Agreement No. CE 47/2006 (TP)

Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study

Final TR3 – Air Ventilation Assessment

November 2009

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0	Final TR3 – Air Ventilation Assessment	Martin Ko	Peter Hitchcock	Collin Chan	30.09.09
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土木工程拓展署
CEDD
Civil Engineering and Development Department

規劃署
Planning Department

SCOTT WILSON LTD

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

CLP Power Wind/Wave Tunnel Facility

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1. INTRODUCTION

1.1 Purpose of the Report

1.1.1 The purpose of this TR3 is to list out the detailed tasks of Air Ventilation Assessment (AVA) undertaken for the preliminary layout plans with the focus on all the study sites based on the Technical Guide for Air Ventilation Assessment for Developments in Hong Kong attached to the joint Technical Circular issued by the Housing, Planning and Lands Bureau and Environment, Transport and Works Bureau No. 1/06 on Air Ventilation Assessments. Three detailed tasks are required for the AVA including the Site Wind Availability Testing, the Expert Evaluation and the Initial Study. These reports were submitted to the concerned departments in July 2008, August 2009 and September 2009 respectively.

1.2 Structure of the Report

1.2.1 The Report is divided into five sections as follows:

(a) **Section 1: Introduction**

This section outlines the purpose and structure of TR3.

(b) **Section 2: Detailed Tasks of Air Ventilation Assessment**

This section introduces the detailed tasks of the AVA and briefly describes the objective of each task.

(c) **Annex A: The Site Wind Availability Testing**

The Site Wind Availability Testing is attached in Annex A of this report.

(d) **Annex B: The Expert Evaluation**

The Expert Evaluation is attached in Annex B of this report.

(e) **Annex C: The Initial Study**

The Initial Study is attached in Annex C of this report.

2. DETAILED TASKS OF AIR VENTILATION ASSESSMENT

2.1 The Site Wind Availability Testing

2.1.1 The Site Wind Availability Testing is to assess the characteristics of the wind availability of the study area. The study also identifies the number and locations of measurement point essential for the AVA.

2.1.2 The report was submitted to PlanD and CEDD on 9 July 2008. The detail of the Site Wind Availability Testing is provided in Annex A.

2.2 The Expert Evaluation

2.2.1 The Expert Evaluation is to provide a qualitative assessment on the preliminary layout plan based on the experimental site wind data.

2.2.2 The Final Expert Evaluation report was submitted to PlanD and CEDD on 25 August 2009. Detail is provided in Annex B of this report.

2.3 The Initial Study

2.3.1 The Initial Study is to assess the ventilation impacts of the proposed developments within the study sites based on the findings of the Expert Evaluation.

2.3.2 The Final Initial Study was circulated to the Working Group Members on 30 September 2009. Detail is provided in Annex C of this report.

Annex A
Site Wind Availability Testing

EXPERIMENTAL SITE WIND AVAILABILITY STUDY FOR TUEN MUN EAST AREA, HONG KONG

INVESTIGATION REPORT WWTF011-2008

June 2008

submitted to Scott Wilson Ltd

CLP Power
Wind/Wave Tunnel Facility

The Hong Kong University
of Science and Technology

EXECUTIVE SUMMARY

At the request of Scott Wilson Ltd**,** a study of wind availability and characteristics at two locations in the Tuen Mun East Area was conducted under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology. The study was undertaken in accordance with the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2005).

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind direction, mean wind speed and turbulence intensity at two locations in the Tuen Mun East Area, in accordance with the instructions of Scott Wilson Ltd on 18 March 2008: Position 1, located in Perowne Height close to Tai Lam Country Park, and Position 2, located at the eastern side of Siu Sau Village and south-east of Position 1.

A miniature pressure probe was used to take measurements of three components of wind speed, i.e. in the longitudinal, lateral and vertical directions, at 22.5º increments for the full 360º azimuth, i.e. for sixteen (16) wind directions, and at nine (9) heights to determine profiles of mean wind speed and turbulence intensity above the study area. The results will be used as input boundary conditions for subsequent detailed air ventilation assessment (AVA) studies. The 1:2000 scale topographical model included the surrounding area up to a distance of approximately 10 km from the study area.

The topographical model study results were combined with WWTF's statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island during the period of 1953 – 2000 inclusive, to determine wind roses corresponding to annual mean wind speeds at the study area.

In general, the directional characteristics of winds at 500 m at Positions 1 and 2 are similar to those for non-typhoon winds approaching Hong Kong, with one significant yaw angle was measured at Position 1 for wind from 22.5°. At a height of 50 m above Position 1 and an elevation of 50 mPD at Position 2, winds from the north-east and north-west quadrants were significantly affected by the Tai Lam Country Park to the north of the study area, causing significant reductions in the magnitudes of mean wind speed and changes to the directional distribution in the corresponding directions. Winds approaching from southerly directions were the least affected due to the area's relatively open exposure in those directions.

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1. INTRODUCTION

At the request of Scott Wilson Ltd**,** a study of wind availability and characteristics at two locations in the Tuen Mun East Area was conducted under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST). The study was undertaken in accordance with the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2005).

There are a total of 14 study sites in the nominated Tuen Mun East Area that is bounded by the Tuen Mun River Channel and Hoi Wong Road to the west, the Tai Lam Country Park to the north, Tai Lam Chung Nullah to the east and the coast to the south, as shown in Figure 1.

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind speeds and turbulence intensities at two locations, agreed with Scott Wilson Ltd on 18 March 2008 and also indicated in Figure 1, within the Tuen Mun East Area:

- In Perowne Height (Position 1 in Figure 1); and
- At the eastern side of Siu Sau Village (Position 2 in Figure 1).

The topographical model study results were combined with WWTF's statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island during the period of 1953 – 2000 inclusive, to determine site-specific annual wind roses for hourly mean wind speeds that are intended to be used for a subsequent detailed air ventilation assessment (AVA) of the study area.

2. ANALYSIS OF THE HONG KONG WIND CLIMATE

Waglan Island, located approximately 5 km southeast of Hong Kong Island, has been used by Hong Kong Observatory (HKO), formerly The Royal Observatory, Hong Kong, for the collection of long-term wind data since December 1952. Due to its location, relative lack of development over the past 50 years and its generally uninterrupted exposure to winds, data collected at Waglan Island is considered to be representative of winds approaching the Hong Kong region and the highest quality available for all wind engineering purposes for Hong Kong. Wind speed and direction measurements at Waglan Island are essentially free from the interference effects of nearby developments that were clearly demonstrated by Melbourne (1984) in a comparison of wind speed measurements taken at both Waglan Island and Hong Kong Observatory in Tsim Sha Tsui. The study of Melbourne (1984) also demonstrated that anemometer position corrections are required to account for the effects of the location and height of an anemometer station, the surrounding topography and buildings, even for those stations that are considered suitable for wind engineering applications.

Waglan Island wind records have been analysed previously in studies of the Hong Kong wind climate, most notably by Davenport et al. (1984), Melbourne (1984) and Hitchcock et al. (2003). Melbourne (1984) conducted wind tunnel model studies to determine directional factors relating wind speeds at each anemometer location to the wind speed at a height equivalent to 50 m in the freestream flow and concluded that:

- Measurements taken during the period 1 January 1964 to 11 July 1966 inclusive were directly and adversely affected by the effects of building on which it was mounted; therefore, records from that period were excluded from that study.

- The anemometer correction factors for mean wind speeds show some sensitivity to the modelled approach flow but they are not strongly dependent on the modelled approach profiles.
- The largest magnitude speed-up effects occur for winds approaching from approximately 67.5°, 180°, 270° and 360°.
- The largest magnitude slow-down effects occur for winds approaching from approximately 112.5°, 225° and 315°.

In the study conducted by Hitchcock et al. (2003), wind tunnel tests were undertaken to correct wind records for position and topographical effects at the four anemometer locations used since 1952, with the exception of the location used during the period 1 January 1964 to 11 July 1966 inclusive. In that study, thermal (hotwire) anemometer measurements were taken at 22.5° intervals for the full 360° azimuth relating wind speeds at anemometer height to wind speeds at a height equivalent to 200 m in the freestream. The directional characteristics of the former anemometer sites were found to be similar to those discussed by Davenport et al. (1984) and Melbourne (1984), whereas the current anemometer site is much less affected than its predecessors, due mainly to its additional height.

Correction factors were determined and subsequently applied to non-typhoon wind data collected at Waglan Island to determine a probability distribution of directional mean wind speeds for Hong Kong. The annual wind rose for mean wind speeds at a height equivalent to 500 m above Waglan Island is presented in Figure 2 and indicates that, on an annual basis, prevailing and strong non-typhoon winds approaching Hong Kong occur mainly from the north-east quadrant and, to a lesser extent, the south-west.

In Figure 2, mean wind speeds are divided into four categories (0 – 3.3 m/s, 3.4 – 7.9 m/s, 8.0 – 13.8 m/s and greater than 13.8 m/s) that are indicated by the thickness of the bars for the 16 cardinal wind directions. The length of the bars indicates the average percentage of occurrence per year. For example, Figure 2 illustrates that, on an annual basis, east winds occur approximately 24% of the time and hourly mean wind speeds exceed 13.8 m/s approximately 6% of the time at a height of 500 m.

3. WIND TUNNEL STUDY

The wind tunnel test techniques used in this investigation were consistent with the procedures and recommendations of the Australasian Wind Engineering Society Quality Assurance Manual, AWES QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). Those requirements cover the satisfactory modelling of the turbulent natural wind, the accuracy of the wind tunnel models, experimental and analysis procedures and quality assurance.

3.1 Modelling the Natural Wind

Air moving relative to the Earth's surface has frictional forces imparted on it, which effectively cause it to be slowed down. These forces have a decreasing effect on air flow as the height above ground increases, generally resulting in mean wind speed increasing with height to a point where the effects of surface drag become negligible. In wind engineering, a convenient measure of the thickness of the atmospheric boundary layer is commonly referred to as the gradient height which will vary depending on the surrounding surface roughness over which the air will flow. Obstacles to air flow can vary from relatively large expanses of smooth, open water, to vegetation such as forests, built-up environments such as city centres, and large, rugged mountain ranges. The resulting gradient heights typically vary from several hundred metres to in excess of 1000 m.

Winds within the atmospheric boundary layer are also usually highly turbulent or gusty. Turbulence intensity is a measure of the gustiness of wind due to eddies and vortices generated by frictional effects at surface level, the roughness of the terrain over which air is flowing and convective effects due to opposing movements of air masses of different temperature. In typical atmospheric boundary layer flow, turbulence intensity generally decreases with height. Closer to the ground, at pedestrian level for example, the magnitude of the turbulence intensity can be very large due to the effects of wind flowing around buildings and other structures.

In conducting wind tunnel model studies of wind characteristics and wind effects on and around tall buildings and other structures on the surface of the Earth, it is necessary to adequately simulate the atmospheric boundary layer. WWTF's boundary layer wind tunnel test sections can be used to simulate atmospheric boundary layer flow over various types of terrain, ranging from open terrain, such as open water, to urban or mountainous terrain.

WWTF comprises two long fetch boundary layer wind tunnel test sections as shown in Figure 3. The 28 m long high speed test section has a 3 m wide × 2 m high working section and a maximum freestream wind speed of approximately 30 m/s. The 40 m long low speed test section has a 5 m wide × 4 m high working section and a maximum freestream wind speed of approximately 10 m/s. Various terrain simulations can be modelled in either test section at length scales ranging from approximately 1:5000 to 1:50.

The wind in the low speed test section of the WWTF can be modified through the use of devices such as spires, grids, and fences to model different scale atmospheric boundary layer flows. For the current study, WWTF's low speed test section was calibrated, by using appropriate combinations of roughness elements, to simulate the characteristics of winds approaching Hong Kong through mean wind speed and turbulence intensity profiles corresponding to wind flowing over open water. The mean wind speed profile of the wind flow approaching the study area was simulated in accordance with the power law expression, defined in Equation (1), specified in Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005).

$$\frac{\bar{u}(z)}{\bar{u}_{ref}} = \left(\frac{z}{z_{ref}}\right)^{\alpha} \qquad (1)$$

where:

$\bar{u}(z)$ = mean wind speed at a height z (m/s);

$\bar{u}_{ref}$ = mean wind speed at a suitable reference height (m/s);

z = height above zero plane displacement height (m);

z_{ref} = a suitable reference height (m);

α = a power law exponent, which is a constant commensurate with the terrain roughness, taken as approximately 0.15 for this study.

The turbulence intensity profile of the approaching wind flow was simulated in accordance with Terrain category 2 stipulated in Australian/New Zealand Standard AS/NZS 1170.2:2002, i.e. corresponding to non-typhoon wind flow above rough open water surfaces.

The simulated mean wind speed and turbulence intensity profiles were generally within ±10% of the target mean speed and turbulence intensity profiles defined and are presented in Figure 4. The spectrum of longitudinal turbulence of the approaching wind flow measured at a height equivalent to 500 m in prototype scale is presented in Figure 5.

3.2 Physical Model of the Study Area

WWTF has a 1:2000 scale topographical model of the New Territories, Kowloon and Hong Kong Island fabricated at 20 m contour intervals from information acquired from the HKSAR's Survey and Mapping Office, Lands Department. The relevant sections of the topographical model were updated to include all known current buildings and the major topographical features in the urban landscapes of Hong Kong Island, Kowloon Peninsula and the New Territories. For all wind directions tested, the wind tunnel model included surrounding areas within a distance of up to approximately 10 km from the study area.

The topographical model was updated to include greater detail within a zone from 1000 m up to approximately 1500 m from the measurement positions. In accordance with information supplied by Scott Wilson Ltd during a period from 4 October 2007 to 15 November 2007, all known existing and relevant future buildings and structures at the time of testing were included in the model to represent their effects on wind flow approaching the study area. Beyond the 1500 m radius, the topographical model included roughness representative of the surrounding areas. A representative view of the 1:2000 scale topographical model used in the current study is shown in Figure 6.

3.3 Experimental and Analysis Procedures

The terrain surrounding the study area comprises complex mixtures of open water, urban and built-up environment, and mountainous areas in the New Territories and Kowloon Peninsula. Winds approaching the modelled region were scaled to simulate non-typhoon winds flowing over open water and the topographical model was used to determine the modifying effects of the surrounding complex terrain on the wind speed and turbulence intensity above the two test locations in the nominated study area.

Position 1 was located in the vicinity of the mountainous region in Tai Lam Country Park. The mountainous topography around Position 1 was included in the topography study, but all buildings within a radius of 1 km were removed from the topographical model as their effects will be directly accounted for by their inclusion in the later more detailed 1:400 scale AVA studies.

Position 2 was located at a region of less significant topography. When wind speed measurements were taken at Position 2, all buildings and topography within a radius of 1000 m were removed from the topographical model for all measured wind directions. All buildings and topography within the radius of 1000 m will be included in the proximity model for the more detailed 1:400 scale AVA studies to be conducted later, to directly account for their effects on the wind flow around Position 2.

Wind tunnel measurements were taken at each test location using a miniature dynamic pressure probe, a Cobra probe manufactured by Turbulent Flow Instrumentation Pty Ltd, at 22.5° intervals for the full 360° azimuth (i.e. 16 wind directions, θ), where a wind direction of 0° or 360° corresponds to an incident wind approaching the study area directly from the north, 90° corresponds to an incident wind approaching the study area directly from the east, etc. For each wind direction tested, mean wind speeds and turbulence intensities were measured at heights equivalent to 25, 50, 75, 100, 150, 200, 300, 400 and 500 m at prototype scale above the local ground level of Position 1 (i.e. approximately 40 mPD) and at 25, 50, 75, 100, 150, 200, 300, 400 and 500 m at prototype scale above Hong Kong Principal Datum at Position 2.

4. EXPERIMENTAL RESULTS AND DISCUSSION

For each wind direction tested, the results of the 1:2000 scale topography study for Positions 1 and 2 are presented in graphical format in Figures 7 to 22 and Figures 23 to 38, respectively and in tabular format in Appendices A and B, respectively. In Figures 7a to 38a, the normalised wind characteristics include mean wind speed profiles and turbulence intensity profiles. Mean wind speed profiles were determined by normalising the local mean wind speeds with respect to the mean wind speed of the approaching wind flow measured at a height equivalent to 500 m, as defined in Equation (2). Vertical profiles of turbulence intensity, defined in Equation (3), are also presented in Figures 7a to 38a. Yaw and pitch angles, i.e. the lateral and vertical deviations respectively, of the local mean wind direction relative to the approaching mean wind direction, are presented in Figures 7b to 38b inclusive. The sign conventions used to define yaw angles and pitch angles are provided in Appendix C.

The profiles of longitudinal mean wind speed and turbulence intensity will be used as input conditions for the more detailed AVA studies of the Tuen Mun East Area.

$$\text{normalised wind velocity} = \frac{\overline{V}_z(\theta)}{\overline{V}_{500,\text{approach}}(\theta)} \qquad (2)$$

$$\text{turbulence intensity} = \frac{\sigma_{V,z}(\theta)}{\overline{V}_z(\theta)} \qquad (3)$$

In Equations (2) and (3):

$\overline{V}_z(\theta)$ = mean wind speed at a height z (z = 25, 50, 75, 100, 150, 200, 300, 400 or 500 m in prototype scale above the local ground level of Position 1 or above Hong Kong Principal

Datum for Position 2) for an approaching wind direction θ (θ = 22.5º, 45º, 67.5º, 90º, 112.5º, 135º, 157.5º, 180º, 202.5º, 225º, 247.5º, 270º, 292.5º, 315º, 337.5º or 360º);

$\overline{V}_{500,\text{approach}}(\theta)$ = mean wind speed of the approaching wind at a height equivalent to 500 m in prototype scale for an approaching wind direction θ;

$\sigma_{V,z}(\theta)$ = the standard deviation of the fluctuating wind speed V_z for an approaching wind direction θ.

Winds approaching the Tuen Mun East Area from northerly directions are affected by the hilly topography of Tai Lam Country Park and are typically characterised by relatively high turbulence intensities and significant reductions in mean wind speeds for the lower portion of the corresponding profiles. Winds approaching from southerly directions flow over Lantau Island and its two largest peaks, Lantau Peak (934 m) and Sunset Peak (869 m), and then above the fetch of open water between Lantau Island and the Tuen Mun East Area. However, as Lantau Island is further from the Tuen Mun East Area than the topography in Tai Lam Country Park, hence it has less influence on the local wind characteristics at the two test positions.

4.1 Wind Characteristics at Position 1

For Position 1, reductions in mean wind speeds and corresponding enhanced turbulence intensities were measured for winds approaching from 22.5º to 45º and 292.5º to 360º as shown in Figures 7a to 8a and 19a to 22a, respectively. For those directions, Position 1 was located downstream of the Tai Lam Country Park, with the hilly topography particularly affecting wind conditions in the lower 200 m of the measured profiles.

Relatively lower turbulence intensities and higher mean wind speeds were measured for winds approaching from 67.5º to 270º, as indicated in Figures 9a to 18a, highlighting the influence of the open water fetch between Lantau Island and the Tuen Mun East Area.

The topographical model study measurements were also used to determine directional factors for the 16 measured wind directions, relating the mean wind speeds at heights equivalent to 50 m and 500 m above the study area to the mean wind speed of the approach flow at a reference height of 500 m. These directional factors were then applied to WWTF's Hong Kong non-typhoon wind climate model, derived from HKO's Waglan Island wind data as discussed in Section 2 of this report, to determine site-specific wind roses pertaining to annual hourly mean wind speeds at heights of 50 m and 500 m above Position 1. The annual wind roses are presented in Figures 39 and 40 for heights of 50 m and 500 m above Position 1 (i.e. approximately 90 mPD and 540 mPD) of the Tuen Mun East Area, respectively.

The measured wind speeds at a height of 500 m above Position 1 were within ±10 % of the approaching mean wind speed at a height of 500 m for all measured wind directions except 360° and 22.5°. Furthermore, a significant yaw angle was measured for a wind direction of 22.5º at a height of 500 m above the local ground level of Position 1. These effects are reflected in the wind rose presented in Figure 40 in which the directional characteristics for wind directions of 360° and 22.5° are significantly different to those of the annual wind rose for Waglan Island presented in Figure 2.

The annual wind rose corresponding to a height of 50 m above the local ground level of Position 1 of the Tuen Mun East Area presented in Figure 39 demonstrates further reductions in the overall magnitudes of wind speed with respect to reference wind speeds of the approach flow at a height of 500 m. Significant yaw angles were also measured for winds approaching from 315º, 337.5º and 360º, resulting in significant changes to the directional distribution of the wind rose at 50 m presented in Figure 39.

4.2 Wind Characteristics at Position 2

For Position 2, high turbulence intensities and reductions in mean wind speeds were measured for winds approaching from 22.5º and 292.5º to 360º, as shown in Figures 23a and 35a to 38a, respectively. For those directions, Position 2 was located downstream of the hilly terrain in Tai Lam Country Park which enhanced the turbulence intensities, particularly in the lower 200 m of the measured wind profiles.

Relatively lower turbulence intensities and higher mean wind speeds were measured for winds approaching from 45º to 270º, as indicated in Figures 24a to 34a, highlighting the effects of the fetch of open water between Lantau Island and the Tuen Mun East Area on winds from those directions.

A comparison of the annual wind rose for Waglan Island presented in Figure 2 to that for Position 2 of the Tuen Mun East Area at a height of 500 mPD in Figure 42 illustrates that the measured wind speeds for all measured wind directions, except 337.5°, were within ±10% of the approaching mean wind speed at a height of 500 m. No significant yaw angles were measured at a height of 500 mPD.

In contrast, the annual wind rose corresponding to height of 50 mPD above Position 2, presented in Figure 41, indicates both significant reductions in the overall magnitudes of wind speed with respect to those at a height of 500 m and significant changes of directional distributions for winds approaching from 112.5º and 337.5º.

5. CONCLUSIONS

A study of wind availability and characteristics of the Tuen Mun East Area was conducted by the CLP Power Wind/Wave Tunnel Facility at The Hong Kong University of Science and Technology under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" administered by Scott Wilson Ltd.

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind speeds and turbulence intensities above the study area. The topography study results were subsequently combined with a statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island, to determine directional wind characteristics and availability at two test positions in the Tuen Mun East Area.

In general, the annual prevailing wind characteristics corresponding to strong non-typhoon winds at a height of 500 m above the Tuen Mun East Area were similar to the overall characteristics of non-typhoon winds approaching the Hong Kong region, although a significant yaw angle was measured for wind approaching from 22.5° for Position 1. At a height of 50 m, winds from directions of 315° to 360° for Position 1 and winds from directions of 112.5° and 337.5° for Position 2 were significantly affected by the surrounding topography, causing significant changes to the wind roses at that height. Significant reductions in the measured magnitudes of wind speed are believed to be caused by the hilly topography of Tai Lam Country Park to the north of the Tuen Mun East Area. Winds approaching from southerly directions were the least affected due to the area's relatively open exposure in those directions.

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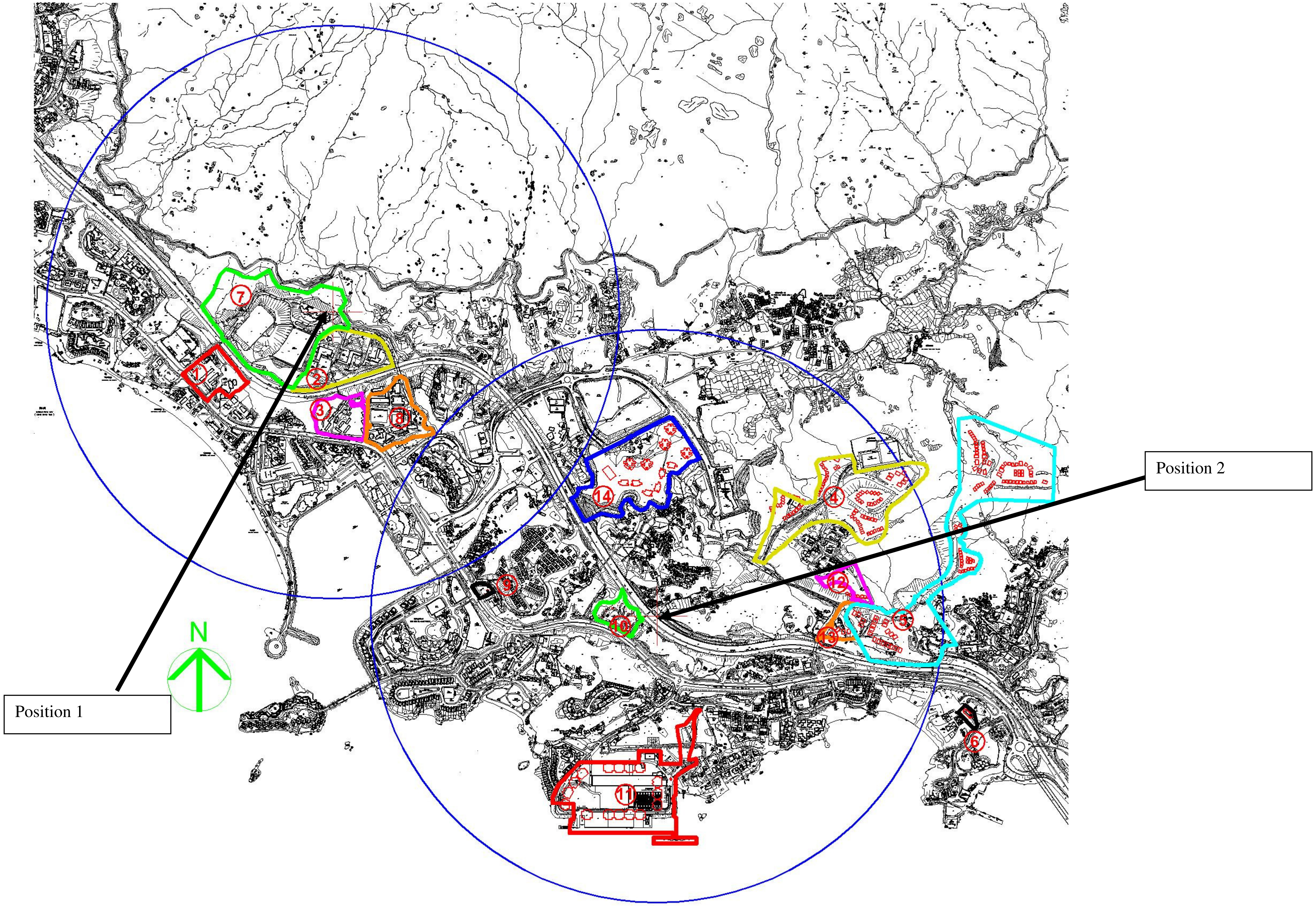

Figure 1: Tuen Mun East Area

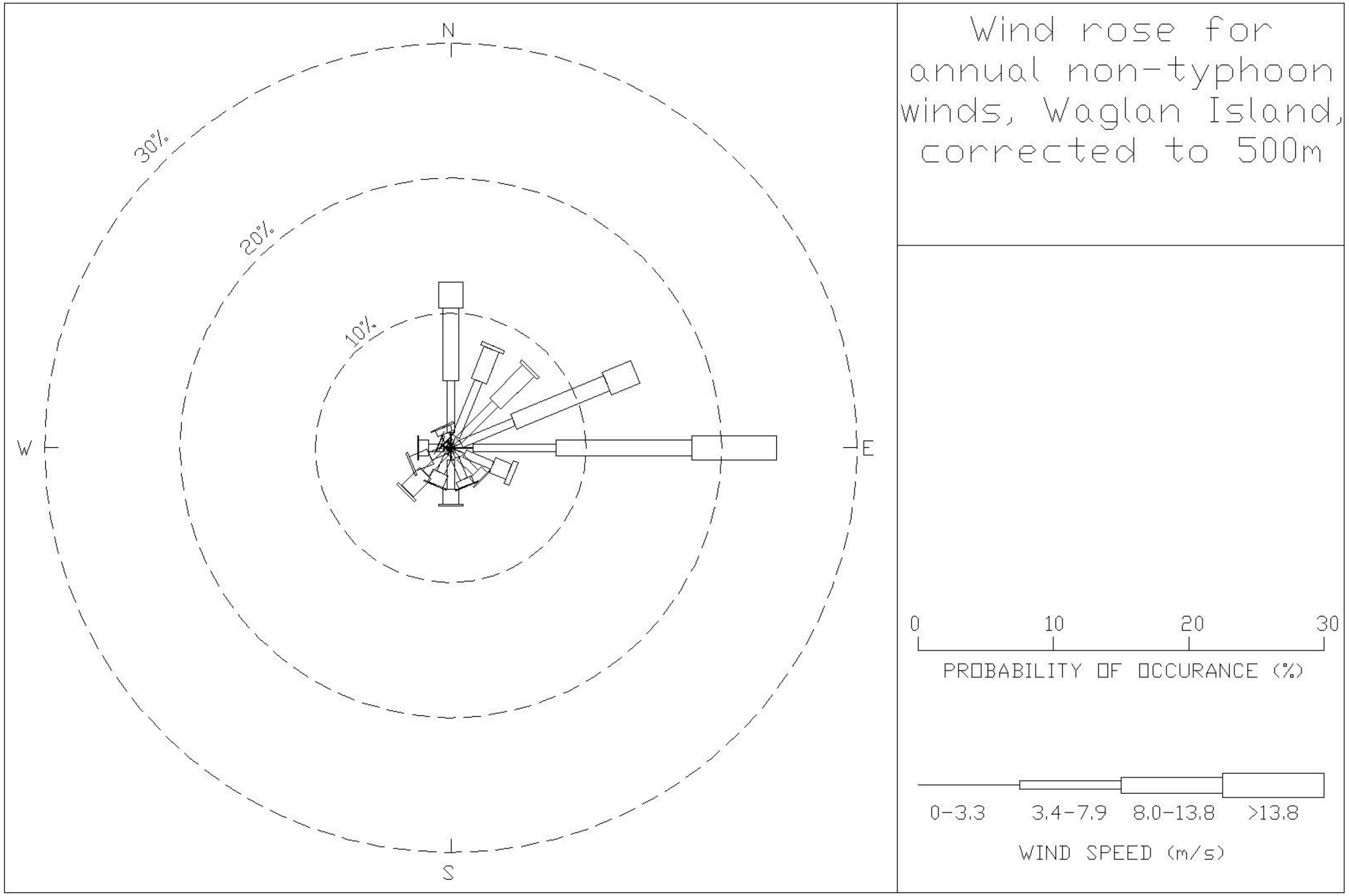

Figure 2: Wind rose for annual, non-typhoon winds, Waglan Island, corrected to 500m, 1953-2000

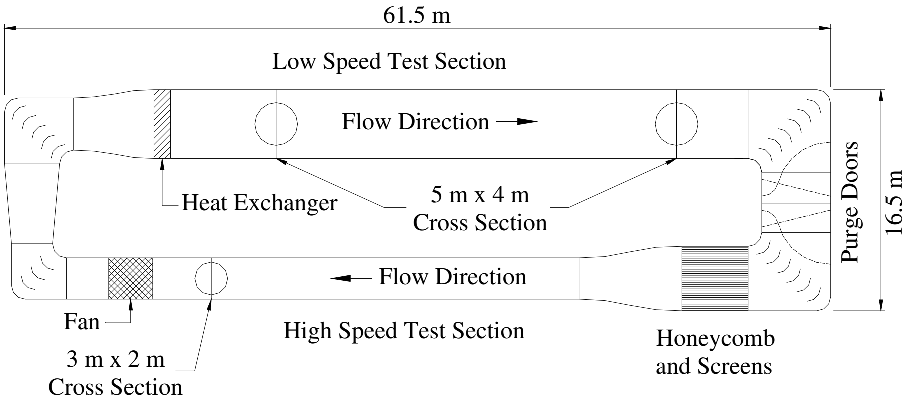

Figure 3: Test sections at the CLP Power Wind/Wave Tunnel Facility

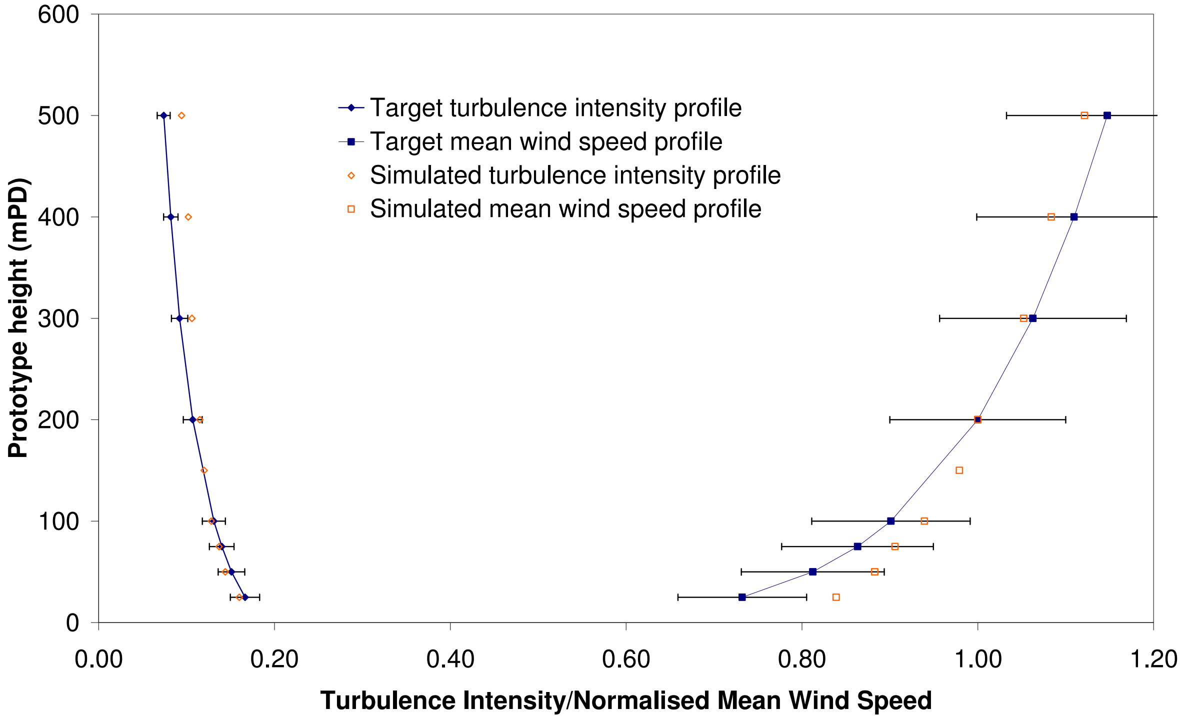

Figure 4: Simulated mean wind speed and turbulence intensity profiles – approach wind

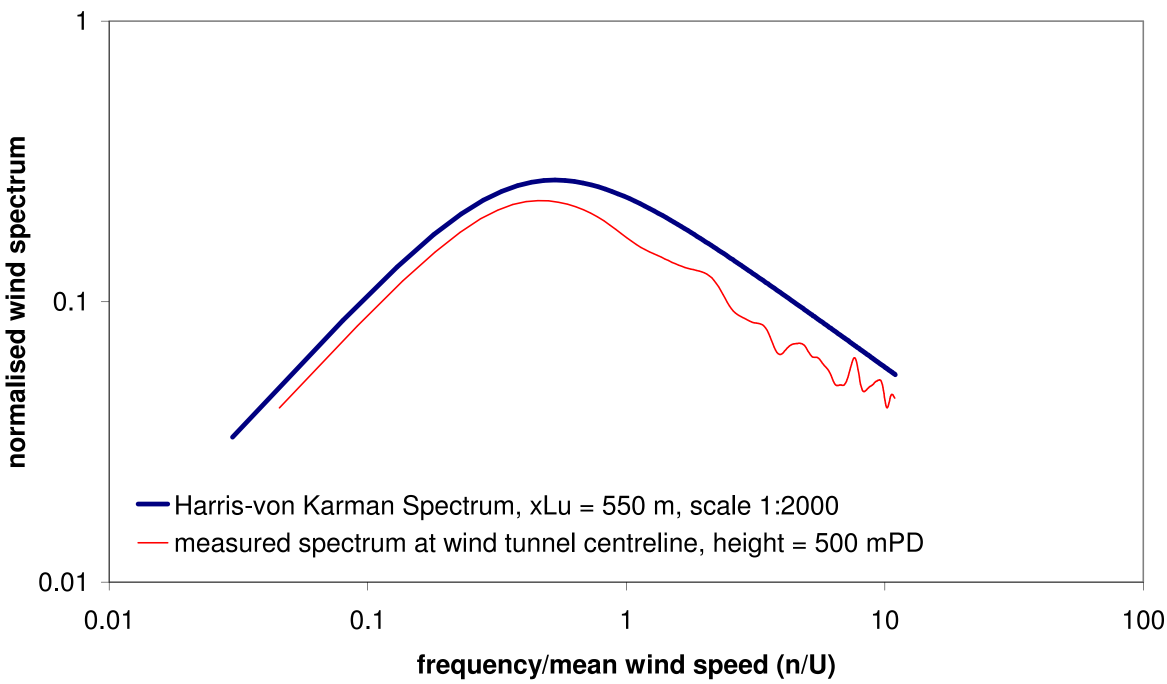

Figure 5: Longitudinal turbulence spectrum – approach wind

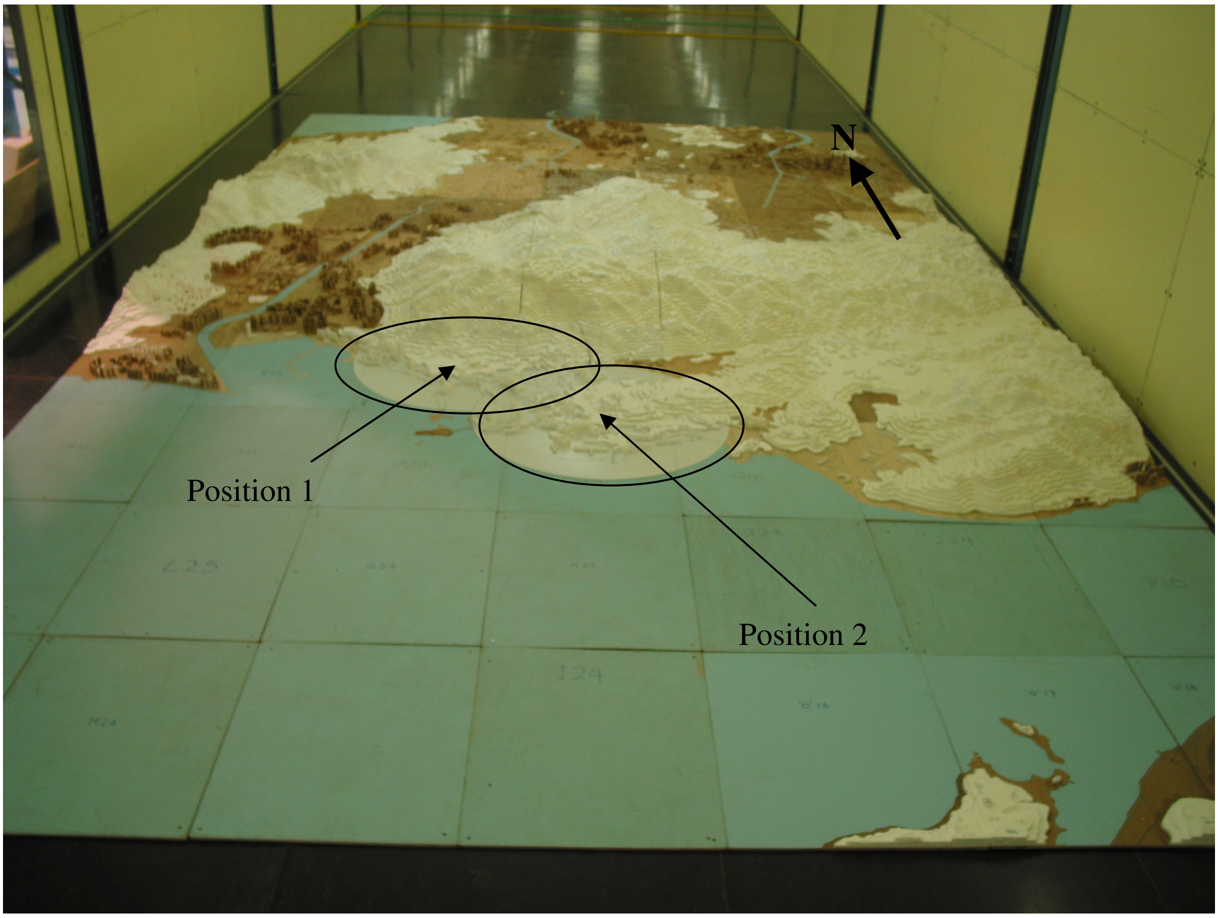

Figure 6: A 1:2000 scale topographical model of the Tuen Mun East Area, Hong Kong in the low speed test section of the CLP Power Wind/Wave Tunnel Facility

