

# APPENDIX F - AIRCRAFT IMPACT ANALYSIS

ACTA Inc Report No. 17-1014-1

AIRCRAFT IMPACT ANALYSIS  
FOR CAMARILLO HOTEL AND CONFERENCE CENTER

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## **1. INTRODUCTION**

This study was conducted to analyze the risk to the Hotel and Conference Center (HCC) in Camarillo from potential aircraft impact. The site is located approximately 4,500 ft due northeast of the west end of the Camarillo Airport runway 8-26.

This analysis predicts risks to individuals located in buildings on the HCC site that could potentially be impacted as a result of an aircraft accident. All Camarillo Airport (CMA) arrivals, departures and touch-and-go operations of fixed-wing aircraft and helicopters were considered in this analysis.

Aircraft operations data, for the period encompassing January 1990 through December 2016 were provided in the FAA Air Traffic Activity System (ATADS) [1]. Aircraft operations data projections for future periods were provided by the FAA Terminal Area Forecast (TAF) [2]. Data provided by the National Transportation Safety Board (NTSB) [3] was used to estimate aircraft accident rates.

## 2. SITE LOCATION

Figure 2-1<sup>1</sup> shows the HCC site location in relation to the Camarillo Airport, which is located south of the 101 Freeway on the east side of Las Posas Rd in the City of Camarillo. Figure 2-3<sup>1</sup> shows the specific site plan, including the proposed locations of various buildings.



**Figure 2-1. Hotel and Conference Center Site Location Relative to Camarillo Airport**

<sup>1</sup> Provided by Cadence Environmental Consultants, 816 Sausalito Drive, Camarillo CA

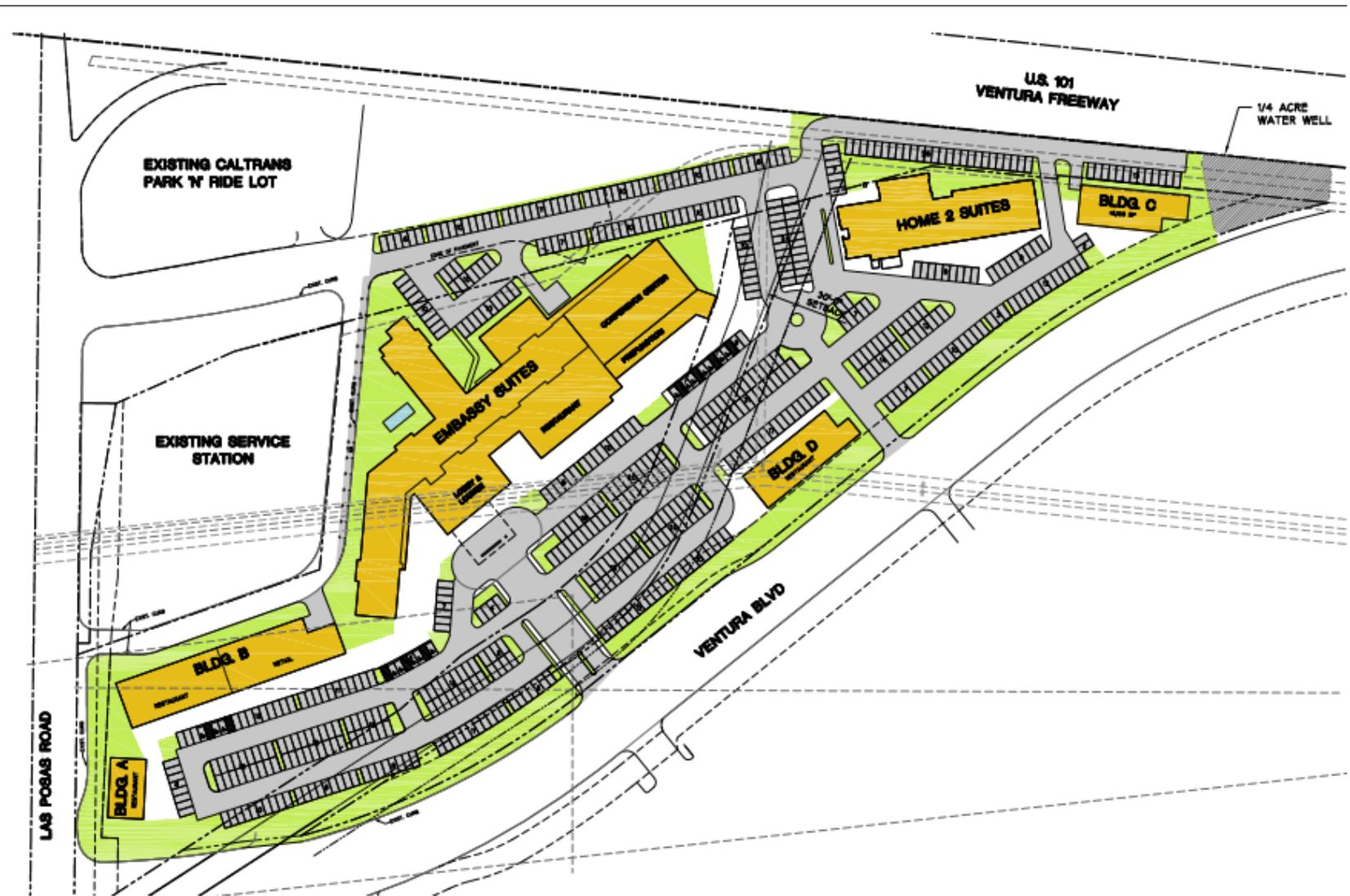


Figure 2-2. Hotel and Conference Center Specific Site Plan

### 3. CAMARILLO AIRPORT OPERATIONS

Two sets of operations data are required in this type of study. The first is the historical number of operations that occurred over the corresponding period for which accident data are available. The second is an estimate for use in determining the annual impact probability to specific site locations. This second estimate is usually based on a prediction of operations for a future year.

#### 3.1 Number of Annual Operations by Aircraft Type

The historical record of operations for the Camarillo Airport was provided by airport personnel. In order to compute the accident rate per operation as used in the impact probability analysis, it is common to define the numbers of annual operations for the years that cover the accident records. If the operations data that is available does not match the years of the accident record for the airport, the accident rate per operation can be computed using only that part of the accident record that matches the operational record. The accident records for the airport, which were obtained from the NTSB and cover the period beginning September 1965 through May 2017, are provided in Section 4 of this report. The operations data provided by the airport span the calendar years 1991 through 2016 and are included in Table 3-1 [1].

**Table 3-1. Annual Operations for Camarillo Airport – Calendar Years 1991 – 2016**

Year	Total Annual Operations	Year	Total Annual Operations
1990	213,100	2004	162,889
1991	215,122	2005	153,501
1992	185,483	2006	149,825
1993	179,025	2007	148,518
1994	190,850	2008	158,245
1995	167,114	2009	162,170
1996	172,905	2010	146,863
1997	179,398	2011	133,403
1998	173,078	2012	132,679
1999	187,572	2013	136,510
2000	186,476	2014	144,637
2001	179,460	2015	147,020
2002	203,941	2016	135,517
2003	185,887	<b>Total</b>	<b>4,531,188</b>

In order to estimate the accident rate by aircraft type or size, specific to the Camarillo Airport, it is necessary to determine the number of accidents and the number of operations by aircraft type. The number of accidents by aircraft type is specified in Section 4. The number of operations by aircraft type must be estimated. Table 3-2 shows the breakdown of airport based aircraft by type based on data provided by AirNav [3]. This information was used as a basis to estimate operations by aircraft type. This data is found to be consistent with the projections from the 2010 Camarillo Airport Master Plan [4].

**Table 3-2. Camarillo Airport Based Aircraft Type Breakdown [3], [4]**

Type	Percentage
Ultralight	5.7%
Single Engine	72.1%
Multi-Engine	9.8%
Jet	6.6%
Helicopter	3.8%
Air Taxi	2.0%
<b>Total</b>	<b>100.0%</b>

For this analysis, the various aircraft types are binned into weight categories. The weight categories are used to infer debris field size, which will be discussed later in the report. The four weight categories include: very small (< 500 lb), small (> 500 lb and < 3,500 lb), medium (>3,500 lb and < 7,500 lb), and large (> 7,500 lb). The aircraft types from Table 3-2 can generally be associated with the following gross takeoff weights: ultralights (< 500 lbs), single-engine (< 3,500 lb), multi-engine (>3,500 lb up to 7,500 lb), jet aircraft (between 7,500lb and 12,500 lb), helicopters (50% < 3,500 lbs and 50% > 3,500), and air taxi (12,500 to 15,000 lb). Table 3-4 re-establishes the breakdown of aircraft by weight category.

**Table 3-3. Camarillo Aircraft Weight Category Distribution**

Weight Category	Aircraft Type	Aircraft Type Percentage	Category Percentage
<b>Very Small (&lt; 500 lb)</b>	Ultralights	5.7%	5.7%
<b>Small (&gt; 500 and &lt; 3,500 lb)</b>	Small FW (Single-Engine)	72.1%	74.0%
	Small Helicopters	1.9%	
<b>Medium (&gt; 3,500 and &lt; 7,500 lb)</b>	Med FW (Multi-Engine)	9.8%	11.7%
	Large Helicopters	1.9%	
<b>Large (&gt; 7,500 lb)</b>	Large FW (Jet)	6.6%	8.6%
	Air Taxi	2.0%	
<b>Total</b>		<b>100.0%</b>	<b>100.0%</b>

What is now required is a determination of the expected number of operations at some time in the future to use in the determination of the annual potential for site impact. Various sources could be studied to determine the expected growth in population and aircraft traffic for the Camarillo area and airport. The 2010 Master Plan cites an estimated 162,100 operations for the year 2018 with slightly lower projections than that of TAF at 157,266. As noted elsewhere, these projections are generally high [5]. The FAA TAF has since updated these projections based on lower operational counts for the years following the 2010 estimates. The updated operational counts for Camarillo Airport are shown in Table 3-4as provided by TAF [2]

**Table 3-4. TAF Projection for Number of Operations [2]**

Year	Total Operations
2017	132686
2018	133064
2019	133444
2020	133825

The analysis will use the year 2020 as the basis for reporting risk. The numbers of operations for the year 2020 by aircraft weight category and type are provided in Table 3-5. This information will be combined with the accident information from Section 4 to determine an accident rate by weight category in Section 5.

