is higher. The total length of the Approach Surface is 15,000 m. The Approach Surface has an inner edge of 300 m starting 60 m from the threshold and extending at a 15% divergence rate on both sides to 4800 m at the outer edge. A notional diagram of the Annex 14 Approach Surface is depicted in Figure 3.

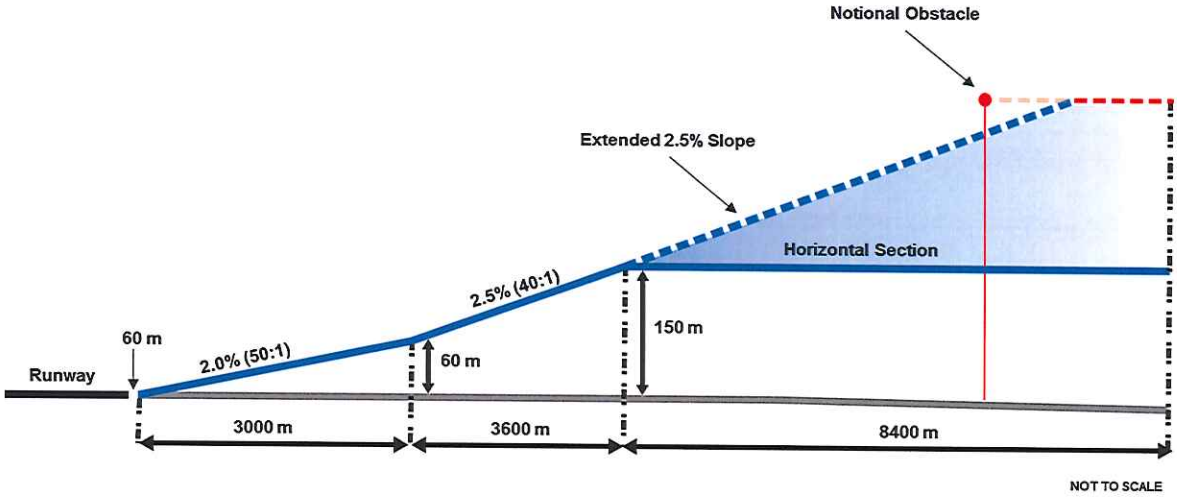


Figure 3. ICAO Annex 14 Approach Surface

3.4 Transitional Surface

The Transitional Surface (along with the Approach Surface) defines the volume of airspace that should be kept free of obstacles in order to protect an aircraft in the final phase of landing. The Transitional Surface is a complex surface along the side of the runway strip and part of the side of the Approach Surface, sloping upwards and outwards to the Inner Horizontal Surface, and composed of the following:

- A lower edge beginning at the intersection of the side of the Approach Surface with the Inner Horizontal Surface and extending down the side of the Approach Surface to the inner edge of the Approach Surface and from there along the length of the runway strip parallel to the runway centerline; and
- An upper edge located in the plane of the Inner Horizontal Surface.

The slope of the Transitional Surface is measured in a vertical plane at right angles to the centerline of the runway. For NAICM, a slope of 14.3% (7:1) was used. The elevation of a point on the lower edge is:

- Along the side of the Approach Surface — equal to the elevation of the Approach Surface at that point; and
- Along the runway strip — equal to the elevation of the nearest point on the centerline of the runway or its extension.

3.5 Take-off Climb Surface

The Take-off Climb Surface provides protection for an aircraft on take-off by indicating which obstacles should be removed, if possible, and marked and/or lighted if removal is impossible.

The Take-off Climb Surface is an inclined plane or other specified surface beyond the end of a runway or clearway, composed of the following:

- An inner edge, horizontal and perpendicular to the centerline of the runway and located either at a specified distance beyond the end of the runway or at the end of the clearway when such is provided and its length exceeds the specified distance;
- Two sides originating at the ends of the inner edge, diverging uniformly at a specified rate from the take-off track to a specified final width and continuing thereafter at that width for the remainder of the length of the Take-off Climb Surface; and
- An outer edge horizontal and perpendicular to the specified take-off track.

The elevation of the inner edge is equal to the highest point on the extended runway centerline between the end of the runway and the inner edge, except that when a clearway is provided the elevation shall be equal to the highest point on the ground on the centerline of the clearway.

For NAICM, a distance of 60 m from the runway end and a slope of 2% (50:1) were used. Each Take-off Climb Surface has an inner edge of 180 m and diverges on each side at a rate of 12.5%. It is important to note that the final width for a straight-out take-off track is 1200 m, and the final width is 1800 m if the intended flight track includes changes of heading greater than 15° or greater in Instrument Meteorological Conditions (IMC) or Visual Meteorological Conditions (VMC) at night. Both types of take-off tracks were assumed to exist at NAICM, and are based on MITRE's procedure development work, which was used to prove the feasibility of the MITRE Recommended Runway Configuration (July 2012), described in Section 4. A notional diagram of the Annex 14 Take-off Climb Surface is depicted in Figure 4, below.

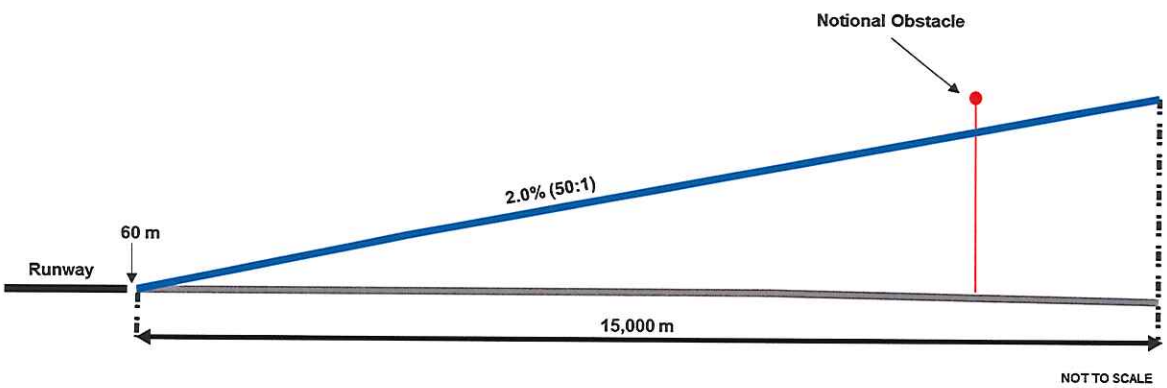


Figure 4. ICAO Annex 14 Take-off Climb Surface

3.6 Outer Horizontal Surface

The Outer Horizontal Surface is not required to be established for precision approaches. Therefore, the Outer Horizontal Surface was not evaluated by MITRE and is not shown in the figures contained in this document. The Airport Services Manual (Doc 9137), Part 6 [4] provides guidance for the establishment of an Outer Horizontal Surface to assist authorities in controlling the development of obstacles beyond the Annex 14 OLS mentioned above.

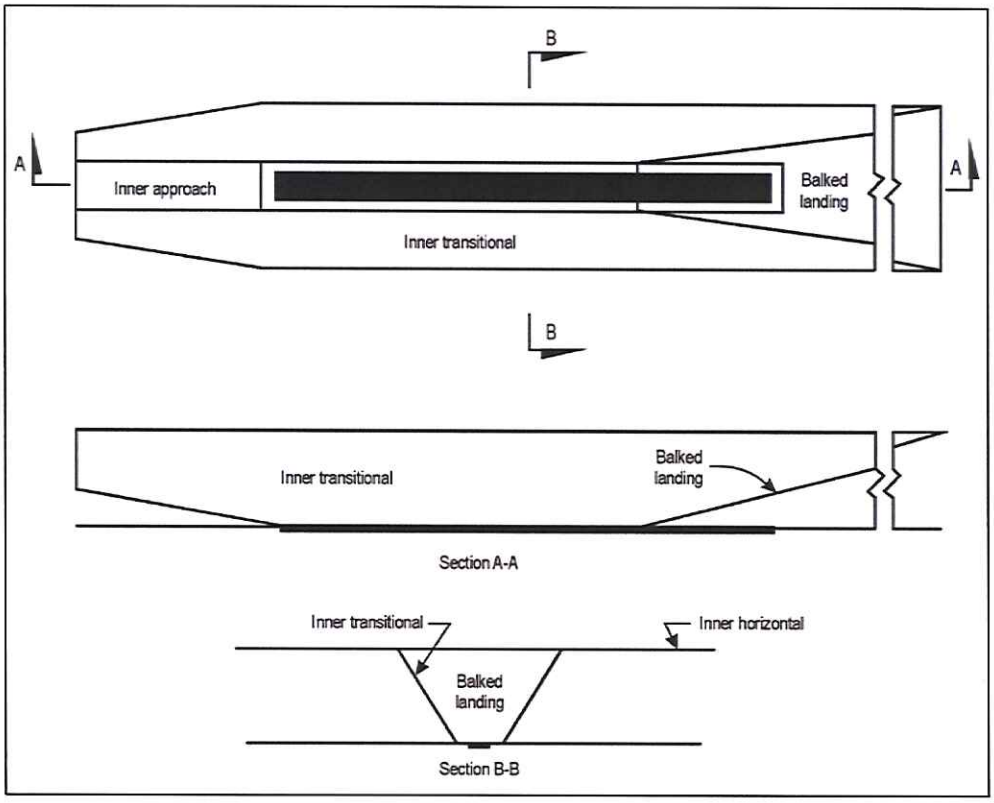
3.7 Obstacle Free Zone

For CAT I precision approach runways, ICAO *recommends* that an Inner Approach Surface, Inner Transitional Surface, and Balked Landing Surface be established. These surfaces, described below, are in the immediate vicinity of the runway and are collectively known as the Obstacle Free Zone (OFZ). As previously mentioned, these surfaces must be established for CAT II/III precision approach runways.

3.7.1 Inner Approach Surface

The Inner Approach Surface (see Figure 5) is a rectangular portion of the Approach Surface immediately preceding the threshold, and composed of the following:

- An inner edge coincident with the location of the inner edge of the Approach Surface, but of its own specified length;
- Two sides originating at the ends of the inner edge and extending parallel to the vertical plane containing the centerline of the runway; and
- An outer edge parallel to the inner edge.



Source: ICAO Annex 14

Figure 5. Inner Approach, Inner Transitional, and Balked Landing Surfaces

For NAICM, a distance of 60 m from the runway end, a length of 900 m, and a slope of 2% (50:1) were used. Additionally, a value of 155 m was used for the width in order to accommodate Code F aircraft.

3.7.2 Inner Transitional Surface

The Inner Transitional Surface (see Figure 5) is similar to the Transitional Surface, but closer to the runway. It is intended that the Inner Transitional Surface be the controlling obstacle limitation surface for navigation aids, aircraft, and other vehicles that must be near the runway and which is not to be penetrated except for frangible objects. In contrast, the Transitional Surface described above is intended to remain as the controlling obstacle limitation surface for buildings, etc. The Inner Transitional Surface is composed of the following:

- A lower edge beginning at the end of the Inner Approach Surface and extending down the side of the Inner Approach Surface to the inner edge of that surface, from there along the runway strip parallel to the runway centerline to the inner edge of the Balked Landing Surface (defined below) and from there up the side of the Balked Landing Surface to the point where the side intersects the Inner Horizontal Surface; and
- An upper edge located in the plane of the Inner Horizontal Surface.

The slope of the Inner Transitional Surface is measured in a vertical plane at right angles to the centerline of the runway. For NAICM, a slope of 33.3% (3:1) was used.

The elevation of a point on the lower edge is:

- Along the side of the Inner Approach Surface and Balked Landing Surface — equal to the elevation of the particular surface at that point; and
- Along the runway strip — equal to the elevation of the nearest point on the centerline of the runway or its extension.

3.7.3 Balked Landing Surface

The Balked Landing Surface (see Figure 5) is an inclined plane located at a specified distance after the threshold, extending between the Inner Transitional Surfaces, and composed of the following:

- An inner edge, horizontal and perpendicular to the centerline of the runway and located at a specified distance after the threshold;
- Two sides originating at the ends of the inner edge and diverging uniformly at 10% from the vertical plane containing the centerline of the runway; and
- An outer edge parallel to the inner edge and located in the plane of the Inner Horizontal Surface.

The elevation of the inner edge is equal to the elevation of the runway centerline at the location of the inner edge. The slope of the Balked Landing Surface is measured in the vertical plane containing the centerline of the runway.

For NAICM, a distance of 1,800 m from the threshold, and a slope of 3.33% (30:1) were used. Additionally, a value of 155 m was used for the length of the inner edge in order to accommodate Code F aircraft.

3.8 Key ICAO Annex 14 OLS SARPs

Fixed objects shall not be permitted above the Inner Approach, Inner Transitional, or the Balked Landing Surfaces, except for frangible objects which, because of their function, must be located on the runway strip. Mobile objects shall not be permitted above these surfaces during the use of the runway for landing.

New objects or extensions of existing objects shall not be permitted above an Approach Surface, a Transitional Surface, or a Take-off Climb Surface, except when, in the opinion of the appropriate authority, the new object or extension would be shielded by an existing immovable object.

ICAO recommends that new objects, or extensions of existing objects, should not penetrate an Approach Surface, Transitional Surface, or Take-off Climb Surface except when, in the opinion of the appropriate authority, the new object or extension would be shielded by an existing immovable object.

ICAO recommends that new objects or extensions of existing objects should not penetrate the Conical and Inner Horizontal Surfaces except when, in the opinion of the appropriate authority, an object would be shielded by an existing immovable object, or after aeronautical study it is determined that the object would not adversely affect the safety or significantly affect the regularity of aircraft operations.

ICAO also recommends that existing objects above an Approach Surface, Transitional Surface, Conical Surface, Inner Horizontal Surface, and Take-off Climb Surface, should as far as practicable, be removed except when an object is shielded by an existing immovable object, or after an aeronautical study determines that the object would not adversely affect safety or significantly affect the regularity of aircraft operations.

4. NAICM Runway Configuration

During the course of this project, as well as a previous study for the Dirección General de Aeronáutica Civil (DGAC) that ended in July 2012, MITRE evaluated various runway configurations and siting options for NAICM, taking into account many considerations regarding runway capacity, terminal airspace design, community noise exposure, and safety. The OLS analysis described in this report was performed using the MITRE Recommended Runway Configuration (July 2012), which was developed during that previous study [5], and is shown in Figure 6. The runway coordinates are given in Table 3.

Table 3. MITRE-Recommended Runway Configuration (July 2012) for NAICM: Coordinates

Runway	Runway End and Displaced Threshold	World Geodetic System 1984 (WGS84) Coordinates on Runway Centerline	Universal Transverse Mercator (UTM) X and Y Coordinates
17R/35L	17R Runway End	19 32 29.9N/99 00 27.8W	499190.7286/2160758.9760
	35L Runway End	19 30 03.5N/99 00 33.2W	499032.8418/2156261.7466
17L/35R	17L Runway End	19 32 39.3N/99 00 13.7W	499601.1598/2161049.0771
	35R Runway End	19 29 56.7N/99 00 19.7W	499425.7300/2156052.1556
18R/36L	18R Runway End	19 32 41.6N/98 59 15.0W	501311.7495/2161121.3721
	36L Runway End	19 29 59.1N/98 59 21.0W	501136.3197/2156124.4506
18L/36R	18L Runway End	19 32 31.3N/98 59 01.6W	501700.8294/2160803.3062
	36R Runway End	19 30 05.0N/98 59 07.1W	501542.9426/2156306.0768
19R/01L	19R Runway End	19 32 53.7N/98 58 15.9W	503032.7720/2161490.8303
	19R Displaced Threshold (Tentative)	19 32 39.8N/98 58 16.4W	503017.7903/2161064.0932
	01L Runway End	19 30 27.3N/98 58 21.4W	502874.8851/2156993.6009
19L/01R	19L Runway End	19 32 53.2N/98 58 02.2W	503432.5283/2161476.8694
	19L Displaced Threshold (Tentative)	19 32 39.3N/98 58 02.7W	503417.5466/2161050.1323
	01R Runway End	19 30 26.9N/98 58 07.6W	503274.6414/2156979.6392

Notes:

1. The runway coordinates contained in this table are associated with a runway configuration whose aeronautical feasibility has been proven. However, the coordinates are subject to changes due to factors such as detailed civil engineering analyses, flight checks, final runway lengths and thresholds, and approvals that must be obtained from the appropriate aviation authorities of Mexico.

2. The MITRE UTM coordinates have a precision of 1/10,000th of a meter (0.0001 m). MITRE then uses MSP GEOTRANS 3.4, a geographic translator available from the U.S. National Geospatial-Intelligence Agency (NGA) Mensuration Service Program, to convert UTM Northing (Y) and Easting (X) to geodetic latitude and longitude for reporting purposes only. In general, the accuracy of the geodetic coordinate output by MSP GEOTRANS 3.4 has only been tested to a level of approximately 1 m (0.1 second).

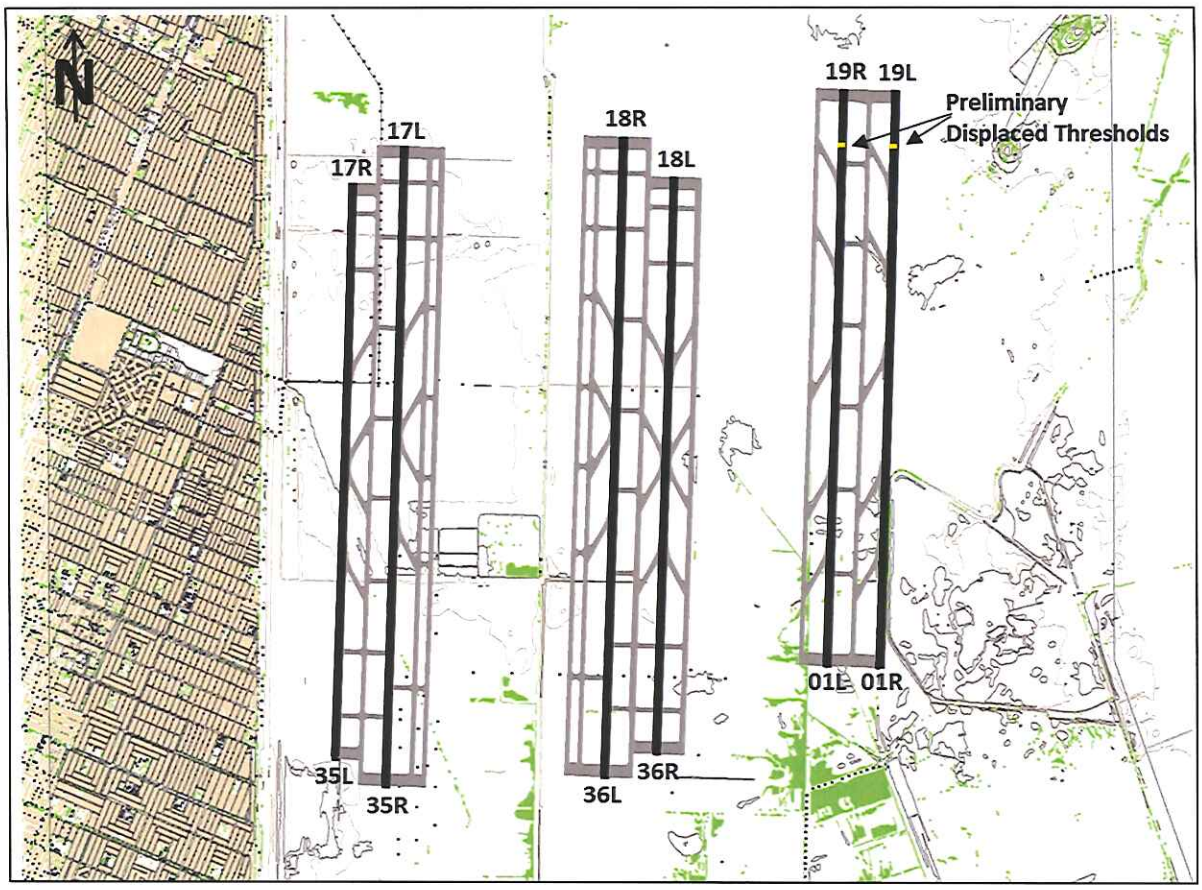


Figure 6. MITRE-Recommended Runway Configuration (July 2012)

5. Methodology

This section describes the methodology used in the study, including the data analyzed, tools utilized, and assumptions made, as well as the limitations of the study.

5.1 Data

Having a comprehensive, accurate, and current obstacle and terrain database with which to evaluate the various OLS is crucial. Accordingly, MITRE commissioned a detailed satellite-based photogrammetric survey of the NAICM site and nearby Texcoco and its surroundings, including high-resolution terrain and obstacle information for Chiconautla, Sierra de Guadalupe, and Chimalhuacán. The photogrammetric survey [6], acquired by MITRE in late 2014, provided ground elevation as well as natural (e.g., trees and other vegetation) and man-made features such as buildings, towers, power line towers (including the power lines running between towers), trees, bridges, poles, posts, antennas, etc.

In addition to the photogrammetric survey, MITRE utilized obstacle data provided by ASA and other project stakeholders, such as proposed construction of new structures.

5.2 Tools

MITRE used obstacle assessment analytical tools, such as PDToolkit, PHX, and other specialized software to evaluate the OLS, including ArcMap, ArcScene, Global Mapper, Google Earth, and AutoCAD.

5.3 Assumptions and Limitations

As mentioned above, the photogrammetric survey of the NAICM site and its surroundings was acquired in late 2014. Any structures or alterations completed after that date would not be included in MITRE's study.

MITRE evaluated only those OLS prescribed by ICAO. However, some countries restrict new construction of tall structures beyond the areas currently recognized in Annex 14 to ensure safety and efficiency of aerodrome operations. If tall structures are erected in or near areas suitable for instrument approach procedures, they may result in increased procedure heights with consequent adverse effects on aircraft operations and runway availability. Moreover, high masts or other structures in some areas beyond those mentioned in Annex 14 can become an impediment for departure or missed approach climb-paths. Therefore, the aviation authorities of Mexico should use caution regarding new construction in the NAICM area to avoid causing operational problems.

The Take-off Climb Surfaces evaluated by MITRE correspond to candidate departure procedures that were developed by MITRE to determine feasibility. The actual departure procedures that will be implemented may differ from these candidate procedures, and therefore the impact of specific obstacles (and penetration amounts) on those future departure procedures may be different than the results contained in this document.

Obstacles within the NAICM site or under the control of airport authority (e.g., in the vicinity of the proposed runways) will be removed and/or modified so as to no longer pose an issue. For example, utility poles in the vicinity of the proposed runways that penetrate certain surfaces will be removed appropriately. Other examples include trees or other man-made obstructions that are located on or near the planned runways.

MITRE was informed by Comisión Nacional del Agua that the crane located at the coordinates shown below would be lowered to less than 10 m Above Ground Level (AGL):

- 99 00 45.2W, 19 29 17.7N (based on WGS84)
- X: 498682.2500, Y: 2154853.1600 (based on UTM, Zone 14 North)

Future airport facilities (e.g., terminal buildings, aircraft parking stands, aprons, and other airfield components) were not considered. MITRE assumed that future airport facilities would not impact any ICAO OLS.

Several tall antennas and structures are located on top of Chiconautla (described below). MITRE assumed that these antennas and other structures (e.g., buildings, utility poles, etc.) on Chiconautla will be removed. Additionally, terrain at Chiconautla penetrates the U.S. Standards for Terminal Instrument Procedures (TERPS) final approach Obstacle Clearance Surfaces for Runways 19L and 19R, which is not permitted. Therefore, MITRE assumed

that terrain will be graded appropriately. Additional details regarding TERPS matters are contained in [7].

MITRE assumed a constant elevation at each runway threshold (i.e., MITRE assumed a level airport). The results included in this document correspond to a threshold elevation of 2223 m MSL. This assumed elevation is based on information derived from a previous survey completed in 2010, and is a conservative estimate for planning purposes.

It is important to note that MITRE assumed a tentative threshold displacement of 427 m for Runways 19L and 19R. However, this displacement is not final and may change depending on decisions to be made by the aviation authorities of Mexico regarding the grading (and to what extent) of Chiconautla and Chimalhuacán, as well as feedback from the airlines.

6. Findings

This section provides the detailed results of MITRE's OLS analysis.

6.1 Conical Surface and Inner Horizontal Surface

The Conical and Inner Horizontal Surfaces are shown in Figure 7. There are penetrations to the Inner Horizontal Surface by antennas, a transmission line, and a crane, as well as penetrations to the western edge of the Conical Surface. More detailed views are shown in Figures 8 and 9.

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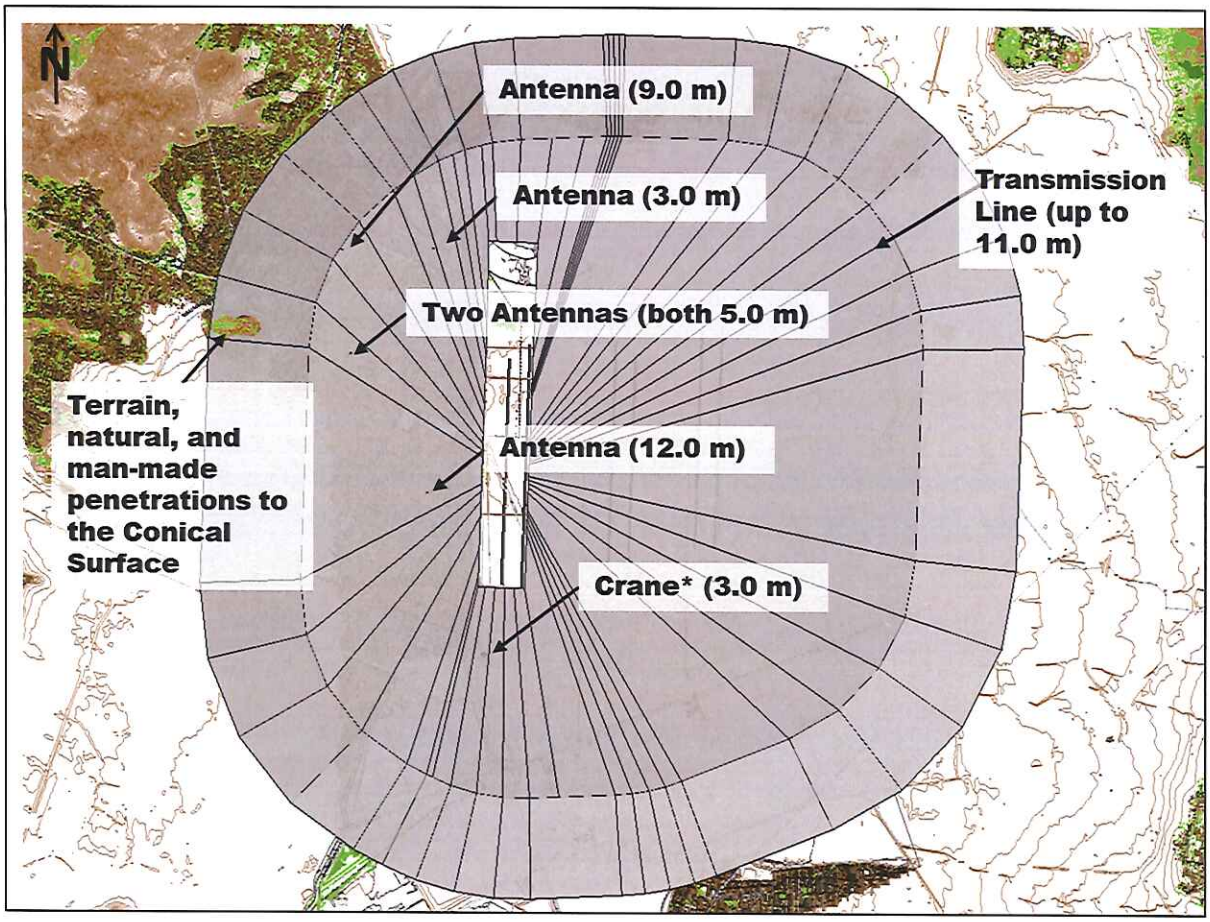
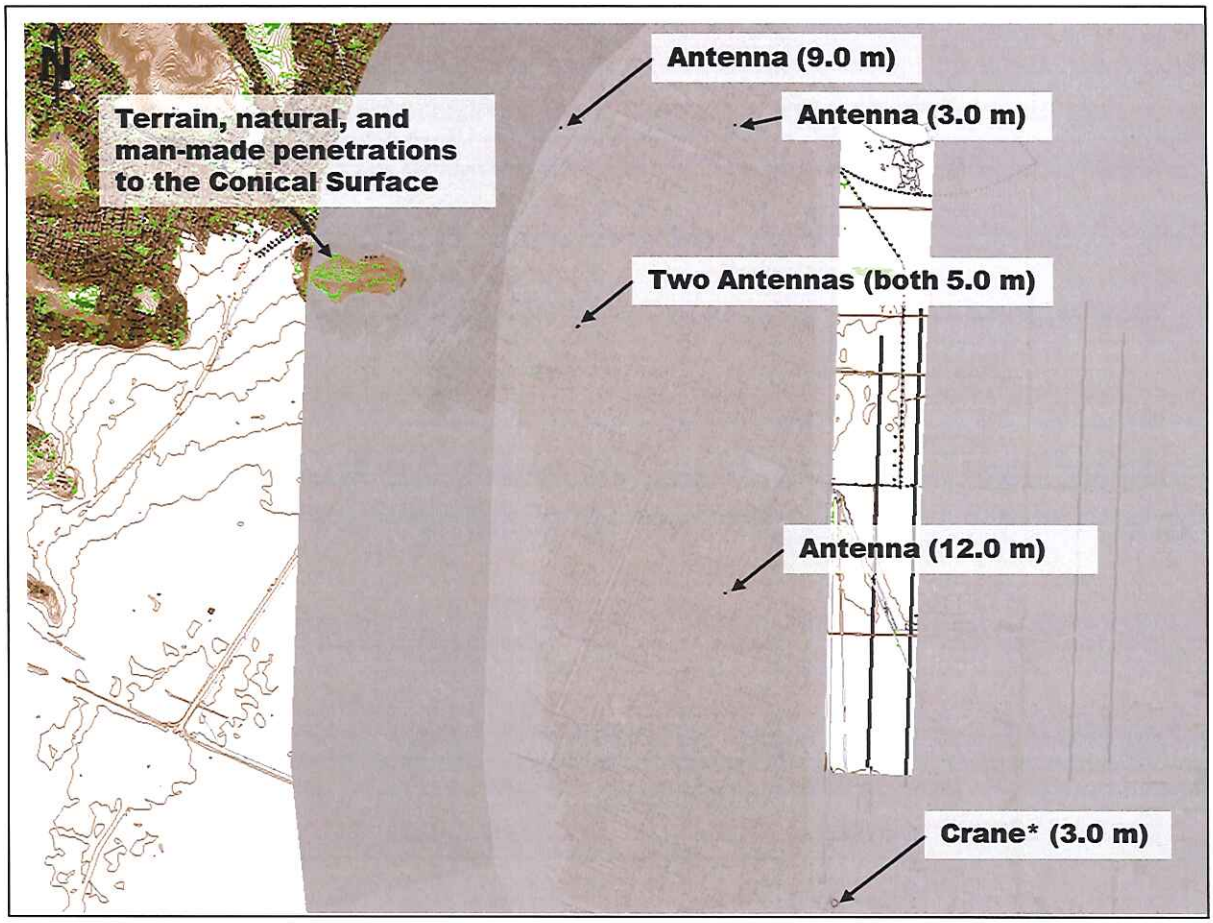


*Note that MITRE has been informed that the height of the crane will be lowered to less than 10 m AGL prior to opening the airport and, therefore, will no longer be a penetration.