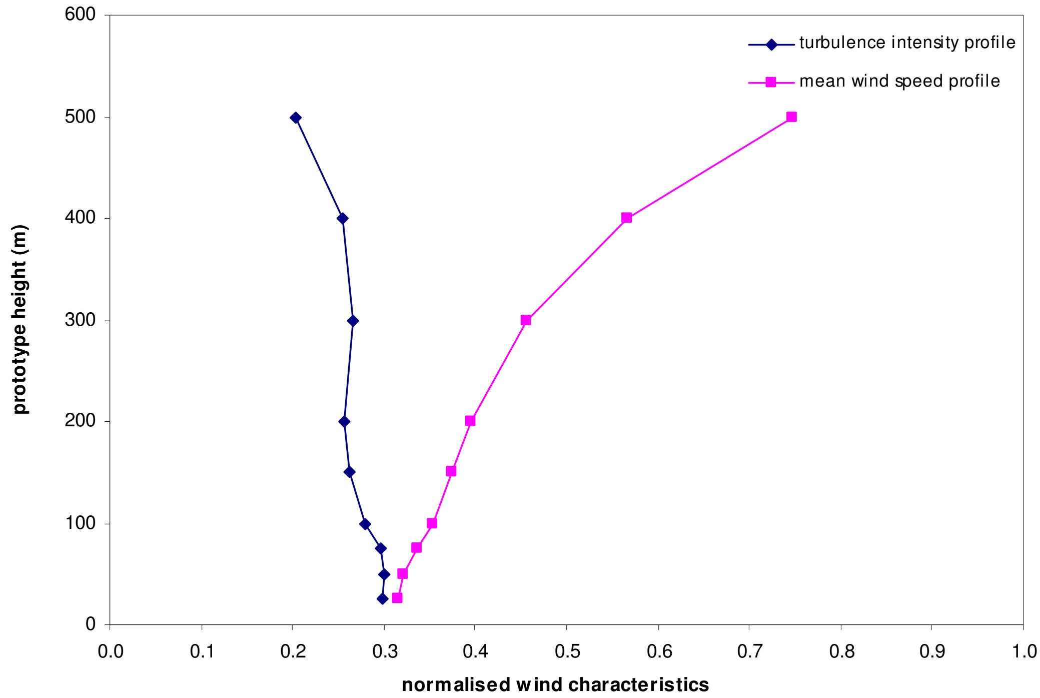

Figure 7a: Wind characteristics, Position 1, Tuen Mun East Area, 22.5°

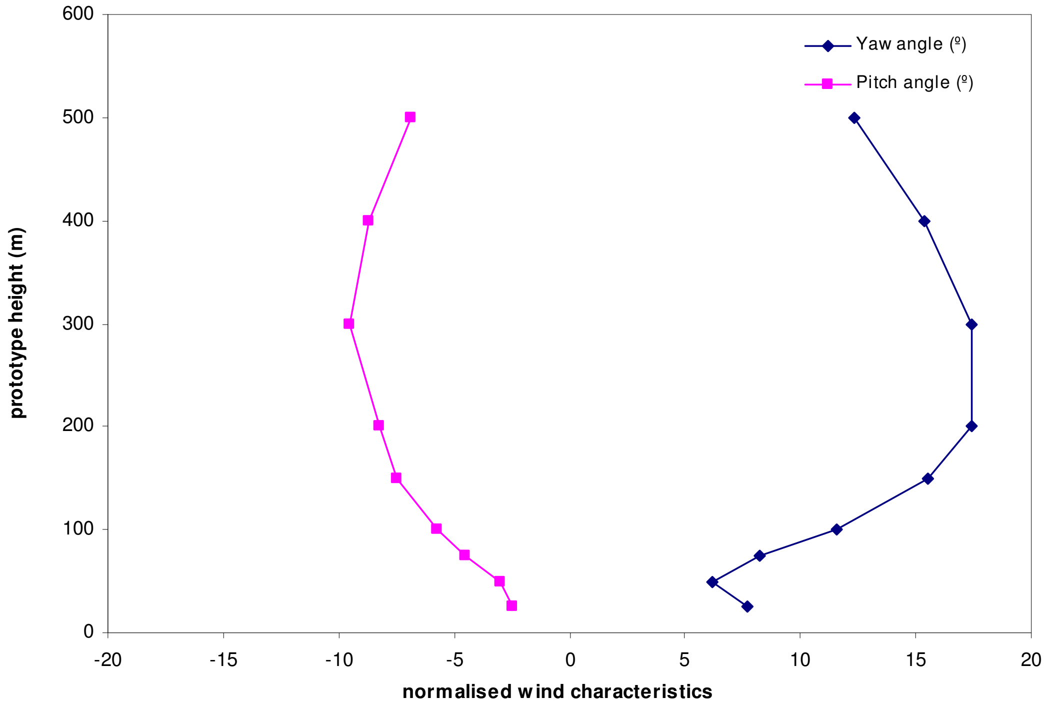

Figure 7b: Mean wind direction, Position 1, Tuen Mun East Area, 22.5°

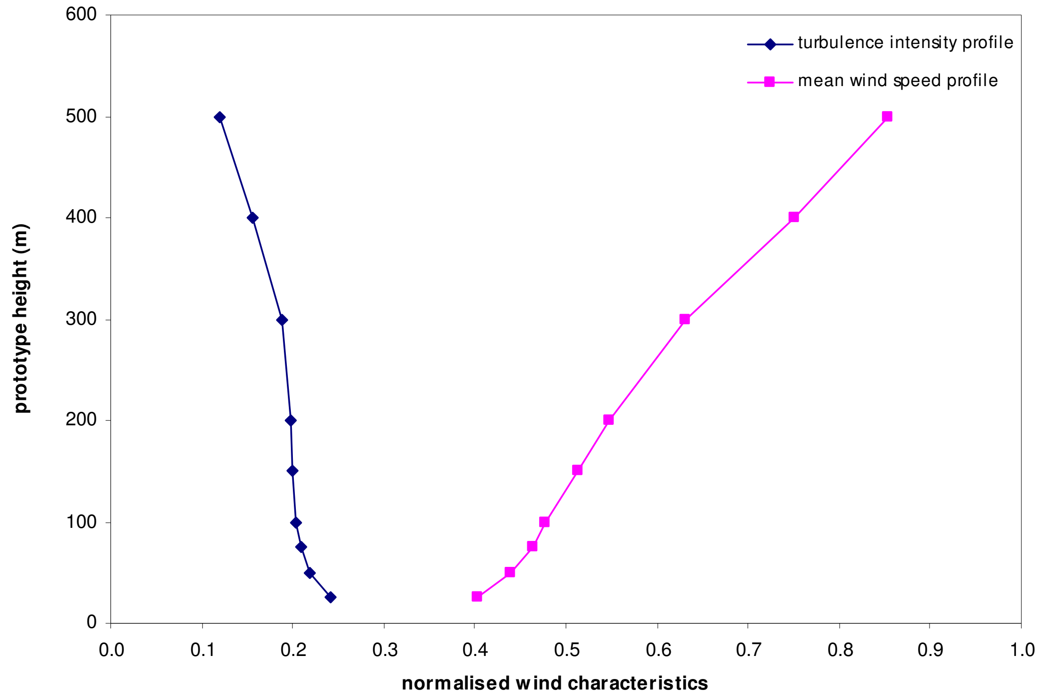

Figure 8a: Wind characteristics, Position 1, Tuen Mun East Area, 45º

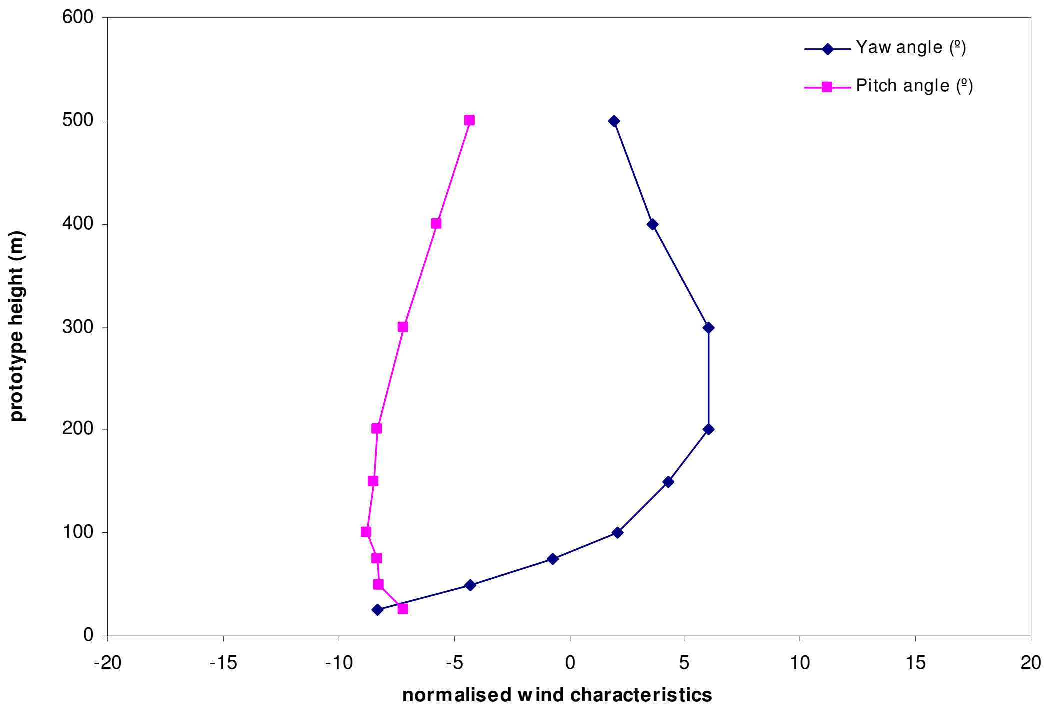

Figure 8b: Mean wind direction, Position 1, Tuen Mun East Area, 45º

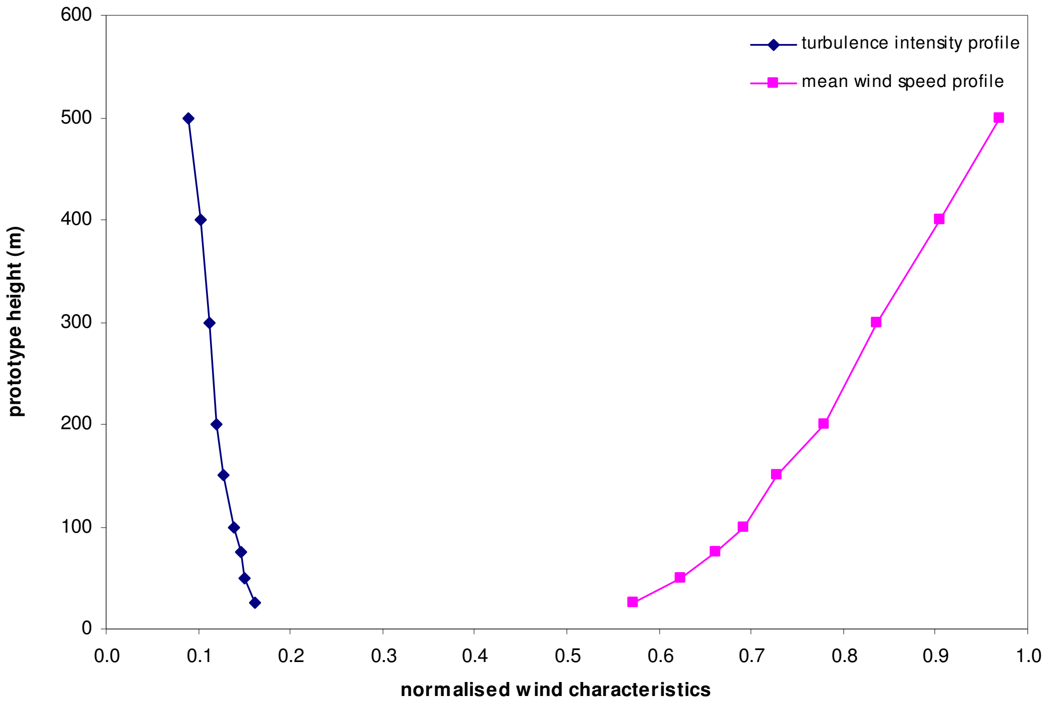

Figure 9a: Wind characteristics, Position 1, Tuen Mun East Area, 67.5º

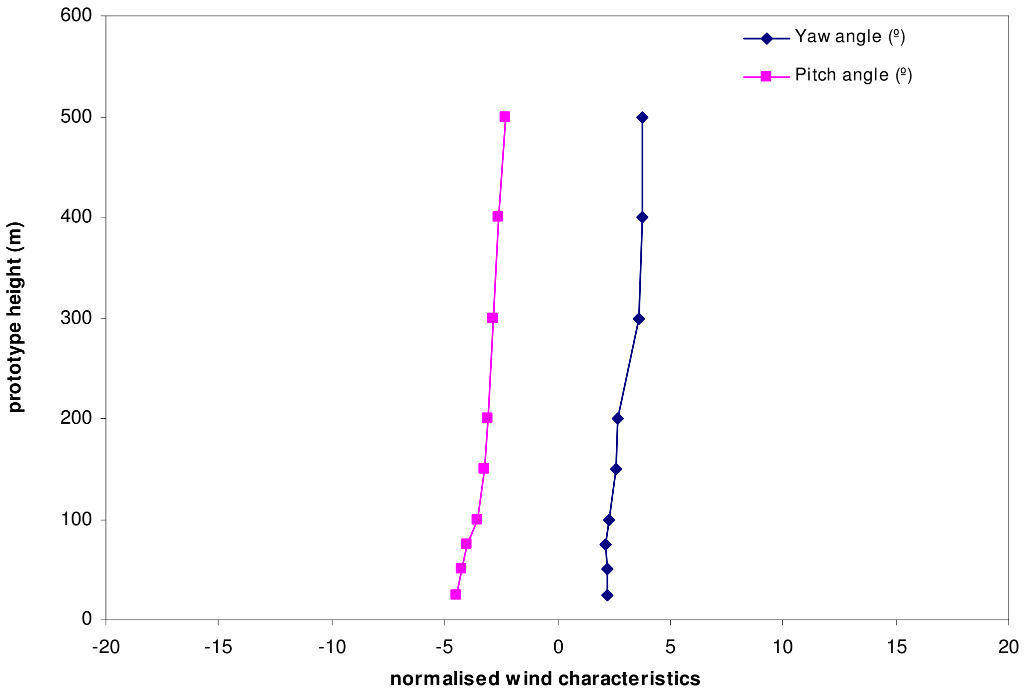

Figure 9b: Mean wind direction, Position 1, Tuen Mun East Area, 67.5º

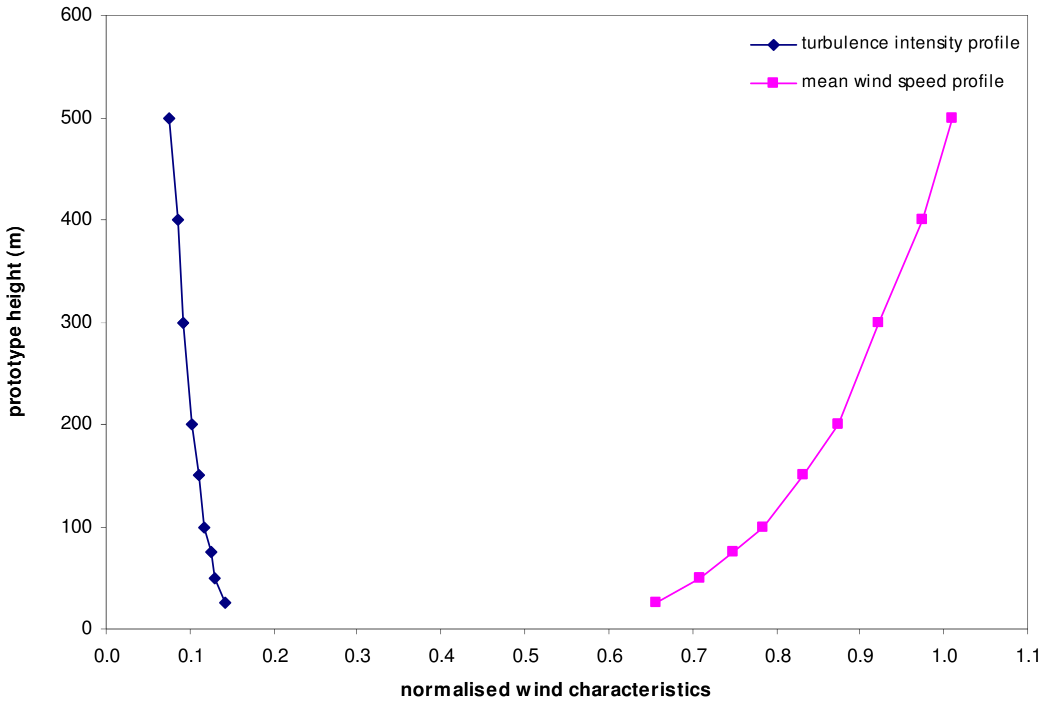

Figure 10a: Wind characteristics, Position 1, Tuen Mun East Area, 90º

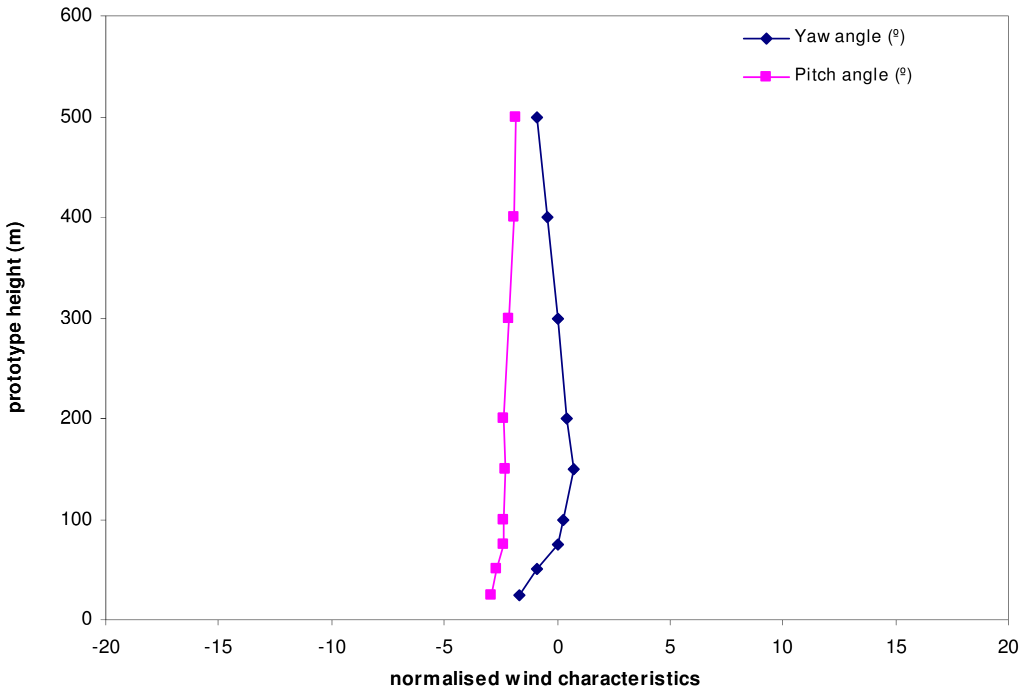

Figure 10b: Mean wind direction, Position 1, Tuen Mun East Area, 90º

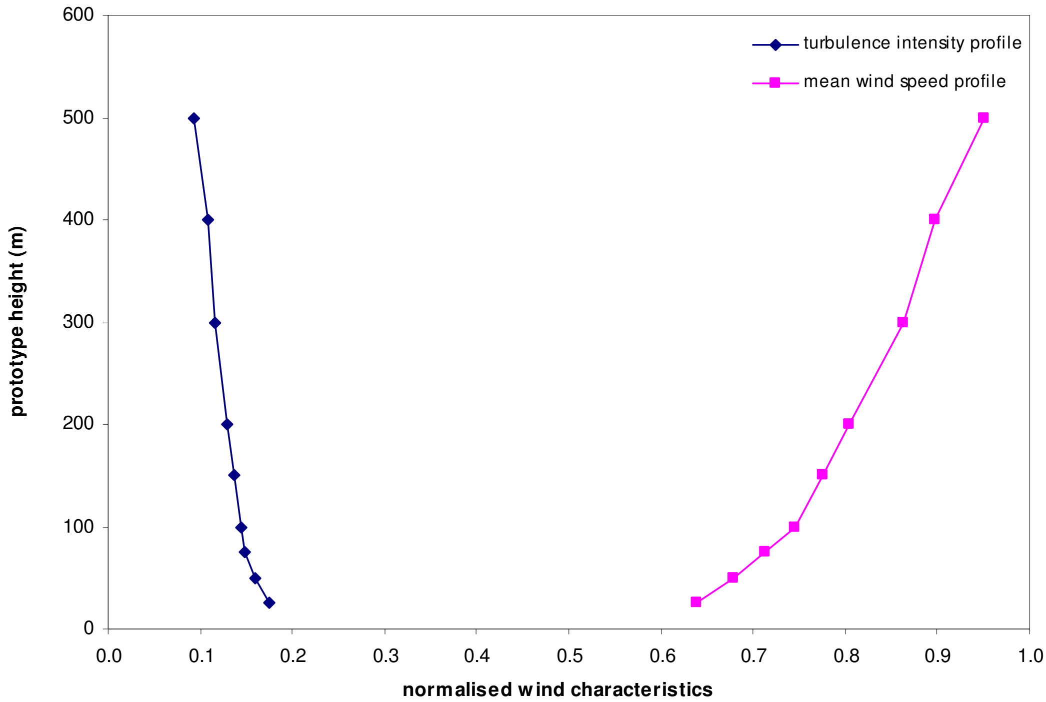

Figure 11a: Wind characteristics, Position 1, Tuen Mun East Area, 112.5º

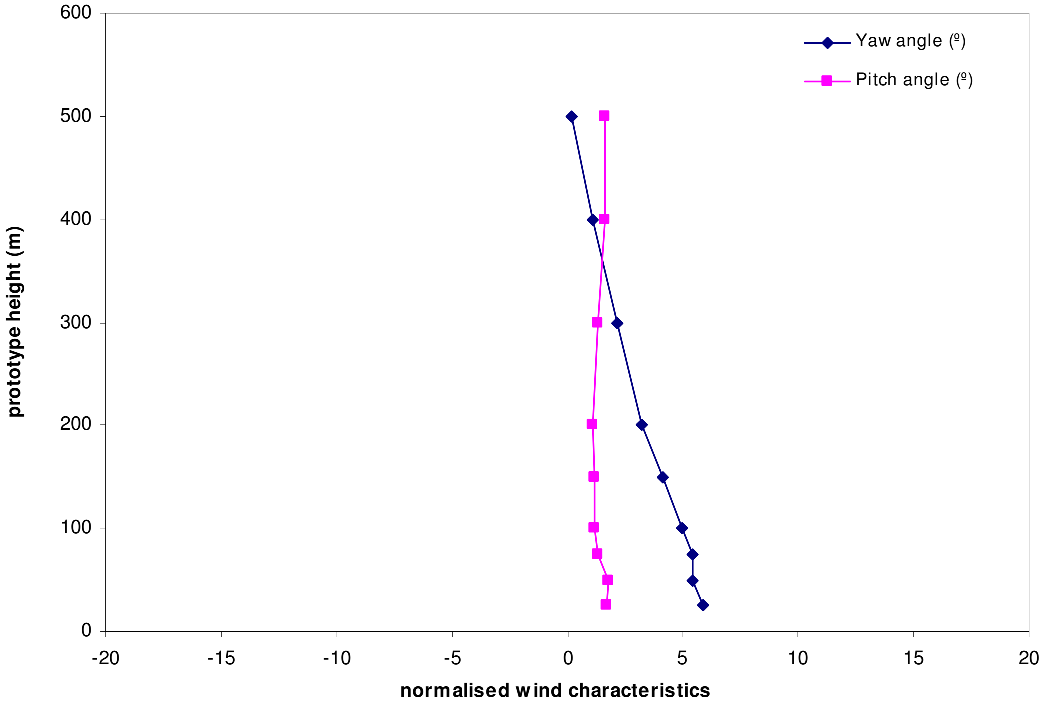

Figure 11b: Mean wind direction, Position 1, Tuen Mun East Area, 112.5º

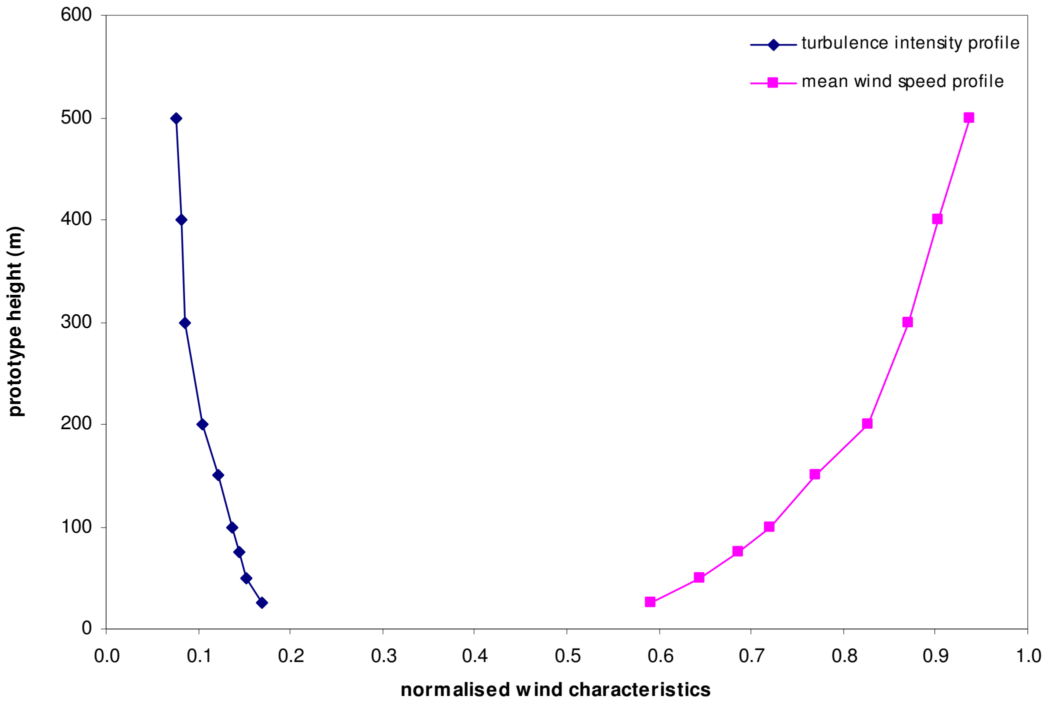

Figure 12a: Wind characteristics, Position 1, Tuen Mun East Area, 135º

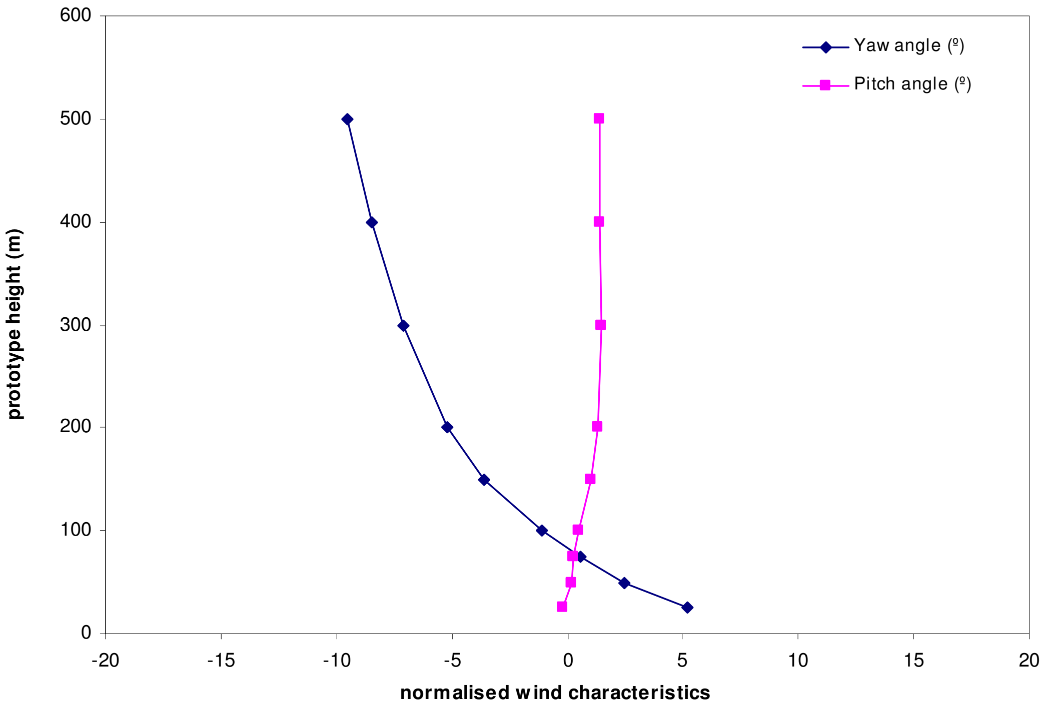

Figure 12b: Mean wind direction, Position 1, Tuen Mun East Area, 135º

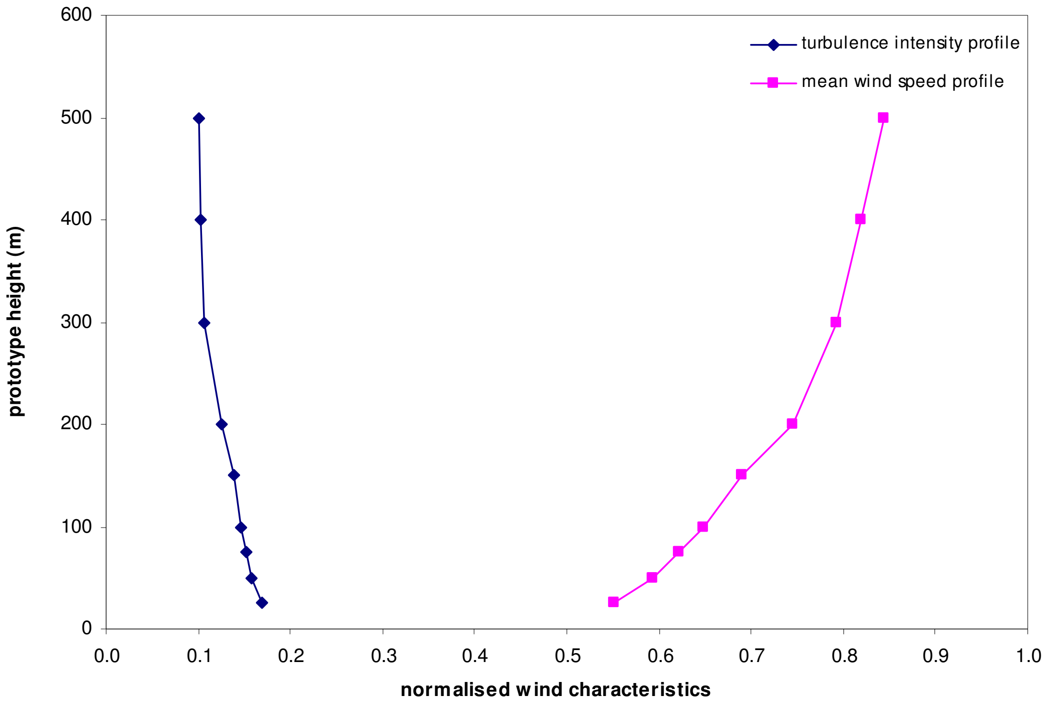

Figure 13a: Wind characteristics, Position 1, Tuen Mun East Area, 157.5º

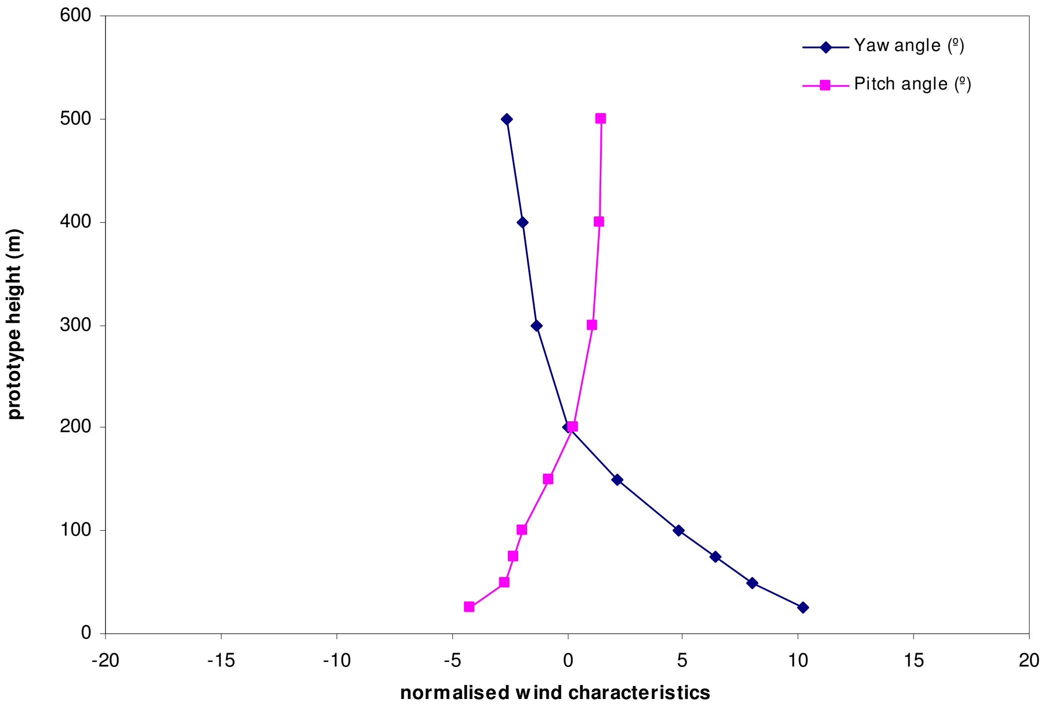

Figure 13b: Mean wind direction, Position 1, Tuen Mun East Area, 157.5º

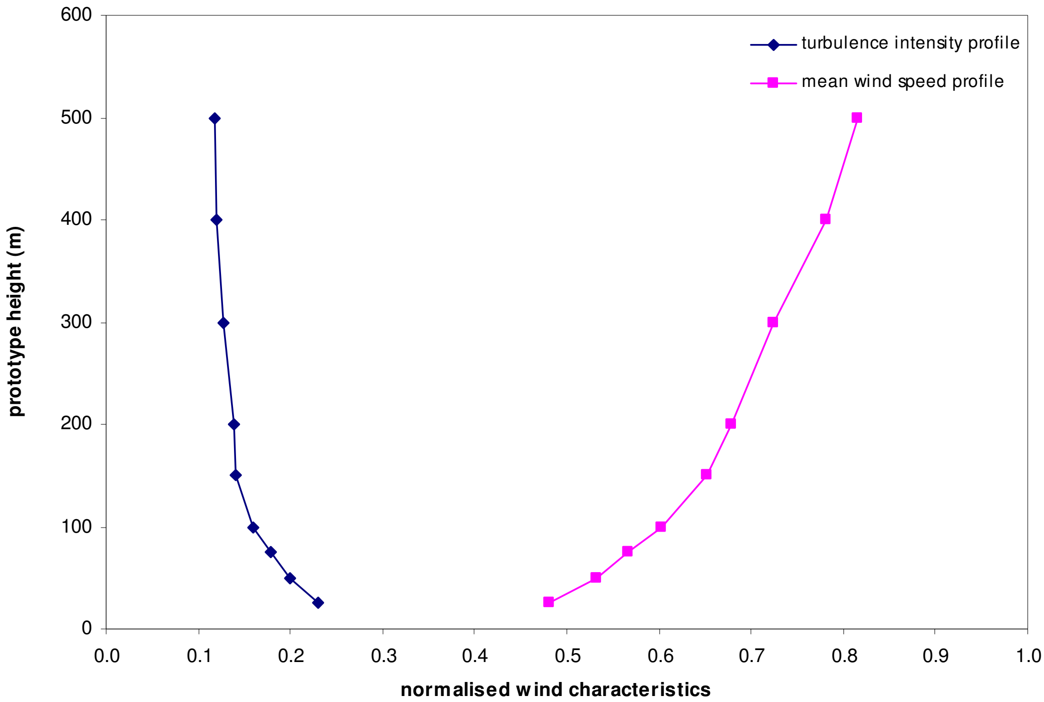

Figure 14a: Wind characteristics, Position 1, Tuen Mun East Area, 180º

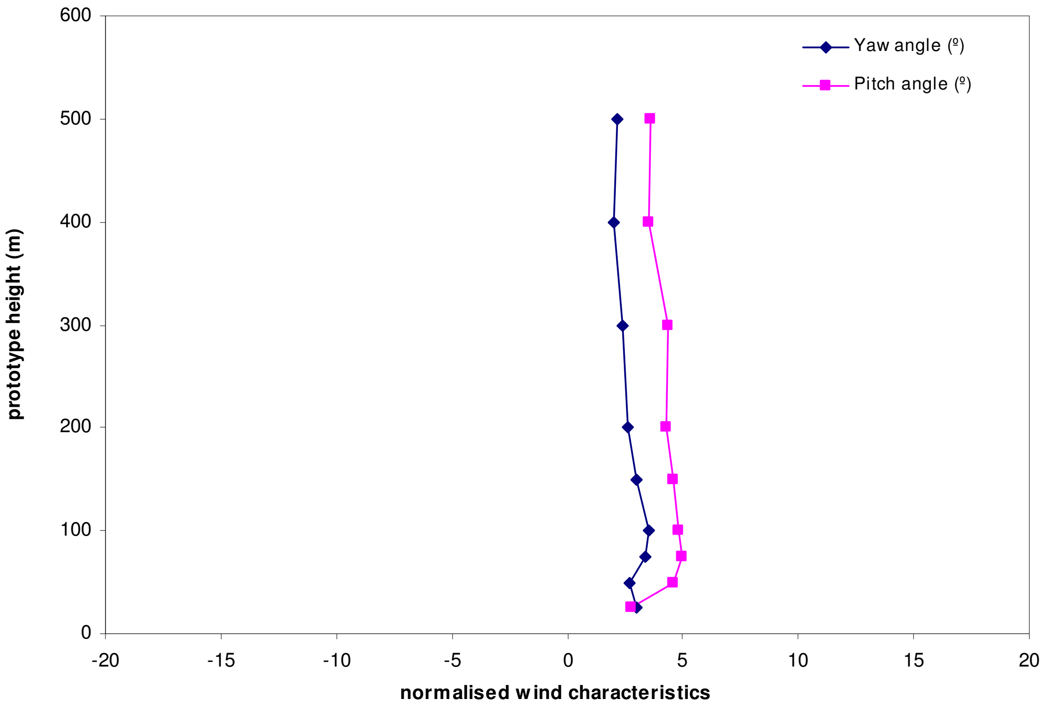

Figure 14b: Mean wind direction, Position 1, Tuen Mun East Area, 180º

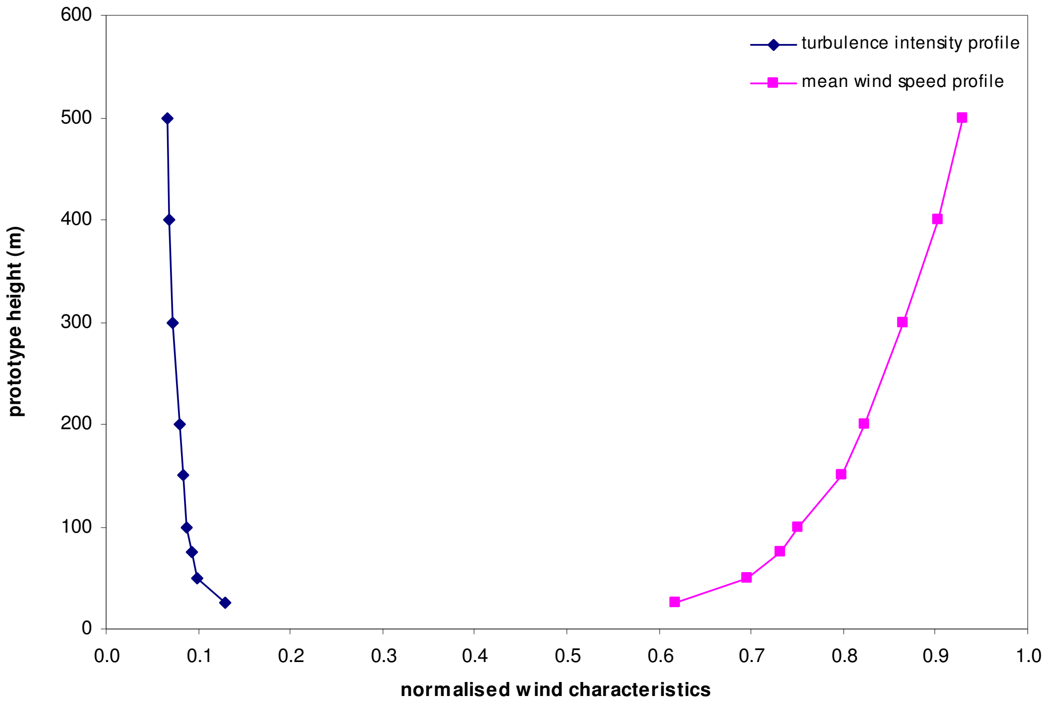

Figure 15a: Wind characteristics, Position 1, Tuen Mun East Area, 202.5º

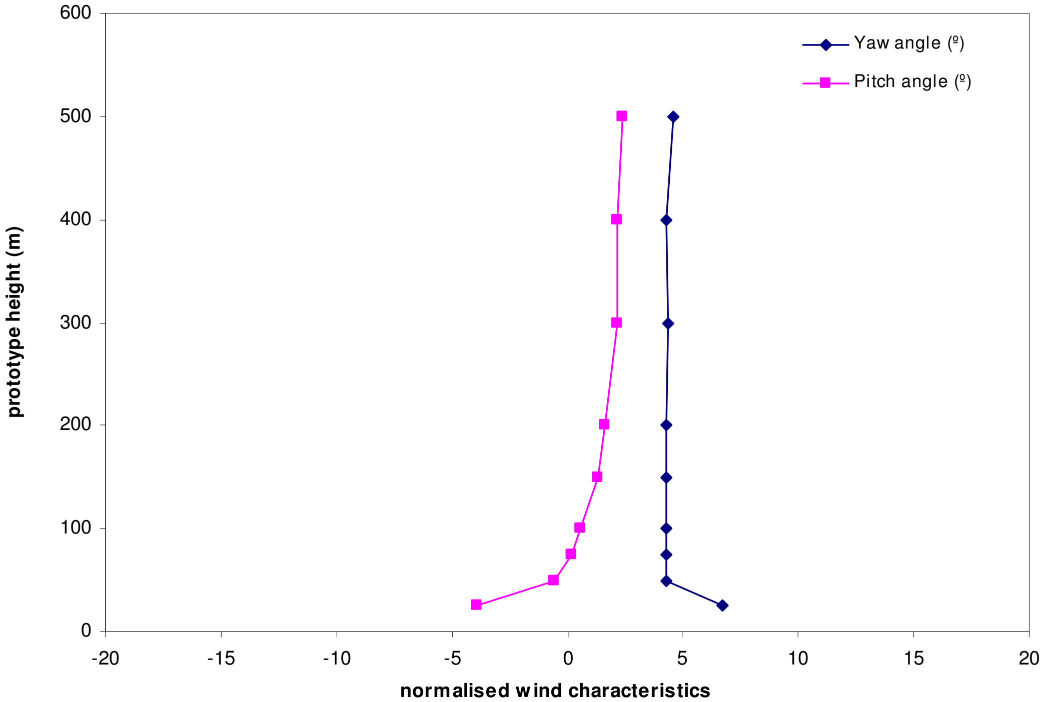

Figure 15b: Mean wind direction, Position 1, Tuen Mun East Area, 202.5º

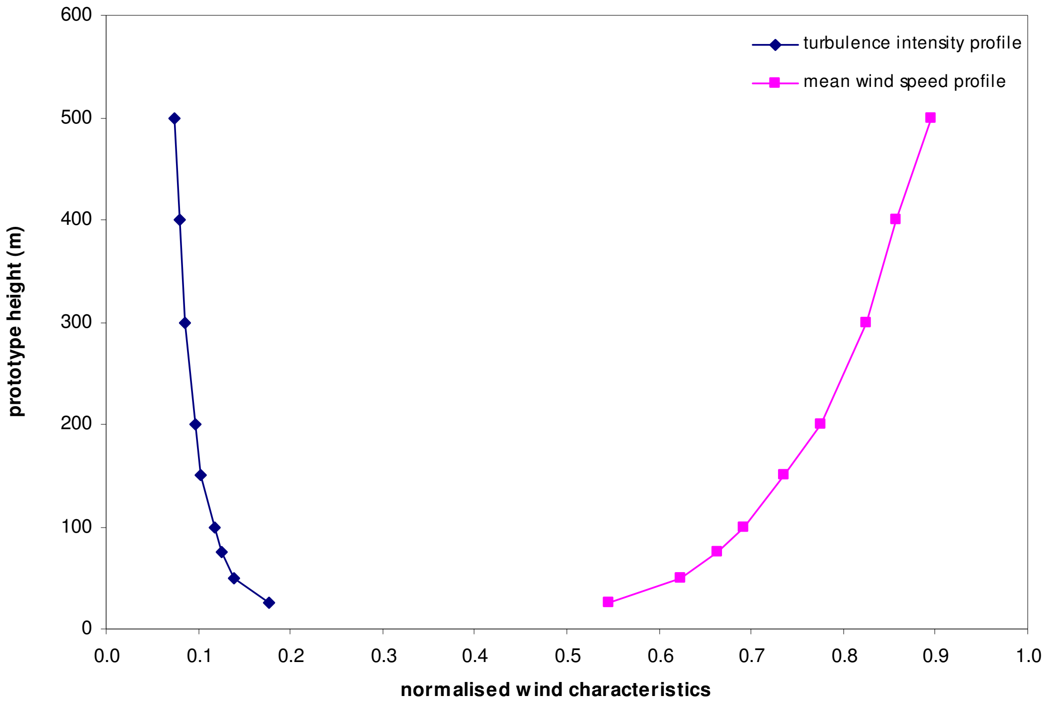

Figure 16a: Wind characteristics, Position 1, Tuen Mun East Area, 225°

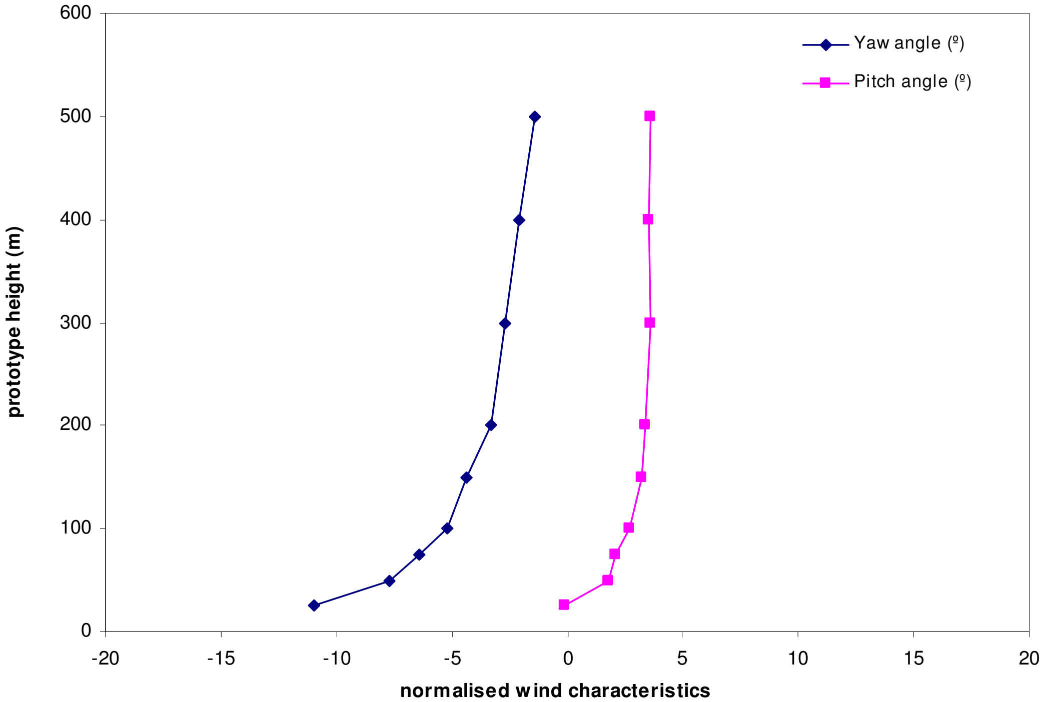

Figure 16b: Mean wind direction, Position 1, Tuen Mun East Area, 225°

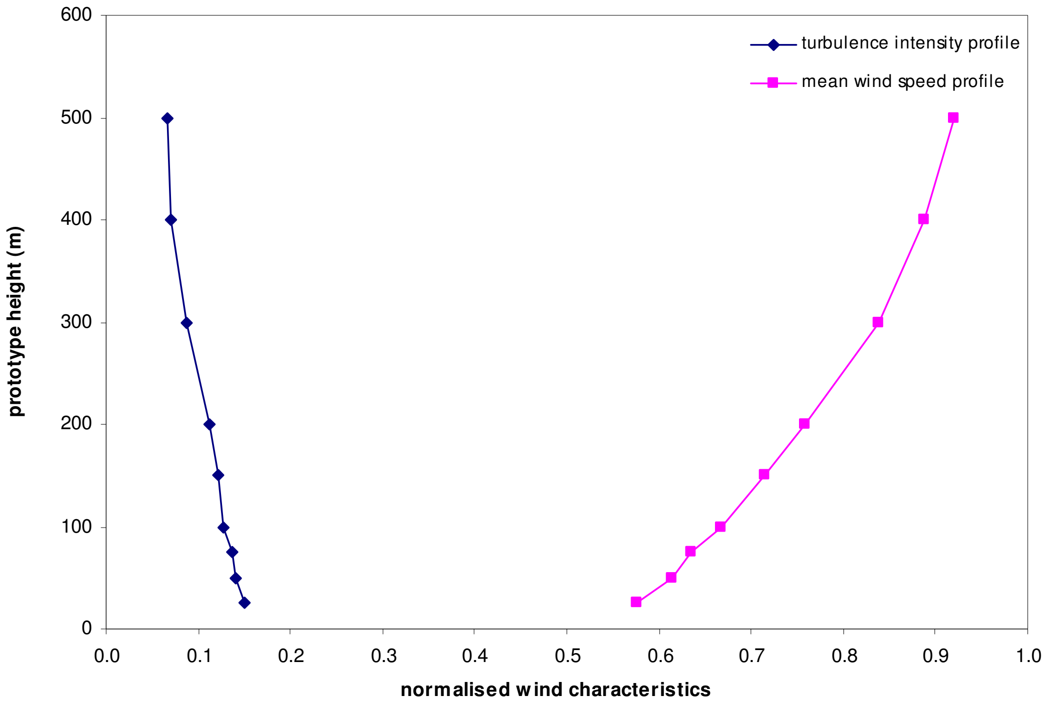

Figure 17a: Wind characteristics, Position 1, Tuen Mun East Area, 247.5º

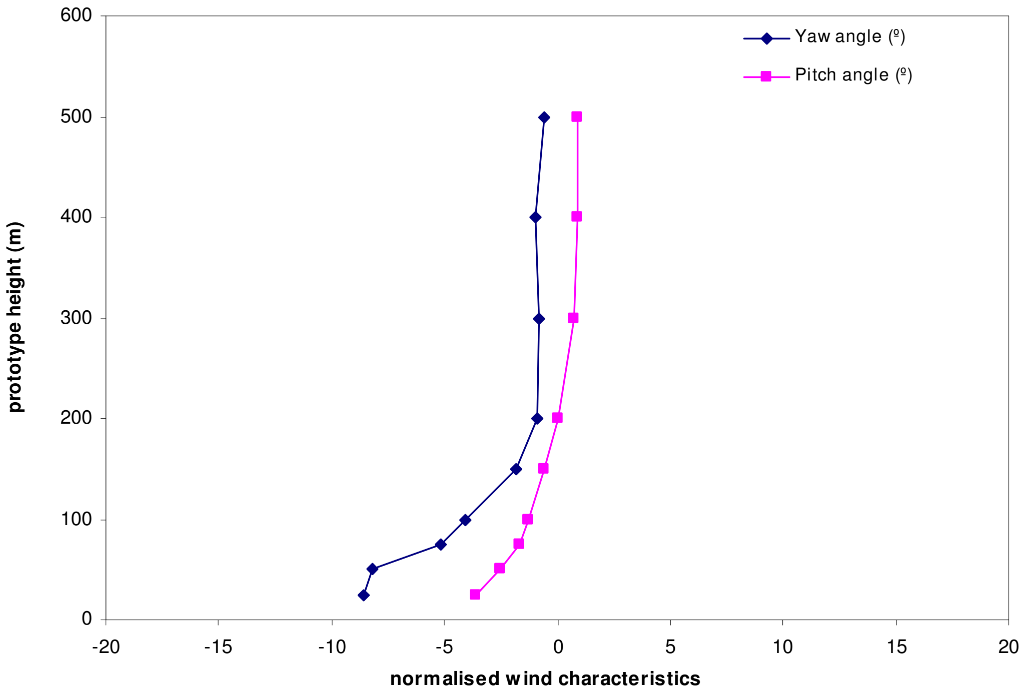

Figure 17b: Mean wind direction, Position 1, Tuen Mun East Area, 247.5º

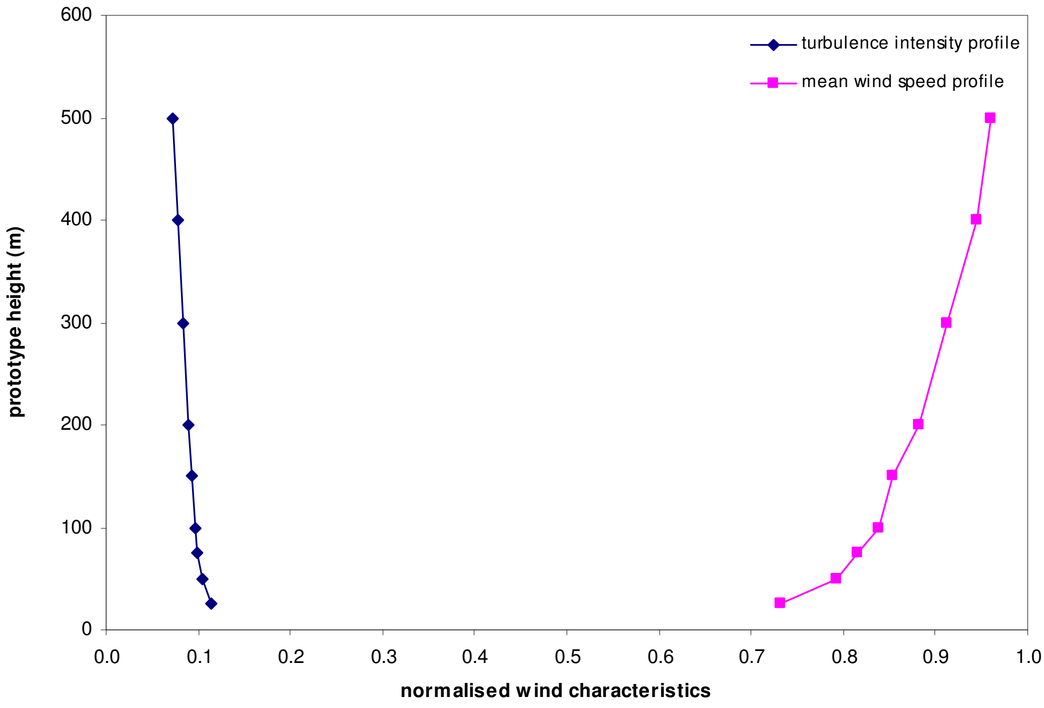

Figure 18a: Wind characteristics, Position 1, Tuen Mun East Area, 270º

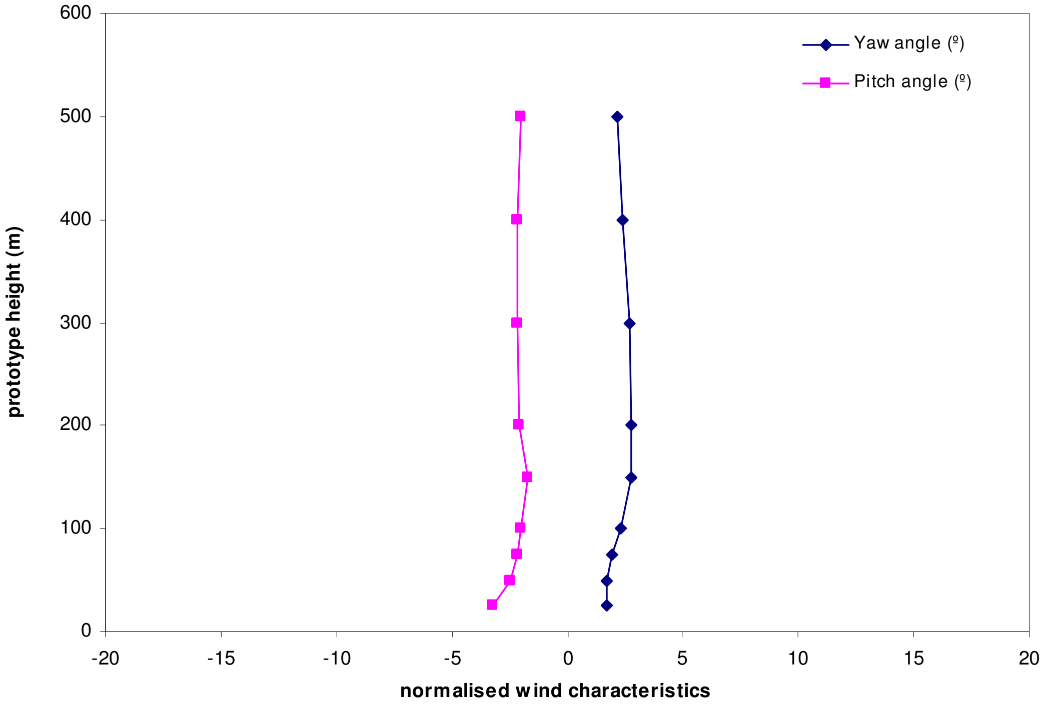

Figure 18b: Mean wind direction, Position 1, Tuen Mun East Area, 270º

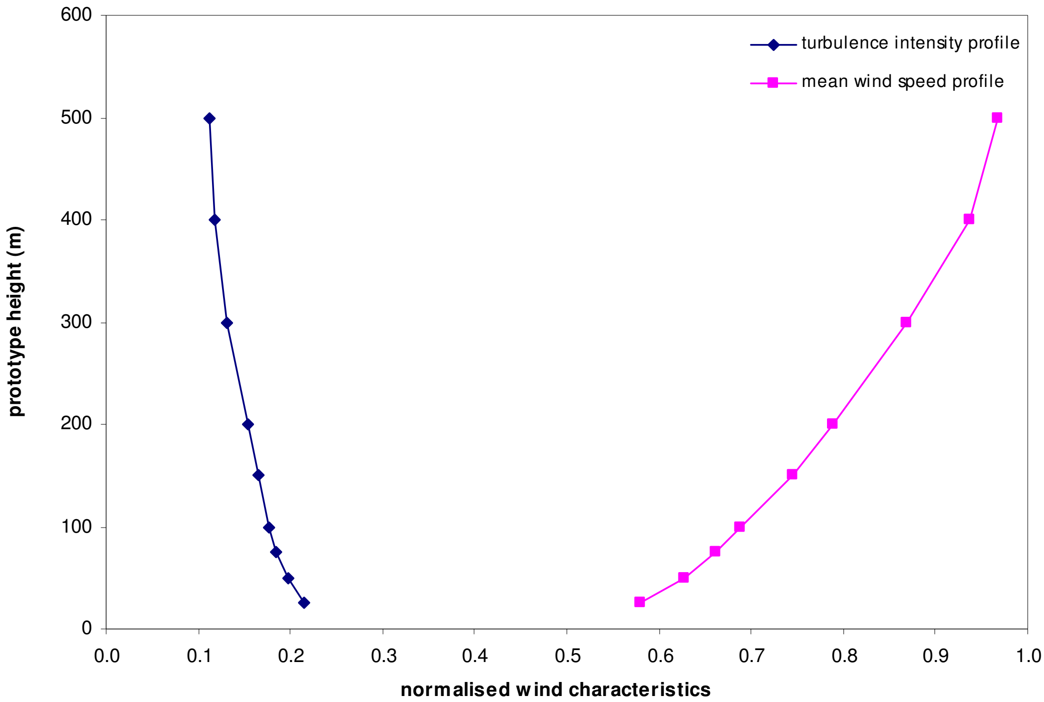

Figure 19a: Wind characteristics, Position 1, Tuen Mun East Area, 292.5º

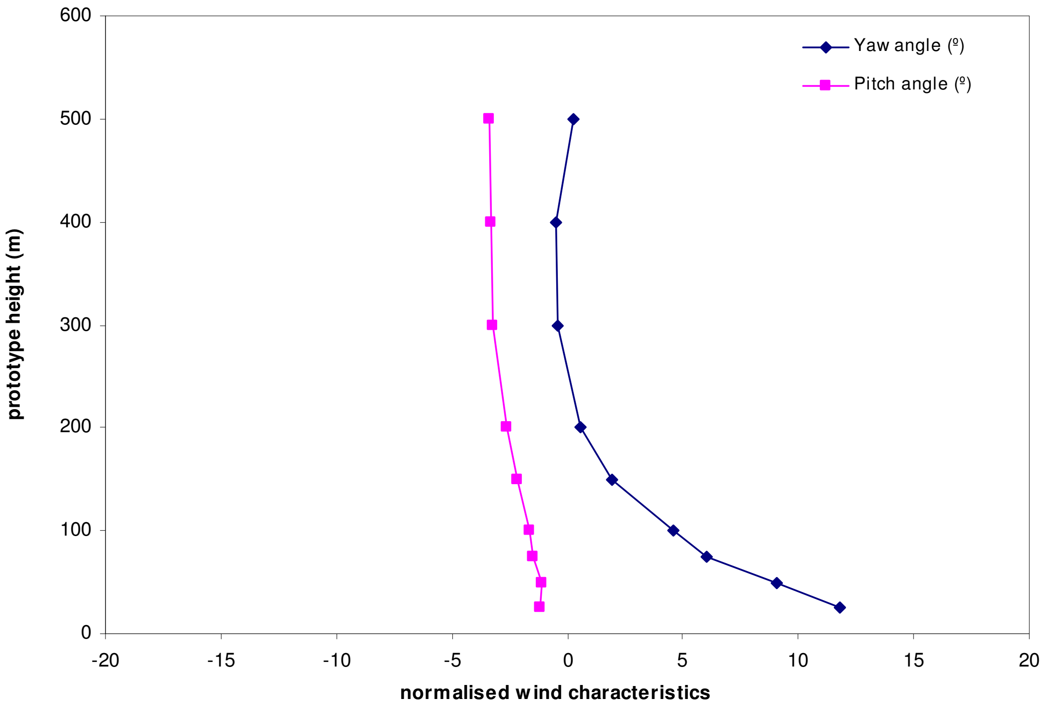

Figure 19b: Mean wind direction, Position 1, Tuen Mun East Area, 292.5º

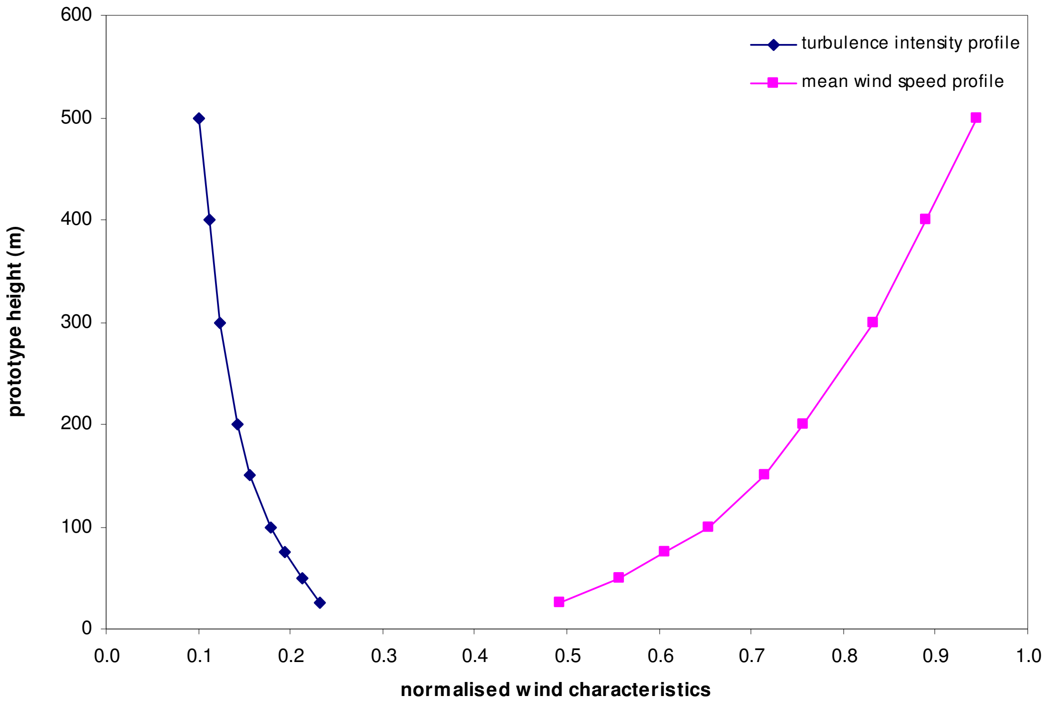

Figure 20a: Wind characteristics, Position 1, Tuen Mun East Area, 315º

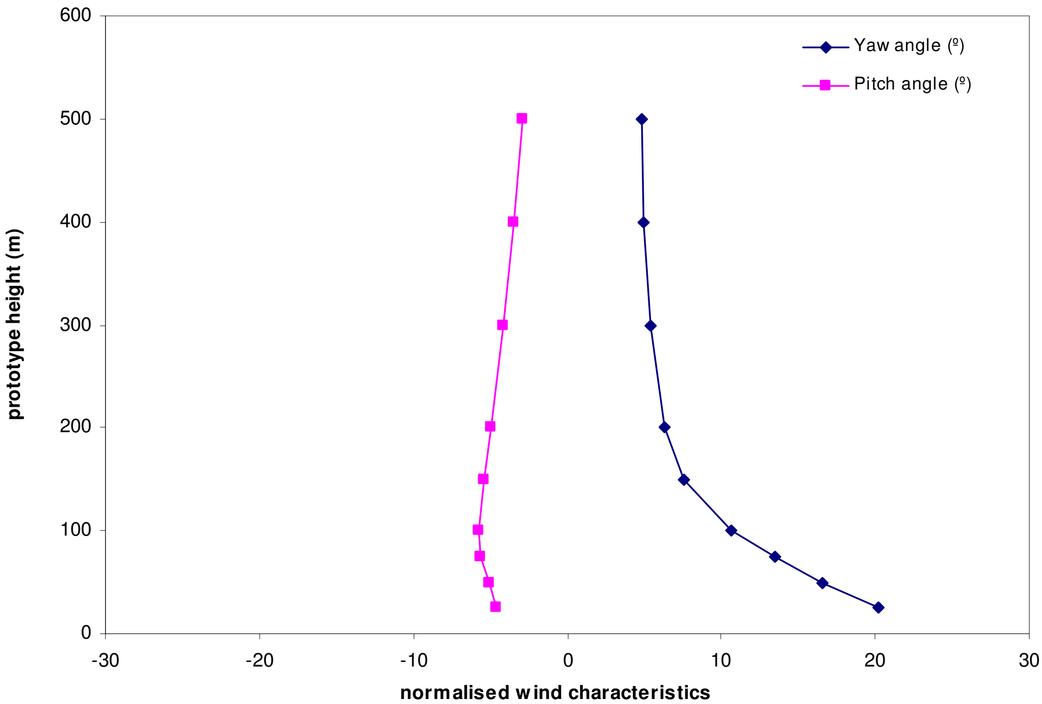

Figure 20b: Mean wind direction, Position 1, Tuen Mun East Area, 315º

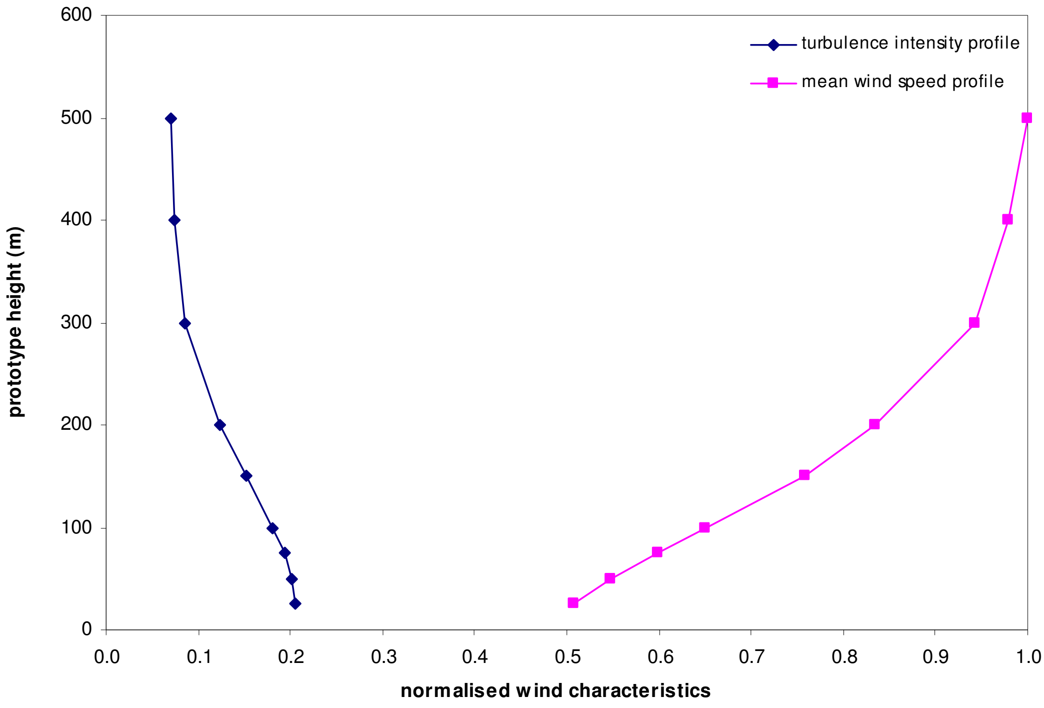

Figure 21a: Wind characteristics, Position 1, Tuen Mun East Area, 337.5º

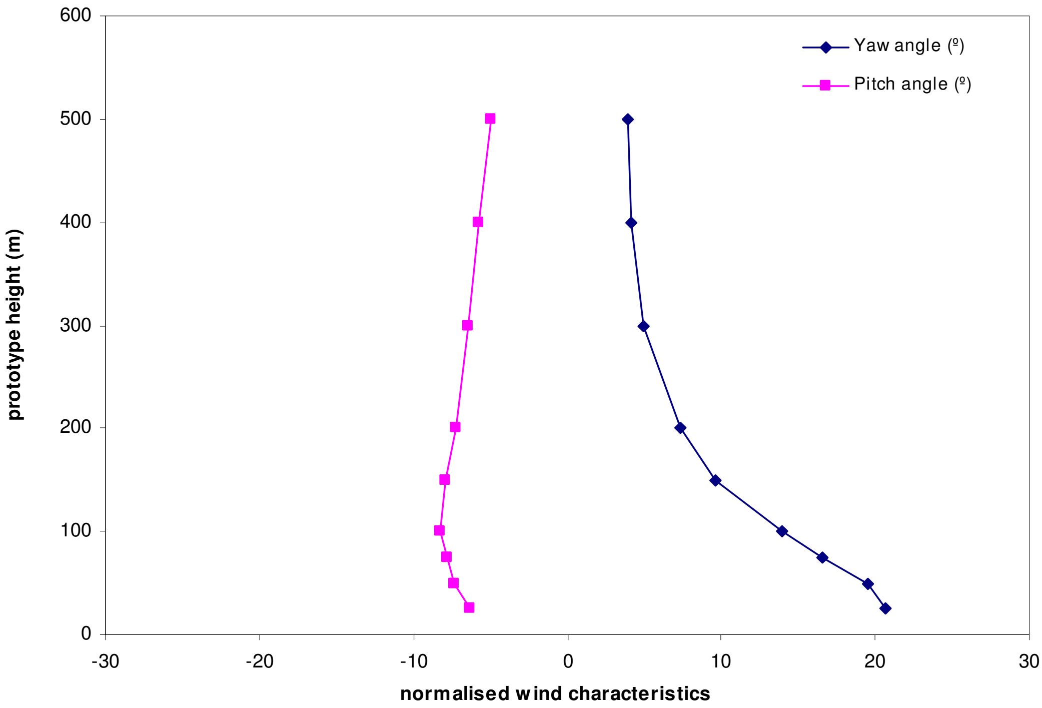

Figure 21b: Mean wind direction, Position 1, Tuen Mun East Area, 337.5º

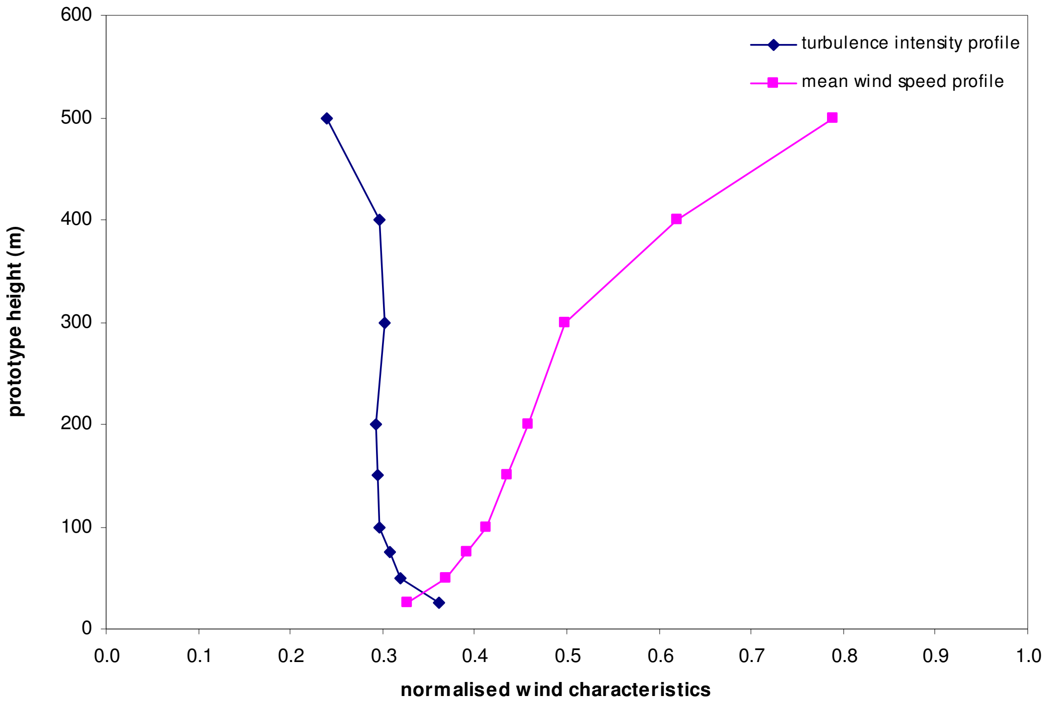

Figure 22a: Wind characteristics, Position 1, Tuen Mun East Area, 360º

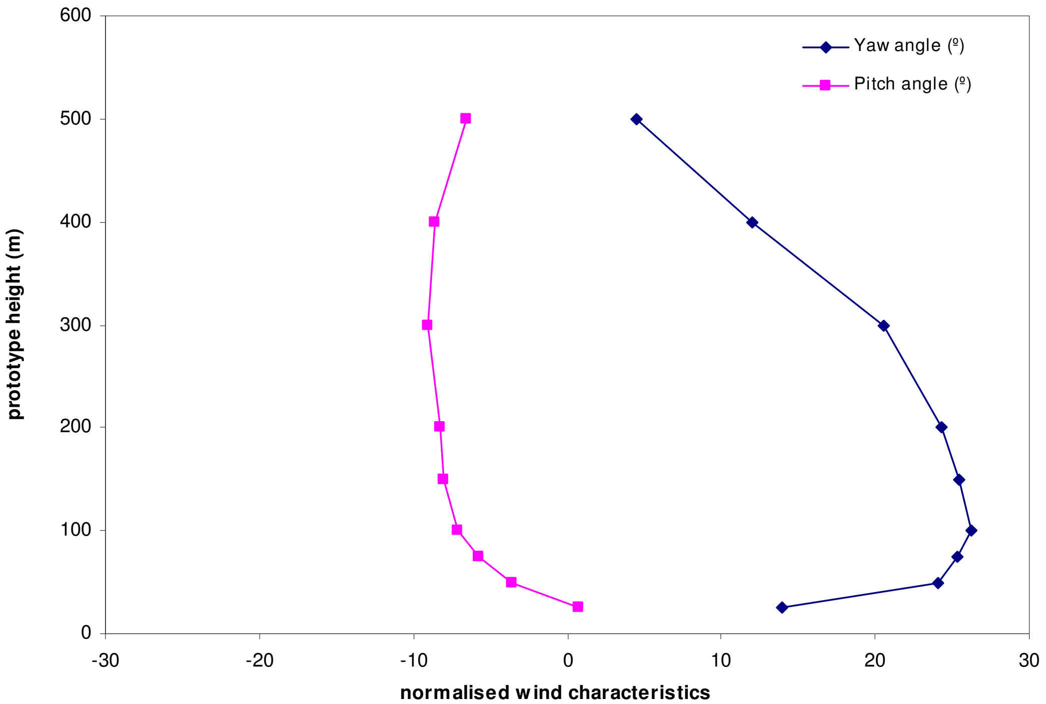

Figure 22b: Mean wind direction, Position 1, Tuen Mun East Area, 360º

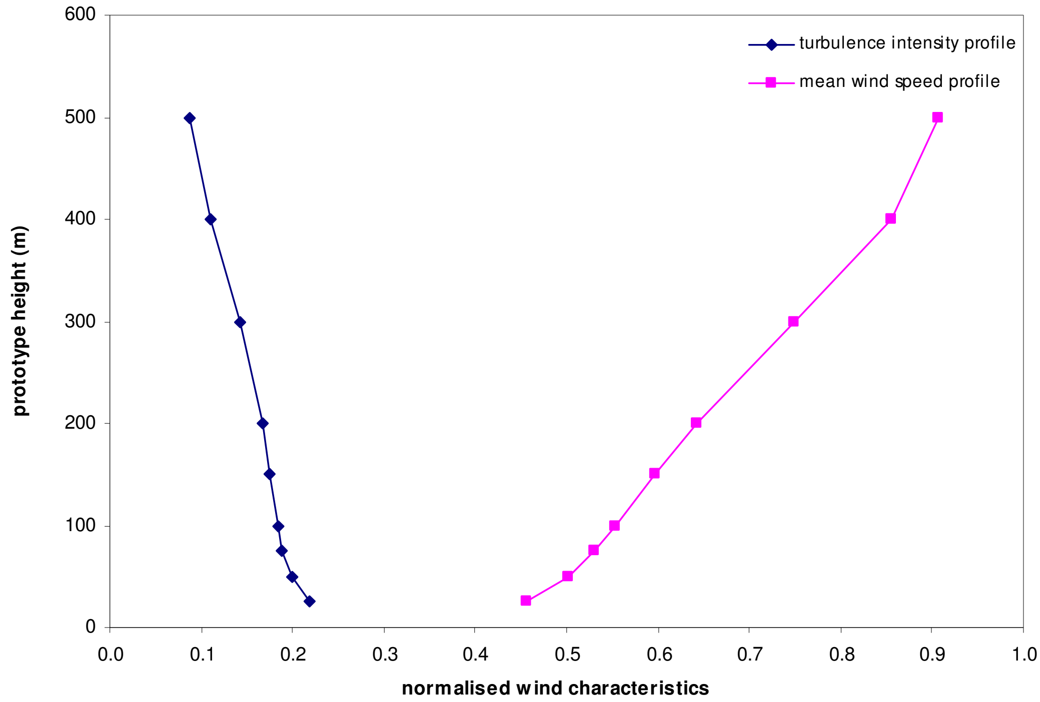

Figure 23a: Wind characteristics, Position 2, Tuen Mun East Area, 22.5º

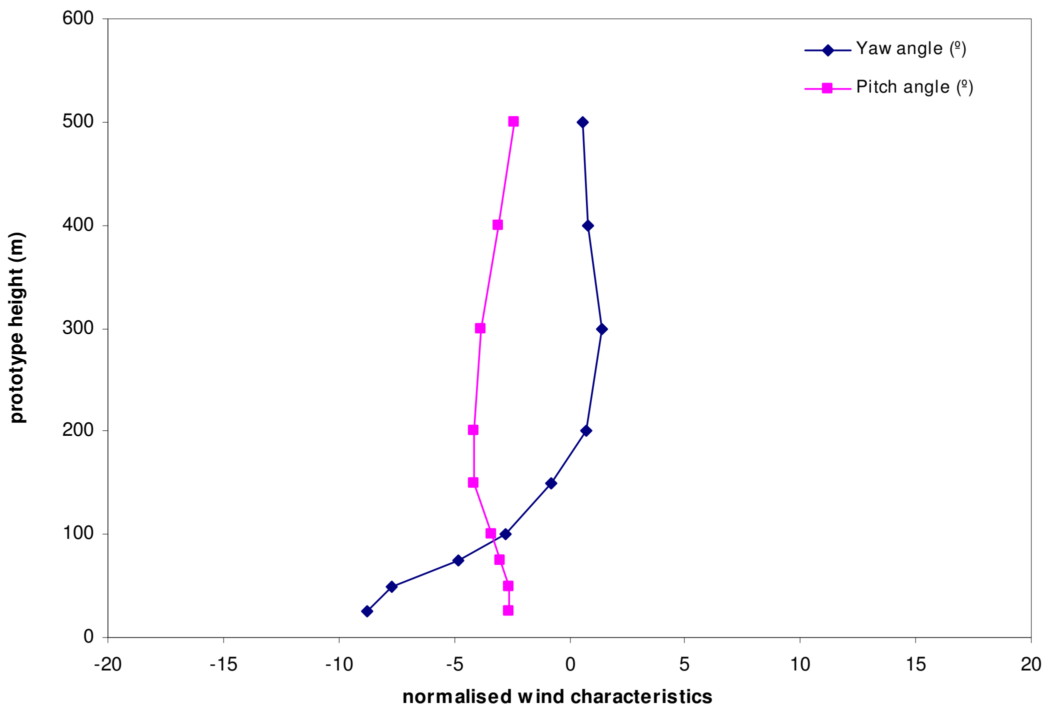