**Table 3-5. Operations for 2020 by Aircraft Weight Category**

Category	Aircraft Type	Number of Arrivals		Number of Departures		Total Operations	
		AC Type	Category	AC Type	Category	AC Type	Category
<b>Very Small</b>	Ultralights	3,814	3,814	3,814	3,814	7,628	7,628
<b>Small</b>	Small FW	48,244	49,516	48,244	49,516	96,488	99,031
	Small Helicopters	1,272		1,272		2,543	
<b>Medium</b>	Med FW	6,558	7,830	6,558	7,830	13,115	15,658
	Large Helicopters	1,272		1,272		2,543	
<b>Large</b>	Large FW	4,416	5,755	4,416	5,755	8,832	11,509
	Air Taxi	1,339		1,339		2,677	
<b>Total</b>		66,915	66,915	66,915	66,915	133,826	133,826

### 3.2 Camarillo Airport Flight Tracks

Figure 3-1 and Figure 3-2, from the Ventura County Airport Land Use Plan [5], are graphic portrayals of the arrival and departure tracks for fixed wing aircraft. Figure 3-3, also reproduced from the Camarillo Airport Land Use Plan, is a graphic portrayal of the helicopter and touch-and-go tracks. From the Airport Master Plan, it is expected that 70% of the arrivals are from the east and 70% of the departures are to the west, on Runway 26. The remaining 10% of operations are in Runway 8. This is reflected in Table 3-6, by aircraft maximum takeoff weight, which is based on the estimate of annual operations for the year 2020. This table of operations will be used in Section 7 to compute annual aircraft impact probabilities to various locations on the HCC site.

**Table 3-6. Camarillo Airport Operations by Runway Designation – 2020 Estimates**

Aircraft Gross Takeoff Weight (lbs)	Number of Operations			
	Arrivals		Departures	
	Total	Percent	Total	Percent
<b>Runway 26</b>	46,839	35.00%	46,839	35.00%
Very Small (< 500 lb)	2,670	2.00%	2,670	2.00%
Small (> 500 and > 3,500 lb)	34,661	25.90%	34,661	25.90%
Medium (> 3,500 and < 7,500 lb)	5,480	4.10%	5,480	4.10%
Large (> 7,500 lb)	4,028	3.01%	4,028	3.01%
<b>Runway 8</b>	20,074	15.00%	20,074	15.00%
Very Small (< 500 lb)	1,144	0.86%	1,144	0.86%
Small (> 500 and > 3,500 lb)	14,855	11.10%	14,855	11.10%
Medium (> 3,500 and < 7,500 lb)	2,349	1.76%	2,349	1.76%
Large (> 7,500 lb)	1,726	1.29%	1,726	1.29%
<b>Total all Operations</b>	<b>133,862</b>	<b>100.00%</b>	<b>133,862</b>	<b>100.00%</b>