Figure 7. Inner Horizontal and Conical Surfaces



*Note that MITRE has been informed that the height of the crane will be lowered to less than 10 m AGL prior to opening the airport and, therefore, will no longer be a penetration.

Figure 8. Inner Horizontal and Conical Surfaces: Detailed View

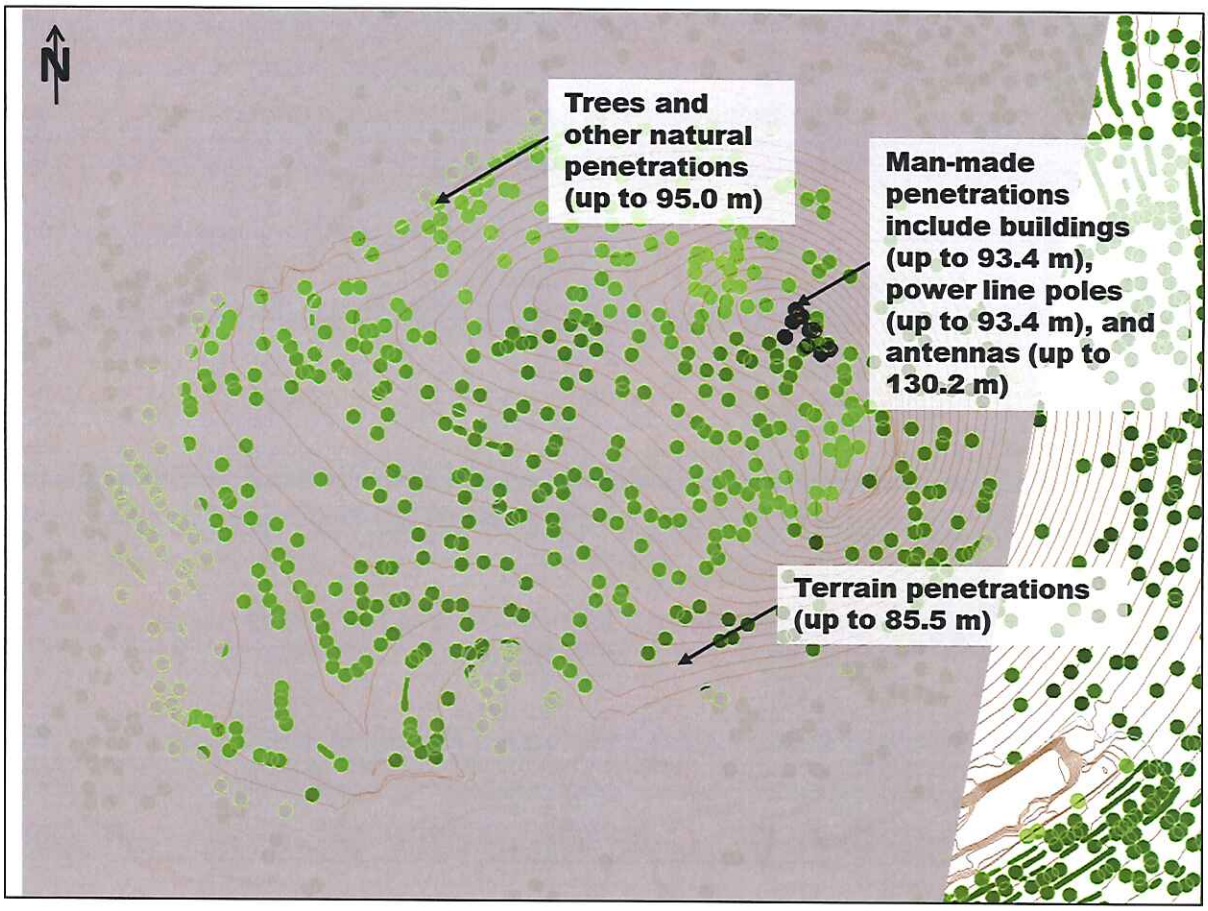


Figure 9. Inner Horizontal Surface: Detailed View to West

6.2 Approach Surfaces and Transitional Surfaces

The Approach and Transitional Surfaces are shown in Figures 10 through 23. The Approach Surfaces for Runways 17L, 17R, 35L, 35R, 36L, and 36R are clear of penetrations. The Approach Surfaces for Runways 18L, 18R, 19L, and 19R are penetrated by terrain at Chiconautla (sometimes referred to as the northern hill), as well as man-made and natural penetrations. As previously mentioned, several tall antennas and structures are located on top of the Chiconautla. MITRE assumed that any antennas and other structures on Chiconautla will be removed.

The Approach Surfaces for Runways 01L and 01R are penetrated by terrain at Chimalhuachi (referred to, because of its location, as Chimalhuacán, and sometimes referred to as the southern hill), as well as natural penetrations.

There are some penetrations to the Transitional Surfaces. However, it is assumed that these will be removed during construction due to their close proximity to the runways.

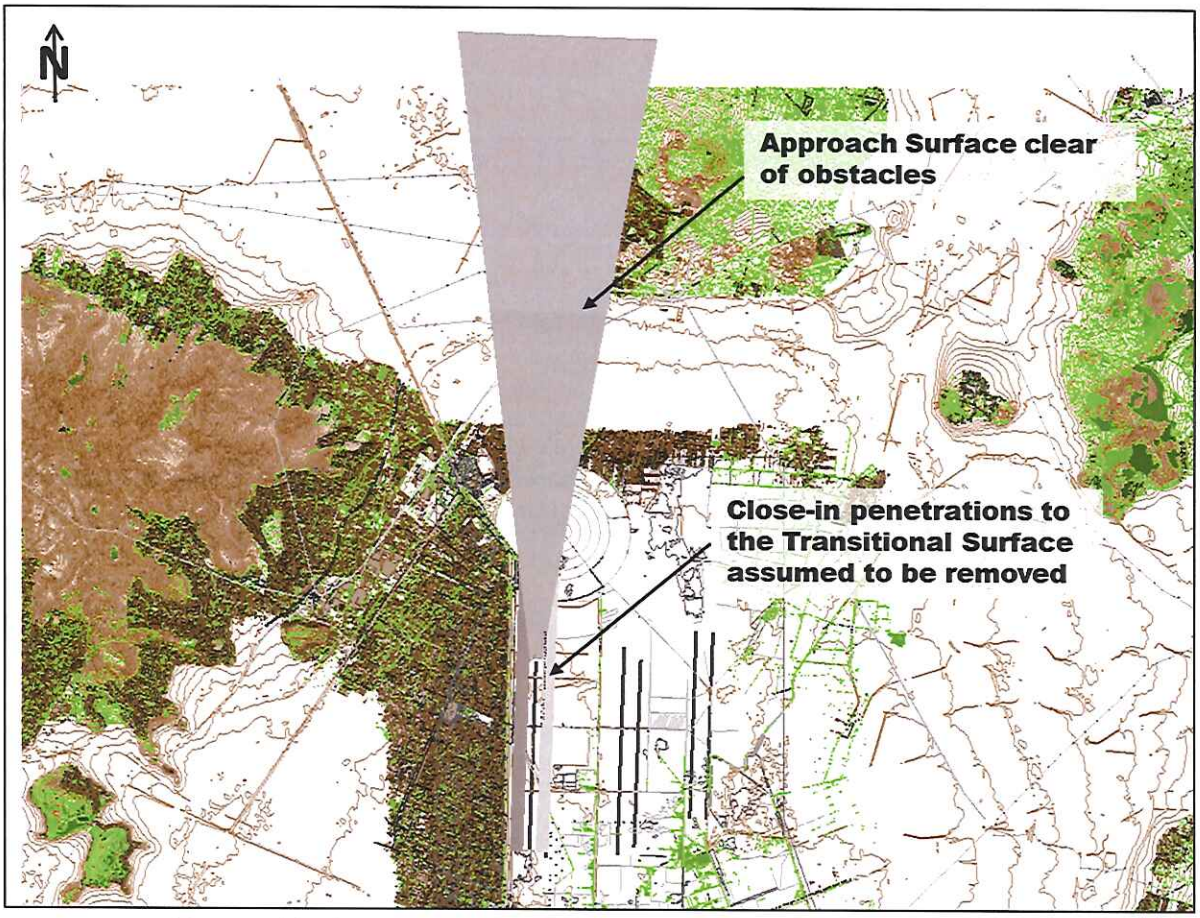


Figure 10. Approach and Transitional Surfaces: Runway 17R

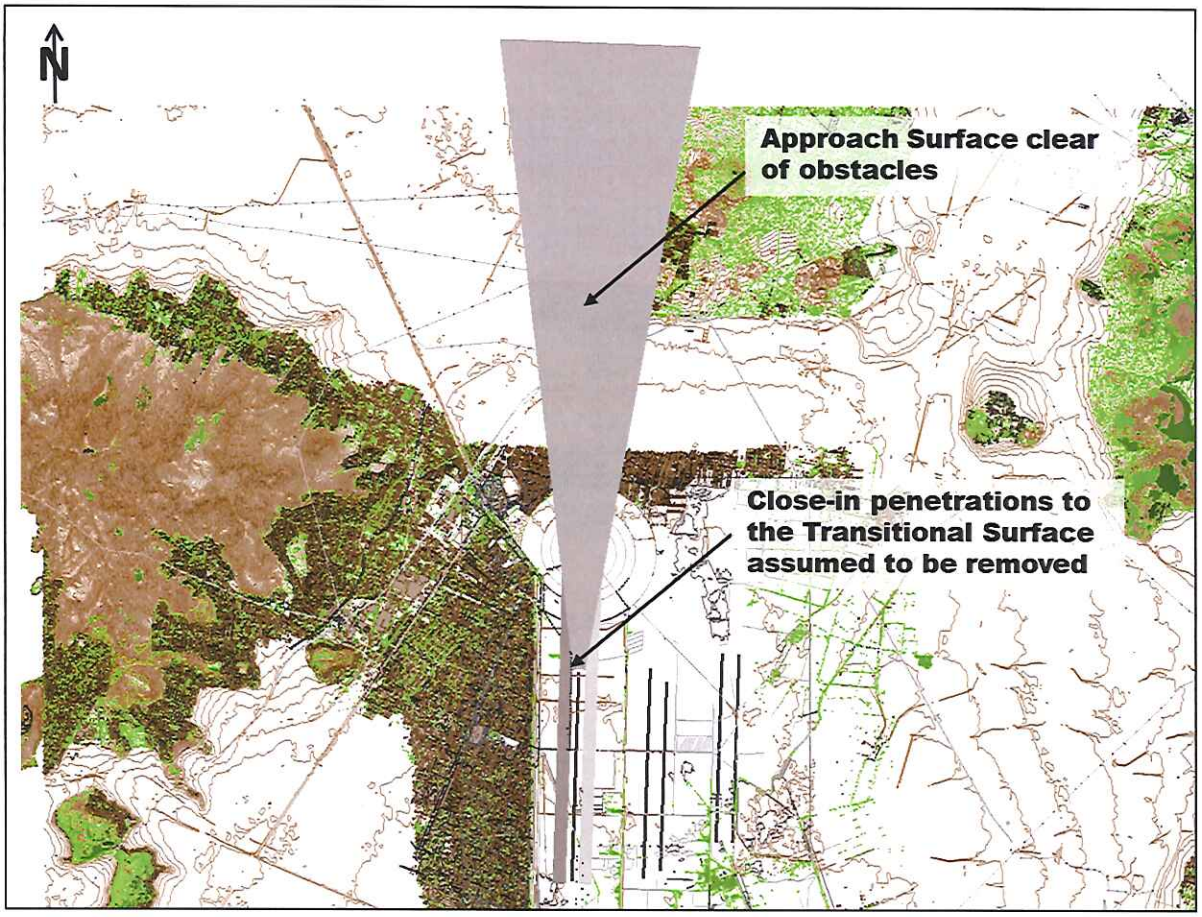


Figure 11. Approach and Transitional Surfaces: Runway 17L

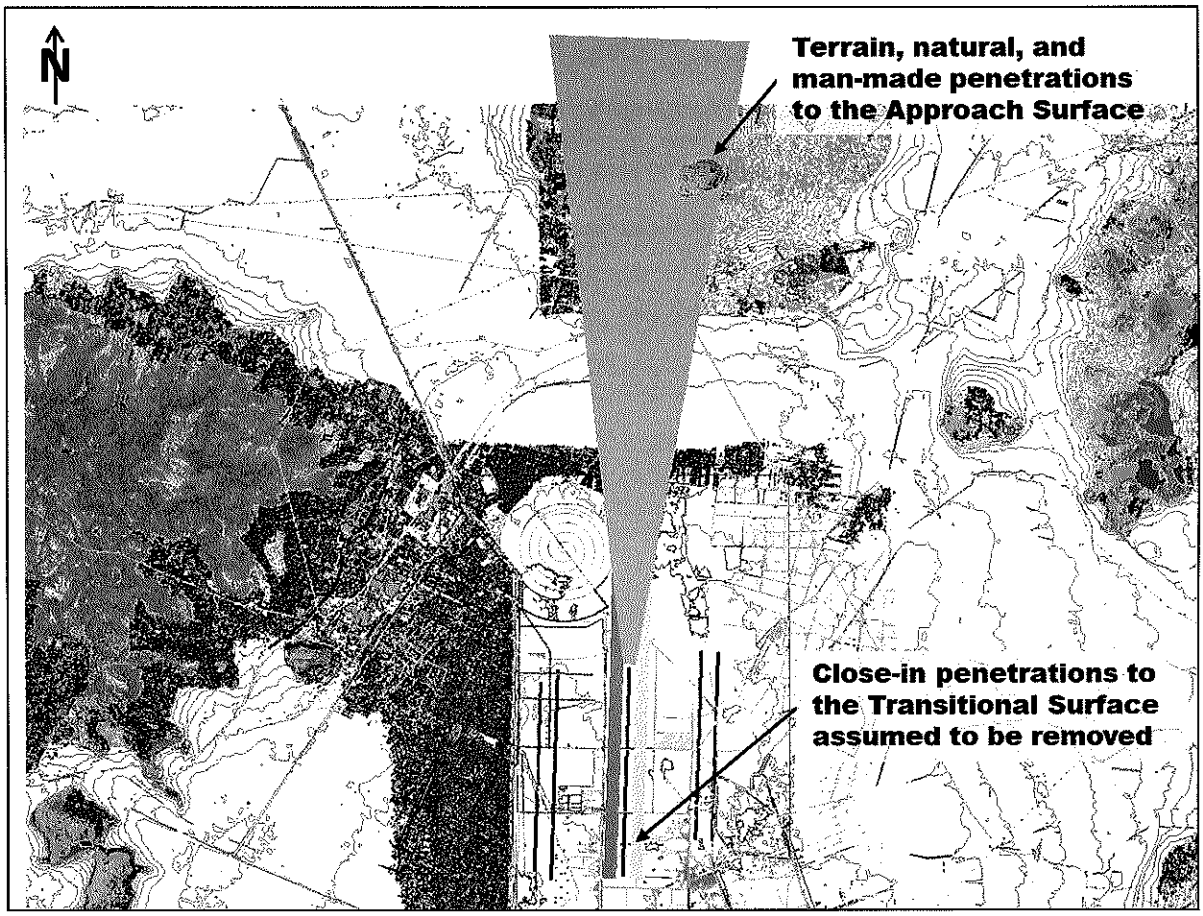
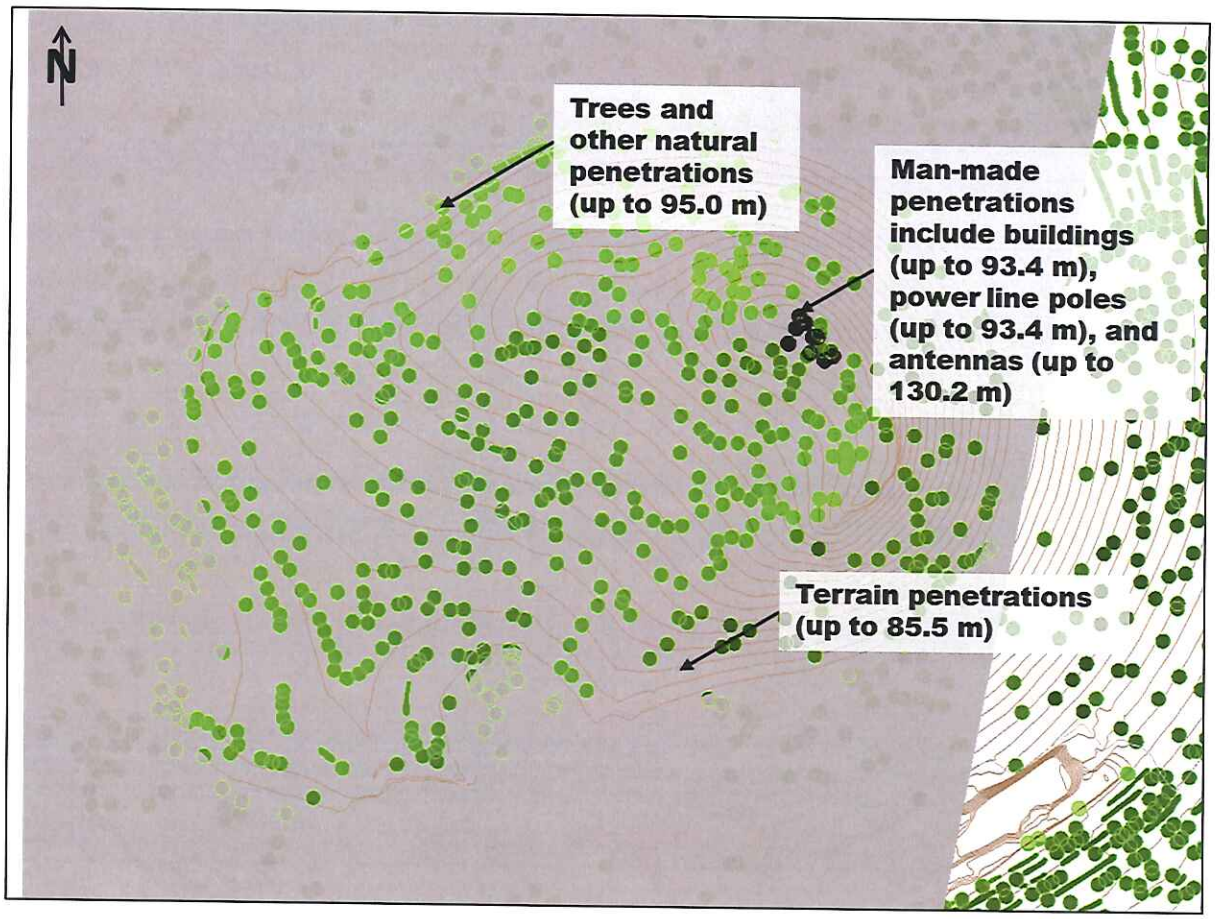


Figure 12. Approach and Transitional Surfaces: Runway 18R



Note: Many of the obstacles shown also penetrate the Approach Surfaces for Runways 18L, 19R, and 19L. However, the penetrations for Runway 18R are representative of the worst case scenario, and therefore the corresponding detailed views are not shown for the above-mentioned runways. See Figures 31, 32, and 33 for detailed profile information pertaining to the Approach Surfaces for Runways 18L, 19R, and 19L, respectively.

Figure 13. Approach and Transitional Surfaces: Runway 18R (Detailed View)

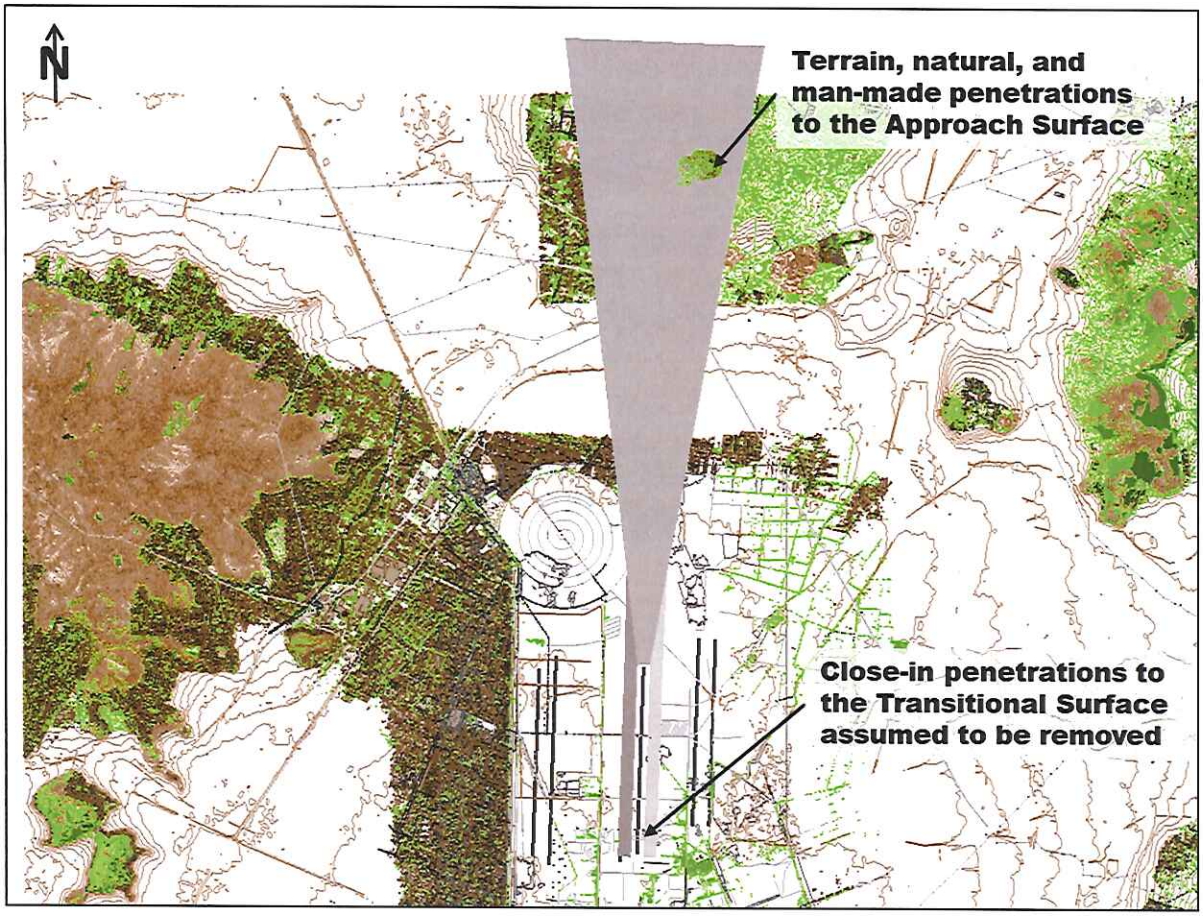


Figure 14. Approach and Transitional Surfaces: Runway 18L

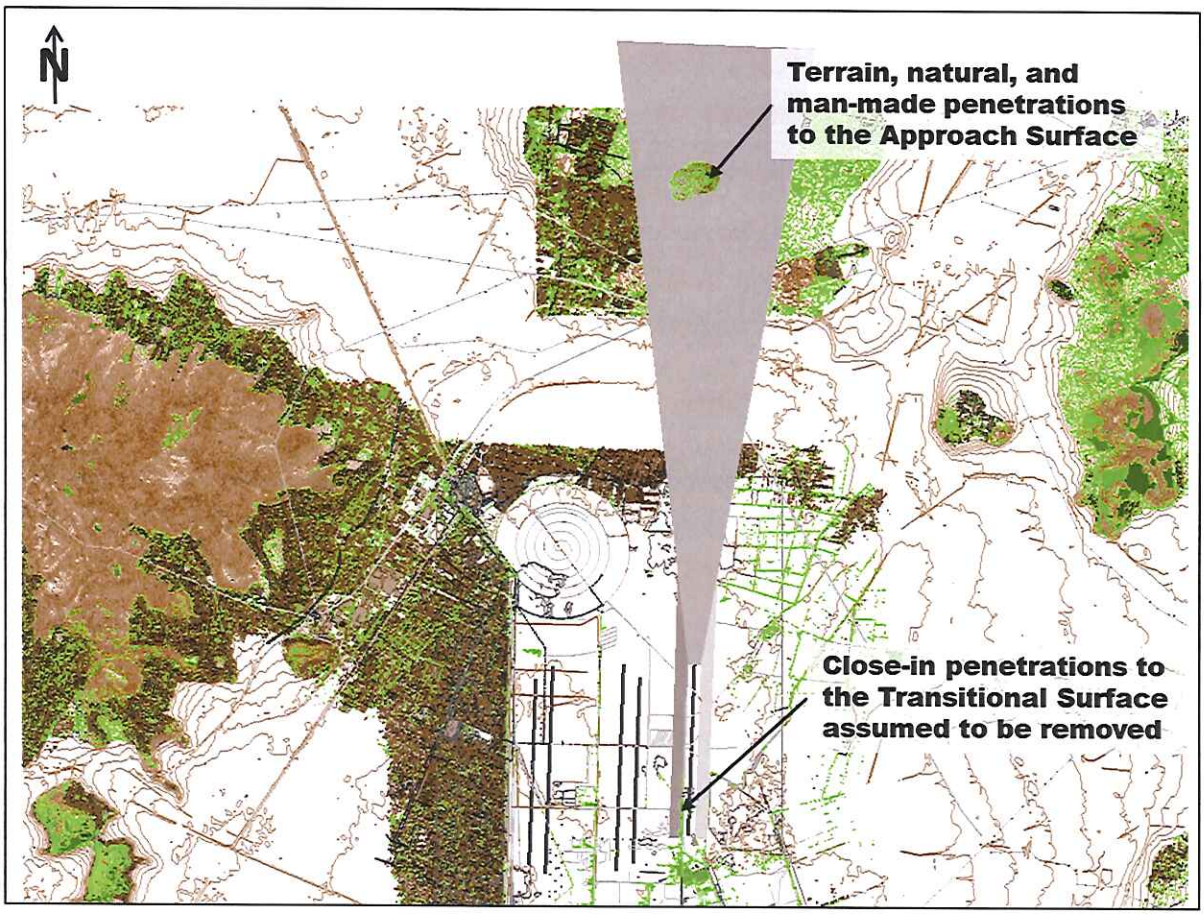


Figure 15. Approach and Transitional Surfaces: Runway 19R

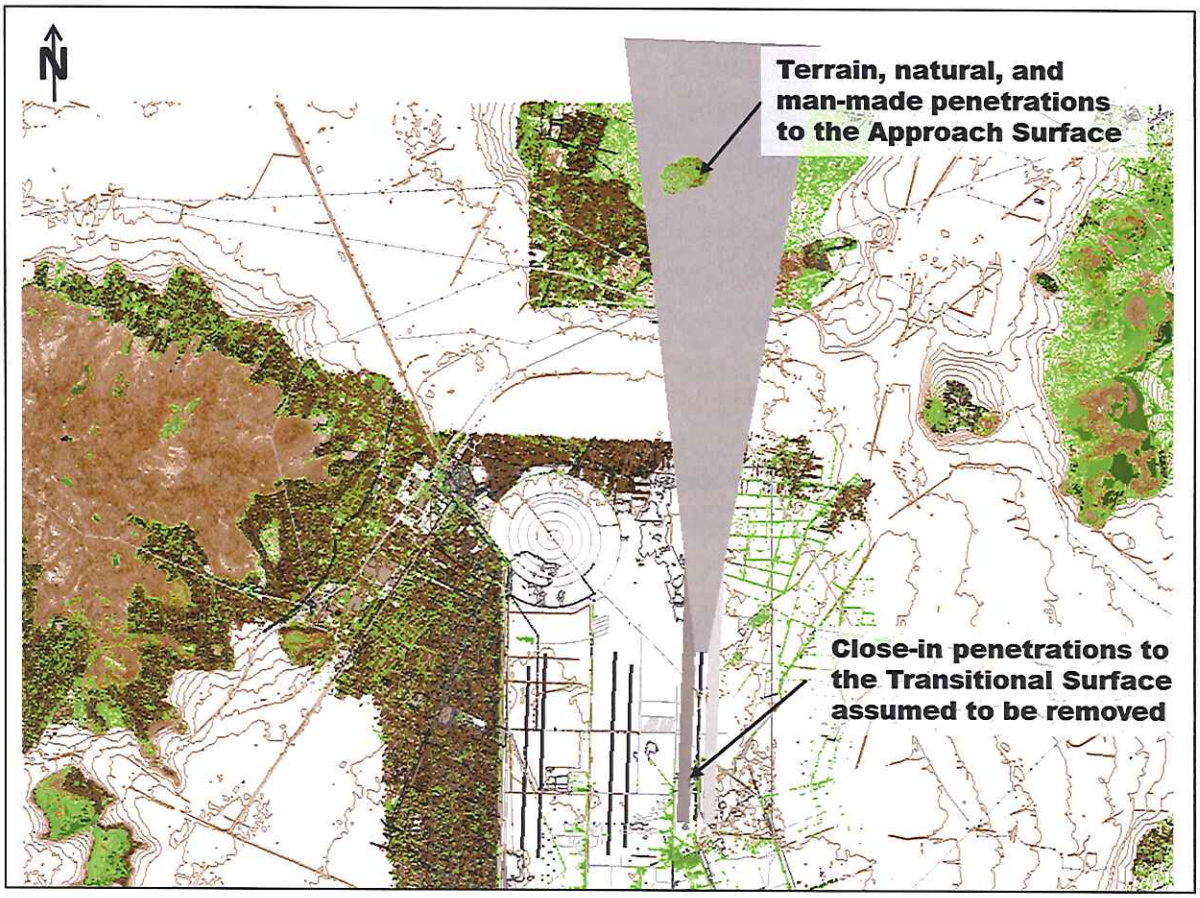
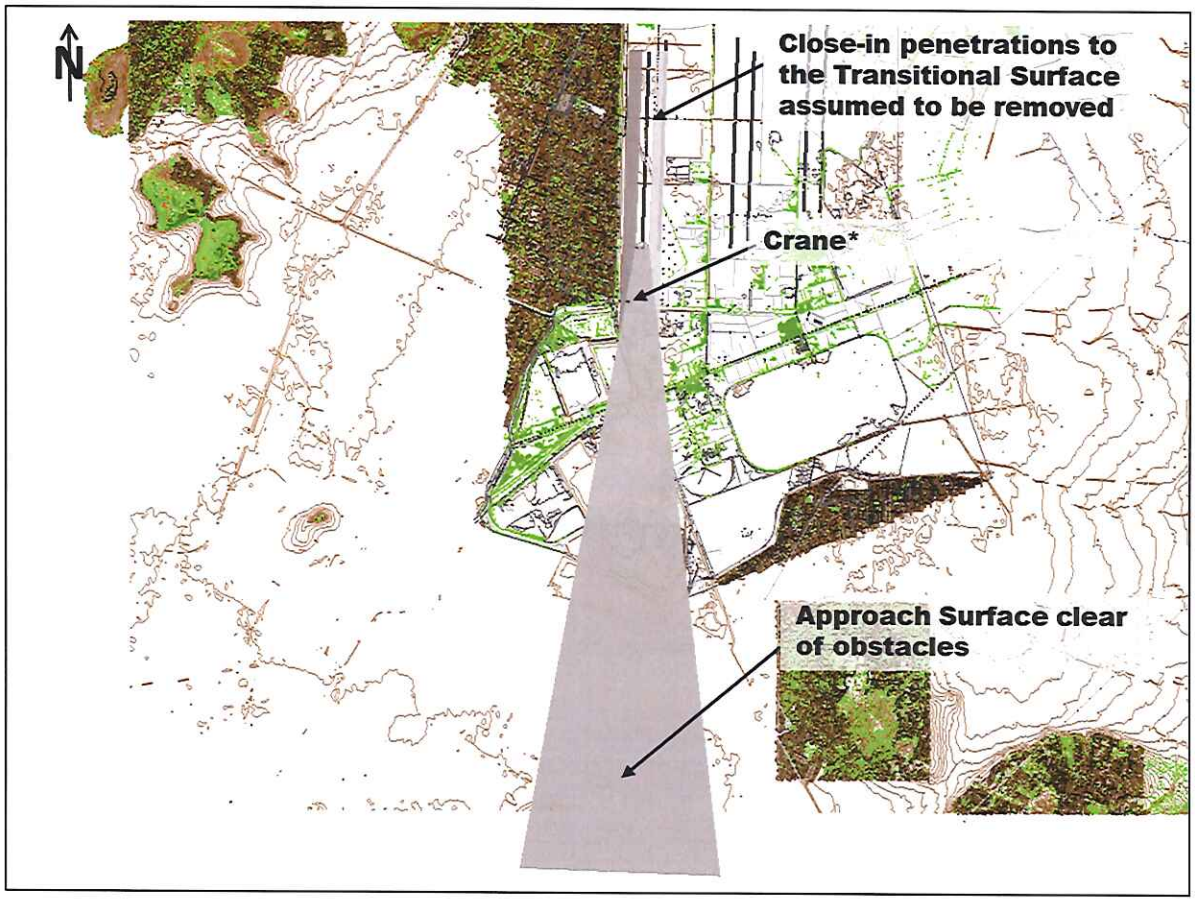


Figure 16. Approach and Transitional Surfaces: Runway 19L



*Note that MITRE has been informed that the height of the crane will be lowered to less than 10 m AGL prior to opening the airport and, therefore, will no longer be a penetration.