Figure 23b: Mean wind direction, Position 2, Tuen Mun East Area, 22.5º

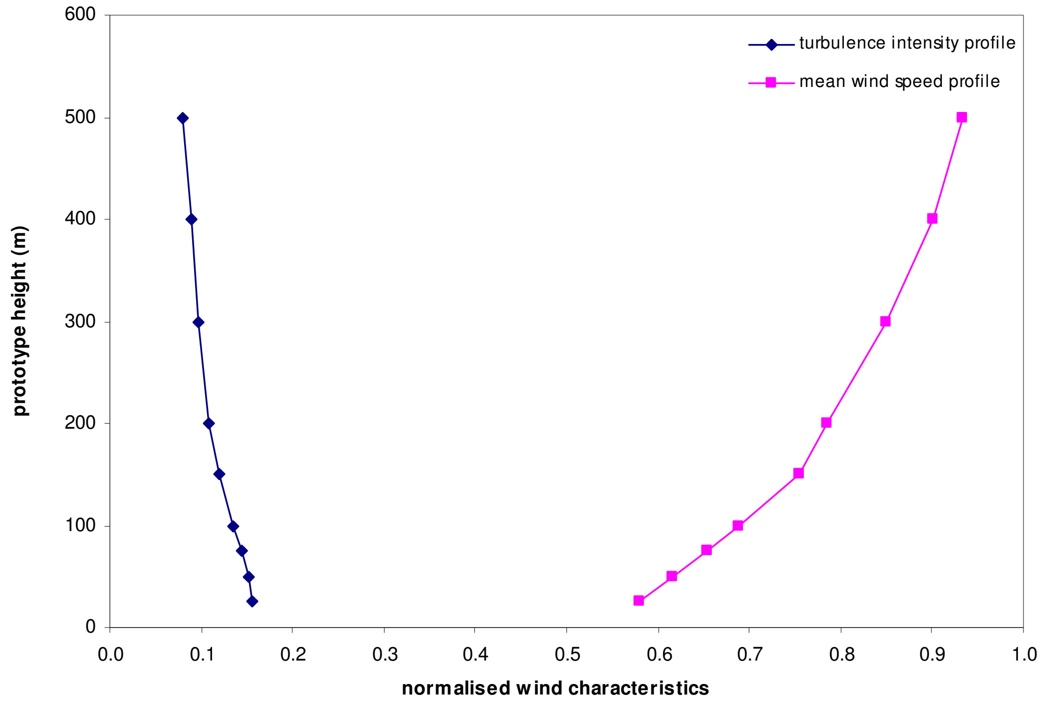

Figure 24a: Wind characteristics, Position 2, Tuen Mun East Area, 45º

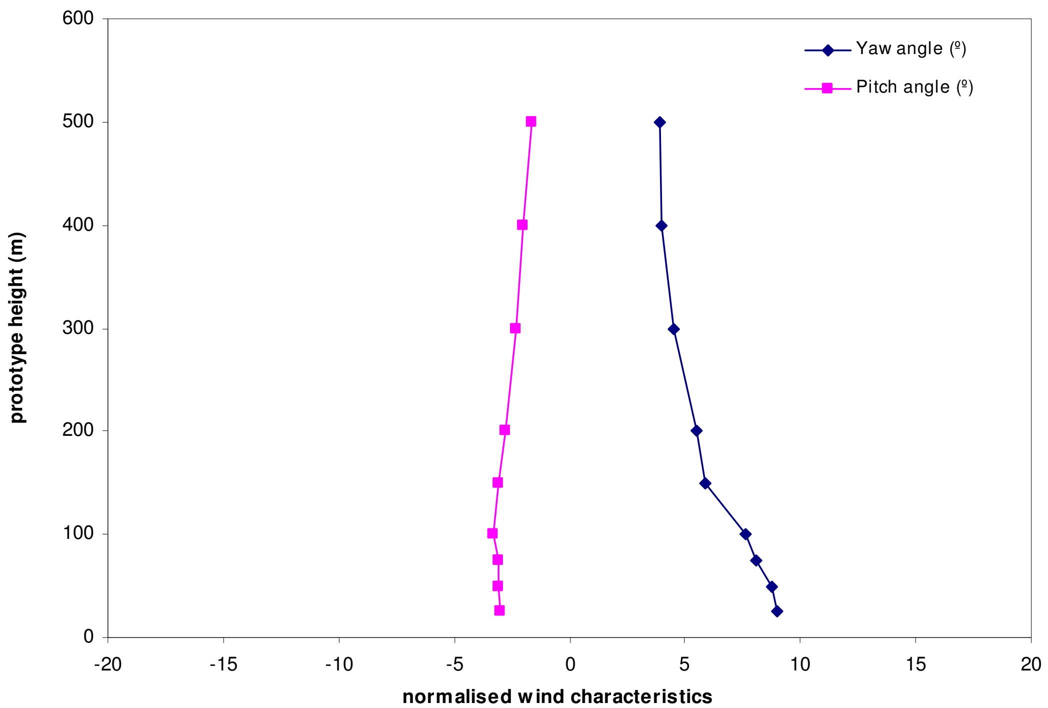

Figure 24b: Mean wind direction, Position 2, Tuen Mun East Area, 45º

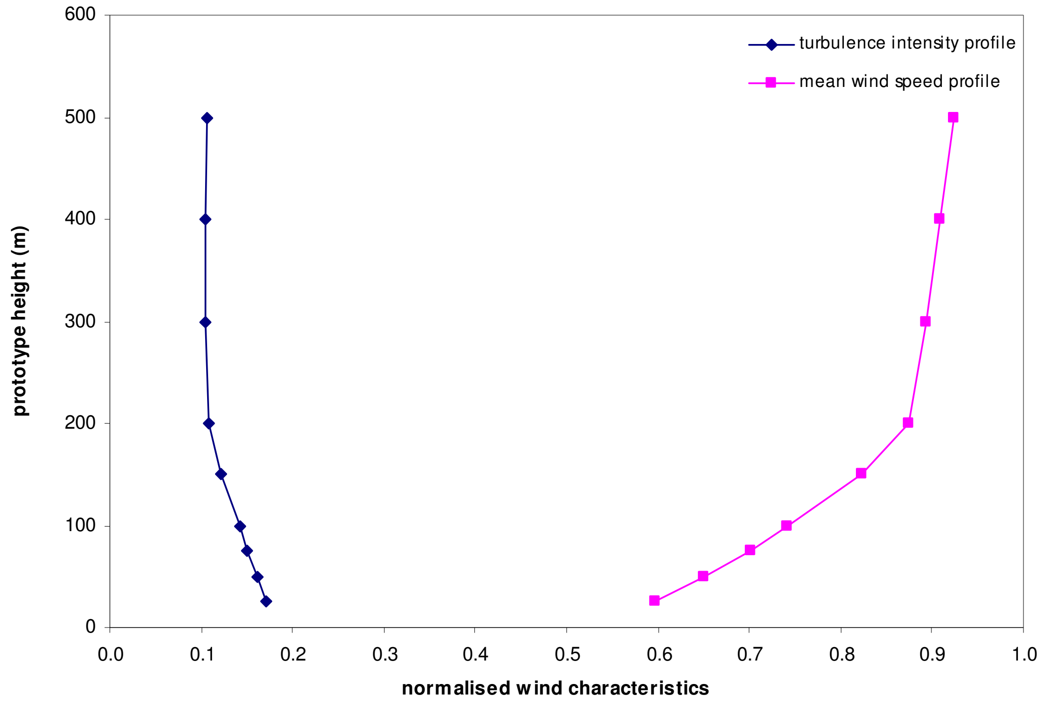

Figure 25a: Wind characteristics, Position 2, Tuen Mun East Area, 67.5º

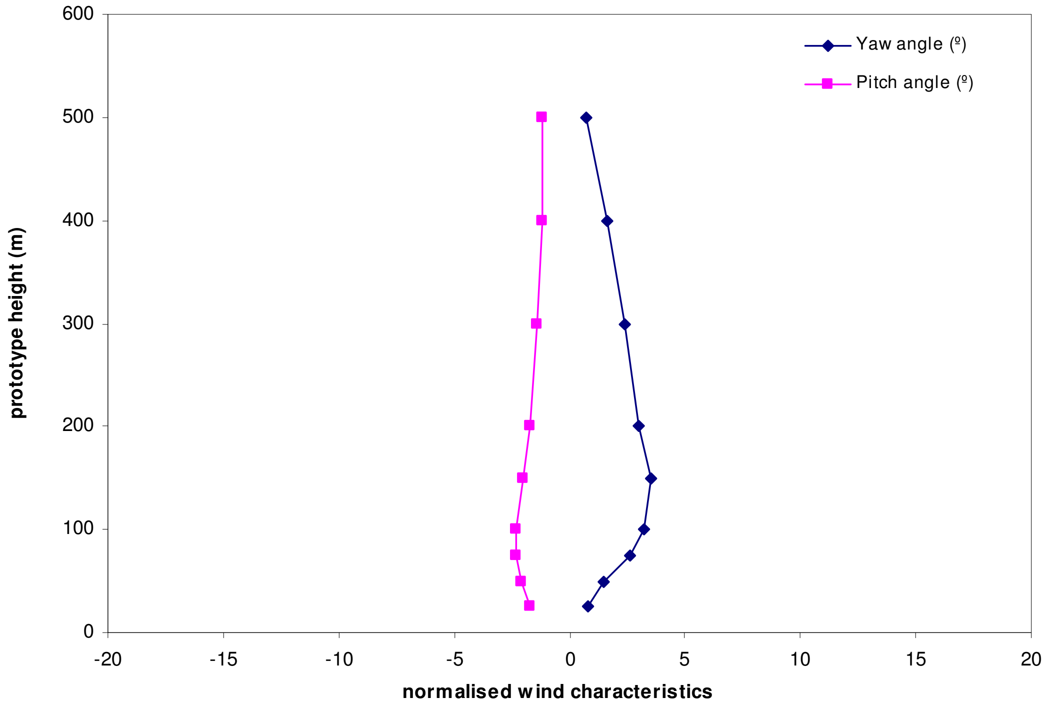

Figure 25b: Mean wind direction, Position 2, Tuen Mun East Area, 67.5º

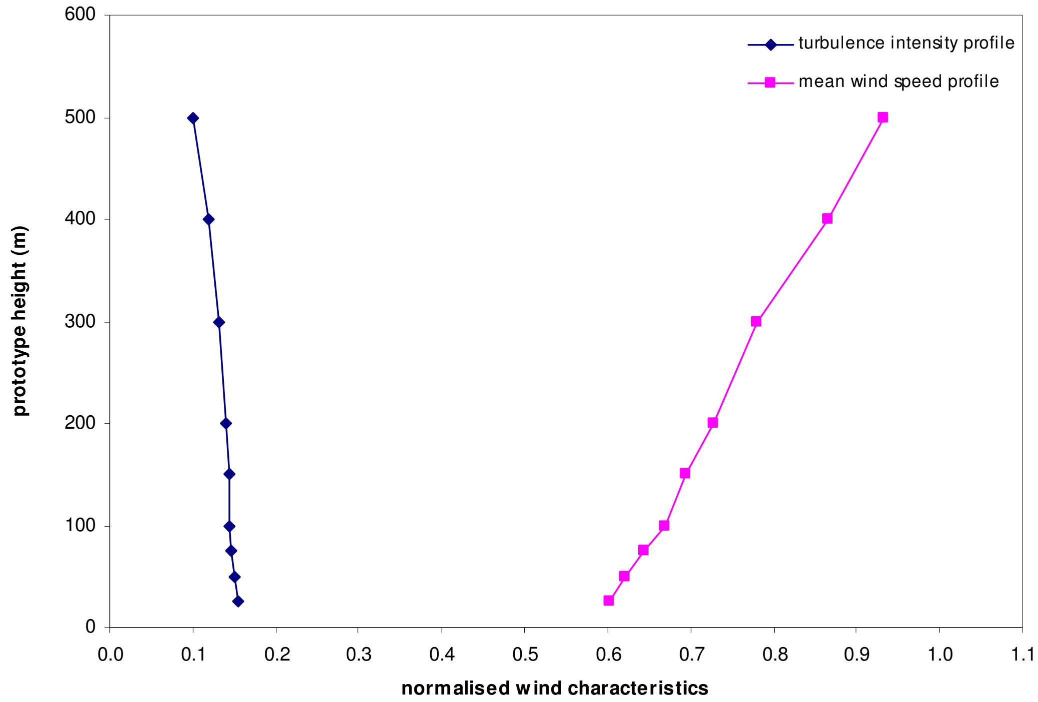

Figure 26a: Wind characteristics, Position 2, Tuen Mun East Area, 90º

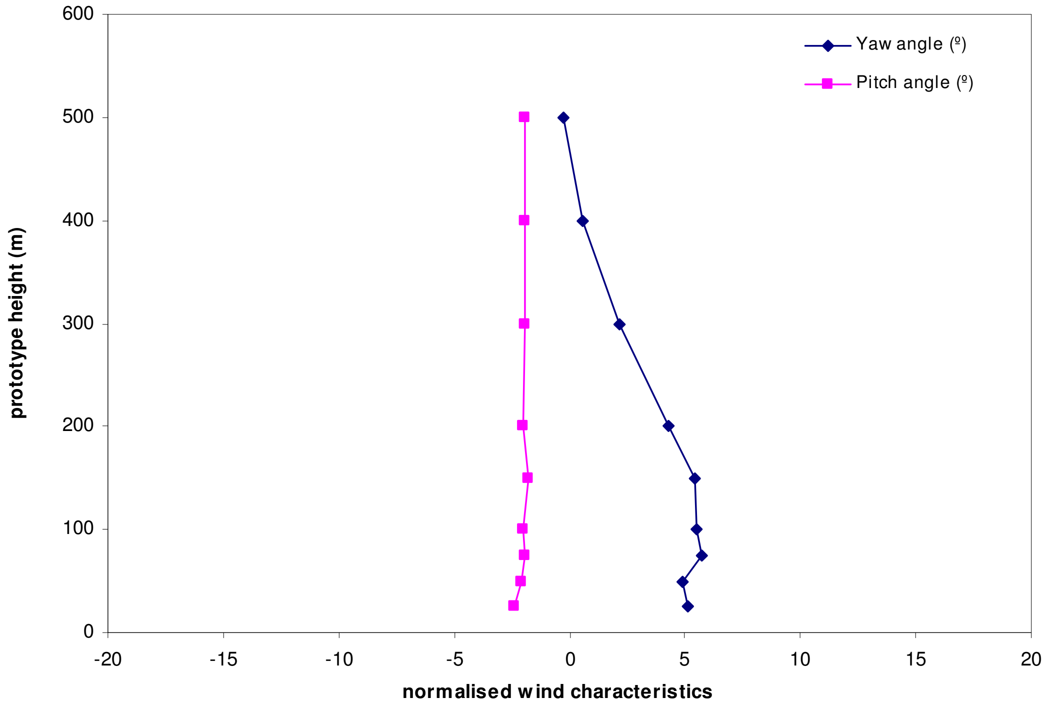

Figure 26b: Mean wind direction, Position 2, Tuen Mun East Area, 90º

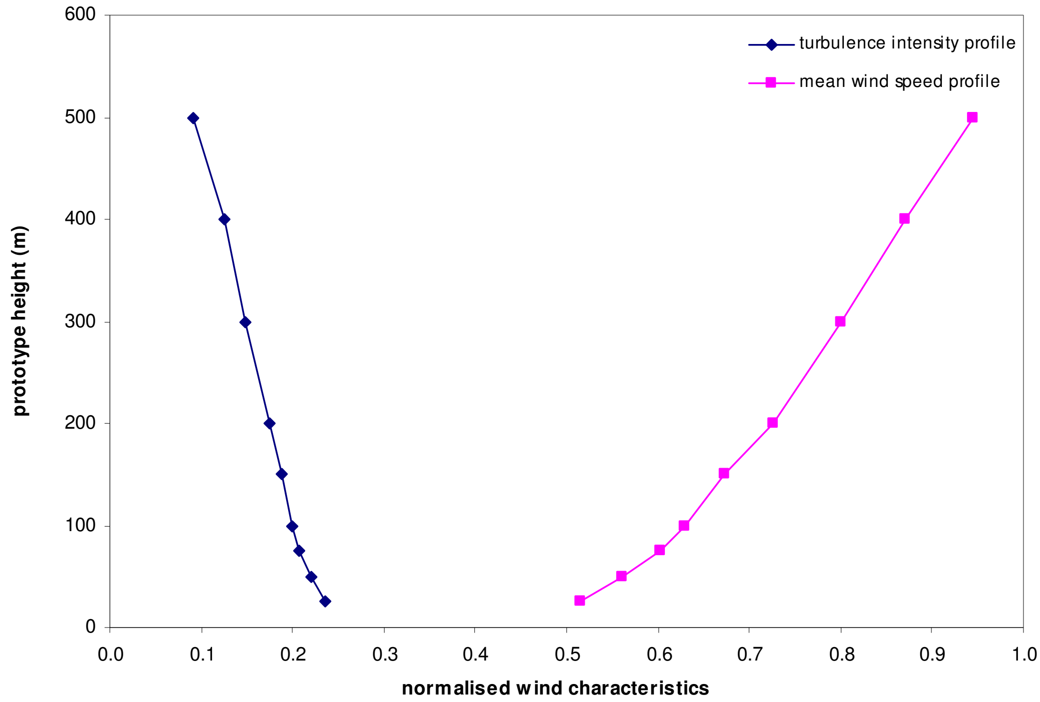

Figure 27a: Wind characteristics, Position 2, Tuen Mun East Area, 112.5°

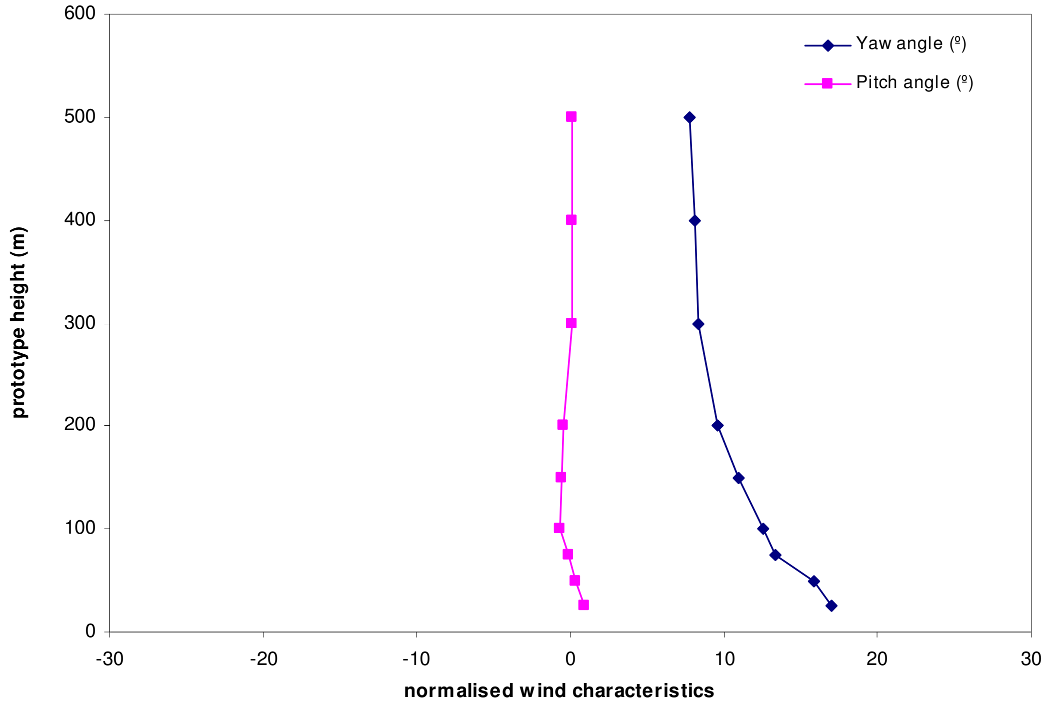

Figure 27b: Mean wind direction, Position 2, Tuen Mun East Area, 112.5°

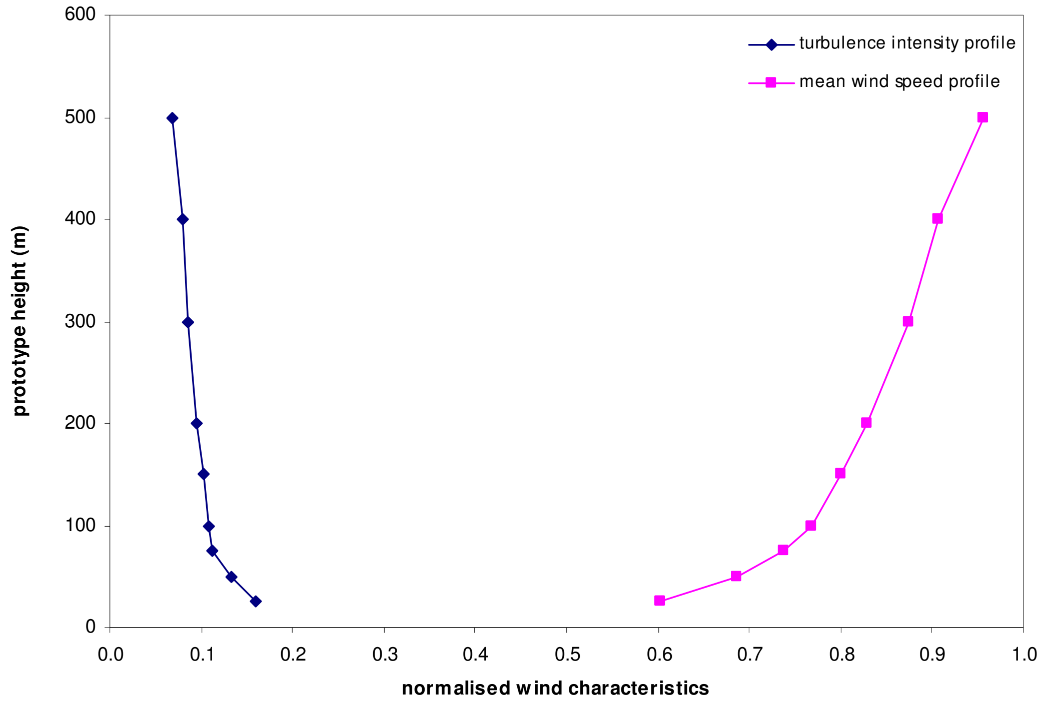

Figure 28a: Wind characteristics, Position 2, Tuen Mun East Area, 135º

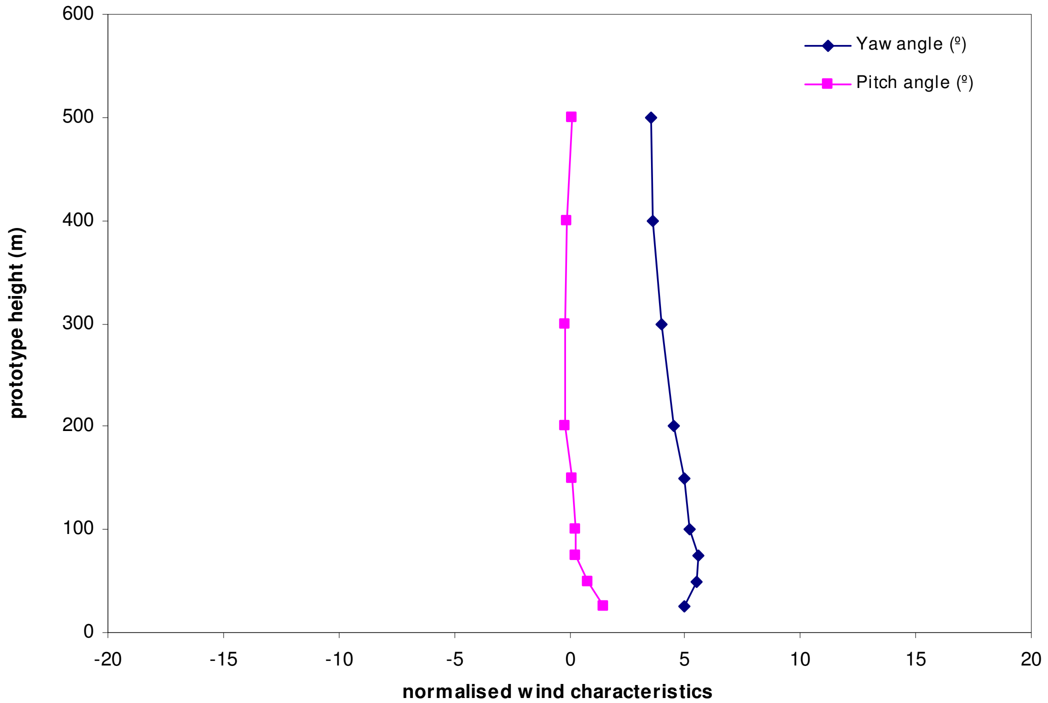

Figure 28b: Mean wind direction, Position 2, Tuen Mun East Area, 135º

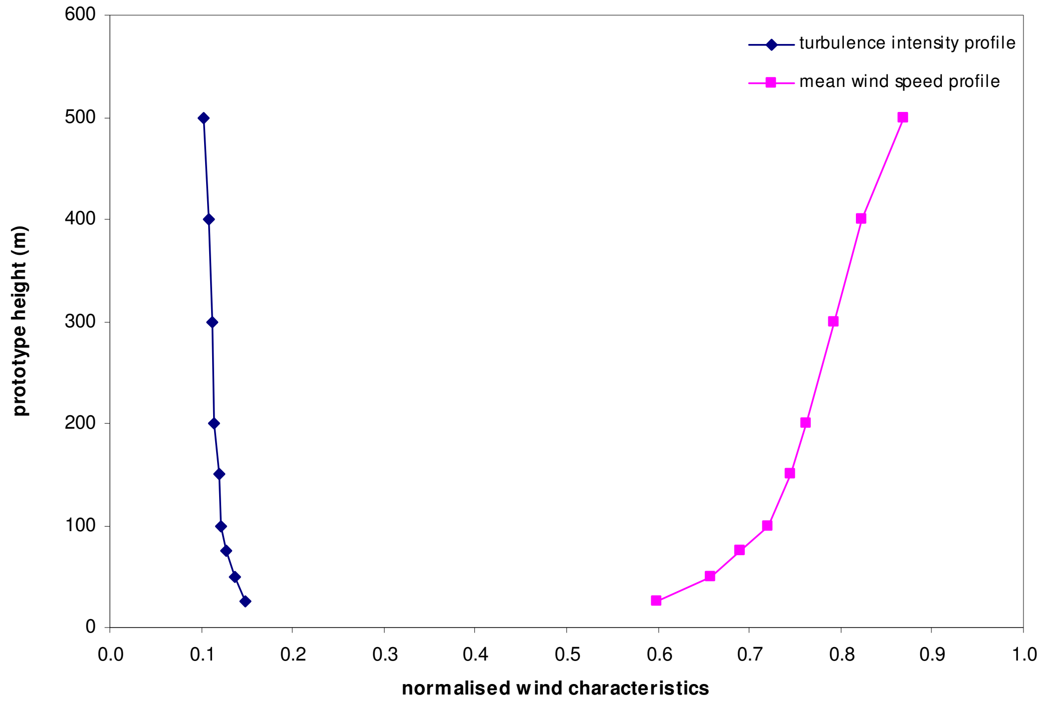

Figure 29a: Wind characteristics, Position 2, Tuen Mun East Area, 157.5°

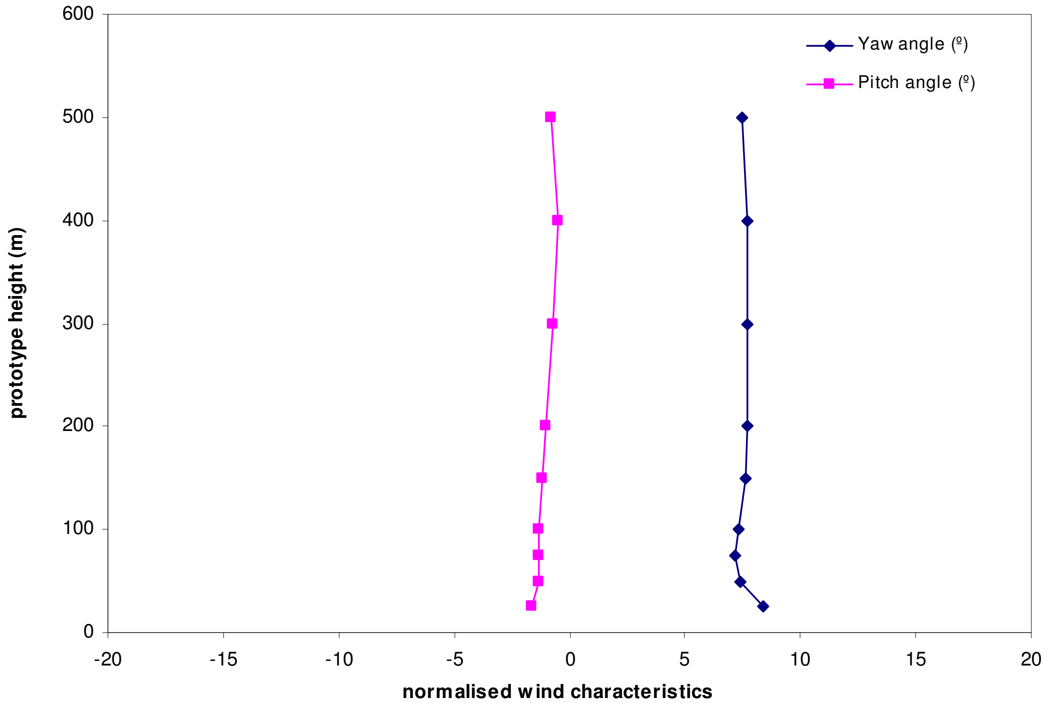

Figure 29b: Mean wind direction, Position 2, Tuen Mun East Area, 157.5°

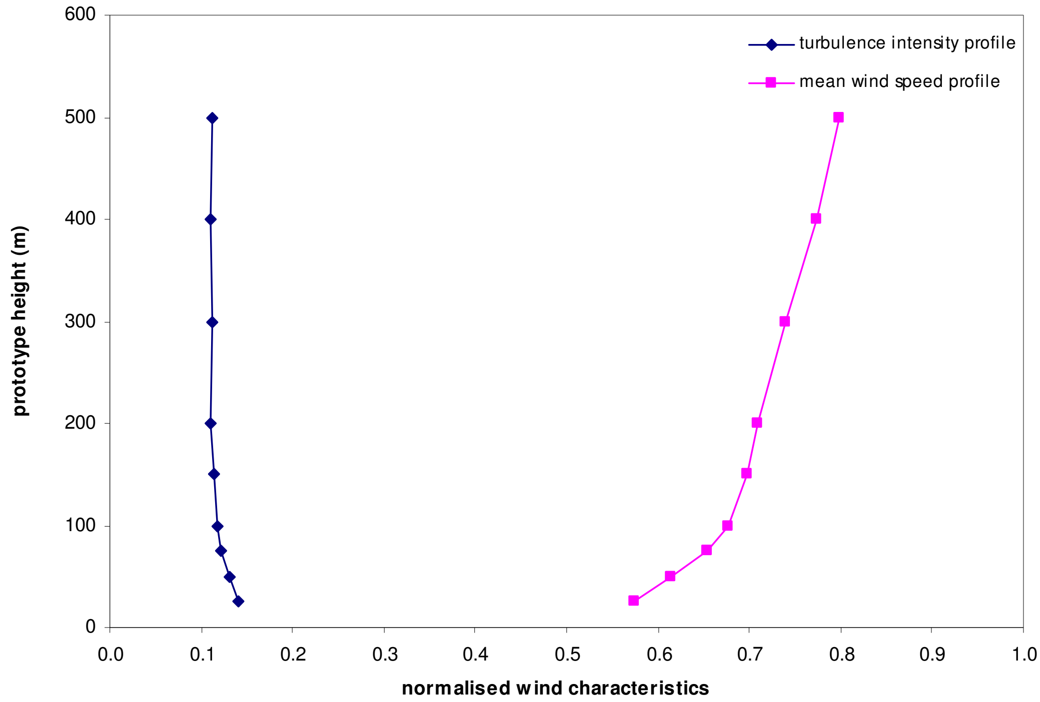

Figure 30a: Wind characteristics, Position 2, Tuen Mun East Area, 180º

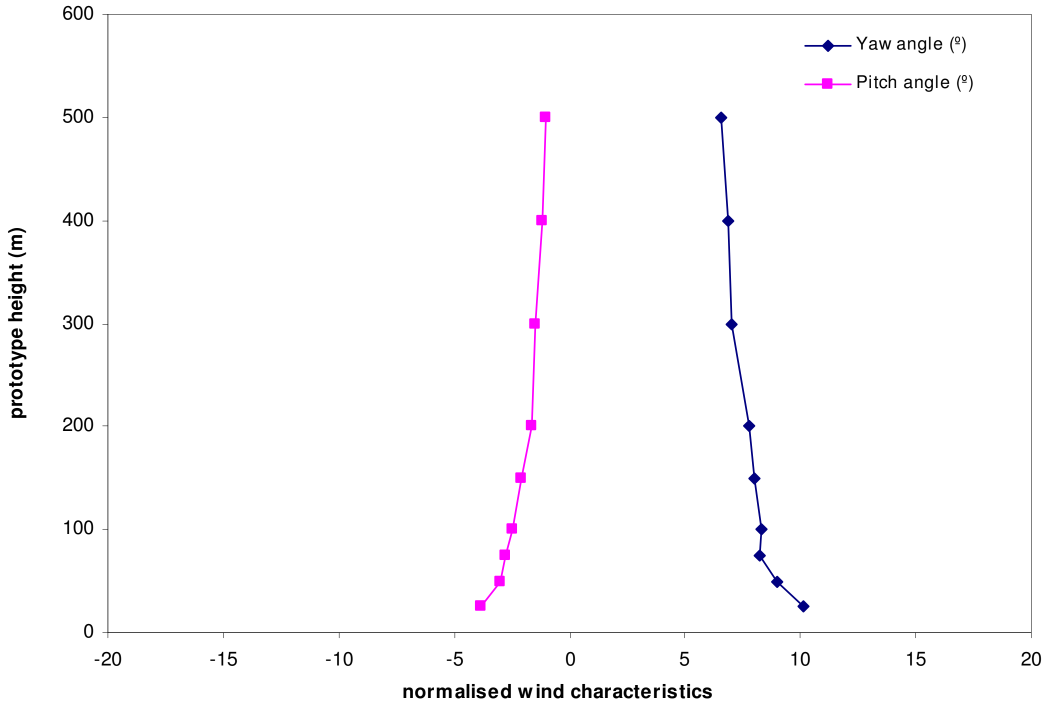

Figure 30b: Mean wind direction, Position 2, Tuen Mun East Area, 180º

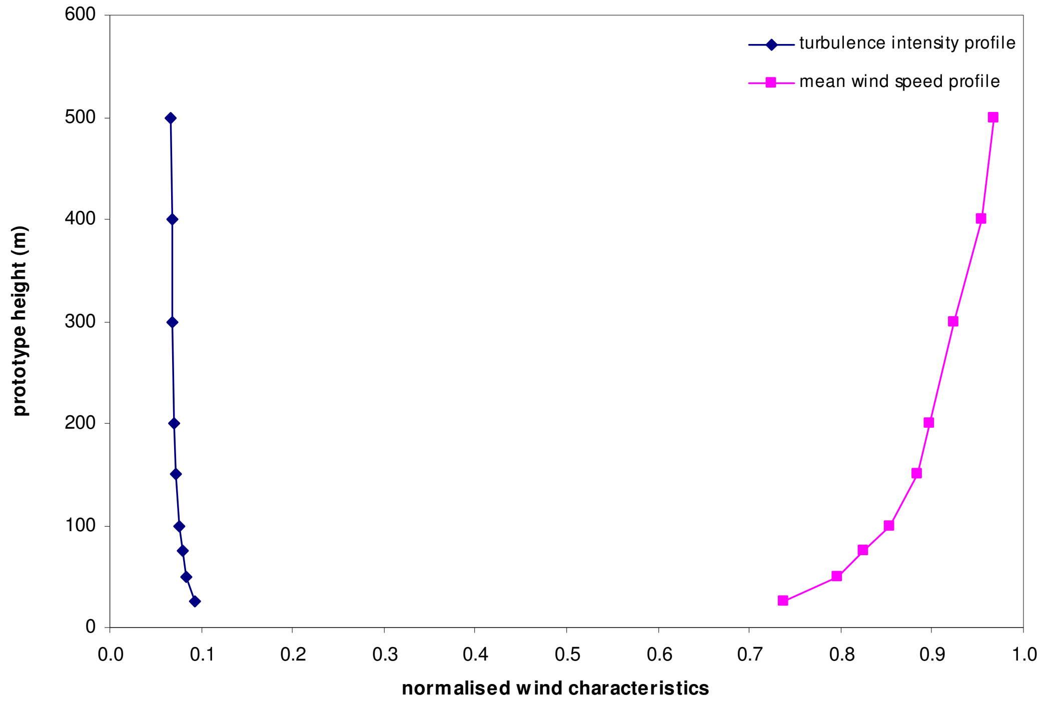

Figure 31a: Wind characteristics, Position 2, Tuen Mun East Area, 202.5º

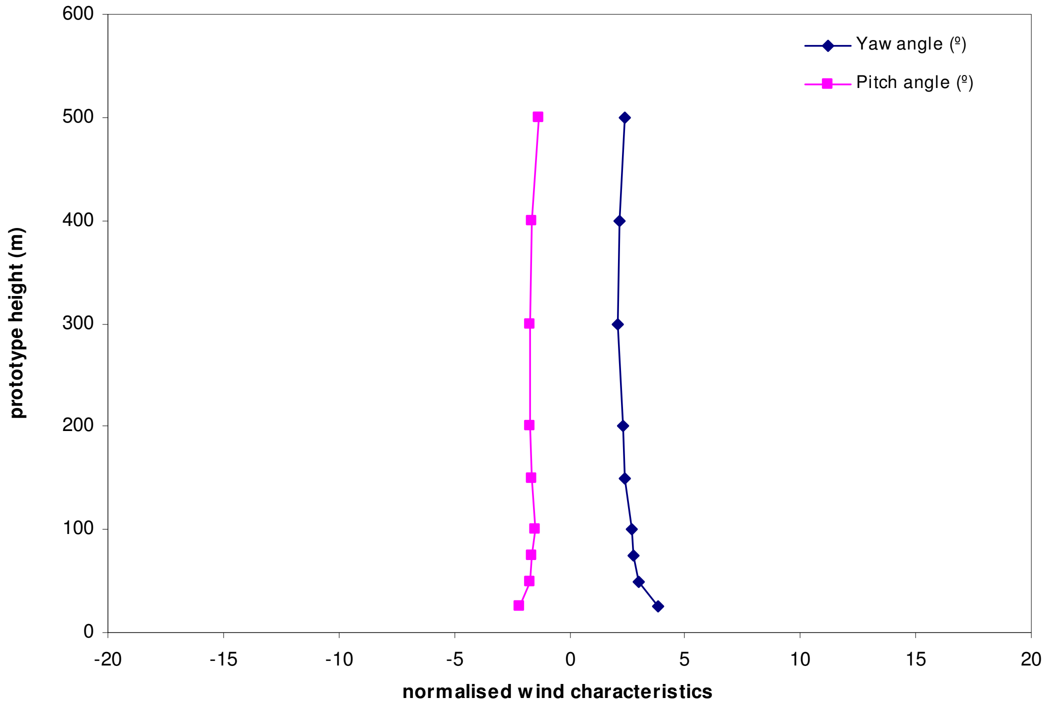

Figure 31b: Mean wind direction, Position 2, Tuen Mun East Area, 202.5º

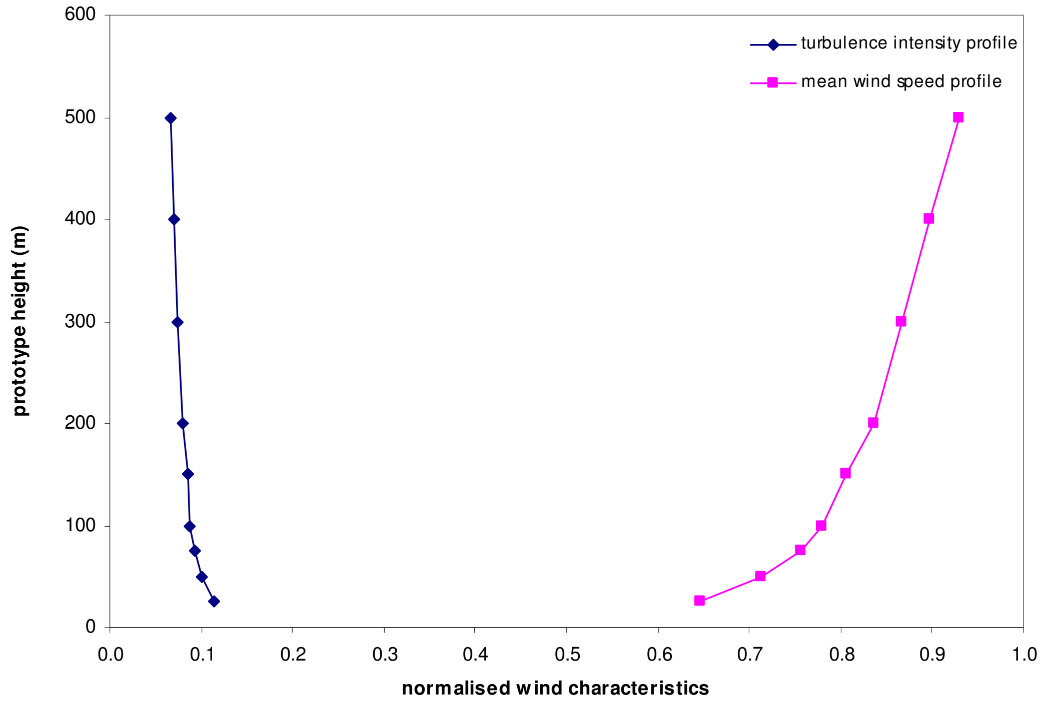

Figure 32a: Wind characteristics, Position 2, Tuen Mun East Area, 225°

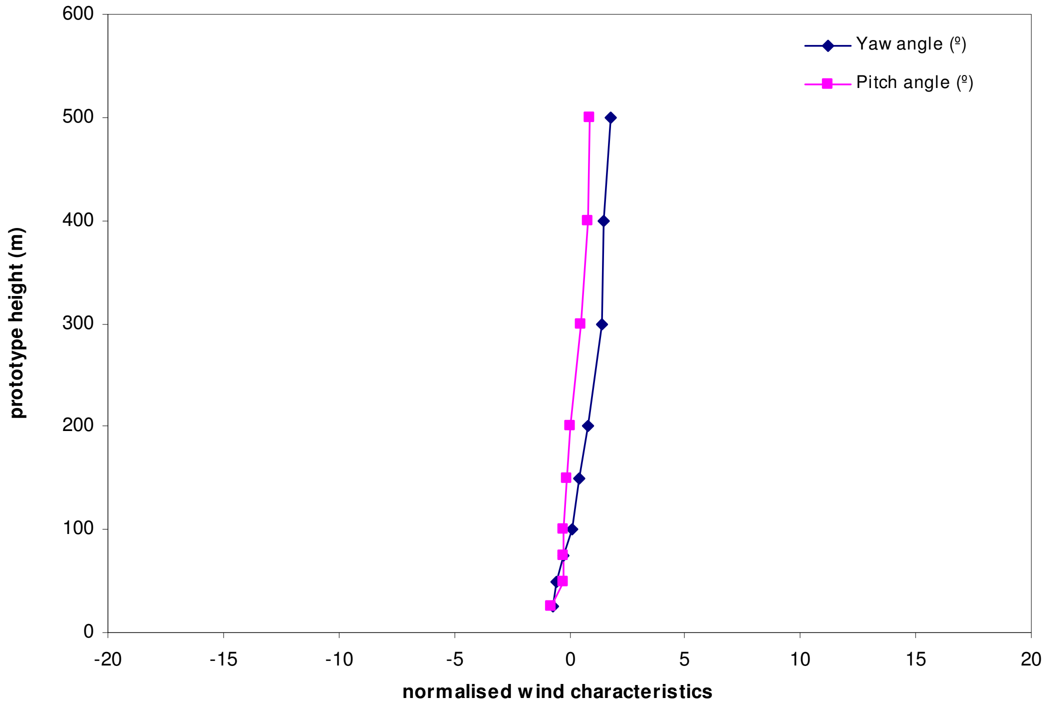

Figure 32b: Mean wind direction, Position 2, Tuen Mun East Area, 225°

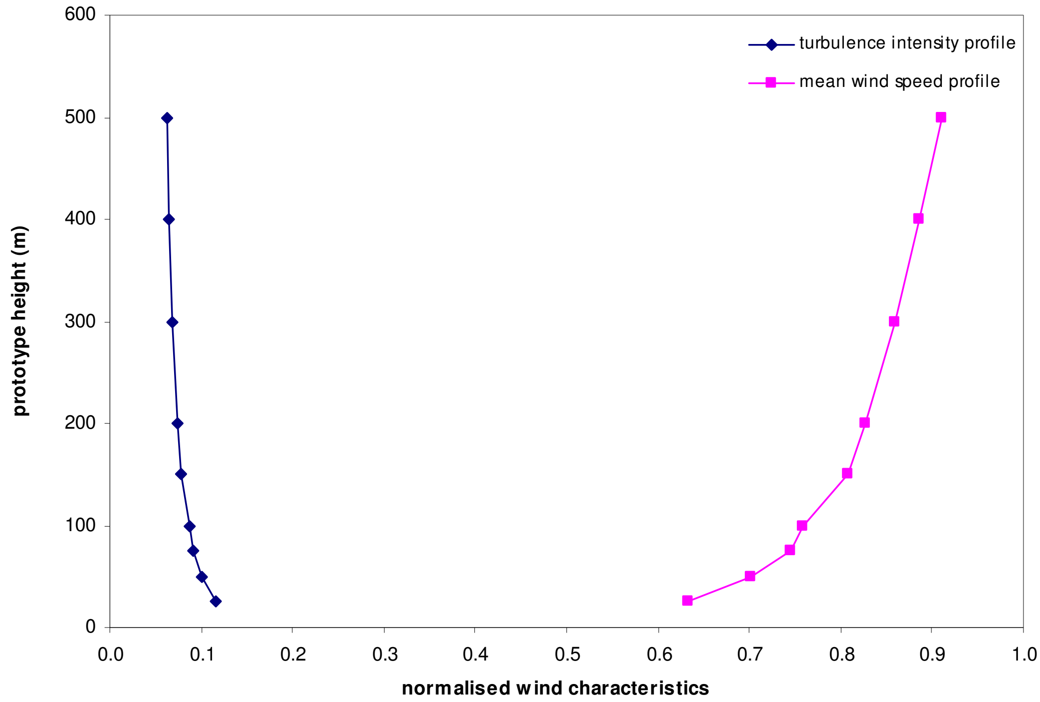

Figure 33a: Wind characteristics, Position 2, Tuen Mun East Area, 247.5º

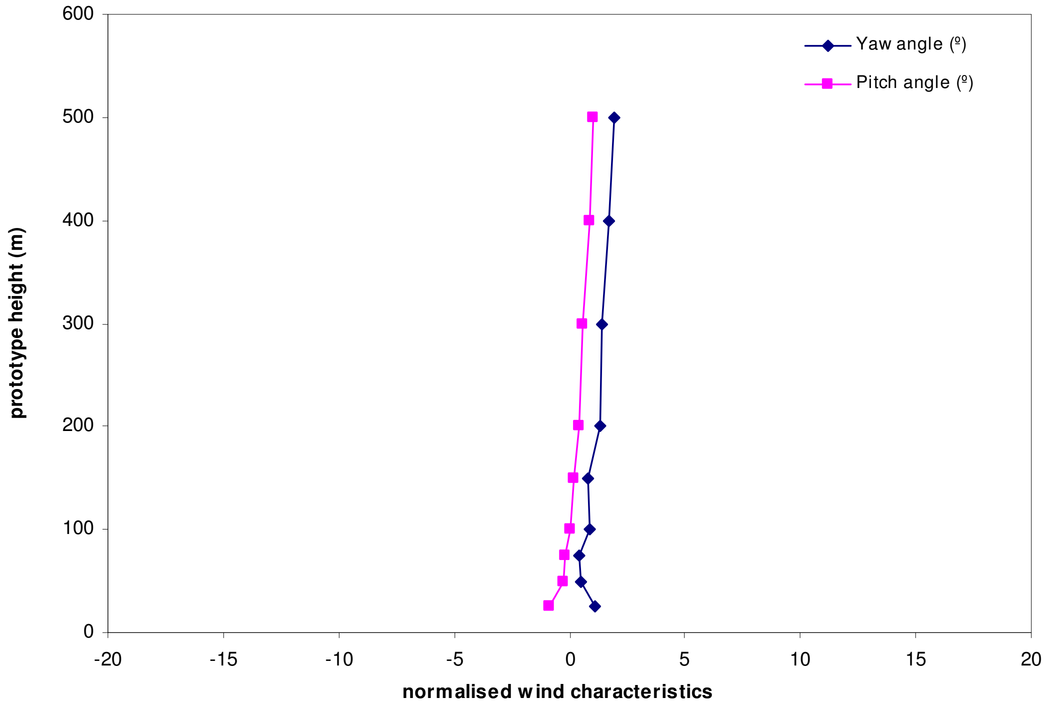

Figure 33b: Mean wind direction, Position 2, Tuen Mun East Area, 247.5º

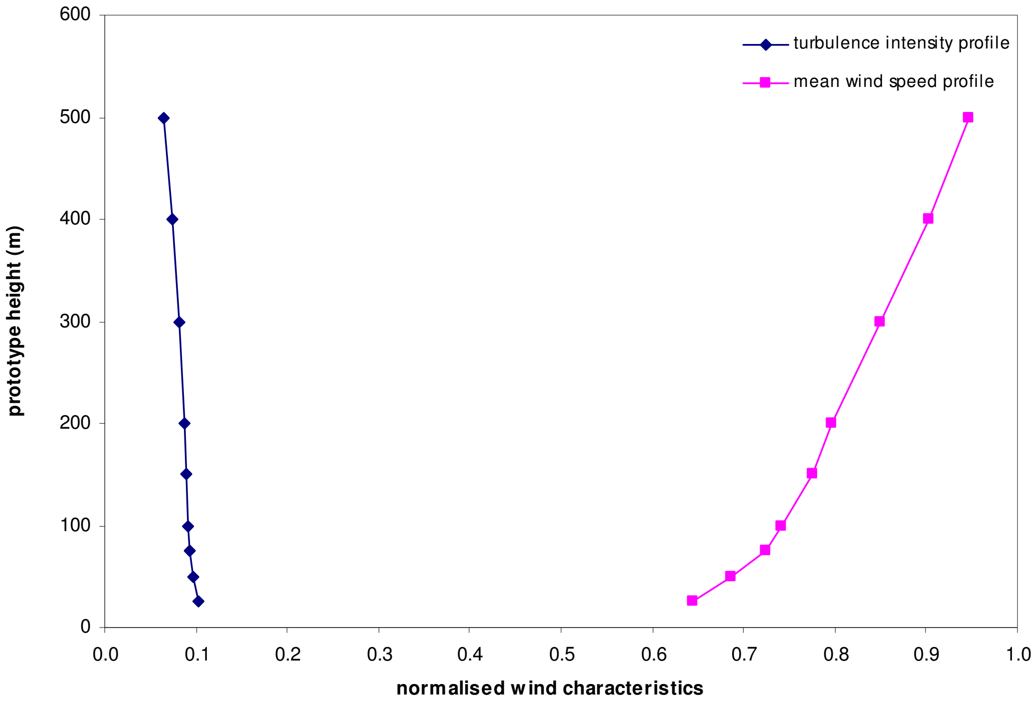

Figure 34a: Wind characteristics, Position 2, Tuen Mun East Area, 270º

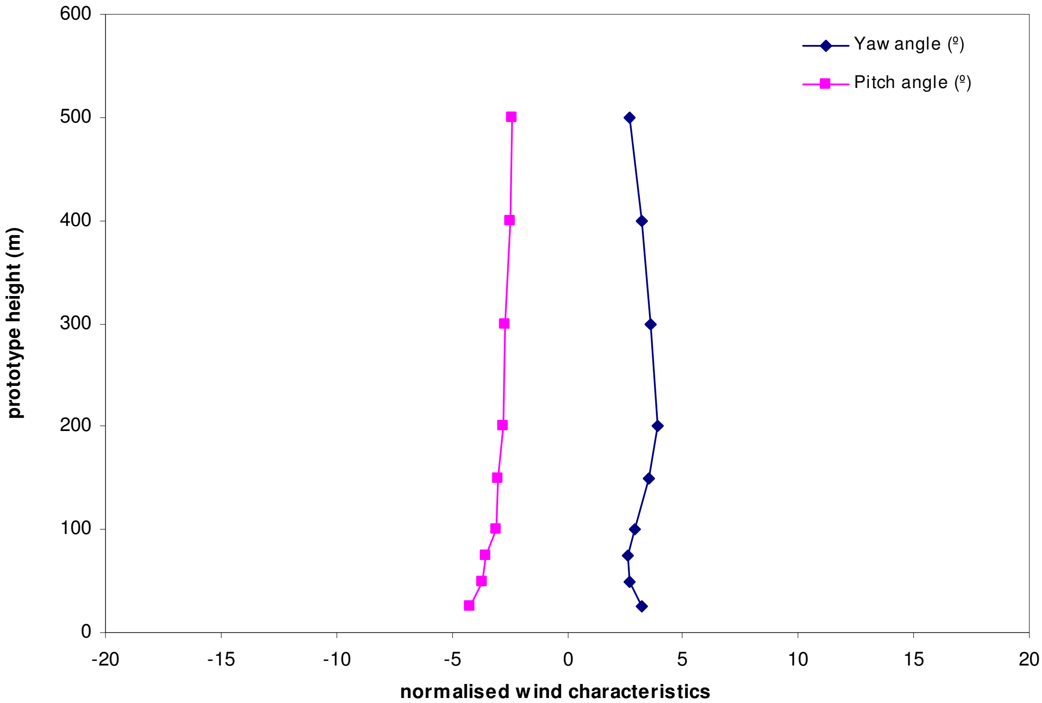

Figure 34b: Mean wind direction, Position 2, Tuen Mun East Area, 270º

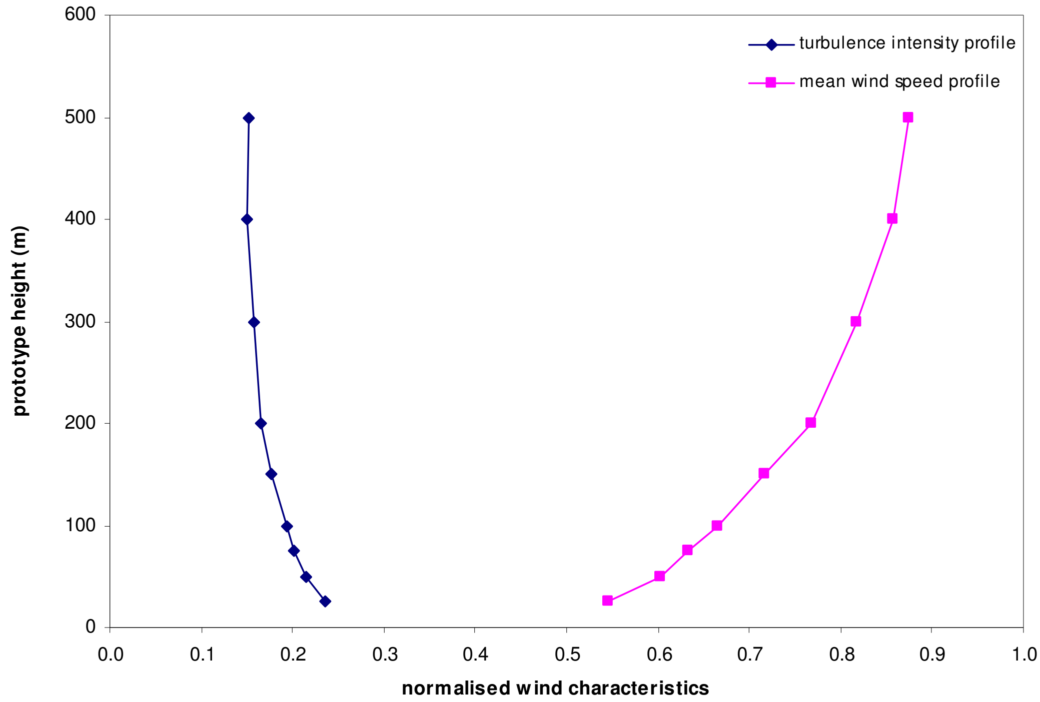

Figure 35a: Wind characteristics, Position 2, Tuen Mun East Area, 292.5°

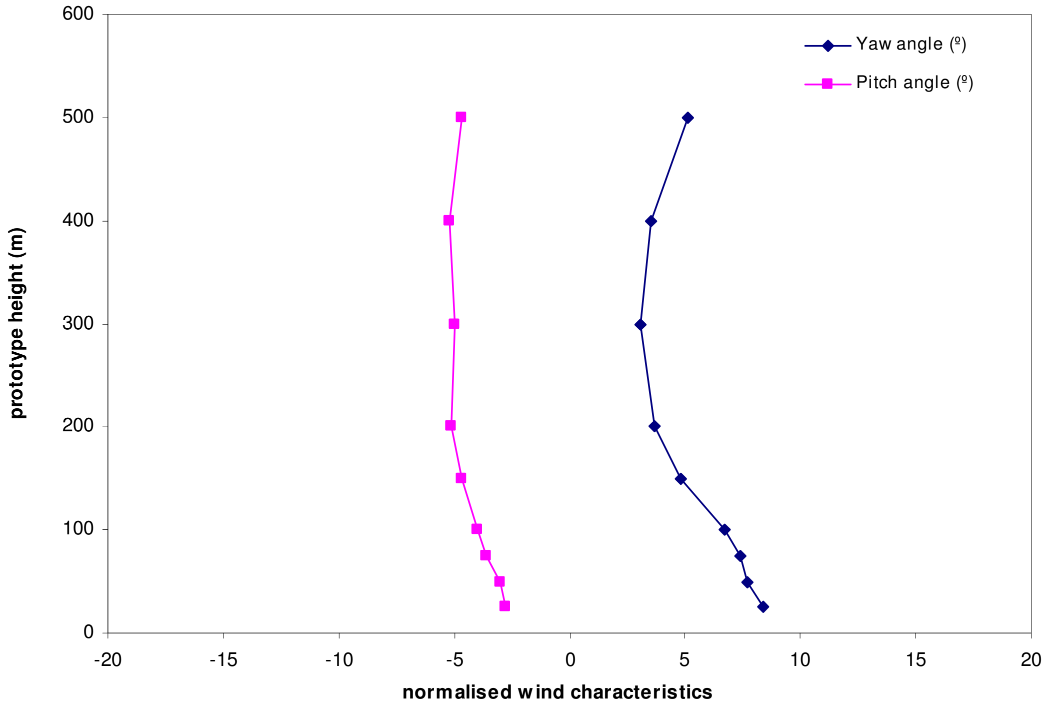

Figure 35b: Mean wind direction, Position 2, Tuen Mun East Area, 292.5°

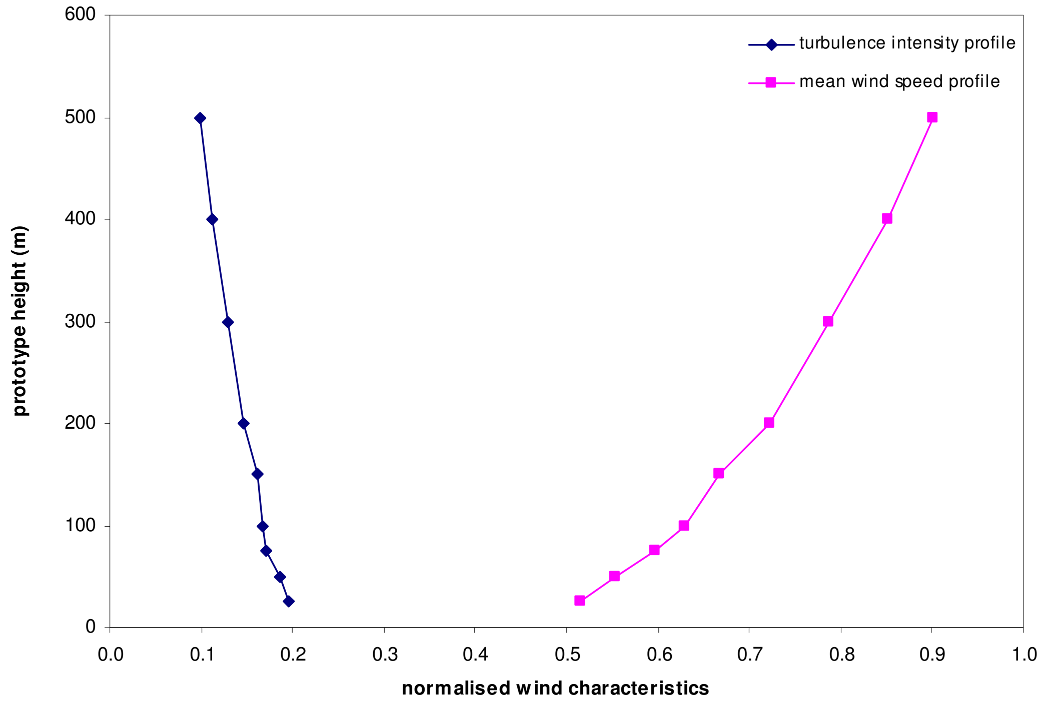

Figure 36a: Wind characteristics, Position 2, Tuen Mun East Area, 315º

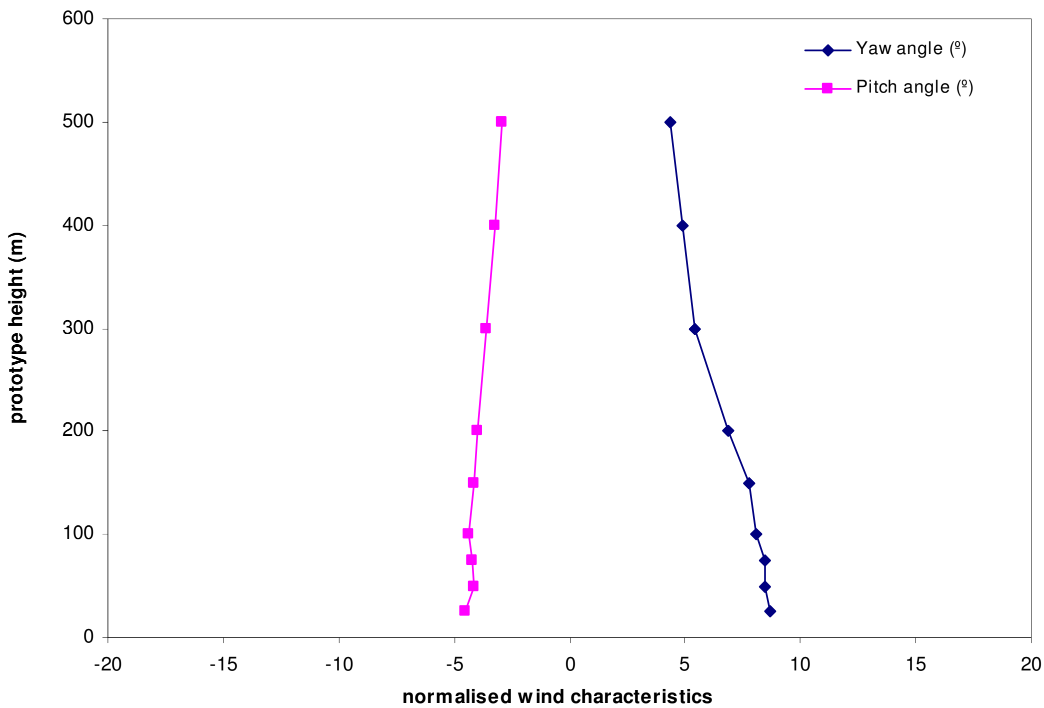

Figure 36b: Mean wind direction, Position 2, Tuen Mun East Area, 315º

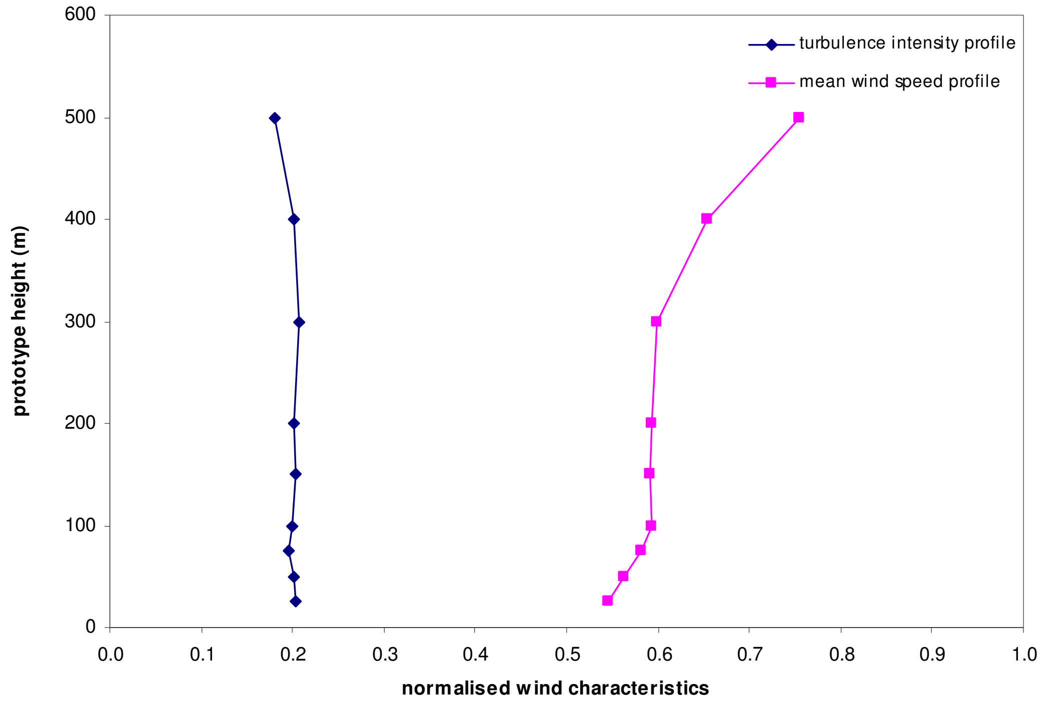

Figure 37a: Wind characteristics, Position 2, Tuen Mun East Area, 337.5º

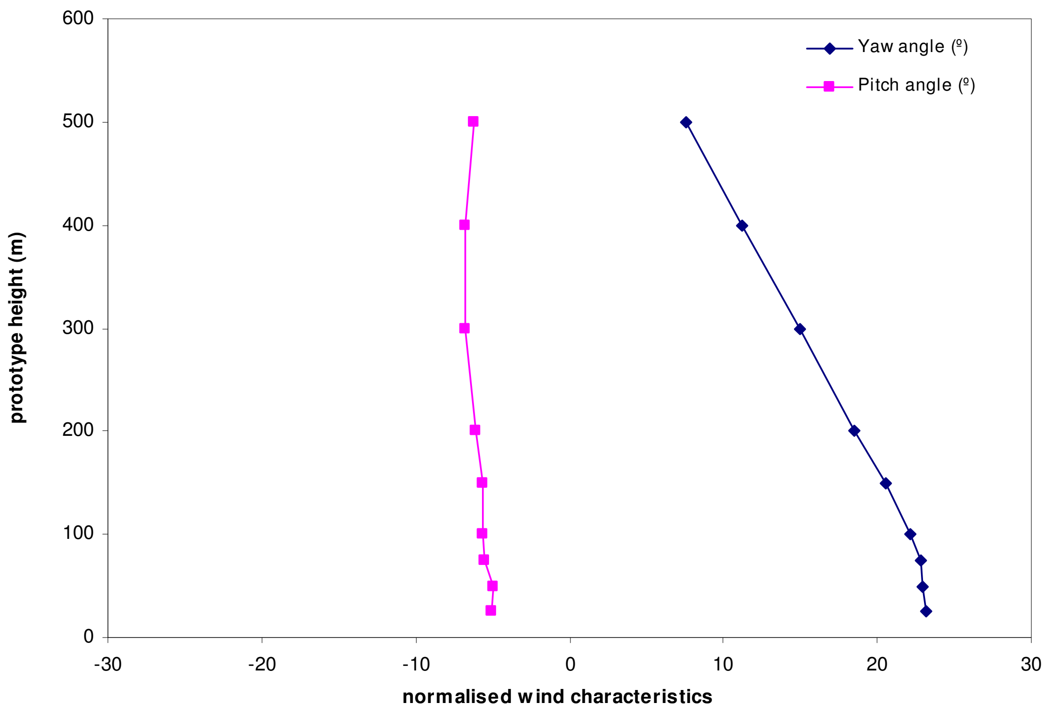

Figure 37b: Mean wind direction, Position 2, Tuen Mun East Area, 337.5º

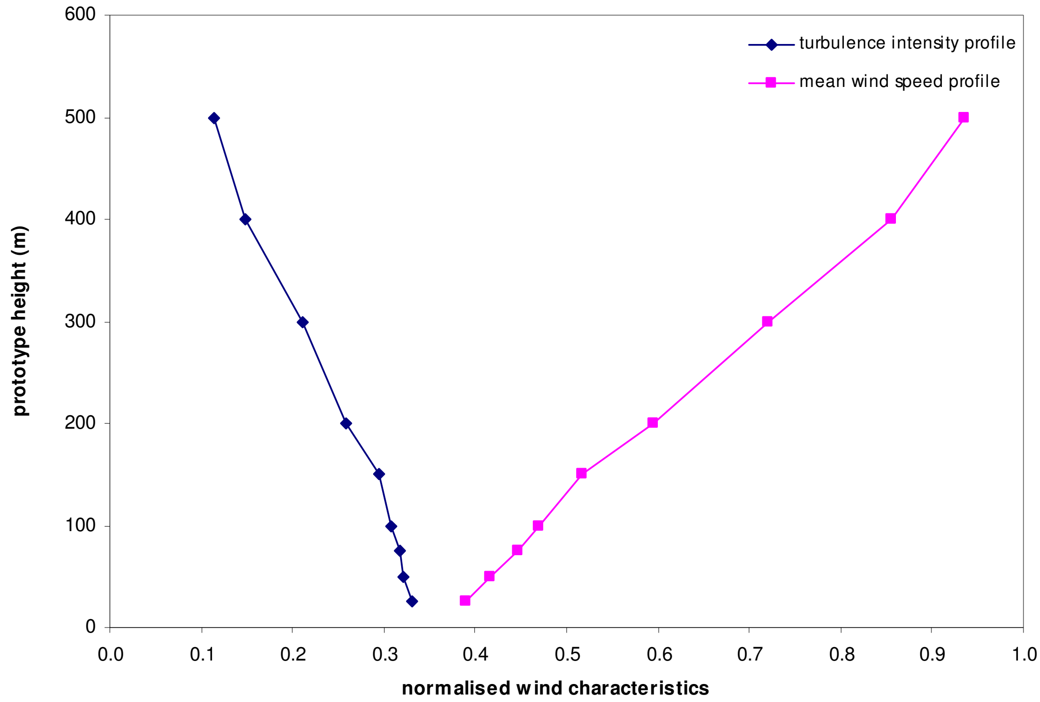

Figure 38a: Wind characteristics, Position 2, Tuen Mun East Area, 360º

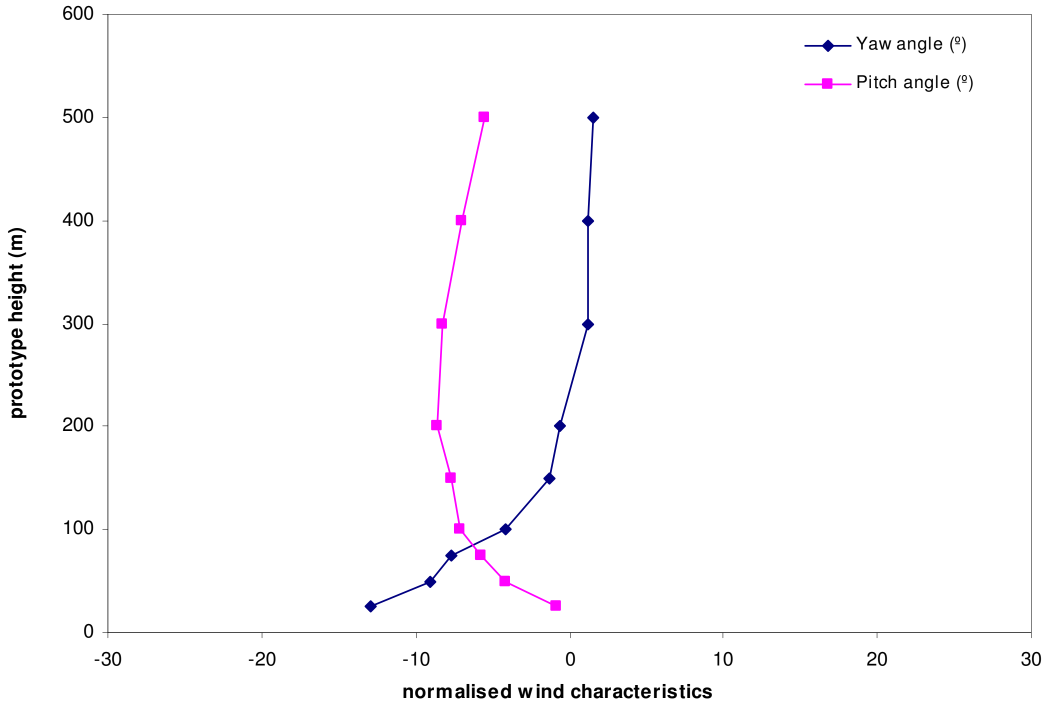

Figure 38b: Mean wind direction, Position 2, Tuen Mun East Area, 360º

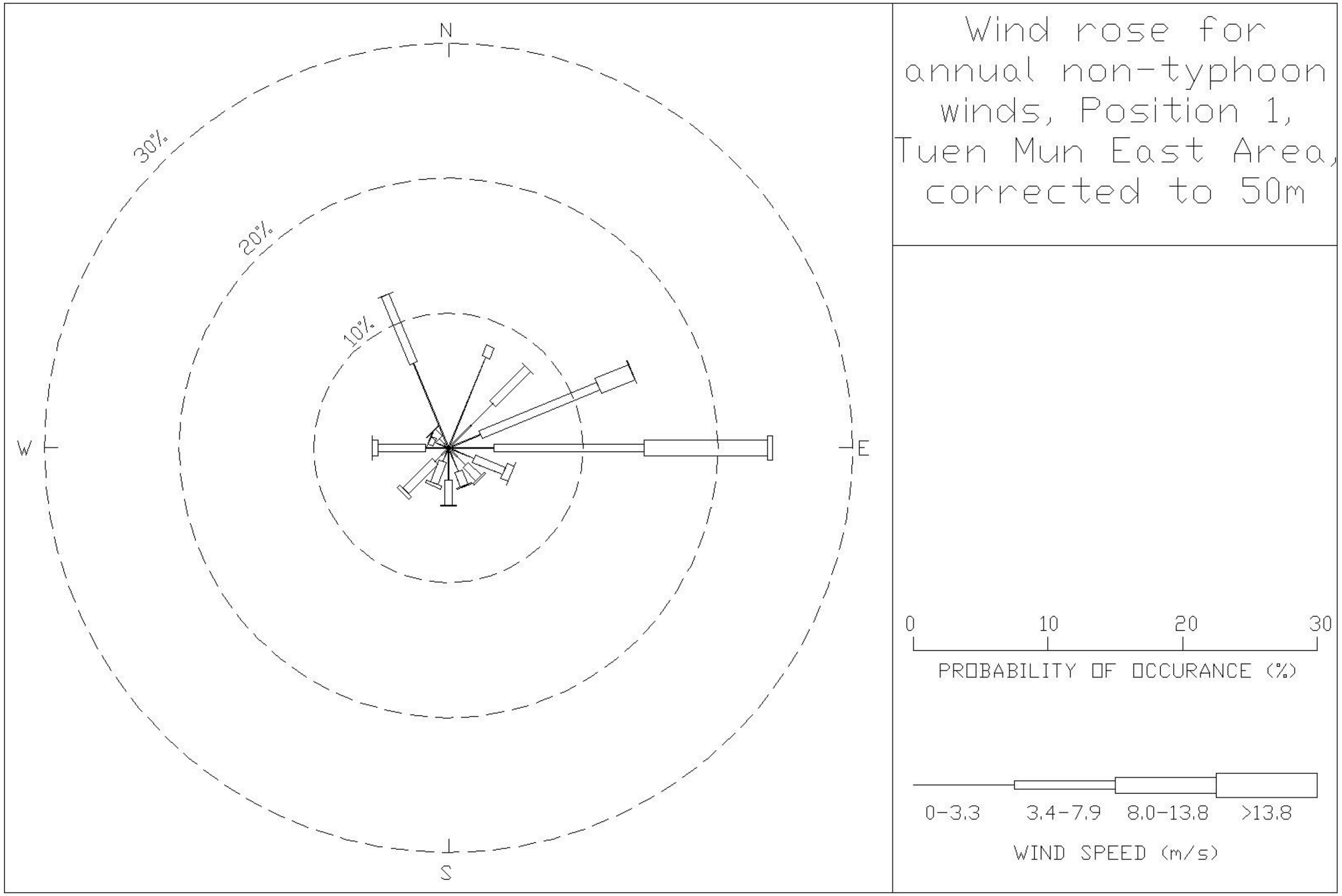

Figure 39: Wind rose for annual, non-typhoon winds for Position 1 of the Tuen Mun East Area, corrected to 50m

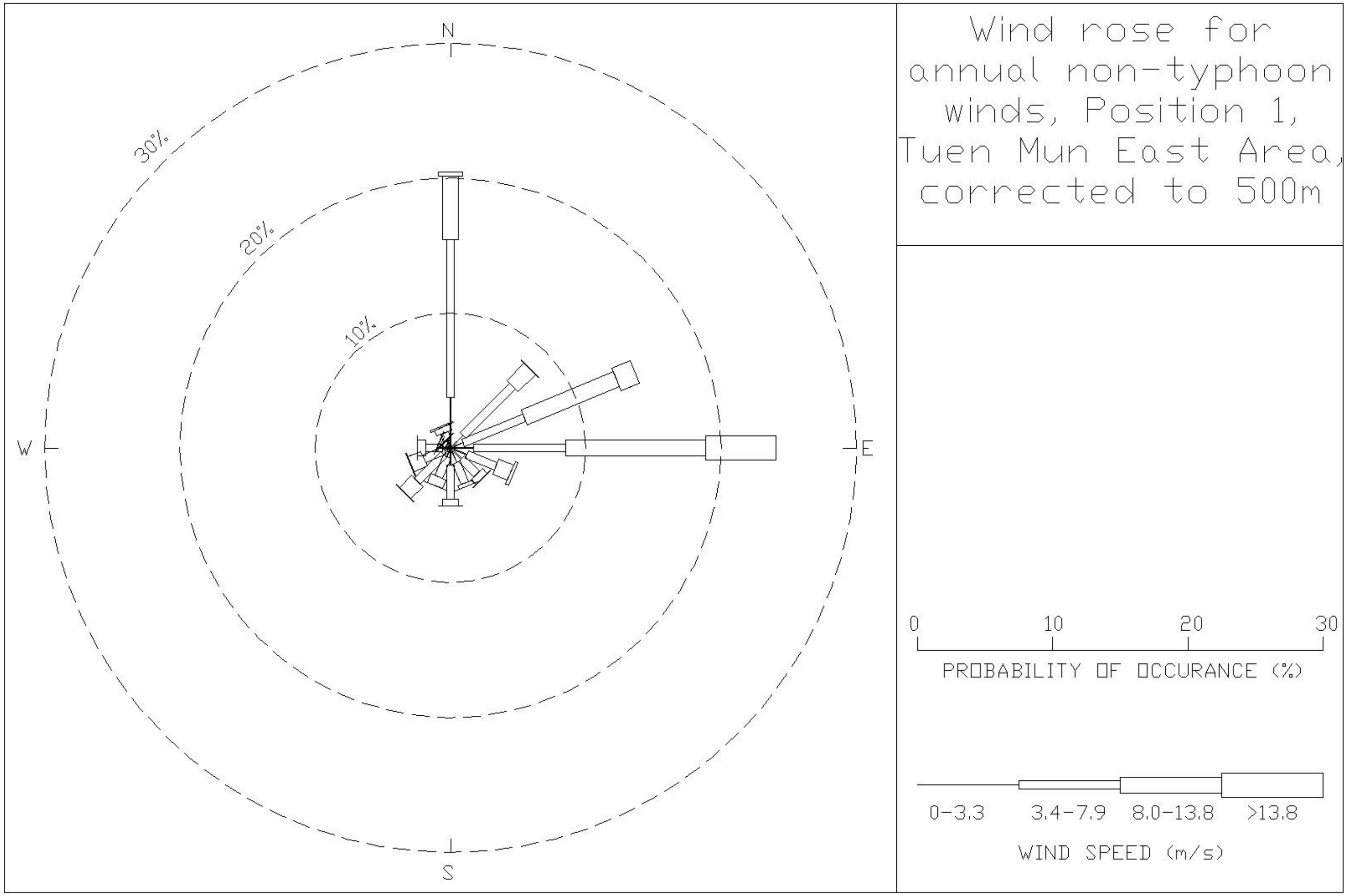

Figure 40: Wind rose for annual, non-typhoon winds for Position 1 of the Tuen Mun East Area, corrected to 500m