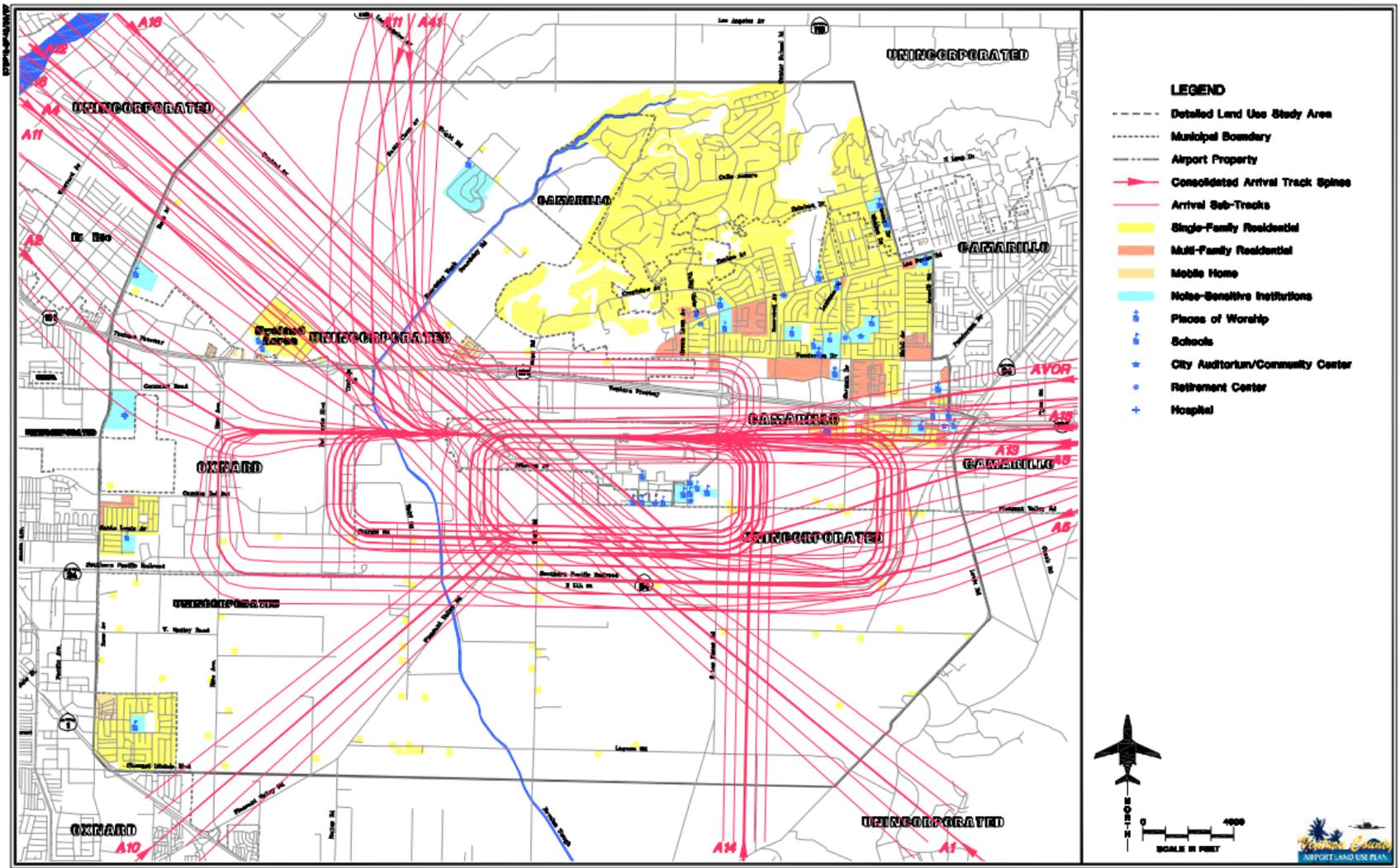


Exhibit 2F  
CAMARILLO AIRPORT ARRIVAL TRACKS

Figure 3-1. Camarillo Airport Arrival Tracks

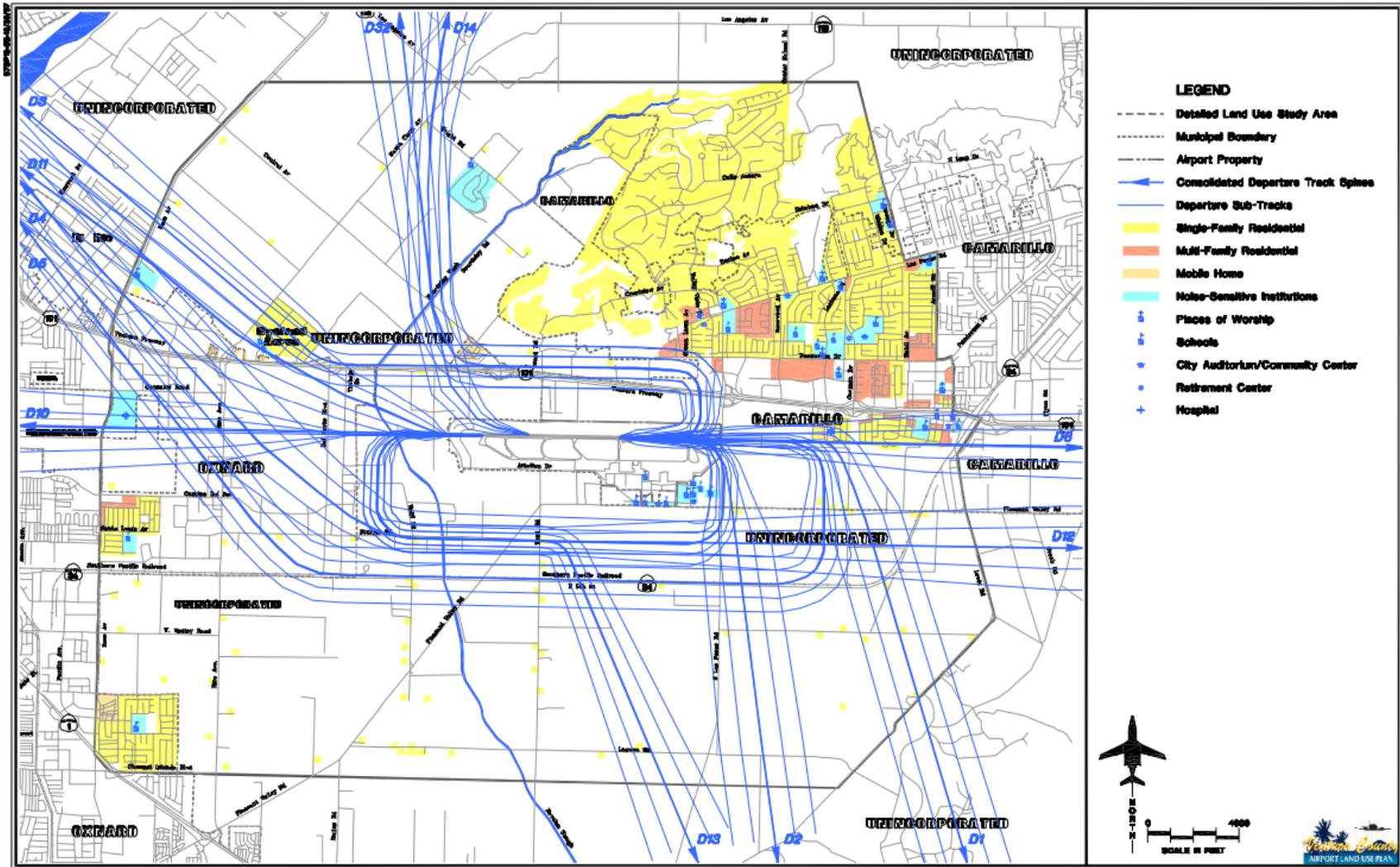


Exhibit 2B  
CAMARILLO AIRPORT DEPARTURE TRACKS

Figure 3-2. Camarillo Airport Departure Tracks

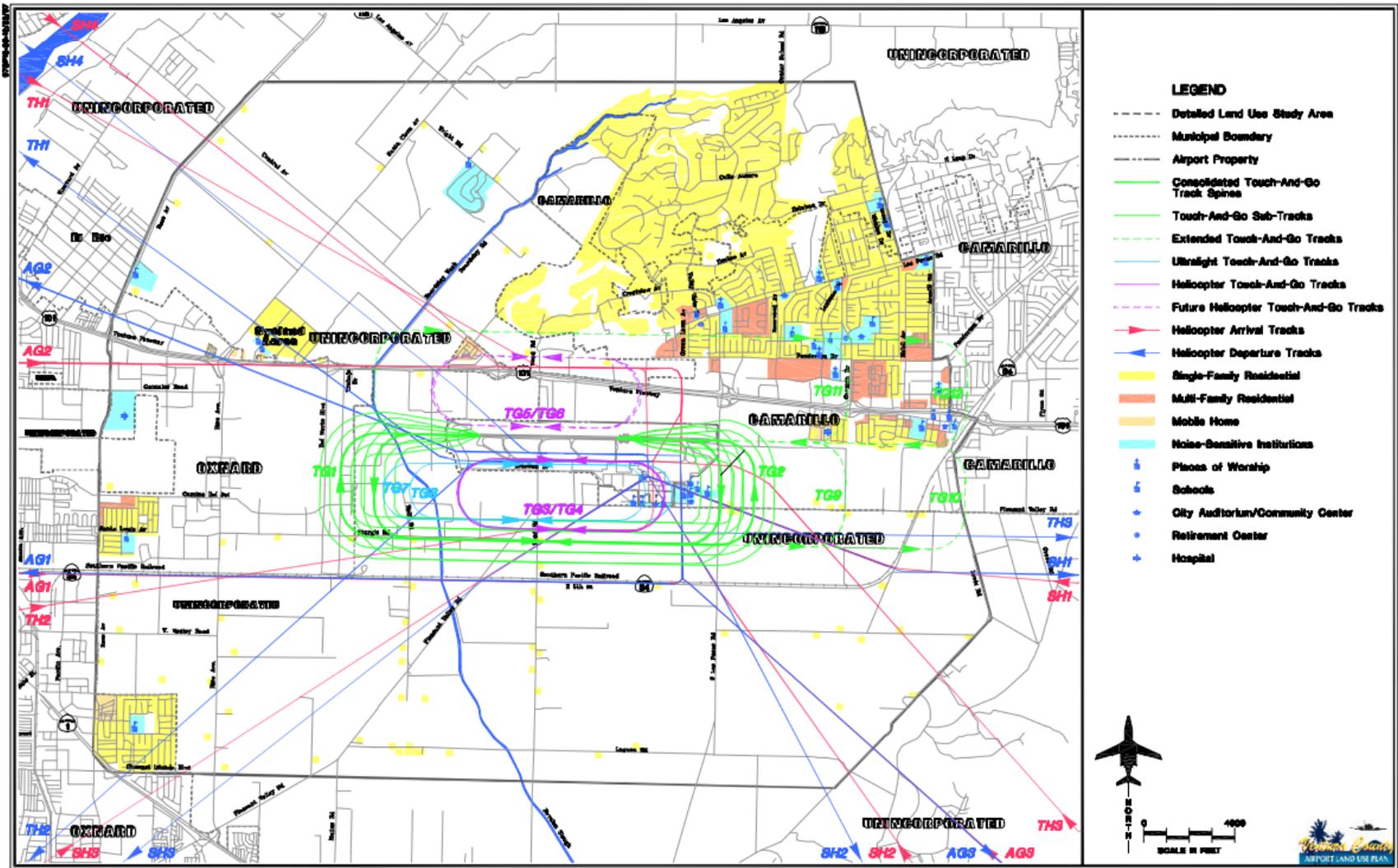


Exhibit 2G  
CAMARILLO AIRPORT HELICOPTER AND TOUCH-AND-GO TRACKS

Figure 3-3. Camarillo Airport Helicopter and Touch-and-Go Tracks

#### **4. CAMARILLO AIRPORT ACCIDENT HISTORY**

The accident history for Camarillo Airport, from 1982 through 2016, is presented in Table 4-1. This data was obtained from the NTSB [7]. All the relevant accidents were in the general aviation category.

From January 1982 through July 2007, there were a total of 65 accidents/incidents involving aircraft in the vicinity of the Camarillo Airport (CMA). Of these 65 events, 60 involved fixed winged aircraft, 3 involved helicopters and two involved ultralights. The largest aircraft accident in the fixed wing group occurred on July 15, 2007. The aircraft involved was a North American F-51D, with a maximum takeoff weight of 12,100 lbs. Of the 65 accidents, 8 involved fatalities, 22 involved some type of injury less than fatal, and 35 had no injuries or were unreported.

During the period coinciding with the available operations data, January 1990 through December 2016, there were a total of 44 accidents. Two of the accidents involved helicopters, two were ultralights, and 40 were fixed wing. Three of the accidents within this period are considered immaterial to the risk posed to the surrounding public. One of the accidents, involving an ultralight, occurred when a bystander was struck on the head when approaching a moving propeller. Another irrelevant entry was a simple damage report with no incident cited. The third event was due to improper use of brakes during taxi. Therefore, the accidents pertinent to calculated the accident rate included 38 fixed wing scenarios, one ultralight, and two helicopters.

**Table 4-1. Aircraft Accidents that Occurred Within the Traffic Area of Camarillo Airport**

<b>Date</b>	<b>Make/Model, Type<sup>1</sup>, Max Lift-off Weight (lbs)</b>	<b>Event Severity</b>	<b>Accident Type/Cause</b>
5/1/1982	Grumman AA-A1 FW, 1,500	2 Minor Injuries	Mid-air collision with another aircraft during final approach. Aircraft landed safely. Substantial aircraft damage.
5/1/1982	Beech A24R, FW, 2,400	2 Minor Injuries	Mid-air collision with another aircraft during final approach. Aircraft landed safely. Substantial aircraft damage.
1/4/1983	Javelin Aircraft WICHAWK 2, FW	2 Fatalities	Aircraft impacted ground while performing low level aerobatic maneuvers off airport. Aircraft destroyed.
6/29/1983	Piper PA-22-150 FW, 2,000	0/2 Injuries	Aircraft ground looped and collided with a light while landing. Substantial aircraft damage.
1/28/1984	Bell 206L-1, H, 4,150	1 Minor Injury	Student pilot drinking and attempted to take off. Helicopter rolled over onto its right side. Aircraft destroyed.
6/23/1984	Stinson 1082, FW, 2,400	0/3 Injuries	Aircraft ground looped while pilot initiating takeoff and right landing gear collapsed on airport. Substantial aircraft damage.
9/24/1984	Cessna 180, FW, 22550	0/1 Minor Injury	Pilot realized right main tire was deflated during his landing roll. Over-controlled the aircraft and ground looped and rolled over on airport. Substantial aircraft damage.
10/13/1984	Cessna 150M, FW, 1,500	0/1 Minor Injury	Loss of directional control prior to takeoff rotation and aircraft veered into a plowed field on airport. Nose gear collapsed and substantial aircraft damage.
10/27/1984	Jack L Bigham Bede 5B 2, FW	0/1 Minor Injury	Prop drive failed during go-around and forced landing in a field adjacent to the taxiway. Landing gear collapse and substantial aircraft damage.
1/4/1985	Cessna 172RG, FW, 2,450	0/3 Minor Injuries	Gusty wind on landing caused aircraft to veer to the left on landing and exit the runway. Aircraft nosed over and incurred substantial damage.
2/6/1985	Milentz Quickie 02 2, FW	1 Minor Injury	Loss of control of home-built experimental aircraft during takeoff roll. Aircraft veered off runway into plowed field on airport. Aircraft destroyed.
2/10/1985	Beech 65, FW, 8,200	0/2 Minor Injuries	Hard landing and failure of nose gear resulting in nose and both propellers contacting the runway. Substantial aircraft damage.
2/26/1986	Ryan ST3KR 2, FW	0/2 Minor Injuries	Engine power loss at 1,200 ft msl after takeoff. Emergency landing in open field about 3 miles north of the airport. Aircraft nosed over onto its back causing substantial damage.

<b>Date</b>	<b>Make/Model, Type<sup>1</sup>, Max Lift-off Weight (lbs)</b>	<b>Event Severity</b>	<b>Accident Type/Cause</b>
10/25/1987	Stits Elkins 85 2, FW	1 Fatality	Pilot received a fatal head injury after airplane jumped the chocks during hand-propping to start the aircraft. Substantial aircraft damage.
8/18/1988	Piper PA-28-236, FW, 2,550	2 Serious Injuries; 2 Minor injuries	Pilot followed a road near to the airport and collided with a tree. Substantial aircraft damage.
8/28/1988	Cessna 172N, FW, 2,300	0/3 Minor Injuries	Pilot maneuvered off the taxiway during taxing for takeoff to allow passage of another aircraft and collided with an airport hanger. Substantial aircraft damage.
9/7/1988	Piper PA-28-235, FW, 2,550	2 Fatalities	Aircraft operated with known electrical deficiency and conduct of a flight operation without certification to do so. Aircraft impacted the ground off airport about 1 minute after takeoff as a result of a spiral. Aircraft destroyed.
11/5/1988	Piper Aerostar 600, FW, 5,500	1 Minor Injury	Struck Cessna T210L, from behind while incorrectly doing a high speed taxi. Aircraft destroyed.
11/5/1988	Cessna T210L, FW, 3,800	3 Minor Injuries	Aircraft struck from behind prior to takeoff by another aircraft (Piper Aerostar 600) incorrectly doing a high speed taxi. Aircraft destroyed.
12/2/1988	Chamberlain Long EZ 2, FW	0/1 Minor Injury	Engine did not respond to request for increased power on approach, due to valve throttle spring malfunction. Off runway landing on airport. Aircraft destroyed.
11/12/1989	Piper PA-28R-200 FW, 2,500	1 Fatality	Failure to maintain minimum descent altitude and veered of course during approach. Inadequate corrective action and collision with mountainous terrain at 1,100 ft msl. Aircraft destroyed.
1/6/1990	Davidson THROP T-18 2, FW	0/1 Minor Injury	Failure to maintain directional control of home built craft in a cross-wind. Aircraft skidded 200 ft, impacted a light and flipped over on airport. Substantial aircraft damage.
1/12/1991	Virgil D Hawks Quickie 2, FW	0/1 Minor Injury	Failure to maintain sufficient landing distance from larger aircraft during landing and wake turbulence at 15 ft above ground, resulting in loss of control and impact with the ground on airport. Substantial aircraft damage.
4/3/1991	Robinson R22HP H, 1,370	0/1 Minor Injury	Failure to maintain directional control and apply proper remedial action during landing on unauthorized helicopter landing site on airport. Helicopter spun and tail contacted the ground, destroying tail rotor blades and stabilizer.
11/5/1991	Cessna 195A, FW, 3,350	0/1 Minor Injury	Failure to maintain directional control during landing roll and aircraft ground loop. Substantial aircraft damage.