Figure 17. Approach and Transitional Surfaces: Runway 35L

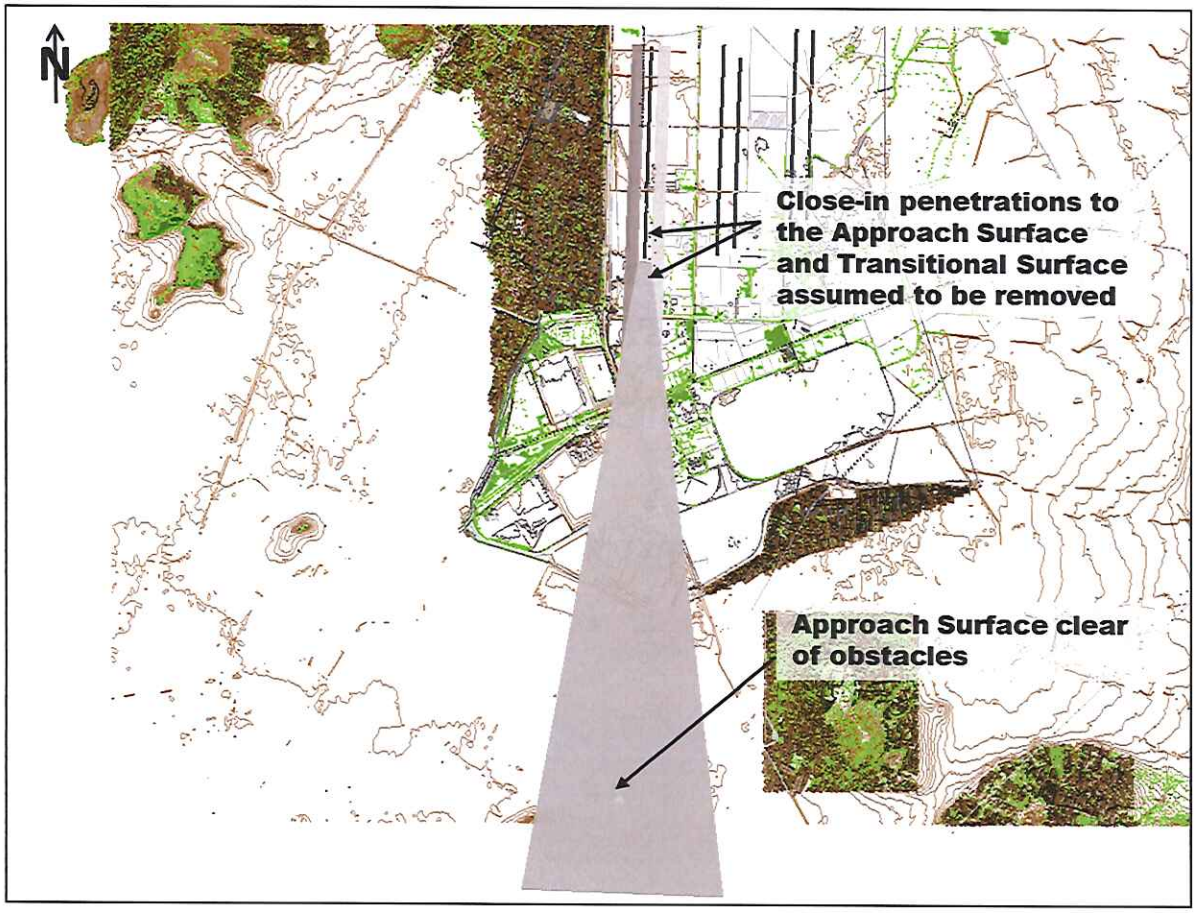


Figure 18. Approach and Transitional Surfaces: Runway 35R

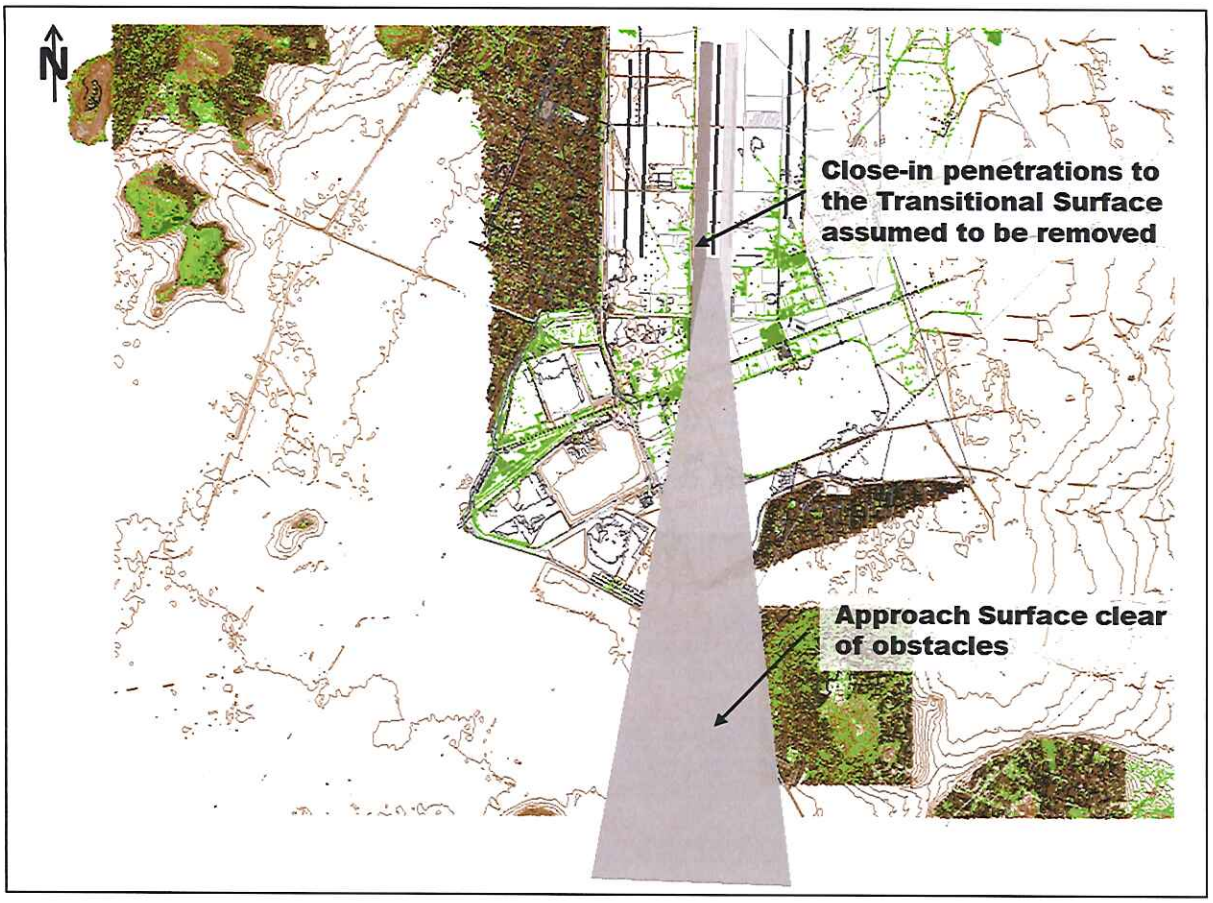


Figure 19. Approach and Transitional Surfaces: Runway 36L

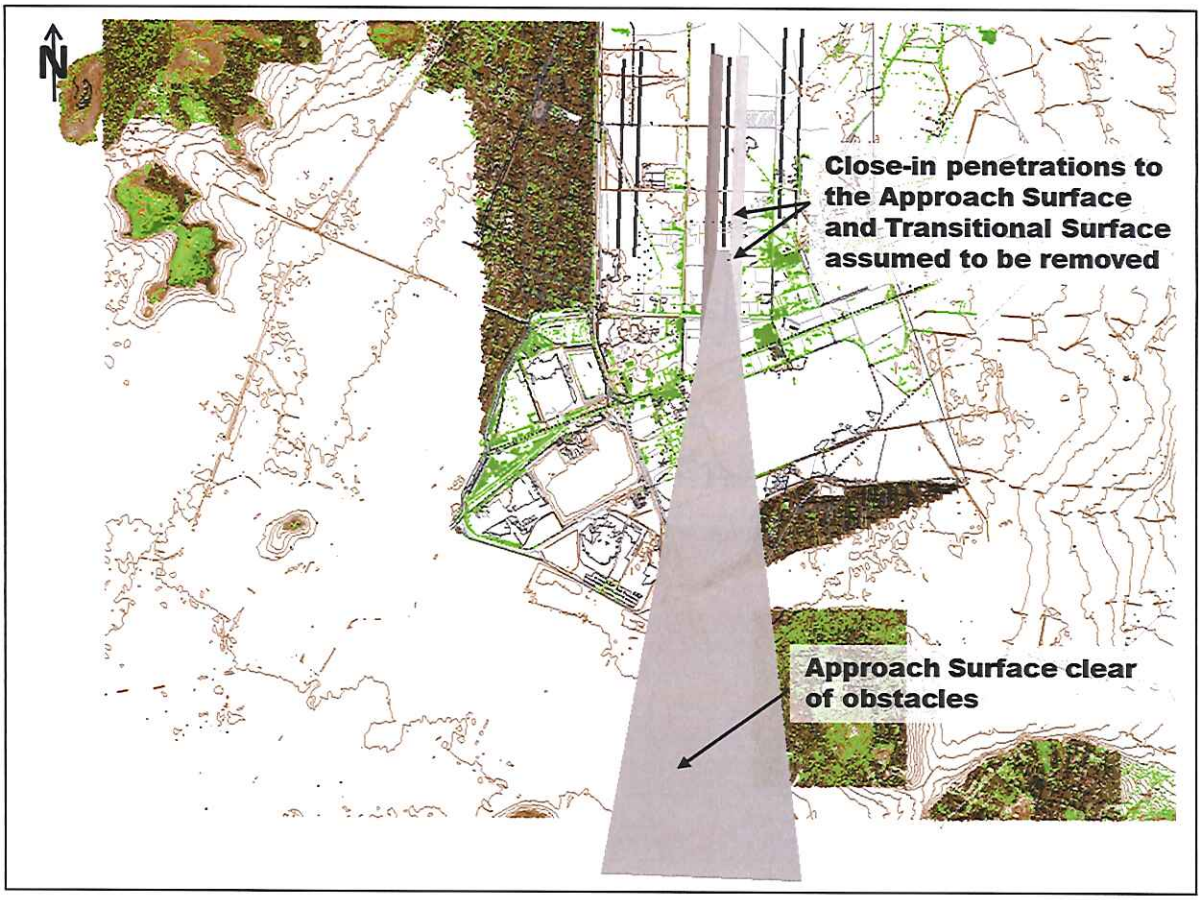
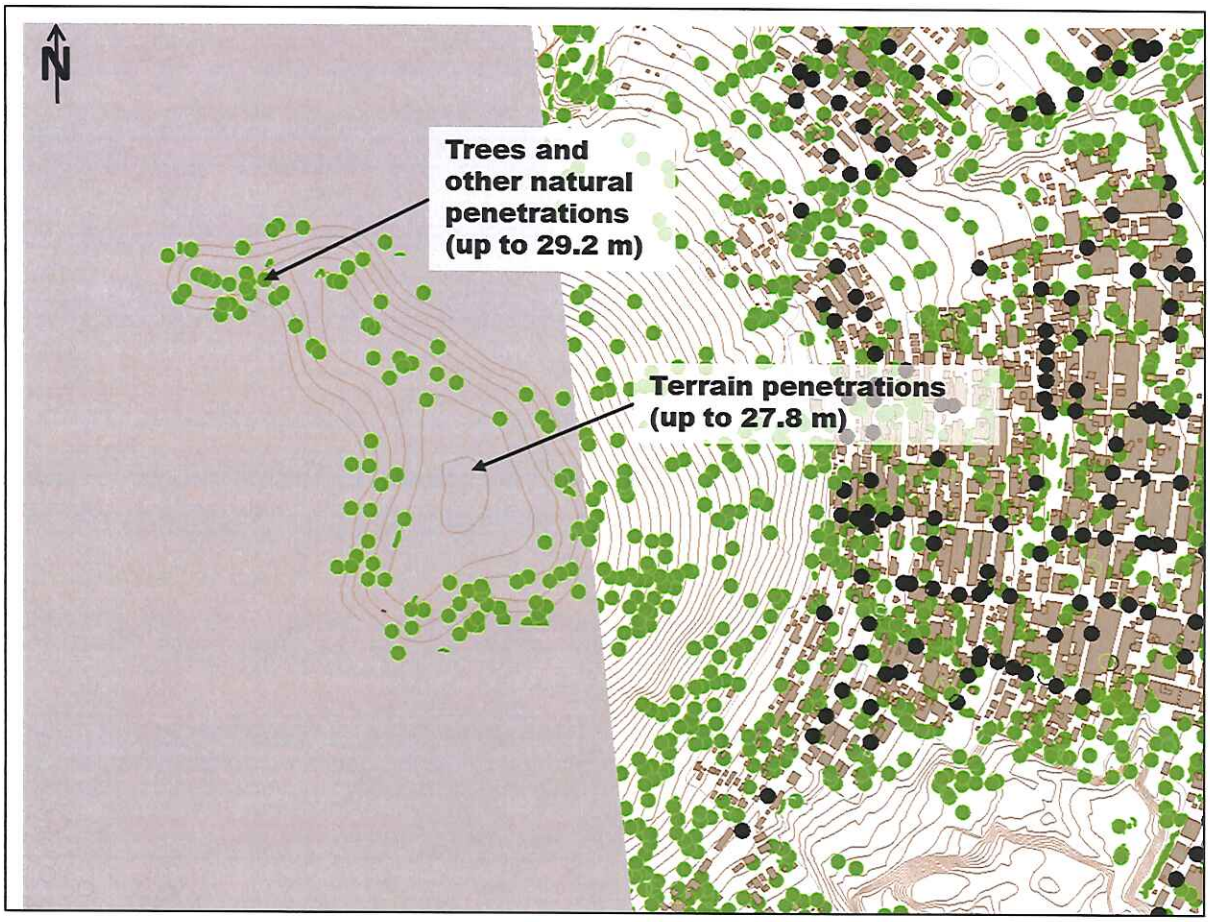


Figure 20. Approach and Transitional Surfaces: Runway 36R

Figure 21. Approach and Transitional Surfaces: Runway 01L

Figure 22. Approach and Transitional Surfaces: Runway 01R



Note: Many of the obstacles shown also penetrate the Approach Surface for Runways 01L. However, the penetrations for Runway 01R are representative of the worst case scenario, and therefore the corresponding detailed view for Runway 01L is not shown. See Figure 34 for detailed profile information pertaining to the Approach Surface for Runway 01L.

Figure 23. Approach and Transitional Surfaces: Runway 01R (Detailed View)

Close-in penetrations to the Transitional Surfaces are shown in Figures 24 through 29. As previously mentioned, MITRE assumed that objects in close proximity to the runways will be removed during construction.

Figure 24. Close-in Penetrations to Transitional Surfaces: Runway 17R/35L

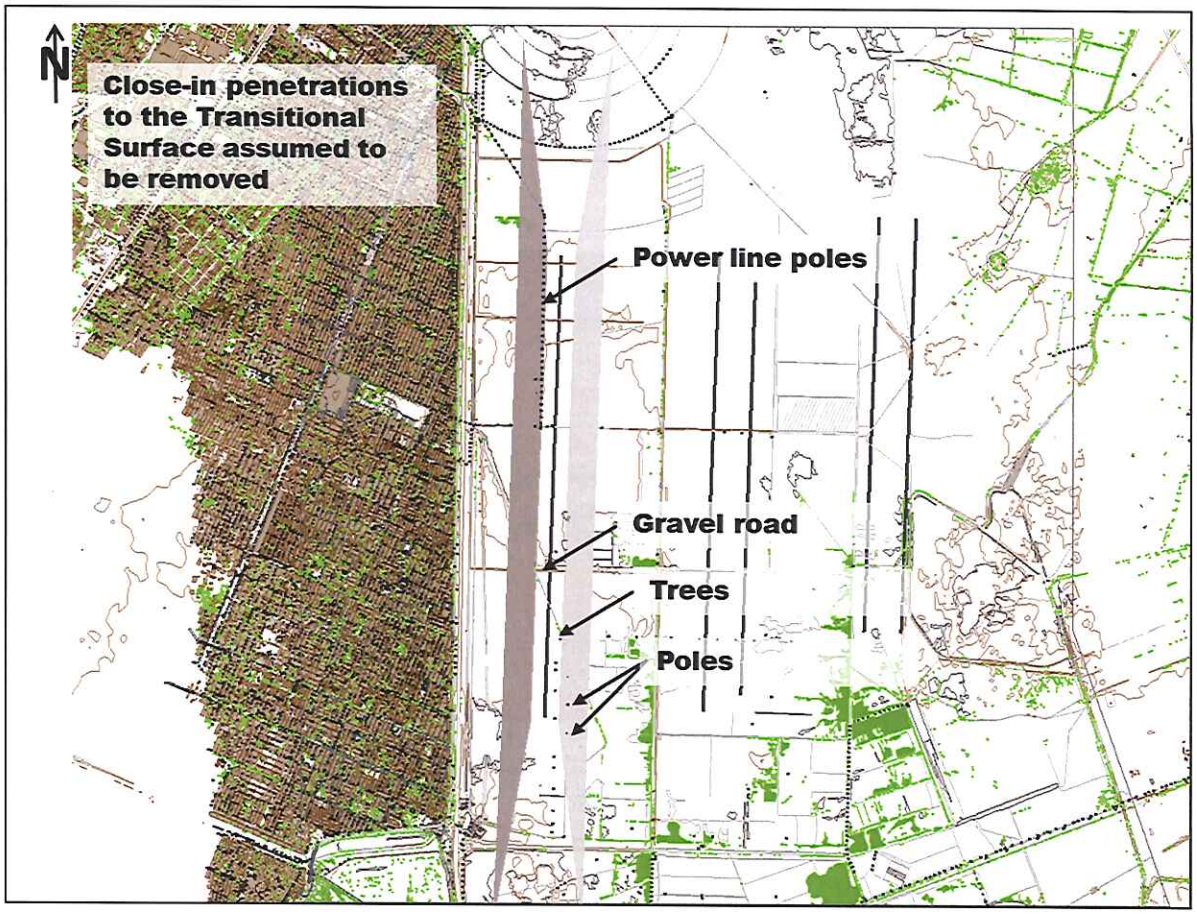


Figure 25. Close-in Penetrations to Transitional Surfaces: Runway 17L/35R

Figure 26. Close-in Penetrations to Transitional Surfaces: Runway 18R/36L

Figure 27. Close-in Penetrations to Transitional Surfaces: Runway 18L/36R

Figure 28. Close-in Penetrations to Transitional Surfaces: Runway 19R/01L

Figure 29. Close-in Penetrations to Transitional Surfaces: Runway 19L/01R

Profile views of the Approach Surfaces that are penetrated by Chiconautla are given in Figures 30 through 33 as follows: Runway 18R is shown in Figure 30; Runway 18L is shown in Figure 31; Runway 19R is shown in Figure 32; Runway19L is shown in Figure 33. Approach Surfaces for Runways 17L and 17R are not penetrated. For completeness, the profile views of these surfaces are provided in Appendix B.

Profile views of the Approach Surfaces that are penetrated by Chimalhuacán are given in Figures 34 and 35 as follows: Runway 01L is shown in Figure 34; and Runway 01R is shown in Figure 35. Approach Surfaces for Runways 35L, 35R, 36L, and 36R are not penetrated. For completeness, the profile views of these surfaces are provided in Appendix B.

As described in Section 3, each Annex 14 Approach Surface has a slope of 2% (50:1) for the first 3000 m, and then the slope increases to 2.5% (40:1) until it intersects either a horizontal plane 150 m above the threshold elevation or the horizontal plane passing through the top of any object that governs the obstacle clearance limit, whichever is higher. It is important to note that each of the Approach Surfaces for Runways 17L, 17R, 18L, 18R, 19L, 19R, 01L, and 01R have objects that govern the obstacle clearance limit that are above the horizontal plane of 150 m above the threshold elevation, and therefore require the extension of the 2.5% slope.

More detailed information regarding terrain penetrations to Annex 14 OLS by Chiconautla and Chimalhuacán are contained in a parametric analysis of runway threshold elevations [8].

