

## AIRCRAFT CRASH FREQUENCY ESTIMATION

This annex summarises the assessment of the aircraft crash frequency for Yau Kom Tau WTW. The assessed frequency of aircraft crashes relates to the year 2006 and takes into account movements of aircraft to and from Chek Lap Kok, local helicopter traffic and high level air routes passing over Hong Kong.

Note that this annex is basically a copy of Annex H of ERM (2001), however after the examination of recent data it has been concluded that the previous estimates are still valid, and a revision of the crash frequencies to be used in the present study is not necessary. For example, according to the US NTSB database, the number of fatal in-flight airliner accidents for the last ten years (October 1997 to September 2007) was six plus two approach accidents – the numbers quite in line with the data provided in *Tables H1* and *H2*. Similarly, according to the latest Hong Kong aviation statistics<sup>1</sup>, the total number of flights in 2006 was 230,387 – a number lower, but of the same magnitude as given in *Table H3*.

Information on flight paths to and from Chek Lap Kok has been obtained from Civil Aviation Department. This shows that the flight path of most concern is the landing approach to Chek Lap Kok passing over the New Territories and West Kowloon.

The methodology used for the assessment is that of Phillips (1987), which has been used in past Hazard Assessment studies of WTWs in Hong Kong. The model takes into account specific factors such as the 'target' area offered by a particular water treatment works, its radial distance from the runway end (R, in km) and its angle from the runway axis/flight path ( $\theta$ ) by using an empirical function

$$f(R, \theta) = 0.23 \exp(-R/5) \exp(-|\theta|/5)$$

The frequency of aircraft crash is calculated by the following equation:

$$F = \{\text{crash rate}\} \times \{f(R, \theta)\} \times \{\text{proportion of flights in specified direction}\} \times \{\text{proportion of flights on specified runway}\} \times \{\text{number of flights}\} \times \{\text{target area of WTW}\}$$

The aircraft crash rates proposed by Phillips have been updated to take into account the most recent data held by the US National Transportation Safety Board (NTSB) for aircraft accidents involving US carriers over the period 1982-1998. The US NTSB data represents the largest and most authoritative source of aircraft accident data currently held.

*Tables H1 and H2* summarise the US NTSB data for fatal accidents associated with the approach of aircraft to airports and the in-flight phase. Ten year 'rolling average' crash rates are calculated to determine the trend in crash rate over the period 1982-91. From *Tables H1 and H2* it can be seen that the

<sup>1</sup><http://www.cad.gov.hk/english/p-through.htm>

'approach' crash rate falls significantly from 5.8E-8 per movement (1982-91) to 1.2E-8 per movement (1989-98), whereas the 'in-flight' crash rate increases from 2.9E-8 per movement to 7.1E-8 per movement over the same period. In this study the 1989-98 data are used, as representative of current conditions.

Table H3 calculates the aircraft crash frequency for Yau Kom Tau WTW using the Phillips methodology combined with the latest US NTSB data. For this study it is the crash frequency for airliners which is the most significant data, as it is crashes involving this type of aircraft which could cause major damage to the chlorine store and, consequently, a large release of chlorine. From Table H3, the frequency of crashes of airliners onto the chlorine store at Yau Kom Tau WTW is estimated to be 1.4E-8 per year.

Table H1 'Approach' Crash Rate for US Carriers (10 year 'rolling average' for 1982-1998)

Year	Mid-year	Total fatal approach accidents over 10 year period	Total departures over 10 year period	10 year 'rolling average' accident rate for approach
1982-91	1986	4	69073254	5.791E-08
1983-92	1987	4	71602828	5.586E-08
1984-93	1988	3	74231627	4.041E-08
1985-94	1989	3	76571081	3.918E-08
1986-95	1990	2	78721787	2.541E-08
1987-96	1991	2	79748570	2.508E-08
1988-97	1992	1	82447237	1.213E-08
1989-98	1993	1	85049176	1.176E-08

Table H2 'In-Flight' Crash Rate for US Carriers (10 year 'rolling average' for 1982-1998)

Year	Mid-year	Total fatal in-flight accidents over 10 year period	Total departures over 10 year period	10 year 'rolling average' accident rate for in-flight phase
1982-91	1986	2	69073254	2.895E-08
1983-92	1987	2	71602828	2.793E-08
1984-93	1988	2	74231627	2.694E-08
1985-94	1989	3	76571081	3.918E-08
1986-95	1990	5	78721787	6.351E-08
1987-96	1991	7	79748570	8.778E-08
1988-97	1992	6	82447237	7.277E-08
1989-98	1993	6	85049176	7.055E-08

Table H3 Frequency of Aircraft Crash for Yau Kom Tau WTW

Type	T-O & Landing/ Descent per movement	Proportion of Flights	f(r,angle) t/o to east or landing runway 07R from east	f(r,angle) t/o to west or landing runway 07R from west	f(r,angle) t/o to east or landing runway 07L from east	f(r,angle) t/o to west or landing runway 07L from west	F t/o to east or landing runway 07R from east	F t/o to west or landing runway 07R from west	F t/o to east or landing runway 07L from east	F t/o to west or landing runway 07L from west	Airfield-Related Crash Rate 2006
Airliner /Military Transport	1.20E-08	1	3.97E-03	2.50E-18	3.97E-03	2.50E-18	6.79E-09	0.00E+00	6.79E-09	0.00E+00	1.36E-08
Angle of Site from Runway = 2.5 degrees Distance of Site from Runway = 17.8 km Target Area of Site (Note 1) = 3137 m <sup>2</sup> Area of Chlorine Store = 587 m <sup>2</sup> Number of Flights = 3.03E+05 2.14E+05 per year 2001 3.03E+05 per year 2006 3.94E+05 per year 2011							p t/o to east or landing runway 07R from east	p t/o to west or landing runway 07R from west	p t/o to east or landing runway 07L from east	p t/o to west or landing runway 07L from west	
Proportion of flights in specified direction = Proportion of flights on specified runway =							0.3	0	0.3	0	
							0.5	0.5	0.5	0.5	
Background Crash Rate for Helicopters = 1.00E-05 per km <sup>2</sup> per year Airway Crash Rate = 7.10E-08 per km <sup>2</sup> per year							Background Crash Rate for Helicopters = 5.87E-09		Airway Crash Rate = 2.23E-10		TOTAL = 1.97E-08

Note 1: target area = plan area of chlorine store + 30m added to each dimension

A brief summary of aircraft incidents that have occurred in Hong Kong, supplied by the Civil Aviation Department, is shown in *Table H4* for reference. The recorded aircraft accidents have all been on the runway which does not provide sufficient information to validate the "off-field" frequency relevant to this report. The nature of the recorded helicopter accidents are not known (e.g. whether crashes or other types of incident); and hence, the data cannot be used to derive the relevant "in-flight" crash rate for helicopters.

*Table H4 Summary of reportable aircraft accidents in Hong Kong*

Year of Occurrence	Type of Aircraft	Approximate Location of Reportable Accidents
1979	Civil helicopter	1 mile west of Jubilee Reservoir
1981	Airliner	Kai Tak
1983	Airliner	Kai Tak
1988	Airliner	Kai Tak
1992	Civil helicopter	Castle Peak
1993	Airliner	Kai Tak
1994	Airliner	Kai Tak
1995	Civil helicopter	7 km WSW of Sekong
1995	Civil helicopter	8 km West of Sekong
1996	Civil helicopter	8 km SW of Sekong
1999	Airliner	Chek Lap Kok 07R Runway