<b>Date</b>	<b>Make/Model, Type<sup>1</sup>, Max Lift-off Weight (lbs)</b>	<b>Event Severity</b>	<b>Accident Type/Cause</b>
5/5/1992	Piper PA-31-301 FW, 6,500	3 Fatalities	Failure to initiate timely climb after missed approach and low altitude alert and controller failure to take timely drastic action. Impact with mountain at 900 ft msl, 6 miles east of airport. Aircraft destroyed.
4/9/1993	Aero Commander 112, FW, 2,800	1 Serious Injury; 1 Minor Injury	Failure to stop en-route for fuel and emergency landing on a road and collision with a culvert, short of the airport in a field. Aircraft destroyed.
6/20/1993	Piper PA-38-112, FW, 1,670	0/1 Minor Injury	Failure to stop en-route for fuel and emergency landing on a road and collision with a culvert. Substantial aircraft damage.
1/16/1994	Clunis Long EZ 2 FW	0/1 Minor Injury	Improper use of brake during taxi after landing and aircraft veered off runway and collapsed nose landing gear in soft plowed field on airport. Substantial aircraft damage.
7/9/1994	Frank M Kopecky Quickie 2, FW	1 Minor Injury	Failure in engine ignition system after takeoff and emergency landing. Touched down in emergency area beyond taxiway and ground looped. Substantial aircraft damage.
7/11/1994	Sam Hale Long EZ 2, FW	1 Minor Injury	Inadequate fuel management and loss of engine power. Emergency landing 2,000 ft short of runway threshold and came to rest inverted. Substantial aircraft damage.
8/10/1995	Cessna 152, FW, 1675	0/1 Minor Injury	Fatigue failure of landing gear strut during takeoff and ground loop on airport. Substantial aircraft damage.
6/29/1996	Cessna 172, FW, 2,300	0/1 Minor Injury	Too high speed during landing and misjudgment of landing flare by student pilot. Hard landing and bounce during touchdown and substantial aircraft damage.
10/8/1996	Richards Lancare IVP 2 FW	2 Serious Injuries	Loss of experimental airplane's engine power for undetermined reasons at 4,500 ft msl. Forced landing off airport and substantial aircraft damage.
3/30/1997	Cessna 180C, FW, 2,550	1/2 Minor Injuries	Failure to compensate for cross-wind conditions during landing. Right wing dragged on the ground and nosed over on runway. Substantial aircraft damage.
11/20/1998	Piper PA-30B, FW, 3,600	1/2 Minor Injuries	Inadequate flight instructor supervision and student pilot's failure to maintain directional control on landing. Aircraft right wing struck ground and came to rest short of runway displaced threshold. Substantial aircraft damage.
2/21/2000	Cohen Van's, RV-6 2, FW	0/2 Minor Injuries	Failure to maintain control of the aircraft during takeoff in crosswind conditions. Aircraft impacted terrain and a runway light on airport. Substantial aircraft damage.

<b>Date</b>	<b>Make/Model, Type<sup>1</sup>, Max Lift-off Weight (lbs)</b>	<b>Event Severity</b>	<b>Accident Type/Cause</b>
1/27/2001	Piper PA-22, FW, 2,000	0/1 Minor Injury	Failure to maintain directional control during takeoff. Aircraft skidded and ground looped and came to rest off right hand edge of runway. Substantial aircraft damage.
8/24/2001	Ryan ST3KR 2, FW	0/2 Minor Injuries	Improper fabrication/reassembly and inspection of engine throttle control linkage of experimental airplane. Loss of engine power during cruise and forced landing in a field off airport. Substantial aircraft damage.
12/17/2001	Vernon Sonerai ILL 2, FW,	0/1 Minor Injury	Inadequate remedial design changes to experimental aircraft. Failure to maintain directional control during landing and aircraft departed the runway and came to rest inverted in an adjacent field. Substantial aircraft damage.
3/25/2002	Cessna 172R, FW, 2,450	0/1 Minor Injury	Failure to maintain directional control on landing. Aircraft veered right and left the runway edge into a ploughed field and nosed over. Substantial aircraft damage.
5/15/2003	Cessna 172S, FW, 2,450	0/2 Minor Injuries	Inadequate flight instructor supervision and student pilot's failure to maintain directional control during takeoff, resulting in aircraft veering left and impacting dirt terrain infield of the airport. Substantial aircraft damage.
10/12/2003	Cessna 172RG FW, 2,550	0/2 Minor Injuries	Failure to comply with manufacture's service bulletin and failure of the left landing gear actuator. Landing gear collapsed on landing. Substantial aircraft damage.
1/15/2005	SlipStream Revelation, U 3	1 Fatality	Failure to maintain adequate airspeed during a go-around, resulting in a stall, uncontrolled descent and ground impact off airport. Aircraft exceeded ultralight weight limitations; pilot did not have a flight training exemption. Substantial aircraft damage.
5/6/2005	Cessna 182R FW, 2,550	0/1 Minor Injury	Failure to maintain directional control during touch-and-go landing. Aircraft veered off the runway into wet dirt and turned up-side-down. Substantial aircraft damage.
1/10/2006	Huntington Kiss 2 FW	1 Serious Injury	Partial loss of engine power during takeoff climb, collision with obstacles and terrain during emergency landing in an open field west of airport. Substantial aircraft damage.
6/11/2006	Cessna 152, FW, 1675	1/2 Minor Injuries	Loss of engine power for undetermined reasons during instructional flight. Emergency landing in a soft field, nosed over and rested inverted. Substantial aircraft damage.
7/18/2006	Cessna 177RG FW, 2,800	0/1 Minor Injury	Failure to extend landing gear prior to landing. Gear up landing on runway and substantial aircraft damage.

Date	Make/Model, Type <sup>1</sup> , Max Lift-off Weight (lbs)	Event Severity	Accident Type/Cause
3/1/2007	Monocoupe 110 FW1,620	2 Minor Injuries	Failure to maintain directional control during landing rollout and left wing impact with the runway, resulting in ground loop on airport. Substantial aircraft damage.
3/25/2007	Boykin Rotorway Exec 162F 2, H	0/1 Minor Injury	Failure to maintain rotor RPM during go-around, hard landing on left forward skid and roll over on airport. Substantial aircraft damage.
7/15/2007	North American, F-51D, FW, 12,100	0/1 Fatality	Loss of control by solo student pilot during a go-around and Impact with terrain beside the runway. Substantial aircraft damage.
10/26/2007	Beech A36, FW, 3,600	0/2 Minor Injuries	The airplane impacted the ground during an attempted go-around. The airplane stalled and impacted the runway.
07/10/2008	Piper PA-18A-150, FW, 3,180	0/1 Minor Injury	Inadequate fuel management caused total loss of engine power. Pilot released banner and made forced landing in field. Plane nosed over.
08/31/2008	PIPER PA-18-150, FW, 3,180	1 Fatality	During a banner pickup maneuver, the airplane caught the banner pickup loop with it's main landing gear instead of the tail hook which caused loss of control and impact with the ground.
09/02/2008	LANCAIR Propjet 2, 2,304	2 Minor Injuries	The loss of engine power due to air within the fuel system caused the pilot to return to the runway after climb. The struck a pile of dirt as it exited the runway as a result of excessive speed during landing.
09/04/2009	CESSNA 195, FW, 3,250	0/2 Injuries	Runway crash due to pilots failure to maintain directional control
03/06/2010	CESSNA 172P, FW, 2,400	0/1 Injuries	High winds caused pilot to veer off runway and nose over
04/09/2011	BEECH 35-B33, FW 2,450	1 Major Injury, 3 Minor Injuries	Loss of power during instruction caused early landing on structure resulting in fire
01/24/2012	MAS EVENTS NEMESIS, 2, 2,600	1 Minor Injury	Forced landing on adjacent field due to landing gear malfunction
01/20/2013	QUICKSILVER SPORT IIS U 3 271	1 Serious, 2 Uninjured	Person on ground struck in head by propeller
02/02/2013	CESSNA 305A, FW, 1,614	0/2 Injuries	Tailwind and loss of control during touchdown caused plane to veer off runway

Date	Make/Model, Type <sup>1</sup> , Max Lift-off Weight (lbs)	Event Severity	Accident Type/Cause
01/28/2014	PIPER PA 23-250, FW, 1,750	0/2 Injuries	Landing gear malfunction caused right wing to contact ground on landing
02/22/2015	PIPER PA 18-150, FW, 3,180	0/2 Injuries	Damage to aircraft due to unknown event found during routine maintenance
03/23/2015	CESSNA 172S, FW, 2,450	Unreported	Pilot failed to maintain direction control during landing and veered off runway
04/20/2016	CESSNA 172, FW, 2,450	0/1 Injuries	Student pilot came in too fast and nosed down on the runway

- 1 FW: Fixed Wing; H: Helicopter; U: Ultralight
- 2 This is a home built aircraft and details of its maximum takeoff weight are not readily available. It is likely to be a small aircraft with a maximum takeoff weight of less than 3,000 lbs.
- 3 This ultralight is expected to have a maximum takeoff weight of less than 500 lbs.

## 5. AIRCRAFT ACCIDENT RATES

The relevant accidents can be used along with the operations data of Section 3 and the accident history of Section 4 to compute accident rates per operation, for each aircraft category. These rates are computed by dividing the number of accidents in a given time period by the number of operations in the same time period. Providing sufficient data is available, accident rates can be provided for arrivals and departures and are specified here as  $P(A)_A$  and  $P(A)_D$ , respectively.

Table 5-1 provides the accident rates for each aircraft category for the period 1990 through 2016. This time span was used as it coincides with the availability of operations data, shown in Table 3-1. The accident rate is computed for each aircraft weight category for both arrival and departure combined. Low numbers of accidents attributed to departures in some categories create negligible accidents rates. Additionally, some accidents could not clearly be classified as an arrival or departure accident. Therefore, a general, combined accident rate was chosen to better represent the accident potential.