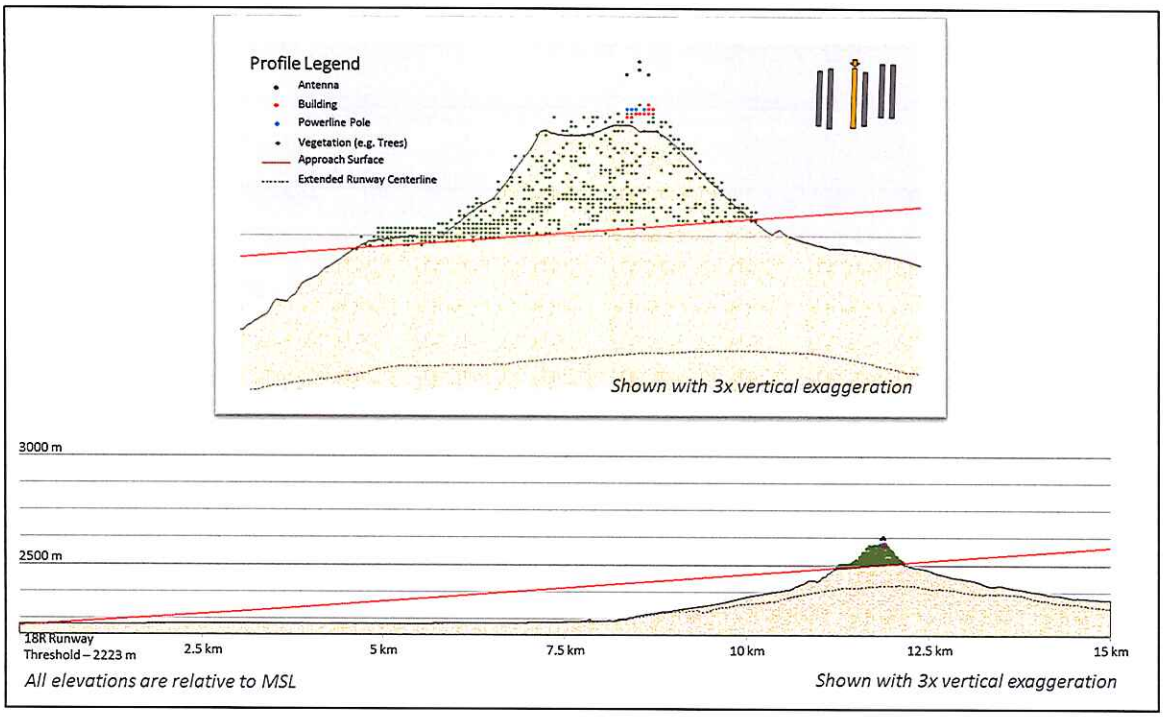


Figure 30. Profile View of Approach Surface: Runway 18R

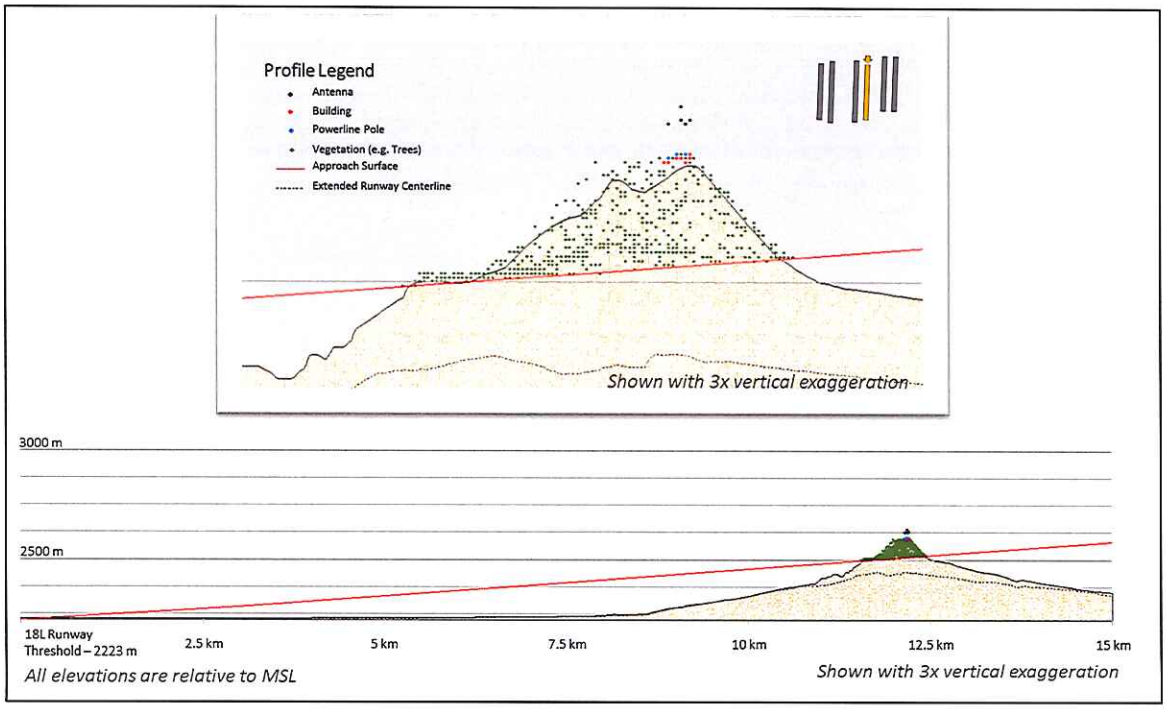


Figure 31. Profile View of Approach Surface: Runway 18L

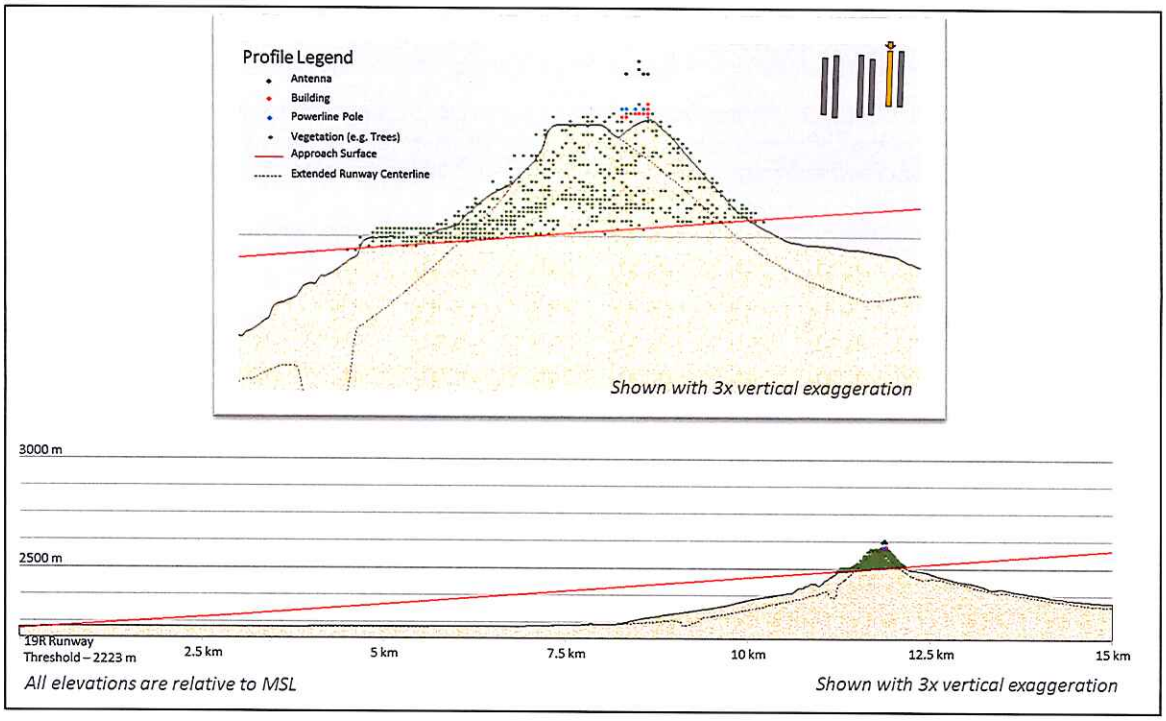


Figure 32. Profile View of Approach Surface: Runway 19R

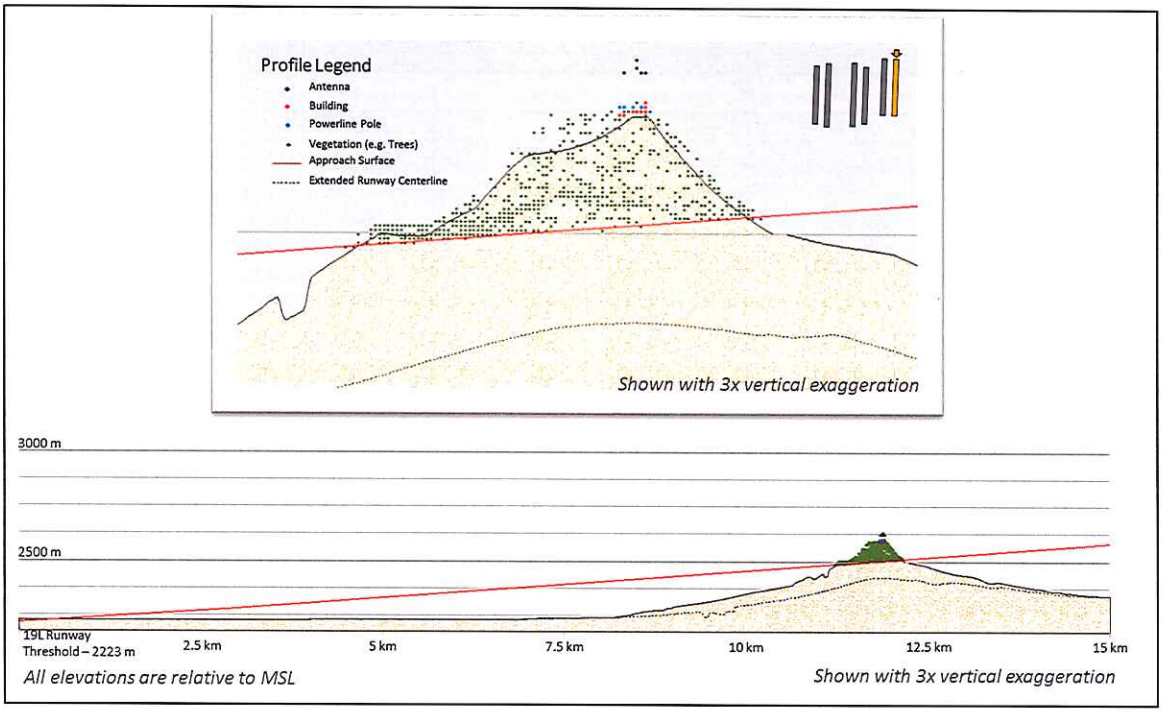


Figure 33. Profile View of Approach Surface: Runway 19L

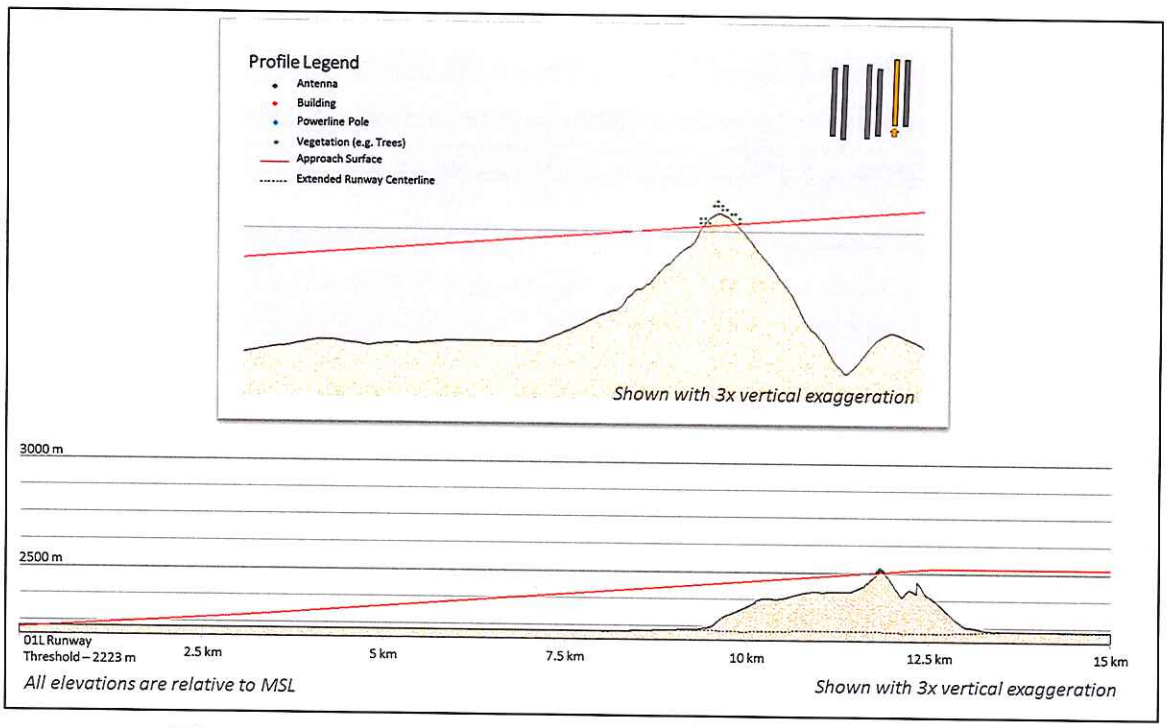


Figure 34. Profile View of Approach Surface: Runway 01L

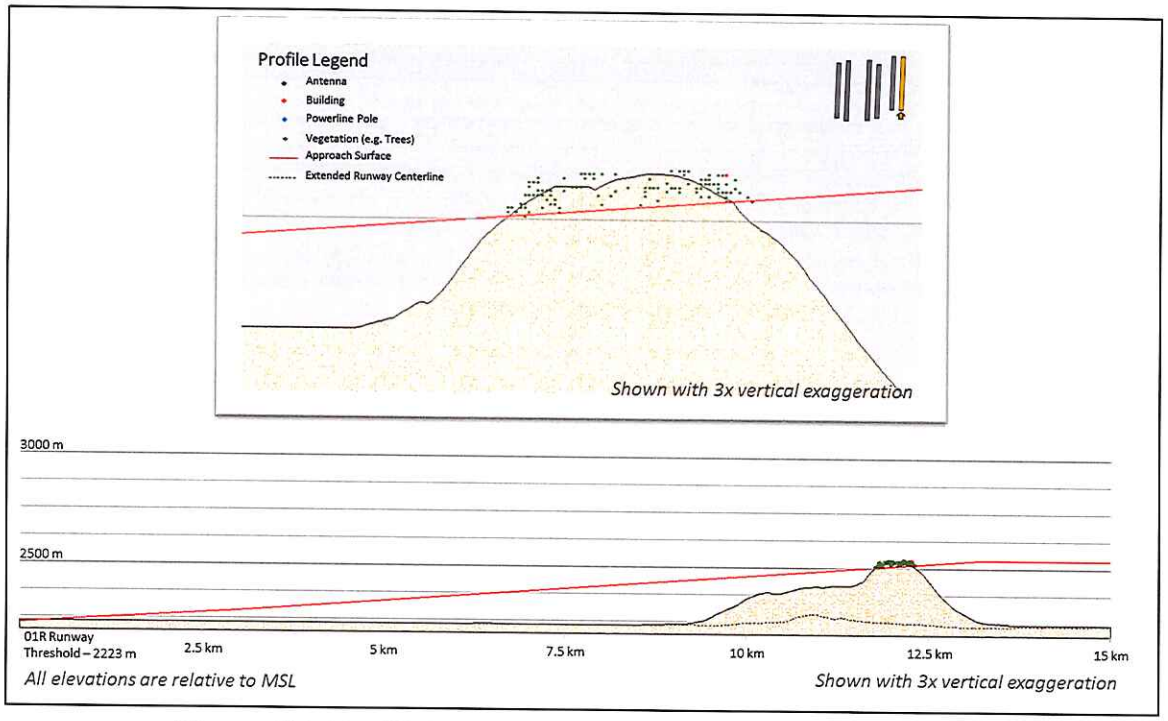


Figure 35. Profile View of Approach Surface: Runway 01R

6.3 Obstacle Free Zone Surfaces

Close-in penetrations to the OFZ surfaces (i.e., the Inner Approach, Inner Transitional, and Balked Landing Surfaces), assumed to be removed during construction, are shown in Figures 36 through 47 as follows:

- Runway 17R is shown in Figure 36
- Runway 17L is shown in Figure 37
- Runway 18R is shown in Figure 38
- Runway 18L is shown in Figure 39
- Runway 19R is shown in Figure 40
- Runway 19L is shown in Figure 41
- Runway 35L is shown in Figure 42
- Runway 35R is shown in Figure 43
- Runway 36L is shown in Figure 44
- Runway 36R is shown in Figure 45
- Runway 01L is shown in Figure 46
- Runway 01R is shown in Figure 47