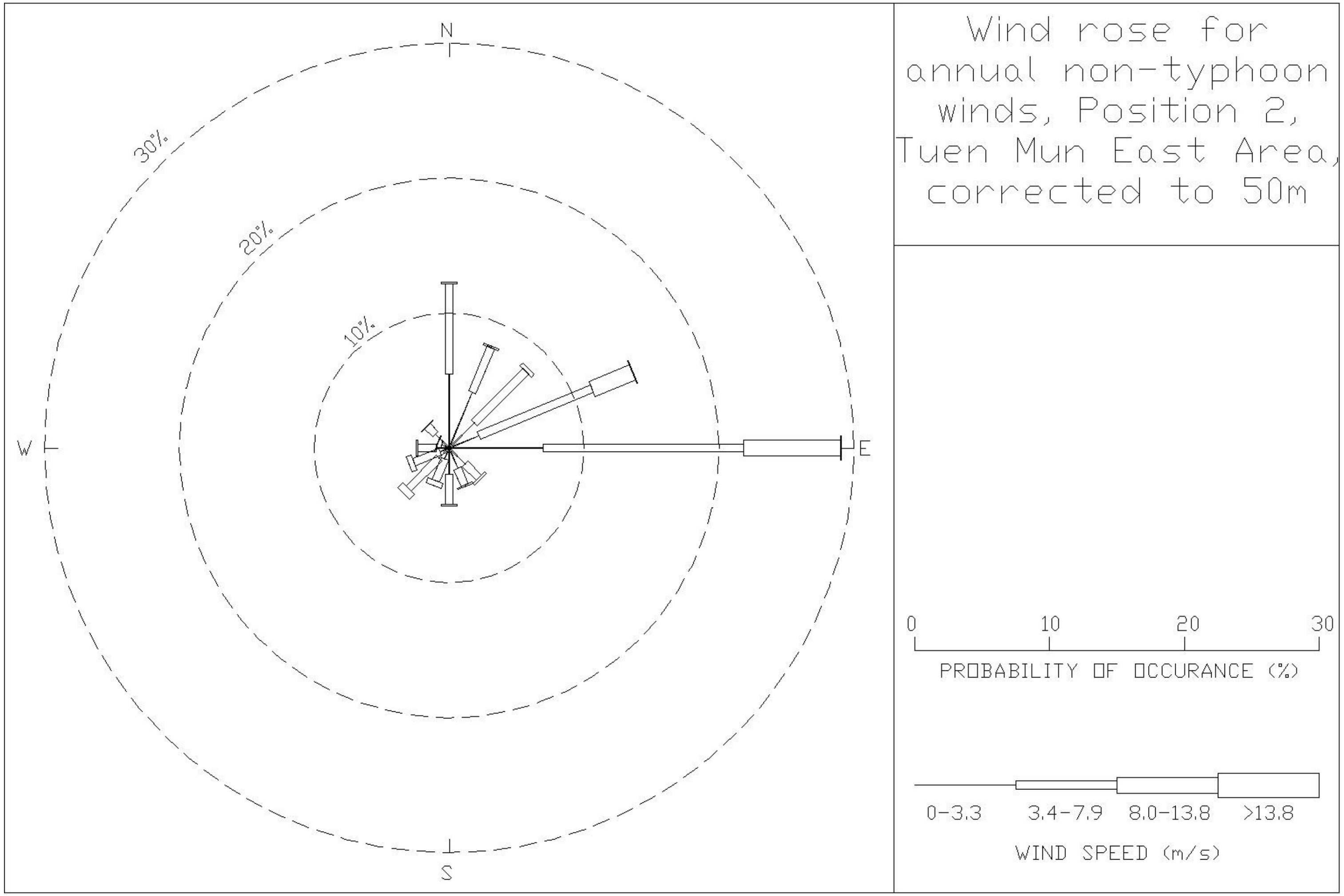

Figure 41: Wind rose for annual, non-typhoon winds for Position 2 of the Tuen Mun East Area, corrected to 50m

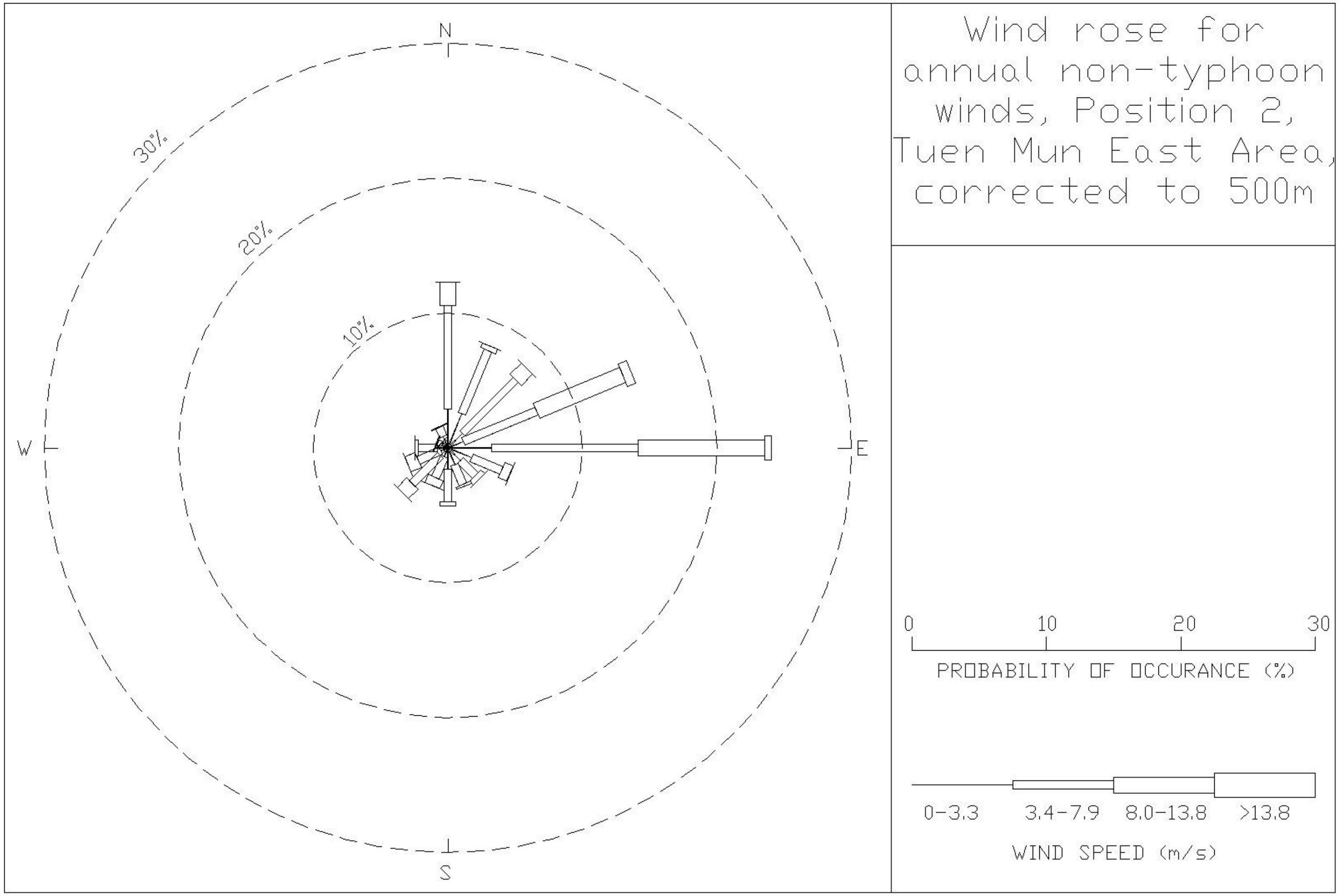

Figure 42: Wind rose for annual, non-typhoon winds for Position 2 of the Tuen Mun East Area, corrected to 500m

APPENDIX A: TABULATED RESULTS FOR POSITION 1, TUEN MUN EAST AREA

Table A1: Site wind characteristics, Position 1, Tuen Mun East Area, 22.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.32	29.9	7.7	-2.5
50	**0.32**	30.1	6.2	-3.0
75	0.34	29.6	8.2	-4.5
100	0.35	28.0	11.6	-5.7
150	0.38	26.3	15.5	-7.5
200	0.40	25.6	17.4	-8.2
300	0.46	26.6	17.4	-9.5
400	0.57	25.5	15.4	-8.7
500	**0.75**	20.4	12.3	-6.9

Table A2: Site wind characteristics, Position 1, Tuen Mun East Area, 45º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.40	24.2	-8.3	-7.2
50	**0.44**	21.9	-4.3	-8.2
75	0.46	21.0	-0.7	-8.3
100	0.48	20.4	2.1	-8.8
150	0.51	19.9	4.3	-8.5
200	0.55	19.8	6.0	-8.3
300	0.63	18.8	6.0	-7.2
400	0.75	15.5	3.6	-5.7
500	**0.85**	11.9	1.9	-4.3

Table A3: Site wind characteristics, Position 1, Tuen Mun East Area, 67.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.57	16.2	2.2	-4.5
50	**0.62**	15.1	2.2	-4.2
75	0.66	14.6	2.1	-4.0
100	0.69	13.9	2.3	-3.5
150	0.73	12.7	2.6	-3.2
200	0.78	12.0	2.7	-3.1
300	0.84	11.3	3.6	-2.8
400	0.91	10.2	3.8	-2.6
500	**0.97**	9.0	3.8	-2.3

Table A4: Site wind characteristics, Position 1, Tuen Mun East Area, 90º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.66	14.3	-1.7	-2.9
50	**0.71**	13.0	-0.9	-2.7
75	0.75	12.5	0.0	-2.4
100	0.78	11.7	0.3	-2.4
150	0.83	11.1	0.7	-2.3
200	0.87	10.2	0.4	-2.4
300	0.92	9.3	0.0	-2.1
400	0.97	8.6	-0.4	-1.9
500	**1.01**	7.5	-0.9	-1.8

Table A5: Site wind characteristics, Position 1, Tuen Mun East Area, 112.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.64	17.4	5.9	1.7
50	**0.68**	16.0	5.4	1.8
75	0.71	14.9	5.4	1.3
100	0.74	14.4	5.0	1.2
150	0.78	13.6	4.1	1.2
200	0.80	12.9	3.2	1.1
300	0.86	11.6	2.2	1.3
400	0.90	10.8	1.1	1.6
500	**0.95**	9.4	0.2	1.6

Table A6: Site wind characteristics, Position 1, Tuen Mun East Area, 135º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.59	17.0	5.2	-0.2
50	**0.64**	15.3	2.5	0.2
75	0.69	14.5	0.6	0.3
100	0.72	13.7	-1.1	0.5
150	0.77	12.2	-3.6	1.0
200	0.83	10.4	-5.2	1.3
300	0.87	8.5	-7.1	1.5
400	0.90	8.2	-8.5	1.4
500	**0.94**	7.6	-9.5	1.4

Table A7: Site wind characteristics, Position 1, Tuen Mun East Area, 157.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.55	16.9	10.2	-4.2
50	**0.59**	15.7	8.0	-2.7
75	0.62	15.2	6.4	-2.3
100	0.65	14.6	4.8	-1.9
150	0.69	13.8	2.2	-0.8
200	0.74	12.5	0.0	0.3
300	0.79	10.6	-1.3	1.1
400	0.82	10.3	-1.9	1.4
500	**0.84**	10.1	-2.6	1.5

Table A8: Site wind characteristics, Position 1, Tuen Mun East Area, 180º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.48	23.0	3.0	2.8
50	**0.53**	19.9	2.7	4.6
75	0.57	17.8	3.4	5.0
100	0.60	16.0	3.5	4.8
150	0.65	14.1	3.0	4.6
200	0.68	13.8	2.6	4.3
300	0.72	12.7	2.4	4.4
400	0.78	11.9	2.0	3.5
500	**0.82**	11.7	2.2	3.6

Table A9: Site wind characteristics, Position 1, Tuen Mun East Area, 202.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.62	13.0	6.7	-3.9
50	**0.70**	9.9	4.3	-0.6
75	0.73	9.4	4.3	0.2
100	0.75	8.8	4.3	0.6
150	0.80	8.4	4.3	1.3
200	0.82	8.0	4.3	1.6
300	0.86	7.2	4.4	2.2
400	0.90	6.9	4.3	2.2
500	**0.93**	6.6	4.6	2.4

Table A10: Site wind characteristics, Position 1, Tuen Mun East Area, 225°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.55	17.6	-11.0	-0.1
50	**0.62**	13.8	-7.7	1.8
75	0.66	12.5	-6.4	2.1
100	0.69	11.8	-5.2	2.7
150	0.74	10.3	-4.4	3.2
200	0.78	9.6	-3.3	3.4
300	0.83	8.6	-2.7	3.6
400	0.86	8.1	-2.1	3.5
500	**0.89**	7.4	-1.4	3.6

Table A11: Site wind characteristics, Position 1, Tuen Mun East Area, 247.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.58	15.0	-8.6	-3.6
50	**0.61**	14.1	-8.2	-2.5
75	0.64	13.6	-5.2	-1.7
100	0.67	12.8	-4.1	-1.3
150	0.72	12.1	-1.8	-0.6
200	0.76	11.2	-0.9	0.0
300	0.84	8.8	-0.8	0.7
400	0.89	7.1	-1.0	0.9
500	**0.92**	6.6	-0.6	0.9

Table A12: Site wind characteristics, Position 1, Tuen Mun East Area, 270°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.73	11.5	1.7	-3.2
50	**0.79**	10.4	1.7	-2.5
75	0.82	10.0	1.9	-2.2
100	0.84	9.8	2.3	-2.0
150	0.85	9.3	2.8	-1.7
200	0.88	9.0	2.8	-2.1
300	0.91	8.3	2.7	-2.2
400	0.94	7.8	2.4	-2.2
500	**0.96**	7.3	2.2	-2.0

Table A13: Site wind characteristics, Position 1, Tuen Mun East Area, 292.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.58	21.5	11.8	-1.2
50	**0.63**	19.7	9.1	-1.1
75	0.66	18.4	6.0	-1.5
100	0.69	17.7	4.6	-1.6
150	0.74	16.5	1.9	-2.2
200	0.79	15.4	0.6	-2.6
300	0.87	13.2	-0.4	-3.2
400	0.94	11.7	-0.5	-3.3
500	**0.97**	11.3	0.3	-3.4

Table A14: Site wind characteristics, Position 1, Tuen Mun East Area, 315°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.49	23.2	20.2	-4.6
50	**0.56**	21.3	16.6	-5.1
75	0.61	19.3	13.5	-5.6
100	0.65	17.9	10.6	-5.7
150	0.71	15.5	7.6	-5.4
200	0.76	14.2	6.3	-5.0
300	0.83	12.4	5.4	-4.2
400	0.89	11.3	5.0	-3.5
500	**0.94**	10.0	4.8	-2.9

Table A15: Site wind characteristics, Position 1, Tuen Mun East Area, 337.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.51	20.6	20.7	-6.3
50	**0.55**	20.1	19.5	-7.3
75	0.60	19.4	16.6	-7.8
100	0.65	18.0	13.9	-8.3
150	0.76	15.2	9.6	-7.9
200	0.83	12.3	7.3	-7.2
300	0.94	8.6	4.9	-6.4
400	0.98	7.4	4.2	-5.7
500	**1.00**	7.0	3.9	-5.0

Table A16: Site wind characteristics, Position 1, Tuen Mun East Area, 360º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.33	36.1	14.0	0.7
50	**0.37**	31.9	24.1	-3.6
75	0.39	30.8	25.3	-5.7
100	0.41	29.7	26.2	-7.1
150	0.44	29.4	25.5	-8.0
200	0.46	29.2	24.3	-8.2
300	0.50	30.2	20.6	-9.1
400	0.62	29.6	12.0	-8.6
500	**0.79**	23.9	4.5	-6.6

APPENDIX B: TABULATED RESULTS FOR POSITION 2, TUEN MUN EAST AREA

Table B1: Site wind characteristics, Position 2, Tuen Mun East Area, 22.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.46	21.9	-8.8	-2.6
50	**0.50**	19.9	-7.7	-2.6
75	0.53	18.9	-4.8	-3.0
100	0.55	18.4	-2.8	-3.4
150	0.60	17.4	-0.8	-4.1
200	0.64	16.8	0.7	-4.1
300	0.75	14.3	1.4	-3.8
400	0.86	11.0	0.8	-3.1
500	**0.91**	8.8	0.6	-2.4

Table B2: Site wind characteristics, Position 2, Tuen Mun East Area, 45°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.58	15.6	9.0	-3.0
50	**0.62**	15.2	8.8	-3.1
75	0.65	14.5	8.1	-3.1
100	0.69	13.5	7.6	-3.3
150	0.75	12.0	5.9	-3.1
200	0.79	10.9	5.5	-2.8
300	0.85	9.7	4.5	-2.3
400	0.90	8.9	4.0	-2.0
500	**0.93**	8.0	3.9	-1.6

Table B3: Site wind characteristics, Position 2, Tuen Mun East Area, 67.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.60	17.1	0.8	-1.7
50	**0.65**	16.1	1.5	-2.1
75	0.70	15.1	2.6	-2.3
100	0.74	14.3	3.2	-2.3
150	0.82	12.1	3.5	-2.0
200	0.88	10.8	3.0	-1.7
300	0.89	10.4	2.4	-1.4
400	0.91	10.4	1.6	-1.2
500	**0.92**	10.7	0.7	-1.2

Table B4: Site wind characteristics, Position 2, Tuen Mun East Area, 90º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	15.4	5.1	-2.4
50	**0.62**	15.1	4.9	-2.1
75	0.64	14.7	5.7	-1.9
100	0.67	14.5	5.5	-2.0
150	0.70	14.4	5.4	-1.8
200	0.73	14.0	4.3	-2.0
300	0.78	13.2	2.2	-1.9
400	0.87	12.0	0.6	-1.9
500	**0.93**	10.0	-0.3	-1.9

Table B5: Site wind characteristics, Position 2, Tuen Mun East Area, 112.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.51	23.5	17.0	0.9
50	**0.56**	22.1	15.8	0.3
75	0.60	20.8	13.4	-0.1
100	0.63	20.0	12.5	-0.7
150	0.67	18.8	10.9	-0.6
200	0.73	17.5	9.6	-0.4
300	0.80	14.8	8.3	0.1
400	0.87	12.5	8.1	0.1
500	**0.94**	9.2	7.8	0.1

Table B6: Site wind characteristics, Position 2, Tuen Mun East Area, 135º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	16.0	5.0	1.5
50	**0.69**	13.3	5.5	0.8
75	0.74	11.3	5.6	0.3
100	0.77	10.8	5.2	0.3
150	0.80	10.2	5.0	0.1
200	0.83	9.5	4.5	-0.2
300	0.88	8.5	4.0	-0.2
400	0.91	8.0	3.6	-0.1
500	**0.96**	6.9	3.5	0.1

Table B7: Site wind characteristics, Position 2, Tuen Mun East Area, 157.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.60	14.8	8.4	-1.6
50	**0.66**	13.7	7.4	-1.3
75	0.69	12.8	7.2	-1.3
100	0.72	12.2	7.3	-1.3
150	0.75	11.9	7.6	-1.2
200	0.76	11.5	7.7	-1.0
300	0.79	11.3	7.7	-0.7
400	0.82	10.8	7.7	-0.5
500	**0.87**	10.2	7.5	-0.8

Table B8: Site wind characteristics, Position 2, Tuen Mun East Area, 180°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.57	14.0	10.1	-3.8
50	**0.61**	13.1	9.0	-3.0
75	0.65	12.2	8.2	-2.8
100	0.68	11.7	8.3	-2.5
150	0.70	11.4	8.0	-2.1
200	0.71	11.0	7.8	-1.6
300	0.74	11.2	7.0	-1.5
400	0.77	11.1	6.9	-1.2
500	**0.80**	11.3	6.6	-1.0

Table B9: Site wind characteristics, Position 2, Tuen Mun East Area, 202.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.74	9.3	3.8	-2.2
50	**0.80**	8.4	3.0	-1.7
75	0.83	8.0	2.8	-1.6
100	0.85	7.6	2.7	-1.5
150	0.88	7.3	2.4	-1.6
200	0.90	7.0	2.3	-1.7
300	0.92	6.9	2.1	-1.7
400	0.95	6.8	2.2	-1.6
500	**0.97**	6.7	2.4	-1.3

Table B10: Site wind characteristics, Position 2, Tuen Mun East Area, 225°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.65	11.4	-0.7	-0.8
50	**0.71**	10.1	-0.6	-0.3
75	0.76	9.3	-0.3	-0.3
100	0.78	8.8	0.1	-0.3
150	0.81	8.5	0.4	-0.1
200	0.84	7.9	0.8	0.0
300	0.87	7.4	1.4	0.5
400	0.90	7.0	1.5	0.8
500	**0.93**	6.6	1.8	0.9

Table B11: Site wind characteristics, Position 2, Tuen Mun East Area, 247.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.63	11.6	1.1	-0.9
50	**0.70**	10.1	0.5	-0.3
75	0.75	9.2	0.4	-0.2
100	0.76	8.8	0.9	0.0
150	0.81	7.9	0.8	0.2
200	0.83	7.4	1.3	0.4
300	0.86	6.8	1.4	0.6
400	0.89	6.4	1.7	0.9
500	**0.91**	6.2	1.9	1.0

Table B12: Site wind characteristics, Position 2, Tuen Mun East Area, 270°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.65	10.3	3.2	-4.2
50	**0.69**	9.8	2.7	-3.7
75	0.72	9.3	2.6	-3.5
100	0.74	9.1	2.9	-3.1
150	0.78	8.9	3.5	-3.0
200	0.80	8.8	3.9	-2.8
300	0.85	8.2	3.6	-2.7
400	0.90	7.4	3.2	-2.5
500	**0.95**	6.5	2.7	-2.4

Table B13: Site wind characteristics, Position 2, Tuen Mun East Area, 292.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.55	23.5	8.4	-2.8
50	**0.60**	21.4	7.7	-3.0
75	0.63	20.2	7.4	-3.6
100	0.67	19.3	6.7	-4.0
150	0.72	17.6	4.8	-4.7
200	0.77	16.6	3.7	-5.1
300	0.82	15.7	3.1	-5.0
400	0.86	15.0	3.5	-5.2
500	**0.87**	15.2	5.1	-4.7

Table B14: Site wind characteristics, Position 2, Tuen Mun East Area, 315°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.52	19.5	8.7	-4.5
50	**0.55**	18.6	8.5	-4.1
75	0.60	17.2	8.5	-4.2
100	0.63	16.7	8.1	-4.4
150	0.67	16.1	7.8	-4.1
200	0.72	14.7	6.9	-4.0
300	0.79	13.0	5.4	-3.6
400	0.85	11.2	4.9	-3.2
500	**0.90**	9.9	4.4	-2.9

Table B15: Site wind characteristics, Position 2, Tuen Mun East Area, 337.5°

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (°)	Pitch angle (°)
25	0.55	20.3	23.2	-5.1
50	**0.56**	20.1	22.9	-4.9
75	0.58	19.5	22.8	-5.5
100	0.59	20.0	22.1	-5.6
150	0.59	20.4	20.5	-5.6
200	0.59	20.2	18.5	-6.1
300	0.60	20.8	15.0	-6.8
400	0.65	20.2	11.2	-6.8
500	**0.76**	18.0	7.6	-6.2

Table B16: Site wind characteristics, Position 2, Tuen Mun East Area, 360º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.39	33.1	-12.9	-0.9
50	**0.42**	32.2	-9.0	-4.2
75	0.45	31.7	-7.7	-5.8
100	0.47	30.8	-4.1	-7.1
150	0.52	29.4	-1.3	-7.7
200	0.60	25.9	-0.6	-8.6
300	0.72	21.1	1.2	-8.2
400	0.86	14.9	1.2	-7.0
500	**0.93**	11.4	1.5	-5.5

APPENDIX C: AXIS SYSTEM OF THE COBRA PROBE

The following figures show the standard axis system of the Cobra Probe:

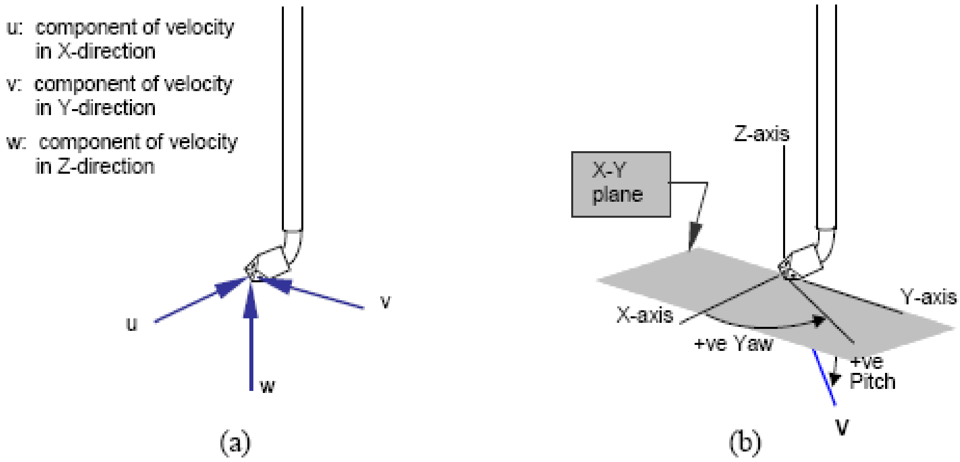

Figure C1: (a) Flow axis system with respect to the Cobra Probe head;
(b) Positive flow pitch and yaw angles

Note: Yaw angle is technically 'azimuth' (rotation angle about the z-axis); Pitch angle is technically 'elevation' (the angle between the flow velocity vector V and the X-Y plane).

Annex B
Expert Evaluation

EXECUTIVE SUMMARY

I At the request of Scott Wilson Limited, an Expert Evaluation was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an air ventilation study under Agreement No. CE47/2006(TP), Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study. The Expert Evaluation was conducted to assess likely pedestrian level wind conditions for the proposed developments in Tuen Mun East Study Area.

II The Tuen Mun East Study Area is bounded by the Tuen Mun River Channel and Hoi Wing Road to its west, Tai Lam Country Pack to its north, Tai Lam Chung Nullah to its east and the coastline to its south. The Study Area comprises a total of 14 study sites in various locations that are currently covered by two Outline Zoning Plans (OZPs), namely the Tuen Mun OZP and the So Kwun Wat OZP.

III For the purposes of this Expert Evaluation, a qualitative assessment of site wind availability at the proposed Tuen Mun Study Area was based on a statistical analysis conducted by Hong Kong Observatory of hourly mean wind speed data for all winds measured at Tuen Mun and WWTF's statistical model of the upper level Hong Kong non-typhoon wind climate, that is based on HKO data measured at Waglan Island. The prevailing non-typhoon winds affecting the Tuen Mun East Study Area are expected to come from south to south-westerly and easterly directions during the summer months.

IV Pedestrian level wind conditions in the Tuen Mun East Study Area are likely to be highly variable due to the effects of ground elevation, proximity and form of significant topography and the variety of building heights, forms and orientations. Specific recommendations were made for each of the study sites considered.

V In general, the non-building areas aligned approximately south to north that have been reserved in Sites 1, 2, 3, 7, 8, 11 and 14 are expected to be more effective than those with a more east to west alignment due to the likely moderating effects of the mixed and complex terrain to the east of the Tuen Mun Study Area. Nevertheless, it is recommended that all of the proposed non-building areas be retained. The effects of southerly winds are likely to be most significant at sites that are located in close proximity to the Tuen Mun coastline, such as Sites 1, 6 and 11. Although the elevation of the topography generally increases from south to north, the complexity of the terrain and the effects of some existing buildings are likely to moderate southerly winds at sites that are further inland.

VI Sites requiring an initial air ventilation study are Sites 1, 2, 3, 4A, 5 (lower), 7, 8, 10, 11 and 14. Sites that do not require an initial air ventilation study are Sites 4B, 5 (middle), 5 (upper), 6, 9, 12 and 13.

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1 INTRODUCTION

1.1 Project Background

1.1.1 At the request of Scott Wilson Limited, an Expert Evaluation was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an air ventilation assessment under Agreement No. CE47/2006(TP) Planning and Engineering Review of Potential Housing and G/IC Sites in the Tuen Mun East Area – Feasibility Study. The Expert Evaluation was conducted to assess likely pedestrian level wind conditions in the vicinity of the proposed developments in the Tuen Mun East Study Area. Proposed layouts of all study sites considered in this Expert Evaluation were supplied for air ventilation assessment (AVA) purposes by Scott Wilson Limited, during the period of September 2007 to April 2009. In particular, the indicative layouts for GIC uses at Sites 1, 2, 3, 4A and 8 are provided by Planning Department for the purpose of conducting air ventilation assessment only.

1.1.2 The Tuen Mun East Study Area is bounded by the Tuen Mun River Channel and Hoi Wing Road to its west, Tai Lam Country Pack to its north, Tai Lam Chung Nullah to its east and the coastline to its south. The Study Area comprises a total of 14 study sites in various locations and at various elevations, as shown in Figure 1. These study sites are currently covered by two Outline Zoning Plans (OZPs), namely the Tuen Mun OZP and the So Kwun Wat OZP.

1.1.3 The specific objectives of this Expert Evaluation are to:

- Analyse key features of the Study Area and the design features of the 14 development sites that are likely to affect the wind characteristics at the sites;
- Identify major potential air paths and comment on the localised wind effects within the Study Area;
- Identify positive design features in air ventilation terms for the 14 development sites;
- Identify potential problem areas and issues in air ventilation terms that may affect the design/layout of the 14 development sites and propose mitigation measures; and
- Recommend if an Initial Study should be carried out for any the 14 sites and the focus and methodologies for the studies, if required, and justifications for not recommending particular sites for an Initial Study.

1.1.4 This report summarises the outcomes of the Expert Evaluation that is based on a site visit to the Tuen Mun East Study Area, studies of WWTF's 1:2000 scale topographical model and 1:400 scale detailed model of the study sites and surrounding areas, and a study of plans and drawings supplied by Scott Wilson Limited.

1.2 Details of the Tuen Mun East Study Area

1.2.1 Under the Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study, the Tuen Mun East Study Area is proposed to include areas for low-rise houses, medium-rise apartments and a variety of Government, institution or community (G/IC) facilities. Five of the proposed development sites, namely Sites 1, 2, 3, 4A and 8, are intended for G/IC use. Ten of the proposed development sites, namely Site 4B, Sites 5 to 7 inclusive and Sites 9 to 14 inclusive, are intended for residential use.

2 SITE WIND AVAILABILITY

2.1 For the purposes of this Expert Evaluation and the wind tunnel study of air ventilation which will be conducted in later stage, an experimental Site Wind Availability Study was conducted at WWTF (as reported in Investigation Report WWTF011-2008) for the Tuen Mun East Study Area. Wind data collected by Hong Kong Observatory (HKO) at their Tuen Mun automatic weather station, as reported by Ng and Cheng (1999) and WWTF's statistical model of the upper level Hong Kong non-typhoon wind climate were also taken into consideration for the purpose of this Expert Evaluation.

2.2 Site wind characteristics were previously measured at two location as shown in Figure 2. As reported in WWTF011-2008, the directional characteristics of the winds at a height of 500 m at the two measurement locations above the study area are similar to those for non-typhoon winds approaching Hong Kong, except for winds from 22.5° above Position 1, which recorded a significant change in wind direction. At a height of 50 m above Position 1 and an elevation of 50 mPD at Position 2, winds from the north-east and north-west quadrants were significantly affected by the Tai Lam Country Park to the north of the study area, causing significant reductions in the magnitudes of mean wind speed and changes to the directional distribution in the corresponding directions. Winds approaching from southerly directions were the least affected due to the area's more open exposure in those directions.

2.3 As reported by Ng and Cheng (1999), during the period of 1988 to 1998, the anemometer at Tuen Mun has been located at heights of 68.1 m and 69.4 m above mean sea level on the roof of the Tuen Mun Government Offices Building, which has a height of 62.6 m above mean sea level. It is considered likely that the rooftop location and the presence of parapets would affect the wind speed measurements taken at the anemometer locations. Furthermore, as the anemometer site is located in the Tuen Mun River valley, it is sheltered by mountains and hills to the east and west, with the most open exposures to the north-north-east and the south. Typhoon winds were not excluded from the analysis of Ng and Cheng (1999) and hence it is also expected that the maximum measured wind speeds would correspond to strong winds associated with typhoons, which typically come from south-easterly directions in Hong Kong.

2.4 Although it is only possible to consider general qualitative trends from the results of the study of Ng and Cheng (1999), the annual wind rose for Tuen Mun, reproduced in Figure 3, gives a general indication of the importance of southerly winds for areas on the western side of Kowloon. Analyses of monthly wind data conducted by Ng and Cheng (1999) demonstrated that southerly winds are of particular importance during the summer months of June, July and August. Similarly, summer windroses determined from WWTF's analyses of HKO data collected at Waglan Island also indicates that south to south-westerly winds occur frequently during the summer months. The three wind roses presented in Figure 4 to Figure 5 also indicate that the prevailing non-typhoon winds affecting Hong Kong are associated with north-easterly monsoons during the winter months, south to south-westerly sea breezes during the summer months and easterly winds that can occur throughout the year.

2.5 The complex topography and variety of locations and elevations of the study sites in Tuen Mun East will cause considerable variation in exposure to winds over the Study Area. Nevertheless, south to south-westerly winds are expected to be an important summer wind resource for most sites due to the topography and orientation of the coastline in the Tuen Mun East Study Area, and the form of the surrounding topography. The shielding provided by the mountains in Tai Lam Country Park to the north and east of the Tuen Mun East Study Area are expected to significantly diminish pedestrian level wind speeds during periods of northerly to easterly winds at sites that are located at low elevations and sites that are shielded by significant topography. Sites that are located very close to the coastline are likely to benefit to a certain extent from their greater exposure to easterly winds. Sites at higher elevations are typically located towards the east of the Study Area and in closer proximity to Tai Lam Chung Reservoir. Some penetration of easterly winds is likely at those sites and they are also likely to benefit from the cooling effects of the relatively large expanse of water held in Tai Lam Chung Reservoir. In general, north to north-easterly winds are likely to be significantly diminished in the Tuen Mun East Study Area due to the large mountains in Tai Lam Country Park.

3 EVALUATION OF PEDESTRIAN LEVEL WIND CONDITIONS WITHIN AND ADJACENT TO THE PROJECT SITES

3.1 Existing Pedestrian Level Wind Conditions

3.1.1 Due to the size of the Tuen Mun East Study Area and the variation of topography and building height and form over its extent, it is expected that pedestrian level wind conditions will vary significantly at the various study sites. Within the Study Area, the existing landscape comprises a mixture of hills, platforms at various elevations and buildings ranging in height from low-rise detached houses to multi-storey residential apartment blocks. It is evident that environmental wind effects were not the main consideration in the planning process for the majority of the existing developments.

3.1.2 The largest existing residential developments in the Study Area are located in relatively close proximity to the coastline, including Aegean Coast, Hong Kong Gold Coast, Peridot Court, The Hillgrove and Aqua Blue. The arrangements of these residential estates are likely to create regions of relatively low wind flow on the leeward sides of the buildings within the estates and in the immediate surrounding areas due to their height, spacing and shape. However, as these developments are mostly surrounded by significant areas of undeveloped land with significant tree coverage, winds are currently able to flow around the estates and penetrate further inland into other parts of the Study Area.

3.1.3 The routes taken by the main arterial roads through the Study Area, namely Castle Peak Road and Tuen Mun Road, are largely governed by and follow the form of the topography and the coastline. Tuen Mun Road is elevated relative to the immediate surrounding areas in many locations and a number of noise barriers have also been erected along Castle Peak Road in areas adjacent to residential developments. These are likely to create localised sheltering effects at pedestrian level, particularly for south to south-westerly winds.

3.1.4 A number of secondary roads branch off from Castle Peak Road and follow irregular paths to the various residential estates and villages located along the coastal and hillside areas. The secondary roads are not expected to be efficient air paths. Low-rise to medium-rise buildings that are located along Castle Peak Road are relatively well-spaced and hence they are not expected to create a significant obstruction to wind penetration. The large areas of undeveloped land in the Study Area are currently the main means of allowing wind penetration from the coastline to areas further inland.

3.1.5 Based on a previously conducted Site Wind Availability Study (as reported in Investigation Report WWTF011-2008) and an examination of available wind data from Tuen Mun and Waglan Island, the prevailing non-typhoon winds in the Tuen Mun East Study Area are expected to come from south to south-westerly and easterly directions due to effects of the nearby topography.

3.2 Site 1

3.2.1 Site 1 covers an area of 1.6 hectares and is located to the north of Castle Peak Road and Cafeteria Beach, to the south of Tuen Mun Road and Site 7, and adjacent to the existing Immigration Service Institute of Training and Development Building that is located to its north-west. Site 1 is part of a former military site in Area 48 and it has been reserved for G/IC purposes to accommodate a post-secondary education institution. The location and proposed layout of Site 1 is shown in Figure 6.

3.2.2 Due to its relatively close proximity to the coastline, with only Castle Peak Road and scattered buildings with heights of 8 to 10 m located in the intervening area, Site 1 has a relatively open exposure to winds from the south to the south-west. Existing buildings around Site 1 are generally irregularly dispersed and shorter than those proposed for Site 1, except for The Immigration Service Institute of Training and Development Building to the north-west. In general, this is likely to facilitate wind penetration into nearby areas.

3.2.3 The ground elevation of Site 1 is lower than areas to its north and north-east, with its largest area at an elevation of +7.6 mPD and a second smaller area at +22 mPD. The hillside areas adjacent to the site, and the surrounding areas to the north and north-east, have a relatively dense coverage of existing mature trees. Site 1 is also sheltered by nearby embankments, hills and Tuen Mun Road to the north-east (elevation approximately +30 mPD), large mountains to the north and the elevated area of Site 7 to the north-east.

3.2.4 The proposed buildings for Site 1 include three rectangular buildings with heights of approximately 30 m at the area with a ground elevation of +7.6 mPD, and one L-shaped building with a height of approximately 15 m at the area with a ground elevation of +22 mPD. The proposed buildings are arranged to preserve two non-building areas; one is aligned approximately south-west to north-east and has a width of 15 m and the second is aligned approximately south-east to north-west and has a width of 10 m.

3.2.5 The south-west to north-east non-building area is likely to be an effective air path that will facilitate the penetration of south to south-westerly winds into Site 1. The proposed south-east to north-west non-building area is likely to be less effective in conveying south-east to easterly winds into Site 1 due to the close proximity of hills to the south-east and east of Site 1. Nevertheless, the two non-building areas are considered to be positive design aspects of the proposed development and it is recommended that they be retained to facilitate wind penetration into the adjacent areas. The relatively low heights of the proposed buildings are also likely to generally facilitate wind penetration.

3.2.6 It is unlikely that north to north-easterly winds will penetrate into Site 1 due to the sheltering effects of the large mountains in Tai Lam Country Park, nearby hills and building developments. The similarity of the proposed building heights in Site 1 is also likely to create localised zones of low wind flow on the leeward side of the buildings for some wind directions. It is recommended that additional trees be planted within Site 1 to provide shade and to alleviate the effects of low winds during the hotter summer months.

3.2.7 In summary:

- Site 1 has a relatively open exposure to south to south-westerly winds and is sheltered by terrain and topography to the north and east.

- The proposed south-west to north-east non-building area is likely to be an effective air path that will facilitate the penetration of south to south-westerly winds into Site 1. The proposed south-east to north-west non-building area is likely to be less effective in conveying south-east to easterly winds into Site 1 but is still considered to be a positive design feature.

- The relatively low heights of the proposed buildings in Site 1 are also likely to facilitate general wind penetration; however, the similarity of the proposed building heights is likely to create localised zones of low wind flow for some wind directions.

- Additional tree planting is recommended for Site 1.

3.3 Site 2

3.3.1 Site 2 covers an area of 3.7 hectares and is located to the north of Tuen Mun Road and Sites 3 and 8, and to the east of Site 7. Site 2 is also part of the former military site in Area 48 and it has been reserved for G/IC purposes for a proposed international school. The location and proposed layout of Site 2 is shown in Figure 7.

3.3.2 The majority of existing buildings in the areas around Site 2 are irregularly dispersed small village type abodes and other low-rise buildings earmarked for redevelopment in the adjacent Sites 3, 7 and 8. The ground elevation at Site 2 varies from +34 to +46.4 mPD and it is lower than the ground elevation of Site 7 to the west (+50 mPD and +60 mPD) and higher than the ground elevation of Site 3 (+10.8 to +16.9 mPD) and Site 8 (+10.5 to +17.7 mPD) to the south. Existing mature trees are present on the hills adjacent to the site and dispersed throughout the surrounding areas. Site 2 has varying exposures due to the varying ground elevations of its different areas. For example, all of Site 2 is generally sheltered by large mountains to the north, locations along the southern edge of Site 2 have relatively open exposures to southerly and easterly winds, and the north-east corner of Site 2 (+34 mPD) has a relatively limited exposure to easterly winds.

3.3.3 Buildings proposed for Site 2 include three rectangular buildings and four L-shaped buildings, with heights ranging from 6 to 8 storeys (approximately 22.5 to 30 m). The proposed buildings are separated by distances ranging from approximately 5 m to more than 40 m. Two 20 m wide north-south aligned non-building areas have been included in Site 2, along with one 15 m wide east-west aligned non-building area. The landscaping of Site 2 is relatively complicated and irregular due to the need to create man-made embankments between platforms with different ground elevations, and these are likely to cause some disruption to wind penetration.

3.3.4 The two north-south aligned non-building areas are likely to facilitate the penetration of southerly winds into Site 2, and while those winds are likely to be of moderate strength they are expected to be important for air ventilation in the hotter summer months. The effectiveness of the proposed east-west aligned non-building area in conveying easterly winds to Site 2 and beyond is likely to be limited due to the varying ground elevations in Site 2, the alignment of the embankments in Site 2 and the general disruption to those winds caused by the complex topography to the east of Site 2. It is unlikely that north to north-easterly winds will penetrate into Site 2 due to the proximity of the large mountains in Tai Lam Country Park and the shelter provided by the varying ground elevations. Locations along the southern edge of Site 2 are likely to benefit from their exposure to southerly and easterly winds. Nevertheless, the combination of higher ground elevations and the proposed non-building areas in Site 2 are considered to be positive air ventilation features and it is recommended that the non-building areas be retained.

3.3.5 Due to the similarity of the building heights in Site 2, it is likely that localised regions of low wind flow will occur on the leeward side of the proposed buildings for some wind directions, particularly for the more closely spaced buildings. Wind penetration may be improved for south to south-westerly winds by adopting a stepped arrangement of building heights in which shorter buildings are located at the southern end of the site. A similar stepped/cascade effect could also be utilised for both buildings and ground elevations in Site 2 to enhance the penetration of easterly winds. It is recommended that additional trees be planted in Site 2 to provide shade and to alleviate the effects of low winds during the hotter summer months.

3.3.6 In summary:

- Site 2 is generally sheltered by large mountains to the north; locations along the southern edge of Site 2 have relatively open exposures to southerly and easterly winds; the north-east corner of Site 2 has a relatively limited exposure to easterly winds.

- The two north-south aligned non-building areas are likely to facilitate the penetration of south to south-westerly winds into Site 2

- The effectiveness of the proposed east-west aligned non-building area in conveying easterly winds to Site 2 and beyond is likely to be limited due to the varying ground elevations in Site 2, the alignment of the embankments in Site 2 and the general disruption to those winds caused by the complex topography to the east of Site 2.

- Recommendations/considerations: 1) locating shorter buildings at the southern and/or eastern ends of Site 2 to create a stepped/cascade effect of building heights may facilitate the penetration of easterly to southerly winds; 2) plant additional trees in Site 2.

3.4 Site 3

3.4.1 Site 3 covers an area of 2.3 hectares and is located to the north of Castle Peak Road and the Hong Kong Gold Coast residential estate, to the south of Tuen Mun Road and Site 2, and to the west of Site 8. Site 3 is also part of the former military site in Area 48 and it has been reserved for G/IC purposes. The location and proposed layout of Site 3 is shown in Figure 8.

3.4.2 Site 3 has varying exposures for different directions due to the surrounding terrain and topography and its varied ground elevations that range from +10.8 mPD to +16.9 mPD. The ground elevation at Site 3 is similar to that of Site 8 to the east and higher than that of the Hong Kong Gold Coast (approximately 5 mPD) to the south. Existing buildings in areas around Site 3 include the Hong Kong Gold Coast to the south and south-west, with heights ranging from approximately 20 m to approximately 70 m, and generally low-rise buildings earmarked for redevelopment in the adjacent Sites 2 and 8. Site 3 is sheltered from northerly winds by large mountains and the proposed developments in Site 2.

3.4.3 Two rectangular buildings and two L-shaped buildings are proposed for Site 3, with separation distances ranging from approximately 5 m to 20 m. The four proposed buildings have heights of approximately 30 m. Two 20 m wide non-building areas have been proposed, one with a north-south alignment and the other with an east-west alignment, the latter potentially providing an air path connecting with a non-building area in Site 8. A number of existing mature and very large trees are also present Site 3 and these should be retained where possible. Additional trees may also be planted within Site 3 to provide additional shade to alleviate the effects of low winds during the hotter summer months.

3.4.4 The ability of southerly winds to penetrate into Site 3 through the proposed north-south aligned non-building areas may be restricted by the taller Hong Kong Gold Coast towers located to the south of Site 3. It is expected that locations close to the southern edge of Site 3 will get some benefit from south to south-westerly winds, although their penetration further into Site 3 may also be limited by the proposed buildings in Site 3. The close spacing of the proposed buildings 1 and 3 in Site 3 is likely to create an area of low wind flow for southerly and easterly winds and increasing that spacing will facilitate wind penetration.

3.4.5 Wind penetration along the proposed east-west aligned non-building area is likely to be disrupted by the surrounding topography, mixed terrain and the sheltering effects of Site 8 to the east of Site 3. As building 1 is directly in the wind shadow of building 3 for easterly wind directions, a greater variation in building heights in Site 3 would also help to convey winds down to pedestrian level and potentially improve pedestrian level wind conditions. It is unlikely that north to north-easterly winds will penetrate into Site 3 due to the proximity of the large mountains in Tai Lam Country Park and the shelter provided by Tuen Mun Road.

3.4.6 In summary:

- The exposure of Site 3 to southerly winds is likely to be affected by buildings in the Hong Kong Gold Coast estate.
- The topography, mixed terrain and sheltering effects of Site 8 to the east of Site 3 are likely to moderate easterly wind penetration.
- Recommendations: 1) consider providing a greater variation in building heights in Site 3 to facilitate air ventilation at pedestrian level; 2) retain the existing trees in Site 3; 3) plant additional trees in Site 3.

3.5 Site 4

3.5.1 Site 4 is located to the north of Tuen Mun Road and covers three areas that are designated as Site 4A, Site 4B (lower) and Site 4B (upper). Site 4A has a ground elevation of +68 mPD, covers an area of 0.92 hectares and has been reserved for G/IC purposes as a site for a proposed secondary school. Site 4B (lower) is located immediately to the north-east of Site 4A, has a ground elevation of +80 mPD, covers an area of 0.77 hectares and has been proposed for residential purposes. Site 4B (upper) is located immediately to the south-east of Site 4B (lower), has ground elevations of +105 mPD, +111 mPD and +116 mPD, covers an area of 4.22 hectares and has been proposed for residential purposes. The location and proposed layout of Site 4 is shown in Figure 9.

3.5.2 The ground elevations at Site 4 are the highest of the 14 sites in the Tuen Mun East Study Area and its location at the top of a hill presents a variety of exposures for different wind directions. The mountains in Tai Lam Country Park to the north of Site 4 form the largest topographical feature near the Study Area and these will significantly diminish winds from northerly directions. Low-rise village housing is located at So Kwun Wat to the north-north-west, in a valley between the mountains and Site 4. Due to its elevation, the site also has a more open exposure to winds from the east to north-east that may flow above Tai Lam Chung Reservoir and hence bring slightly cooler winds to the site. There are currently very few intervening large developments between Site 4 and the coastline to the south, although the topography in this direction is complex and has a dense coverage of mature existing trees. In particular, Site 4B (upper) has relatively open exposures to easterly and southerly winds.

3.5.3 The secondary school buildings proposed for Site 4A comprise two irregularly shaped 4 storey buildings with high ground coverage. The proposed secondary school site will be largely shielded from winds from the north-east quadrant due to the large mountains in Tai Lam Country Park and the topography and proposed buildings in Site 4B (lower) and Site 4B (upper). The location of Site 4A currently has some exposure to south-westerly winds due to its ground elevation, although it is expected that south-westerly winds will be moderated to some extent by the intervening topography and the distance of Site 4A from the coast. The proposed alignment, arrangement and site coverage of the two school buildings are also expected to significantly impede south-westerly winds and low wind flow is expected between the two proposed buildings. To improve pedestrian level wind conditions at Site 4A, it is recommended that consideration be given to modifying the alignment and/or form and/or vary the height of the proposed school buildings to facilitate the penetration of south-westerly winds, and to plant a significant number of shade trees to alleviate the effects of low wind flow during the hotter summer months.

3.5.4 The buildings proposed for Site 4B (lower) comprise 14 rectangular 3 storey residential buildings with a general north-westerly aspect. Site 4B (lower) will be shielded from winds from the north-east quadrant due to the large mountains in Tai Lam Country Park and from east to south-easterly winds by the topography and developments at Site 4B (upper). The penetration of south to south-westerly winds into Site 4B (lower) is likely to be moderated by the surrounding topography, buildings proposed for Site 4A and its distance from the coast. The more open north-westerly aspect may allow north to north-westerly winds to penetrate into the site, although these are likely to be of moderate strength. The consistent height and close spacing of the proposed buildings in Site 4B (lower) is likely to diminish general wind penetration into this area. It is recommended that consideration be given to increasing the spacing between proposed buildings in Site 4B (lower) in combination with increasing and varying building height to facilitate wind penetration. It is also recommended to plant additional shade trees in Site 4B to provide some relief to residents during the hotter summer months.

3.5.5 The buildings proposed for Site 4B (upper) comprise 41 rectangular 3 storey residential buildings and a clubhouse with relatively open exposures to the east and south. The high ground elevations of Site 4B (upper) provides it with relatively open exposures to the prevailing winds that are likely to come from easterly and southerly directions. Some sheltering effects are expected at Site 4B (upper) for north to north-easterly winds due to the large mountains in Tai Lam Country Park. The different ground elevations and alignment of the proposed landscaping are likely to benefit Site 4B (upper), facilitating wind penetration to most areas in the site, but they are also likely to moderate pedestrian level wind speeds in Site 4B (lower) and Site 4A. Shade trees should be planted within Site 4B (upper) to further enhance pedestrian comfort during the hotter summer months. An initial air ventilation study of Site 4B (upper) is not required due to its positive design aspects and generally favourable location in terms of air ventilation.

3.5.6 In summary:

- The higher elevations of Site 4 provide relatively open exposures to south to south-westerly winds and some exposure to northerly and easterly winds.

- Recommendations: 1) consider modifying the alignment and/or form and/or vary the height of the proposed school buildings in Site 4A to facilitate the penetration of south-westerly winds; 2) consider increasing the spacing between proposed buildings in Site 4B (lower) in combination with increasing and varying building height to facilitate wind penetration; 3) plant additional trees in Site 4.

- An initial air ventilation study of Site 4B (upper) is not required.

3.6 Site 5

3.6.1 Site 5 is located north of Tuen Mun Road, east of Site 4B, and south west of the Tai Lam Chung Reservoir. The site comprises three areas that are designated as Site 5 (lower), Site 5 (middle) and Site 5 (upper), all of which have been proposed for residential purposes. Site 5 (lower) is located to the east of Site 13, covers an area of 4 hectares and has two platforms at ground elevations of +28 mPD and +40 mPD. Site 5 (middle) is located to the north-east of Site 5 (lower) at a ground elevation of +65 mPD and covers an area of 1.2 hectares. Site 5 (upper) is located to the north of Site 5 (middle), covers an area of 4.3 hectares and has two platforms at ground elevations of +55 mPD and +70 mPD. The locations and proposed layouts of Site 5 (lower), Site 5 (middle) and Site 5 (upper) are shown in Figure 10, Figure 11 and Figure 12 respectively.

3.6.2 The three areas within Site 5 are likely to have very different exposures to the prevailing wind directions due to their different ground elevations and the complexity of the surrounding topography. Existing buildings in the areas around Site 5 comprise irregularly dispersed lowrise village type housing, villas in residential estates and relatively high-rise apartments with heights of approximately 85 m. Site 5 (middle) and Site 5 (upper) are relatively isolated and at relatively high ground elevations relative to the surrounding developed areas, hence having reasonably open exposures to winds from the east to the south-west. The surrounding undeveloped areas are covered predominantly by existing mature trees. Similar to the other sites in the Tuen Mun East Study Area, northerly winds at Site 5 are expected to be slowed significantly by the large mountains in Tai Lam Country Park.

3.6.3 In its current configuration, the area at +28 mPD is quite sheltered and likely to experience conditions of low wind flow. It is likely that Tuen Mun Road will cause some sheltering from southerly winds, which will be increased if noise barriers are erected along Tuen Mun Road adjacent to Site 5 (lower). The area is also sheltered from easterly winds by neighbouring residential developments, such as Grand Pacific Views and Grand Pacific Heights, and from north-easterly winds by the nearby hills. The area at +40 mPD includes a private open space in its centre that will facilitate the ingress of southerly winds due to its close proximity to the coastline.

3.6.4 Buildings proposed for Site 5 (lower) include 34 rectangular 3 storey residential buildings and a club house. The proposed residential buildings have consistent heights which is likely to cause localised areas of low wind flow for some wind directions. Increasing the spacing between the proposed buildings, particularly in the +28 mPD area, may provide clearer air paths to facilitate wind penetration. Additional trees should be planted in Site 5 (lower) to provide shade and to alleviate the effects of low winds during the hotter summer months.

3.6.5 Site 5 (middle) has a more open exposure to southerly and easterly winds than Site 5 (lower) due to its higher ground elevation, although northerly and north-easterly winds are likely to moderated by the surrounding topography. Some moderation of southerly winds may also be experienced due to the existing buildings in the Grand Pacific estate to the south of Site 5 (middle). The access road to Site 5 (middle) provides a potential air path to the site for south-westerly winds and, if sufficiently wide, it may also facilitate wind penetration further into Site 5 (upper).

3.6.6 The proposed buildings in Site 5 (middle) comprise 24 rectangular 3 storey residential buildings with generally south-westerly and southerly aspects. The consistent height of the proposed buildings in Site 5 (middle) is likely to cause localised shielding at a number of areas, although the spacing between the buildings is likely to allow reasonable wind penetration. Due to the relative isolation of this area, Site 5 (middle) is unlikely to have significant effects on the surrounding developed areas. Consideration should be given to the planting of shade trees in Site 5 (middle) to alleviate the effects of low winds during the hotter summer months. An initial air ventilation study is not required for Site 5 (middle) due to its relatively isolated location, low building height and low building density.

3.6.7 Site 5 (upper) has relatively open exposures to the prevailing south to south-westerly and easterly winds due to its isolation and relatively high ground elevations. North-east to easterly winds may provide some cooling effects to the site as they flow above Tai Lam Chung Reservoir. However, the strength of those winds will be moderated by the large mountains in the surrounding areas. The +55 mPD area is likely to experience some sheltering for southerly winds due to its slightly lower ground elevation.

3.6.8 Buildings proposed for Site 5 (upper) include 52 rectangular 3 storey residential buildings and a club house. The +70 mPD area is likely to cause some shielding to the +55 mPD area during easterly winds, although the east-west alignment of the proposed buildings in the +70 mPD area is likely to facilitate wind penetration. The east-west alignment and close spacing of the buildings in the +70 mPD area will inhibit the penetration of southerly winds into this area. Consideration should be given to increasing the spacing between proposed buildings in Site 5 (upper) in combination with varying building heights to improve the potential for air ventilation for easterly and southerly wind directions. Shade trees are likely to be an important landscaping component for Site 5 (upper). An initial air ventilation study is not required for Site 5 (upper) due to its relatively isolated location, low building height and low building density.

3.6.9 In summary:

- Site 5 (lower) is relatively sheltered from southerly, easterly and north-easterly winds; Site 5 (middle) has a more open exposure to southerly and easterly winds than Site 5 (lower) due to its higher ground elevation, but it is sheltered from northerly and north-easterly winds; Site 5 (upper) has relatively open exposures to the prevailing south to south-westerly and easterly winds.

- Recommendations for Site 5 (lower): 1) increase the spacing between the proposed buildings, particularly in the +28 mPD area; 2) plant additional trees.

- Recommendations for Site 5 (middle): 1) maintain or increase the width of the access road to Site 5 (middle) and Site 5 (upper); 2) plant additional trees.

- Recommendations for Site 5 (upper): 1) increase the spacing between proposed buildings in Site 5 (upper) in combination with varying building heights; 2) plant additional trees.

- An initial air ventilation study is not required for Site 5 (middle) or Site 5 (upper) due to their relatively isolated location, low building height and low building density.

3.7 Site 6

3.7.1 Site 6 covers an area of 0.36 hectares and is located to the south of Castle Peak Road and adjacent to a beachside barbeque area. A single rectangular residential building with a height of approximately 20 m has been proposed for Site 6. The location and proposed layout of Site 6 are shown in Figure 13.

3.7.2 Due to its very close proximity to the coastline, Site 6 has a mostly open exposure to winds from the south-west. Although there are only a limited number of existing buildings located in areas close to Site 6, its low ground elevation (+4 mPD) relative to nearby areas, including Government married persons quarters and a hillside to the south-east, and embankments, hills and Castle Peak Road to the north, will create significant shielding from easterly and southerly winds. These are features of the existing topography that are very difficult and probably impractical to change.

3.7.3 The single proposed building is located at the south-western border of the development site and it has a uniform height. The current form of the building is likely to cause a localised area of low wind flow in the lee of the building during periods of south-westerly winds. Although these winds are typically only of moderate strength, they can be particularly beneficial during the summer months. However, this alignment and location of the proposed building may facilitate natural indoor ventilation. Consideration should be given to planting shade trees around the proposed building in Site 6.

3.7.4 An initial air ventilation study is not required for Site 6 due to its localised impact on pedestrian level air ventilation.

3.7.5 In summary:

- Site 6 has a mostly open exposure to winds from the south-west but its low ground elevation will create significant shielding from easterly and southerly winds.

- The current form of the single building in Site 6 is likely to cause a localised area of low wind flow in the lee of the building during periods of south-westerly winds but may facilitate natural indoor ventilation.

- Recommendations: plant additional trees in Site 6.

- An initial air ventilation study is not required for Site 6 due to its localised impact on pedestrian level air ventilation.

3.8 Site 7

3.8.1 Site 7 covers an area of 6.7 hectares and is located to the north of Tuen Mun Road and Site 1, and to the west of Site 2. Site 7 is also part of the former military site in Area 48 and it has been rezoned for residential use. The hills adjacent to the site and in surrounding areas currently have a dense coverage of mature trees. Existing buildings in nearby areas around Site 7 are generally low-rise buildings in the adjacent Sites 1, 2, 3 and 8 that are earmarked for redevelopment. Site 7 is generally sheltered from northerly winds by the mountains in Tai Lam Country Park. The location and proposed layout of Site 7 is shown in Figure 14.

3.8.2 Ground elevations (+25mPD, +50mPD and +60mPD) at Site 7 correspond to three major platforms that will accommodate a total of 24 proposed residential buildings with various orientations and a consistent roof elevation of +70 mPD. The area at +25 mPD will include 11 buildings with a height of 13 storeys (approximately 45 m high), the area at +50 mPD will include 7 buildings with a height of 6 storeys (approximately 20 m high), while 6 residential buildings, with a height of 3 storeys (approximately 3 m high), and one club house will be located in the area at +60 mPD. A 15 m wide non-building area, aligned approximately south-east to north-west, has also been proposed for the +25 mPD and +50 mPD areas of Site 7.

3.8.3 The area at +25 mPD is very sheltered by the surrounding topography and proposed developments for most wind directions. The closely spaced buildings and large site coverage in the area at +25 mPD are likely to have a significant negative effect on pedestrian level air ventilation. The consistent building elevation (+70 mPD) between all areas in Site 7 inhibits upper level winds being conveyed to pedestrian level. The effectiveness of the proposed non-building area to provide an air path is likely to be limited due to the general moderation of winds from the east and the south caused by the complex surrounding topography and proposed developments. Further sheltering effects will be created if a noise barrier is eventually constructed along Tuen Mun Road.

3.8.4 The area at +50 mPD currently has a relatively open exposure to south to south-westerly winds and the proposed building configurations and layout are expected to facilitate general wind penetration into this area. However, if a proposed noise barrier is constructed along the boundary of Site 7 and Tuen Mun Road it is likely to significantly impede the penetration of south to south-westerly winds into this area.

Easterly winds are likely to be moderated by proposed buildings in Site 2 and the complex terrain to the east of this area.

3.8.5 The area at +60 mPD has the most open exposure of the three areas in Site 7 to the prevailing wind directions due to its higher ground elevation. This area is likely to benefit from its more open exposures to the east, although the proposed buildings in the other two areas of Site 7 have the potential to moderate winds from the south to south-west.

3.8.6 It is recommended that consideration be given to reduce the number of buildings, increasing the spacing between buildings and vary the building heights in the +25 mPD and +50 mPD platforms to improve the potential of easterly and southerly winds to penetrate into these areas. This may be facilitated by widening the proposed non-building areas, align the proposed non-building area of the +25 mPD platform with the non-building area of the +50 mPD platform and introducing a north-south non-building area to further facilitate the penetration of southerly winds into these areas. It is also recommended to plant shade trees throughout Site 7.

3.8.7 In summary:

- The area at +25 mPD is very sheltered for most wind directions. The close spacing and consistent heights of buildings in this area are likely to have a significant negative effect on pedestrian level air ventilation. For this area it is recommended that the numbers of buildings be reduced, spacing between buildings be increased and building heights be varied. It is also recommended that the width and alignment of the proposed non-building area be adjusted and an additional north-south non-building area be introduced.

- The configurations and layout of the proposed buildings in the area at +50 mPD are expected to facilitate general wind penetration and are reasonably compatible with the area's exposure to south to south-westerly winds.

- The area at +60 mPD has relatively open exposures to the prevailing wind directions due to its higher ground elevation.

- Additional tree planting would benefit all of Site 7.

3.9 Site 8

3.9.1 Site 8 covers an area of 2.7 hectares and is located to the north of Castle Peak Road, to the north-east of the Hong Kong Gold Coast residential estate, to the south of Tuen Mun Road and Site 2, and to the east of Site 3. Site 8 is also part of the former military site in Area 48 and has been reserved for G/IC purposes. The location and proposed layout of Site 8 is shown in Figure 15.

3.9.2 Site 8 has varying exposures for different directions due to the surrounding terrain and topography and its proposed ground elevations range from +10.5 mPD to +17.7

mPD. The ground elevation at Site 8 is similar to that of Site 3 to its west and higher than the Hong Kong Gold Coast and the Aegean Coast. Existing buildings in areas around Site 8 include the Hong Kong Gold Coast to the south and south-west, with heights ranging from approximately 10 m to approximately 70 m, the Aegean Coast to the south-east, with tower heights of approximately 90 m, and generally low-rise buildings earmarked for redevelopment in the adjacent Sites 2 and 3. Site 8 is sheltered from northerly winds by large mountains.

3.9.3 Buildings proposed for Site 8 include two rectangular buildings, one L-shaped building and one T-shaped building, separated by distances ranging from approximately 5 m to 20 m. The four proposed buildings have heights of approximately 30 m and localised regions of low wind flows can be expected in the lee of the proposed buildings for southerly and easterly wind directions. Non-building areas with widths of 20 m have been proposed with a north-south alignment and an east-west alignment, the latter potentially connecting with a non-building area in Site 3. It is recommended that the non-building areas be maintained. A number of existing mature and very large trees are also present within Site 8 and these should be retained where possible. Additional trees may also be planted within Site 8 to provide shade and to alleviate the effects of low winds during the hotter summer months.

3.9.4 The ability of southerly winds to penetrate into Site 8 through the proposed north-south aligned non-building area may be moderated slightly by the taller Hong Kong Gold Coast and Aegean Coast towers located to the south of Site 8. Nevertheless, the alignment of the proposed buildings in Site 8 is likely to facilitate the penetration of the available southerly winds. Wind penetration along the proposed east-west aligned non-building area is likely to be moderated by the surrounding topography and mixed terrain to the east of Site 8. Locations close to the south-eastern corner of Site 8 are likely to benefit from southerly winds. It is unlikely that north to north-easterly winds will penetrate into Site 8 due to the proximity of the large mountains in Tai Lam Country Park and the shelter provided by Tuen Mun Road.

3.9.5 In summary:

- Site 8 has varying exposures for different directions due to the surrounding terrain and topography and its varied ground elevations.
- The penetration of southerly winds into Site 8 may be moderated by buildings in the Hong Kong Gold Coast and Aegean Coast. Nevertheless, the alignment of the proposed buildings in Site 8 is likely to facilitate the penetration of the available southerly winds.
- The surrounding topography and mixed terrain to the east of Site 8 is likely to moderate easterly winds.
- The proposed non-building areas should be maintained.
- Existing trees should be retained and additional trees should be planted in Site 8.

3.10 Site 9

3.10.1 Site 9 covers an area of 0.3 hectares and is located at Tuen Mun Area 55 between Castle Peak Road and Ka Wo Li Hill Road. A single irregularly shaped residential building with a height of approximately 20 m has been proposed for Site 9. The location and proposed layout of Site 9 are shown in Figure 16.

3.10.2 The ground elevation at Site 9 (+10 mPD) is significantly lower than the surrounding areas and it is significantly shielded due to hills to its north, the Hong Kong Gold Coast to its west and an existing noise barrier along Castle Peak Road to its south and west.

3.10.3 The proposed building is significantly taller than the existing residential building immediately adjacent to its south-east, Ngan Tsui House, and may have a sheltering effect on pedestrian level wind conditions there. However, as the largest sheltering effect is likely to be for north-westerly winds, and these are typically weak and infrequently occurring in Hong Kong, the overall effects may not be significant. Consideration should be given to reducing the site coverage of the proposed building. It is likely that landscaping and substantial planting of shade trees will be necessary to improve the pedestrian level wind environment in Site 9.

3.10.4 An initial air ventilation study is not required for Site 9 due to its localised impact on pedestrian level air ventilation.

3.10.5 In summary:

- Site 9 is significantly shielded due to hills to its north, the Hong Kong Gold Coast to its west and an existing noise barrier along Castle Peak Road to its south and west.
- The proposed building in Site 9 may have a sheltering effect on pedestrian level wind conditions at Ngan Tsui House for north-west winds, although these winds are typically weak and infrequently occurring.
- Recommendations: 1) consideration should be given to reducing the site coverage of the proposed building in Site 9; 2) make use of landscaping and substantial planting of shade trees to improve the pedestrian level wind environment in Site 9.
- An initial air ventilation study is not required for Site 9 due to its localised impact on pedestrian level air ventilation.