**Table 5-1. Aircraft Accident Rates per Operation, Camarillo Airport, 1990 - 2016**

Historical Information			Total Accidents	Total Operations	Total Accident Rate
<b>Very Small</b>	< 500 lb	<b>Ultralights</b>	<b>1</b>	<b>258278</b>	<b><math>3.87 \times 10^{-6}</math></b>
<b>Small</b>	500 - 3,500 lb	Small FW	34	3266987	$1.04 \times 10^{-5}$
		Small Helicopters	2	86093	$2.32 \times 10^{-5}$
		<b>Total Small</b>	<b>36</b>	<b>3353079</b>	<b><math>1.07 \times 10^{-5}</math></b>
<b>Medium</b>	3,500 - 7,500 lb	Med FW	3	444056	$6.76 \times 10^{-6}$
		Large Helicopters	0	86093	0
		<b>Total Medium</b>	<b>3</b>	<b>530149</b>	<b><math>5.66 \times 10^{-6}</math></b>
<b>Large</b>	7,500 - 20,000 lb	Large FW	1	299058	$3.34 \times 10^{-6}$
		Air Taxi	0	90624	0
		<b>Total Large</b>	<b>1</b>	<b>389682</b>	<b><math>2.57 \times 10^{-6}</math></b>
<b>All</b>			<b>41</b>	<b>4531188</b>	<b><math>9.05 \times 10^{-6}</math></b>

## **6. DISTRIBUTION OF ACCIDENTS**

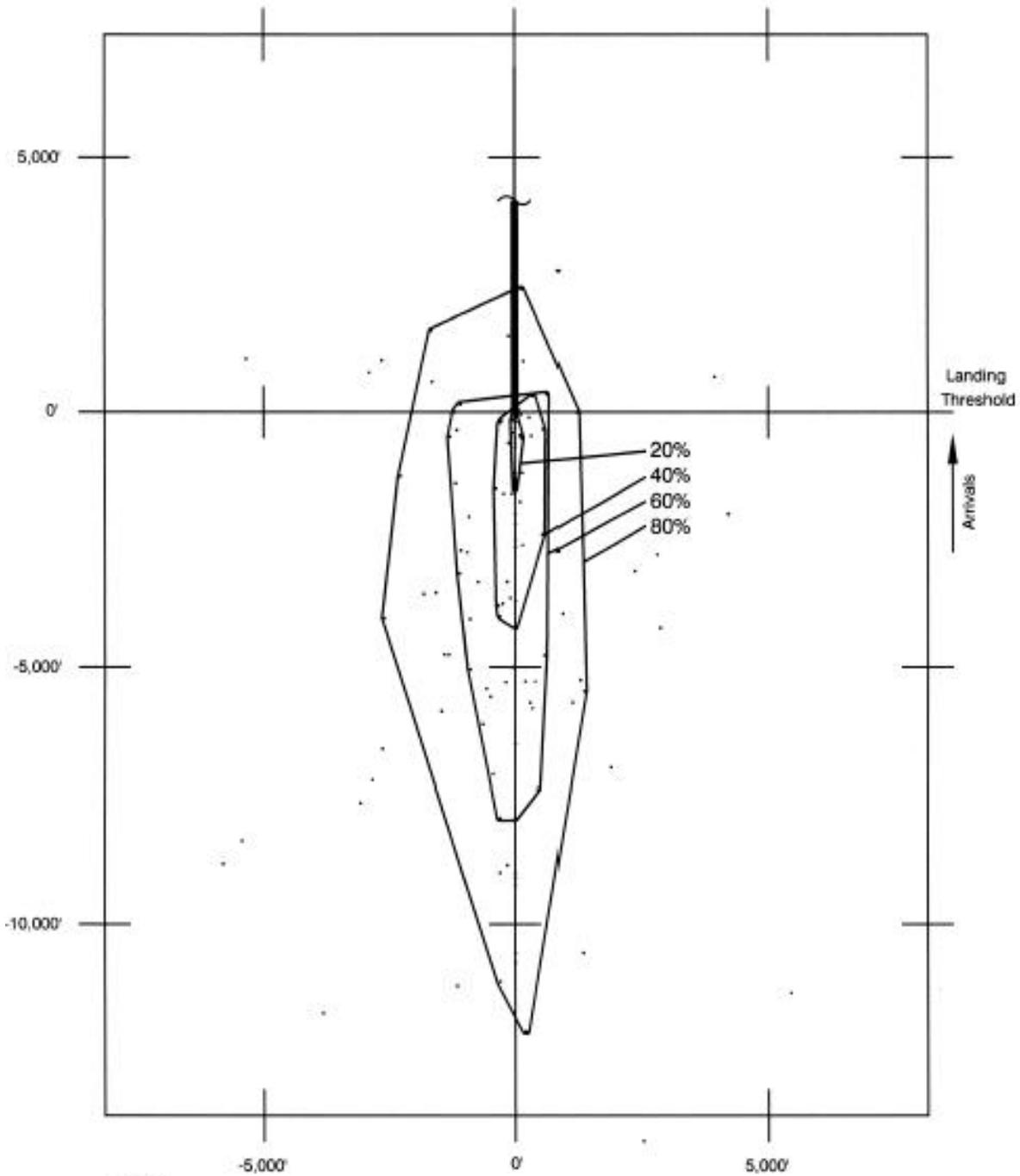
The distribution of accidents in the vicinity of an airfield can be described according to a downrange distance impact distribution and a cross-range distance impact distribution. Downrange distance is measured along the runway centerline from a specific location on the runway and cross-range distance is measured from, and perpendicular to, the runway centerline. From a downrange perspective, the distribution of accidents is highest at locations near to the end of the runway. From a cross-range perspective, the highest concentration of accidents occurs close to the extended runway centerline.

### **6.1 Probability of Impact Given an Accident Occurs**

Data specific to the Camarillo Airport is not available to determine the locations of impacts with reasonable accuracy. For this reason, it was necessary to rely on data contained in the California Airport Land Use Planning Handbook [8]. This handbook provided analyses of the distribution of general aviation accidents, based on research conducted by the Institute of Transportation Studies of the University of California, Berkeley, in 2002. The work defined a database that encompasses accidents that occurred in all 50 states and covered the time period from 1983 into 1992. The database contains a total of 873 accidents, arrivals and departures; it excludes helicopters, airline aircraft, blimps, military aircraft and ultralights.

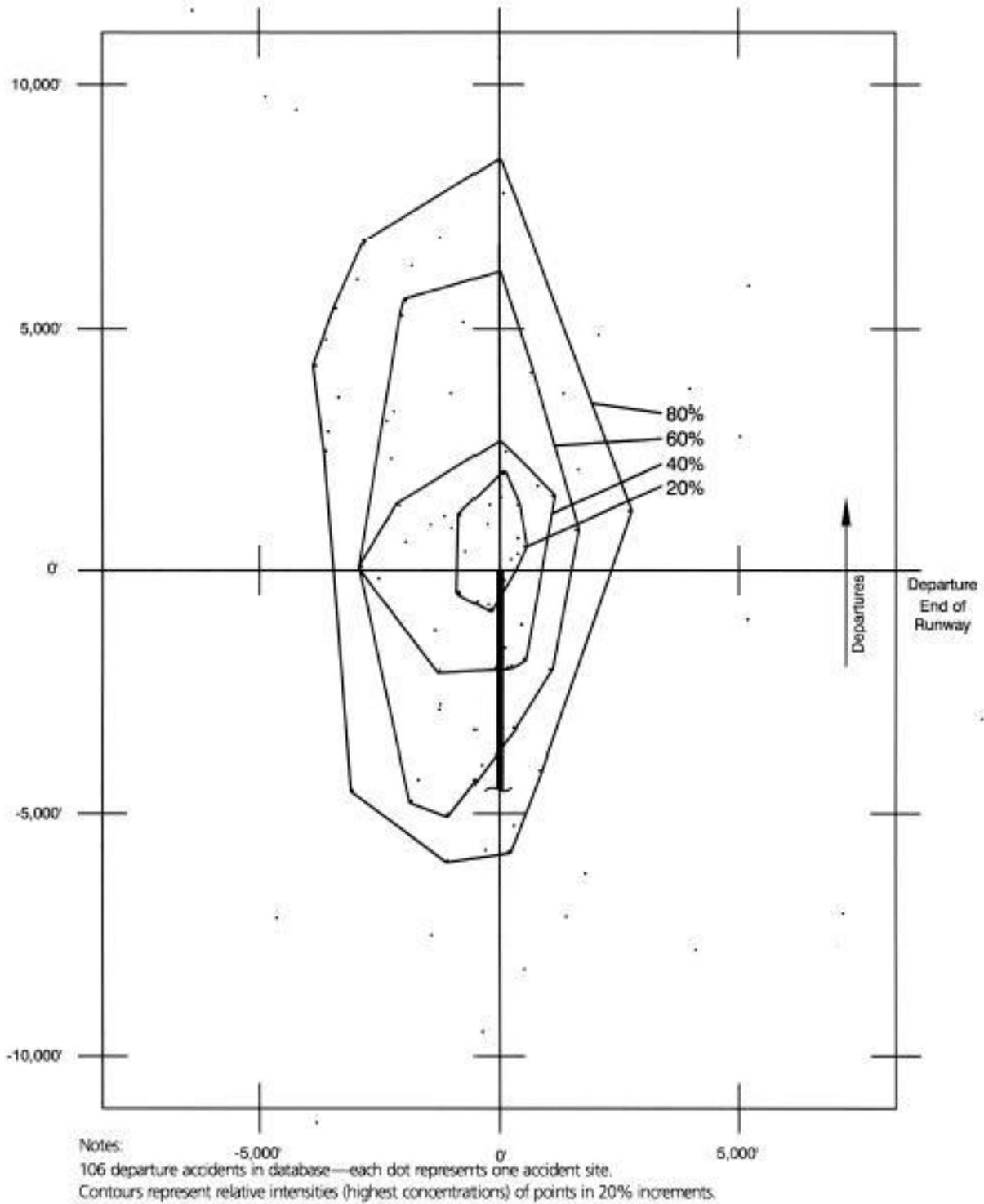
Figures 6-1 and 6-2 are reproduced here from this handbook [8], which shows the location of accidents with respect to the landing and departure ends of runways, respectively, for runways of length greater than 6,000 feet. This data is considered to be relevant for Camarillo Airport, which is 6,010 feet long. In order to be useable in calculating the probability of impact, given an accident occurs, it was necessary to prepare a model from this data. The approach to preparing this model is described in the following paragraphs.

The pooled accident data for each category of runway, for arrivals or departures, was used to develop stochastic (probabilistic) models. The data are referred to as pooled because they are aggregated over different airports and accumulated over a period of time. The stochastic models were used to, in effect, estimate empirical confidence limits. These confidence limits provide the basis for estimating the probability of future accidents in an arbitrarily-shaped area in the vicinity of the existing accident data. The probability estimates are conditioned on the data and assume it was perfectly observed. The stochastic model produced in each case is non-parametric. This means that regardless of the spatial distribution of the accident data, the probabilities that are calculated from the stochastic model will be greatest in the vicinity of accident “clusters.” The stochastic model is based on a Markov Chain Monte Carlo (MCMC) technique that is described in [9]. The following discussion is intended as a general outline.