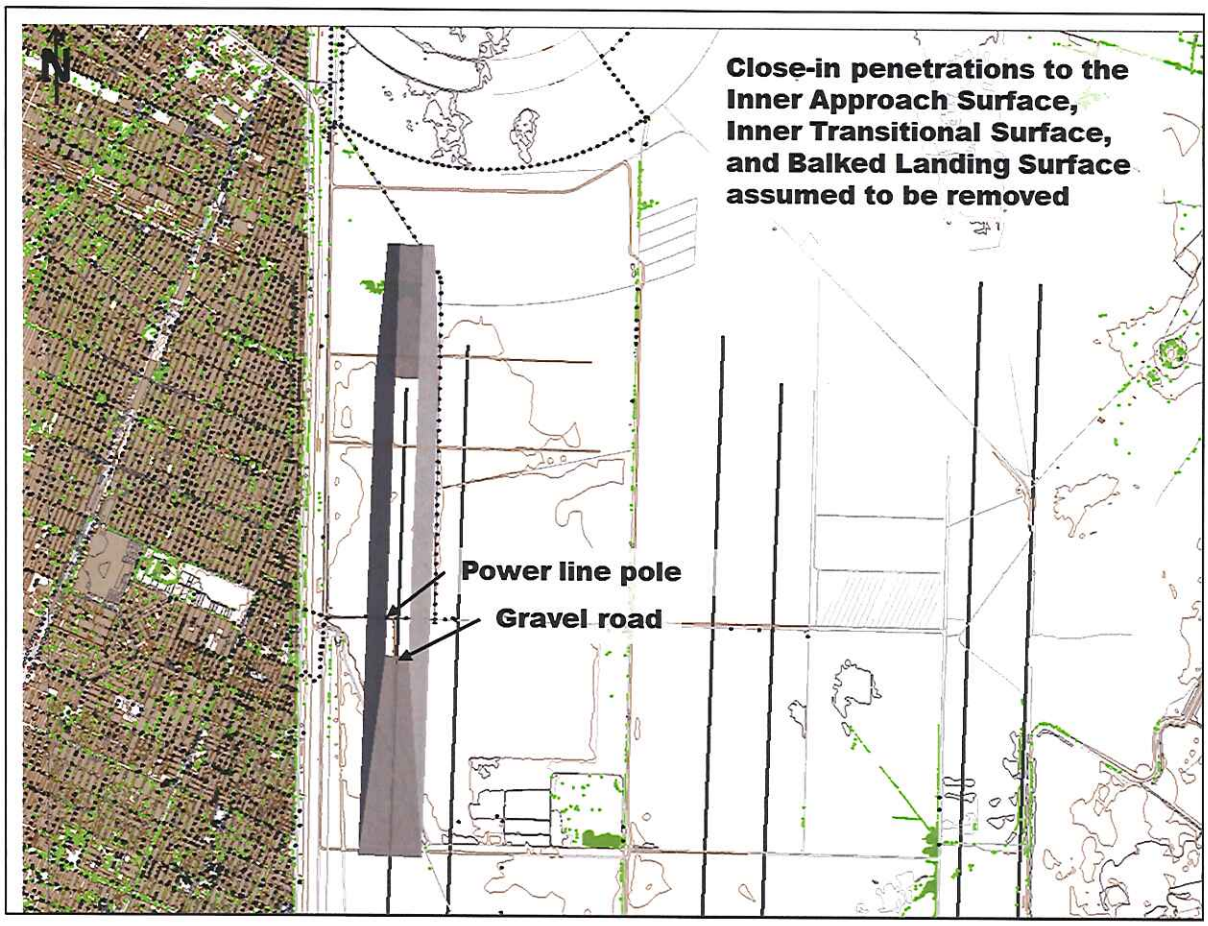


Figure 36. OFZ Surfaces: Runway 17R

Figure 37. OFZ Surfaces: Runway 17L

Figure 38. OFZ Surfaces: Runway 18R

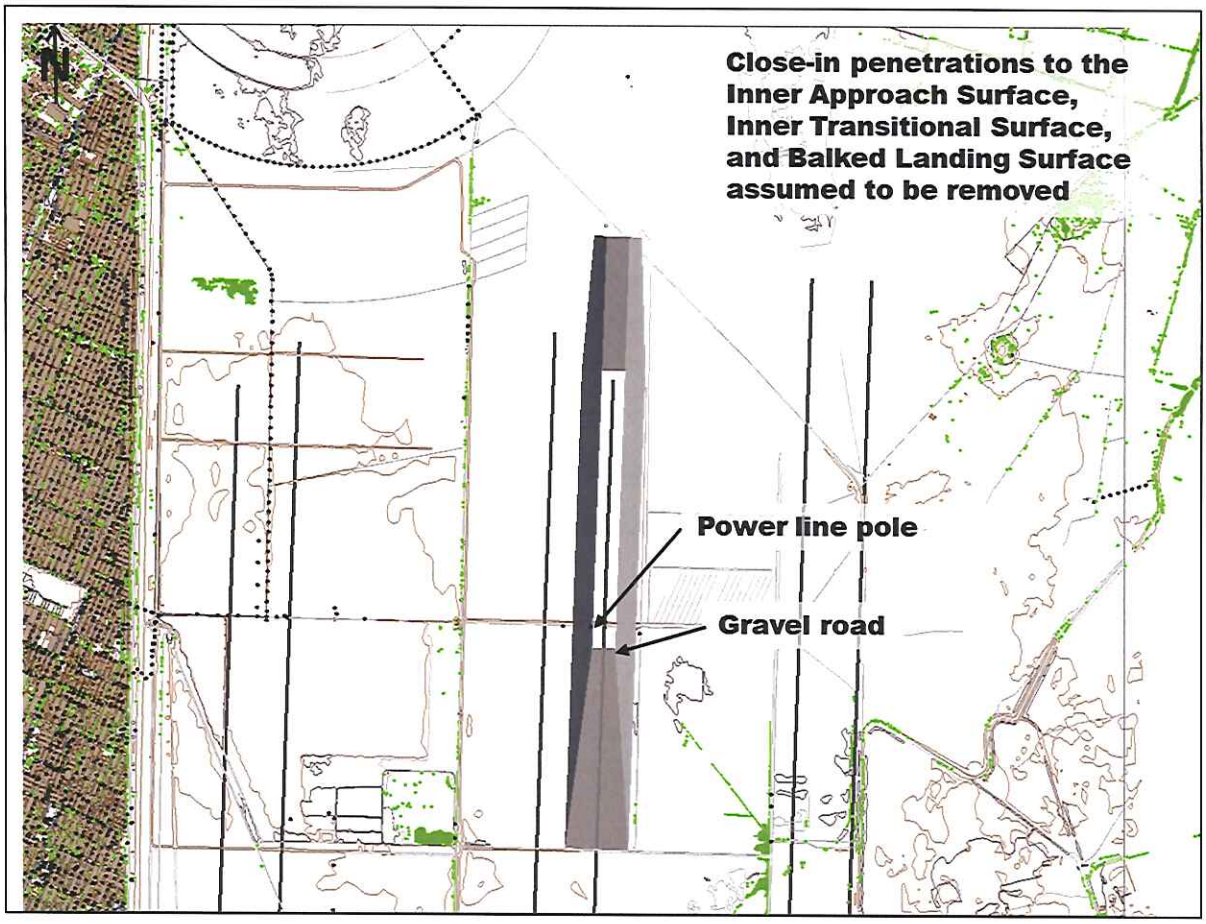


Figure 39. OFZ Surfaces: Runway 18L

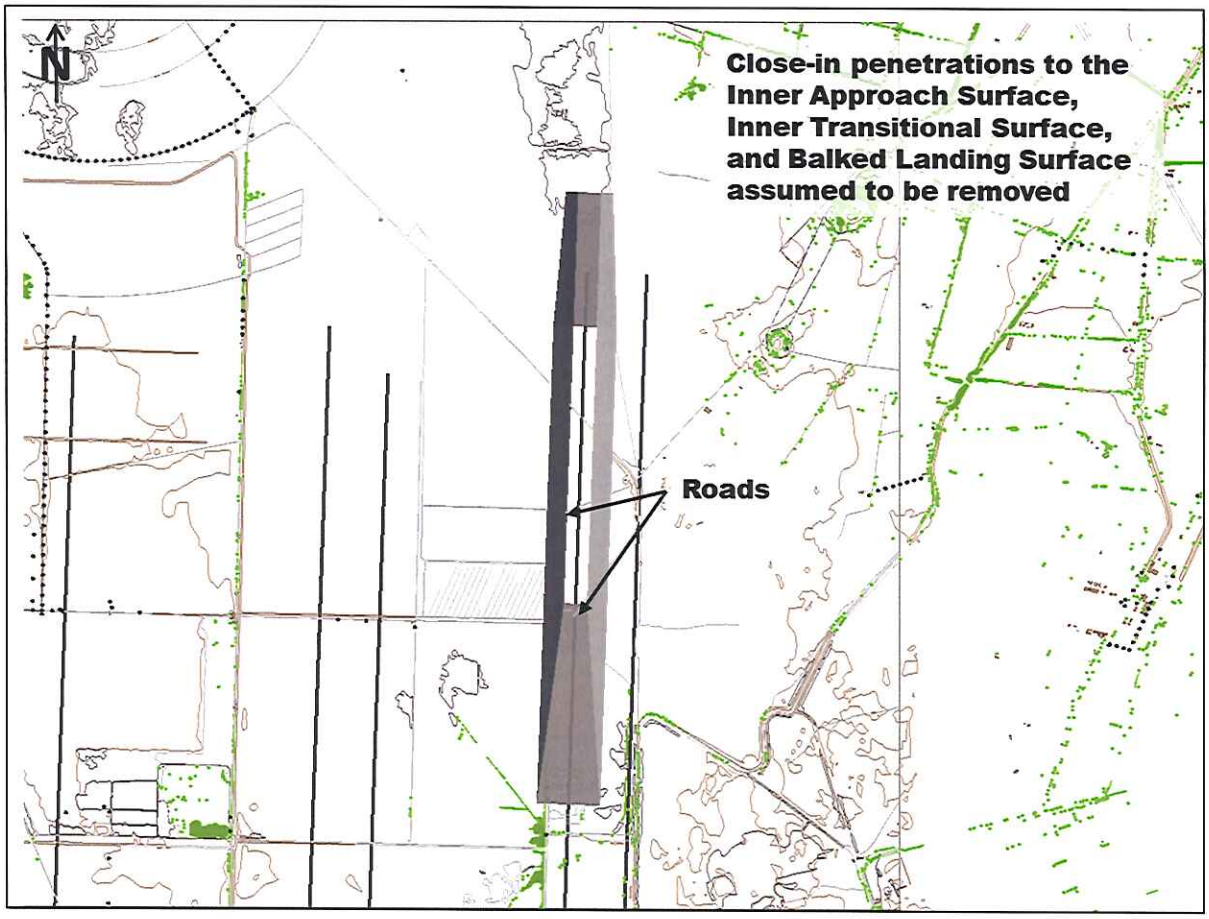


Figure 40. OFZ Surfaces: Runway 19R

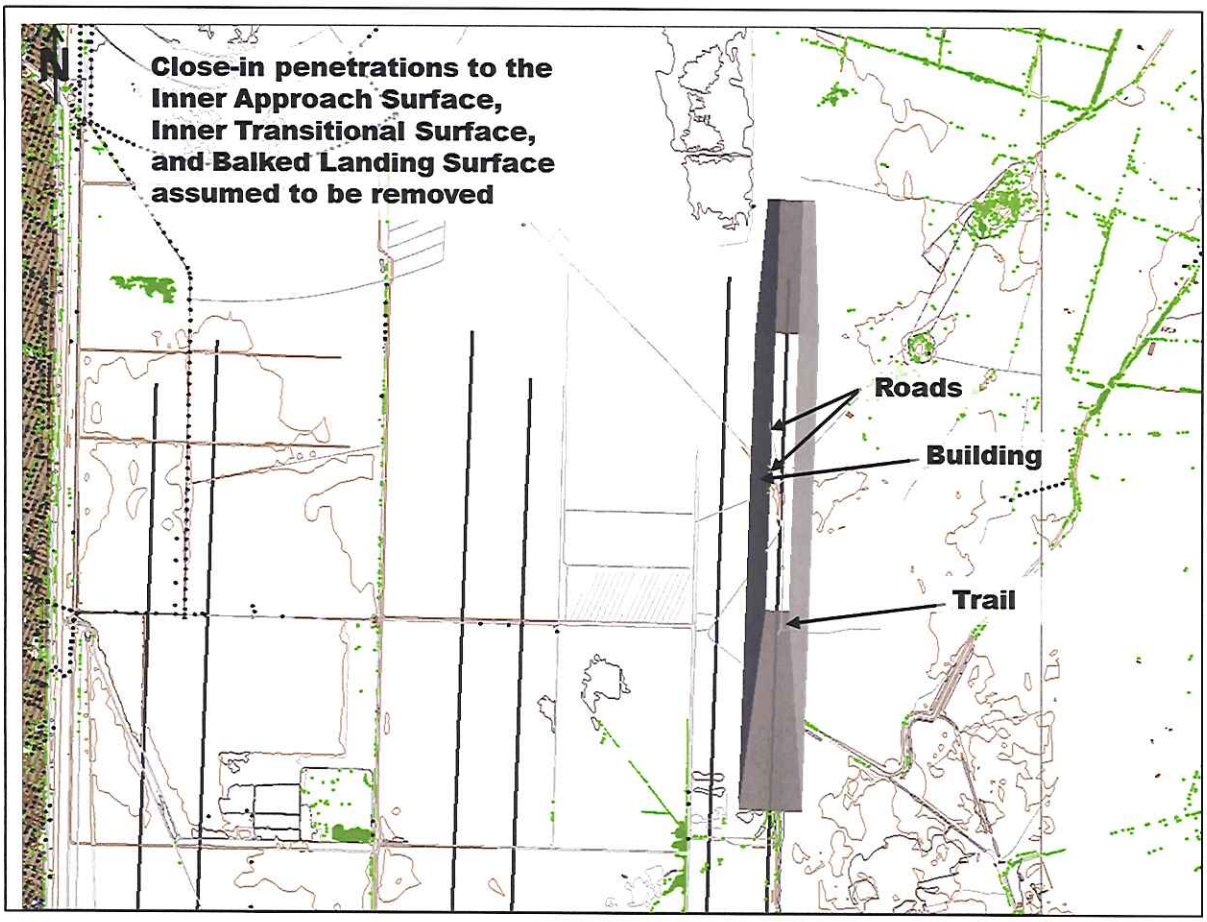


Figure 41. OFZ Surfaces: Runway 19L

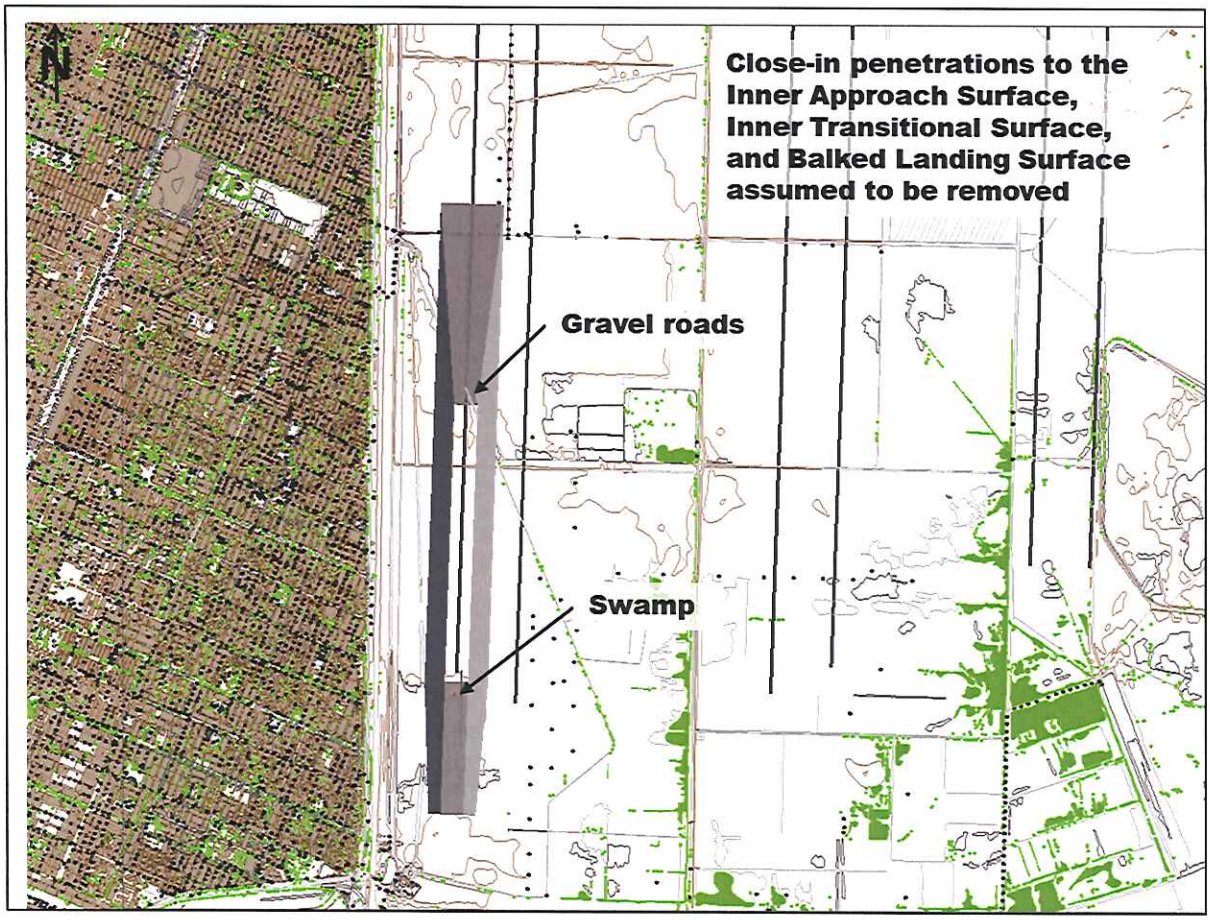


Figure 42. OFZ Surfaces: Runway 35L

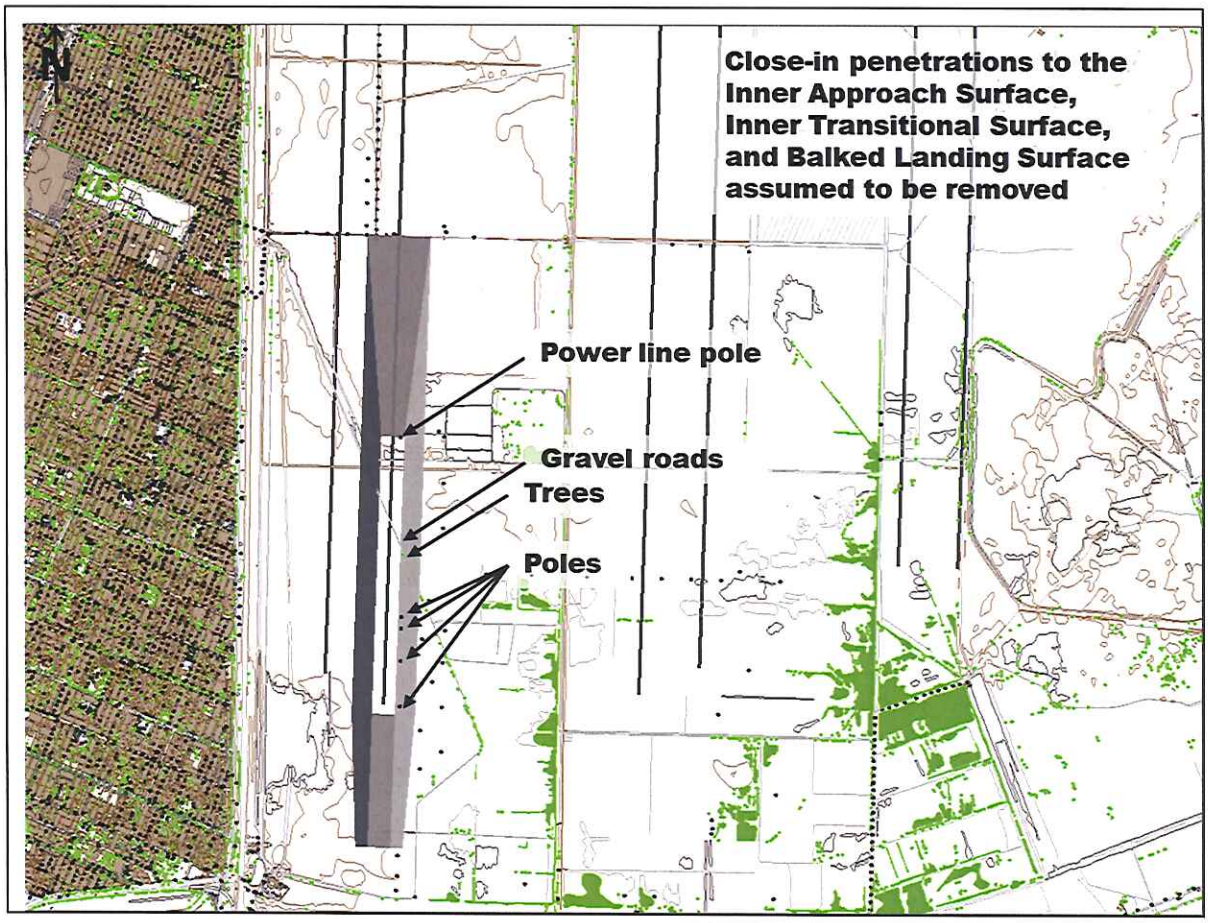


Figure 43. OFZ Surfaces: Runway 35R

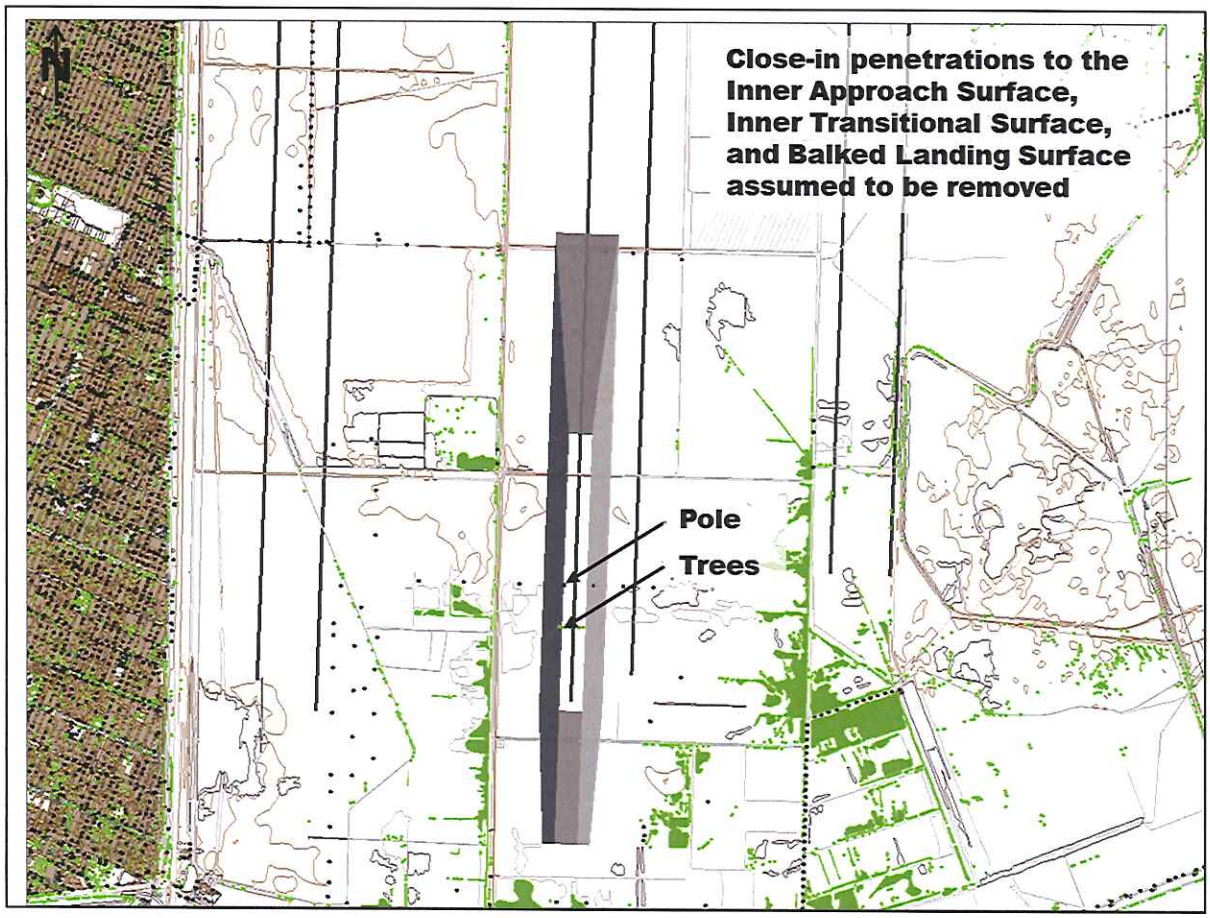


Figure 44. OFZ Surfaces: Runway 36L

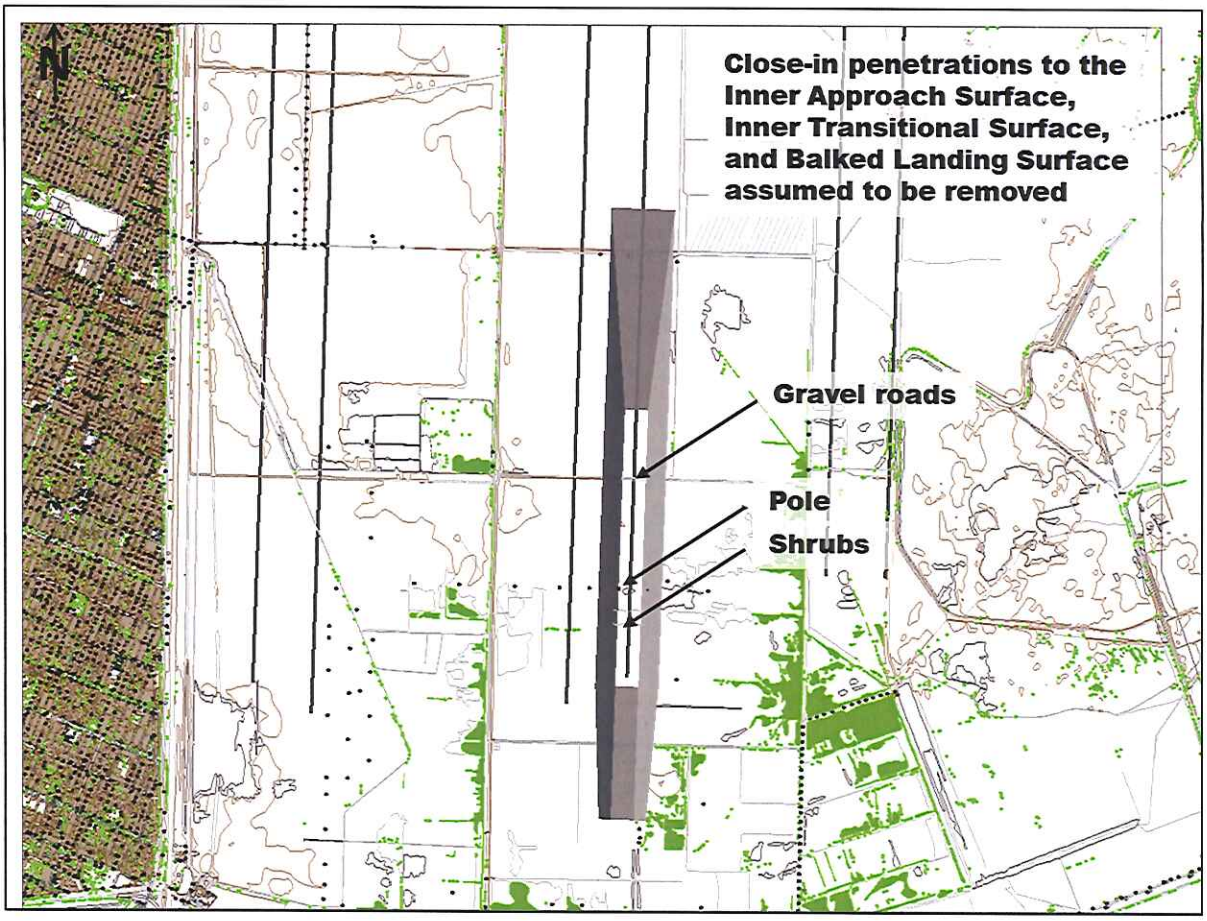


Figure 45. OFZ Surfaces: Runway 36R

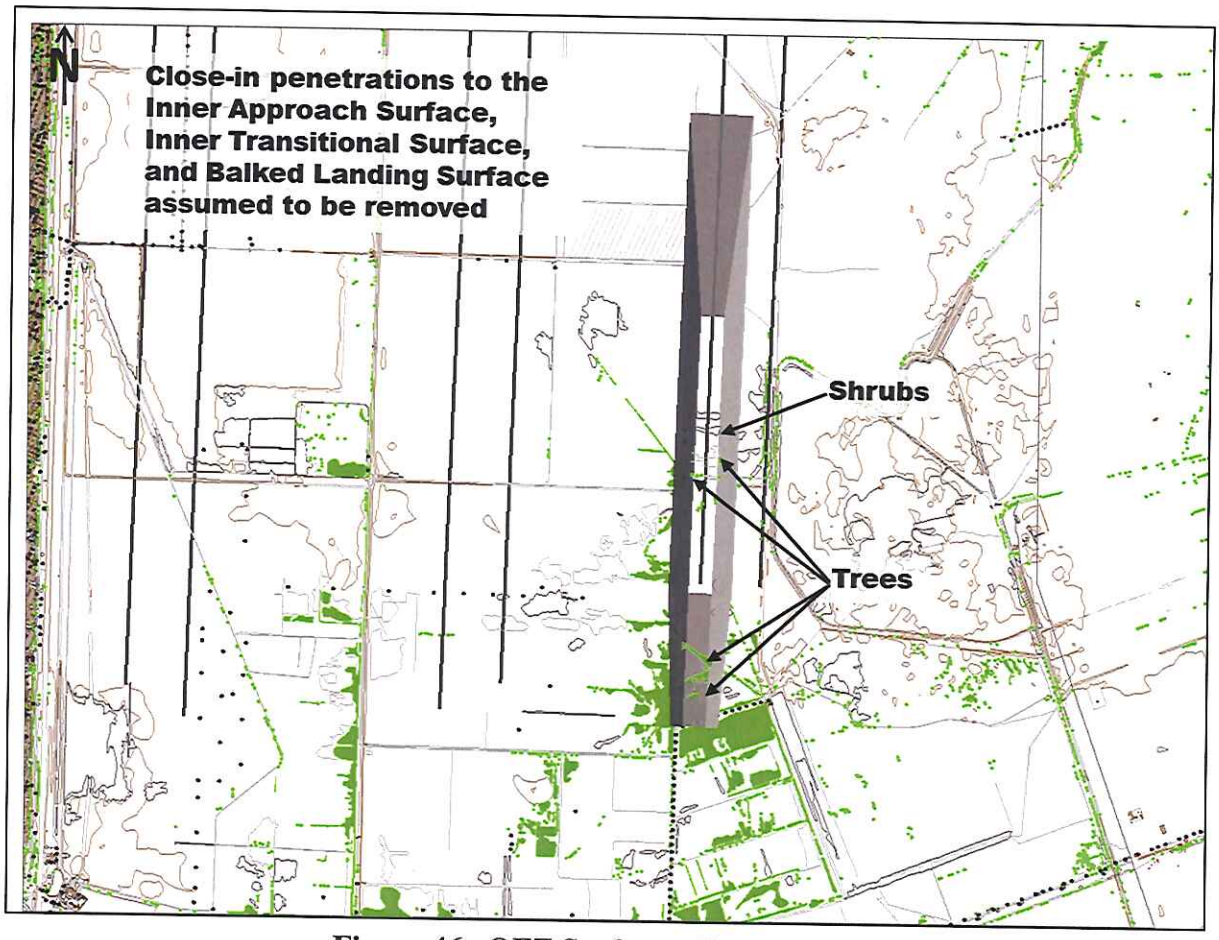


Figure 46. OFZ Surfaces: Runway 01L

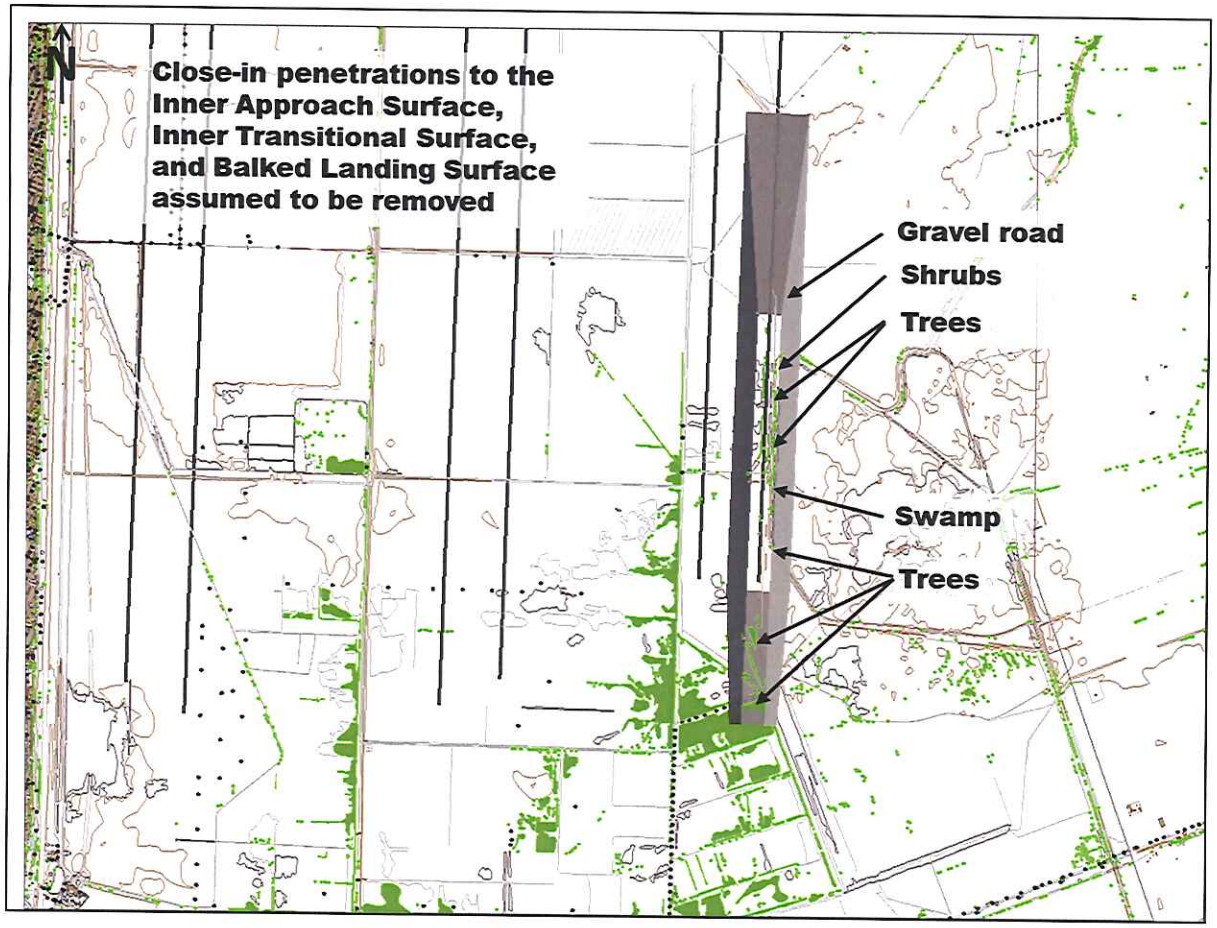


Figure 47. OFZ Surfaces: Runway 01R

6.4 Take-off Climb Surfaces

MITRE evaluated the Take-off Climb Surfaces corresponding to candidate departure procedures that were developed by MITRE for the MITRE-Recommended Runway Configuration (July 2012). These candidate procedures are described in detail in [7]. As identified in that document, the departure procedures are as follows:

Runways 17L and 17R:

1. A right turn to SMO Very High Frequency Omni Directional Range (VOR)/Distance Measuring Equipment (DME), then V14/V22
2. A right turn proceeding to the AVSEK Intersection (INT)

Runways 18L and 18R: A single departure to the south.

Runways 19L and 19R:

1. A left turn to the ALKOM INT
2. A left turn to the APN VOR/DME

Runways 35L and 35R:

1. A hard left turn to the TLC VOR/DME
2. A left turn around the north side of Sierra de Guadalupe then turning southwest to the TLC VOR/DME
3. A left turn to the northwest proceeding to TEX R-337/35 DME

Runways 36L and 36R: A single departure to the north.

Runways 01L and 01R:

1. A right turn to the ALKOM Intersection
2. A right turn to the APN VOR/DME

The Take-off Climb Surfaces are shown in Figures 48 through 71 as follows:

- Runway 17R Departure 1 is shown in Figure 48
- Runway 17R Departure 2 is shown in Figure 49
- Runway 17L Departure 1 is shown in Figure 50
- Runway 17L Departure 2 is shown in Figure 51
- Runway 18R Departure is shown in Figure 52
- Runway 18L Departure is shown in Figure 53
- Runway 19R Departure 1 is shown in Figure 54
- Runway 19R Departure 2 is shown in Figure 55
- Runway 19L Departure 1 is shown in Figure 56
- Runway 19L Departure 2 is shown in Figure 57
- Runway 35L Departure 1 is shown in Figures 58 and 59 (detailed view)
- Runway 35L Departure 2 is shown in Figure 60
- Runway 35L Departure 3 is shown in Figure 61
- Runway 35R Departure 1 is shown in Figure 62
- Runway 35R Departure 2 is shown in Figure 63
- Runway 35R Departure 3 is shown in Figure 64
- Runway 36L Departure is shown in Figure 65
- Runway 36R Departure is shown in Figures 66 and 67 (detailed view)
- Runway 01L Departure 1 is shown in Figure 68
- Runway 01L Departure 2 is shown in Figure 69

- Runway 01R Departure 1 is shown in Figure 70
- Runway 01R Departure 2 is shown in Figure 71

As previously mentioned, MITRE assumed that objects in close proximity to the runways will be removed during construction.