3.11 Site 10

3.11.1 Site 10 covers an area of 1.2 hectares and is located at Tuen Mun Area 55 between Castle Peak Road and Tuen Mun Road. Seven irregularly shaped, 10 storey residential buildings have been proposed for Site 10. The ground elevation of Site 10 will be levelled to a consistent +25 mPD, which is significantly higher than the adjacent sections of Castle Peak Road (approximately +20 mPD). The location and proposed layout of Site 10 are shown in Figure 17.

3.11.2 Due to its higher ground elevation relative to its surroundings, Site 10 has a moderate exposure to easterly winds. Significant sheltering at Site 10 is expected for north to north-easterly winds due to the effects of the mixed terrain to the north and north-east and existing residential buildings nearby. Some moderation is also likely for southerly winds due to existing residential developments, such as The Hillgrove, and the valley formed by Castle Peak Road to its south.

3.11.3 The central public space and access road into Site 10 are likely to facilitate the penetration of the available easterly winds into the site. Although the configuration of four proposed buildings located toward the southern side of the site boundary may cause some further moderation of southerly winds, the proposed gaps between the buildings are considered to be a positive design feature that will facilitate the penetration of available southerly winds into the site. The proposed building configuration is also likely to allow southerly winds to penetrate further inland.

3.11.4 In summary:

- Site 10 has a moderate exposure to easterly winds. Southerly winds are likely to be moderated by existing residential developments and nearby topography.
- The central public space, access road into Site 10 and gaps between the buildings are likely to facilitate the penetration of the easterly winds into the site.

3.12 Site 11

3.12.1 Site 11 covers an area of 9.7 hectares at a waterfront area south of Castle Peak Road on Tsing Fat Street that was the former site of the Lok On Pai desalination plant at Tuen Mun Area 59. Site 11 has been rezoned for residential purposes and its location and proposed layout are shown in Figure 18.

3.12.2 The prominent waterfront location of Site 11 provides it with generally open exposures to winds ranging from the east to the west. Nearby buildings include low-rise residential buildings to the east and north-east of the site, the Aqua Blue residential estate to the west and north-west, and The Hillgrove and other new and existing residential buildings to the north. The elevation of the topography in Site 11 is higher towards the north of the site, which is expected to facilitate the penetration of southerly winds. However, northerly winds are expected to be significantly diminished by the mountains in Tai Lam Country Park and the intervening mixed terrain before reaching Site 11.

3.12.3 The buildings proposed for Site 11 include 26 irregularly shaped residential buildings and a club house. 20 residential buildings are located in an area with ground elevations of +6 mPD and +8 mPD, with building heights ranging from 6 storeys close to the ocean frontage to 10 storeys further inland. A further six 3 storey buildings are located further away from the coastline at a ground elevation of +24 mPD. The buildings have been arranged to preserve significant areas of open space within Site 11, including one 30 m wide non-building area that is oriented north to south and two 25 m wide non-building areas that are oriented approximately south-east to north-west. The non-building areas, open spaces and building forms in the +6 mPD and +8 mPD areas are expected to allow good air ventilation within Site 11. The arrangement of buildings in the +24 mPD area is also likely to facilitate general wind penetration for easterly and southerly winds, although the closer building spacing may also create some localised areas of low wind flow for some wind directions.

3.12.4 The presence of the proposed buildings in Site 11 may have some moderating affect on pedestrian level winds experienced in the vicinity of the Aqua Blue residential estate. However, the major south-east to north-west aligned non-building area and the setback of the proposed Site 11 buildings from Tsing Fat Street is not likely to create a significant impediment to the general penetration of winds from south to south-easterly directions. The arrangement of buildings in the Aqua Blue estate is also likely to be dominant factor affecting winds within that estate.

3.12.5 It is recommended that the non-building areas and open spaces in Site 11 be retained. Consideration should also be given to planting shade trees within Site 11 to maximise the potential benefits of those spaces.

3.12.6 In summary:

- Site 11 has generally open exposures to winds ranging from the east to the west.
- Non-building areas, open spaces and building forms in the +6 mPD and +8 mPD areas of Site 11 are expected to allow good air ventilation.
- In the +24 mPD area, the arrangement of buildings is likely to facilitate general wind penetration for easterly and southerly winds, although the closer building spacing may also create some localised areas of low wind flow for some wind directions.
- Recommendations: 1) the non-building areas and open spaces in Site 11 should be retained; 2) consideration should be given to planting additional trees in Site 11.

3.13 Site 12

3.13.1 Site 12 covers an area of 0.2 hectares and is located at Kwun Fung Street in So Kwun Wat, to the north of Tuen Mun Road and Site 13. Three 10 m tall residential buildings are proposed for Site 12, which will have a ground elevation of +67 mPD. The location and proposed layout of Site 12 are shown in Figure 19.

3.13.2 The ground elevation at Site 12 and the current absence of significant nearby developments provides it with relatively open exposures to winds from the east to the south-west. Complex and mixed terrain to the north and north-east of Site 13 will shelter it from winds from those directions.

3.13.3 The relatively high ground elevation, low site coverage and low-rise nature of the buildings proposed for Site 12 will facilitate pedestrian level air ventilation in the site and nearby areas. Planting of shade trees will also be of benefit to the pedestrian level wind environment in Site 12.

3.13.4 An initial air ventilation study is not required for Site 12 as it is expected to have generally positive air ventilation characteristics and it is not expected to have adverse effects on other developments nearby.

3.13.5 In summary:

- Site 12 has relatively open exposures to winds from the east to the south-west.
- The relatively high ground elevation, low site coverage and low-rise nature of the buildings proposed for Site 12 will facilitate pedestrian level air ventilation in the site and nearby areas.
- Recommendation: plant additional shade trees.
- An initial air ventilation study is not required for Site 12 as it is expected to have generally positive air ventilation characteristics and it is not expected to have adverse effects on other developments nearby.

3.14 Site 13

3.14.1 Site 13 covers an area of 0.9 hectares and is located adjacent to Kwun Yat Street in So Kwun Wat to the north of Tuen Mun Road, to the east of Kwun Fat Street, and to the west of Site 5 (lower). The buildings proposed for Site 13, which will have a ground elevation of +30 mPD, include six rectangular 3 storey residential buildings. The location and proposed layout of Site 13 are shown in Figure 20.

3.14.2 Although there are very few existing buildings in close proximity to Site 13, it is expected that it will be sheltered significantly from easterly winds by Site 5 (lower) to its east, which has a ground elevation of +40 mPD, and from northerly winds by nearby hills. Southerly winds are likely to be moderated by existing residential buildings and Tuen Mun Road to the south of Site 13.

3.14.3 Moderated wind flows are likely to occur in Site 13 due to its location and the surrounding topography. The relatively low building heights are unlikely to be sufficient to capture upper level winds, but their low height is also unlikely to cause adverse effects on air ventilation in nearby areas. The alignment and relatively low ground coverage of the proposed buildings in Site 13, in combination with substantial spacing between the proposed buildings, is considered to be a positive design aspect that is likely to facilitate the penetration of the available southerly winds into the site. It is recommended that shade trees be planted in the open spaces of Site 13.

3.14.4 An initial air ventilation study is not required for Site 13 because the proposed configuration of low-rise buildings is not expected to have a significant effect on air ventilation conditions in nearby areas.

3.14.5 In summary:

- Site 13 is sheltered significantly from easterly winds by Site 5 (lower) and from northerly winds by nearby hills; southerly winds are likely to be moderated by existing residential buildings and Tuen Mun Road.
- Moderated wind flows are likely to occur in Site 13 due to its location and the surrounding topography.
- The alignment and relatively low ground coverage of the proposed buildings in Site 13, in combination with substantial spacing between the proposed buildings, is considered to be a positive design aspect that is likely to facilitate the penetration of the available southerly winds into the site.
- Recommendation: plant additional trees in Site 13.
- An initial air ventilation study is not required for Site 13 because the proposed configuration of low-rise buildings is not expected to have a significant effect on air ventilation conditions in nearby areas.

3.15 Site 14

3.15.1 Site 14 covers an area of 5.1 hectares and is located at Tuen Mun Area 55 between Tuen Mun Road and So Kwun Wat Road. Site 14 has a ground elevation of +20 mPD and has been zoned for residential purposes and its location and proposed layout are shown in Figure 21.

3.15.2 Site 14 is likely to be shielded to a certain extent by the surrounding topography for the prevailing wind directions. The site will be sheltered from northerly winds due to the combined effects of the mountains in Tai Lam Country Park and planned developments in Sites A, B and F, located immediately to the north. Air ventilation conditions in Site 14 are also expected to be moderated by hills located to its south, which have ground elevations ranging from approximately 30 mPD to 70 mPD at Siu Sau, and the hilltop (+40 mPD) and residential buildings at Ka Wo Lei to the south-west. Site 14 may have some exposure to north-easterly winds that pass through the natural valley in the vicinity of So Kwun Wat Tsuen, although these are likely to be moderated by the complex and mixed terrain to the east and north-east of the site.

3.15.3 The proposed buildings at Site 14 that are being considered in the current study correspond to the private housing option. Those buildings include 13 residential buildings, with heights of 10 storeys, and a club house. Orthogonal non-building areas, with widths of 25 m and approximately south-east to north-west and south-west to north-east alignments, have been proposed for Site 14 to provide significant areas of open space. It is recommended that the non-building areas and open spaces in Site 14 be retained.

3.15.4 The relatively low site coverage of the buildings proposed for Site 14 is unlikely to significantly impede the penetration of winds at pedestrian level. However, as previously mentioned, the strength of winds reaching Site 14 are likely to be moderated by the surrounding topography. Nevertheless, the buildings proposed for Site 14 are unlikely to have a significant impact on other nearby development sites. Planting of shade trees will benefit the pedestrian level conditions in Site 14.

3.15.5 In summary:

- Site 14 is sheltered from northerly winds due to the combined effects of the mountains in Tai Lam Country Park and planned developments in Sites A, B and F; southerly winds are expected to be moderated by hills and residences located to its south and south-west; north-east to east winds are likely to be moderated by complex and mixed terrain.
- The relatively low site coverage of the buildings proposed for Site 14 is unlikely to significantly impede the penetration of winds at pedestrian level.
- Recommendation: retain the non-building areas and open spaces in Site 14 and plant additional trees in Site 14.

4 CONCLUSIONS

4.1 An Expert Evaluation was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an air ventilation assessment for proposed developments at 14 sites in the Tuen Mun East Study Area. The effects of topography on wind characteristics at the Tuen Mun East Study Area were determined from a previously conducted experimental Site Wind Availability Study and qualitative assessments of a statistical analysis conducted by Hong Kong Observatory of hourly mean wind speed data for all winds measured at Tuen Mun and WWTF's statistical model of the upper level Hong Kong non-typhoon wind climate, that is based on HKO data measured at Waglan Island.

4.2 Pedestrian level wind conditions in the Tuen Mun East Study Area are likely to be highly variable due to the effects of ground elevation, proximity and form of significant topography and the variety of building heights, forms and orientations. The prevailing non-typhoon winds in the Tuen Mun East Study Area are expected to come from south to south-westerly and easterly directions.

4.3 Significant non-building areas have been reserved in Sites 1, 2, 3, 7, 8, 11 and 14 in an attempt to facilitate wind penetration into those sites and nearby areas. In general, the non-building areas that are aligned approximately south to north are expected to be more effective than those with a more east to west alignment due to the likely moderating effects of the mixed and complex terrain to the east of the Tuen Mun Study Area. Nevertheless, sites that are located towards the east of the Study Area, such as Site 5, are considered more likely to benefit from easterly winds that flow above Tai Lam Chung Reservoir.

4.4 The beneficial effects of southerly winds are likely to be most significant at sites that are located in close proximity to the Tuen Mun coastline, such as Sites 1, 6 and 11. Although the elevation of the topography generally increases from south to north, the complexity of the terrain and the effects of some existing buildings are likely to moderate southerly winds at sites that are further inland. Specific recommendations were made for each of the study sites considered.

4.5 Sites requiring an initial air ventilation study are Sites 1, 2, 3, 4A, 5 (lower), 7, 8, 10, 11 and 14. Sites that do not require an initial air ventilation study are Sites 4B, 5 (middle), 5 (upper), 6, 9, 12 and 13.

5 REFERENCES

5.1 Australasian Wind Engineering Society (2001), Wind Engineering Studies of Buildings, AWES-QAM-1-2001.

5.2 CLP Power Wind/Wave Tunnel Facility, The Hong Kong University of Science and Technology (2008), Experimental Site Wind Availability Study for Tuen Mun East Study Area Investigation Report WWTF011-2008 June 2008

5.3 Manual of practice for wind tunnel studies of buildings and structures (1999), Editor Nicholas Isyumov, Task Committee on Wind Tunnel Testing of Buildings and Structures, Aerodynamics Committee, Aerospace Division, American Society of Civil Engineers.

5.4 Ng, M.C. and Cheng, Y.Y. (1999), Climatology of Tuen Mun 1988-1998, Hong Kong Observatory Technical Note (Local) No. 97.

5.5 Planning Department, The Government of the Hong Kong Special Administrative Region (2005), Feasibility Study for Establishment of Air Ventilation Assessment – Final Report, Department of Architecture, The Chinese University of Hong Kong.

5.6 Planning Department, The Government of the Hong Kong Special Administrative Region (2005), Technical Guide for Air Ventilation Assessment for Developments in Hong Kong.

The indicative layouts for G/IC uses at Sites 1, 2, 3, 4A & 8 are provided by Planning Department for the purpose of conducting Air Ventilation Assessment only

Figure 1: Locations of the proposing Housing and G/IC sites in the Tuen Mun East Study Area

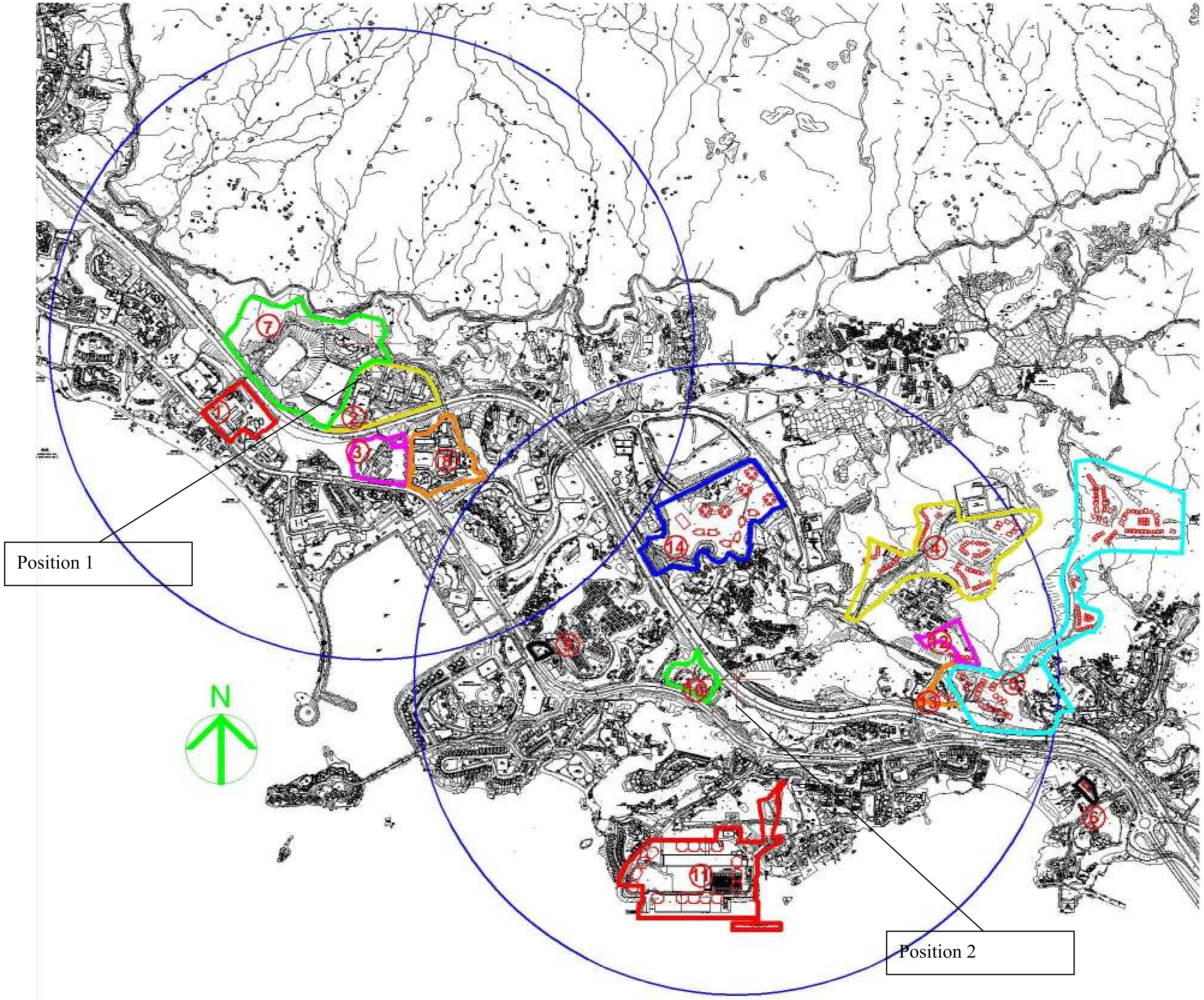

Figure 2: Measurement positions of site wind availability study for the Tuen Mun East Study Area

TUEN MUN AUTOMATIC WEATHER STATION

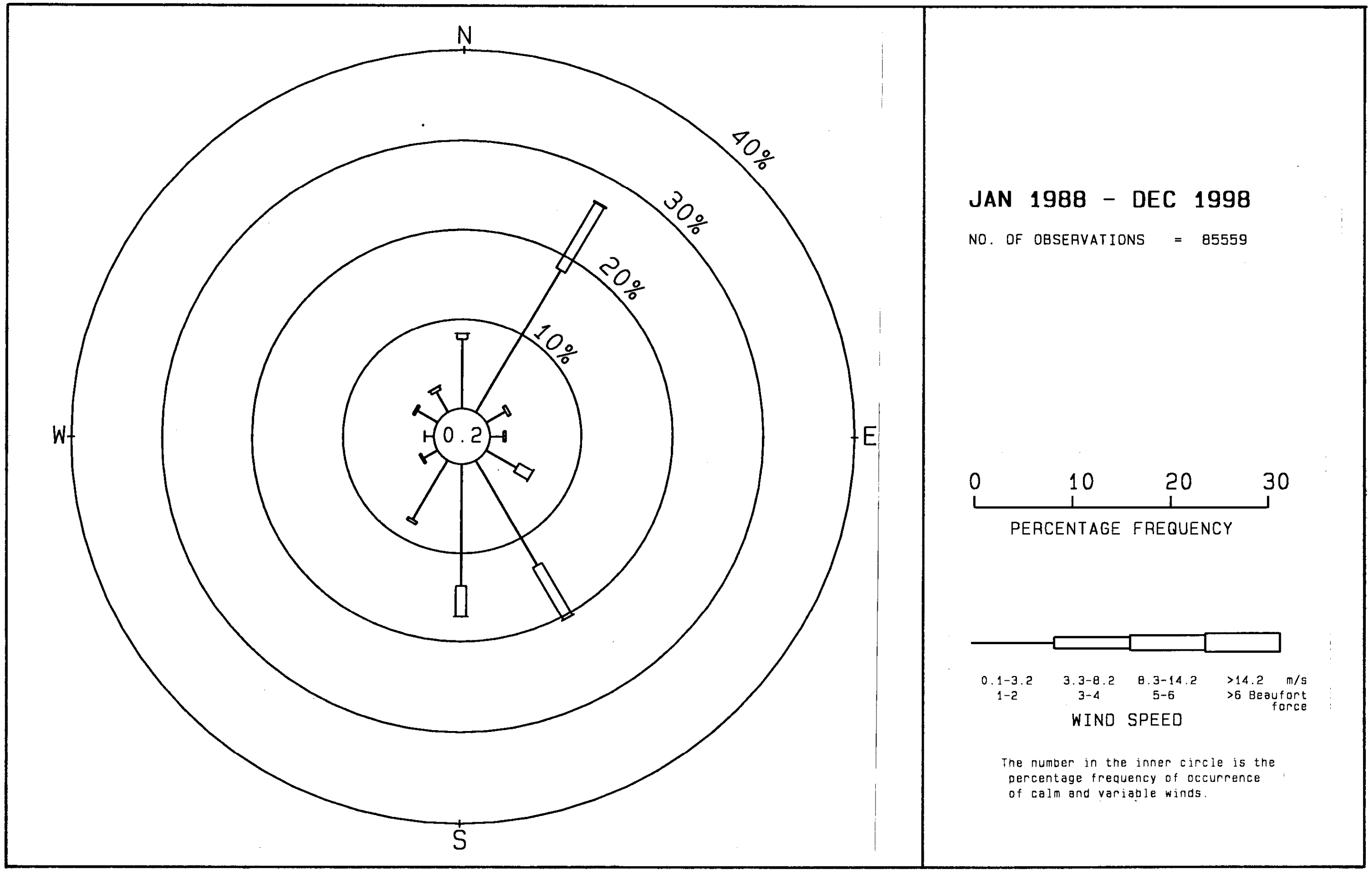

Figure 3: Annual wind rose for Tuen Mun, (after Ng and Cheng, 1999)

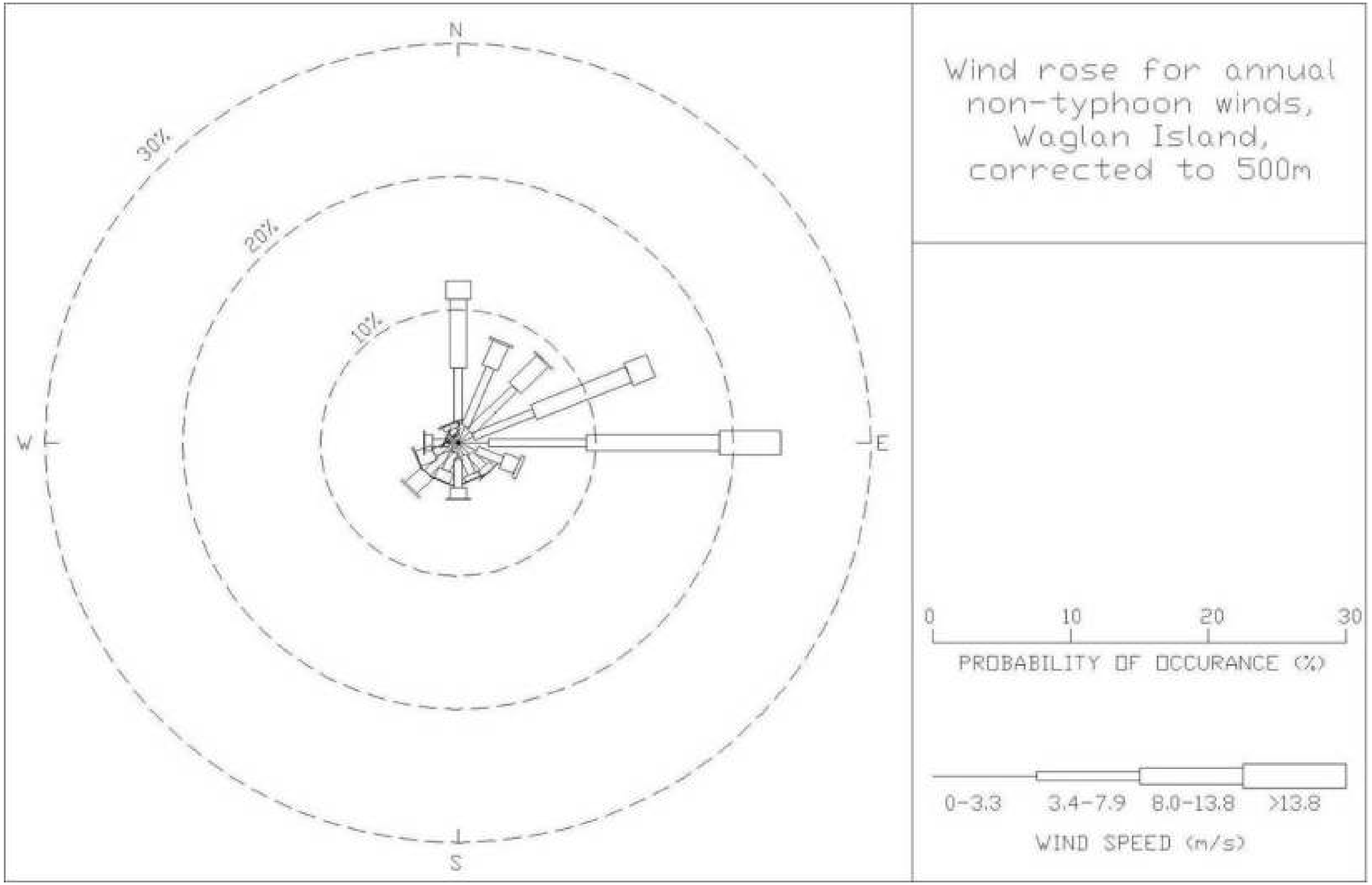

Figure 4: Wind rose for annual non-typhoon winds, Waglan Island, corrected to 500 m, 1953-2006

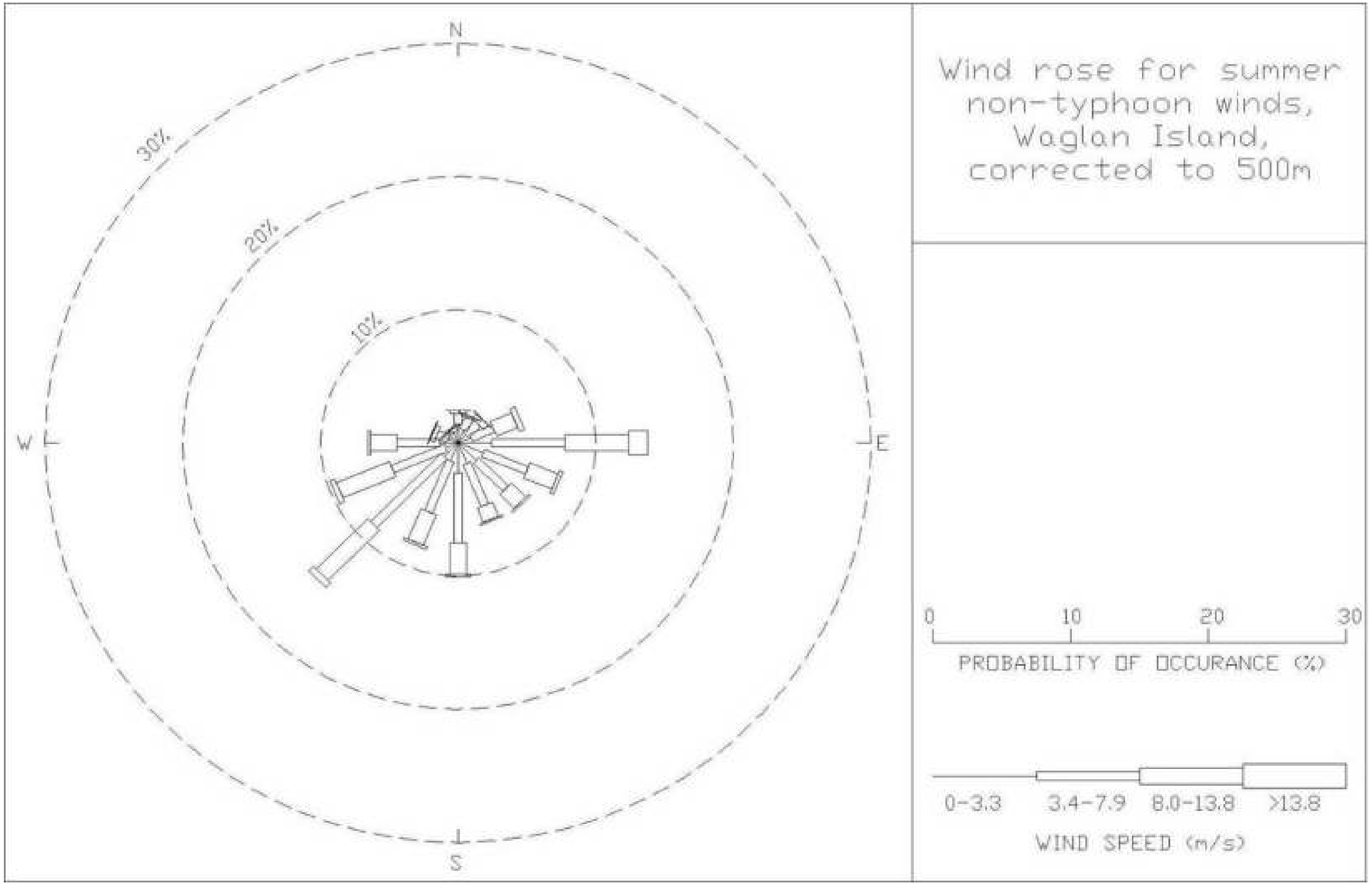

Figure 5: Wind rose for summer non-typhoon winds, Waglan Island corrected to 500 m, 1953-2006

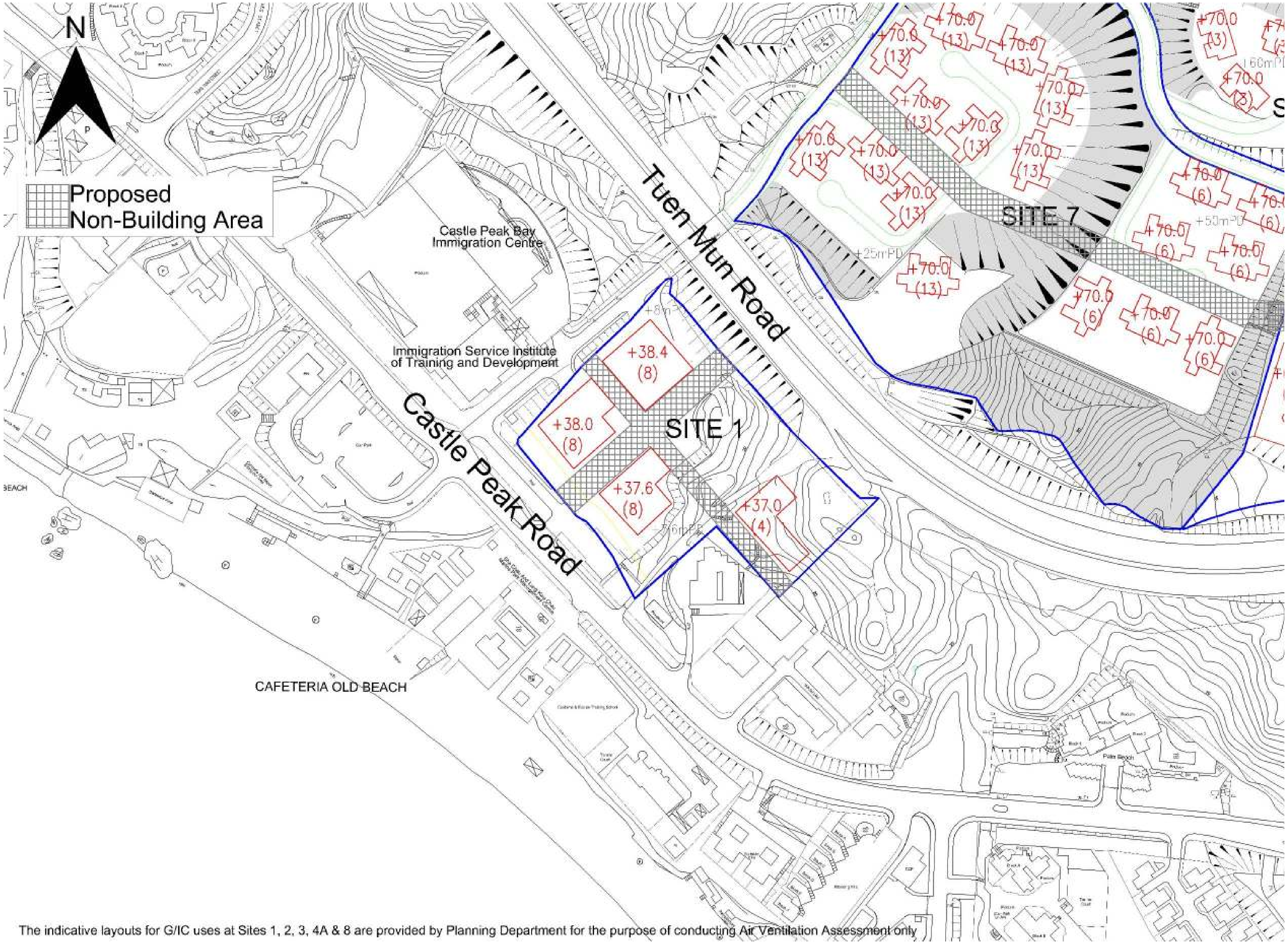

Figure 6: Location and proposed layout of Site 1

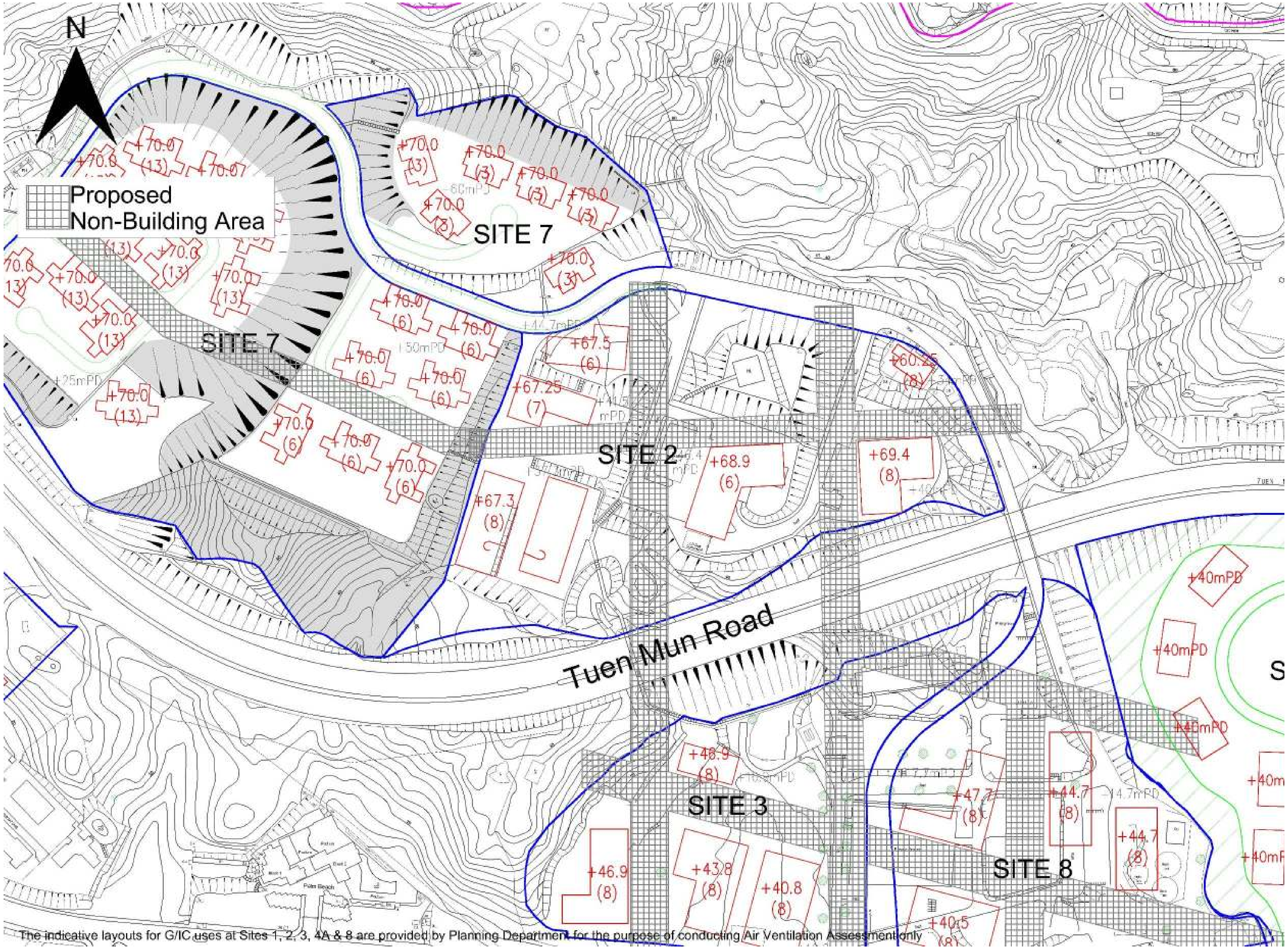

Figure 7: Location and proposed layout of Site 2

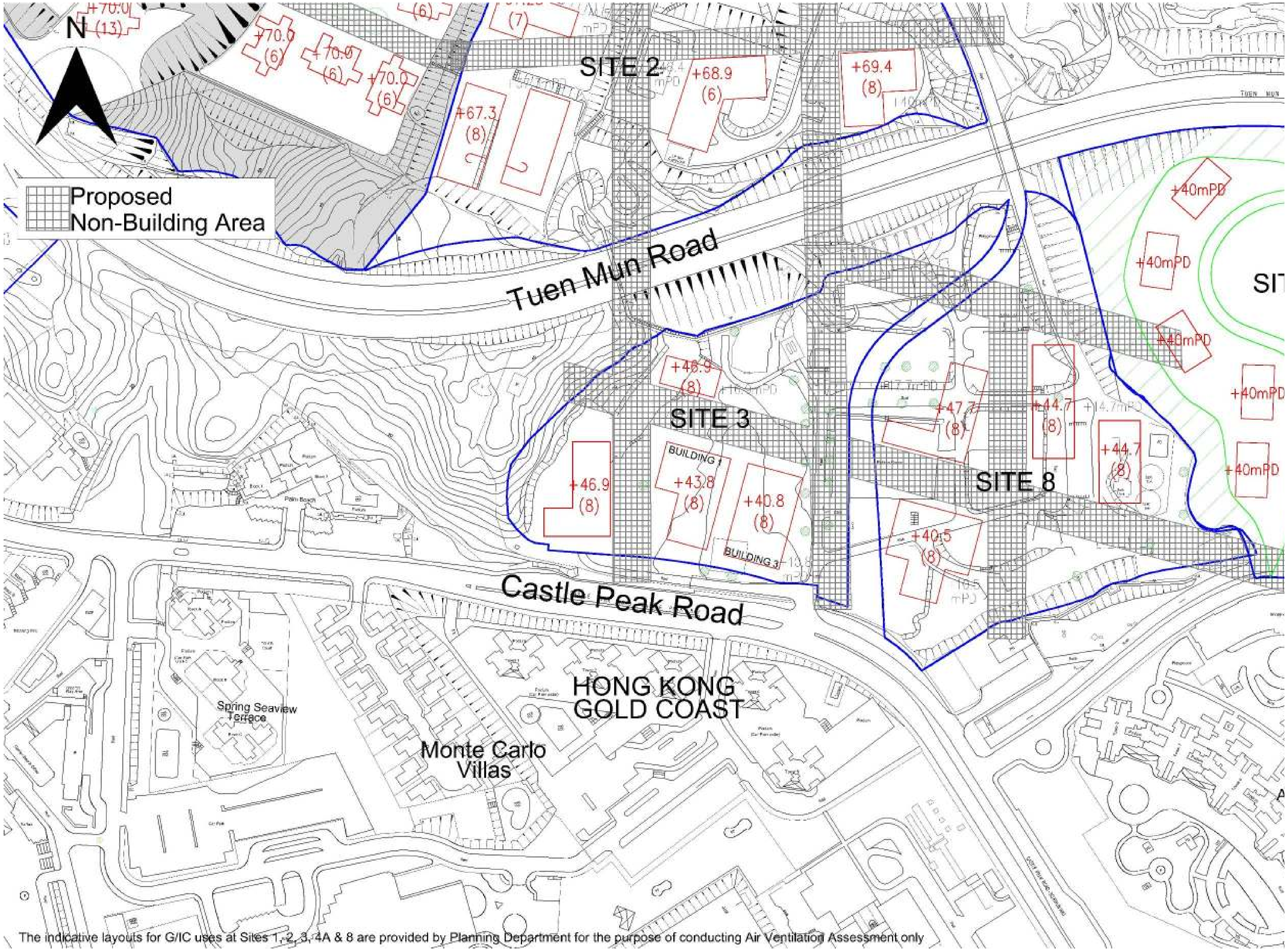

Figure 8: Location and proposed layout of Site 3

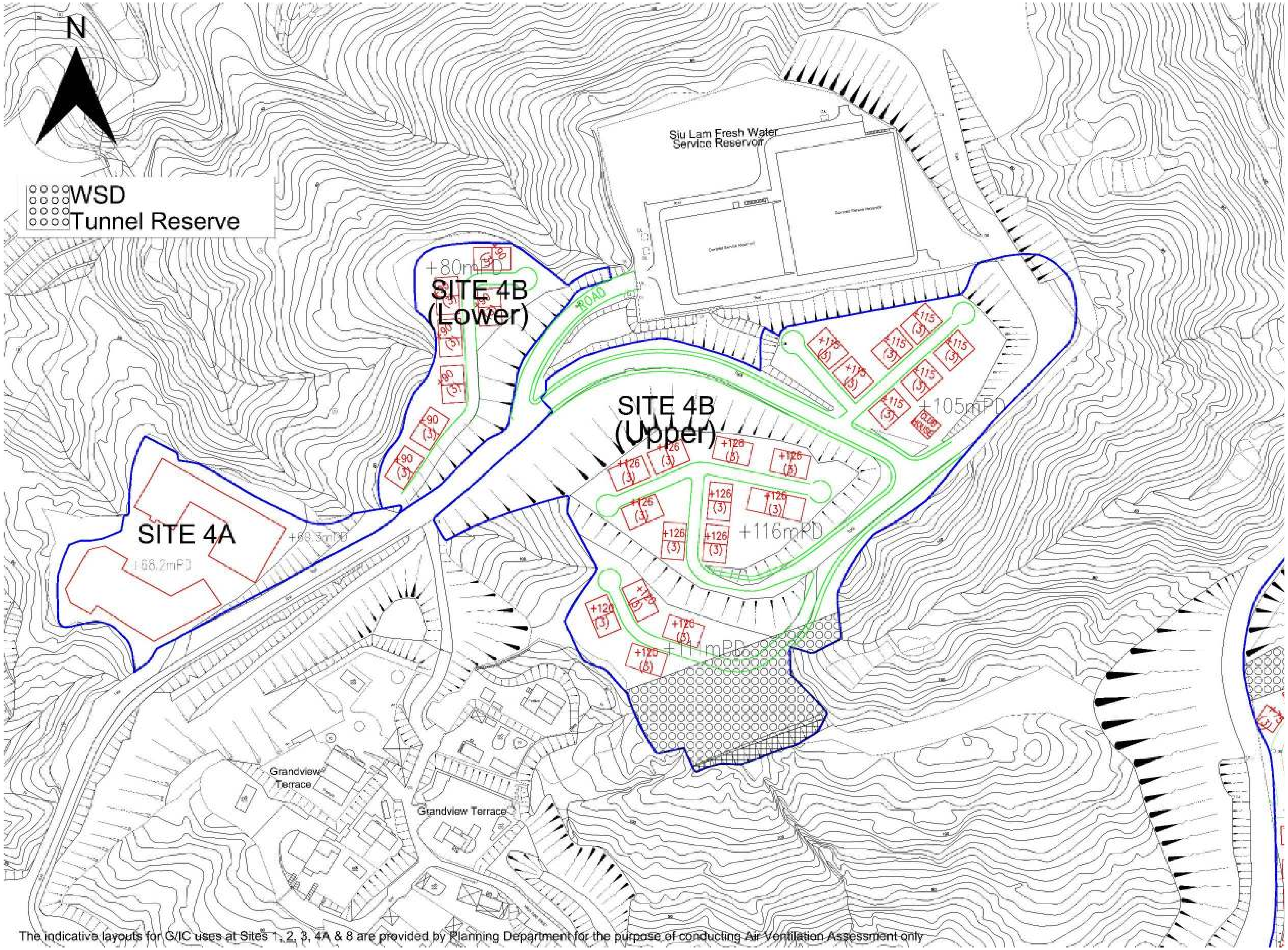

Figure 9: Location and proposed layout of Site 4

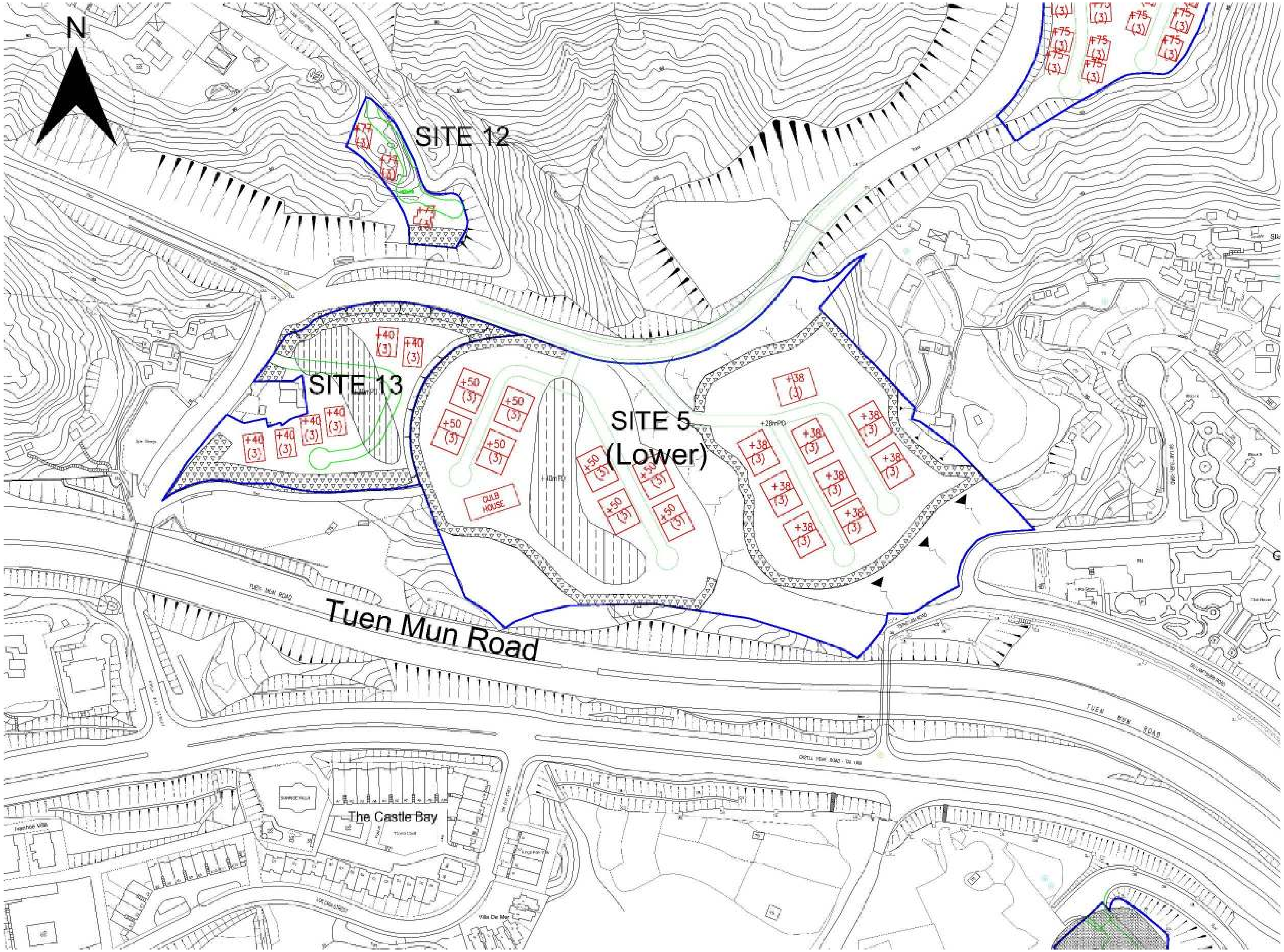

Figure 10: Location and proposed layout of Site 5 (lower)

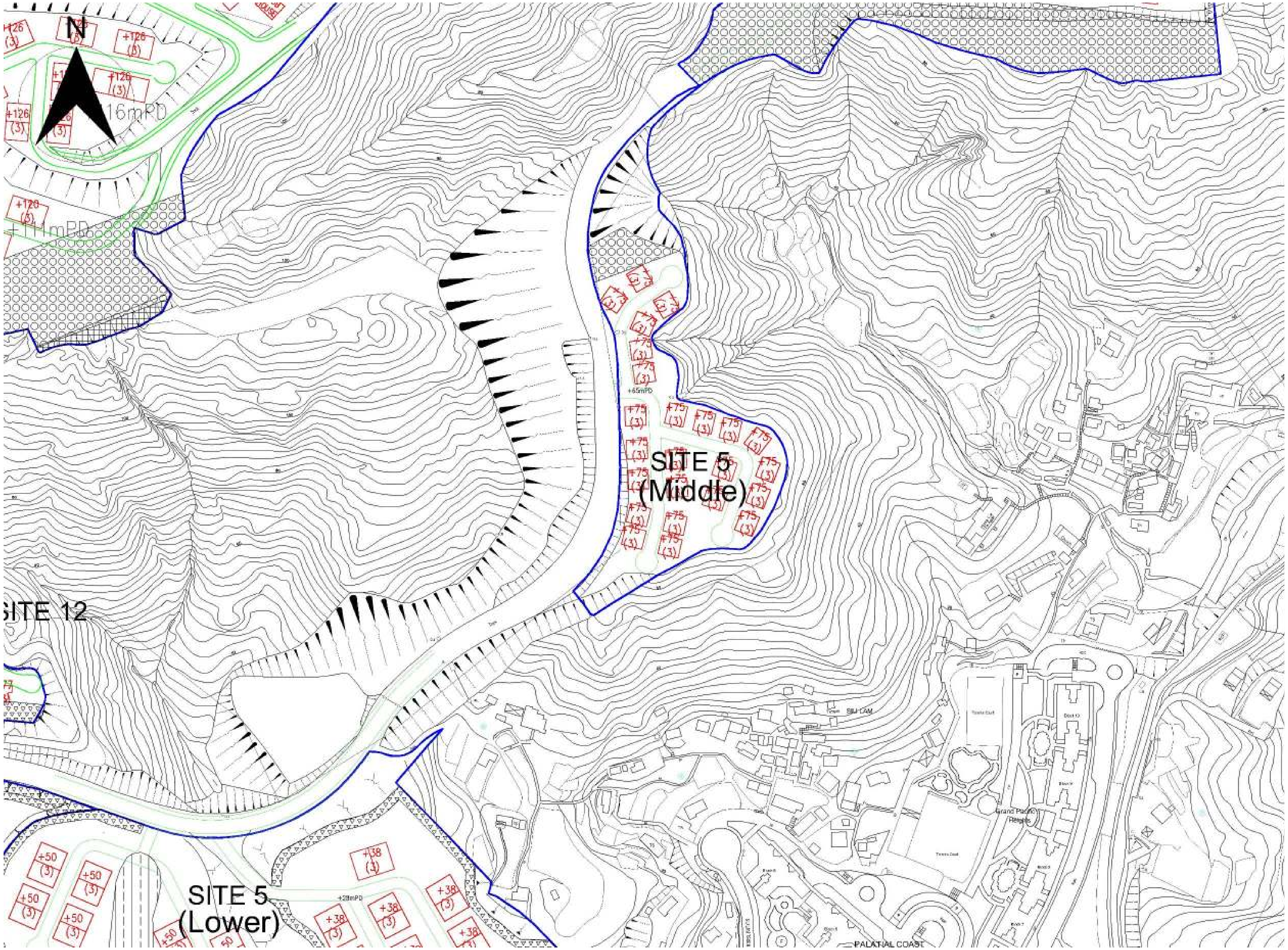

Figure 11: Location and proposed layout of Site 5 (middle)

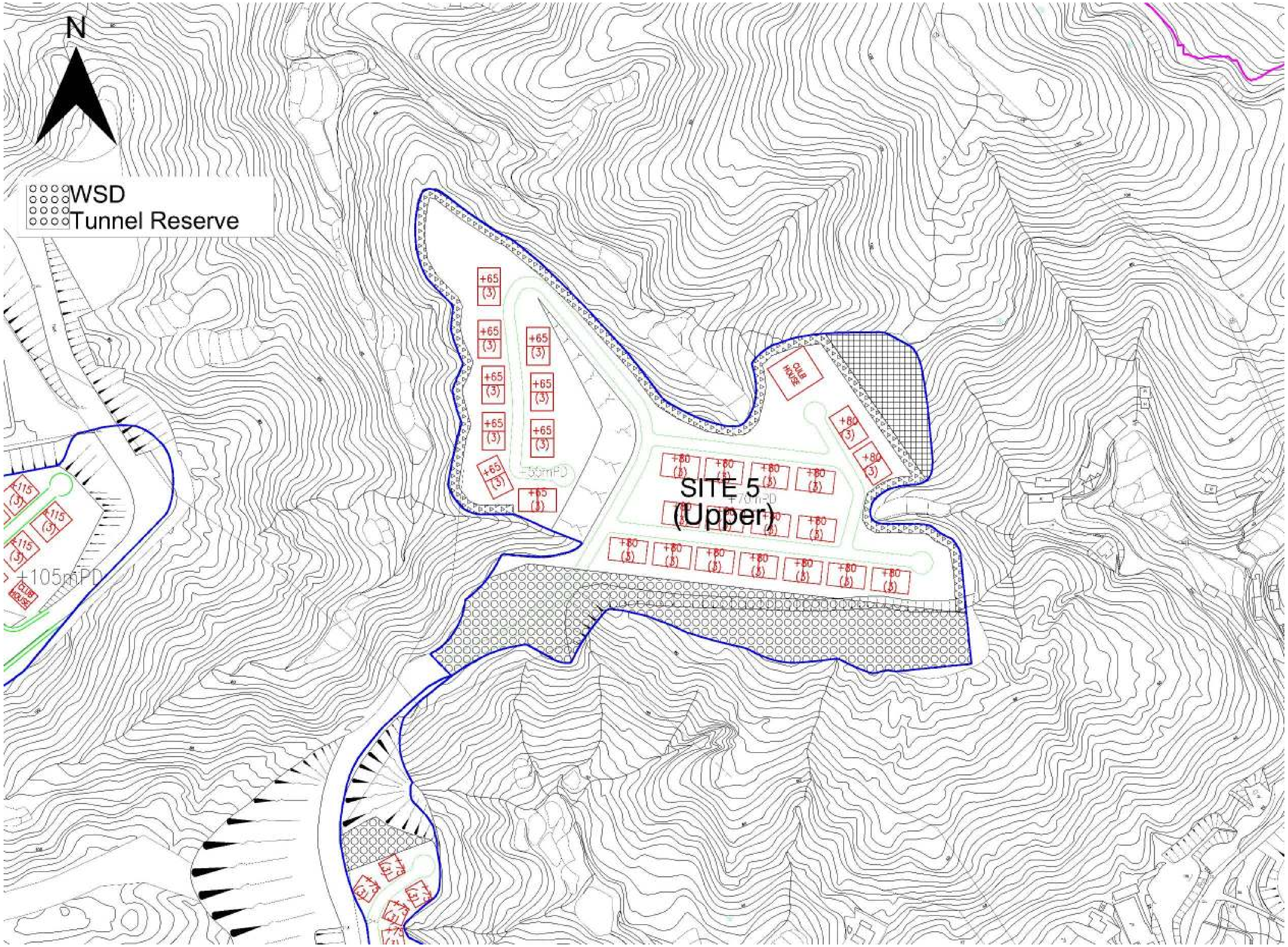

Figure 12: Location and proposed layout of Site 5 (upper)