Notes:  
 142 arrival accidents in database—each dot represents one accident site.  
 Contours represent relative intensities (highest concentrations) of points in 20% increments.

**Figure 6-1. General Aviation Accident Distribution Contours of Arrival Accidents on Runways of 6000 feet or greater [8]**



**Figure 6-2. General Aviation Accident Distribution Contours of Departure Accidents on Runways of 6000 feet or greater [8]**

The MCMC methodology consists of: 1) constructing a surrogate random process for the accident data; 2) setting up a random walk in the space of the surrogate random process, and 3) ensuring that the walk traverses the posterior density in a finite time (finite number of steps) via Metropolis-Hastings acceptance testing. The last step is the “Markov Chain” aspect of the methodology, in that state-transition probabilities are calculated and used during this step.

The first step requires transforming the observed random process to a better structured probabilistic space. This is done using a Karhunen-Loeve transformation. The resulting space is one of uncorrelated standard normal random variables. This probabilistic space is also one in which a random walk is easy to construct, which is the second step of the method. Although a random walk is easy to construct, there is no guarantee that results belong to the probabilistic description empirically described by the airport crash data (the source random process). The third step addresses this issue by “guiding” the random walk using likelihood ratios calculated from proposed random steps and an empirical density description based on kernel density estimators. The final step ensures that the results from the walk are probabilistically indistinguishable from the source random process, even though they are serially correlated.

Once a stochastic model for a particular accident data set is constructed, the procedure used to estimate accident probabilities in a finite region,  $A_{new}$ , is to sample from the stochastic model many times. This is the Monte Carlo aspect of the MCMC methodology. (The Markov Chain aspect yields an efficient and usable algorithm.) For regions of interest in the vicinity of the existing accident data, the number of samples used was 30000. Accident probability, conditioned on the area is then given directly by

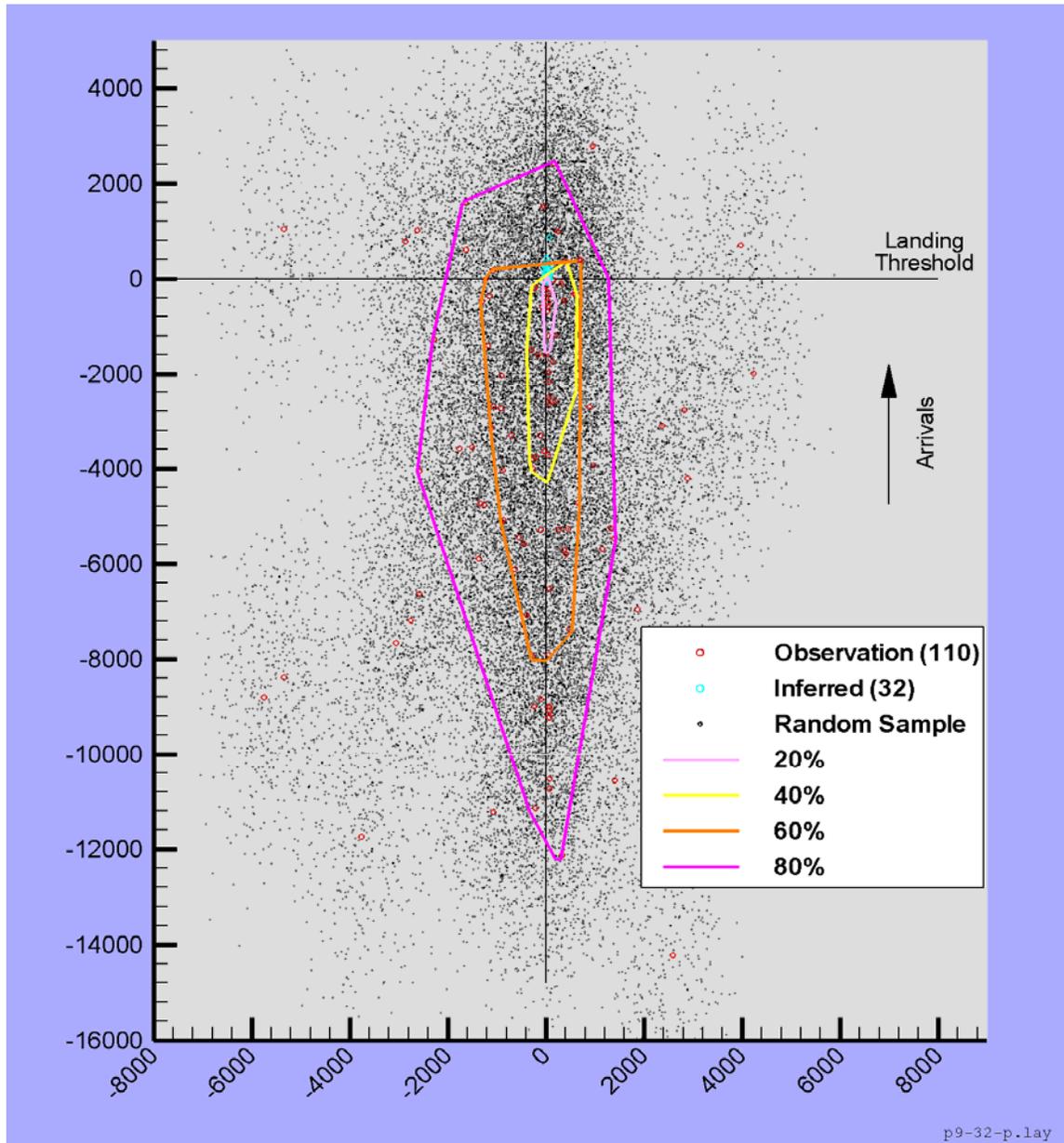
$$\Pr(\text{Accident}|A_{new}) = \frac{\text{number of samples inside } A_{new}}{\text{total number of samples}}$$

Because the data on which the stochastic models were based were pooled, accident observations incompatible with a particular airport are conceivable. An issue such as this would require detailed investigation of the catalogued data as well as intimate knowledge of the particular airport in question. Such issues, of course, transcend any particular stochastic modeling procedure or statistical analysis.

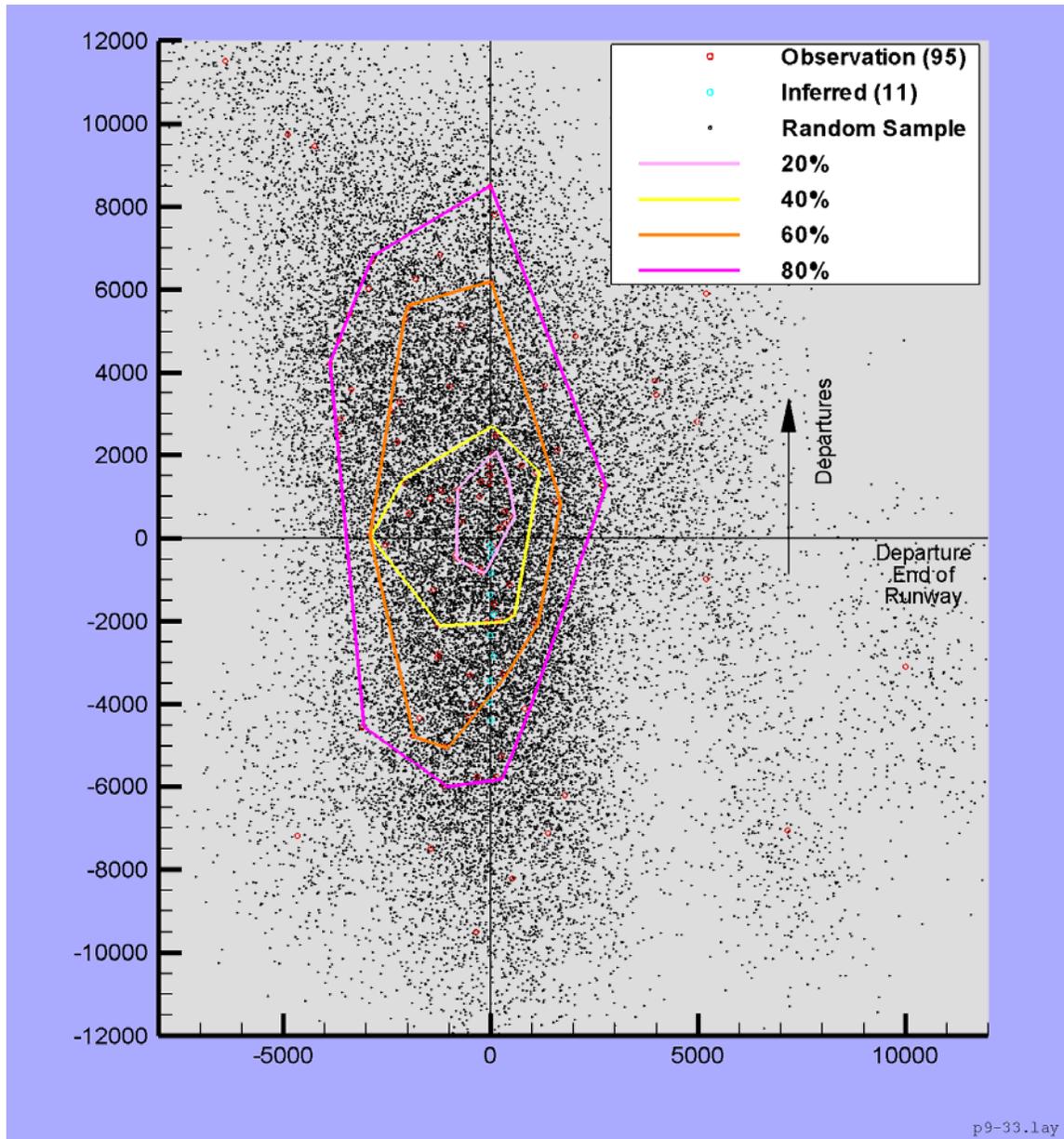
Because the sets of data on which the stochastic models were based are finite in size (roughly 100-150 accidents per set), azimuthal asymmetries and multi-modal characteristics are evident, even pronounced in some cases. However, these features are consistent with the empirical descriptions of the accident spatial distributions, as observed. The incorporation of additional prior information should be decided on a case-by-case basis.