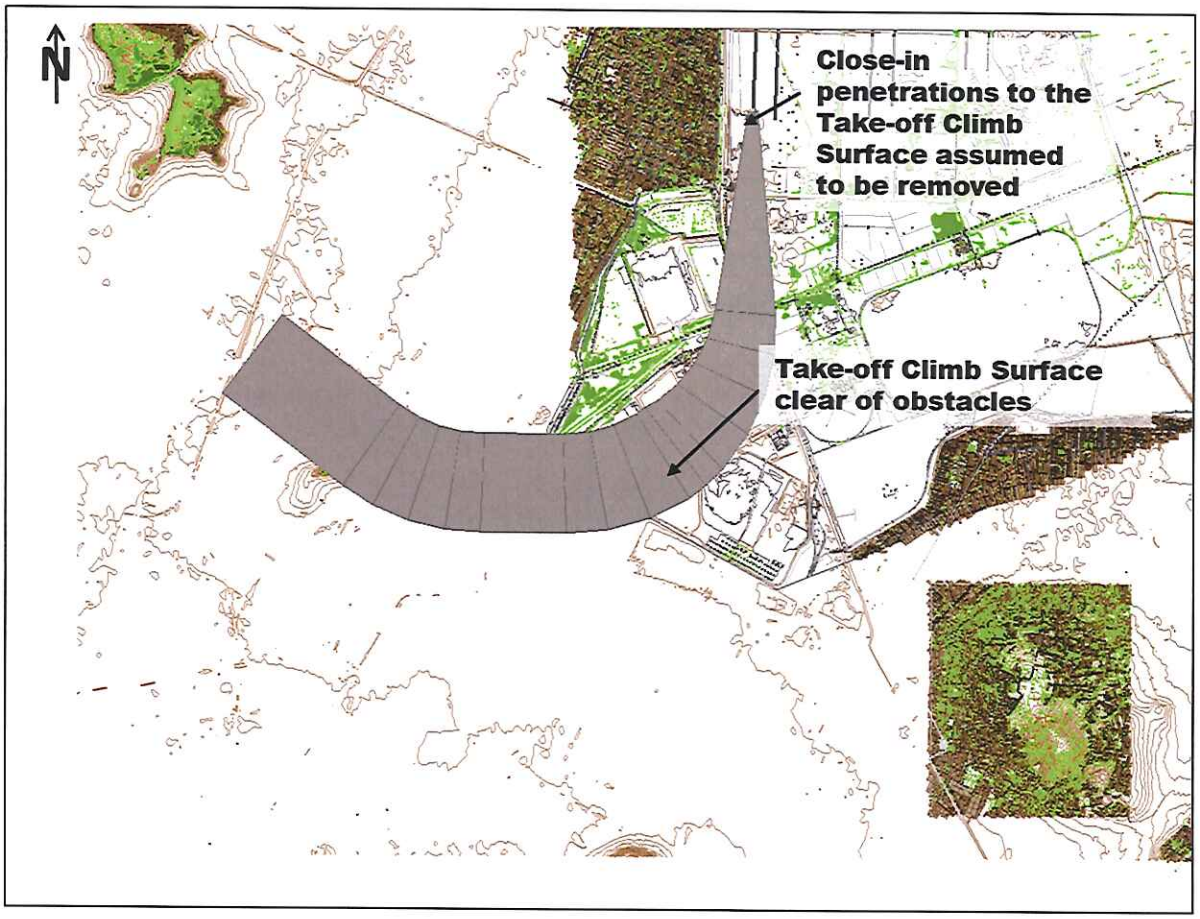


Figure 48. Take-off Climb Surface: Runway 17R Departure 1

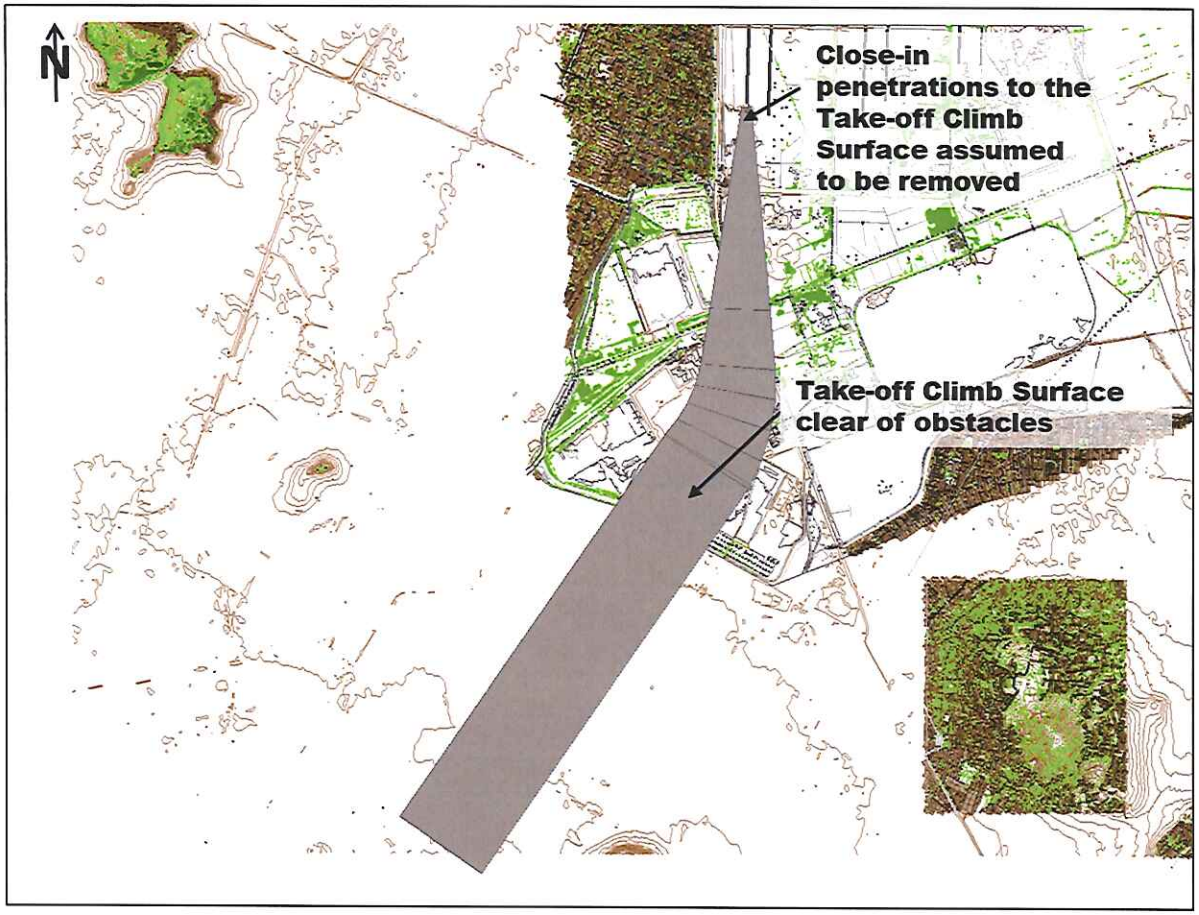


Figure 49. Take-off Climb Surface: Runway 17R Departure 2

Figure 50. Take-off Climb Surface: Runway 17L Departure 1

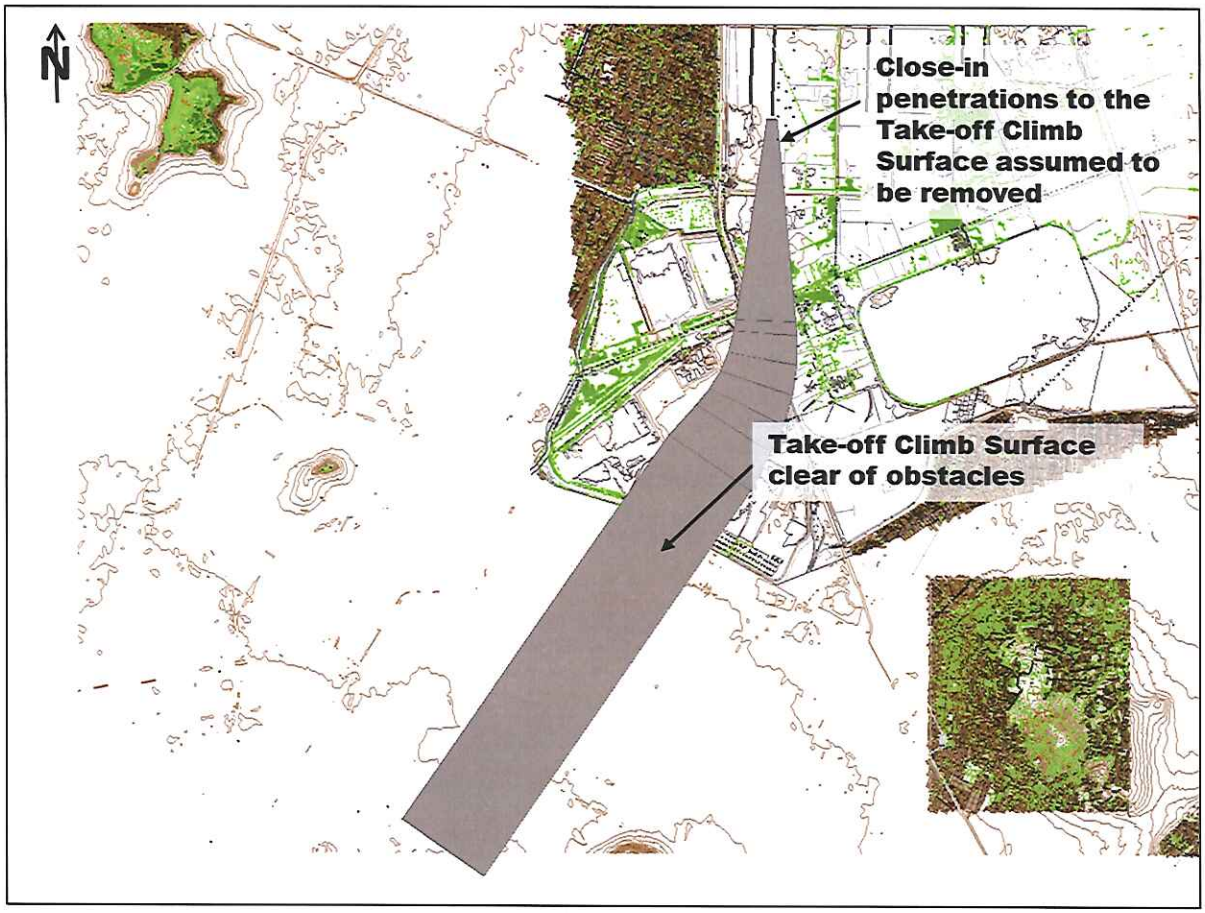


Figure 51. Take-off Climb Surface: Runway 17L Departure 2

Figure 52. Take-off Climb Surface: Runway 18R Departure

Figure 53. Take-off Climb Surface: Runway 18L Departure

Figure 54. Take-off Climb Surface: Runway 19R Departure 1

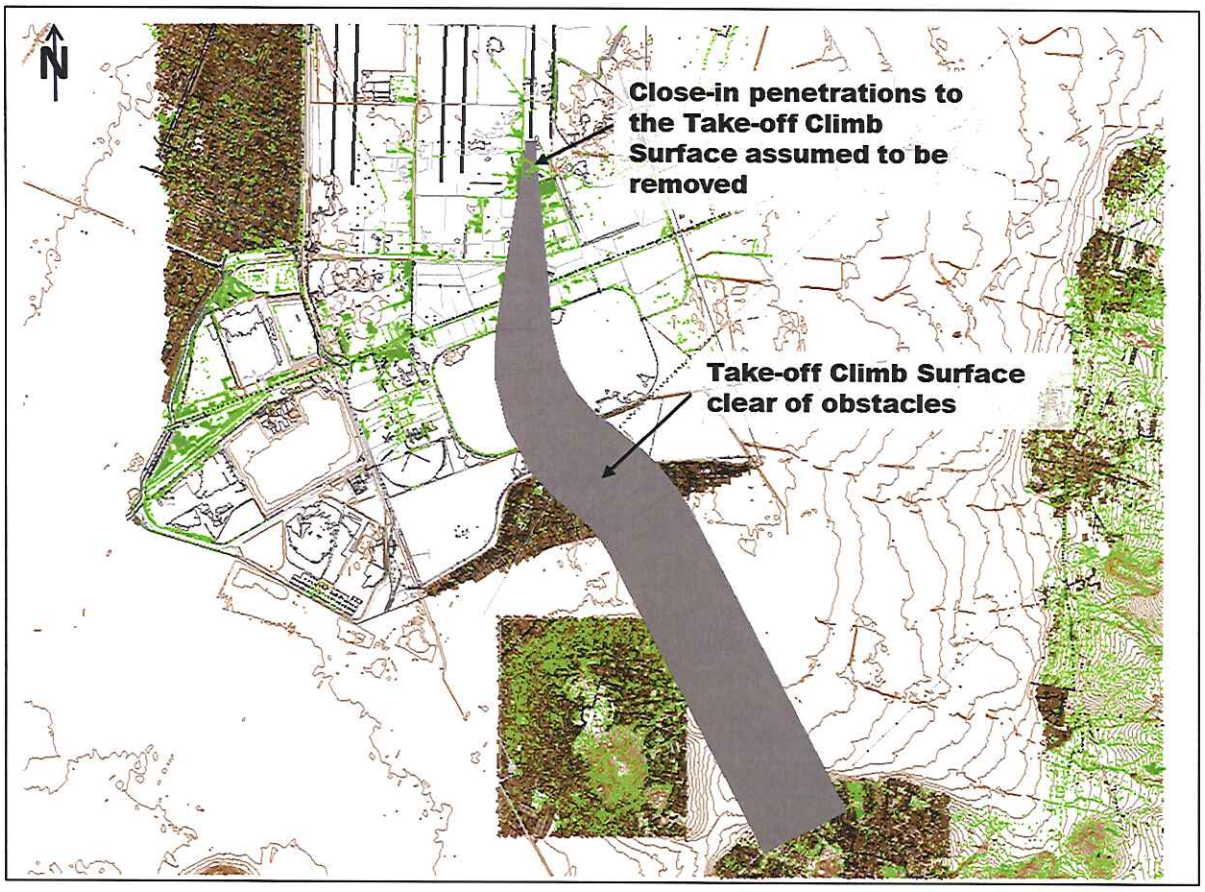


Figure 55. Take-off Climb Surface: Runway 19R Departure 2

Figure 56. Take-off Climb Surface: Runway 19L Departure 1

Figure 57. Take-off Climb Surface: Runway 19L Departure 2

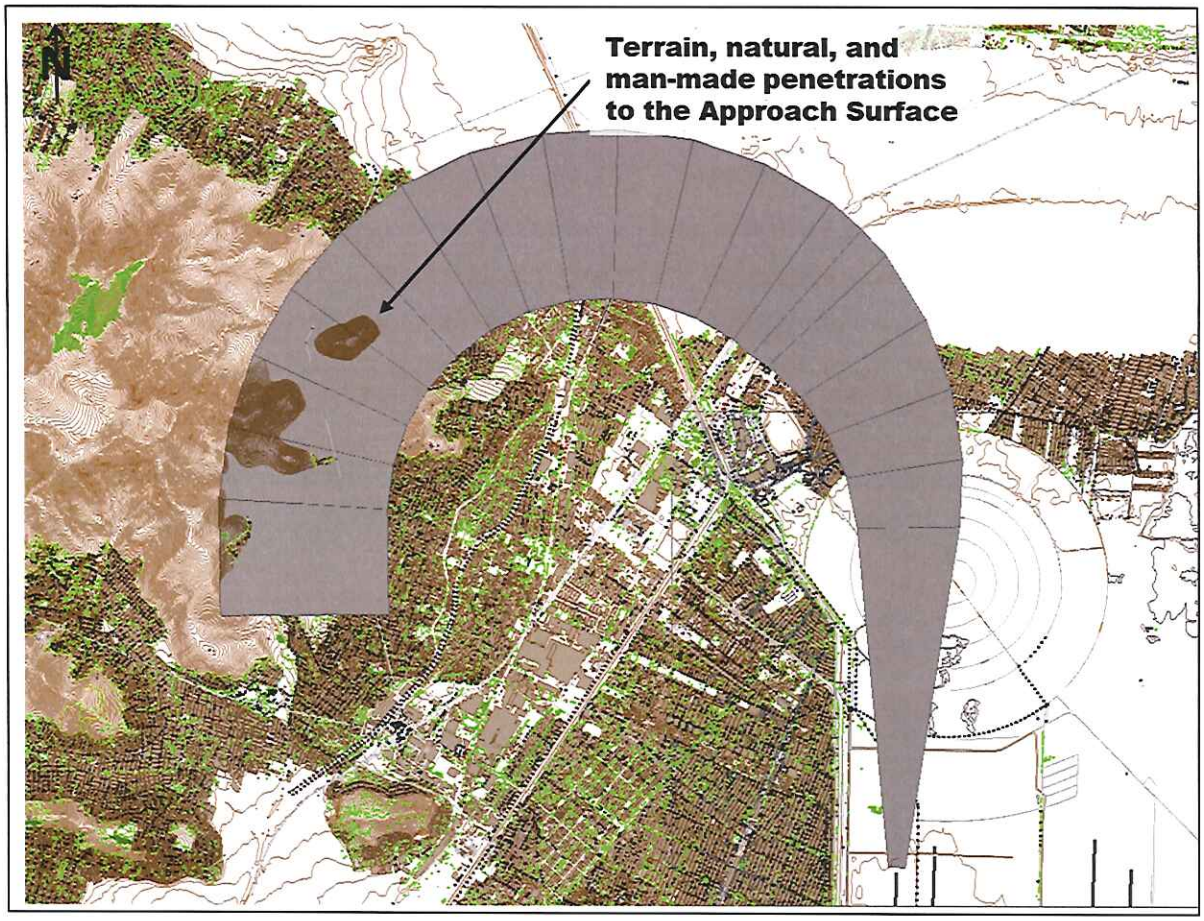
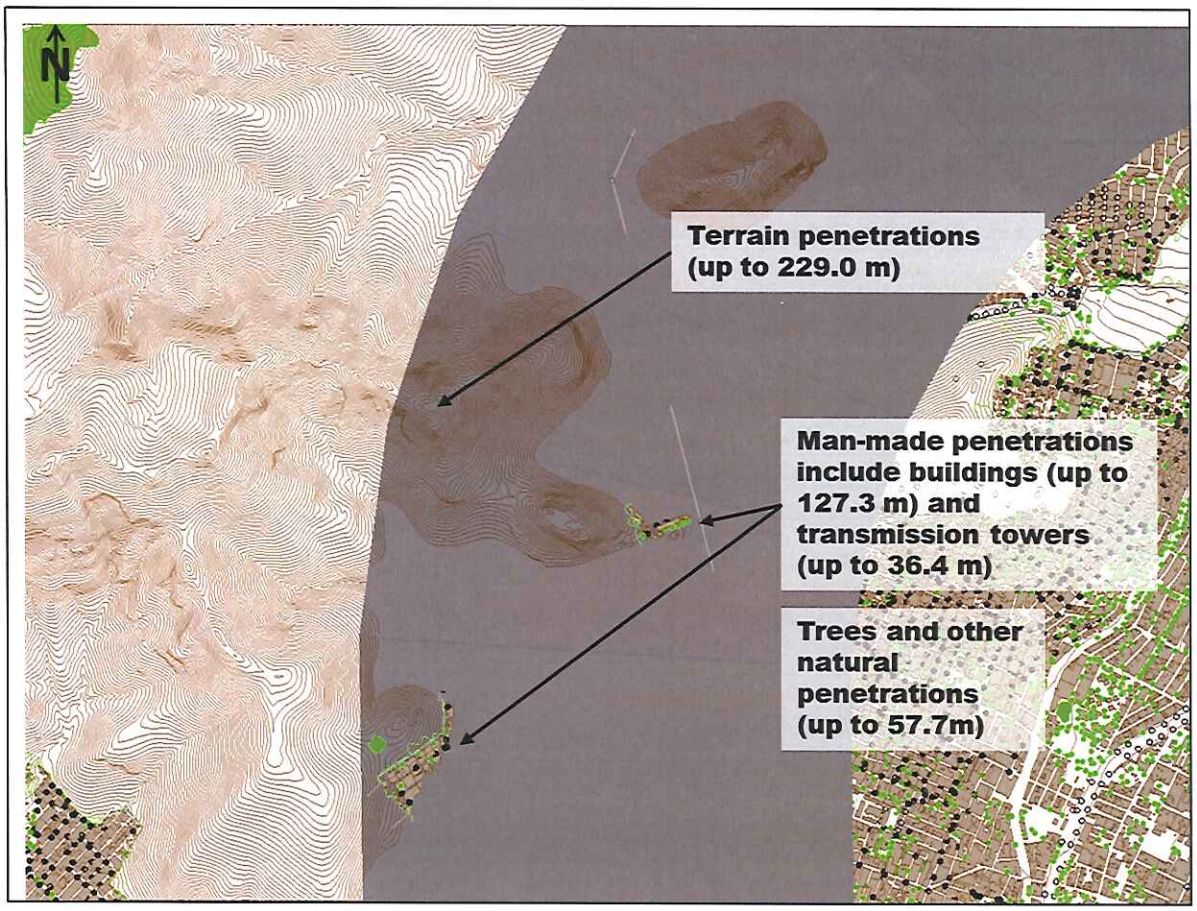


Figure 58. Take-off Climb Surface: Runway 35L Departure 1



Note: Many of the obstacles shown also penetrate the Take-off Climb Surface for Runway 35R Departure 1. However, the penetrations for Runway 35L are representative of the worst case scenario, and therefore the corresponding detailed view for Runway 35R is not shown.

Figure 59. Take-off Climb Surface: Runway 35L Departure 1 (Detailed View)

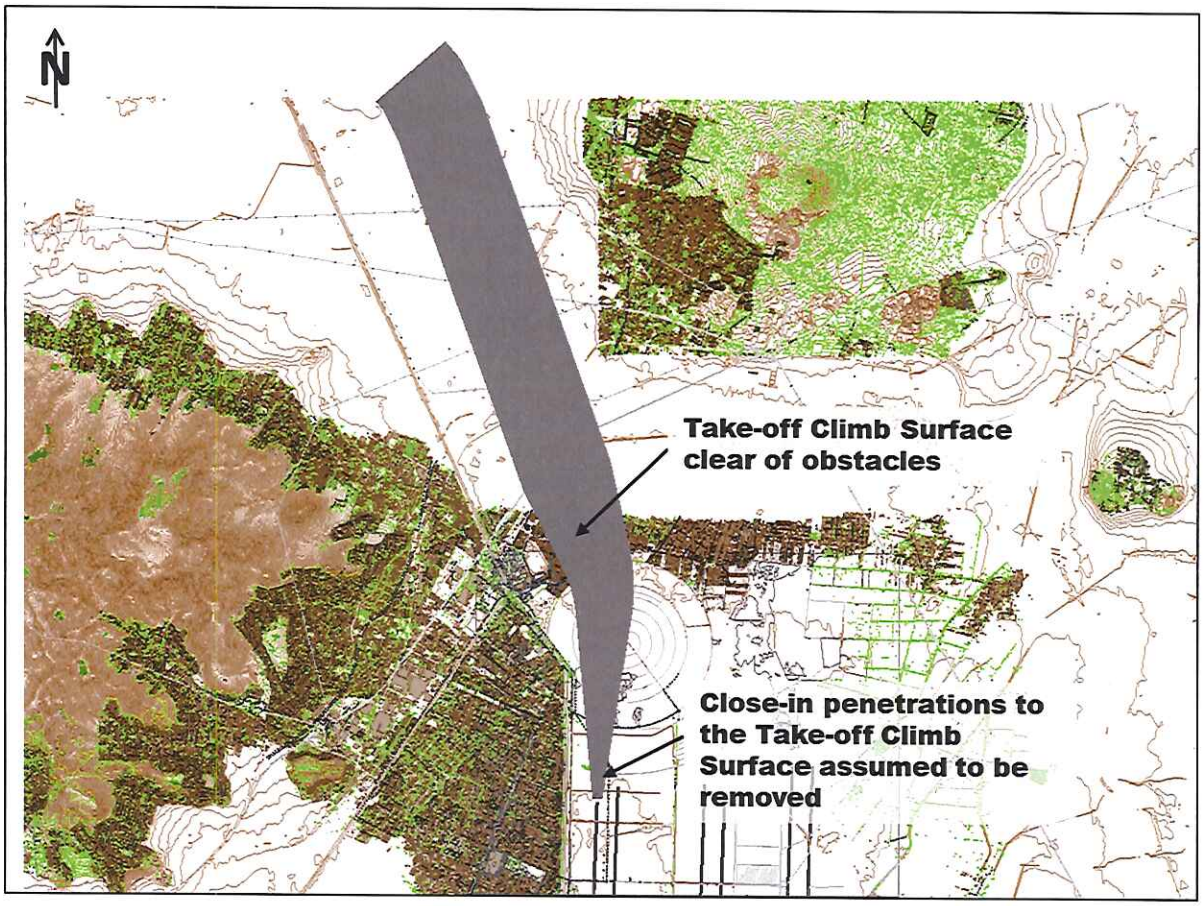


Figure 60. Take-off Climb Surface: Runway 35L Departure 2

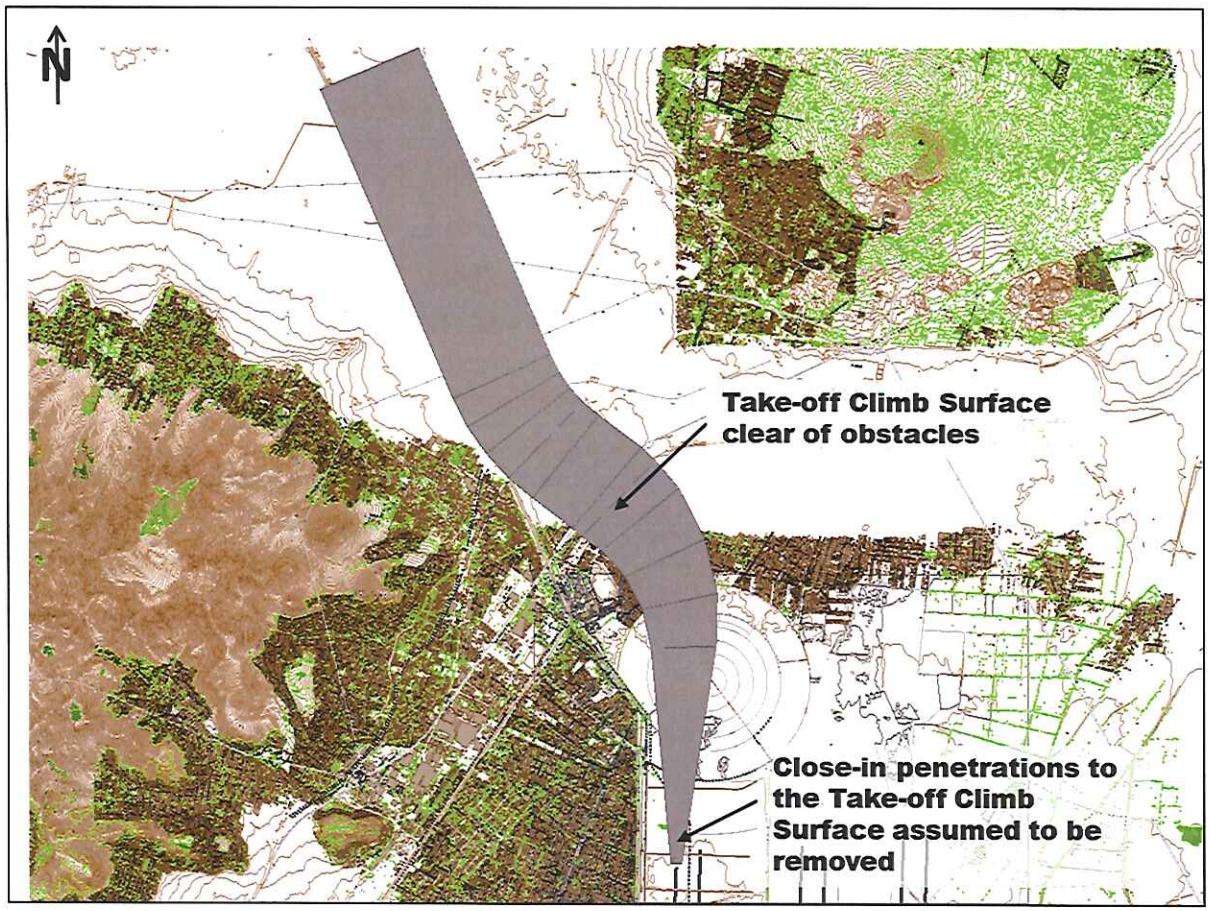


Figure 61. Take-off Climb Surface: Runway 35L Departure 3

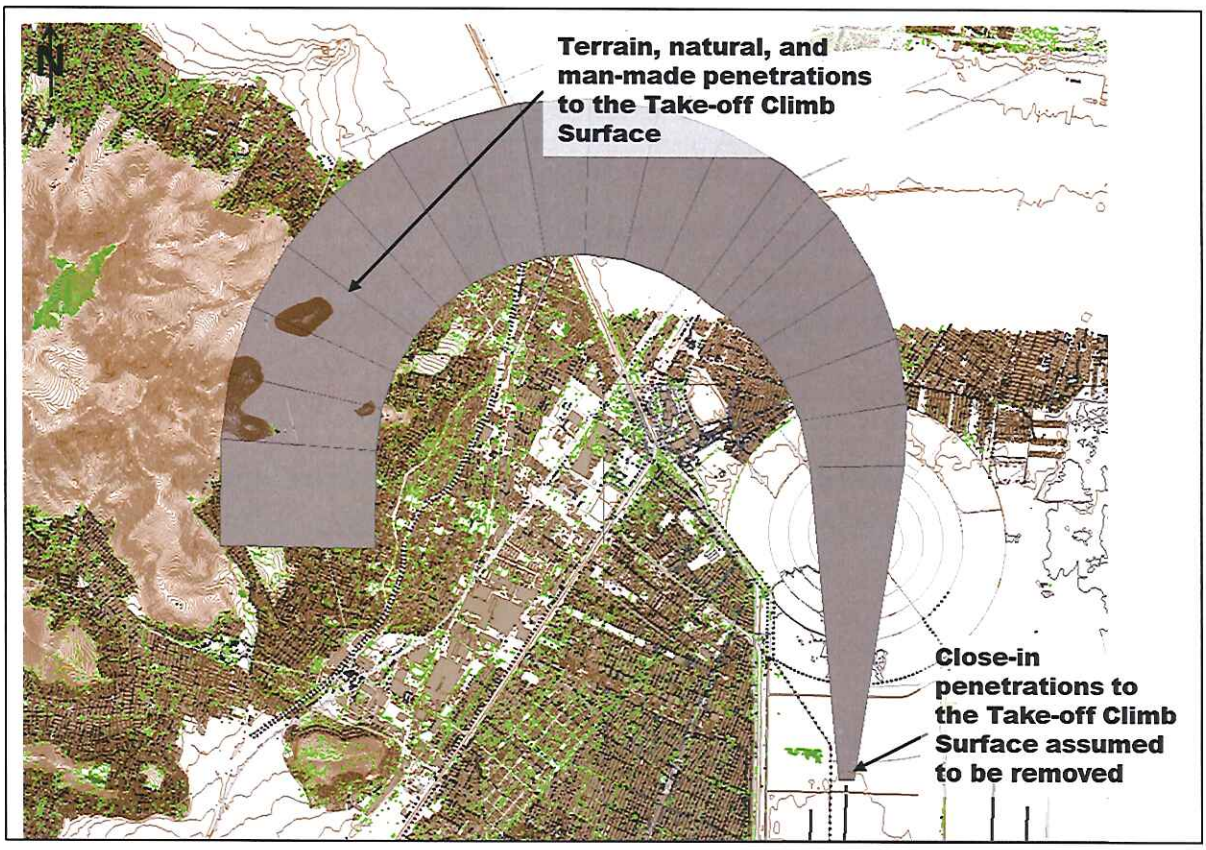


Figure 62. Take-off Climb Surface: Runway 35R Departure 1

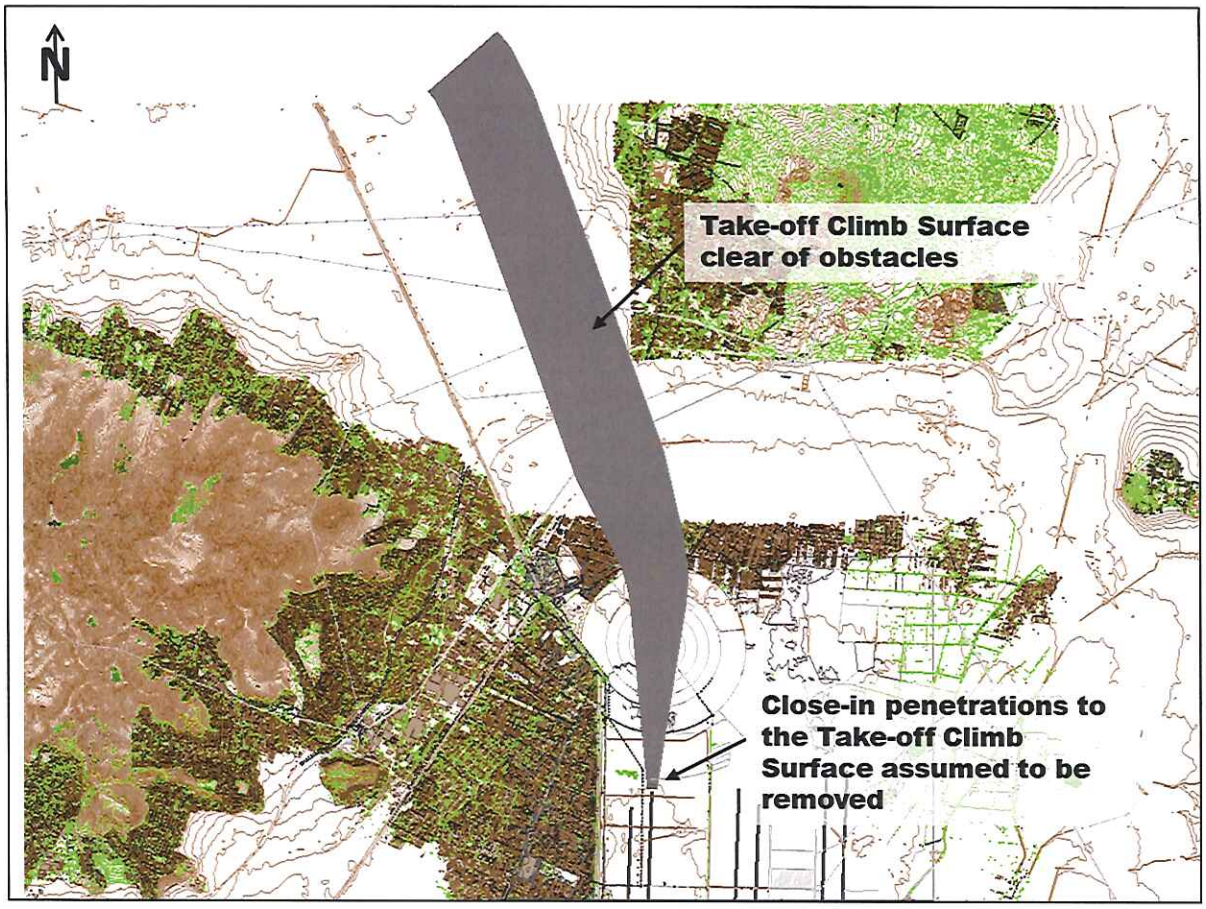


Figure 63. Take-off Climb Surface: Runway 35R Departure 2

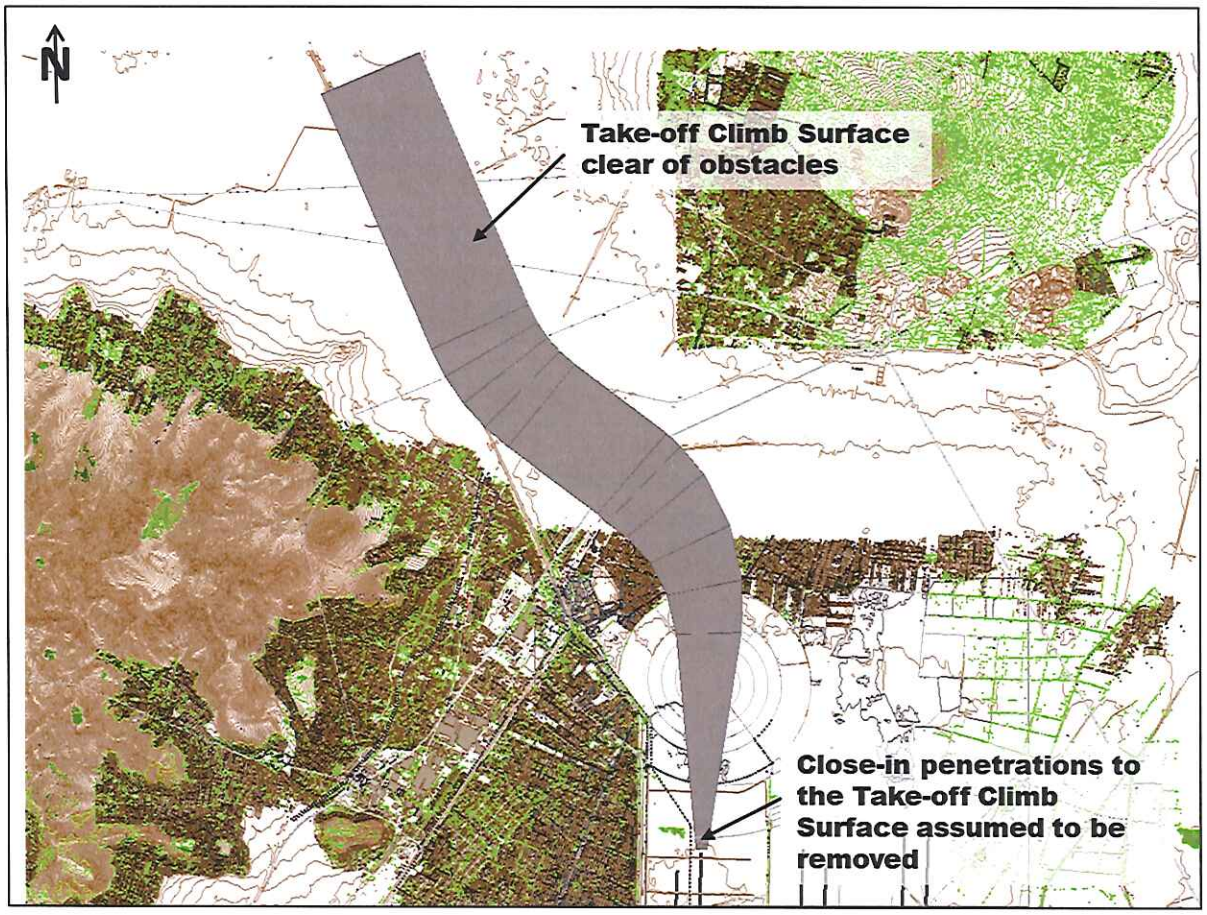


Figure 64. Take-off Climb Surface: Runway 35R Departure 3

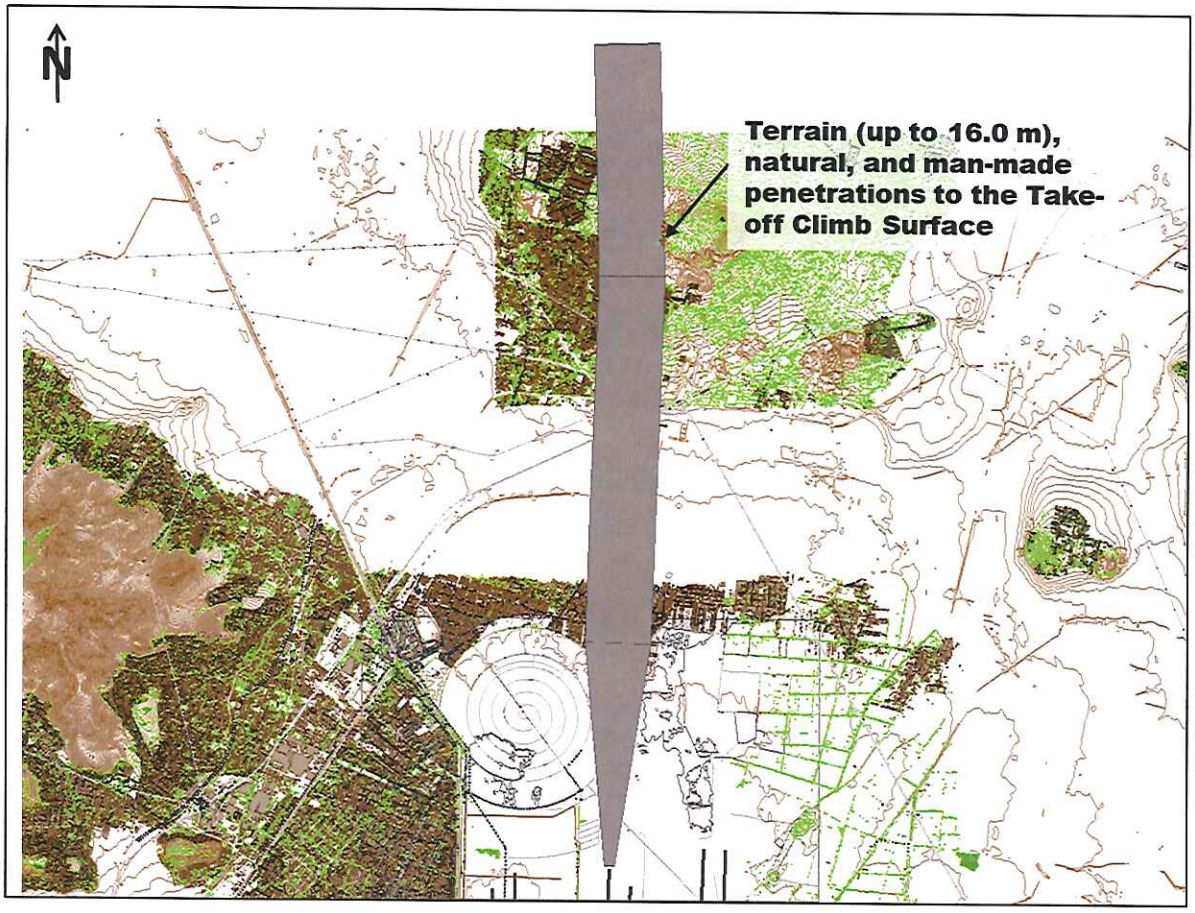


Figure 65. Take-off Climb Surface: Runway 36L Departure

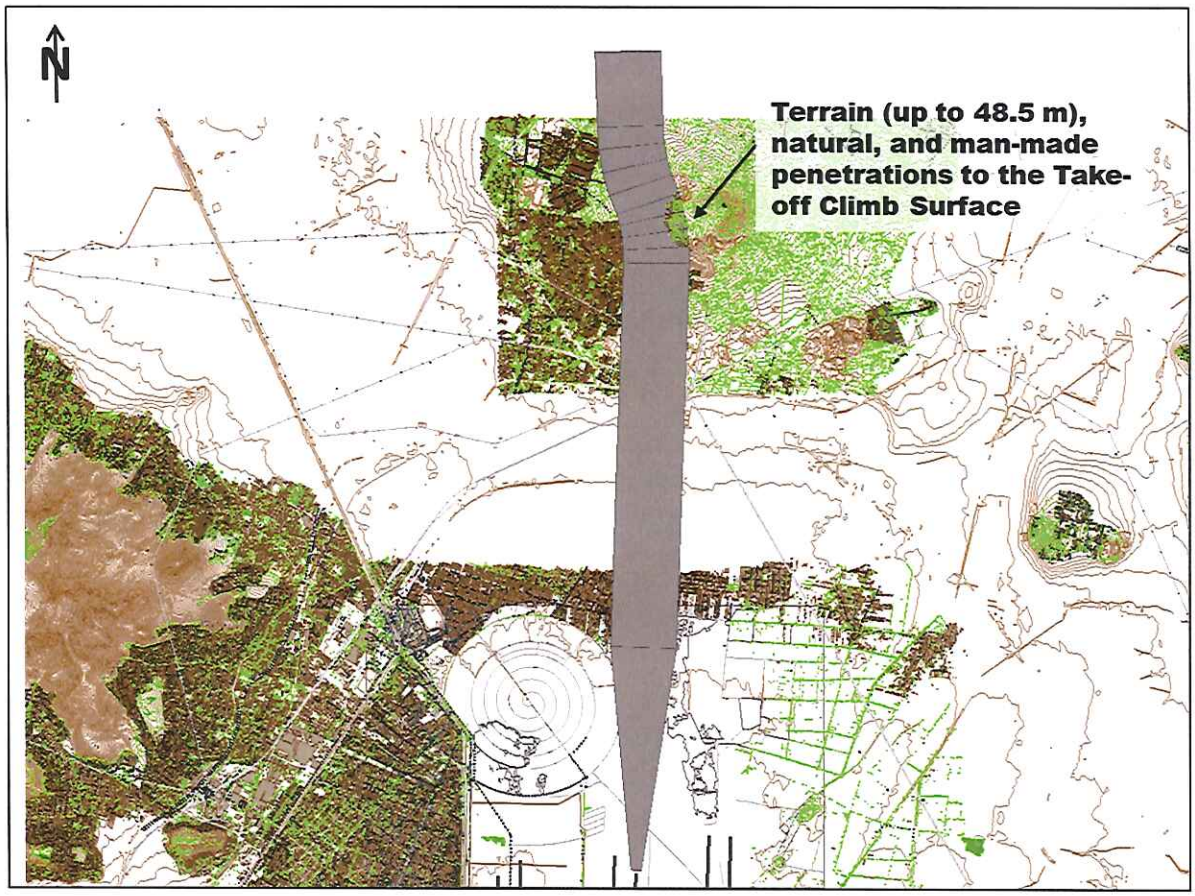
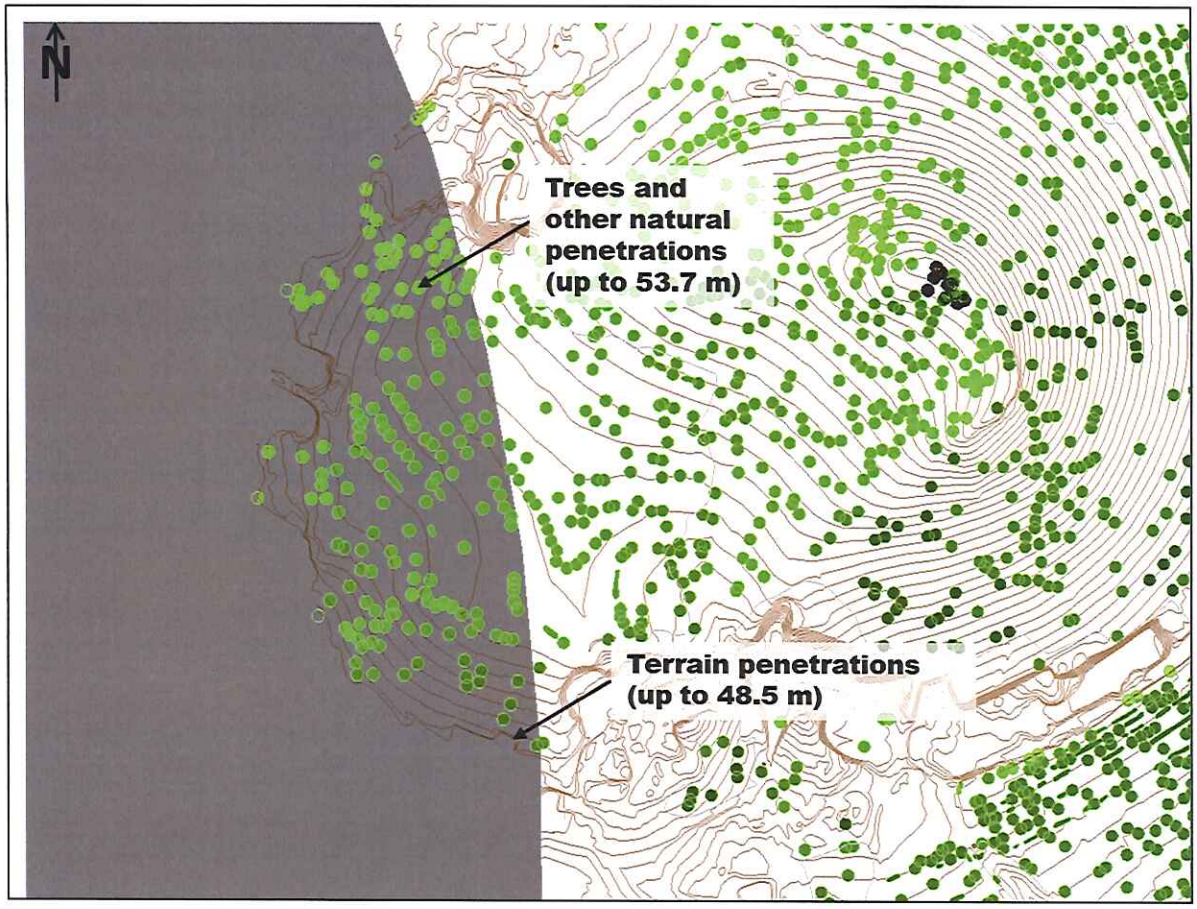