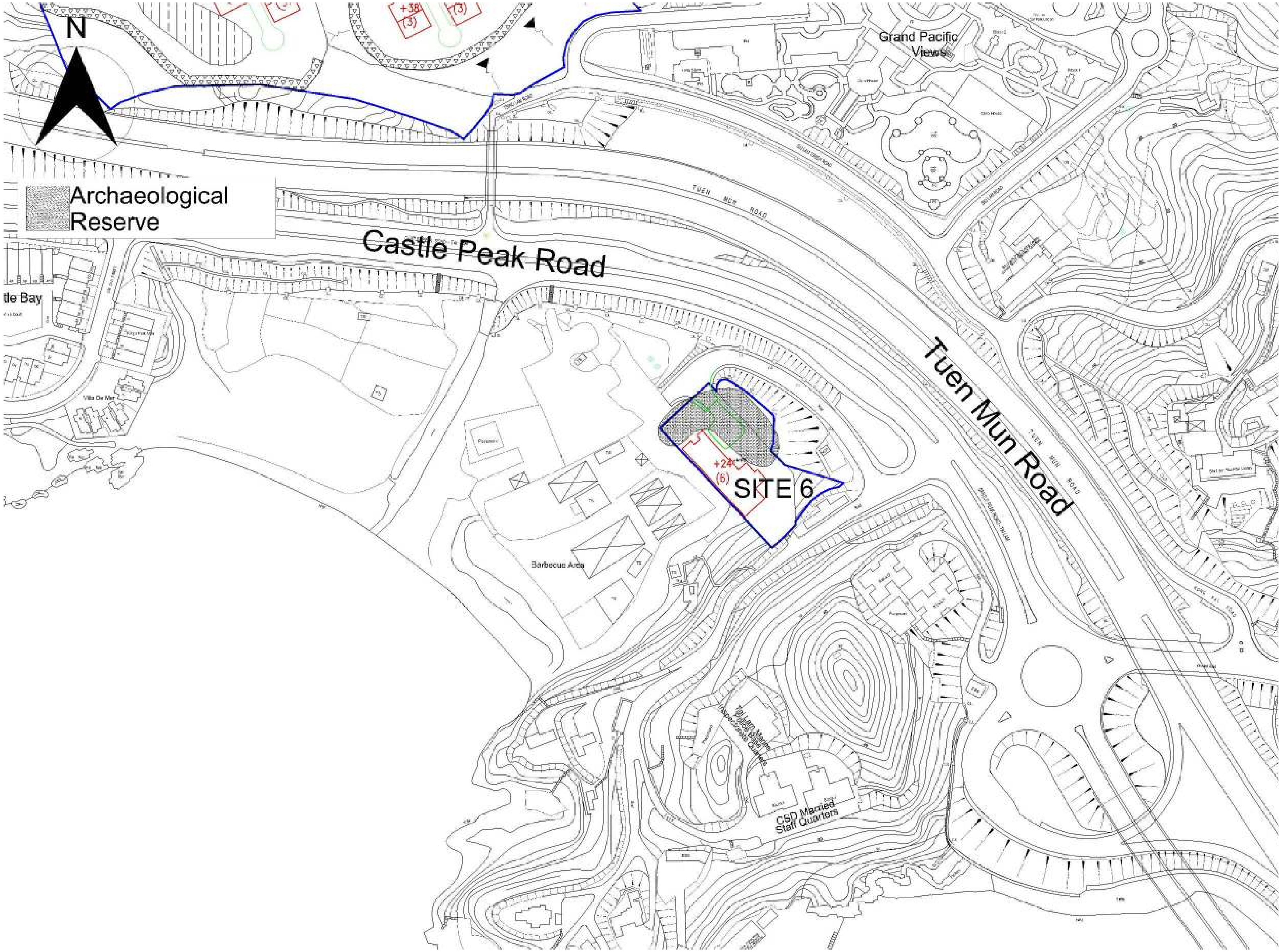

Figure 13: Location and proposed layout of Site 6

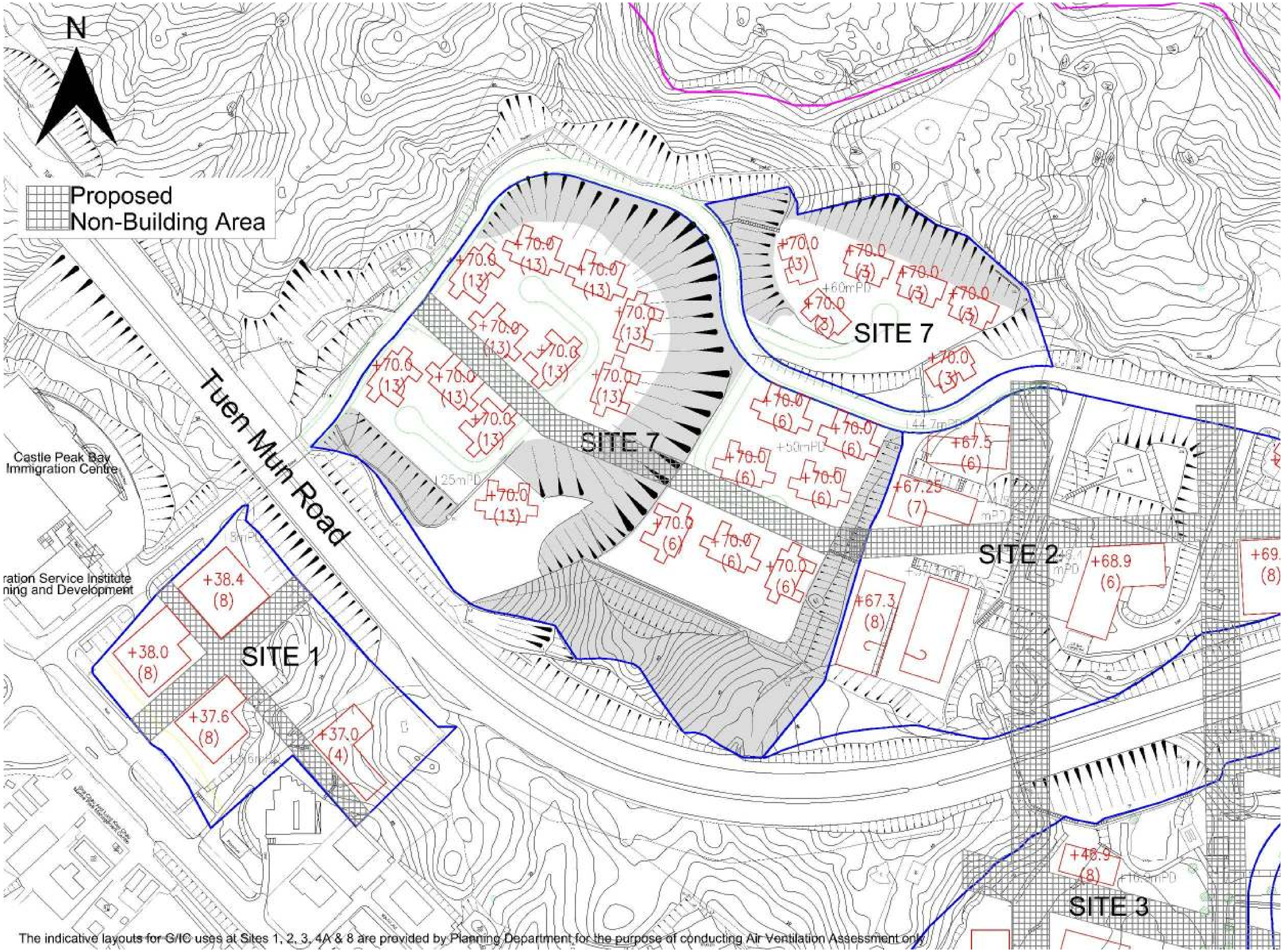

Figure 14: Location and proposed layout of Site 7

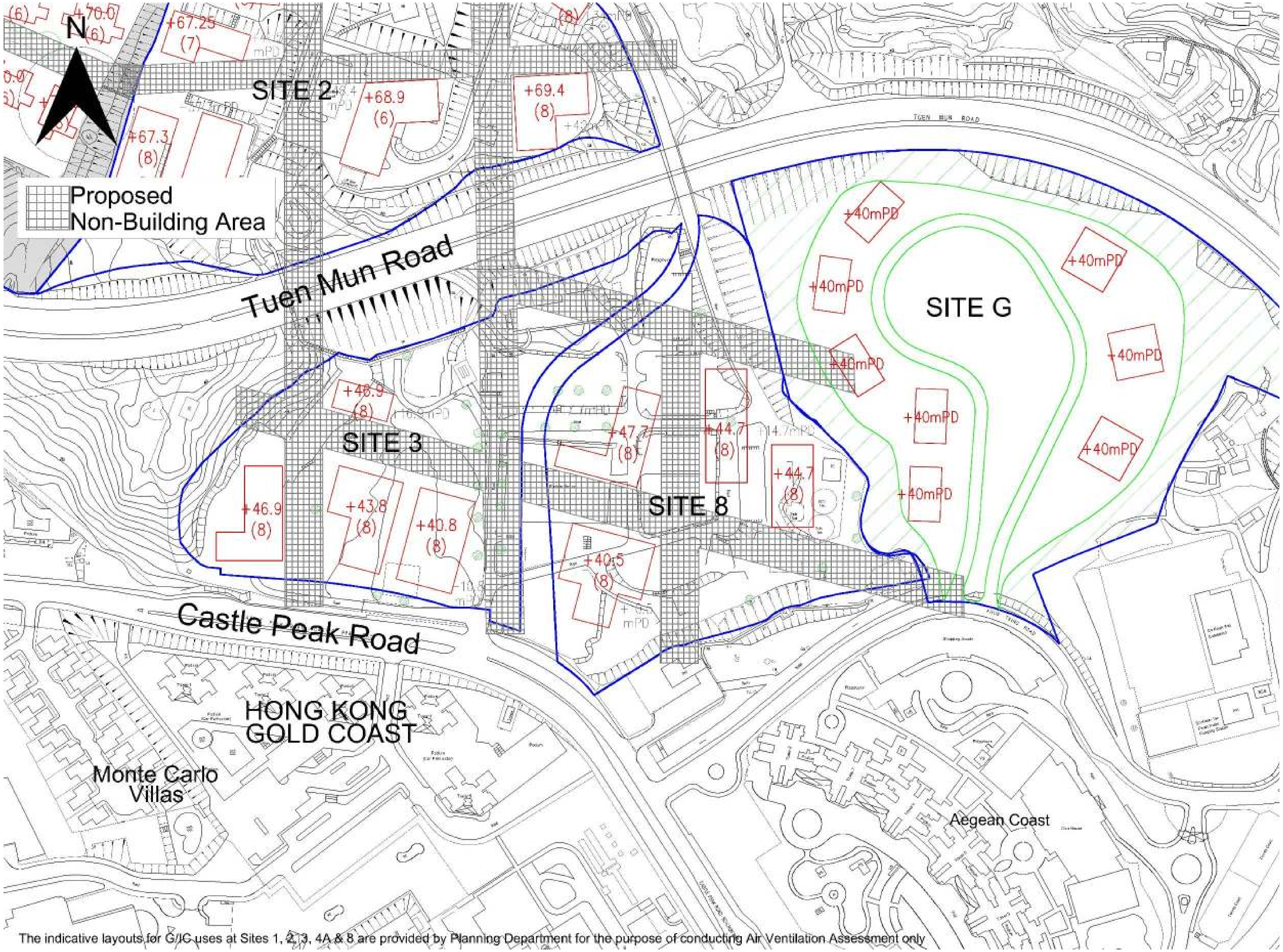

Figure 15: Location and proposed layout of Site 8

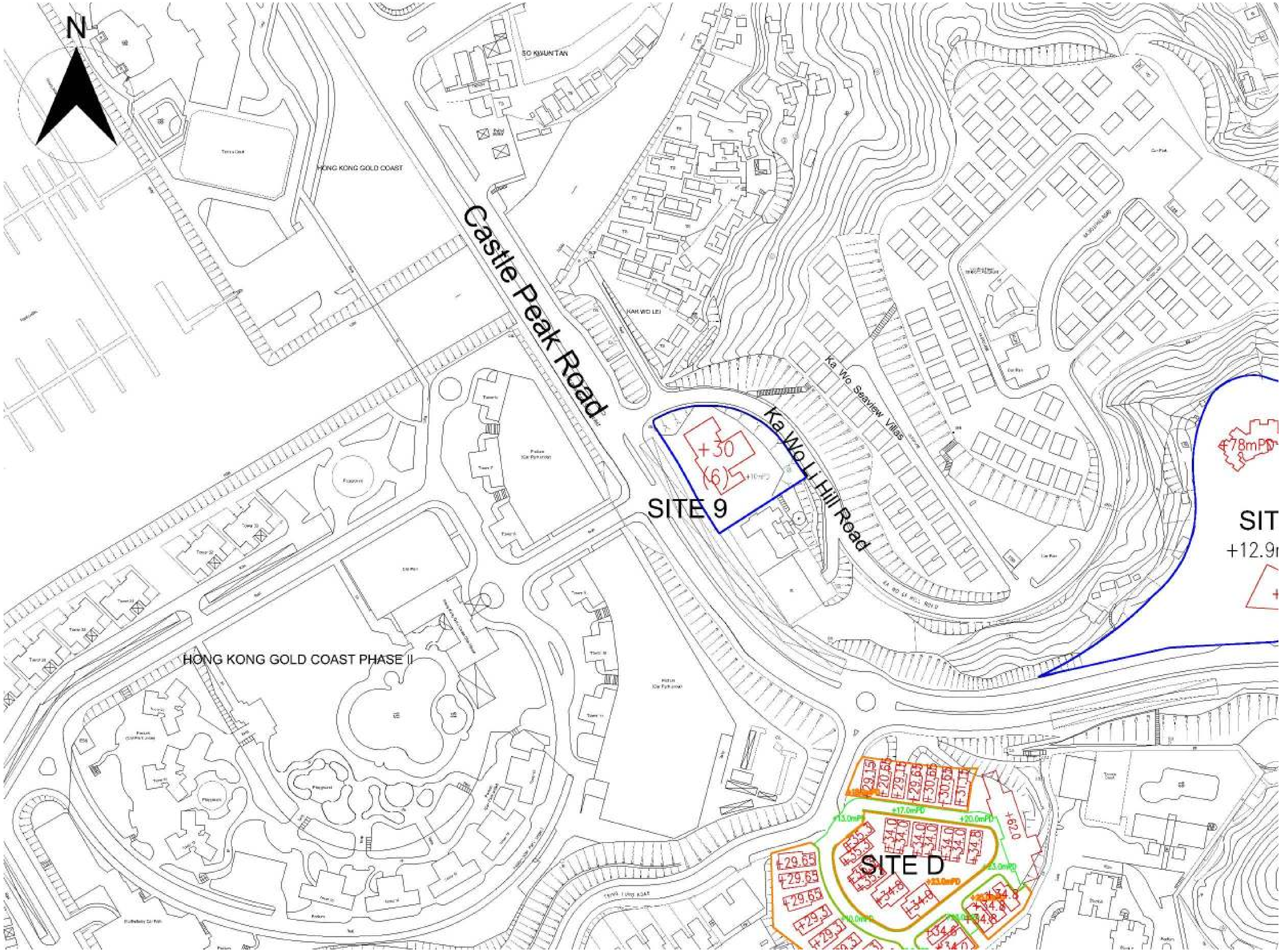

Figure 16: Location and proposed layout of Site 9

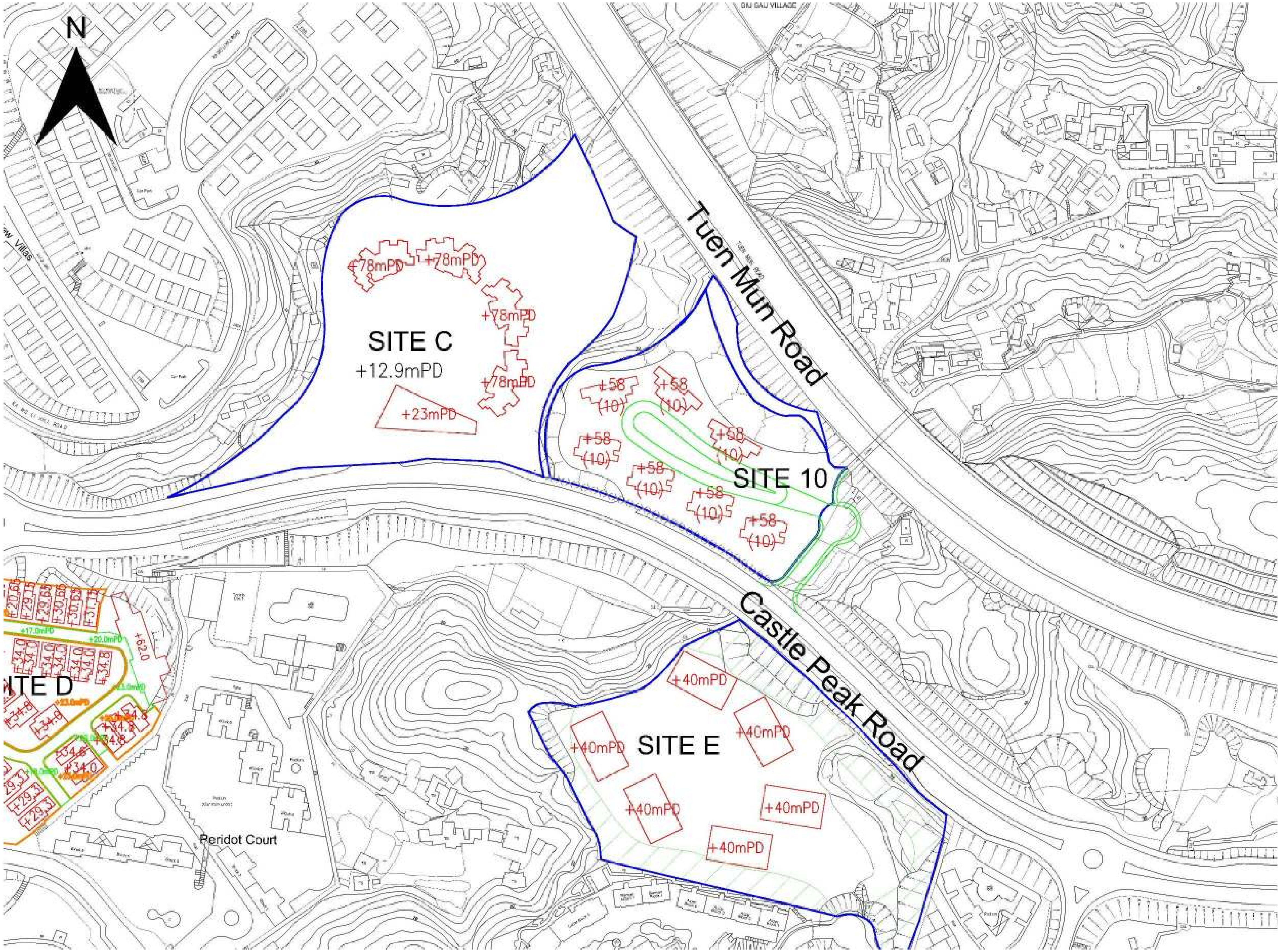

Figure 17: Location and proposed layout of Site 10

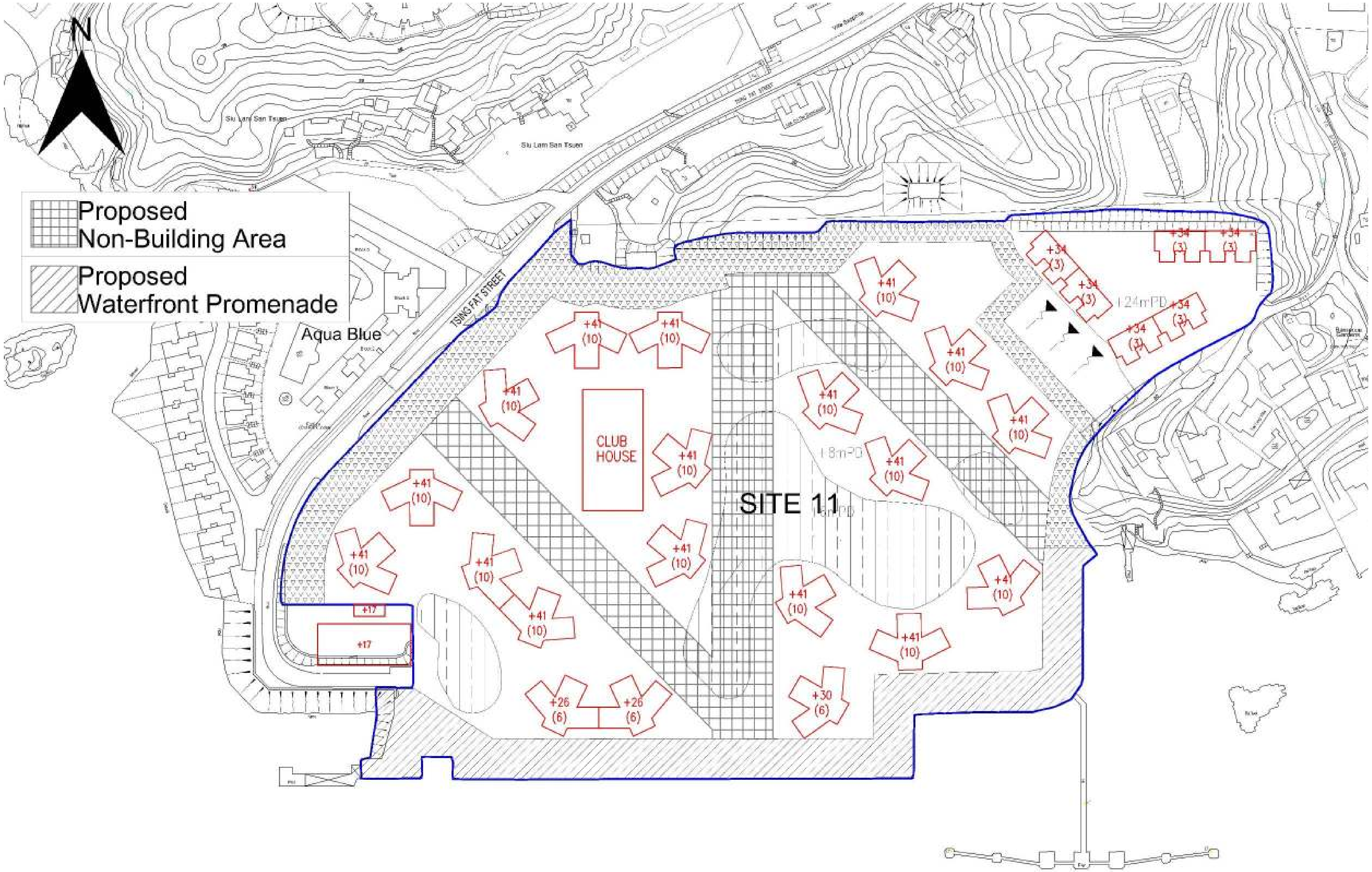

Figure 18: Location and proposed layout of Site 11

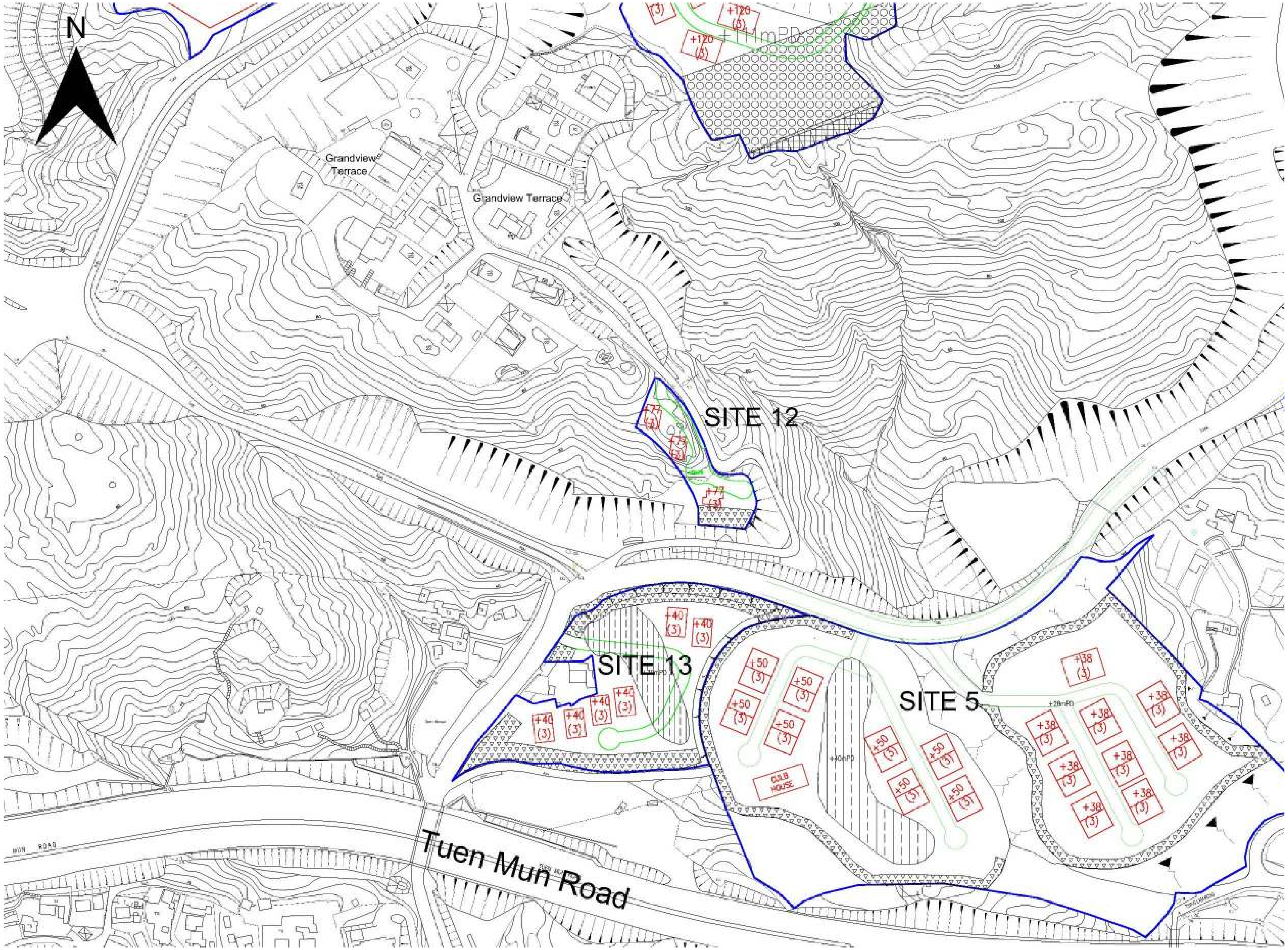

Figure 19: Location and proposed layout of Site 12

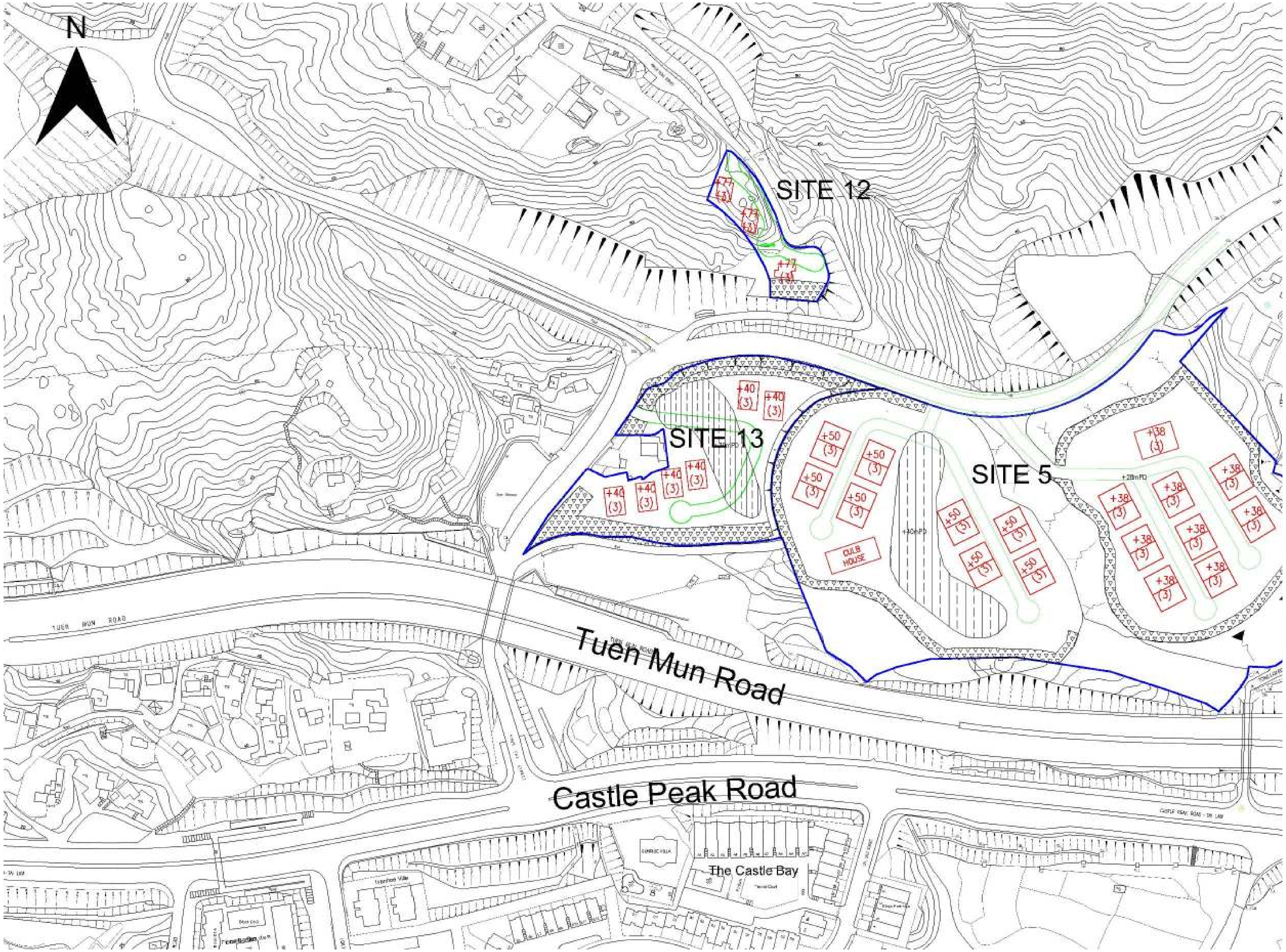

Figure 20: Location and proposed layout of Site 13

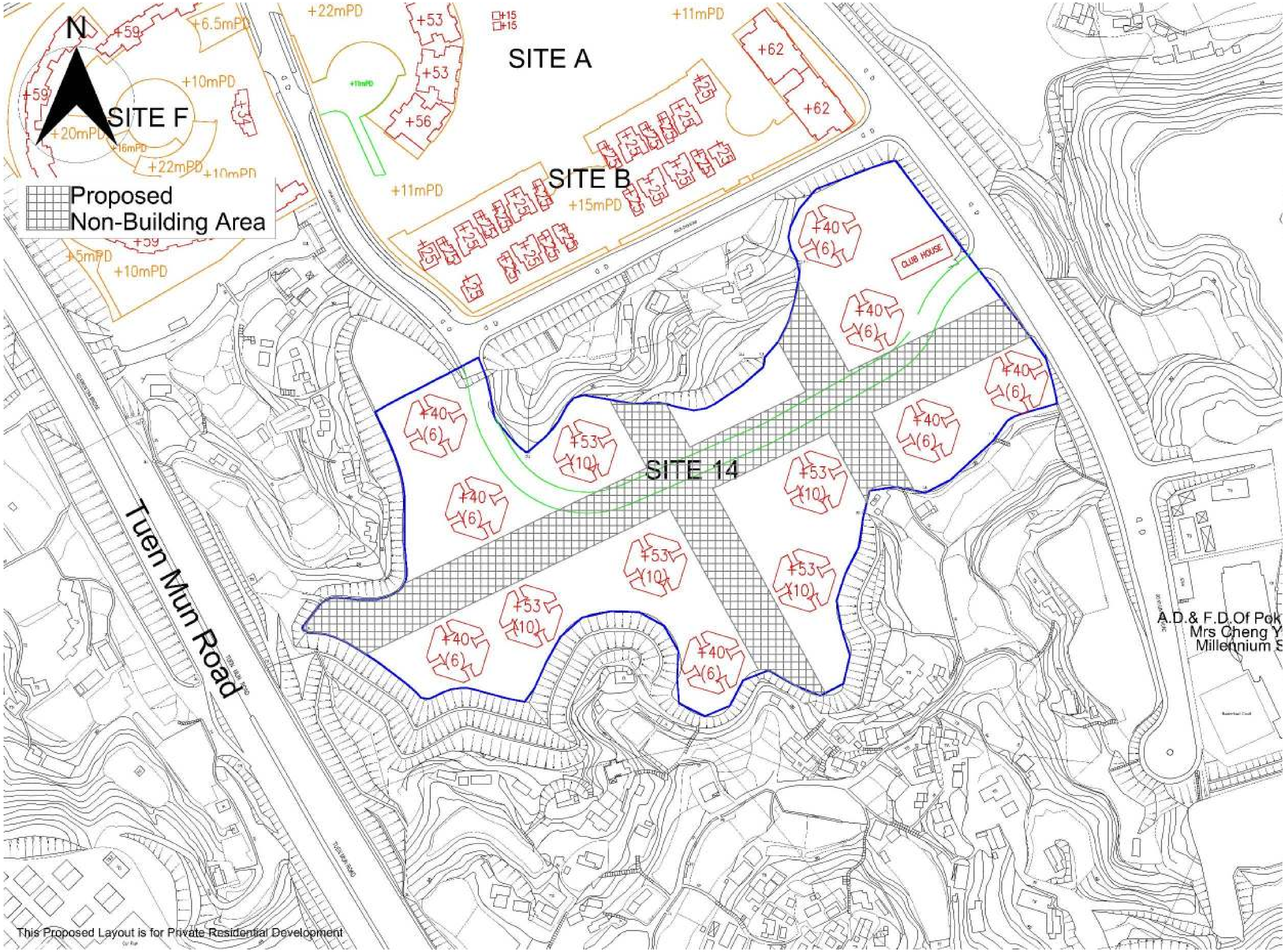

Figure 21: Location and proposed layout of Site 14

Annex C
Initial Study

EXECUTIVE SUMMARY

I. At the request of Scott Wilson Limited, an Initial Study was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an Air Ventilation Assessment (AVA) under Agreement No. CE47/2006(TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study. An experimental Site Wind Availability Study and an Expert Evaluation have been conducted previously under this agreement. The results of those previous studies were considered and used in this Initial Study.

II. The Tuen Mun East Study Area is bounded by the Tuen Mun River Channel and Hoi Wing Road to its west, Tai Lam Country Park to its north, Tai Lam Chung Nullah to its east and the coastline to its south. It comprises a total of 14 study sites at various elevations; Site 4 has subsequently been split into Sites 4A and 4B. These study sites are currently covered by two Outline Zoning Plans (OZPs), namely the Tuen Mun OZP and the So Kwun Wat OZP.

III. In accordance with the recommendations of the Expert Evaluation, the Initial Study was conducted for Sites 1, 2, 3, 4A, 5 (lower), 7, 8, 10, 11 and 14. Sites 9, 12 and 13 and also part of Site 4B were included in the physical model due to the large coverage of the physical models and were also considered in this Initial Study.

IV. The wind tunnel test techniques used for this study satisfied the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the relevant recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2006).

V. Two 1:400 scale wind tunnel models were fabricated to cover each of the study sites. The models were installed with a total of 314 test points and measurements were taken at all test points for 16 wind directions at increments of 22.5° using a multi-channel thermal anemometer system. Directional, annual overall and summer overall velocity ratios were determined by combining analytically the wind speed measurements and WWTF's probabilistic model of the Hong Kong non-typhoon wind climate that is based on measurements of wind speed and direction taken by Hong Kong Observatory (HKO) at Waglan Island.

VI. Northerly winds are generally weak at the Tuen Mun East Study Area due to large mountains to the north of the Study Area. The availability of southerly winds is higher due to the proximity of the seafront to the south of the Study Area. The variation of local topography and ground elevations among the G/IC and potential housing sites cause large variations in the air ventilation performance over the Study Area.

VII. In general, the most favourable conditions for good air ventilation characteristics were measured at Sites 1, 11 and 14. Windy conditions are likely to occur in parts of Sites 4 and 12 due to their relatively exposed and higher ground elevations. Pedestrian level wind conditions for Sites 5 (Lower), 9 and 13 are likely to be weak to moderate. Variable wind conditions are expected for Sites 2, 3, 7, 8 and 10 due to proposed and existing buildings and the complex local topography.

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1 INTRODUCTION

1.1 Project Background

1.1.1 At the request of Scott Wilson Limited, an Initial Study was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an Air Ventilation Assessment (AVA) under Agreement No. CE47/2006(TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study. An experimental Site Wind Availability Study and an Expert Evaluation have been conducted previously under this Agreement. The results of those previous studies were considered and used in this Initial Study.

1.1.2 The specific objectives of this Initial Study are to:

- Assess the merits or demerits of the layout and design of the selected sites and advise whether they are paramount to the effects on air ventilation either positively or negatively;
- If any problem areas are identified, outline and test the mitigation measures to address the problems satisfactorily;
- Based on the tested results, prepare appropriate site and area specific design guidelines to facilitate the preparation of recommended layout plans for a better wind environment.

1.1.3 The wind tunnel test techniques used for this study satisfied the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the relevant recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2006).

1.2 Details of the Tuen Mun East Study Area

1.2.1 The Tuen Mun East Study Area is bounded by the Tuen Mun River Channel and Hoi Wing Road to its west, Tai Lam Country Park to its north, Tai Lam Chung Nullah to its east and the coastline to its south. It comprises a total of 14 study sites at various elevations, as shown in **Figure 1,** Site 4 has subsequently been split into Sites 4A and 4B. These study sites are currently covered by two Outline Zoning Plans (OZPs), namely the Tuen Mun OZP and the So Kwun Wat OZP.

1.2.2 Under the Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study, the Tuen Mun East Study Area is proposed to include areas for low-rise houses, medium-rise apartments and a variety of Government, Institution or Community (G/IC) facilities. Five of the study sites, namely Sites 1, 2, 3, 4A and 8, are intended for G/IC use. Ten of the study sites, namely Site 4B, Sites 5 to 7 inclusive and Sites 9 to 14 inclusive, are intended for residential use.

1.2.3 Proposed layouts of all study sites considered in this Initial Study were supplied for air ventilation assessment (AVA) purposes by Scott Wilson Limited during the period of September 2007 to April 2009. The layouts for residential sites are mainly based on the preliminary layout plans in the Draft Final WP3 (February 2009), except the layouts of Sites 7 and 11 which are based on the modified layouts as of early April 2009. In particular, the indicative layouts for GIC uses at Sites 1, 2, 3, 4A and 8 are provided by Planning Department for the purpose of conducting air ventilation assessment only. The areas mentioned in the following sections refer to Developable Area of the sites.

Site 1

1.2.4 Site 1 covers an area of 1.6 hectares and is located to the north of Castle Peak Road and Cafeteria Beach, to the south of Tuen Mun Road and Site 7, and adjacent to the existing Immigration Service Institute of Training and Development Building that is located to its north-west. Site 1 is part of a former military site in Area 48 and it has been reserved for G/IC purposes to accommodate a post-secondary education institution. The location and proposed layout of Site 1 is shown in **Figure 2**.

Site 2

1.2.5 Site 2 covers an area of 3.7 hectares and is located to the north of Tuen Mun Road and Sites 3 and 8, and to the east of Site 7. Site 2 is also part of the former military site in Area 48 and it has been reserved for G/IC purposes for a proposed international school. The location and proposed layout of Site 2 is shown in **Figure 3**.

Site 3

1.2.6 Site 3 covers an area of 2.3 hectares and is located to the north of Castle Peak Road and the Hong Kong Gold Coast residential estate, to the south of Tuen Mun Road and Site 2, and to the west of Site 8. Site 3 is also part of the former military site in Area 48 and it has been reserved for G/IC purposes. The location and proposed layout of Site 3 is shown in **Figure 4**.

Site 4

1.2.7 Site 4 is located to the north of Tuen Mun Road and covers three areas that are designated as Site 4A, Site 4B (lower) and Site 4B (upper). Site 4A has a ground elevation of +68 mPD, covers an area of 0.92 hectares and has been reserved for G/IC purposes as a site for a proposed secondary school. Site 4B (lower) is located immediately to the north-east of Site 4A, has a ground elevation of +80 mPD, covers an area of 0.77 hectares and has been proposed for residential purposes. Site 4B (upper) is located immediately to the south-east of Site 4B (lower), has ground elevations of +105 mPD, +111 mPD and +116 mPD, covers an area of 4.22 hectares and has been zoned for residential purposes. The location and proposed layout of Site 4 is shown in **Figure 5**.

Site 5

1.2.8 Site 5 is located north of Tuen Mun Road, east of Site 4B, and south west of the Tai Lam Chung Reservoir. The site comprises three areas that are designated as Site 5 (lower), Site 5 (middle) and Site 5 (upper), all of which have been proposed for residential purposes. Site 5 (lower) is located to the east of Site 13, covers an area of 4 hectares and has two platforms at ground elevations of +28 mPD and +40 mPD. Site 5 (middle) is located to the north-east of Site 5 (lower) at a ground elevation of +65 mPD and covers an area of 1.2 hectares. Site 5 (upper) is located to the north of Site 5 (middle), covers an area of 4.3 hectares and has two platforms at ground elevations of +55 mPD and +70 mPD. The locations and proposed layouts of Site 5 (lower), Site 5 (middle) and Site 5 (upper) are shown in **Figure 6**, **Figure 7** and **Figure 8**, respectively.

Site 6

1.2.9 Site 6 covers an area of 0.36 hectares and is located to the south of Castle Peak Road and adjacent to a beachside barbeque area. A single rectangular residential building with a height of approximately 20 m has been proposed for Site 6. The location and proposed layout of Site 6 are shown in **Figure 9**.

Site 7

1.2.10 Site 7 covers an area of 6.7 hectares and is located to the north of Tuen Mun Road and Site 1, and to the west of Site 2. Site 7 is also part of the former military site in Area 48 and it has been rezoned for residential use. Site 7 is located to the north-east of Site 1, to the west of Site 2 and to the north-west of Sites 3 and 8. Site7 has three platforms at ground elevations of +25 mPD, +50 mPD and +60 mPD. A total of 24 residential buildings, with various orientations and a consistent roof elevation of +70 mPD, and one club house have been proposed for Site 7. The location and proposed layout of Site 7 is shown in **Figure 10**.

Site 8

1.2.11 Site 8 covers an area of 2.7 hectares and is located to the north of Castle Peak Road, to the north-east of the Hong Kong Gold Coast residential estate, to the south of Tuen Mun Road and Site 2, and to the east of Site 3. Site 8 is also part of the former military site in Area 48 and has been reserved for G/IC purposes. The location and proposed layout of Site 8 is shown in **Figure 11**.

Site 9

1.2.12 Site 9 covers an area of 0.3 hectares and is located at Tuen Mun Area 55 between Castle Peak Road and Ka Wo Li Hill Road. A single irregularly shaped residential building with a height of approximately 20 m has been proposed for Site 9. The location and proposed layout of Site 9 are shown in **Figure 12**.

Site 10

1.2.13 Site 10 covers an area of 1.2 hectares and is located at Tuen Mun Area 55 between Castle Peak Road and Tuen Mun Road. Seven irregularly shaped, 10 storey residential buildings have been proposed for Site 10. The ground elevation of Site 10 will be levelled to a consistent +25 mPD, which is significantly higher than the adjacent sections of Castle Peak Road (approximately +20 mPD). The location and proposed layout of Site 10 are shown in **Figure 13**.

Site 11

1.2.14 Site 11 covers an area of 9.7 hectares at a seafront area south of Castle Peak Road on Tsing Fat Street that was the former site of the Lok On Pai desalination plant at Tuen Mun Area 59. Site 11 has been rezoned for residential purposes and its location and proposed layout are shown in **Figure 14**.

Site 12

1.2.15 Site 12 covers an area of 0.2 hectares and is located at Kwun Fung Street in So Kwun Wat, to the north of Tuen Mun Road and Site 13. Three 10 m tall residential buildings are proposed for Site 12, which will have a ground elevation of +67 mPD. The location and proposed layout of Site 12 are shown in **Figure 15**.

Site 13

1.2.16 Site 13 covers an area of 0.9 hectares and is located adjacent to Kwun Yat Street in So Kwun Wat to the north of Tuen Mun Road, to the east of Kwun Fat Street, and to the west of Site 5 (lower). The buildings proposed for Site 13, which will have a ground elevation of +30 mPD, include six rectangular 3 storey residential buildings. The location and proposed layout of Site 13 are shown in **Figure 16**.

Site 14

1.2.17 Site 14 covers an area of 5.1 hectares and is located at Tuen Mun Area 55 between Tuen Mun Road and So Kwun Wat Road. Site 14 has a ground elevation of +20 mPD and has been zoned for residential purposes. The location and proposed layout of Site 14 are shown in **Figure 17**.

1.3 Sites recommended for Initial Study

1.3.1 In accordance with the recommendations of the previously conducted Expert Evaluation, the Initial Study was conducted for Sites 1, 2, 3, 4A, 5 (lower), 7, 8, 10, 11 and 14. The findings of the Expert Evaluation indicated that an Initial Study was not required for Sites 4B, 5 (middle), 5 (upper), 6, 9, 12 and 13. However, due to the coverage of the wind tunnel models used for the Initial Study, Sites 9, 12 and 13 and also part of Site 4B were included in the physical model and, in accordance with the instruction of Scott Wilson Ltd, test points were included in those modelled areas. Part of Sites 4B, 5 (middle & upper) and 6 were not included in this Initial Study as the Expert Evaluation alone is sufficient to assess pedestrian level wind conditions in those sites.

2 WIND TUNNEL MODELLING

2.1 Physical Model of the Tuen Mun Study Area

2.1.1 Two 1:400 scale wind tunnel models, designated as the East and West Models, were fabricated to cover each of the study sites requiring an Initial Study. Each proximity model included the surrounding areas within a diameter up to 2 km, in which the topography was modelled at 4 m contour intervals, and all known existing and committed buildings and structures within the area. Each model was fabricated in accordance with plans, drawings and information supplied by Scott Wilson Ltd, during the period of September 2007 to May 2009. The locations and the coverage areas of the two models were agreed with Scott Wilson Ltd on 18 March 2008 for the Site Wind Availability Study and the same model areas were also used in this Initial Study.

2.1.2 The East Model includes Sites 4A, 4B (part), 5 (Lower), 9, 10, 11, 12, 13 and 14, formerly designated as Position 2 in the Site Wind Availability Study. Sites 1, 2, 3, 7, and 8 are included in the West Model, formerly designated as Position 1 in the Site Wind Availability Study.

2.1.3 Existing trees within the modelled area were modelled with foliage and in their mature state. The coverage of the two models are shown in **Figure 18** and various views of the wind tunnel models are shown in **Figure 19** to **Figure 26** inclusive.

2.1.4 The East Model was installed with a total of 190 test points, designated as E001 to E190 inclusive, and the West Model was installed with a total of 124 test points, designated as W001 to W124 inclusive, as shown in **Figure 27** to **Figure 30** inclusive, to measure pedestrian level mean wind speeds in and around the relevant study sites.

2.2 Modelling the Natural Wind

2.2.1 In conducting wind tunnel model tests of structures on the surface of the Earth, it is necessary to adequately simulate the lowest layer of the atmosphere, known as the atmospheric boundary layer. It is within this layer that the surface of the Earth imparts drag forces on the moving air, generally resulting in mean wind speed increasing with height to a point where the effects of surface drag become negligible. In wind engineering, a convenient measure of the thickness of the atmospheric boundary layer is commonly referred to as the gradient height and its magnitude depends on the surrounding surface roughness over which the air must flow. Obstacles to air flow can vary from relatively large expanses of smooth, open water, to vegetation such as forests, built-up environments such as city centres, and large, rugged mountain ranges. The resulting gradient heights are typically in the range of several hundred metres to in excess of 1000 m.

2.2.2 A 1:2000 scale experimental Site Wind Availability Study has been undertaken previously (WWTF Investigation Report WWTF011-2008) to determine the effects of topography on local wind conditions and the site wind availability for the East and West Models. Due to the similarities between both mean wind speed and turbulence intensity profiles for certain wind directions, four representative approach profiles are considered to be adequate to represent the range of wind conditions affected by the local terrain for the full 360° azimuth for the East Model and for 90° to 315° for the West Model. Due to the significant topography in the West Model for wind directions ranging from 337.5° to 67.5° inclusive, the approach conditions for these wind directions were calibrated individually. The approach conditions corresponding to each of the 16 wind directions tested are presented in **Table 1**. Mean wind speed profiles and turbulence intensity profiles for the approach conditions are presented in graphical form in **Figure 31** to **Figure 39** inclusive.

2.2.3 For all tests, reference wind speeds were measured at a height of 300 mPD. Wind speed scaling factors (F) were applied to relate the non-typhoon wind speed at 500 mPD above open terrain to wind speeds at the reference height, as shown in Equation (1).

$$V_{ref} = FV_{500,open} \qquad (1)$$

where:
F = wind speed scaling factor;
V_{ref} = the mean wind speed measured at the reference height (equivalent to 300 mPD in this 1:400 scale study); and
$V_{500,open}$ = directional non-typhoon mean wind speed at 500 mPD above open water terrain.

2.2.4 The wind speed scaling factors, F, are based on the matching of mean wind speeds between the 1:2000 scale topographical model and the 1:400 scale model as shown in Equation (2), averaged over five heights equivalent to 25 mPD, 50 mPD, 75 mPD, 100 mPD and 150 mPD at prototype scale.

$$F = \left[\frac{V_z}{V_{500,open}}\right]_{1:2000} \left[\frac{V_{ref}}{V_z}\right]_{1:400} \qquad (2)$$

where:
V_z = mean wind speed measured at a height z (i.e. where z is equivalent to 25 mPD, 50 mPD, 75 mPD, 100 mPD and 150 mPD at prototype scale);
V_{ref} = wind speed measured at the reference height (z_{ref}) in the 1:400 scale tests, taken as 300 mPD for this study; and
$V_{500,open}$ = directional mean wind speed at 500 mPD above open water terrain.

2.2.5 The wind speed scaling factors presented in **Table 2** for each of the 16 measured wind directions were determined as an average from the wind speeds measured in the 1:2000 and 1:400 scale tests at 25 mPD, 50 mPD, 75 mPD, 100 mPD and 150 mPD.

3 EXPERIMENTAL AND ANALYSIS PROCEDURE

3.1 Wind Tunnel Testing

3.1.1 The AVA Initial Study of the Tuen Mun East Study Area was conducted in WWTF's low speed test section using two 1:400 scale models. Wind speed measurements were taken using a multi-channel thermal anemometer at a total of 314 measurement locations specified by Scott Wilson Limited, at 22.5º increments for the full 360º azimuth (i.e. 16 wind directions), where a wind direction of 0º or 360º corresponds to an incident wind approaching the proposed development site directly from the north, 90º corresponds to an incident wind approaching the proposed development site directly from the east, etc

3.2 Wind Speed Measurements and Analysis Procedures

3.2.1 Determining Directional and Overall Wind Velocity Ratios

3.2.1.1 Wind speeds at each test point were measured using a multi-channel thermal anemometer whose signals were sampled using a dedicated computer for a period corresponding to approximately one hour at prototype scale. The mean wind speed measurements at each test point were subsequently related to the approaching upper level wind speed as a directional wind velocity ratio ($VR_{500,i,j}$).

3.2.1.2 Directional wind velocity ratios are defined as the ratio $V_{p,i,j}/V_{\infty}$, where $V_{p,i,j}$ is the mean wind speed at pedestrian level (i.e. measured at 2 m above ground at each test point in the 1:400 scale models) and V_{∞} is the mean wind speed at the top of the atmospheric boundary layer (taken as the mean wind speed at 500 mPD in this study, and denoted as $V_{500,i}$ in the following sections). Directional wind velocity ratios are used as an indicator of the wind characteristics at each of the test points.

3.2.1.3 Directional wind velocity ratios were determined at 22.5º intervals for the full 360º azimuth (i.e. 16 wind directions) for each test point. At a particular wind direction (i), the wind velocity ratio of the j-th test point is expressed in Equation (3).

$$VR_{500,i,j} = \frac{V_{p,i,j}}{V_{500,i}} \qquad (3)$$

3.2.1.4 The overall wind velocity ratio of the j^{th} test point ($VR_{w,j}$) is defined in Equation (4), which accounts for the probability of occurrence (p_i) of winds approaching the Study Area from each of the 16 measured wind directions. The average wind shifts and probabilities of occurrence (p_i) of the approach winds for the Tuen Mun East Study Area are presented in **Table 3** and **Table 4** respectively. Annual and summer wind roses for the Tuen Mun East Study Area, corrected to a height of 150 mPD and with the average wind shifts applied, are presented in **Figure 40** to **Figure 43** inclusive. Corresponding data are also presented in tabular form in **Appendix A**.

$$VR_{w,j} = \sum_{i=1}^{16} p_i \times VR_{500,i,j} \qquad (4)$$

3.2.2 Definition of Spatial Average Velocity Ratio

3.2.2.1 The spatial average velocity ratio (SAVR) for a particular site, defined as the spatial average of the $VR_{w,j}$ of all test points that are relevant to that site, is defined in Equation (5). In the current study, the SAVR is used as a representative and relative indicator of pedestrian level wind conditions within each relevant site.

$$SAVR = \sum_{j=1}^{n} \frac{VR_{w,j}}{n} \qquad (5)$$

where n is the total number of test points relevant to the particular site.

4 EXPERIMENTAL RESULTS AND DISCUSSION

Directional velocity ratios, annual and summer overall velocity ratios measured for all test points are presented in **Appendix B**.

4.1 Site 1

4.1.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 1 (W104, W105, W108, W109, W110, W114 and W115) are presented in **Table 5**. The annual and summer SAVR for the test points within Site 1 are 0.20 and 0.24 respectively. The higher summer SAVR for Site 1 is due to its relatively open exposure to winds from the south to south-west directions that are more prevalent during the summer months.

4.1.2 The highest annual overall velocity ratio (0.21) was measured at test points W108, W109, W110 and W115, and the lowest annual overall velocity ratio was measured at test point W105 (0.14). The highest summer overall velocity ratio was measured at test point W115 (0.31) and the lowest summer overall velocity ratio was also measured at test point W105 (0.14).

4.1.3 The directional velocity ratios measured at test point W105 show that this location is sheltered from winds for most directions and low wind speeds are expected throughout the year. This is caused by the combined effects of the nearby topography and the proposed +37.0 mPD building to the south of the test point location.

4.1.4 The north-east to south-west aligned non-building area acted as an effective air path for wind directions from 180° to 247.5°, as indicated by the directional velocity ratios measured at test points W104, W109 and W114. As the total probability of winds coming from 180° to 247.5° inclusive is 42.5% during the summer months, this non-building area is an effective means of conveying the prevailing summer winds into Site 1, which is expected to be beneficial to the local pedestrian level wind environment. Similar characteristics were measured at test points W103, W110 and W113, that are located to the north-east of Site 1 and which are aligned parallel to the non-building area in Site 1. This indicates that the proposed development at Site 1 allows the penetration of south to south-westerly winds into and around the site.

4.1.5 The effectiveness of the south-east to north-west aligned non-building area in Site 1 to serve as an air path for easterly winds is limited, as evidenced by the directional velocity ratios measured at test points W108, W109 and W110. In general, directional velocity ratios measured at these test points are relatively low for winds from 45° to 157.5° inclusive.

4.1.6 In summary:

4.1.6.1 The proposed development at Site 1 allows the general penetration of south to south-westerly winds into and around the site.

4.1.6.2 The north-east to south-west aligned non-building area in Site 1 serves as an effective air path.

4.1.6.3 The effectiveness of the south-east to north-west aligned non-building area in Site 1 to serve as an air path for easterly winds is limited.

4.1.6.4 The penetration of east to south-easterly winds into Site 1 is limited to areas immediately adjacent to Castle Peak Road.

4.2 Site 2

4.2.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 2 (W059 – W074 inclusive and W077 – W079 inclusive) are presented in **Table 6**. Annual and summer SAVR for test points located in Site 2 are 0.22 and 0.21 respectively. The similarity of the annual and summer SAVR is attributed to the effects of the nearby topography to the north of Site 2, the buildings and developments between Site 2 and the coastline to its south and south-west and the layout of the proposed buildings in Site 2.

4.2.2 The highest annual overall velocity ratio was measured at test point W060 (0.30) and the lowest annual overall velocity ratio was measured at test point W068 (0.17). The highest summer overall velocity ratio was measured at test point W073 (0.29) and the lowest summer overall velocity ratio was measured at test point W068 (0.16).

4.2.3 The directional velocity ratios measured for most test points within Site 2 for winds approaching from 180° and 202.5° were relatively low, except for test points W059, W061 and W072. These test points experienced relatively high wind speeds due to their proximity to the slope defining the southern boundary of Site 2, which caused localised flow accelerations for some wind directions. The arrangement of the proposed buildings within Site 2 prevented these enhanced winds from penetrating deeper into the Site, which can be seen from the directional velocity ratios for test points W060, W065, W068, W071 and W079. These test points are located immediately to the north of some proposed buildings which shelter these locations from southerly winds.

4.2.4 Relatively low overall velocity ratios were measured at test points W067 (0.18annual / 0.18summer), W068 (0.17annual / 0.16summer) and W069 (0.19annual / 0.18summer). Test point W067 is very sheltered for most wind directions due its location in a small gap between the two proposed buildings of Building 1 which inhibits local wind penetration. At test points W068 and W069, the low annual and summer overall velocity ratios were due to the shelter from northerly winds by Building 5, from southerly winds by Building 1 and from south-westerly winds by the topography and proposed buildings located on the +50 mPD Platform of Site 7.

4.2.5 For wind approaching from 90°, the directional velocity ratios measured at test points located on the east-west aligned non-building area, i.e. test points W060, W068, W069, W070 and W071, are 0.50, 0.19, 0.25, 0.23 and 0.29 respectively. The large variation in the magnitude of the directional velocity ratios along the east-west aligned non-building area demonstrates the localised effects of nearby buildings on pedestrian level wind speeds. Of these test points, the highest directional velocity ratio was measured at test point W060, which is likely to be due to a combination of accelerated wind flow caused by the sloping terrain to the east of Site 2 and the winds accelerating around Building 3 to its south.

4.2.6 Directional velocity ratios for south winds measured at test points W061 (0.31) and W074 (0.12), located on the north-south aligned non-building area to the east of the site, highlight the variable wind conditions that are likely to occur along this area due to the effects of nearby buildings and topography. Test point W061 is exposed to winds from 112.5° to 202.5°, whereas test point W074 is very sheltered by the local topography for winds from directions 135° to 292.5° inclusive.

4.2.7 At the north-south aligned non-building area in the west of Site 2, the directional velocity ratios for winds from 180° measured at test points W063 (0.13), W070 (0.12) and W077 (0.10) are significantly lower than those measured for adjacent wind directions. It is likely that these wind conditions are caused by a combination of the effects of Tower 1 to Tower 4 of the Hong Kong Gold Coast, the proposed buildings of Site 3 and the nearby topography. These effects also reduce the effectiveness of this non-building area to convey southerly winds into Site 2.

4.2.8 In summary:

4.2.8.1 Locations close to the southern boundary of Site 2 are likely to experience more favourable pedestrian level wind conditions due to their exposure to southerly winds and the effects of the nearby sloping terrain.

4.2.8.2 The north-south aligned non-building area in the east of Site 2 is likely to allow some penetration of southerly winds, although their strength is likely to be reduced further into Site 2 due to the topography and proposed buildings.

4.2.8.3 The north-south aligned non-building area in the west of Site 2 is effective in facilitating wind penetration into Site 2. However, southerly winds reaching this area are likely to be inhibited by the combined effects of the Hong Kong Gold Coast, the proposed buildings of Site 3 and the nearby topography.

4.2.8.4 The proposed east-west aligned non-building area is likely to enable the penetration of easterly winds into Site 2, although the proposed buildings and topography in Site 2 will have localised effects on the strength of pedestrian level wind speeds along the non-building area.

4.2.8.5 It is recommended that consideration be given to removing one of the pair of buildings for Building 1 and/or including greater variations in building height for Buildings 1, 4 and 5. However, it should be noted that increasing building heights in Site 2 may have some impact on pedestrian level wind conditions in the adjacent areas of Site 7.

4.3 Site 3

4.3.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 3 (W029 – W032 inclusive, W040 – W044 inclusive and W055) are presented in **Table 7**. The annual and summer SAVR for Site 3 are 0.18 and 0.20 respectively, indicating that the air ventilation performance of Site 3 during the summer months is slightly better than the annual average.

4.3.2 The highest annual and summer overall velocity ratios were measured at test point W032 (0.25_{annual} / 0.28_{summer}). The lowest annual and summer overall velocity ratios were measured at test point W055 (0.11_{annual} / 0.12_{summer}).

4.3.3 Test points W032 and W055 are located on the north-south aligned non-building area in the east of Site 3. Test point W032, which is located adjacent to Castle Peak Road to the south of Site 3, is relatively exposed to winds from the east to the south-west inclusive, although the existing towers in the Hong Kong Gold Coast estate are likely to be responsible for reduced wind speeds from 247.5°. At the northern end of this non-building area, the directional velocity ratios measured at test point W055 are relatively low for most wind directions. These characteristics are likely to be due to the topography and localised effects caused by nearby buildings. Nevertheless, the ability of this non-building area to facilitate wind penetration into Site 3 is indicated by the relatively high directional velocity ratios at test point W040 for winds from the south-east quadrant.

4.3.4 Test points W030, W042 and W043 are located on the north-south aligned non-building area in the west of Site 3. For winds from 180°, the directional velocity ratios measured at W030, W042 and W043 were 0.25, 0.15 and 0.07 respectively. Similar characteristics were measured for adjacent wind directions, demonstrating that the penetration of southerly winds into Site 3 is inhibited by the local topography and nearby proposed buildings.

4.3.5 Test point W044 is located on the east-west aligned non-building area in Site 3. The relatively low magnitudes of directional velocity ratios measured at this location for easterly winds indicate that those winds are disrupted by the surrounding topography and the proposed buildings in Site 8.

4.3.6 Directional velocity ratios measured at test points W029 and W041 demonstrate the localised sheltering effects of adjacent proposed buildings and nearby topography on pedestrian level wind speeds at those locations.

4.3.7 In summary:

4.3.7.1 Winds approaching Site 3 from southerly directions are likely to be moderated by the tall buildings in the Hong Kong Gold Coast estate.

4.3.7.2 The north-south aligned non-building areas in Site 3 allow some penetration of southerly winds, although these winds are diminished further into Site 3 due to the combined effects of topography and proposed buildings.

4.3.7.3 Wind penetration along the proposed east-west aligned non-building area is disrupted by the surrounding topography and the proposed buildings in Site 8.

4.3.7.4 Localised sheltering effects are likely to be experienced in areas adjacent to the proposed buildings in Site 3.

4.3.7.5 Introducing greater variation of building heights in Site 3 may facilitate the conveyance of higher level winds to pedestrian level in Site 3 to provide localized improvements. However, the localized benefits coming from introducing that measure would need to be considered against potential negative impacts on the penetration of southerly winds and pedestrian level winds conditions in Site 8, Site 2 and other existing residential areas.

4.4 Site 4

4.4.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 4 are presented in **Table 8**.

Site 4A

4.4.2 Annual and summer SAVR for the test points located in Site 4A (E118 – E120 inclusive) are 0.31 and 0.29 respectively. The highest annual overall velocity ratio was measured at test point E118 (0.37) and the lowest annual overall velocity ratio was measured at test point E120 (0.24). The highest summer overall velocity ratio was measured at test point E119 (0.30) and the lowest summer overall velocity ratio was also measured at test point E120 (0.26). It is noted that the magnitudes of the lowest overall velocity ratios and the annual and summer SAVR are relatively large, which indicates that windy conditions are likely to occur relatively frequently at exposed locations in Site 4A.

4.4.3 Test point E118, located at the northern corner of Site 4A, is exposed to winds from 225° to 67.5° inclusive, as indicated by the magnitudes of the directional velocity ratios measured at this location. Directional velocity ratios measured at test point E118 for winds from 112.5° to 180° inclusive are significantly lower, which is attributed to the combined effects of the proposed school buildings and the topography to the south-east. Winds approaching from 22.5° and 45° were accelerated significantly by the adjacent hilly terrain. The large difference between the annual and summer overall velocity ratios at test point E118 is due to the shelter of this location from southerly winds.

4.4.4 Wind conditions at test points E119 and E120, located between the proposed school buildings in Site 4A, indicate that the spacing between the two buildings facilitates the penetration of easterly, south-easterly and south-westerly winds. Windy conditions are likely in this area during the winter months and it is recommended to consider planting suitable trees and/or including other appropriate landscaping to provide local shelter from cold winds.

4.4.5 In summary:

4.4.5.1 Windy conditions are likely to occur relatively frequently in Site 4A.

4.4.5.2 Some localised sheltering will be experienced for certain wind directions due to the proposed buildings in Site 4A. Sheltering effects will vary over the site and will also depend on wind direction.

4.4.5.3 It is recommended to consider planting suitable trees and/or including other appropriate landscaping to provide local shelter from cold winds in the typically windy winter months.

Site 4B

4.4.6 Annual and summer overall velocity ratios for the test points within Site 4B (Lower) are E122 (0.30_{annual} / 0.30_{summer}) and E123 (0.32_{annual} / 0.28_{summer}), both of which are located at an elevation of +80 mPD. Annual and summer overall velocity ratios for the test points within Site 4B (Upper) are E111 (0.35_{annual} / 0.43_{summer}), which is located at an elevation of +111 mPD, and E112 (0.31_{annual} / 0.32_{summer}), which is located at an elevation of +116 mPD.

4.4.7 Although the proximity of Site 4B to the perimeter of the East model is likely to be partly responsible for the high magnitudes of velocity ratio measured in this area, the annual and summer overall velocity ratios measured are representative of the effects of high elevation and the absence of nearby developments on pedestrian level wind speed. As windy conditions are expected to occur in Site 4B on a relatively frequent basis, it is recommended to include suitable landscaping, such as mature trees, to provide some shelter from winds from the north-east quadrant that typically occur during the cooler winter months.

4.4.8 In summary:

4.4.8.1 Windy conditions are likely to occur relatively frequently in Site 4B.

4.4.8.2 It is recommended to consider planting suitable trees in Site 4B to provide shelter from strong winds in the typically cooler windy winter months.

4.5 Site 5 (Lower)

4.5.1 Due to limit of the detailed model used for the current study, only two test points (E098 and E099) were installed in the modelled area of Site 5 (lower) and the magnitudes of the velocity ratios measured at those locations are likely to be affected by their proximity to the perimeter of the East model. Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 5 are presented in **Table 9**.

4.5.2 The measured directional velocity ratios for test point E099 indicate that this location is likely to be sheltered to some extent for south-westerly winds by the proposed buildings in Site 5 (lower). Tree planting is recommended to improve pedestrian level conditions during the warmer summer months.

4.5.3 In summary:

4.5.3.1 Some sheltering is likely for south-westerly winds.

4.5.3.2 It is recommended to plant additional trees to improve pedestrian level conditions during the warmer summer months.

4.6 Site 7

4.6.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 7 are presented in **Table 10**.

4.6.2 A qualitative assessment of a refined layout of Site 7, provided by Scott Wilson in June 2009 and hence which was not included in the wind tunnel tests conducted for this Initial Study, has been included in **Appendix C**.

Platform at +25 mPD

4.6.3 Test points W092, W093 and W095 to W099 inclusive are located on the +25mPD platform in Site 7. The annual and summer SAVR for these test points are 0.15 and 0.17 respectively, indicating that pedestrian level wind speeds are likely to be generally low. The air ventilation performance during the summer months is slightly better than the annual average due to the local topography sheltering this location from northerly to north-easterly winds and the more open exposure to southerly winds.

4.6.4 The highest annual overall velocity ratio was measured at test point W098 (0.18) and the lowest annual overall velocity ratio was measured at test point W097 (0.12). The highest summer overall velocity ratio was also measured at test point W098 (0.20) and the lowest summer overall velocity ratio was measured at test points W092, W093 and W097 (0.15).

4.6.5 Low directional velocity ratios were measured at most test points on the +25 mPD platform for winds from 0° to 180° inclusive. This is likely to be due to the sheltering effects of the surrounding topography to the north and east of the platform and Tuen Mun Road to its south. The closely spaced proposed buildings and consistent building elevation also generally inhibit pedestrian level wind penetration into this area.

4.6.6 Test point W098, located at the southern end of the +25 mPD platform, is sheltered for wind directions of 45° to 157.5° inclusive, 247.5° and 292.5° while being more exposed to winds from 180° to 225°. This is attributed to the proximity of test point W098 to Tuen Mun Road and some upper level winds being captured by the nearby proposed building and conveyed to pedestrian level. A similar effect can also be seen in the directional velocity ratios of test point W099 for winds approaching from 180°. Other test points on the +25 mPD platform recorded significantly lower directional velocity ratios for winds from 180° which is attributed to the close spacing and consistent elevation of the proposed buildings.

4.6.7 Directional velocity ratios measured for easterly winds at test points W095, W096 and W097, which are located on the approximately south-east to north-west aligned non-building area, were all of low magnitude. These low wind conditions are caused by the higher topography and buildings to the east of this area and the consistent heights of the proposed buildings.

Platform at +50 mPD

4.6.8 Test points W084 to W090 inclusive are located on the +50mPD platform in Site 7. The annual and summer SAVR are both 0.20. The highest annual overall velocity ratio was measured at test points W087 and W088 (0.23) and the lowest annual overall velocity ratio was measured at test point W085 (0.13). The highest summer overall velocity ratio was measured at test point W089 (0.24) and the lowest summer overall velocity ratio was also measured at test point W085 (0.14).

4.6.9 Annual and summer overall velocity ratios measured at test points W084 and W085, located towards the north of the +50 mPD platform, are relatively lower than those measured for the other test points on this platform. The directional velocity ratios measured at test point W085 indicate significant sheltering from wind directions of 0° to 202.5° inclusive. Similarly, directional velocity ratios at test point W084 indicate sheltering from wind directions of 0° to 67.5° inclusive and 135° to 202.5° inclusive. These sheltering effects are attributed to the significant topography to the north of this platform and to the close spacing and consistent heights of the proposed buildings.

4.6.10 Test points W086, W087 and W088, located on the south-east to north-west aligned non-building area, and test points W089 and W090, located close to the southern edge of the platform, are significantly more exposed to southerly winds. However, directional velocity ratios for winds from 180° generally decrease with distance from the southern edge of the platform indicating that the penetration of southerly winds into the site is mainly limited by the configuration of the proposed buildings.

4.6.11 Directional velocity ratios measured at test points W086 to W088 inclusive for winds from 67.5° to 112.5° inclusive indicate the potential for moderate penetration of easterly winds into this area.

Platform at +60 mPD

4.6.12 Test points W081, W082 and W083 are located on the smaller +60mPD platform in Site 7. The annual and summer SAVR of these test points are 0.17. The highest annual and summer overall velocity ratios were measured at test point W081 (0.20annual / 0.20summer) and the lowest annual overall velocity ratios were measured at test point W083 (0.15annual / 0.13summer).

4.6.13 Directional velocity ratios measured at test point W083, the northern-most test point on the +60 mPD platform, indicates that this location is sheltered for most wind directions by the topography to the north and the adjacent proposed buildings. The sheltering effects caused by the mountains to the north-east of the site also resulted in low directional velocity ratios at test points W081 and W082 for winds approaching from 0° to 67.5° inclusive.

4.6.14 Relatively low directional velocity ratios measured at test points W081, W082 and W083 for wind directions ranging from 157.5° to 202.5° are likely to be caused by the consistent elevation of the proposed buildings located at the+25 mPD and +50 mPD platforms. However, the embankment between the +25mPD platform and +50mPD platform allowed winds from 225° to reach the +60 mPD platform, which is indicated by the relatively higher directional velocity ratios. The directional velocity ratios for test points located on the +60mPD also indicated moderate penetration for wind directions ranging from 90° to 135° which will be of benefit during the summer months.

4.6.15 In summary:

4.6.15.1 The +25 mPD platform was significantly sheltered for most wind directions. Wind penetration decreases at locations towards the north of this area due to the close spacing and consistent heights of the proposed buildings. For this area, it is recommended to introduce appropriate non-building areas to reduce the number of buildings and increase spacing between buildings. Varying building heights may also allow upper level winds to be utilised.

4.6.15.2 The annual and summer SAVR for the platform at an elevation of +50 mPD were significantly higher than those for the +25 mPD platform due to its higher elevation and a more open exposure to southerly winds. However, the penetration of southerly winds was inhibited to some extent by the configuration of the proposed buildings. The east-west aligned non-building area facilitated the local penetration of easterly winds into the +50 mPD platform.

4.6.15.3 For the +60 mPD platform, moderate penetration is likely for wind directions ranging from 90° to 135°, which will be of benefit during the summer months. The consistent heights of the proposed buildings located on the +25 mPD and +50 mPD platforms significantly reduced the strength of south-easterly to south-westerly winds reaching the +60 mPD platform.

4.7 <u>Site 8</u>

4.7.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 8 (W033 – W039 inclusive, W045 – W048 inclusive, W054 and W057) are presented in **Table 11**. The annual and summer SAVR for Site 8 are 0.21 and 0.22 respectively.

4.7.2 The highest annual and summer overall velocity ratios were measured at test point W035 (0.30annual / 0.34summer). The lowest annual and summer overall velocity ratios were measured at test point W057 (0.13annual / 0.13summer).

4.7.3 Test point W035, located immediately adjacent to a slope at the south-east corner of Site 8, is exposed to winds ranging from 90° to 225°. The slope adjacent to test point W035 is likely to cause accelerated wind flow, and this effect was most significant for wind approaching from 90°. Winds approaching from 180° to 225° inclusive are accelerated by existing buildings in the Aegean Coast estate and similar effects were also measured at test point W034.

4.7.4 Test points W035, W038, W039 are located on the south-east to north-west aligned non-building area in the south of Site 8. The annual and summer overall velocity ratios at these test points decrease from the east to the west along this non-building area. This is primarily due to the reduction in the strength of winds from 90° and 112.5° caused by the proposed buildings adjacent to the non-building area. This has also affected the strength of easterly winds available to Site 3.

4.7.5 Test points W034, W047 and W054 are located on the north-south aligned non-building area that facilitates the penetration of south winds into Site 8. Although the strength of south winds are moderated towards the north of Site 8, which is attributed to the effects of the adjacent proposed buildings, the non-building area is an effective means of improving pedestrian level wind conditions at a site that is located in complex terrain.

4.7.6 In summary:

4.7.6.1 Pedestrian level wind conditions close to the southern boundary of Site 8 are likely to be relatively windy due to their exposed location and localised acceleration of wind flow. These conditions are caused by topography to the east and south of Site 8 and the existing buildings of the Aegean Coast estate to the south.

4.7.6.2 The north-south aligned non-building area in Site 8 facilitates the penetration of southerly winds, although the strength of those winds will diminish towards the north of Site 8.

4.7.6.3 The strength of easterly winds along the east-west aligned non-building area will diminish toward the west of Site 8, which also affects the available winds penetrating deeper into Site 3.

4.7.6.4 Windy conditions may be alleviated locally through the judicious planting of trees to provide localised shelter without reducing the ability of winds to penetrate further into Site 8.

4.8 Site 9

4.8.1 Due to the small size of Site 9, only one test point (E046) was installed at that site. The directional velocity ratios and annual and summer overall velocity ratios measured for test point E046 in Site 9 are presented in **Table 12**.

4.8.2 Directional velocity ratios measured at test point E046 for winds from 225° to 90° inclusive are very low due to the close proximity of the site to the hills to its north, an existing building to its south-east, a noise barrier along the adjacent section of Castle Peak Road and the Hong Kong Gold Coast to the west.

4.8.3 The effects of the noise barrier on local wind conditions can be illustrated by comparing directional wind velocity ratios for test point E045, which are also presented in **Table 12**, located to the south-west of Site 9 at the junction of Castle Peak Road and the access road to the Hong Kong Gold Coast, and test point E046. The effects of the noise barrier were significant for wind directions from 225° to 270°, which is likely to significantly diminish the potential benefit of south-westerly winds in the summer months.

4.8.4 In summary:

4.8.4.1 Site 9 is significantly sheltered by hills to its north, an existing building to its south-east, a noise barrier along the adjacent section of Castle Peak Road and the Hong Kong Gold Coast to the west.

4.8.4.2 It is recommended to make use of landscaping and substantial planting of shade trees to improve pedestrian comfort and the pedestrian level wind environment in Site 9.

4.9 Site 10

4.9.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 10 (E055 – E057 inclusive and E062) are presented in **Table 13**. The annual and summer SAVR for Site 10 are 0.21 and 0.20 respectively. The highest annual and summer overall velocity ratios were measured at test point E056 (0.26_{annual} / 0.24_{summer}). The lowest annual and summer overall velocity ratios were measured at test point E062 (0.15_{annual} / 0.12_{summer}).

4.9.2 Test point E062 is sheltered by the local topography and a nearby proposed building in Site 10, especially for winds approaching from 112.5° to 270° inclusive. This is likely to create a localised area of low wind speed during the summer months.

4.9.3 The penetration of easterly winds into the central private open space of Site 10 is demonstrated by the magnitudes of the corresponding directional velocity ratios for test point E056, and particularly for wind directions ranging from 67.5° to 135°.

4.9.4 Directional velocity ratios also indicate that the strength of south to south-westerly winds will vary over Site 10 due to the localised effects of the proposed buildings in the site. Although these winds are likely to be moderate, the elevation of Site 10 and the spacing between the proposed buildings will allow some penetration of winds from the south to south-west during the summer months.

4.9.5 In summary:

4.9.5.1 The central private open space of Site 10 will facilitate the penetration of easterly winds into the site.

4.9.5.2 Although south to south-westerly winds are likely to be of moderate strength at Site 10, the elevation of the site and the spacing between the proposed buildings is likely to allow some penetration of these winds during the summer months.

4.10 Site 11

4.10.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 11 (E001 – E014 inclusive, E016 – E019 inclusive, E022, E069 – E071 inclusive, E075, E076, E078 and E079) are presented in **Table 14**. The annual and summer SAVR for Site 11 are 0.23 and 0.26 respectively. The better air ventilation performance during the summer months is due to the relatively open exposure of Site 11 to winds from the seafront. In general, winds from the northerly directions of 315°, 337.5° and 0° are relatively weak due to the effects of the topography and buildings to the north of Site 11.

4.10.2 The highest annual and summer overall velocity ratios were measured at test point E001 (0.36annual / 0.36summer). The lowest annual overall velocity ratio was measured at test point W078 (0.12annual / 0.15summer) and the lowest summer overall velocity ratio was measured at test point E022 (0.17_{annual} / 0.15_{summer}).

4.10.3 Test point E001, located at the south-east corner of Site 11, is relatively exposed to winds ranging from the north-east to the south-west inclusive. Its proximity to the seafront promenade is likely to result in relatively windy conditions.

4.10.4 To the north of test point E001, test point E009 marks the eastern-most point of a non-building area extending through Site 11 towards the north-west. Although the magnitudes of the directional velocity ratios of test point E009 are markedly less than those for test point E001, they showed similar directional characteristics and indicate the availability of winds from the east to the south-west. The directional velocity ratios measured at test points E009, E069 and E070 on that north-west to south-east aligned non-building area indicates that south-easterly winds are able to penetrate into Site 11, although the strength of the winds will decrease further away from the seafront due to the sloping terrain at the north of the site and the proposed buildings.

4.10.5 Test points E003, E013, E017 and E019 are located at the north-west to south-east aligned proposed non-building area towards the western side of Site 11. A similar trend in the directional velocity ratios at these test points indicate the general penetration of south-easterly winds into Site 11 and the gradual diminishing of wind speeds away from the seafront due to the effects of the proposed buildings adjacent to the proposed non-building area.

4.10.6 Test points E003, E007 and E011 are located on the north-south aligned non-building area that extends through the central portion of Site 11. The directional velocity ratios measured at test points E003, E007 and E011 for winds from 180° are 0.43, 0.36 and 0.31 respectively. The consistency of these directional velocity ratios demonstrates the ability of the non-building area to allow southerly winds to penetrate into Site 11.