A computer program was prepared from the model which enables the computation of the conditional probability of impact to a specific location, defined by its downrange and cross-range

coordinates in feet from a reference location. For arrival accidents, the reference location is the landing threshold of the runway and for departures it is the departure end of the runway. Figures 6-3 and 6-4 provide the results of many thousands of random samples of impact location using the model for comparison with the contours provided in the California Airport Land Use Planning Handbook of January 2002. The results appear to be reasonable.



**Figure 6-3. Arrival Accident Locations Scatter Plot of Thousands of Random Samples From Model for Airports with Runways 6,000 ft or Greater [9]**



**Figure 6-4. Departure Accident Locations Scatter Plot of Thousands of Random Samples From Models for Airports with Runways 6,000 or Greater [9]**

## 7. PROPERTY IMPACT PROBABILITIES

Impact probabilities can be computed based on several variables, e.g. per operation, unit of time, etc. Here, they are computed as the probability of impact per year. The reciprocal is the return period, which is the number of years expected, on average, between impacts. The probability of impact per year is computed for each part of the site as follows:

$$P(I) = P(A) * P(IL | A) * P(C | A) * N \quad (6-1)$$

where,

$P(A)$  = probability of an accident per operation

$P(IL|A)$  = probability of impact to a specific location given an accident

$N$  = number of operations per year

$P(IL|A)$  is computed using the model described in Section 6.1.

### 7.1 Property Impact Probabilities

Different aircraft sizes will yield different debris footprints on impact and so it is necessary to compute impact probabilities for each type of aircraft that uses the airport. Debris will generally be scattered over a larger area for heavier aircraft and so the potential for building impact will be greater. In determining the impact footprint area, therefore, the potential for impact from non-direct hits must be included. The size of the impact footprints for different aircraft sizes was determined from US Air Force data [10], for fixed-wing aircraft.

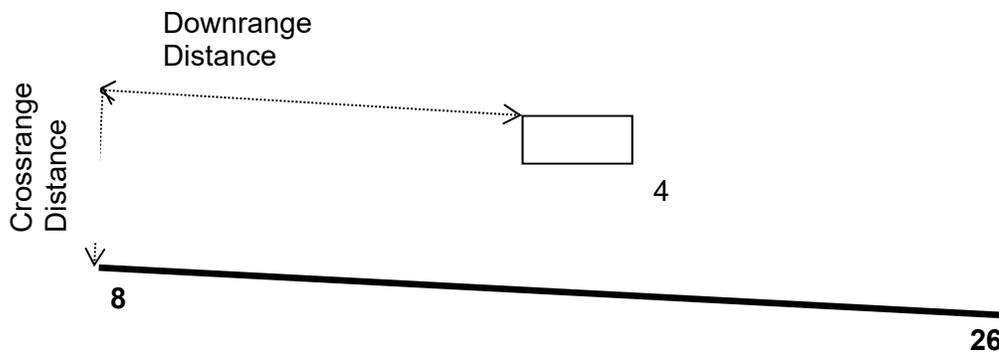
An impact area of 1 acre was used as the size of the possible impact footprint for small fixed wing aircraft, those with maximum takeoff weights of less than 3,500 lbs. It is assumed too that the impact footprint for helicopters of maximum takeoff weight up to 3,500 lbs will also be about 1 acre. The impact footprint for aircraft, including helicopters, with weights ranging from 3,500 lbs to 7,500 lbs is assumed to be 2 acres and the impact footprint for aircraft with maximum takeoff weight between 7,500 lbs and 15,000 lbs is assumed to be 3 acres. The impact footprint for ultralights is assumed to be about ½ an acre.

Figure 2-3 shows the location of the HCC site in relation to the airport runway. A scaled map of this figure was used to determine the coordinate distances from the runway arrival and departure locations for ½ acre, 1 acre, 2 acre and 3 acre locations on the HCC. These areas are likely to encompass any debris resulting from an accident involving the types of aircraft that use the airport. The airport runway is 6,010 feet long and 150 feet wide. Assuming the momentum of an aircraft on impact carries the debris three times further in the direction of the travel of the aircraft than in a cross-wise direction will result in the debris field dimensions as shown in Table 7-1.

**Table 7-1. Debris Field Dimensions Corresponding to Maximum Aircraft Takeoff Weight**

Maximum Aircraft Takeoff Weight (lbs)	Debris Field Size (Acres)	Downrange Dimension (ft)	Crossrange Dimension (ft)
< 500	0.5	255	85
< 3,500	1.0	360	120
> 3,500 to < 7,500	2.0	510	170
7,500 to 15,000	3.0	630	210

In order to compute the probabilities of impacting a given location, given an accident, the code prepared to determine these results requires input of the downrange and crossrange coordinate locations of the impact locations with reference to the runway 8-26. Figure 7-1 is a graphic portrayal of the dimensions required. Here, the runway is designated as 8-26 and a potential location on the site is defined by its four corners as 1, 2, 3 and 4. For corner 1, the arrowed lines represent the dimensions required to obtain the downrange (east-west) distance and the crossrange distance from the centerline of runway 8.



**Figure 7-1. Example of Coordinate Measurements that Define Potential Impact Locations on the SSP Site With Respect to Runway 8-26**

Figure 7-2 shows the HCC site plan in which each building serves as the potential impact locations considered in the analysis. The impact probabilities were computed based on the nearest point of each building to the end of the runway. The analysis considered overlap of the nearest point of each building with a debris field corresponding to aircraft category debris field sizes. Measurements were taken to the debris field edges closest to the runway end. Due to the different debris field sizes, measurements differ for each aircraft category. The corner coordinates of debris fields with respect to the runway end for the half-acre and 1-acre debris fields are presented in Table 7-2 for each building. The full list of debris field coordinates used in the analysis is included in Appendix XXX. These coordinates are used to determine the conditional probability of aircraft debris impacting each building given that an accident occurs.

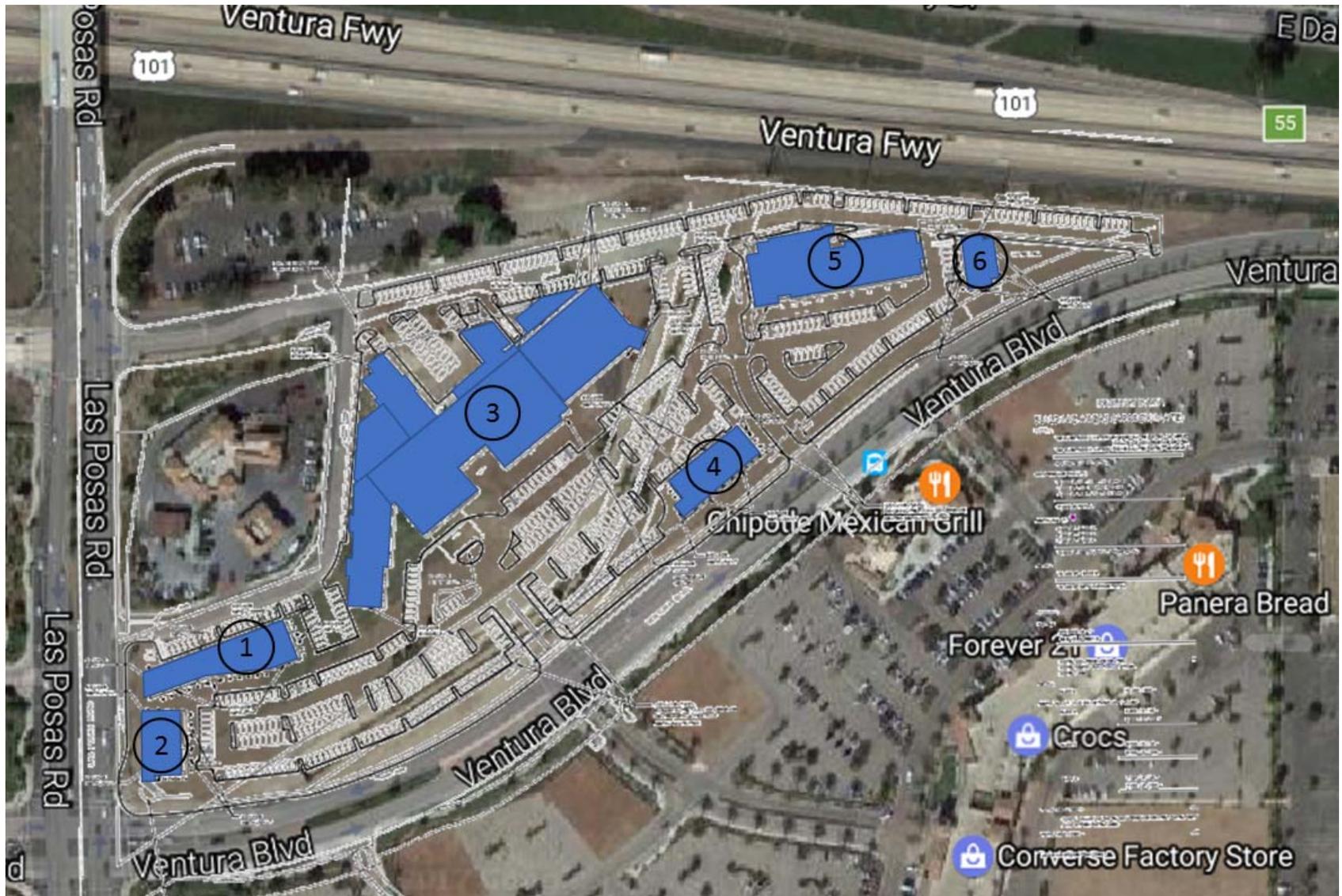


Figure 7-2. Building Locations on HCC Site for Which Impact Probabilities Were Computed

**Table 7-2. Coordinate Distances from Runway to Debris Field Edges on HCC Site**

Corner Coordinates			Runway 26 (East to West)			
			Arrival		Departure	
			Downrange	Cross Range	Downrange	Cross Range
			(ft)	(ft)	(ft)	(ft)
<b>Very Small Category ( &lt; 500 lb)</b>  <b>0.5 Acre</b>	Building 1	Near	-4442.5	932.5	-10452.5	932.5
		Far	-4697.5	847.5	-10707.5	847.5
	Building 2	Near	-4437.5	1057.5	-10447.5	1057.5
		Far	-4692.5	972.5	-10702.5	972.5
	Building 3	Near	-4712.5	1182.5	-10722.5	1182.5
		Far	-4967.5	1097.5	-10977.5	1097.5
	Building 4	Near	-5212.5	1312.5	-11222.5	1312.5
		Far	-5467.5	1227.5	-11477.5	1227.5
	Building 5	Near	-5322.5	1607.5	-11332.5	1607.5
		Far	-5577.5	1522.5	-11587.5	1522.5
	Building 6	Near	-5627.5	1652.5	-11637.5	1652.5
		Far	-5882.5	1567.5	-11892.5	1567.5
<b>Small Category ( &gt; 500 and &lt; 3,500 lb)</b>  <b>1 Acre</b>	Building 1	Near	-4390	950	-10400	950
		Far	-4750	830	-10760	830
	Building 2	Near	-4385	1075	-10395	1075
		Far	-4745	955	-10755	955
	Building 3	Near	-4660	1200	-10670	1200
		Far	-5020	1080	-11030	1080
	Building 4	Near	-5160	1330	-11170	1330
		Far	-5520	1210	-11530	1210
	Building 5	Near	-5270	1625	-11280	1625
		Far	-5630	1505	-11640	1505
	Building 6	Near	-5575	1670	-11585	1670
		Far	-5935	1550	-11945	1550

The results of the impact probability for the areas potentially affecting a building are provided in Table 7-3. This table provides the conditional probability for each aircraft category that could potentially impact a building or near a building such that debris could affect the structure. The debris field sizes are as defined in Table 7-1. These probabilities are combined with the accident rate for each aircraft category, as presented in Table 5-1 and the expected number of operations in 2020 for each category, as presented in Table 3-5. This yields the annual impact probabilities for each category for all locations, Building 1 – Building 6, which is shown in Table 7-4. Due to the nature of limited accident data by category and undistinguishable accident types, probabilities are calculated for all operations rather than by arrival/departure. Therefore,

total accident rate was used for each category combined with the conditional probability of all operations.