Figure 66. Take-off Climb Surface: Runway 36R Departure



Note: Many of the obstacles shown also penetrate the Take-off Climb Surface for Runway 36L. However, the penetrations for Runway 36R are representative of the worst case scenario, and therefore the corresponding detailed view for Runway 36L is not shown.

Figure 67. Take-off Climb Surface: Runway 36R Departure (Detailed View)

The Take-off Climb Surfaces for Runways 36L and 36R are penetrated by terrain at the hill of Chiconautla as well as trees and other natural penetrations.

As mentioned previously, more detailed information regarding terrain penetrations to Annex 14 OLS by Chiconautla are contained in a parametric analysis of runway threshold elevations [8].

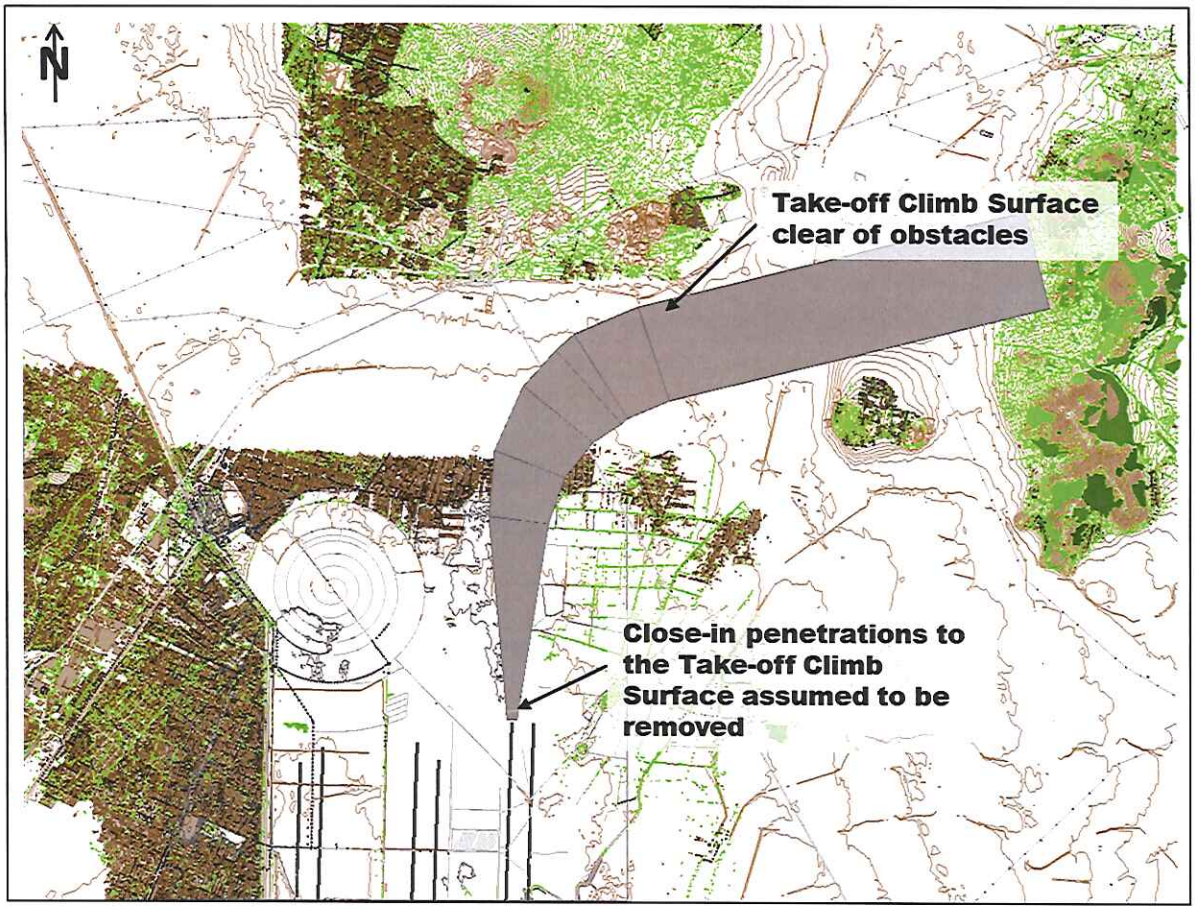


Figure 68. Take-off Climb Surface: Runway 01L Departure 1

Figure 69. Take-off Climb Surface: Runway 01L Departure 2

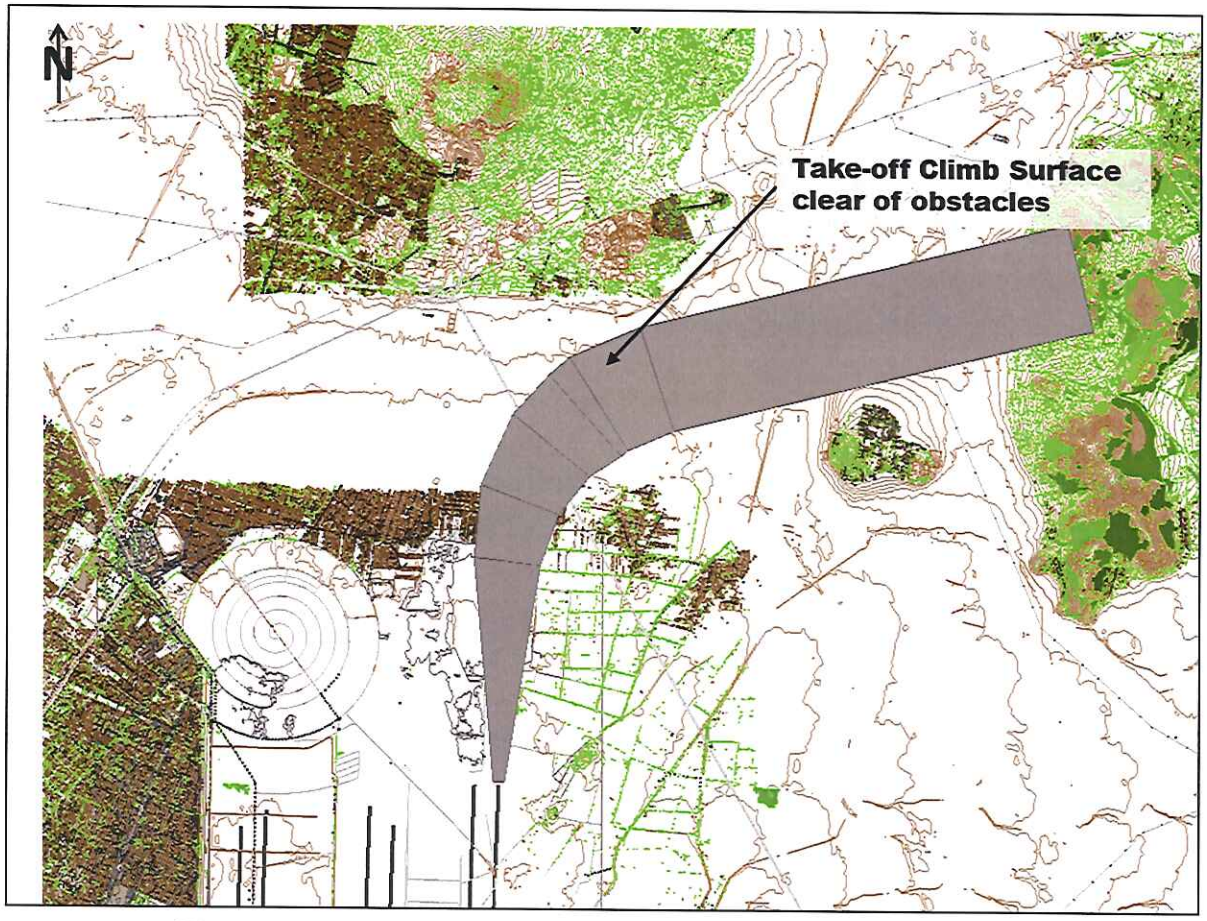


Figure 70. Take-off Climb Surface: Runway 01R Departure 1

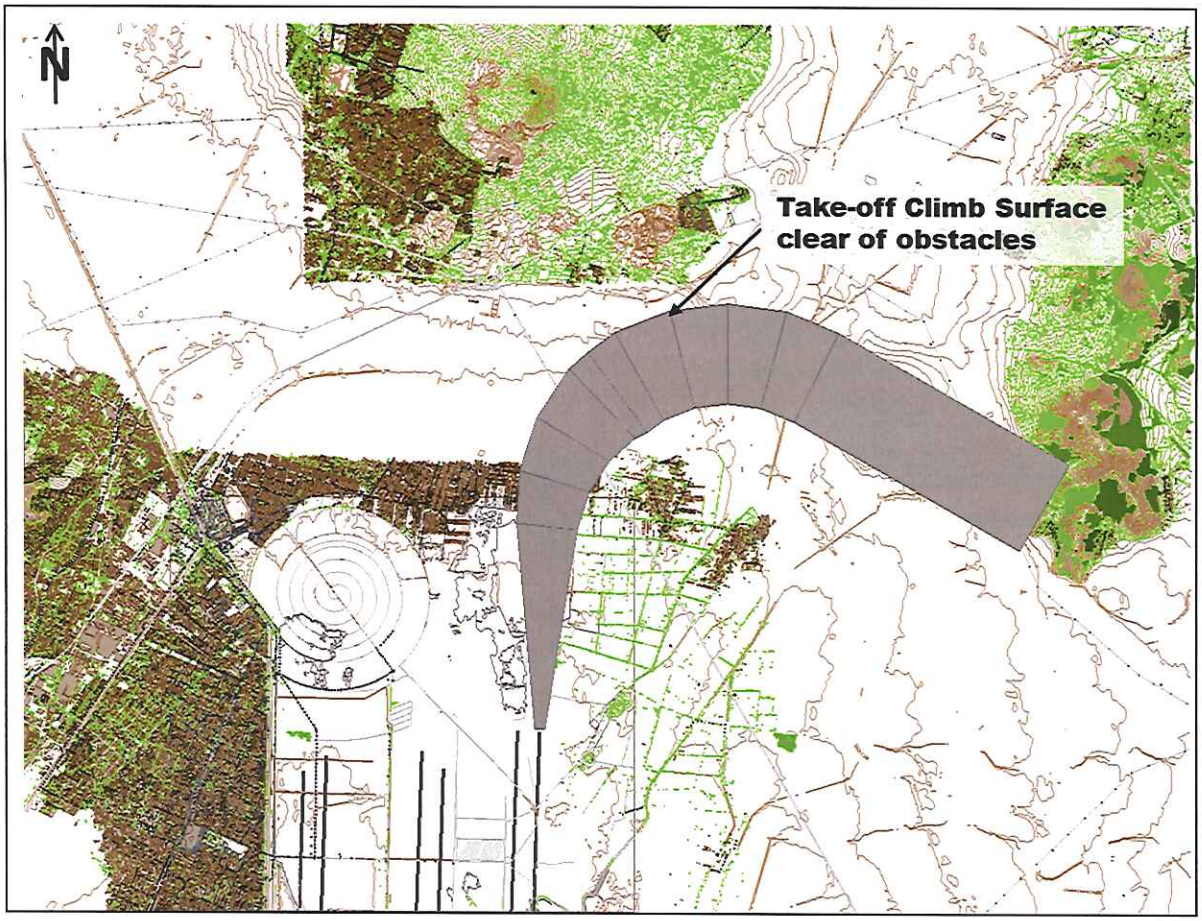


Figure 71. Take-off Climb Surface: Runway 01R Departure 2

6.5 Additional OLS Considerations

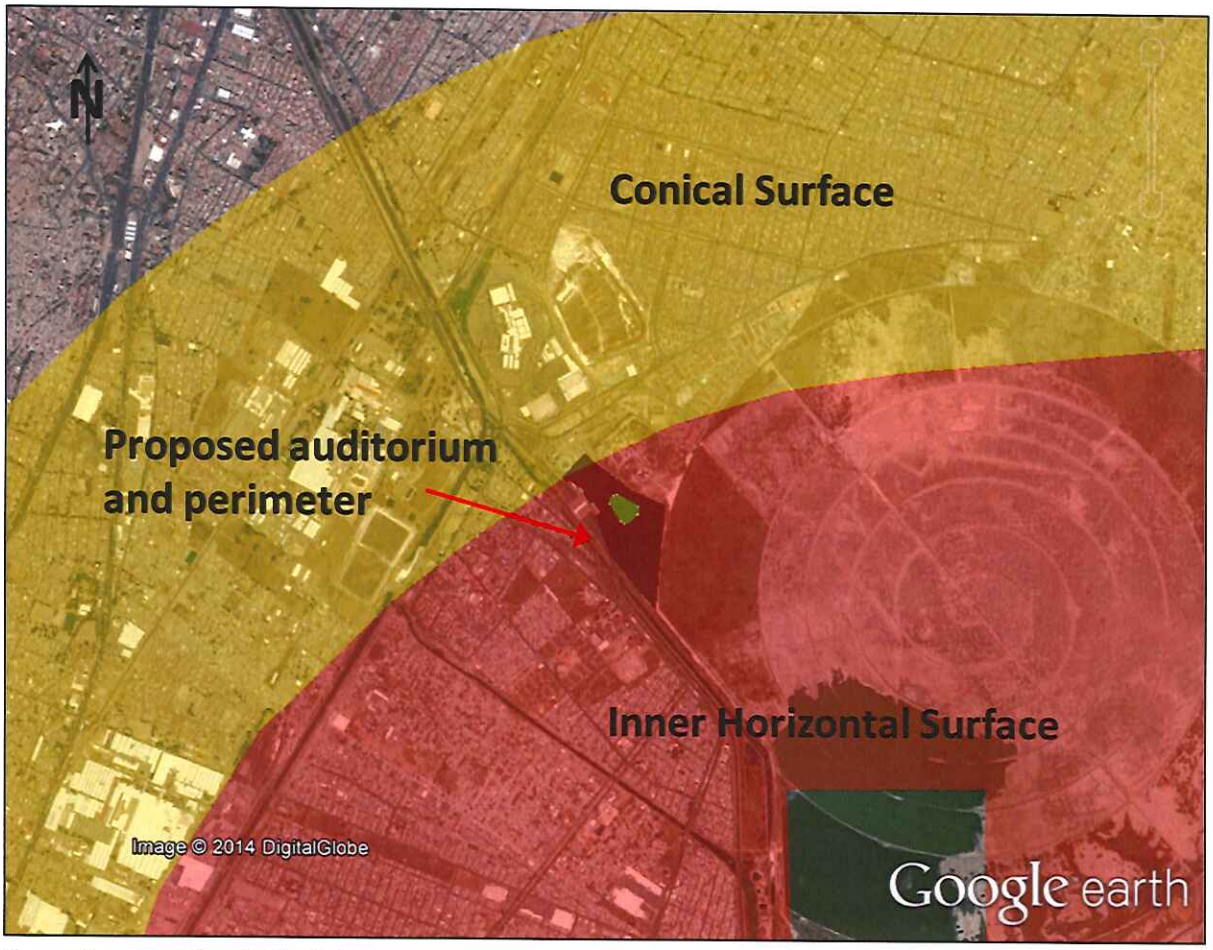
MITRE also considered some structures that are being proposed in the vicinity of the NAICM site. In particular, MITRE performed OLS analyses for an auditorium and for water storage tanks near the NAICM site.

MITRE has also been informed of plans by Comisión Federal de Electricidad to install power lines in the vicinity of the NAICM site. Some portions of the power line may be below ground and other portions may be above ground. However, these power line plans are still being formalized. Therefore, the impact of the proposed power lines on Annex 14 OLS and other critical matters, such as the development of instrument approach and departure procedures, has not been examined by MITRE. <u>It is important to reiterate that if any power lines are to be located above ground, it is critical that MITRE analyze them to determine their potential impact on operations at NAICM before they are constructed</u>.

6.5.1 Auditorium

In mid-February 2014, ASA informed MITRE of plans by the government of the State of Mexico to construct an auditorium near the NAICM site.

MITRE evaluated the impact of the auditorium and its perimeter against Annex 14 OLS and results of this analysis were provided in [9]. Figure 72 shows the location of the auditorium and perimeter in relation to the Inner Horizontal and Conical Surfaces. While both the auditorium and perimeter fall within the lateral confines of the Inner Horizontal and Conical Surfaces, they do not penetrate either surface and cause no impact to Annex 14 OLS.



Source Imagery: Google Earth Pro

Figure 72. NAICM Inner Horizontal Surface and Conical Surface Showing Proposed Auditorium

6.5.2 Water Storage Tanks

In May 2014, ASA provided information from Comisión Nacional del Agua to MITRE about two water storage tanks in the vicinity of Chiconautla: Tanque Chiconautla, an existing water storage tank, and Depósito Chiconautla, a proposed water storage tank. MITRE evaluated the impact of the two water storage tanks against Annex 14 OLS and results of this analysis were provided in [10].

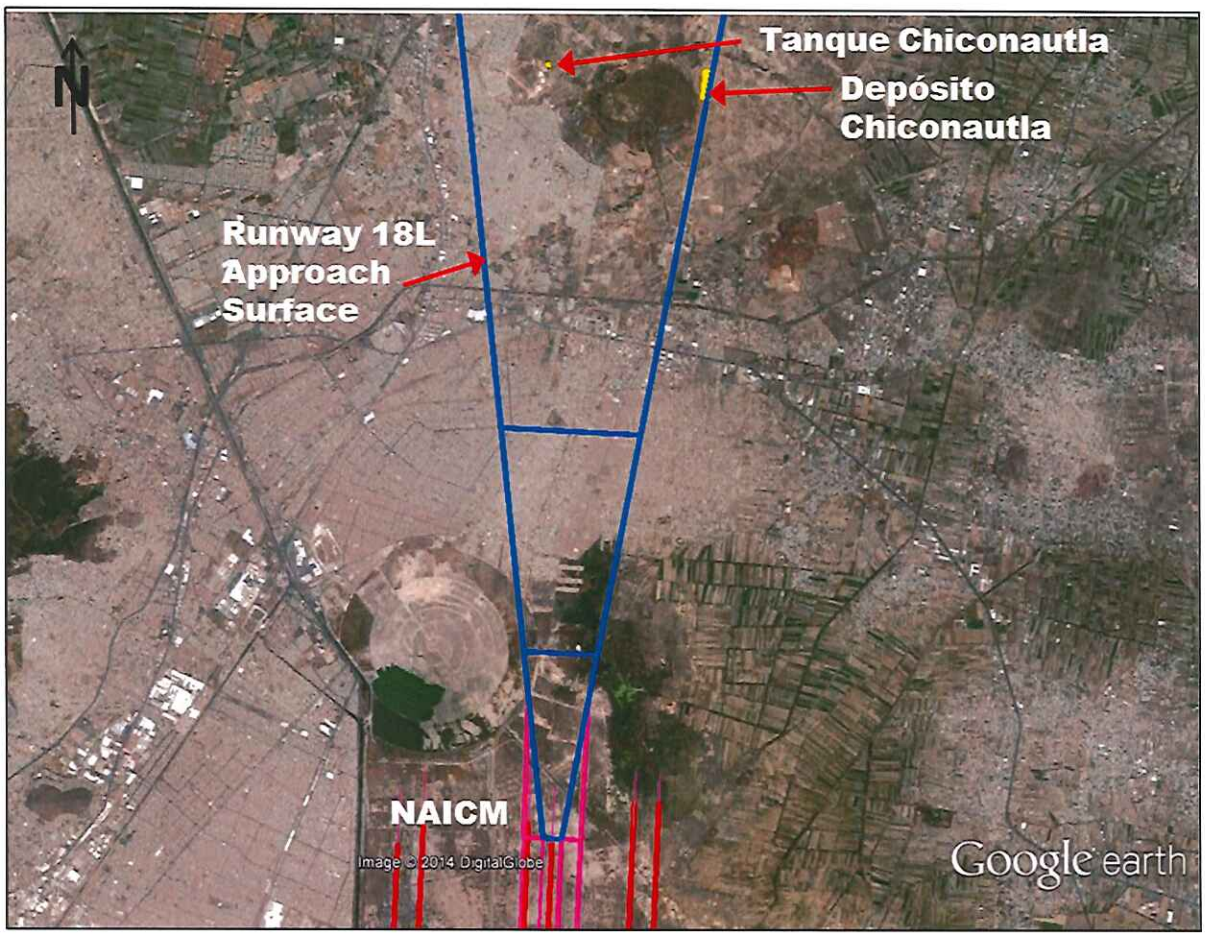
MITRE analyzed the potential impact of Tanque Chiconautla on the proposed Approach Surfaces to all runways at NAICM. However, Tanque Chiconautla is only located within the

lateral confines of the Approach Surfaces to the following runways: 17R, 17L, 18R, 18L, and 19R. It does not penetrate any of the Approach Surfaces.

MITRE also analyzed the potential impact of Depósito Chiconautla on the proposed Approach Surfaces to all runways at NAICM. However, Depósito Chiconautla is only located within the lateral confines of the Approach Surfaces for the following runways: 18L, 19R, and 19L; however, it, too, does not penetrate any of the Approach Surfaces.

Therefore, neither Tanque Chiconautla nor Depósito Chiconautla impact the Annex 14 Approach Surfaces.

Figure 73 shows the Approach Surface for Runway 18L. This is one example in which both Tanque Chiconautla and Depósito Chiconautla are located within the lateral confines of the Approach Surface, but do not penetrate the surface.



Note: As per the above-mentioned ICAO Annex 14 OLS criteria, the 2.5% slope of the Approach Surfaces, in the area of Tanque Chiconautla and Depósito Chiconautla, was extended due to existing terrain and/or natural obstructions associated with Chiconautla, which govern the obstacle clearance limit.

Figure 73. NAICM Runway 18L Approach Surface

MITRE also analyzed the potential impact of Tanque Chiconautla and Depósito Chiconautla on all proposed Take-off Climb Surfaces from all runways at NAICM. Tanque

Chiconautla is only located within the lateral confines of the Take-off Climb Surfaces for Runways 36L and 36R and does not penetrate either surface (See Figure 74). Depósito Chiconautla is located outside of the lateral confines of all proposed Take-off Climb Surfaces. It is important to note that the departure tracks that serve as the basis for the Take-off Climb Surfaces for the easternmost and westernmost pair of runways turn prior to Tanque Chiconautla and Depósito Chiconautla. Therefore, Tanque Chiconautla and Depósito Chiconautla do not impact the Annex 14 Take-off Climb Surfaces.

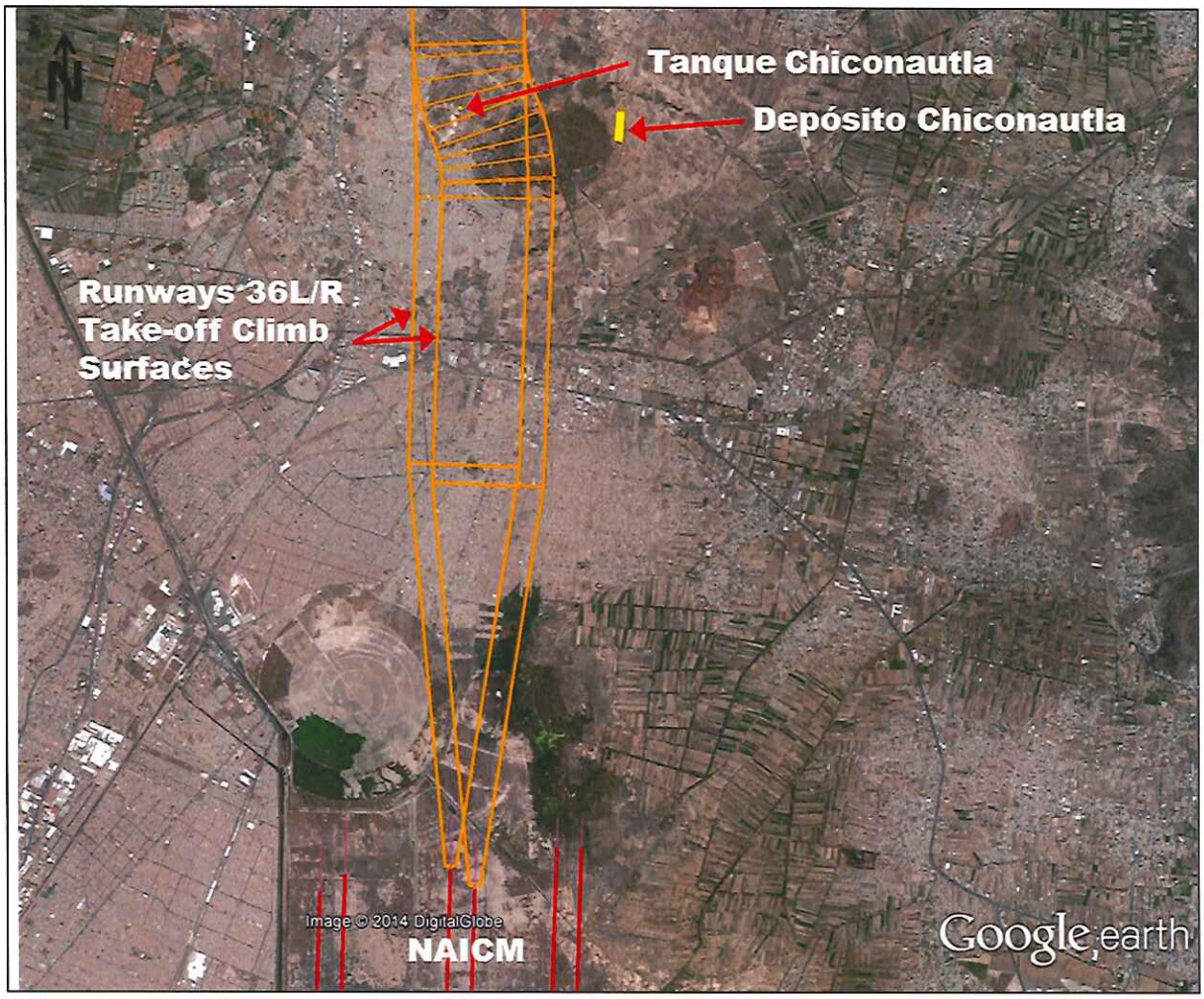


Figure 74. NAICM Runways 36L/R Take-off Climb Surfaces

7. Closing Remarks

Important Annex 14 OLS were examined by MITRE in order to identify obstacles that could impact future aircraft operations. The Annex 14 OLS are also sometimes used to assist authorities with the establishment of land-use regulations by defining obstacle height limits in order to prevent the development of man-made structures that could adversely impact aircraft operations.