4.10.7 To the west of Site 11, winds from the south-east to south-west inclusive were able to penetrate into neighbouring areas via Tsing Fat Street, as evidenced by the results for test points E015, E020 and E021. Therefore, the proposed development at Site 11 is not expected to have a significant effect on pedestrian level wind conditions at the existing Aqua Blue estate.

4.10.8 Test point E078, located at the +24mPD platform in Site 11, is sheltered from winds for most directions due to the topography to the north and the proposed buildings. However, a comparison with the directional velocity ratios for test point E079 indicates that these are relatively local effects, particularly for easterly and southerly wind directions.

4.10.9 In summary:

4.10.9.1 Windy conditions are likely to occur relatively frequently at locations in close proximity to seafront areas in Site 11.

4.10.9.2 The proposed non-building areas in Site 11 will allow coastal winds to penetrate further into Site 11.

4.10.9.3 Localised sheltering effects are expected at some locations on the leeward side of the proposed buildings. These effects may be more noticeable in areas that are located further away from the seafront.

4.10.9.4 The proposed development at Site 11 is not expected to have a significant effect on pedestrian level wind conditions at the Aqua Blue estate.

4.10.9.5 Windy conditions may be alleviated locally through the judicious planting of trees to provide localised shelter without reducing the ability of winds to penetrate further into Site 11.

4.11 Site 12

4.11.1 Due to its small area and expected satisfactory air ventilation performance, only one test point (E102) was installed in Site 12, presented in **Table 15**. The annual overall velocity ratio for test point within E102 was 0.31 and the summer overall velocity ratio was 0.34.

4.11.2 Pedestrian level wind conditions at Site 12 were generally positive for all measured wind directions. This is attributed to the ground elevation at Site 12 and the current absence of significant nearby developments. The directional velocity ratios measured at test point E102 for winds from 337.5° and 0° were slightly lower due to the significant topography to the north, although this did not significantly diminish the overall positive air ventilation performance of Site 12.

4.11.3 In summary:

4.11.3.1 Site 12 has relatively open exposures for most wind directions and is well placed to benefit from the available wind resources for air ventilation purposes.

4.12 Site 13

4.12.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 13 (E096, E097 and E100) are presented in **Table 16**. The annual and summer SAVR for Site 13 are 0.17 and 0.17 respectively.

4.12.2 The annual and summer overall velocity ratios measured at each test point in Site 13 did not vary significantly, ranging from 0.16 to 0.17. This is attributed to the significant sheltering effects caused by Site 5 (lower) for easterly winds, by nearby hills for northerly winds and by existing residential buildings and Tuen Mun Road for southerly winds.

4.12.3 Directional velocity ratios measured at Site 13 indicate weak penetration of southerly winds and moderate penetration of east to south-easterly winds.

4.12.4 In summary:

4.12.4.1 Site 13 is sheltered for most wind directions.

4.12.4.2 Winds from the east to south-east are likely to be relatively weak to moderate, although they will provide some benefit during the summer months.

4.12.4.3 It is recommended that tree planting be used to improve pedestrian comfort and the pedestrian level wind environment in Site 13.

4.13 Site 14

4.13.1 Directional velocity ratios and annual and summer overall velocity ratios measured for the test points in Site 14 (E136 – E139 inclusive, E145 – E153 inclusive, E171 – E173 inclusive, E176 and E177) are presented in **Table 17**. The annual and summer SAVR are 0.25 and 0.24 respectively. The highest annual and summer overall velocity ratios were measured at test point E172 (0.35_{annual} / 0.32_{summer}). The lowest annual and summer overall velocity ratios were measured at test point E139 (0.15_{annual} / 0.15_{summer}).

4.13.2 The magnitude of the directional velocity ratio (0.55) measured at test point E172 for a wind direction of 67.5° is significantly higher than the corresponding value measured at nearby test points E176 (0.37) and E151 (0.39). This is likely to be due to the shape and the alignment of the proposed building adjacent to test point E172 causing a localised region of accelerated wind flow around the building.

4.13.3 Test point E139 is located close to the western boundary of Site 14 and registered relatively low directional velocity ratios for most measured wind directions. Test point E139 is significantly sheltered by the hills to its north and south and proposed buildings nearby.

4.13.4 Pedestrian level wind conditions along the north-east to south-west aligned non-building area in Site 14 are represented by test points E139, E146, E151, E172 and E176. Except for test point E139, directional velocity ratios measured at these test points for winds from 67.5°, i.e. approximately parallel to the non-building area, are higher than those measured for adjacent wind directions. Although some of the higher directional velocity ratios are due to localised accelerated wind flow caused by the proposed buildings, this proposed non-building area is likely to be effective in facilitating wind penetration into the site.

4.13.5 Test points E150 and E171 are located on the north-west to south-east aligned non-building area in the east of Site 14 and test points E136 and E152 are located on the north-west to south-east aligned non-building area in the west of Site 14. The directional velocity ratios measured at these locations for the southerly wind directions, ranging from 135° to 202.5°, were higher than those for the adjacent directions and relatively consistent in magnitude along the proposed non-building areas. This indicates that both proposed north-south non-building areas are likely to facilitate the penetration of southerly winds into Site 14.

4.13.6 Furthermore, the spacing between the proposed buildings in Site 14 facilitated the general penetration of winds into the site. This is evidenced by the relatively consistent magnitudes of both annual and summer overall velocity ratios in Site 14. Test points with relatively lower overall velocity ratios, such as test points E139 (0.15_{annual} / 0.15_{summer}) and E145 (0.22_{annual} / 0.19_{summer}), are isolated and caused by localised sheltering effects.

4.13.7 In summary:

4.13.7.1 The site coverage and spacing of the proposed buildings in Site 14 is sufficient to facilitate the overall penetration of winds into the site.

4.13.7.2 Some localised areas of accelerated wind flow and low wind flow due to sheltering are likely to occur.

4.13.7.3 It is recommended that tree planting be used to further improve pedestrian comfort and the pedestrian level wind environment in Site 14.

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5 CONCLUSIONS

5.1.1 An Initial Study was conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST) as part of an Air Ventilation Assessment (AVA) for proposed developments at 14 sites in the Tuen Mun East Study Area.

5.1.2 The AVA Initial Study was conducted in WWTF's low speed test section using two 1:400 scale models of the Tuen Mun East Study Area. Wind speed measurements were taken using a multi-channel thermal anemometer at a total of 314 measurement locations for 16 wind directions ranging from 0º (north) to 337.5º at increments of 22.5º. Directional, annual overall and summer overall velocity ratios were determined by combining analytically the wind speed measurements and WWTF's probabilistic model of the Hong Kong non-typhoon wind climate that is based on measurements of wind speed and direction taken by Hong Kong Observatory (HKO) at Waglan Island.

5.1.3 Northerly winds are generally weak at the Tuen Mun East Study Area due to large mountains to the north of the Study Area. The availability of southerly winds is higher due to the proximity of the seafront to the south of the Study Area. The variation of local topography and ground elevations among the G/IC and potential housing sites cause large variations in the air ventilation performance over the Study Area.

5.1.4 Proposed buildings for all G/IC developments within the Study Area are generally bulky and closely spaced due to several limitations such as building heights, plot ratios and the proposed non-building areas. Proposed G/IC buildings which have a significant width perpendicular to a non-building area are likely to cause some reduction in the effectiveness of the non-building area to facilitate wind penetration.

5.1.5 For Site 1, the north-east to south-west aligned non-building area serves as an effective air path allowing the general penetration of south to south-westerly winds. The effectiveness of the south-east to north-west aligned non-building area to serve as an air path for easterly winds is limited.

5.1.6 For Site 2, the north-south aligned non-building area in the east of Site 2 is likely to allow some penetration of southerly winds. The north-south aligned non-building area in the west of Site 2 facilitates the penetration of available southerly winds. The east-west aligned non-building area is likely to facilitate the penetration of easterly winds into Site 2.

5.1.7 For Site 3, southerly winds are likely to be moderated by the tall buildings in the Hong Kong Gold Coast estate. The strength of southerly winds will diminish along the north-south aligned non-building areas in Site 3. Wind penetration along the proposed east-west aligned non-building area is disrupted by the surrounding topography and the proposed buildings in Site 8.

5.1.8 Windy conditions are likely to occur relatively frequently in Site 4A and 4B and tree planting is recommended to provide shelter from cold winds in the winter months.

5.1.9 Site 5 (Lower) is sheltered from south-westerly winds. Tree planting is recommended to improve the pedestrian level environment during the summer months.

5.1.10 For the +25 mPD platform in Site 7, it is recommended to introduce appropriate non-building areas, reduce the number of buildings, increase spacing between buildings and to vary building heights to address the relatively low wind flows. For the +50 mPD platform, the tested configuration presented some obstruction to southerly winds, although the east-west aligned non-building area facilitated the local penetration of easterly winds. For the +60 mPD platform, moderate penetration is likely for east to south-easterly winds, which will be of benefit during the summer months.

5.1.11 Windy conditions are likely close to the southern boundary of Site 8 due to the topography to the east and south of the site and the buildings in the Aegean Coast estate. The north-south aligned non-building area will facilitate the penetration of southerly winds, although the strength of those winds will diminish towards the north of Site 8. The strength of easterly winds along the east-west aligned non-building area will diminish toward the west of Site 8, which will also affect the available winds penetrating deeper into Site 3.

5.1.12 Site 9 is significantly sheltered by hills to its north, an existing building to its south-east, a noise barrier along the adjacent section of Castle Peak Road and the Hong Kong Gold Coast to the west. It is recommended to make use of landscaping and substantial planting of shade trees to improve pedestrian comfort and the pedestrian level wind environment in Site 9.

5.1.13 The central private open space of Site 10 will facilitate the penetration of easterly winds into the site. The elevation of Site 10 and the spacing between the proposed buildings is also likely to allow some penetration of south to south-westerly winds during the summer months.

5.1.14 Windy conditions are likely to occur relatively frequently at locations in close proximity to seafront in Site 11. The proposed non-building areas in Site 11 will allow coastal winds to penetrate further into the site. Localised sheltering effects are expected to cause a noticeable reduction in wind speed in areas on the leeward side of the proposed buildings.

5.1.15 The open exposure of Site 12 for most wind directions will allow it to benefit from the available wind resources.

5.1.16 Site 13 is sheltered for most wind directions by the surrounding topography. Tree planting is recommended to improve pedestrian comfort and the pedestrian level wind environment in Site 13.

5.1.17 For Site 14, the site coverage and spacing of the proposed buildings is sufficient to facilitate the overall penetration of winds into the site. It is recommended that tree planting be used to further improve pedestrian comfort and the pedestrian level wind environment in Site 14.

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TABLES

Table 1: Directional approach wind conditions

East Model				West Model			
Wind Direction (°)	Approach Condition	Wind Direction (°)	Approach Condition	Wind Direction (°)	Approach Condition	Wind Direction (°)	Approach Condition
0	C	180	B	0	W0	180	B
22.5	C	202.5	A	22.5	W22	202.5	B
45	B	225	A	45	W45	225	B
67.5	B	247.5	A	67.5	W67	247.5	D
90	B	270	A	90	D	270	B
112.5	C	292.5	C	112.5	D	292.5	D
135	B	315	C	135	D	315	D
157.5	B	337.5	C	157.5	D	337.5	W337

Table 2: Wind speed scaling factors

East Model				West Model			
Wind Direction (°)	Wind Speed Scaling Factor	Wind Direction (°)	Wind Speed Scaling Factor	Wind Direction (°)	Wind Speed Scaling Factor	Wind Direction (°)	Wind Speed Scaling Factor
0	0.67	180	0.76	0	0.67	180	0.78
22.5	0.73	202.5	0.91	22.5	0.67	202.5	0.86
45	0.78	225	0.83	45	0.52	225	0.83
67.5	0.82	247.5	0.82	67.5	0.53	247.5	0.70
90	0.76	270	0.80	90	0.82	270	0.80
112.5	0.83	292.5	0.88	112.5	0.79	292.5	0.76
135	0.85	315	0.82	135	0.75	315	0.78
157.5	0.80	337.5	0.80	157.5	0.66	337.5	0.87

Table 3: Wind shift of directional winds for the Tuen Mun East Study Area

East Model				West Model			
Wind Direction (°)	Wind Shift (°)	Wind Direction (°)	Wind Shift (°)	Wind Direction (°)	Wind Shift (°)	Wind Direction (°)	Wind Shift (°)
0	-1.7	180	8.7	0	23.0	180	2.6
22.5	-5.0	202.5	2.9	22.5	9.8	202.5	4.9
45	7.9	225	-0.2	45	-1.4	225	1.2
67.5	2.3	247.5	0.7	67.5	2.3	247.5	1.3
90	5.3	270	3.0	90	3.1	270	2.0
112.5	13.9	292.5	7.0	112.5	9.9	292.5	-11.8
135	5.3	315	8.3	135	14.4	315	-21.4
157.5	7.6	337.5	22.3	157.5	14.7	337.5	16.1

Table 4: Probability of occurrence of directional winds for the Tuen Mun East Study Area

East Model						West Model					
Wind Direction (°)	Annual Probability	Summer Probability	Wind Direction (°)	Annual Probability	Summer Probability	Wind Direction (°)	Annual Probability	Summer Probability	Wind Direction (°)	Annual Probability	Summer Probability
0	12.1%	2.5%	180	4.3%	10.1%	0	0.0%	0.0%	180	4.3%	10.1%
22.5	8.3%	2.2%	202.5	3.1%	8.3%	22.5	8.3%	2.2%	202.5	3.1%	8.3%
45	8.8%	2.5%	225	4.9%	14.5%	45	8.8%	2.5%	225	4.9%	14.5%
67.5	15.2%	4.9%	247.5	3.3%	9.7%	67.5	15.2%	4.9%	247.5	3.3%	9.7%
90	28.3%	21. 7%	270	2.5%	6.6%	90	23.4%	13.8%	270	2.5%	6.6%
112.5	0.0%	0.0%	292.5	1.0%	2.0%	112.5	8.0%	14.4%	292.5	0.0%	0.0%
135	3.1%	6.5%	315	2.2%	2.3%	135	3.0%	6.4%	315	2.5%	3.2%
157.5	3.0%	6.4%	337.5	0.0%	0.0%	157.5	0.0%	0.0%	337.5	12.8%	3.6%

Table 5: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 1

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	104	0.18	0.23	0.15	0.11	0.17	0.21	0.13	0.27	0.32	0.31	0.28	0.21	0.23	0.16	0.15	0.30	0.20	0.23
W	105	0.13	0.14	0.11	0.13	0.14	0.19	0.10	0.15	0.18	0.15	0.12	0.12	0.11	0.09	0.11	0.19	0.14	0.14
W	108	0.21	0.24	0.17	0.15	0.14	0.14	0.12	0.16	0.29	0.33	0.38	0.32	0.21	0.13	0.16	0.33	0.21	0.24
W	109	0.15	0.17	0.11	0.10	0.18	0.21	0.15	0.17	0.27	0.42	0.40	0.37	0.42	0.25	0.12	0.28	0.21	0.27
W	110	0.21	0.23	0.16	0.13	0.14	0.20	0.12	0.19	0.19	0.24	0.31	0.32	0.39	0.23	0.15	0.37	0.21	0.23
W	114	0.15	0.18	0.13	0.11	0.20	0.20	0.25	0.28	0.29	0.28	0.33	0.30	0.38	0.25	0.11	0.26	0.20	0.25
W	115	0.13	0.13	0.11	0.14	0.18	0.24	0.20	0.25	0.20	0.42	0.56	0.48	0.58	0.38	0.12	0.17	0.21	0.31

Table 6: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 2

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
W	059	0.29	0.27	0.19	0.18	0.27	0.25	0.28	0.29	0.30	0.16	0.13	0.10	0.13	0.10	0.16	0.24	0.22	0.20
W	060	0.22	0.24	0.24	0.33	0.50	0.22	0.15	0.14	0.11	0.15	0.14	0.13	0.14	0.14	0.26	0.27	0.30	0.22
W	061	0.24	0.20	0.15	0.18	0.24	0.30	0.30	0.31	0.31	0.31	0.21	0.15	0.24	0.19	0.32	0.31	0.24	0.25
W	062	0.15	0.16	0.15	0.18	0.25	0.26	0.20	0.17	0.13	0.41	0.31	0.17	0.16	0.10	0.15	0.17	0.21	0.23
W	063	0.19	0.17	0.14	0.15	0.32	0.34	0.29	0.21	0.13	0.31	0.24	0.27	0.27	0.15	0.21	0.29	0.24	0.26
W	064	0.17	0.19	0.17	0.20	0.26	0.29	0.26	0.23	0.12	0.39	0.19	0.15	0.16	0.11	0.11	0.19	0.22	0.22
W	065	0.19	0.20	0.16	0.17	0.23	0.27	0.23	0.20	0.17	0.34	0.26	0.27	0.25	0.17	0.13	0.22	0.22	0.24
W	067	0.18	0.22	0.20	0.18	0.18	0.14	0.23	0.23	0.15	0.29	0.25	0.15	0.11	0.09	0.09	0.15	0.18	0.18
W	068	0.18	0.19	0.15	0.17	0.19	0.19	0.22	0.13	0.10	0.15	0.15	0.13	0.14	0.09	0.11	0.18	0.17	0.16
W	069	0.16	0.16	0.17	0.19	0.25	0.27	0.29	0.25	0.10	0.21	0.09	0.09	0.10	0.08	0.13	0.18	0.19	0.18
W	070	0.22	0.27	0.22	0.22	0.23	0.16	0.21	0.18	0.12	0.29	0.22	0.25	0.30	0.18	0.20	0.23	0.22	0.22
W	071	0.22	0.23	0.21	0.24	0.29	0.15	0.12	0.09	0.09	0.18	0.13	0.16	0.17	0.12	0.22	0.25	0.22	0.18
W	072	0.28	0.25	0.19	0.20	0.26	0.33	0.30	0.28	0.25	0.27	0.20	0.15	0.20	0.12	0.28	0.29	0.25	0.24
W	073	0.25	0.25	0.24	0.28	0.36	0.31	0.37	0.22	0.19	0.34	0.30	0.26	0.25	0.16	0.28	0.28	0.29	0.29
W	074	0.14	0.18	0.19	0.26	0.40	0.23	0.13	0.13	0.12	0.12	0.10	0.08	0.13	0.12	0.19	0.22	0.24	0.19
W	077	0.19	0.21	0.21	0.24	0.36	0.23	0.19	0.17	0.10	0.18	0.08	0.09	0.14	0.14	0.23	0.26	0.24	0.19
W	078	0.13	0.15	0.14	0.23	0.39	0.24	0.22	0.17	0.12	0.23	0.13	0.12	0.10	0.08	0.13	0.18	0.23	0.20
W	079	0.18	0.19	0.15	0.18	0.27	0.23	0.25	0.22	0.12	0.19	0.16	0.16	0.19	0.14	0.24	0.23	0.21	0.20

Table 7: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 3

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
W	029	0.11	0.15	0.14	0.18	0.20	0.16	0.26	0.12	0.17	0.28	0.31	0.16	0.22	0.17	0.18	0.19	0.19	0.21
W	030	0.14	0.18	0.16	0.17	0.17	0.24	0.34	0.22	0.25	0.40	0.43	0.19	0.21	0.15	0.16	0.21	0.21	0.26
W	031	0.18	0.17	0.12	0.13	0.16	0.22	0.29	0.24	0.25	0.30	0.24	0.13	0.17	0.12	0.12	0.24	0.18	0.21
W	032	0.16	0.15	0.13	0.20	0.30	0.24	0.29	0.33	0.45	0.47	0.28	0.14	0.24	0.17	0.20	0.24	0.25	0.28
W	040	0.17	0.21	0.16	0.15	0.32	0.26	0.28	0.24	0.32	0.27	0.12	0.09	0.17	0.11	0.12	0.19	0.22	0.22
W	041	0.21	0.26	0.21	0.19	0.15	0.18	0.17	0.15	0.22	0.13	0.18	0.13	0.19	0.11	0.13	0.21	0.19	0.17
W	042	0.13	0.16	0.12	0.11	0.16	0.22	0.27	0.19	0.15	0.18	0.23	0.19	0.21	0.18	0.18	0.21	0.17	0.19
W	043	0.17	0.23	0.21	0.25	0.24	0.11	0.15	0.11	0.07	0.22	0.20	0.16	0.15	0.11	0.10	0.15	0.20	0.17
W	044	0.15	0.17	0.12	0.11	0.13	0.16	0.22	0.14	0.11	0.14	0.23	0.10	0.12	0.09	0.11	0.18	0.14	0.15
W	055	0.09	0.09	0.07	0.08	0.10	0.10	0.11	0.09	0.13	0.12	0.19	0.10	0.12	0.10	0.09	0.14	0.11	0.12

Table 8: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 4

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	111	0.32	0.30	0.32	0.27	0.32	0.57	0.61	0.41	0.45	0.60	0.55	0.48	0.31	0.37	0.25	0.30	0.35	0.43
E	112	0.46	0.32	0.27	0.30	0.21	0.23	0.44	0.28	0.28	0.33	0.30	0.32	0.55	0.68	0.45	0.34	0.31	0.32
E	118	0.52	0.63	0.65	0.40	0.20	0.17	0.14	0.15	0.17	0.20	0.37	0.34	0.49	0.46	0.34	0.35	0.37	0.29
E	119	0.48	0.38	0.24	0.23	0.37	0.31	0.20	0.17	0.31	0.42	0.24	0.32	0.25	0.30	0.26	0.48	0.33	0.30
E	120	0.18	0.19	0.28	0.19	0.26	0.31	0.20	0.14	0.35	0.45	0.30	0.21	0.17	0.20	0.20	0.33	0.24	0.26
E	122	0.26	0.36	0.40	0.32	0.26	0.30	0.28	0.30	0.20	0.29	0.32	0.33	0.47	0.33	0.28	0.30	0.30	0.30
E	123	0.48	0.33	0.44	0.30	0.25	0.23	0.33	0.25	0.16	0.27	0.18	0.19	0.57	0.68	0.55	0.54	0.32	0.28

Table 9: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 5

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	098	0.32	0.26	0.37	0.39	0.39	0.30	0.33	0.25	0.22	0.22	0.22	0.30	0.23	0.33	0.27	0.15	0.33	0.29
E	099	0.33	0.24	0.46	0.44	0.30	0.22	0.22	0.29	0.29	0.32	0.25	0.18	0.15	0.22	0.21	0.14	0.32	0.27

Table 10: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 7

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
W	081	0.18	0.15	0.12	0.14	0.24	0.23	0.26	0.19	0.13	0.17	0.20	0.14	0.26	0.20	0.25	0.24	0.20	0.20
W	082	0.19	0.17	0.14	0.13	0.20	0.20	0.22	0.16	0.12	0.16	0.20	0.12	0.18	0.13	0.18	0.19	0.17	0.17
W	083	0.15	0.14	0.14	0.13	0.20	0.13	0.12	0.08	0.08	0.09	0.10	0.11	0.15	0.17	0.21	0.19	0.15	0.13
W	084	0.19	0.16	0.12	0.11	0.20	0.19	0.16	0.15	0.11	0.12	0.18	0.14	0.19	0.12	0.19	0.25	0.17	0.16
W	085	0.15	0.13	0.09	0.07	0.09	0.10	0.13	0.12	0.09	0.10	0.21	0.20	0.22	0.17	0.21	0.25	0.13	0.14
W	086	0.16	0.16	0.15	0.20	0.29	0.20	0.16	0.17	0.11	0.13	0.15	0.14	0.19	0.14	0.17	0.29	0.21	0.18
W	087	0.24	0.21	0.14	0.23	0.30	0.18	0.17	0.23	0.18	0.18	0.20	0.14	0.19	0.14	0.20	0.33	0.23	0.20
W	088	0.23	0.19	0.13	0.17	0.30	0.21	0.24	0.22	0.13	0.14	0.20	0.21	0.25	0.17	0.26	0.34	0.23	0.21
W	089	0.11	0.12	0.11	0.21	0.32	0.19	0.23	0.19	0.23	0.24	0.24	0.30	0.30	0.20	0.13	0.18	0.22	0.24
W	090	0.20	0.17	0.11	0.16	0.24	0.17	0.21	0.15	0.24	0.26	0.25	0.28	0.30	0.21	0.21	0.28	0.21	0.23
W	092	0.13	0.15	0.14	0.12	0.15	0.08	0.07	0.09	0.14	0.25	0.25	0.14	0.16	0.10	0.09	0.14	0.14	0.15
W	093	0.10	0.10	0.10	0.13	0.22	0.13	0.09	0.05	0.12	0.20	0.15	0.11	0.14	0.09	0.13	0.16	0.15	0.15
W	095	0.13	0.17	0.11	0.10	0.08	0.08	0.09	0.08	0.11	0.15	0.23	0.22	0.35	0.12	0.25	0.27	0.14	0.16
W	096	0.11	0.11	0.08	0.09	0.10	0.09	0.12	0.09	0.17	0.21	0.21	0.24	0.34	0.12	0.28	0.31	0.15	0.17
W	097	0.11	0.10	0.08	0.07	0.08	0.10	0.12	0.07	0.13	0.20	0.19	0.19	0.29	0.12	0.20	0.20	0.12	0.15
W	098	0.20	0.21	0.15	0.11	0.13	0.14	0.16	0.13	0.30	0.25	0.24	0.17	0.26	0.13	0.20	0.30	0.18	0.20
W	099	0.11	0.12	0.07	0.06	0.09	0.09	0.14	0.14	0.35	0.29	0.24	0.16	0.30	0.10	0.25	0.21	0.14	0.19

Table 11: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 8

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
W	033	0.15	0.19	0.16	0.23	0.45	0.29	0.17	0.20	0.23	0.30	0.33	0.23	0.21	0.15	0.10	0.15	0.27	0.28
W	034	0.18	0.19	0.15	0.18	0.26	0.19	0.17	0.21	0.39	0.43	0.37	0.24	0.20	0.11	0.17	0.23	0.23	0.27
W	035	0.14	0.14	0.15	0.20	0.49	0.37	0.29	0.30	0.34	0.41	0.40	0.28	0.25	0.12	0.12	0.17	0.30	0.34
W	036	0.14	0.13	0.10	0.14	0.22	0.26	0.28	0.28	0.24	0.20	0.20	0.15	0.16	0.13	0.22	0.21	0.19	0.21
W	037	0.10	0.10	0.07	0.08	0.15	0.16	0.20	0.18	0.24	0.26	0.18	0.14	0.15	0.10	0.11	0.15	0.14	0.17
W	038	0.17	0.20	0.16	0.18	0.40	0.37	0.24	0.19	0.14	0.21	0.10	0.14	0.14	0.13	0.13	0.21	0.24	0.22
W	039	0.19	0.22	0.14	0.11	0.18	0.13	0.13	0.13	0.24	0.30	0.21	0.11	0.30	0.16	0.17	0.24	0.18	0.19
W	046	0.18	0.24	0.20	0.20	0.21	0.14	0.16	0.13	0.18	0.20	0.19	0.13	0.18	0.19	0.18	0.22	0.20	0.18
W	047	0.25	0.24	0.15	0.16	0.27	0.29	0.29	0.25	0.36	0.32	0.22	0.20	0.24	0.23	0.30	0.34	0.25	0.26
W	048	0.15	0.16	0.13	0.15	0.26	0.24	0.22	0.24	0.23	0.44	0.28	0.20	0.31	0.15	0.18	0.18	0.21	0.25
W	054	0.12	0.14	0.08	0.09	0.16	0.26	0.32	0.24	0.21	0.14	0.21	0.13	0.17	0.17	0.16	0.20	0.16	0.19
W	057	0.11	0.11	0.10	0.12	0.14	0.10	0.13	0.10	0.13	0.12	0.19	0.13	0.13	0.12	0.13	0.16	0.13	0.13

Table 12: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 9

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	45	0.20	0.19	0.21	0.13	0.10	0.14	0.22	0.21	0.25	0.14	0.18	0.19	0.20	0.29	0.41	0.35	0.17	0.18
E	046	0.11	0.10	0.12	0.10	0.11	0.18	0.23	0.20	0.17	0.22	0.09	0.07	0.09	0.13	0.12	0.12	0.12	0.13

Table 13: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 10

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	055	0.12	0.19	0.32	0.27	0.22	0.21	0.23	0.19	0.16	0.36	0.12	0.21	0.06	0.08	0.13	0.12	0.21	0.20
E	056	0.18	0.20	0.26	0.32	0.33	0.35	0.44	0.23	0.20	0.26	0.15	0.21	0.08	0.12	0.21	0.18	0.26	0.24
E	057	0.14	0.14	0.18	0.20	0.18	0.24	0.25	0.16	0.28	0.29	0.32	0.31	0.07	0.14	0.21	0.18	0.19	0.23
E	062	0.17	0.17	0.20	0.16	0.16	0.11	0.12	0.10	0.09	0.13	0.09	0.11	0.04	0.17	0.20	0.23	0.15	0.12

Table 14: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 11

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	001	0.10	0.27	0.34	0.51	0.46	0.33	0.21	0.23	0.34	0.55	0.45	0.28	0.20	0.14	0.12	0.11	0.36	0.36
E	002	0.13	0.11	0.13	0.35	0.51	0.43	0.38	0.27	0.18	0.34	0.22	0.26	0.16	0.18	0.17	0.13	0.30	0.30
E	003	0.22	0.18	0.23	0.21	0.17	0.39	0.55	0.49	0.43	0.52	0.47	0.33	0.21	0.19	0.16	0.15	0.25	0.34
E	004	0.08	0.09	0.12	0.18	0.17	0.37	0.54	0.53	0.37	0.30	0.22	0.25	0.31	0.30	0.19	0.16	0.19	0.27
E	005	0.07	0.08	0.14	0.19	0.20	0.20	0.22	0.31	0.27	0.25	0.34	0.33	0.14	0.20	0.12	0.13	0.18	0.24
E	006	0.13	0.13	0.24	0.27	0.27	0.23	0.29	0.22	0.25	0.40	0.37	0.52	0.28	0.18	0.14	0.13	0.25	0.30
E	007	0.17	0.16	0.17	0.17	0.22	0.18	0.23	0.38	0.36	0.44	0.18	0.16	0.13	0.16	0.15	0.12	0.20	0.24
E	008	0.13	0.18	0.28	0.33	0.34	0.24	0.29	0.23	0.22	0.29	0.31	0.14	0.15	0.17	0.17	0.16	0.26	0.26
E	009	0.11	0.11	0.15	0.21	0.32	0.45	0.52	0.48	0.41	0.30	0.11	0.09	0.14	0.15	0.10	0.14	0.23	0.26
E	010	0.13	0.12	0.16	0.30	0.36	0.39	0.21	0.21	0.19	0.26	0.34	0.21	0.23	0.13	0.14	0.11	0.25	0.26
E	011	0.18	0.17	0.20	0.17	0.20	0.23	0.29	0.35	0.31	0.30	0.32	0.22	0.20	0.16	0.16	0.13	0.21	0.25
E	012	0.10	0.12	0.15	0.17	0.18	0.25	0.15	0.32	0.18	0.36	0.23	0.29	0.23	0.22	0.16	0.11	0.18	0.22
E	013	0.13	0.17	0.30	0.22	0.31	0.20	0.40	0.44	0.17	0.23	0.27	0.26	0.21	0.20	0.13	0.16	0.25	0.27
E	014	0.08	0.11	0.11	0.11	0.10	0.13	0.25	0.42	0.37	0.31	0.21	0.17	0.28	0.38	0.19	0.18	0.15	0.22
E	016	0.11	0.20	0.21	0.28	0.25	0.34	0.30	0.16	0.32	0.37	0.59	0.59	0.33	0.36	0.18	0.18	0.26	0.35
E	017	0.15	0.18	0.29	0.21	0.25	0.27	0.28	0.33	0.43	0.49	0.56	0.36	0.29	0.18	0.11	0.15	0.27	0.34
E	018	0.08	0.10	0.13	0.12	0.17	0.29	0.19	0.24	0.24	0.31	0.39	0.34	0.38	0.16	0.13	0.12	0.17	0.25
E	019	0.13	0.22	0.26	0.22	0.15	0.29	0.17	0.20	0.29	0.28	0.44	0.46	0.45	0.39	0.19	0.16	0.22	0.28
E	022	0.20	0.18	0.31	0.18	0.10	0.11	0.14	0.13	0.10	0.13	0.14	0.19	0.17	0.24	0.24	0.28	0.17	0.15
E	069	0.15	0.13	0.15	0.12	0.16	0.18	0.20	0.16	0.19	0.31	0.21	0.16	0.15	0.19	0.20	0.14	0.16	0.18
E	070	0.17	0.14	0.15	0.23	0.30	0.40	0.45	0.32	0.13	0.22	0.23	0.29	0.18	0.26	0.14	0.16	0.23	0.25
E	071	0.12	0.11	0.16	0.24	0.30	0.33	0.43	0.45	0.39	0.26	0.12	0.23	0.15	0.27	0.16	0.23	0.23	0.26
E	075	0.20	0.11	0.16	0.26	0.25	0.28	0.36	0.28	0.29	0.21	0.16	0.23	0.14	0.27	0.18	0.27	0.22	0.23
E	076	0.17	0.15	0.15	0.22	0.31	0.22	0.19	0.11	0.20	0.08	0.09	0.15	0.07	0.22	0.09	0.17	0.20	0.17
E	078	0.07	0.10	0.11	0.12	0.12	0.12	0.11	0.16	0.13	0.27	0.19	0.17	0.15	0.15	0.11	0.09	0.12	0.15
E	079	0.17	0.29	0.36	0.44	0.38	0.33	0.35	0.14	0.21	0.32	0.17	0.27	0.23	0.22	0.13	0.12	0.31	0.28

Table 15: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 12

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	102	0.28	0.30	0.22	0.34	0.28	0.41	0.41	0.37	0.46	0.51	0.36	0.24	0.26	0.35	0.31	0.18	0.31	0.34

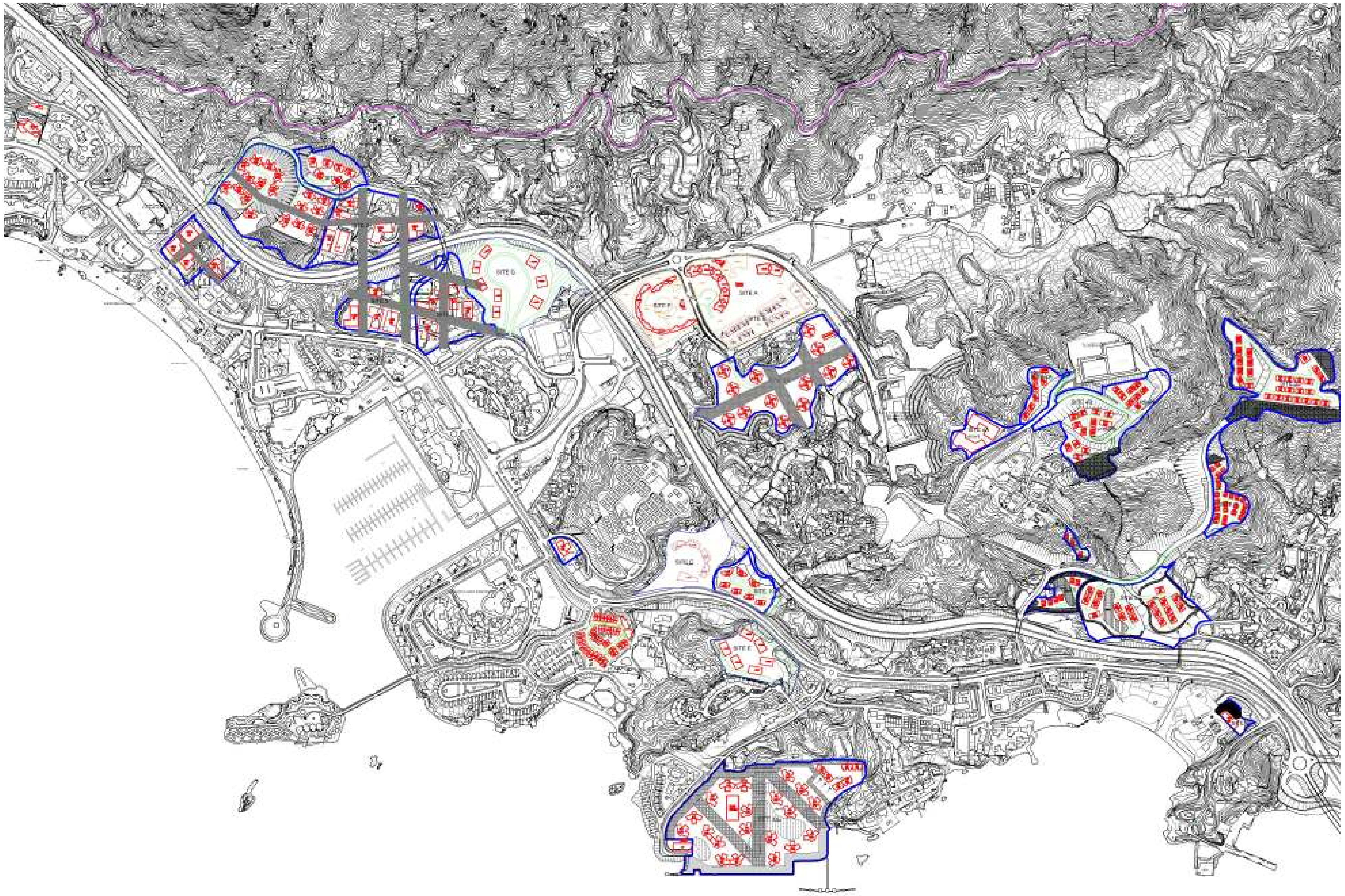
Table 16: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 13

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	096	0.11	0.13	0.18	0.16	0.18	0.27	0.18	0.12	0.11	0.14	0.21	0.21	0.11	0.17	0.14	0.15	0.16	0.16
E	097	0.19	0.21	0.23	0.12	0.16	0.18	0.13	0.13	0.19	0.22	0.16	0.14	0.10	0.20	0.19	0.18	0.17	0.16
E	100	0.14	0.14	0.19	0.28	0.13	0.20	0.25	0.14	0.11	0.16	0.19	0.22	0.18	0.28	0.16	0.19	0.17	0.17

Table 17: Directional, Annual Overall and Summer Overall Velocity Ratios measured at Site 14

		Directional Velocity Ratio																Annual Overall Velocity Ratio	Summer Overall Velocity Ratio
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5		
E	136	0.33	0.17	0.22	0.29	0.22	0.19	0.28	0.26	0.21	0.29	0.16	0.15	0.34	0.35	0.37	0.36	0.25	0.24
E	137	0.25	0.17	0.27	0.27	0.23	0.19	0.30	0.23	0.22	0.28	0.30	0.17	0.28	0.21	0.19	0.20	0.24	0.25
E	138	0.18	0.17	0.14	0.19	0.28	0.27	0.35	0.22	0.24	0.16	0.22	0.12	0.23	0.19	0.20	0.20	0.22	0.22
E	139	0.13	0.17	0.15	0.15	0.16	0.16	0.20	0.15	0.14	0.10	0.14	0.13	0.18	0.15	0.16	0.15	0.15	0.15
E	145	0.16	0.21	0.17	0.39	0.20	0.18	0.26	0.15	0.19	0.12	0.15	0.19	0.20	0.23	0.18	0.18	0.22	0.19
E	146	0.18	0.21	0.24	0.35	0.30	0.26	0.34	0.18	0.21	0.14	0.26	0.28	0.36	0.27	0.22	0.21	0.27	0.26
E	147	0.27	0.22	0.19	0.17	0.24	0.24	0.38	0.30	0.25	0.23	0.24	0.17	0.33	0.32	0.31	0.29	0.24	0.25
E	148	0.24	0.19	0.32	0.41	0.33	0.28	0.29	0.29	0.24	0.36	0.21	0.16	0.25	0.25	0.30	0.29	0.30	0.27
E	149	0.23	0.19	0.26	0.25	0.23	0.21	0.25	0.28	0.23	0.32	0.27	0.20	0.43	0.37	0.30	0.29	0.25	0.26
E	150	0.30	0.32	0.26	0.26	0.24	0.26	0.32	0.36	0.23	0.21	0.19	0.14	0.38	0.38	0.43	0.40	0.26	0.25
E	151	0.20	0.20	0.35	0.39	0.26	0.23	0.20	0.24	0.19	0.36	0.26	0.21	0.27	0.22	0.22	0.22	0.27	0.26
E	152	0.25	0.22	0.18	0.25	0.20	0.19	0.28	0.27	0.22	0.21	0.26	0.19	0.33	0.32	0.28	0.30	0.23	0.24
E	153	0.17	0.20	0.15	0.29	0.19	0.18	0.28	0.21	0.21	0.14	0.20	0.30	0.30	0.20	0.19	0.19	0.21	0.22
E	171	0.17	0.24	0.25	0.37	0.25	0.24	0.26	0.27	0.17	0.25	0.18	0.23	0.24	0.25	0.26	0.19	0.25	0.23
E	172	0.17	0.34	0.47	0.55	0.33	0.32	0.28	0.26	0.22	0.28	0.30	0.37	0.40	0.31	0.21	0.17	0.35	0.32
E	173	0.33	0.38	0.37	0.24	0.20	0.25	0.29	0.30	0.24	0.26	0.15	0.13	0.25	0.32	0.38	0.35	0.26	0.23
E	176	0.21	0.33	0.43	0.37	0.26	0.23	0.16	0.17	0.18	0.32	0.23	0.25	0.25	0.20	0.18	0.17	0.28	0.25
E	177	0.40	0.40	0.39	0.34	0.23	0.23	0.21	0.18	0.17	0.19	0.17	0.24	0.27	0.37	0.25	0.34	0.29	0.23

FIGURES



This indicative layouts for G/IC uses at Sites 1, 2, 3, 4A & 8 are provided by Planning Department for the purpose of conducting Air Ventilation Assessn

Figure 1: The Tuen Mun East Study Area

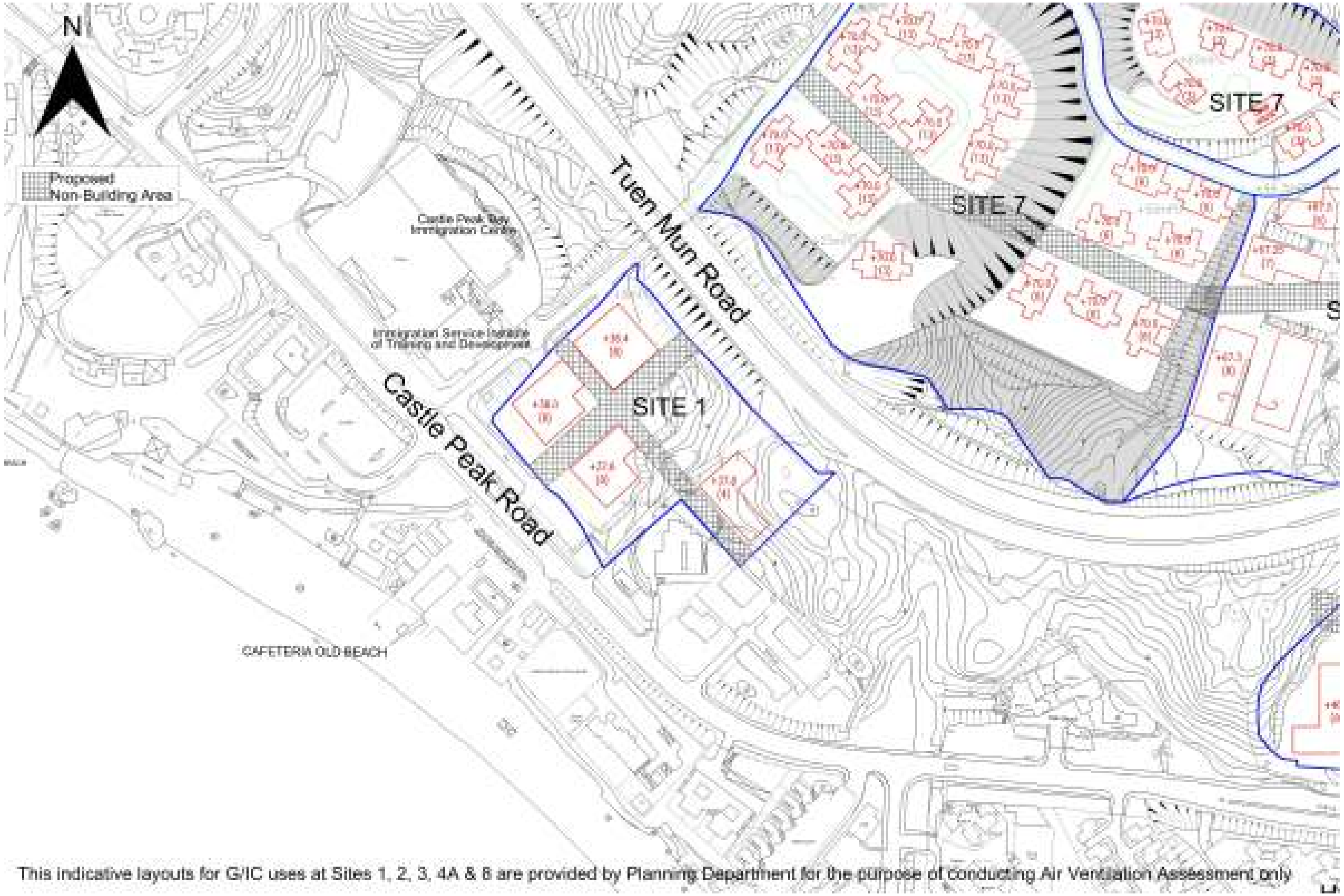


Figure 2: Location and proposed layout of Site 1

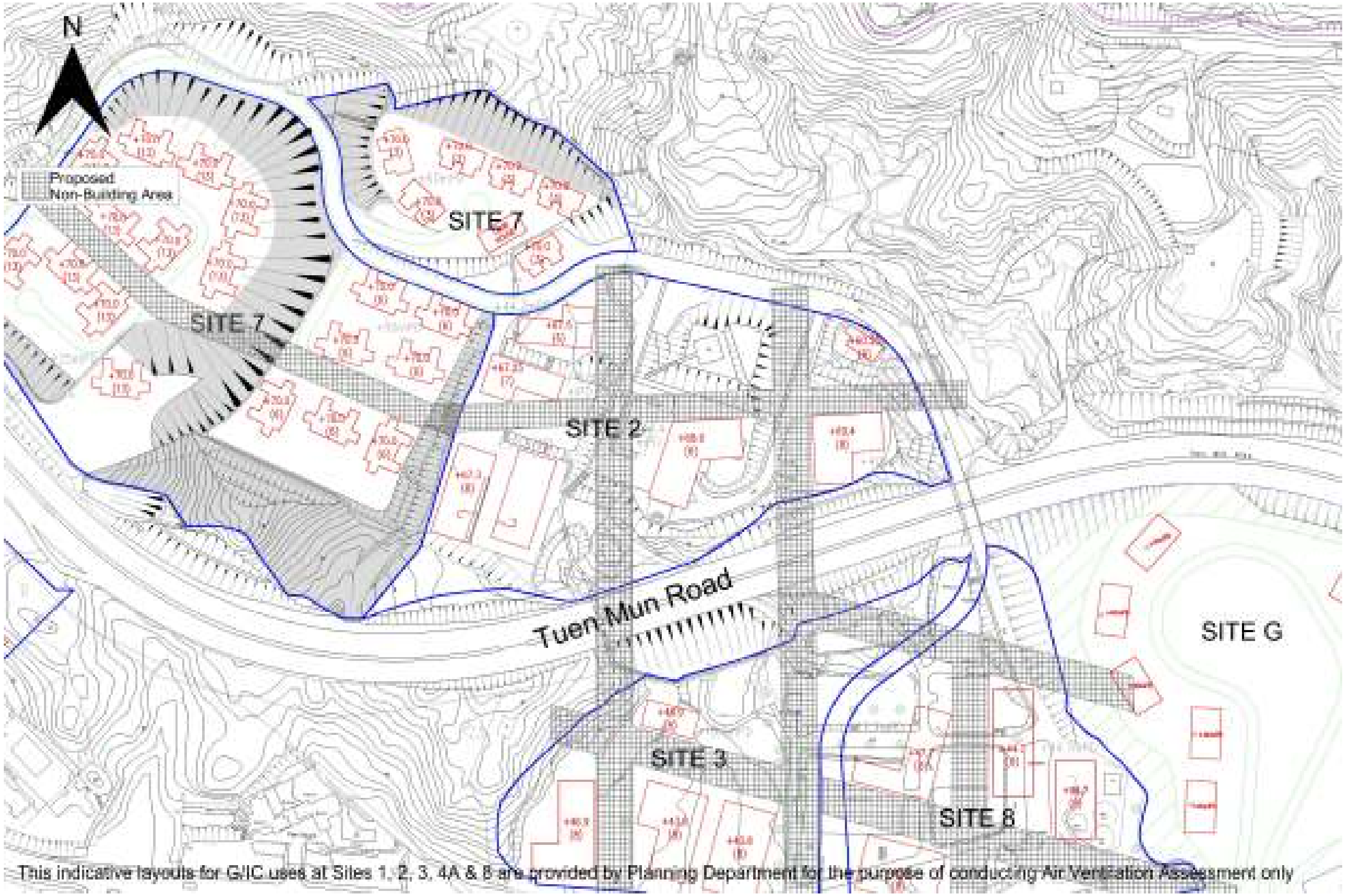


Figure 3: Location and proposed layout of Site 2

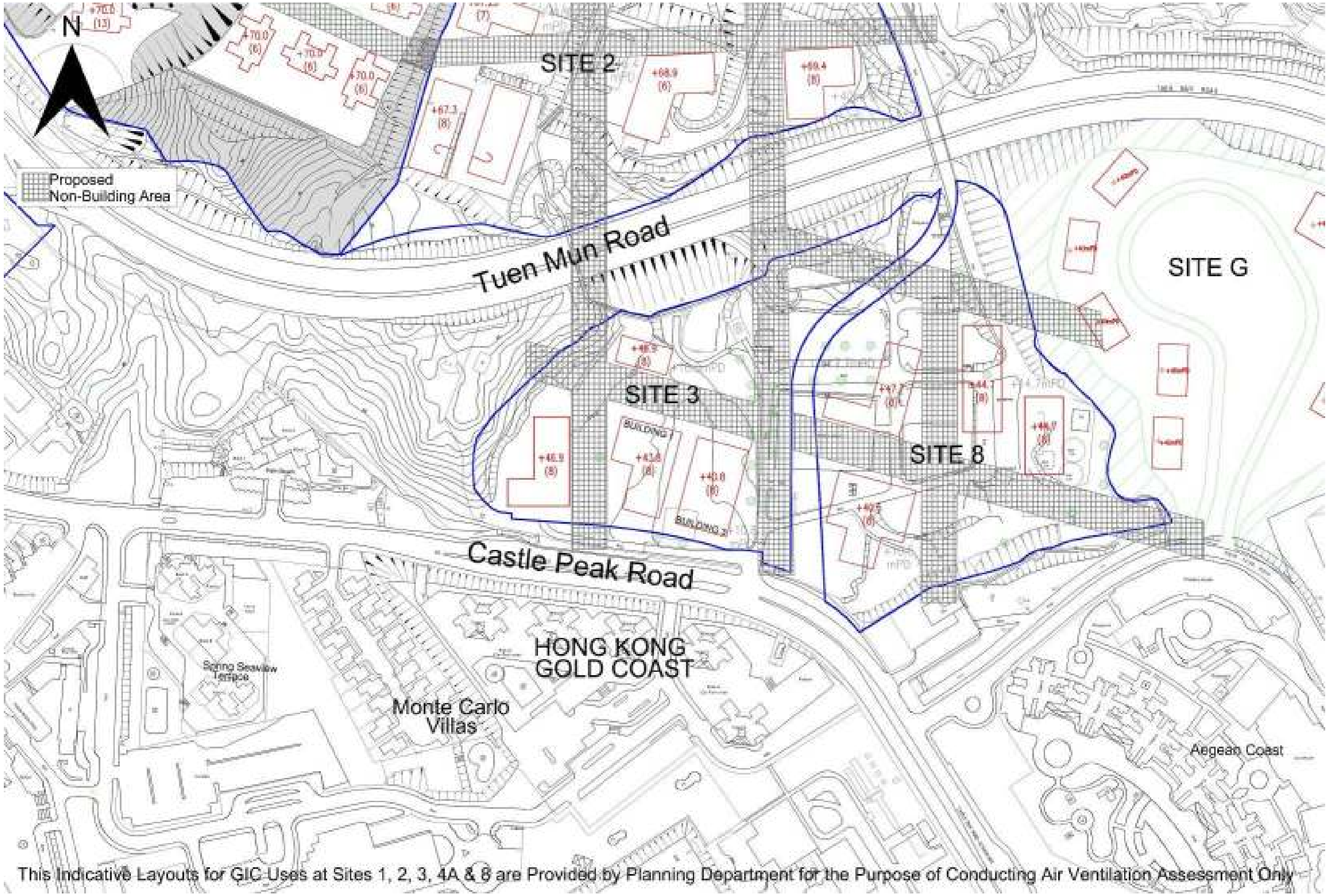


Figure 4: Location and proposed layout of Site 3

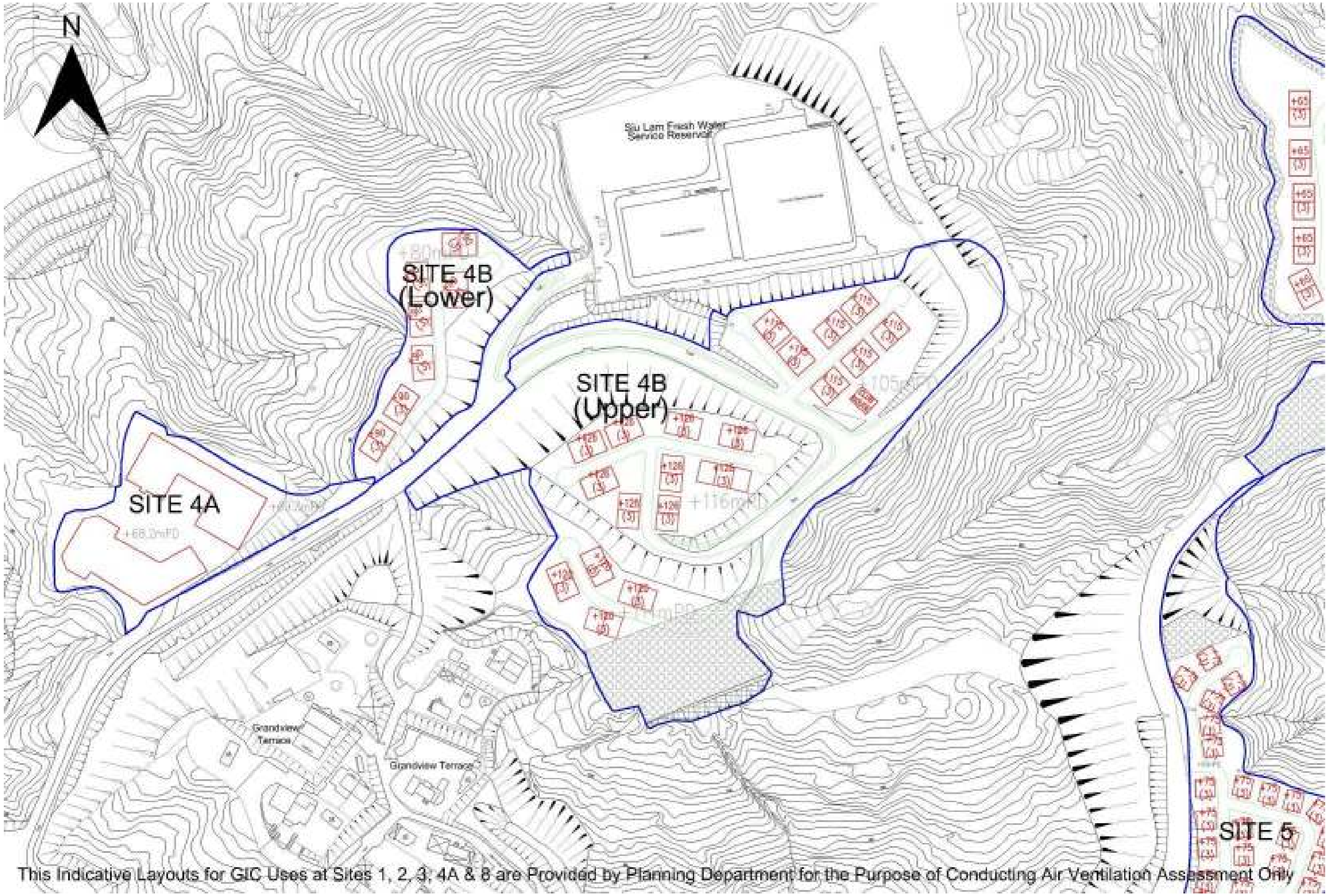


Figure 5: Location and proposed layout of Site 4

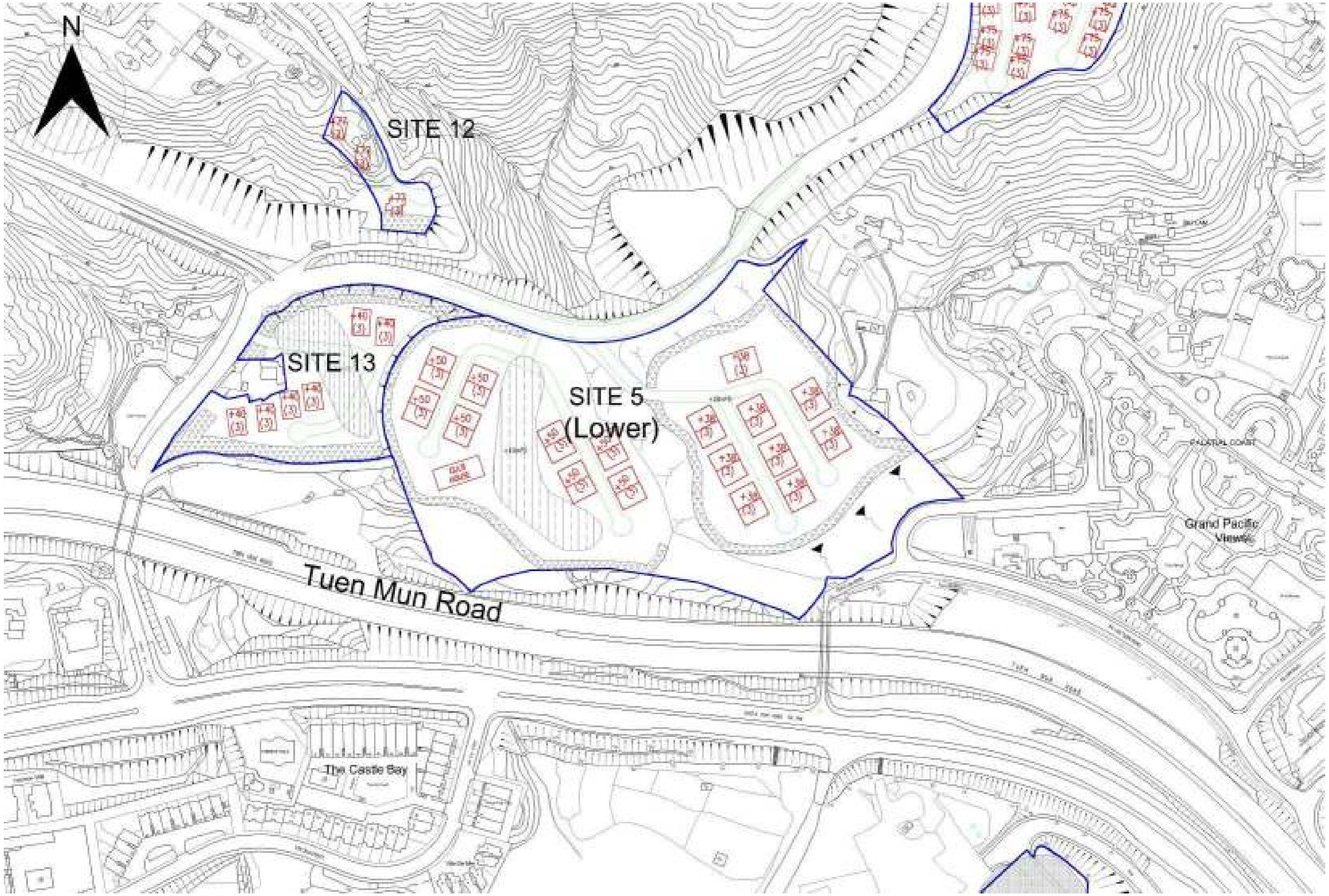


Figure 6: Location and proposed layout of Site 5 (lower)

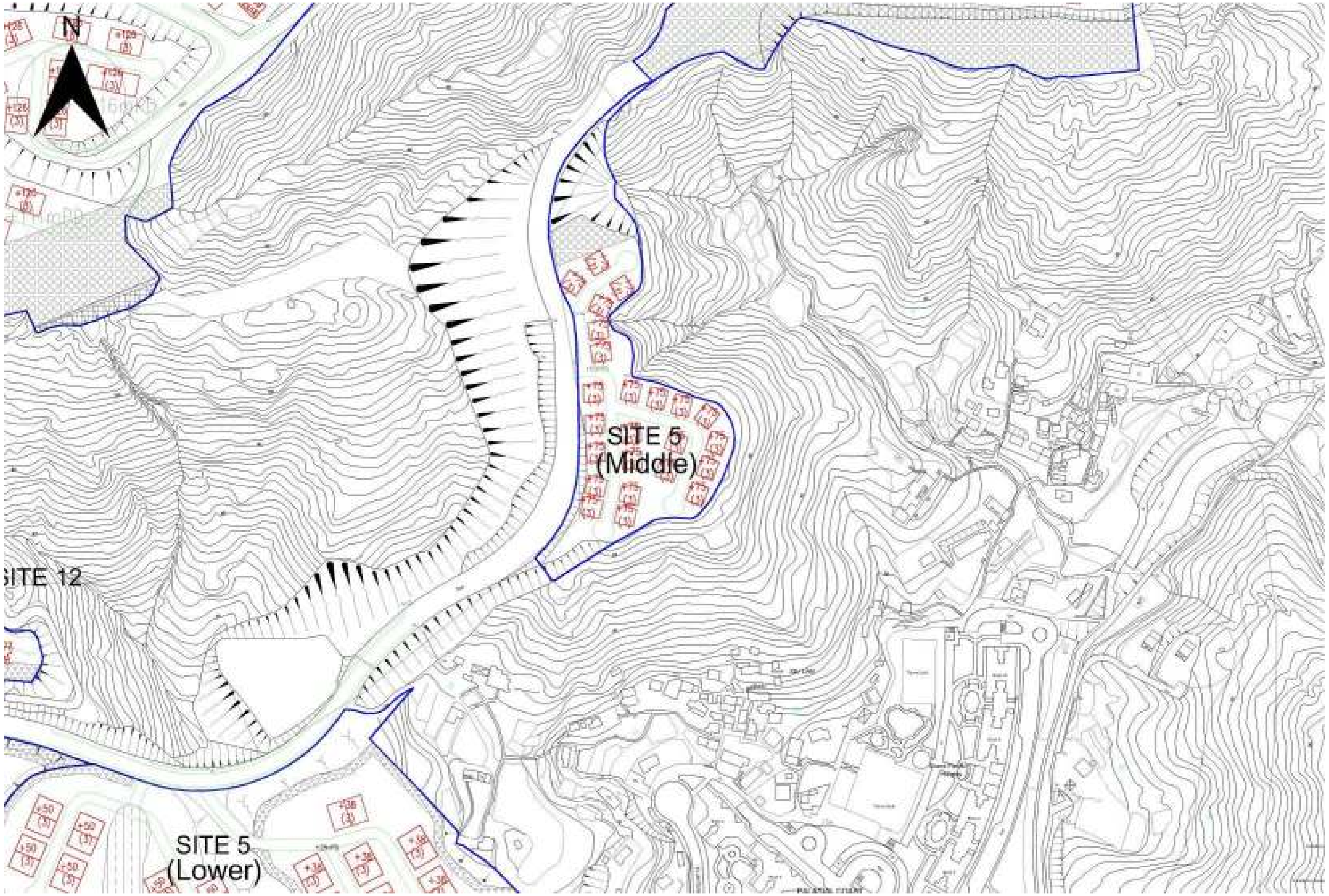


Figure 7: Location and proposed layout of Site 5 (middle)

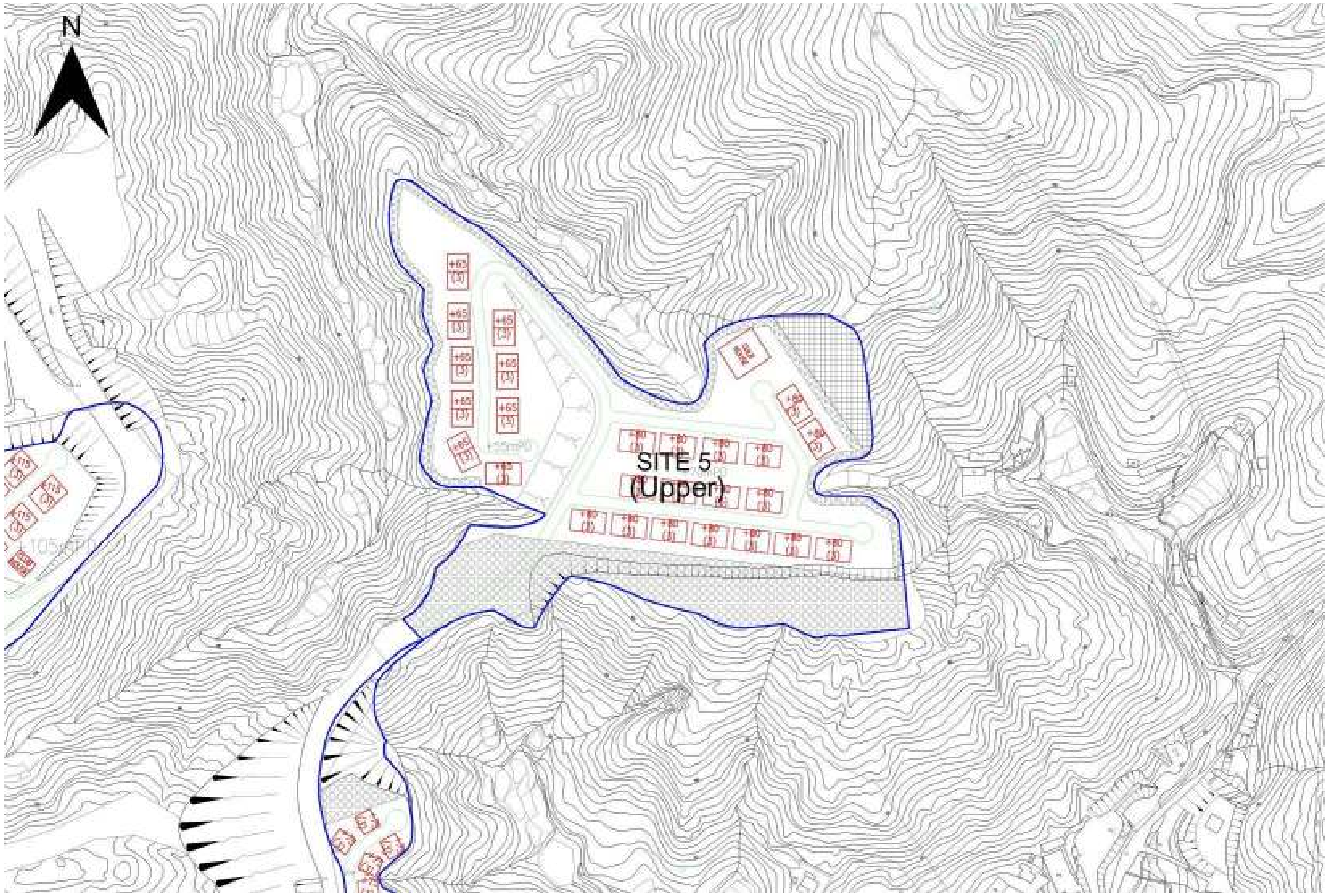


Figure 8: Location and proposed layout of Site 5 (upper)