**Table 7-3. Probability of Impact by Building Given an Accident Occurs**

<b>Aircraft Category (Field Size)</b>	<b>Building</b>	<b>Arrivals</b>	<b>Departures</b>	<b>All Operations</b>
<b>Very Small (0.5 Acre)</b>	Building 1	2.23E-04	6.99E-05	1.47E-04
	Building 2	2.50E-04	8.28E-05	1.66E-04
	Building 3	1.70E-04	6.57E-05	1.18E-04
	Building 4	2.14E-04	5.43E-05	1.34E-04
	Building 5	1.32E-04	3.87E-05	8.52E-05
	Building 6	1.10E-04	4.44E-05	7.72E-05
<b>Small Aircraft (1 Acre)</b>	Building 1	5.24E-04	1.39E-04	3.31E-04
	Building 2	4.37E-04	1.37E-04	2.87E-04
	Building 3	3.60E-04	1.44E-04	2.52E-04
	Building 4	4.13E-04	9.99E-05	2.56E-04
	Building 5	2.50E-04	9.99E-05	1.75E-04
	Building 6	1.93E-04	7.86E-05	1.36E-04
<b>Medium Aircraft (2 Acre)</b>	Building 1	8.44E-04	2.77E-04	5.60E-04
	Building 2	9.46E-04	3.02E-04	6.24E-04
	Building 3	7.90E-04	2.77E-04	5.34E-04
	Building 4	7.23E-04	1.99E-04	4.61E-04
	Building 5	5.30E-04	1.91E-04	3.61E-04
	Building 6	3.90E-04	1.71E-04	2.81E-04
<b>Large Aircraft (3 Acre)</b>	Building 1	1.28E-03	4.19E-04	8.49E-04
	Building 2	1.35E-03	4.84E-04	9.16E-04
	Building 3	1.23E-03	4.31E-04	8.32E-04
	Building 4	1.04E-03	3.26E-04	6.83E-04
	Building 5	7.30E-04	3.02E-04	5.16E-04
	Building 6	6.66E-04	2.69E-04	4.67E-04

**Table 7-4. Annual Site Impact Probabilities for Year 2020**

<b>Aircraft Category (Field Size)</b>	<b>Building</b>	<b>All Operations</b>
<b>Very Small (0.5 Acre)</b>	Building 1	4.33E-06
	Building 2	4.91E-06
	Building 3	3.48E-06
	Building 4	3.95E-06
	Building 5	2.51E-06
	Building 6	2.28E-06
<b>Small Aircraft (1 Acre)</b>	Building 1	3.52E-04
	Building 2	3.05E-04
	Building 3	2.68E-04
	Building 4	2.73E-04
	Building 5	1.86E-04
	Building 6	1.44E-04
<b>Medium Aircraft (2 Acre)</b>	Building 1	4.96E-05
	Building 2	5.53E-05
	Building 3	4.73E-05
	Building 4	4.08E-05
	Building 5	3.20E-05
	Building 6	2.49E-05
<b>Large Aircraft (3 Acre)</b>	Building 1	2.51E-05
	Building 2	2.70E-05
	Building 3	2.46E-05
	Building 4	2.02E-05
	Building 5	1.52E-05
	Building 6	1.38E-05

**8. RISK TO BUILDING OCCUPANTS**

In order to determine the risk of a casualty inside one or more of the site properties, the potential for penetration of a structure and impact to one-or-more people inside needs to be determined. Building impact is defined as anything from a minor impact of a part of an aircraft, which does not penetrate the structure to full structural penetration. The probability of structural penetration and impact to one or more individuals inside the structure can only be provided with wide ranges of uncertainty, given all of the variables associated with the calculation.

## 8.1 Casualty Potential

Table 8-1 is a suggested severity classification for building occupants and property of the HCC site. It is typical of that used by various jurisdictions in California, and elsewhere, to classify the severity of accidents for various hazardous industrial activities.

**Table 8-1. Severity Classification for HCC Site**

Description	Definition
Catastrophic	Death or damage and other losses > \$1,000,000
Severe	Multiple injuries or losses between \$100,000 and \$1,000,000
Moderate	A single injury or losses between \$25,000 and \$100,000
Negligible	No casualties or losses < \$25,000

Table 8-2 provides estimates of the potential for building damage, penetration and casualties, given an aircraft impacts on or close to a building. These estimates are affected by the location of impact, a direct hit versus an impact of debris, and the velocity and size of debris. The likelihood of structural penetration increases as aircraft size and impact velocity increases. For small fixed wing aircraft, the size of the impact area is considered to be 1 acre, which was used to compute the impact probabilities in Section 7. The potential for penetration by impacting debris from a small aircraft if it lands near to a property, but within a 1 acre area that includes a structure is therefore less than 100%, and so these estimates are considered reasonable.

**Table 8-2. Percent of People Who Will Suffer Specified Effect Given an Aircraft Impact**

Ultralights				Small Fixed Wing				Medium Fixed Wing				Large Fixed Wing			
Neg	Mod	Sev	Cat	Neg	Mod	Sev	Cat	Neg	Mod	Sev	Cat	Neg	Mod	Sev	Cat
60%	30%	8%	2%	30%	50%	15%	5%	25%	45%	20%	10%	20%	40%	25%	15%

The results of Table 7-4, the annual impact probabilities, were multiplied by the percentages (probabilities) of Table 8-2 to determine the probability of various levels of effect to persons located on the Hotel and Conference Center site. Table 8-3 presents the resulting risk matrices for each site and type of aircraft.

**Table 8-3. Annual Risk for Buildings on HCC Site**

<b>Aircraft Category (Field Size)</b>	<b>Building</b>	<b>Moderate</b>	<b>Severe</b>	<b>Catastrophic</b>
<b>Very Small (0.5 Acre)</b>	Building 1	1.30E-06	3.46E-07	8.66E-08
	Building 2	1.47E-06	3.93E-07	9.83E-08
	Building 3	1.04E-06	2.79E-07	6.96E-08
	Building 4	1.19E-06	3.16E-07	7.91E-08
	Building 5	7.54E-07	2.01E-07	5.03E-08
	Building 6	6.84E-07	1.82E-07	4.56E-08
<b>Small Aircraft (1 Acre)</b>	Building 1	1.76E-04	5.28E-05	1.76E-05
	Building 2	1.53E-04	4.58E-05	1.53E-05
	Building 3	1.34E-04	4.02E-05	1.34E-05
	Building 4	1.36E-04	4.09E-05	1.36E-05
	Building 5	9.30E-05	2.79E-05	9.30E-06
	Building 6	7.22E-05	2.17E-05	7.22E-06
<b>Medium Aircraft (2 Acre)</b>	Building 1	2.23E-05	9.93E-06	4.96E-06
	Building 2	2.49E-05	1.11E-05	5.53E-06
	Building 3	2.13E-05	9.46E-06	4.73E-06
	Building 4	1.84E-05	8.17E-06	4.08E-06
	Building 5	1.44E-05	6.39E-06	3.20E-06
	Building 6	1.12E-05	4.97E-06	2.49E-06
<b>Large Aircraft (3 Acre)</b>	Building 1	1.00E-05	6.27E-06	3.76E-06
	Building 2	1.08E-05	6.76E-06	4.06E-06
	Building 3	9.83E-06	6.15E-06	3.69E-06
	Building 4	8.07E-06	5.04E-06	3.03E-06
	Building 5	6.09E-06	3.81E-06	2.28E-06
	Building 6	5.52E-06	3.45E-06	2.07E-06

Summing the risk contributions for each aircraft size category yields Table 8-4, the total annual risk by severity level. Building 1 shows the highest risk for each severity level, followed by Building 2. This corresponds to proximity to the airport runway.

**Table 8-4. Total Annual Risk by Building on HCC Site**

<b>Building</b>	<b>Moderate</b>	<b>Severe</b>	<b>Catastrophic</b>
Building 1	2.10E-04	6.94E-05	2.64E-05
Building 2	1.90E-04	6.40E-05	2.49E-05
Building 3	1.66E-04	5.61E-05	2.19E-05
Building 4	1.64E-04	5.44E-05	2.08E-05
Building 5	1.14E-04	3.83E-05	1.48E-05
Building 6	8.96E-05	3.03E-05	1.18E-05

## 9. CONCLUSION

The risk results for the six buildings on the HCC site have been calculated for various severity levels, as shown in Table 8-4. The *Severe* consequence level corresponds to a significant injury and the *Catastrophic* consequence level corresponds to a fatality. Table 9-1 provides the sum of these two consequence levels to represent the risk of a significant injury or worse. It was found that Building 1, the closest building to the end of Runway 26, has the highest risk of consequence on the HCC site. Therefore, the HCC site shows a highest individual risk corresponding to the risk reported for Building 1. The risk of a *Severe* or worse consequence at the HCC site was found to be  $9.58 \times 10^{-5}$ , or almost 10 in 100,000.

**Table 9-1. Total Risk Due to Aircraft Impact at HCC Site**

Building	Sever or Worse
Building 1	9.58E-05
Building 2	8.89E-05
Building 3	7.80E-05
Building 4	7.52E-05
Building 5	5.31E-05
Building 6	4.21E-05

## 10. References

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