Ideally, penetrations to Annex 14 OLS should be removed as far as practicable. If removal is not practicable, the aviation authorities of Mexico should conduct an aeronautical study (outside the scope of MITRE's work) to determine that the obstacle(s) would not adversely affect the safety or regularity of aircraft operations and/or what actions should be taken to mitigate the impact of the obstacle(s). See Appendix A for FAA guidance on aeronautical studies in the U.S. MITRE's procedure design work for NAICM as described in [7] provides key input that can support aviation authorities in conducting an aeronautical study.

The penetration by the hills Chiconautla, including the antennas and other man-made structures located on the hill (which MITRE assumed will be removed), and Chimalhuacán represent the most significant penetrations to the Annex 14 OLS at NAICM. Therefore, it is important that aviation authorities make a decision on the grading (including to what extent) of Chiconautla and Chimalhuacán as soon as possible. MITRE's parametric analysis of runway threshold elevations that considers terrain at Chiconautla and Chimalhuacán was provided to authorities to assist them in making this decision. It is important to note that decisions regarding the grading of Chiconautla and Chimalhuacán may affect other aeronautical matters, such as runway lengths, location of displaced thresholds, and instrument procedure designs.

The impact of Annex 14 OLS penetrations, as determined through an aeronautical study, in some cases may be mitigated and/or alleviated through measures such as marking and lighting the obstacle, publishing it in the AIP and other navigational charts in accordance with Mexican regulations. Other measures such as the modification of runway lengths, displacement of thresholds, conducting only vertically-guided approach procedures and utilizing climb gradients on departure procedures are other mitigation methods that can be considered. However, these measures need to be carefully considered with the airlines and various other stakeholders to ensure a safe and efficient operational environment for arriving and departing aircraft.

Finally, MITRE recommends that this document be reviewed by personnel from the DGAC and Servicios a la Navegación en el Espacio Aéreo Mexicano, who have background in dealing with Annex 14 OLS penetrations and in conducting aeronautical studies.

References

[1] Articles of the Convention on International Civil Aviation (ICAO Doc 7300), 9th edition, 2006, through Corrigendum No. 2 (3 December 2010), ICAO, Montreal, Quebec, Canada

[2] Mexico Dirección General de Aeronáutica Civil, *Circular Obligatoria: Requisitos para Regular la Construcción, Modificación y Operación de los Aeródromos Civiles*, CO DA-04-07 R-2, October 2013, Mexico City, Mexico

[3] ICAO Annex 14, Aerodromes, Volume 1, *Aerodrome Design and Operations*, 6th edition, July 2013, incorporating Amendments 1–11-B (13 November 2014), ICAO, Montreal, Quebec, Canada

[4] ICAO Airport Services Manual (Doc 9137), Part 6, *Control of Obstacles*, 2nd edition, 1983, ICAO, Montreal, Quebec, Canada

[5] MITRE Technical Letter F500-L14-022, 28 March 2014, *Summary of Work During the Period 1 February 2014 through 31 March 2014*, MITRE Corporation, McLean, Virginia, U.S.A.

[6] Photogrammetric, Satellite-Based Survey of the Texcoco Area and Its Surroundings: Final Report, MDA Report GSI-RP-53-7063, January 2015, MacDonald, Dettwiler and Associates, Ltd., Richmond, British Columbia, Canada

[7] MITRE Technical Letter F500-L15-021, 24 June 2015, Enclosure 1, *Nuevo Aeropuerto Internacional de la Ciudad de México, Feasibility of Independent Approach and Departure Procedures*, MITRE Corporation, McLean, Virginia, U.S.A.

[8] MITRE Technical Letter F500-L15-018, 26 March 2015, *Parametric Analysis of Runway Threshold Elevations (REVISION)*, MITRE Corporation, McLean, Virginia, U.S.A.

[9] MITRE Technical Letter F500-L14-039, 13 August 2014, *Auditorium Assessment*, MITRE Corporation, McLean, Virginia, U.S.A.

[10] MITRE Technical Letter F500-L15-001, 23 October 2014, *Assessment of Tanque Chiconautla and Depósito Chiconautla*, MITRE Corporation, McLean, Virginia, U.S.A

[11] U.S. Code of Federal Regulations (CFR) Title 14, Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*, January 2012, U.S. Government Publishing Office, Washington, D.C., U.S.A.

Appendix A. U.S. Regulations and FAA Procedures for Notification and Evaluation of Obstacles

General Overview

Much like ICAO, the U.S. CFR Title 14, Part 77 [11], referred to simply as Part 77, establishes standards and notification requirements for objects affecting navigable airspace. Part 77 also provides for aeronautical studies of obstructions to air navigation, in order to determine their effect on the safe and efficient use of airspace. It also allows for public hearings on the hazardous effect of proposed construction or alteration on air navigation.

FAA Part 77 Surfaces/Civil. Part 77.25 establishes the imaginary surfaces associated with civil airports and their individual runways. The shape of each imaginary surface is based on the category of its associated runway, according to the type of approach the runway is able to support. A complete explanation and description of the Part 77 imaginary surfaces is given below.

Aeronautical Studies. FAA regulations also establish the requirements for conducting aeronautical studies in order to determine the effect of proposed construction on the use of navigable airspace. Once the aeronautical study has been completed, a determination is made regarding the impact to air navigation. The determination concludes whether the object has no foreseeable effect on air navigation; is acceptable after necessary mitigation measures are implemented; or the object is considered to be a hazard and therefore objectionable.

An object is considered to have an adverse effect when it:

- Exceeds the obstruction standards outlined in Part 77 and/or may have a physical and/or electromagnetic effect on air navigational facilities
- Prompts a change to an instrument procedure or minimum flight altitude
- Restricts Control Tower line-of-sight
- Reduces airport capacity and efficiency
- Affects useable runway length

The result of an aeronautical study will determine whether an object has an adverse effect on aviation safety and/or a significant volume of aeronautical operations will be affected.

An aeronautical study is an important tool that can be used in determining the impact of an object on air navigation or aircraft operations at an airport. Unfortunately, detailed guidance on how to conduct an aeronautical study is not clearly provided by ICAO. Therefore, the FAA guidance is being provided.

FAA Regulations for Objects Affecting Navigable Airspace

As mentioned above, Part 77 establishes standards for determining obstructions in navigable airspace, sets the requirements for notice to the Administrator and provides for aeronautical studies of obstructions to air navigation to determine their effect on the safe and efficient use of airspace. It applies to any object of natural growth, terrain, or permanent or

temporary construction or alteration, including equipment or materials used therein and apparatus of a permanent or temporary character. Notification allows the FAA to identify potential aeronautical hazards in advance, thus preventing or minimizing the adverse impacts to the safe and efficient use of navigable airspace. The regulation establishes the standard heights for determining if an existing object or a future object would be an obstruction to air navigation if it is of greater height than any of the standard heights, such as for example, any imaginary surface established under Part 77.25.

Construction or alteration of objects on or around airports can have an adverse impact to operations at an airport, such as the following:

- An increase to approach minimums
- Impacts on runway protection zones, safety areas, object free areas and obstacle free zones
- Impacts on the proper operation of navigational aid facilities, such as those that could be caused by the transmitting frequency of a proposed communications facility

It is prudent for airport owners to protect the airspace around their airport to prevent loss of existing approaches or other negative impacts affecting utilization of their airport.

Civil Airport Imaginary Surfaces. Part 77.25, establishes imaginary surfaces with relation to the airport and to each runway. The size of each imaginary surface is based on the category of each runway according to the type of approach available or planned for that runway. The slope and dimensions of the Approach Surface applied to each end of a runway are determined by the most precise approach existing or planned for that runway end. Of significance are the following surfaces (see Figures 75 and 76):

- The **Primary Surface** is a surface longitudinally centered on a runway. When the runway has a specially prepared hard surface, the Primary Surface extends 200 feet beyond each end of that runway; the elevation of any point on the Primary Surface is the same as the elevation of the nearest point on the runway centerline. The width of a Primary Surface is 1000 feet for precision instrument runways.
- The **Approach Surface** is a surface longitudinally centered on the extended runway centerline and extending outward and upward from each end of the Primary Surface. An Approach Surface is applied to each end of each runway based upon the type of approach available or planned for that runway end.
- The **Transitional Surface** extends outward and upward at right angles to the runway centerline and the runway centerline extended, at a slope of 7:1 from the sides of the Primary Surface and from the sides of the Approach Surfaces.
- The **Horizontal Surface** consists of a horizontal plane 150 feet above the established airport elevation, the perimeter of which is constructed by swinging arcs of a specified radius from the center of each end of the Primary Surface of each runway of each airport and connecting the adjacent arcs by lines tangent to those arcs.

- The **Conical Surface** extends outward and upward from the periphery of the Horizontal Surface at a slope of 20:1 for a horizontal distance of 4000 feet.

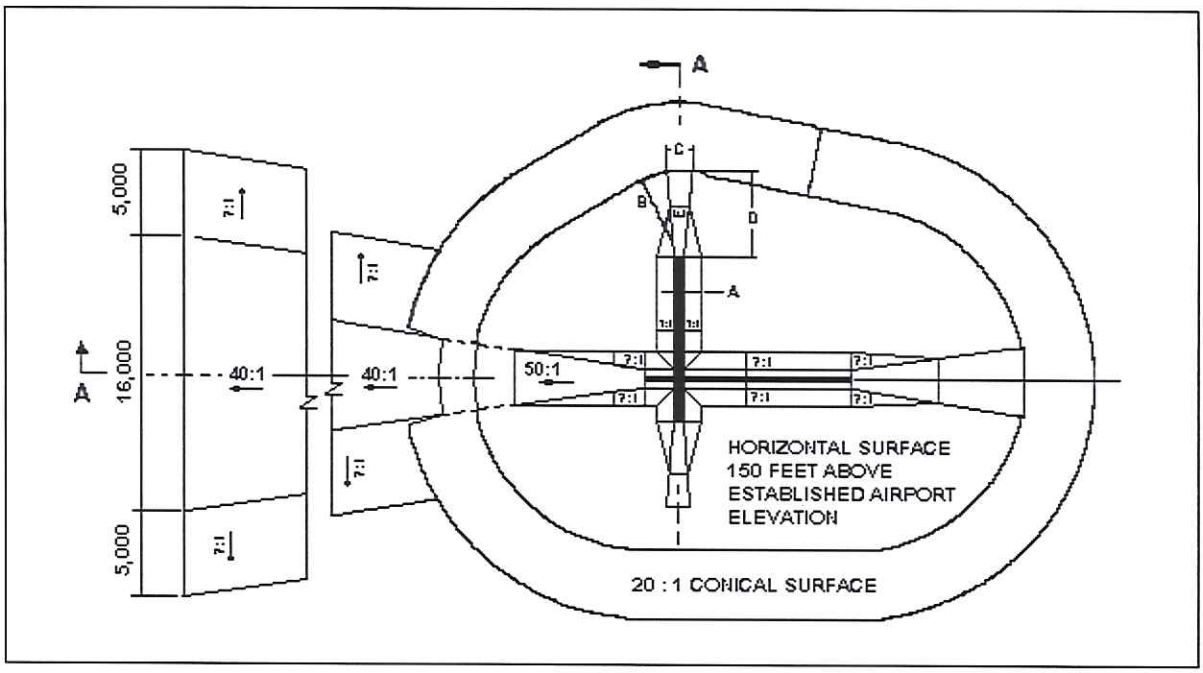


Figure 75. Plan View of FAA Civil Airport Imaginary Surfaces

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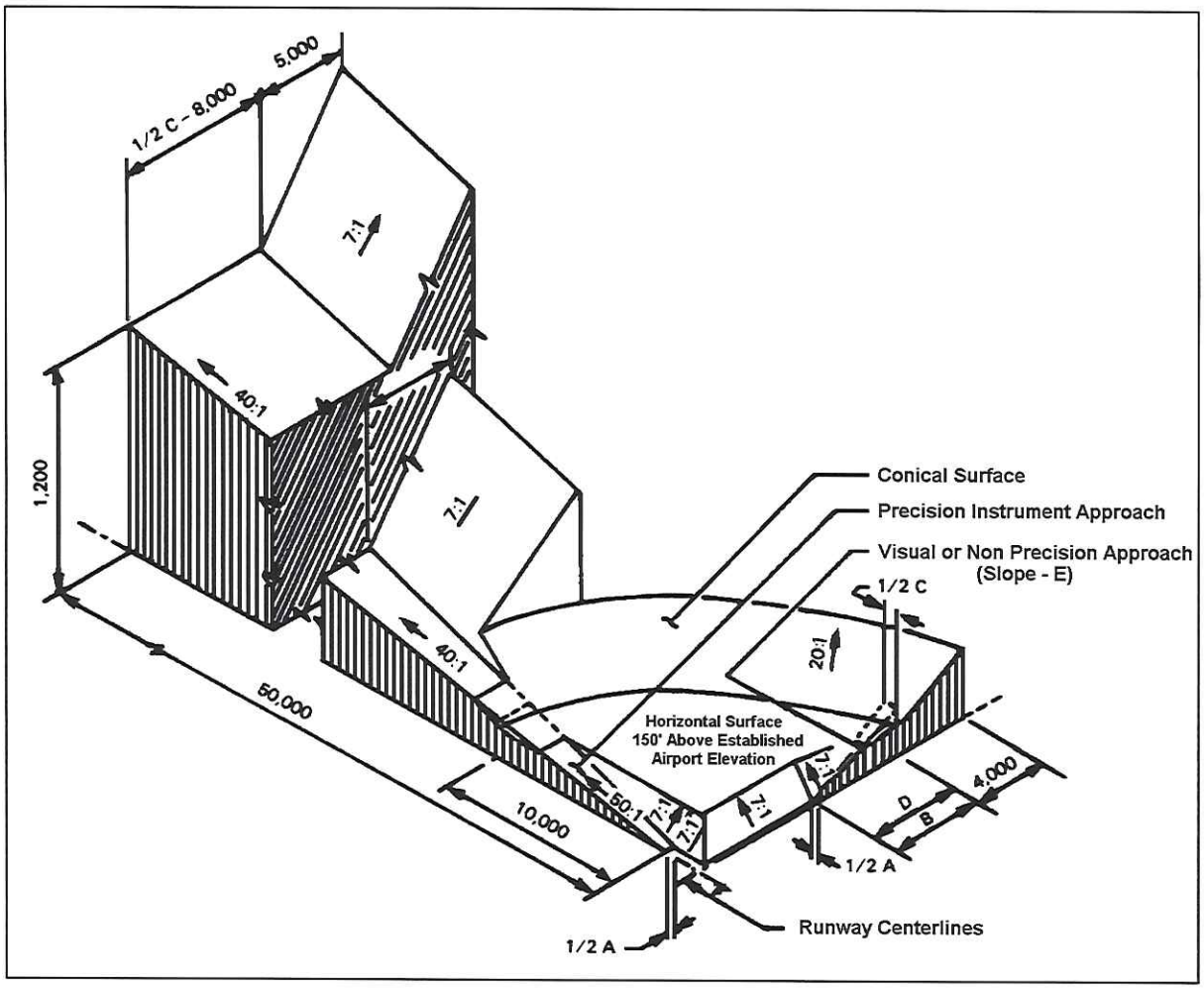

Figure 76. Three-Dimensional View of FAA Civil Airport Imaginary Surfaces

FAA's Notification Procedure for Objects Affecting Navigable Airspace

Part 77, Subpart B: Notice of Construction or Alteration, establishes standards and notification requirements for objects affecting navigable airspace. This notification serves as the basis for evaluating the effect of the construction or alteration on operating procedures, determining the potential hazardous effect of the proposed construction on air navigation, identifying mitigation measures to enhance safe air navigation, and determining other appropriate measures to be applied for continued safety of air navigation and the charting of new objects.

Any person or organization who intends to sponsor any of the following construction or alterations must notify the Administrator of the FAA.

- Any construction or alteration exceeding 200 feet above ground level
- Any construction or alteration:

  - Within 20,000 feet of a public-use or military airport which exceeds a 100:1 surface from the nearest point of the nearest runway of each airport with at least one runway more than 3200 feet
  - Within 10,000 feet of a public-use or military airport which exceeds a 50:1 surface from the nearest point of the nearest runway of each airport with its longest runway no more than 3200 feet
  - Within 5000 feet from the nearest landing and take-off area of a public-use heliport which exceeds a 25:1 surface
- Any highway, railroad, or other traverse way with prescribed adjusted height that would exceed the above noted standards
- When requested by the FAA, any construction or alteration that would be in an instrument approach area, and available information indicates it might exceed an appropriate obstacle clearance standard
- Any construction or alteration located on a public-use airport or heliport regardless of height or location

Once the FAA has completed an aeronautical study, a determination is made regarding the impact to air navigation. One of three responses is typically issued:

- **No Objection** - The subject construction did not exceed obstruction standards and marking/lighting is not required
- **Conditional Determination** - The proposed construction/alteration would be acceptable contingent upon implementing mitigation measures (e.g., marking and lighting, etc.)
- **Objectionable** - The proposed construction/alteration is determined to be a hazard and is thus objectionable. The reasons for this determination are outlined to the proponent.

FAA's Procedure for Conducting Aeronautical Studies of Effect of Proposed Construction on Navigable Airspace

Part 77, Subpart D: Aeronautical Studies of Effect of Proposed Construction on Navigable Airspace also establishes the requirements for the conduct of aeronautical studies to determine the effect of proposed construction on the use of navigable airspace by aircraft. At the conclusion of an aeronautical study, a determination is made as to whether or not the proposed construction would be a hazard to air navigation.

An aeronautical study is normally initiated when requested by the sponsor of any construction or alteration or whenever the FAA determines it appropriate. The FAA is responsible for conducting aeronautical studies. Typically, this process begins at the regional level within the FAA, and involves all operational and regulatory divisions of the FAA, such as Airports, Airway Facilities, Flight Standards, Flight Procedures, and Air Traffic. The FAA's philosophy in evaluating objects that may impact navigable airspace is that each is

presumed to be a hazard until proven otherwise. This posture clearly favors the aeronautical community, and is consistent with the FAA's overall mission of promoting aviation safety.

If a tower or other object is found to have a significant adverse impact, a "hazard" determination will be issued. However, in nearly 80% of all such cases, the FAA typically negotiates with the proponent until conditions are met for a "no-hazard" determination. It is important to note that by congressional mandate, the FAA cannot prohibit any construction activities. Instead, as described above, the FAA evaluates the proposed construction, and as necessary, works with the proponent to mitigate any impact that may result. These efforts are a key benefit of the FAA's participation at this level.

There are four steps in the U.S. FAA's aeronautical study process, as follows:

1. **Notice to the FAA:**
   Part 77 outlines the type of construction or alteration requiring notice to the FAA. In many cases, the proponent will submit their information for study to the FAA in spite of the fact their activities do not meet notice criteria, because the issuance of a no-hazard determination from the FAA will all but ensure no federal entanglements will halt construction efforts.

2. **Obstruction Evaluation:**
   If a proposed structure exceeds any Part 77 obstruction standard, an aeronautical study must be conducted to identify the effects of the proposal on the use of navigable airspace. In this case, the different offices within the FAA (Air Traffic, Airports, Flight Procedures and Flight Standards, Airways Facilities, and the military representative, if appropriate) determine the possible impact as it relates to their area of responsibility.

3. **Circulation of Evaluation Results for Public Comment:**
   Notification and public circulation is required for the following types of proposals:

   a. Those that would affect a public-use airport

   b. Those requiring a change in aeronautical operations or procedures

   c. When a structure exceeds obstruction standards

   d. When a structure would have a possible impact on Visual Flight Rules (VFR) operations

   There are limited, specific situations where notification is not required, as follows:

   a. Any object that would be shielded by existing structures of a permanent and substantial character or by natural terrain or topographic features of equal or greater height, and would be located in the congested area of a city, town, or settlement where it is evident beyond all reasonable doubt

that the structure so shielded will not adversely affect safety in air navigation

b. Any antenna structure of 20 feet or less in height except one that would increase the height of another antenna structure

c. Any air navigation facility, airport visual approach or landing aid, aircraft arresting device, or meteorological device, of a type approved by the Administrator, or an appropriate military service on military airports, the location and height of which is fixed by its functional purpose

d. Any construction or alteration for which notice is required by any other FAA regulation

4. Evaluating Aeronautical Effect and Issuing a Determination:
After an appropriate period of time for comment by the aeronautical community, the FAA makes a final determination if an object is a hazard to air navigation. Not all obstructions are necessarily a hazard. In order for an object to be considered for adverse effect, one or more of the following conditions must be met:

a. The object must exceed the obstruction standards outlined in Part 77 and/or

b. The object must have a physical and/or electromagnetic effect on air navigational facilities

Hazards and Mitigations

Typically, a determination will have to be made as to whether or not a proposal for new construction or an alteration to an existing structure has an adverse effect on navigable airspace, as described above, or would have an effect on a significant volume of operations. The determination of whether or not a structure will have an adverse effect on air navigation is made through a detailed aeronautical study, also described above.

There are many demands on uses of airspace, both aviation and non-aviation. A responsible agency is designated with the responsibility of managing navigable airspace to ensure equitable and maximum utilization. To help accomplish this there are a number of mitigation methods that may be employed:

- Removal
- Marking and lighting
- Publishing the location of the obstacle in the AIP
- Limiting the use of the runway to certain types of approaches (e.g., instrument approaches)
- Restricting the type of traffic
- Establishment of appropriate operational procedures to ensure that the obstacle and/or area is avoided.

Appendix B. Additional Profile Views of Approach Surfaces

Profile views of those Approach Surfaces that are penetrated by Chiconautla or Chimalhuacán were given in Section 6 (the Approach Surfaces for those runways that are not penetrated were not included in that section). This appendix provides the profile views of Approach Surfaces that are not penetrated. In particular, the profile views of the Approach Surfaces for Runways 17L and 17R are provided in Figures 77. Similarly, the profile views of the Approach Surfaces for Runways 35L and 35R are provided in Figure 78, and the profile views of the Approach Surfaces for Runways 36L, and 36R are provided in Figure 79.

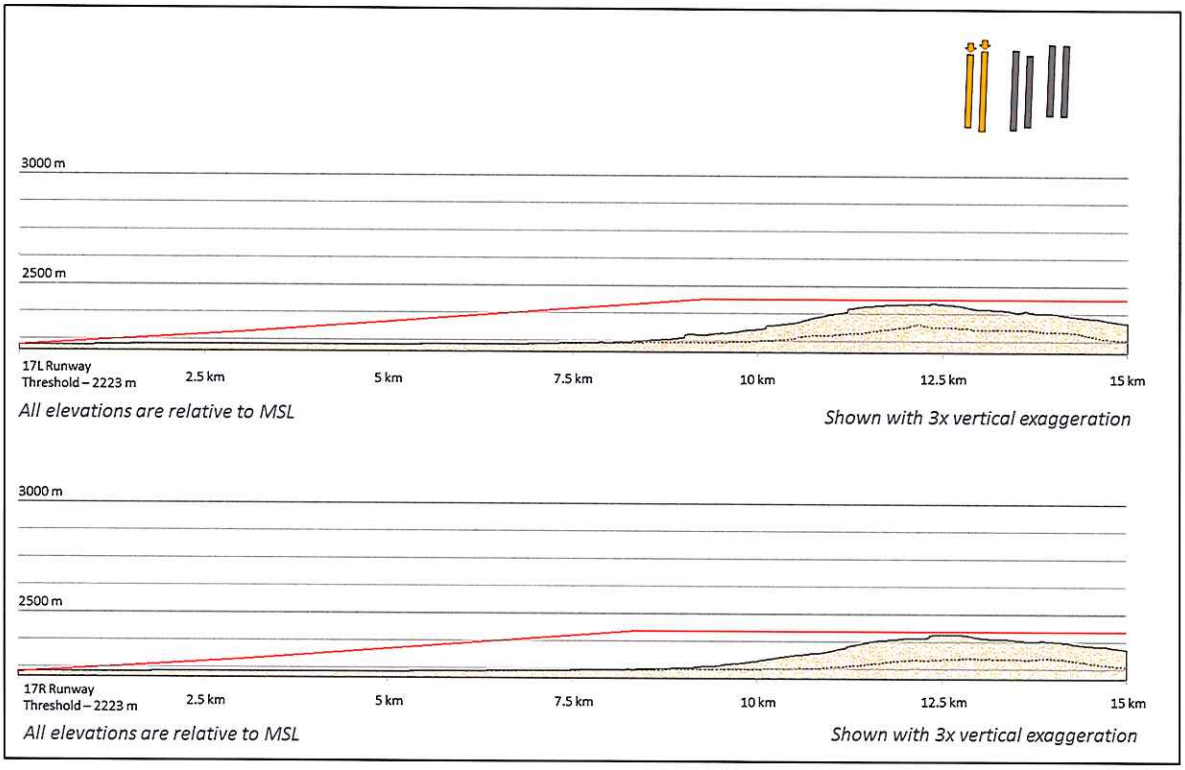

Figure 77. Profile View of Approach Surfaces: Runway 17L/R

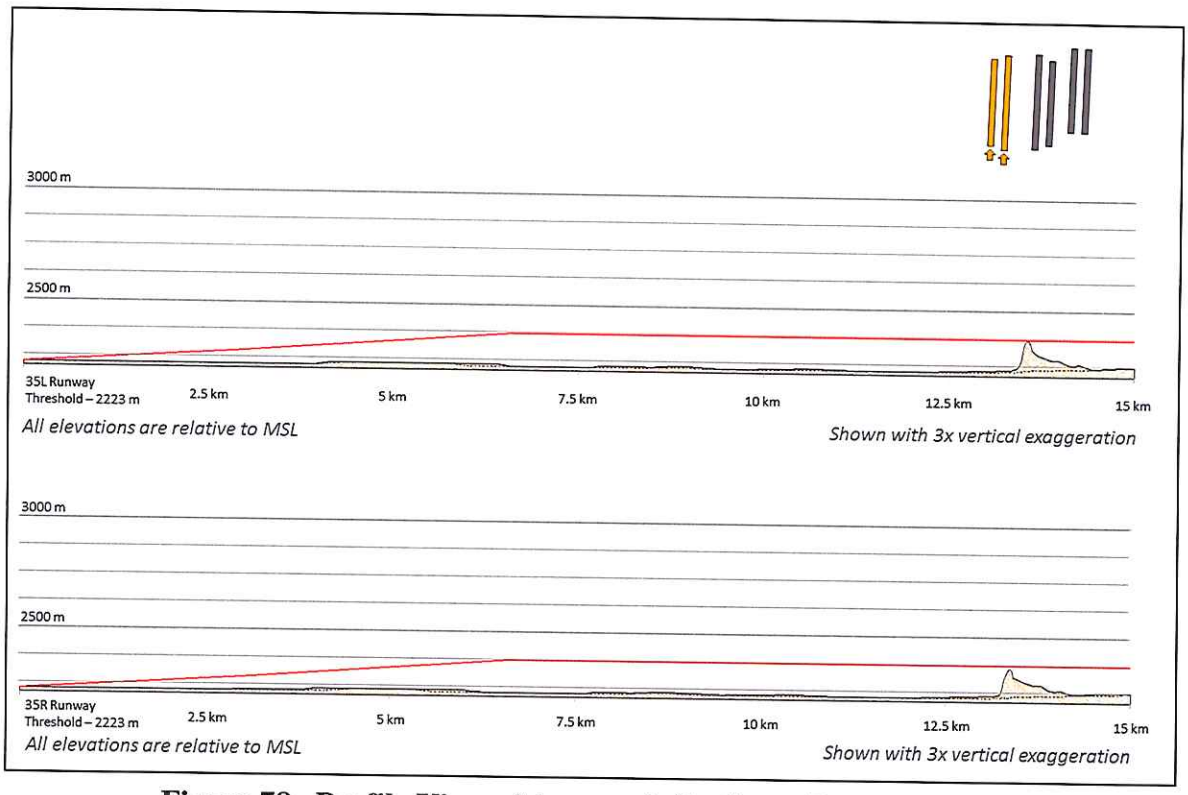

Figure 78. Profile View of Approach Surfaces: Runway 35L/R

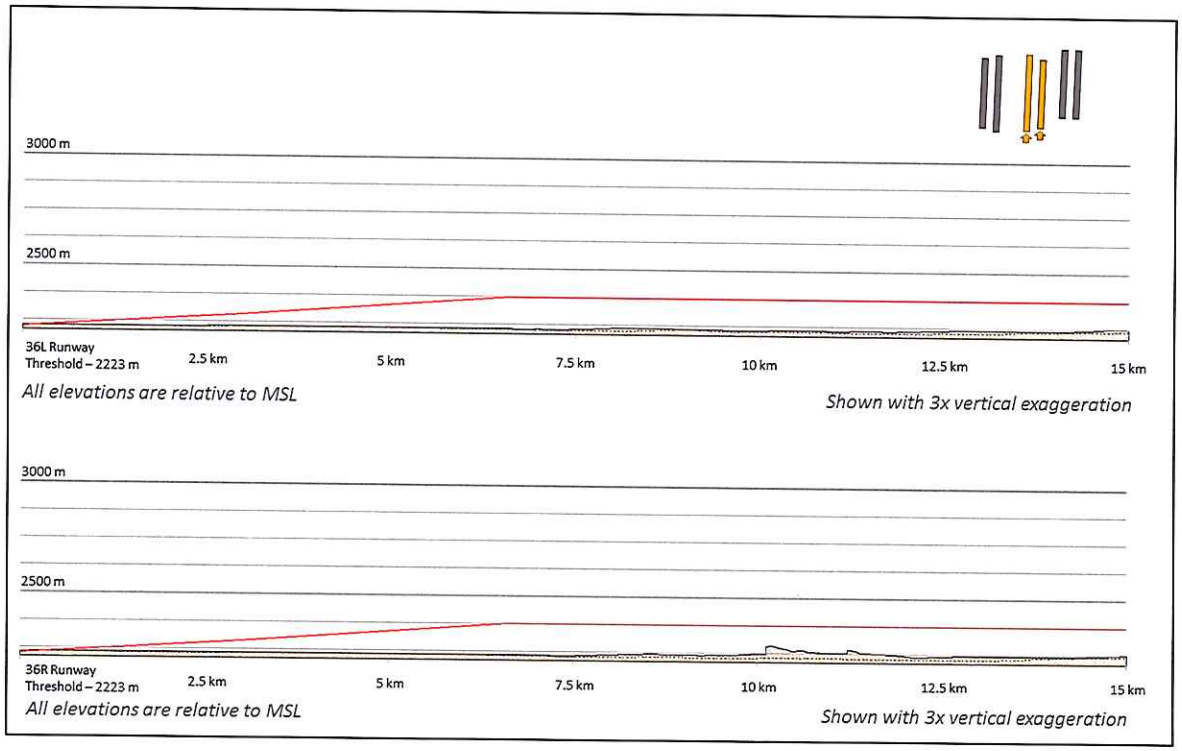

Figure 79. Profile View of Approach Surfaces: Runway 36L/R