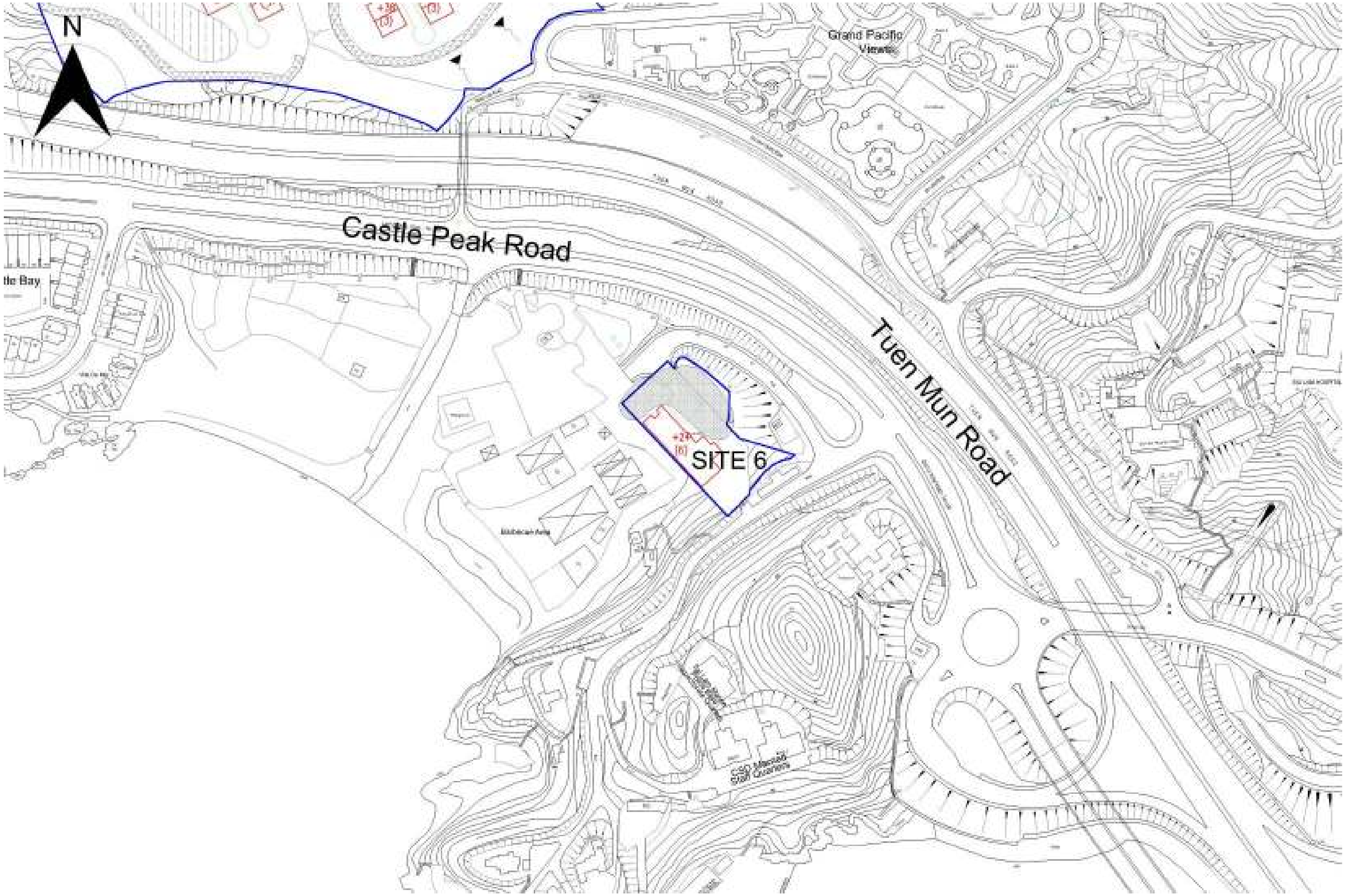


Figure 9: Location and proposed layout of Site 6

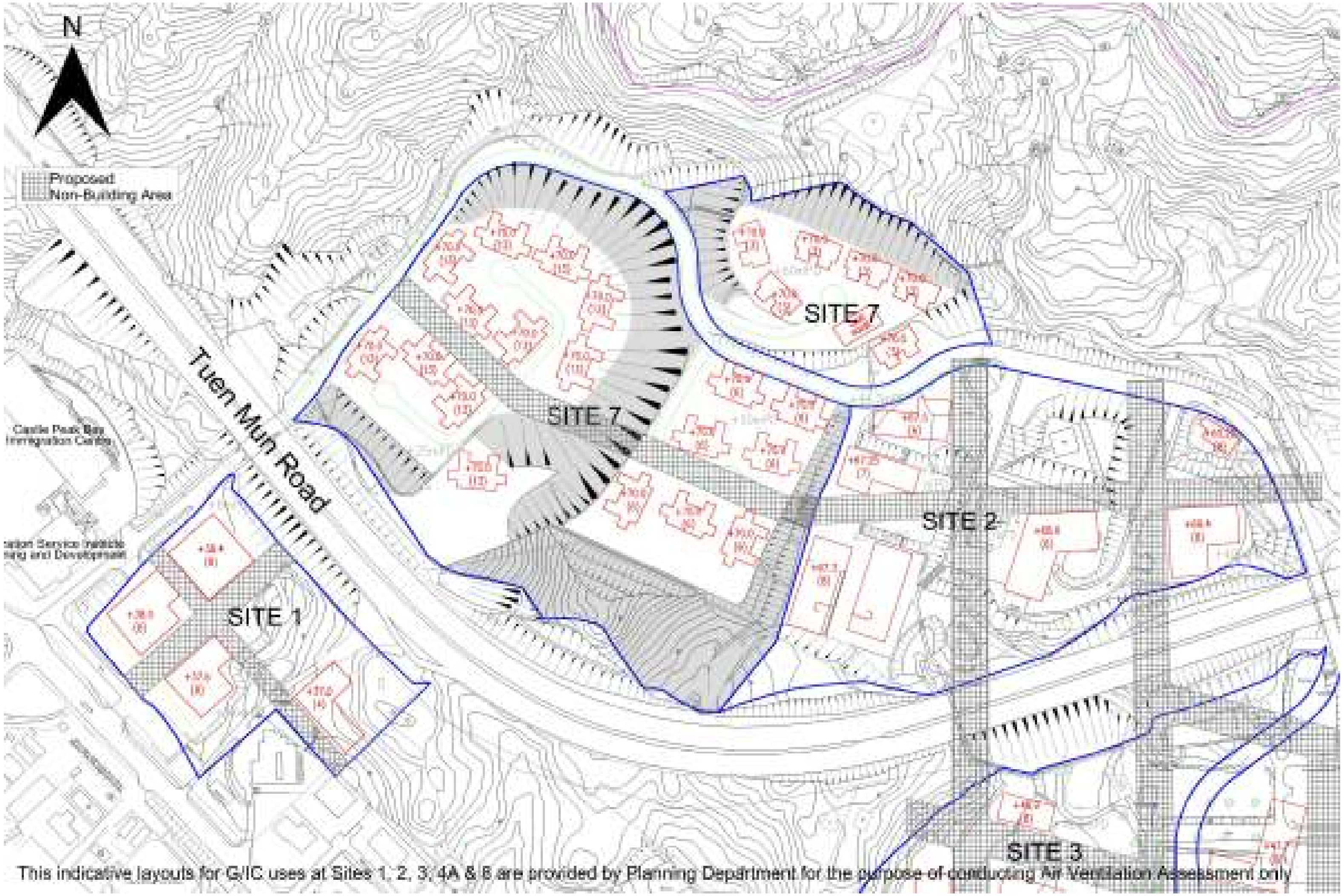


Figure 10: Location and proposed layout of Site 7

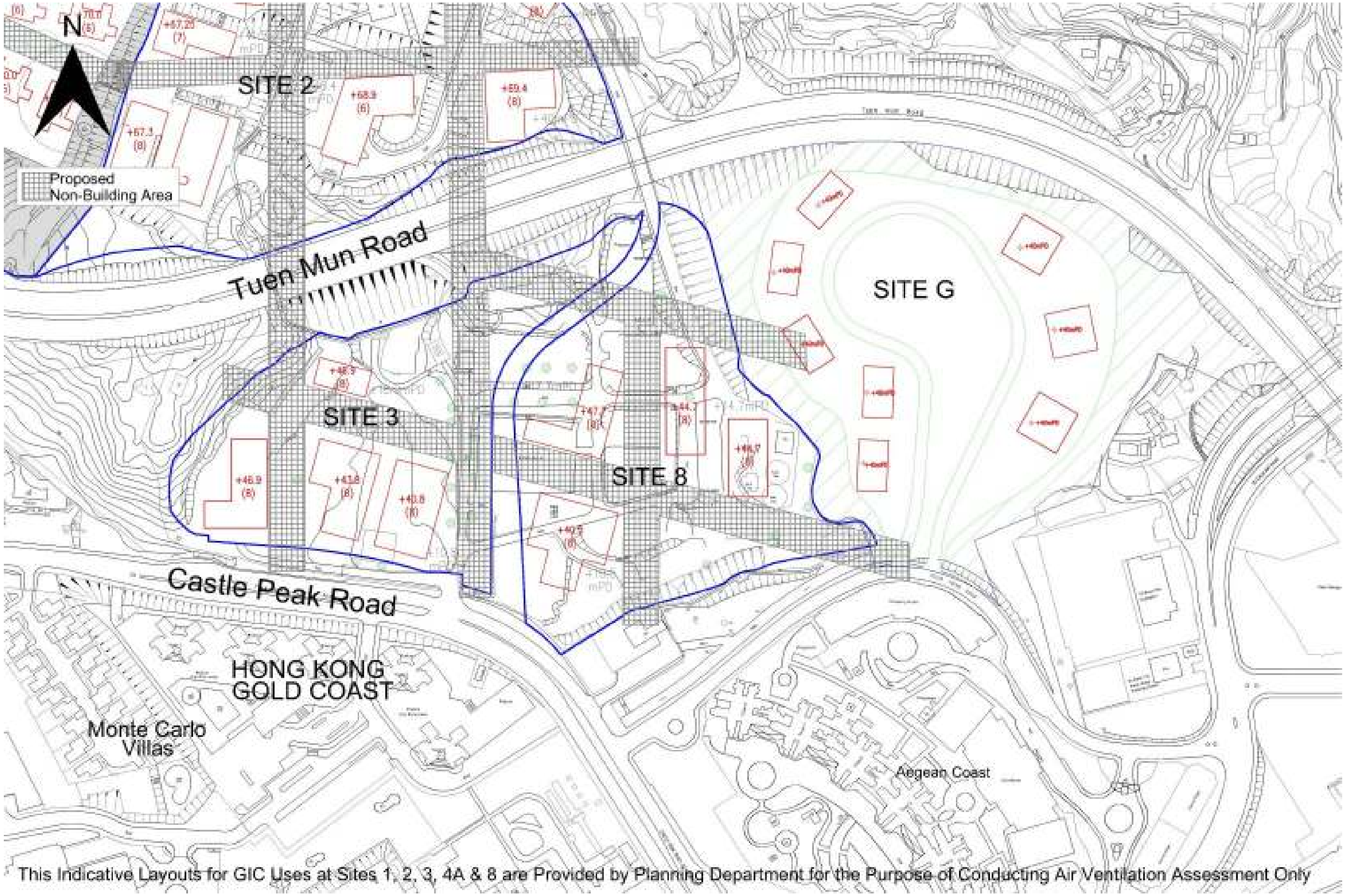


Figure 11: Location and proposed layout of Site 8

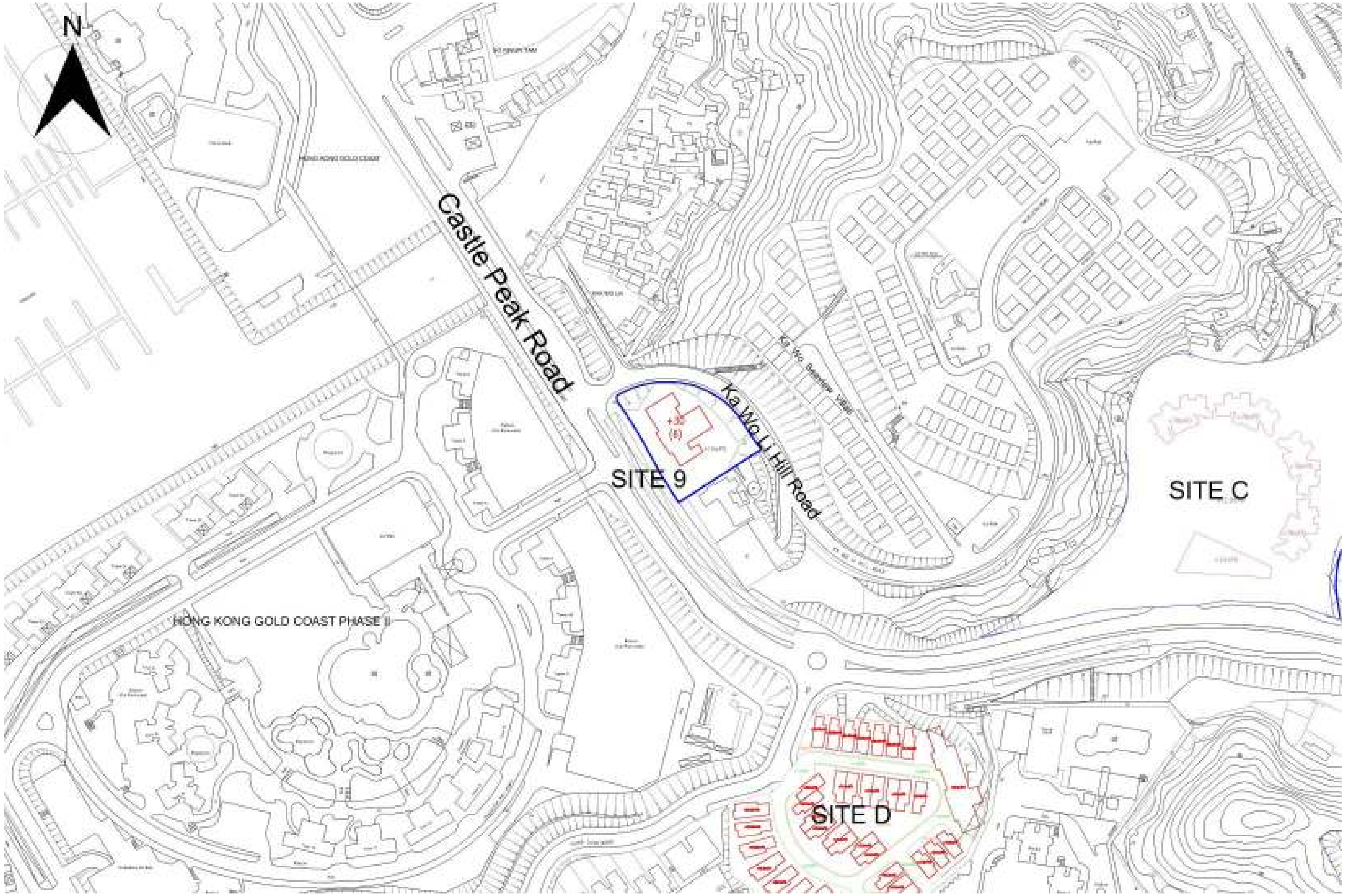


Figure 12: Location and proposed layout of Site 9

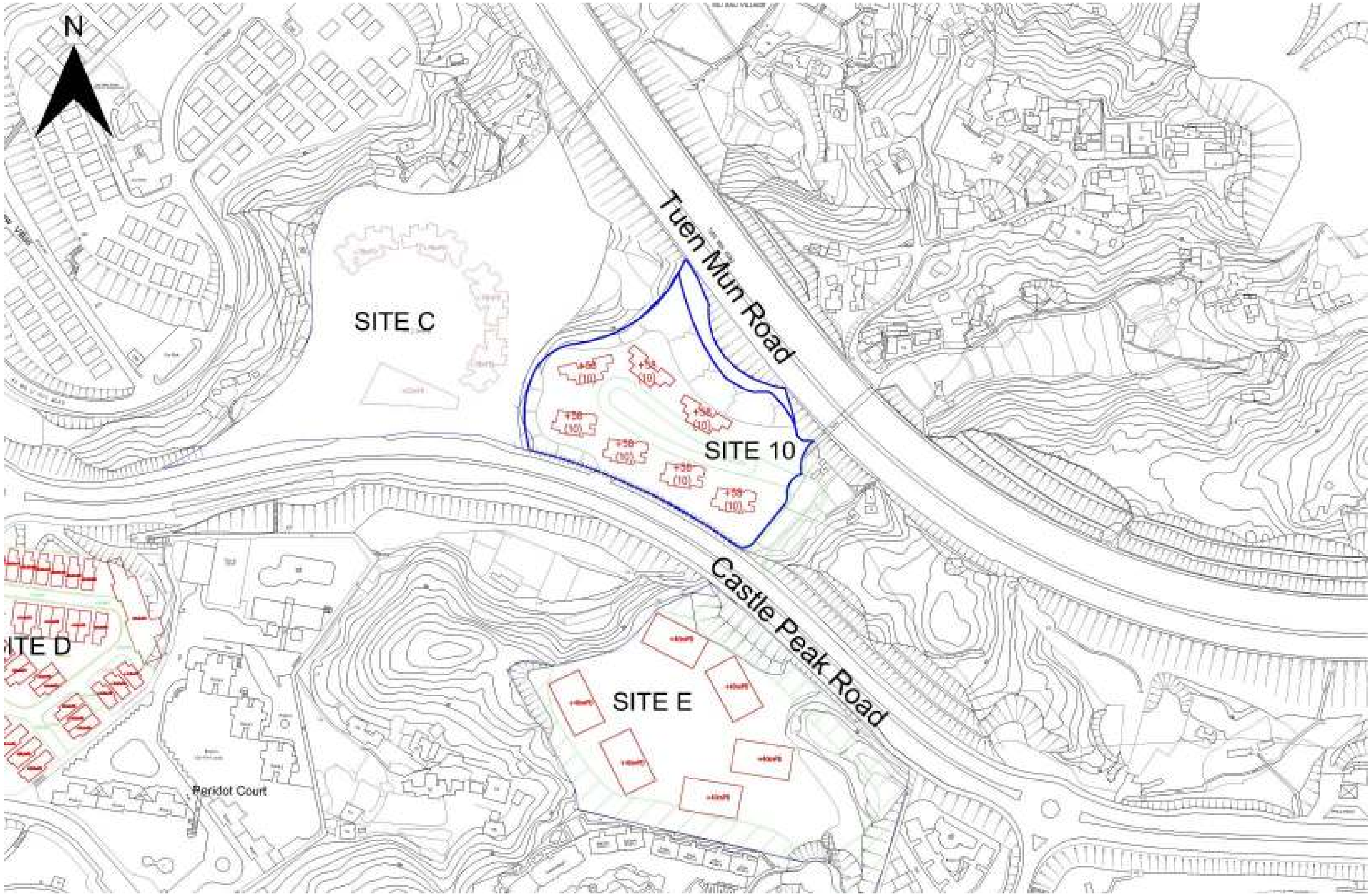


Figure 13: Location and proposed layout of Site 10

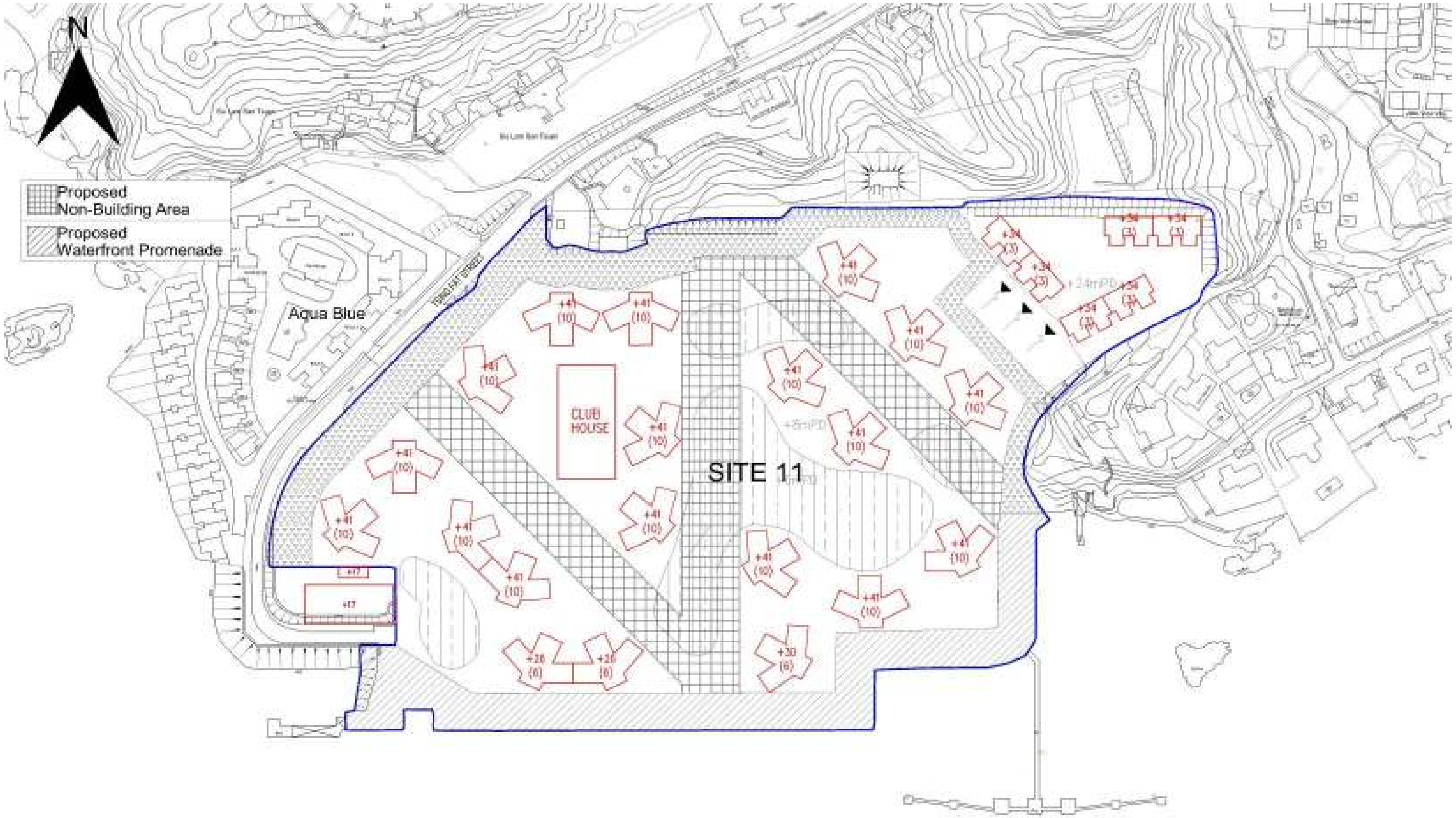


Figure 14: Location and proposed layout of Site 11

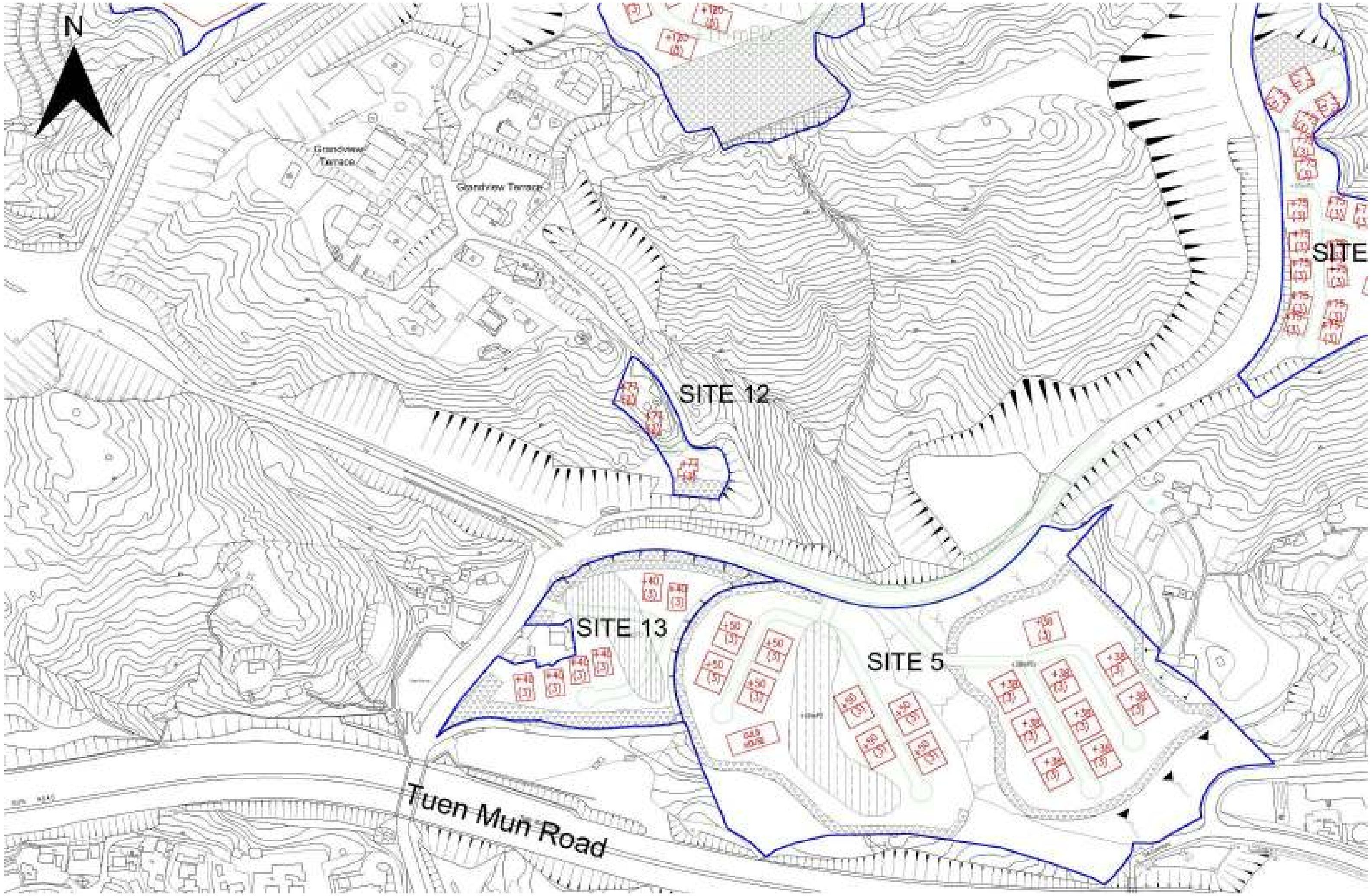


Figure 15: Location and proposed layout of Site 12

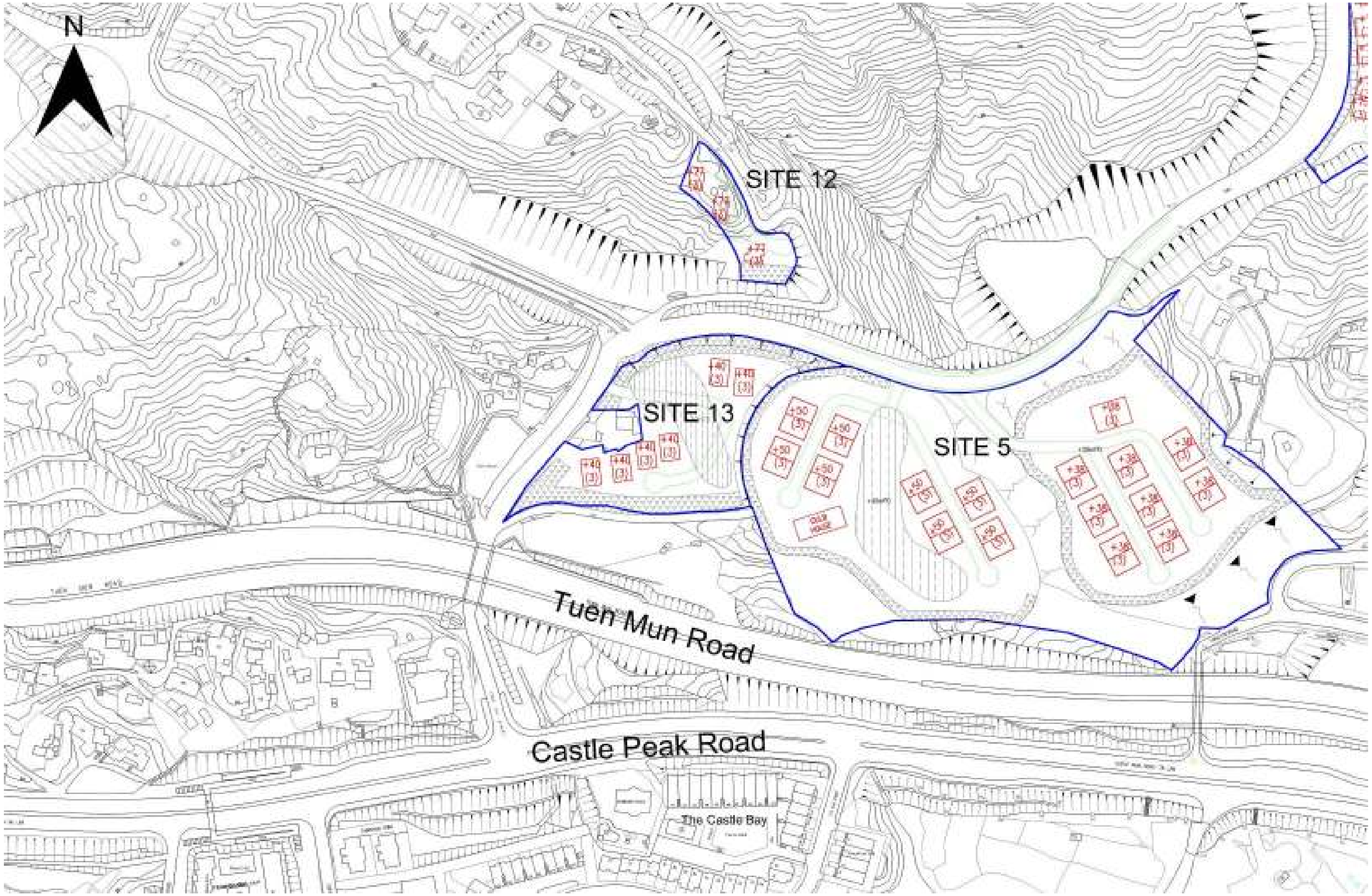


Figure 16: Location and proposed layout of Site 13

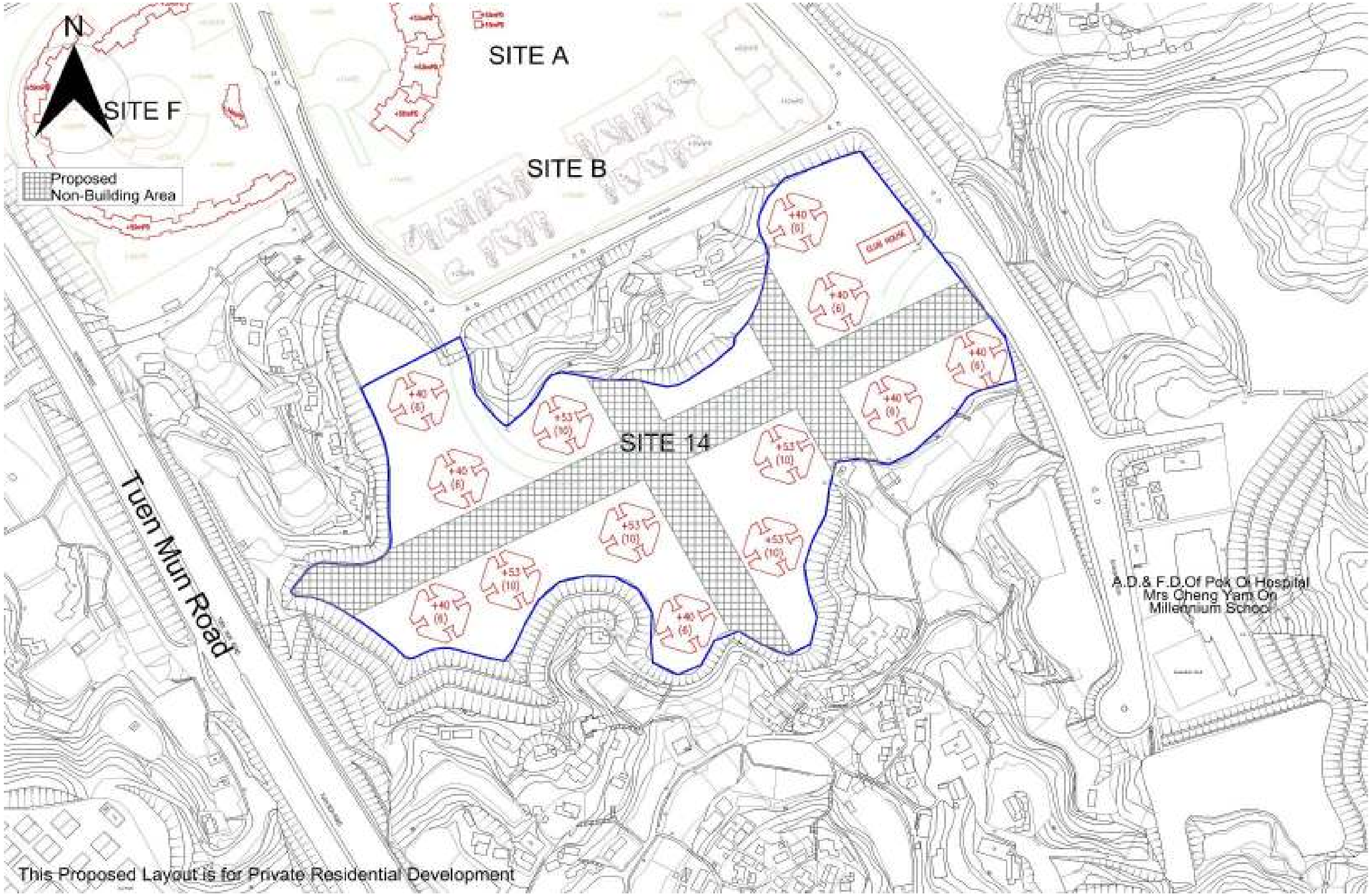


Figure 17: Location and proposed layout of Site 14

Figure 18: Coverage of the 1:400 scale wind tunnel models

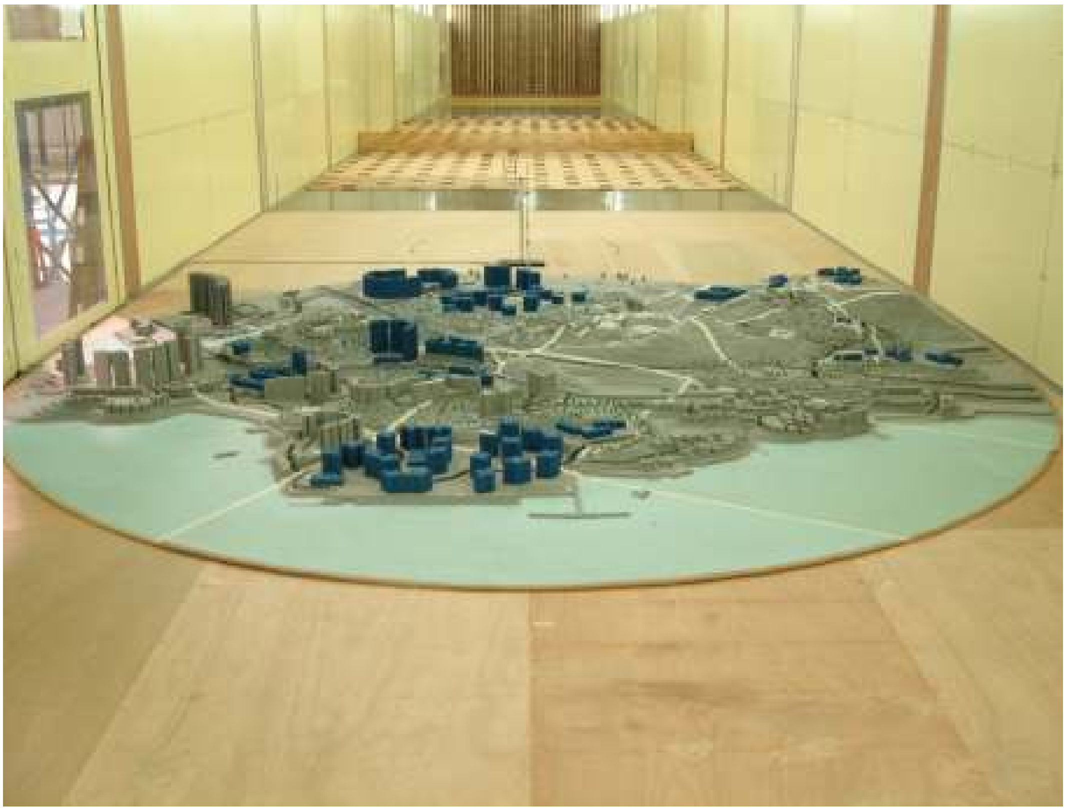


Figure 19: 1:400 scale East Model of the Tuen Mun East Study Area, ,wind direction = 0°

Figure 20: 1:400 scale East Model of the Tuen Mun East Study Area, wind direction = 90°

Figure 21: 1:400 scale East Model of theTuen Mun East Study Area, wind direction = 180°

Figure 22: 1:400 scale East Model of the Tuen Mun East Study Area, wind direction = 270°

Figure 23: 1:400 scale West Model of the Tuen Mun East Study Area, wind direction = 0°

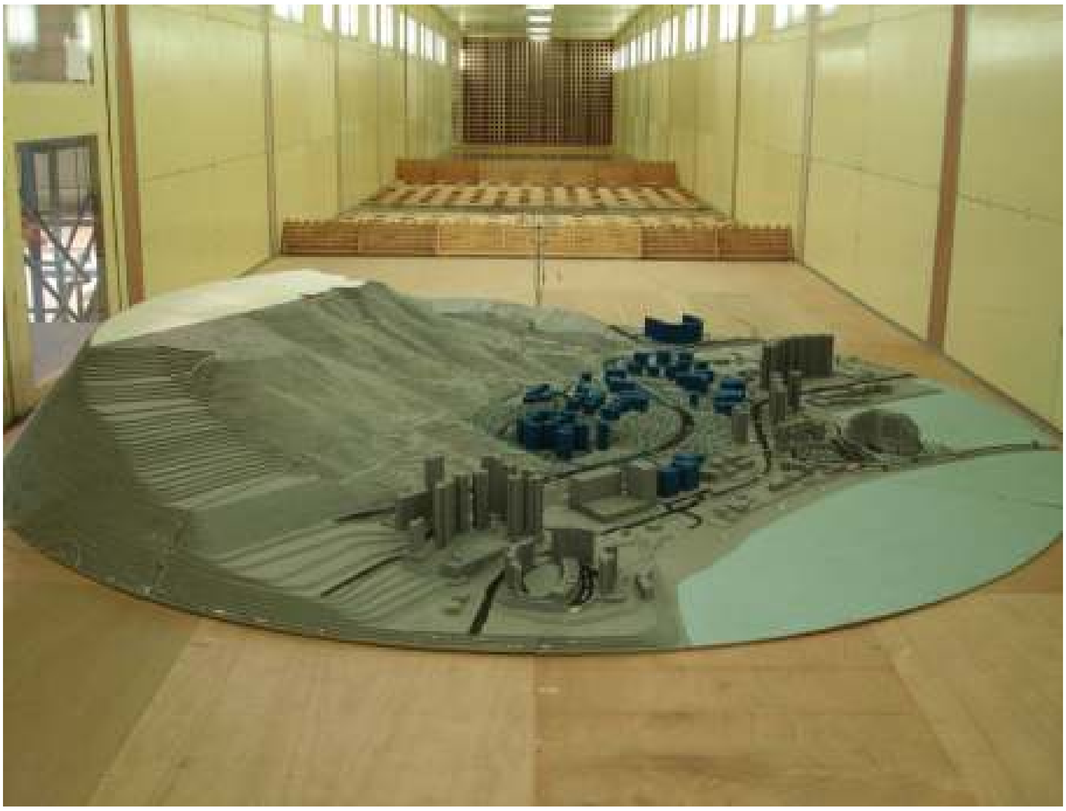


Figure 24: 1:400 scale West Model of the Tuen Mun East Study Area, wind direction = 90°

Figure 25: 1:400 scale West Model of the Tuen Mun East Study Area, wind direction = 180°

Figure 26: 1:400 scale West Model of the Tuen Mun East Study Area, wind direction = 270°

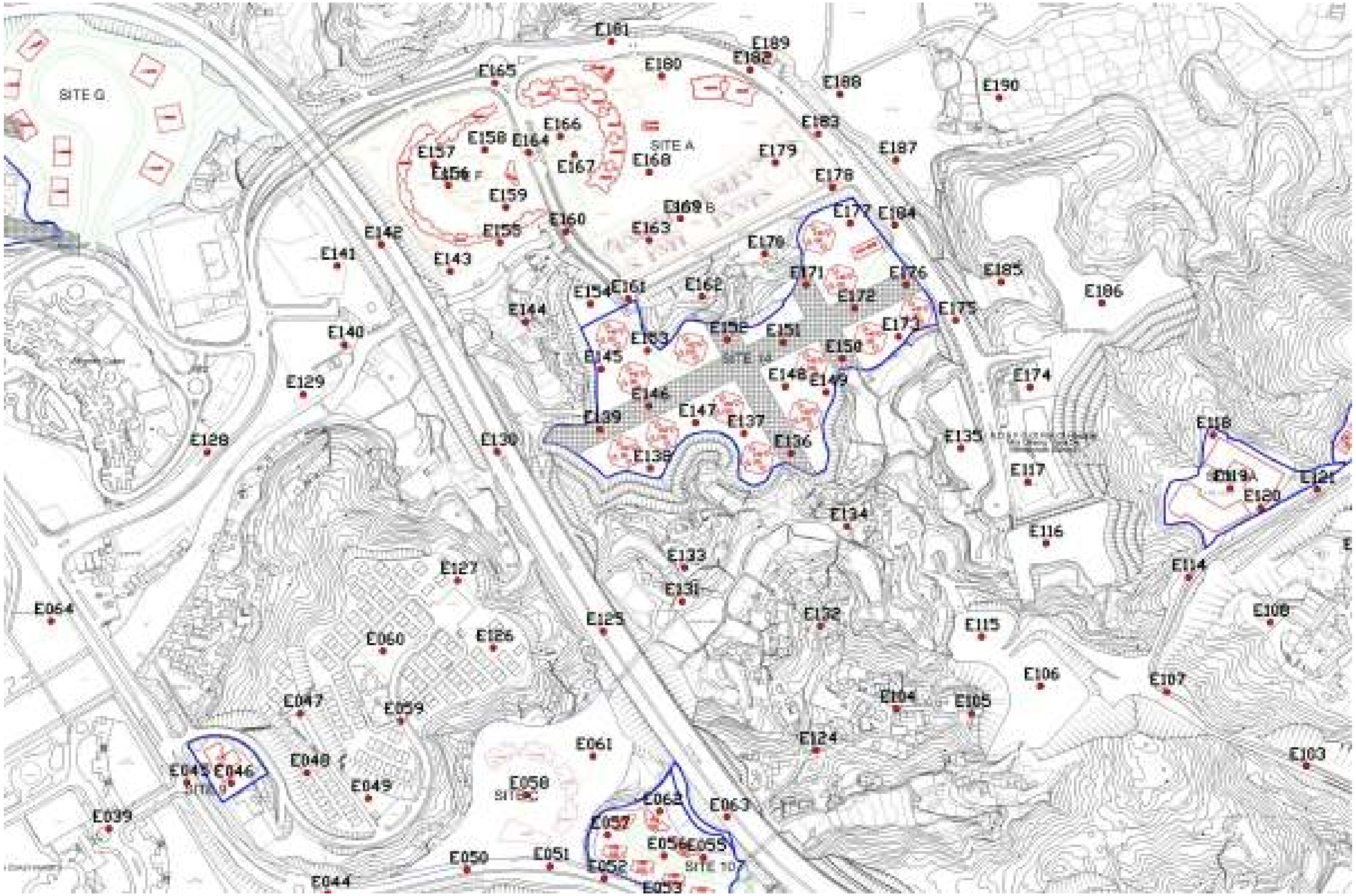


Figure 27: Test point locations on the East Model (1)

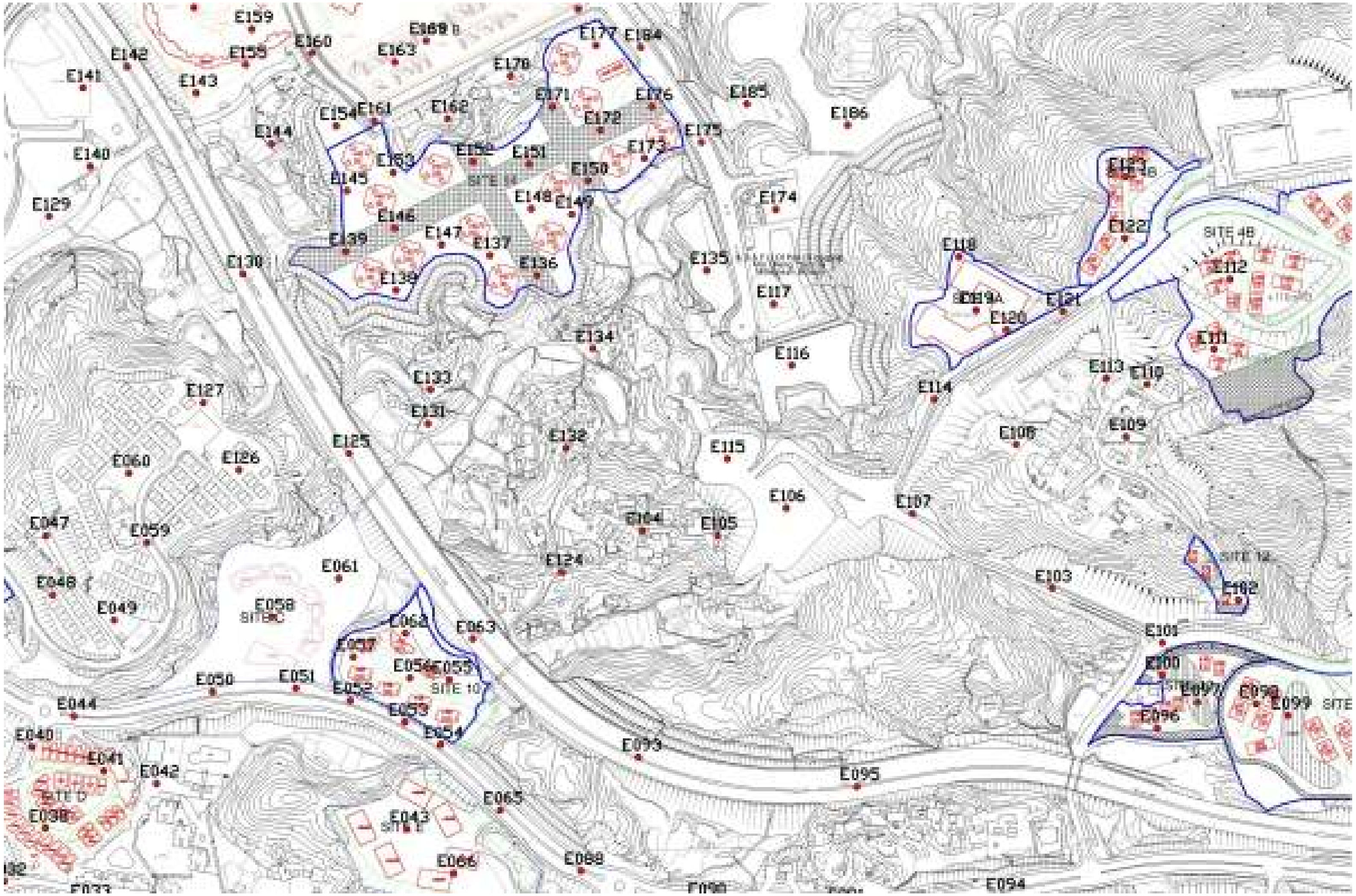


Figure 28: Test point locations on the East Model (2)

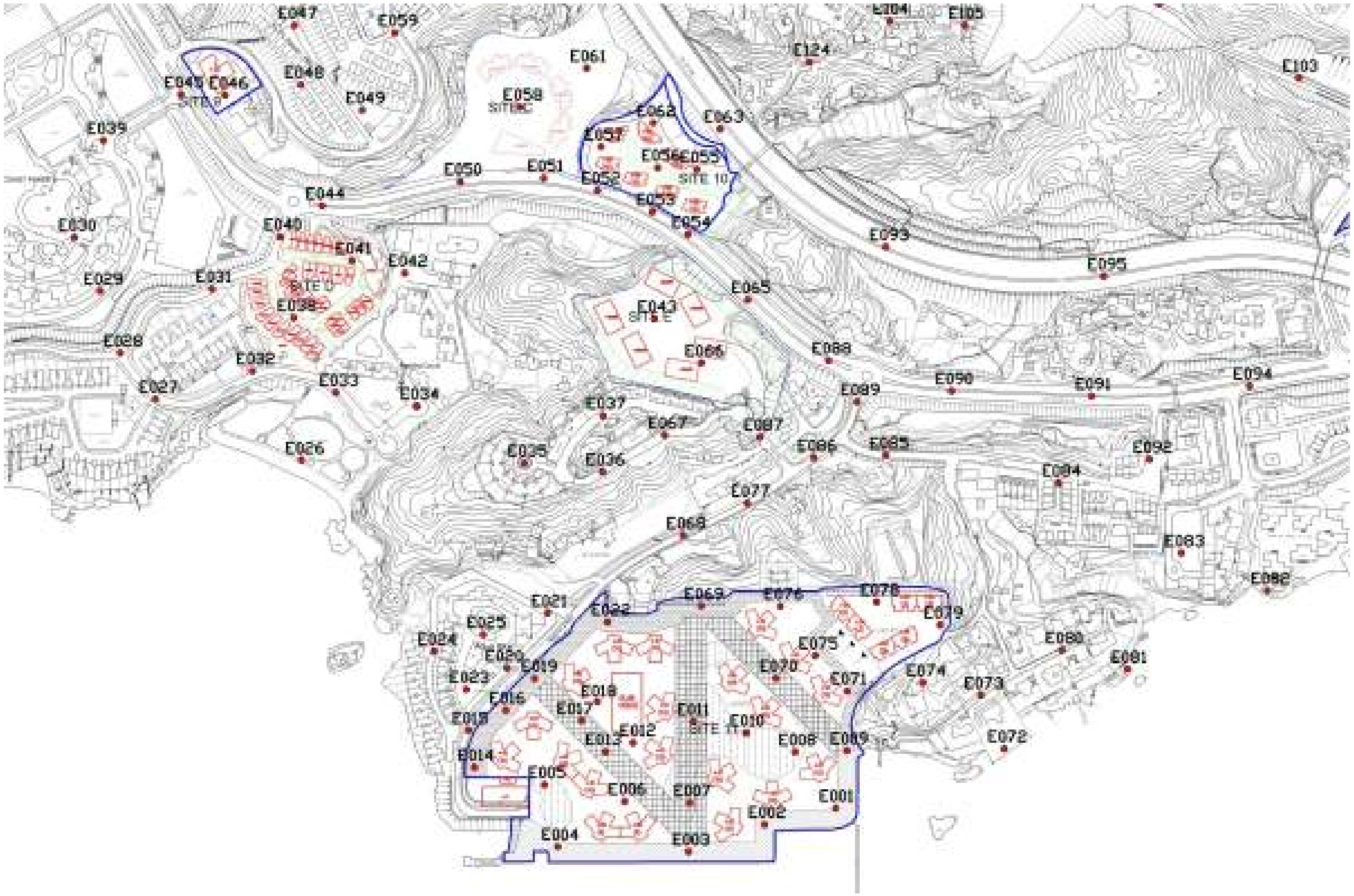


Figure 29: Test point locations on the East Model (3)

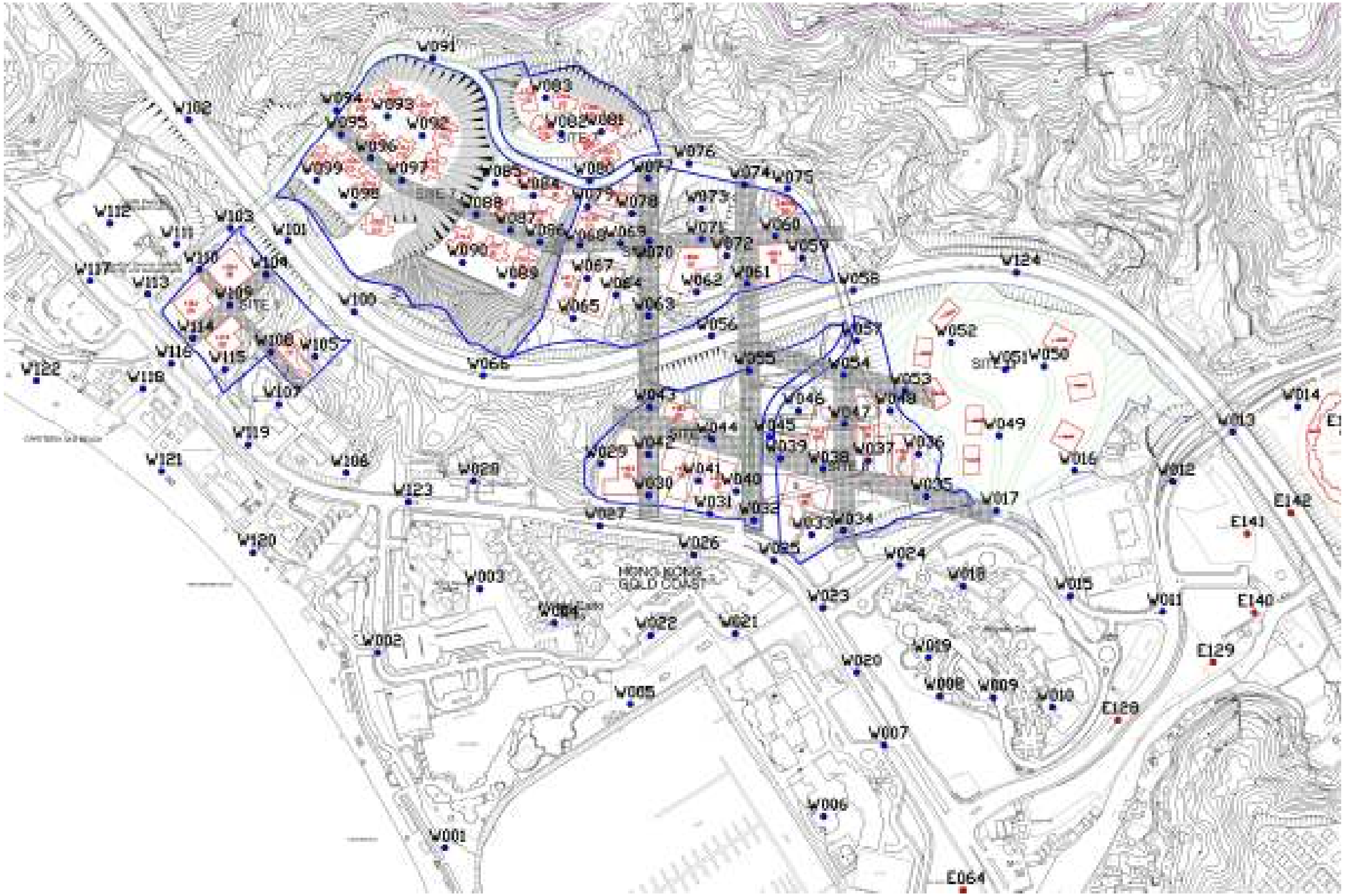


Figure 30: Test point locations on the West Model

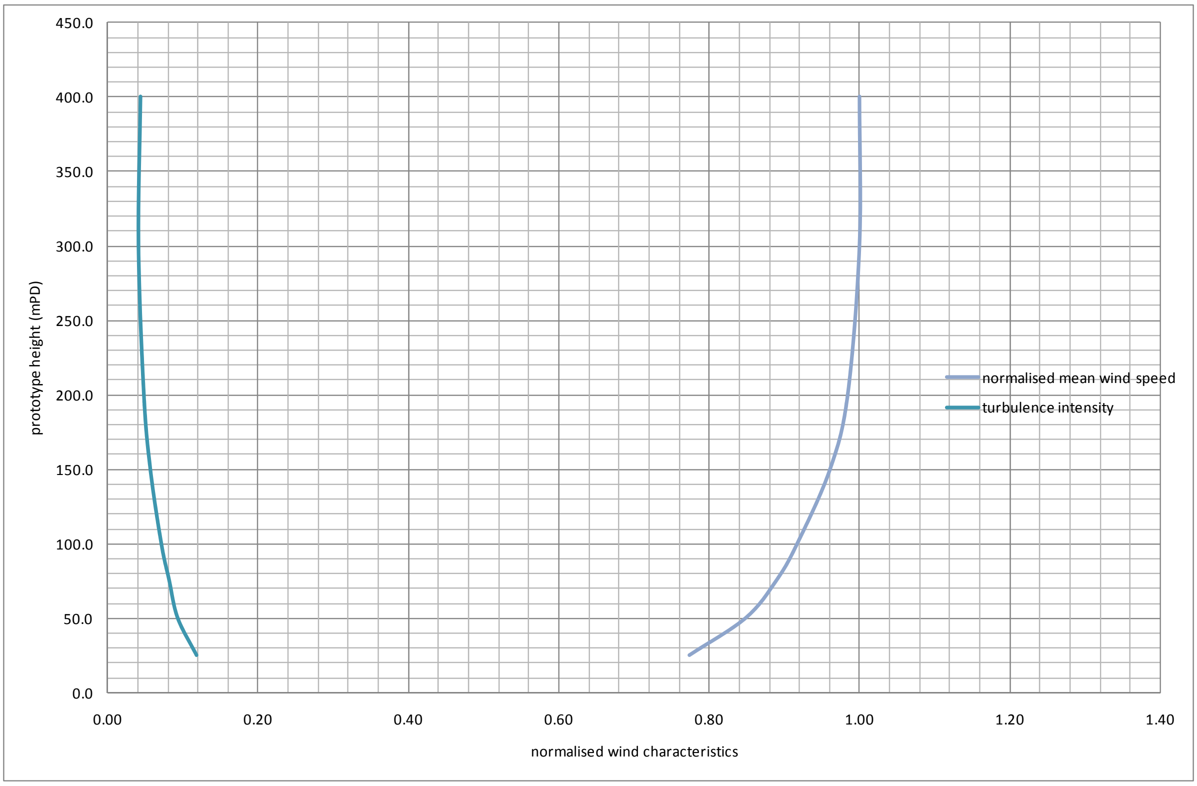


Figure 31: Approach condition A

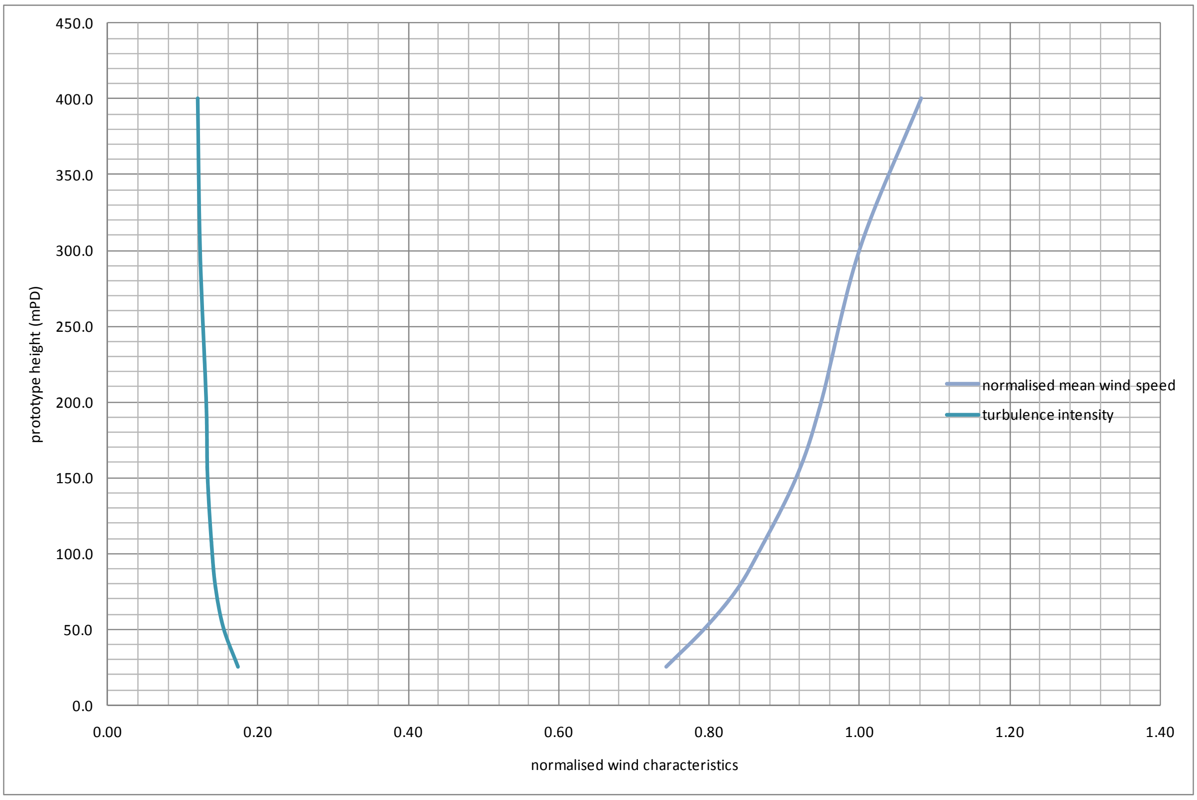


Figure 32: Approach condition B

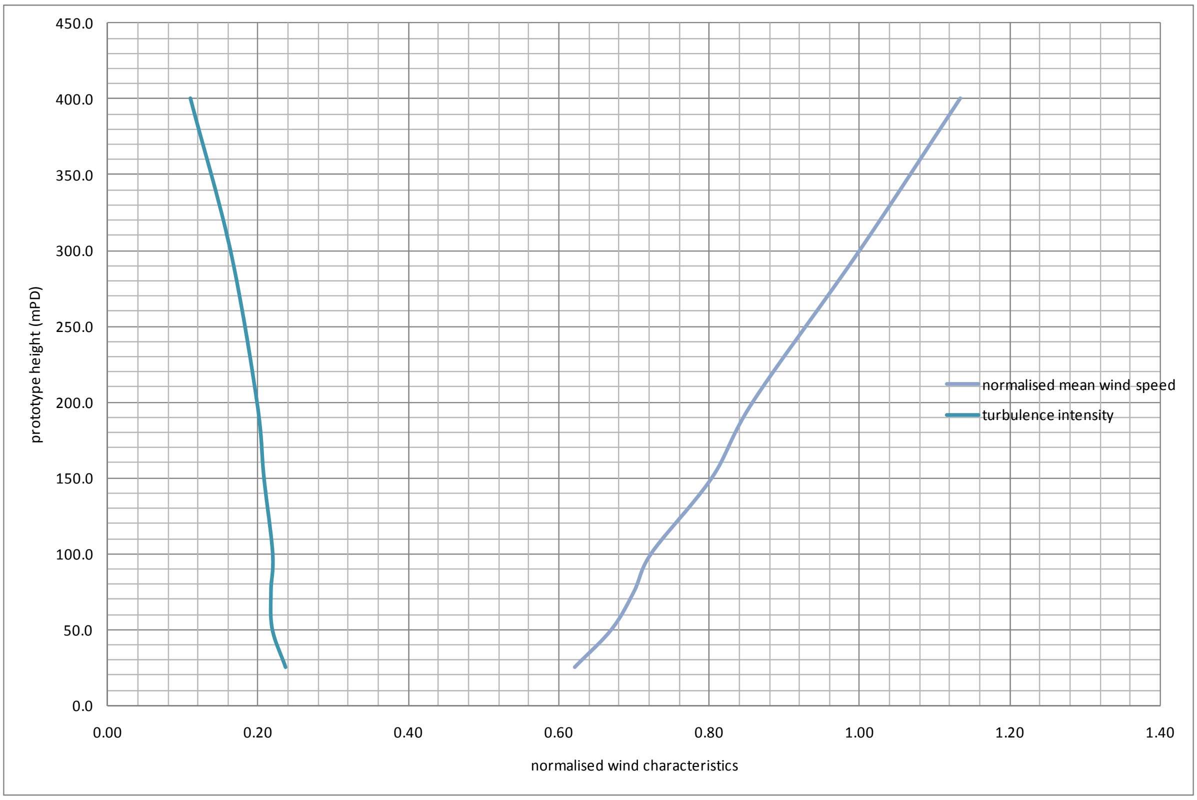


Figure 33: Approach condition C

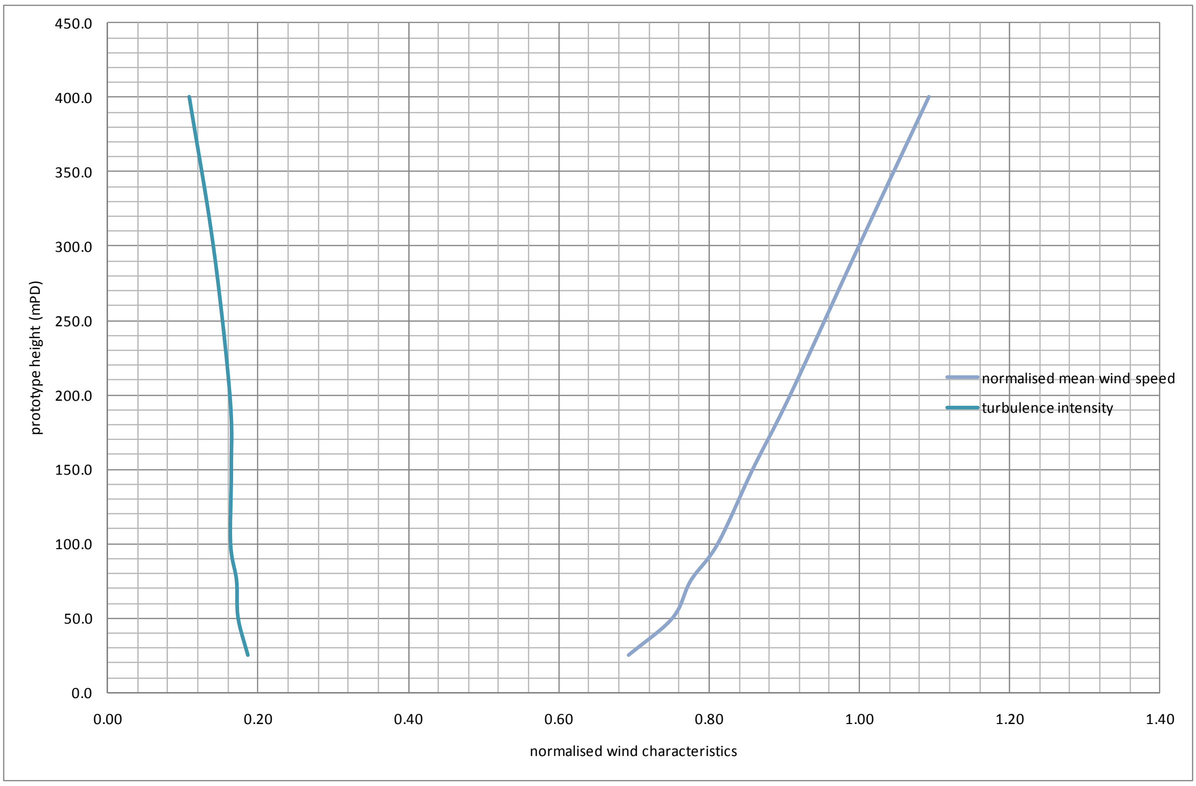


Figure 34: Approach condition D

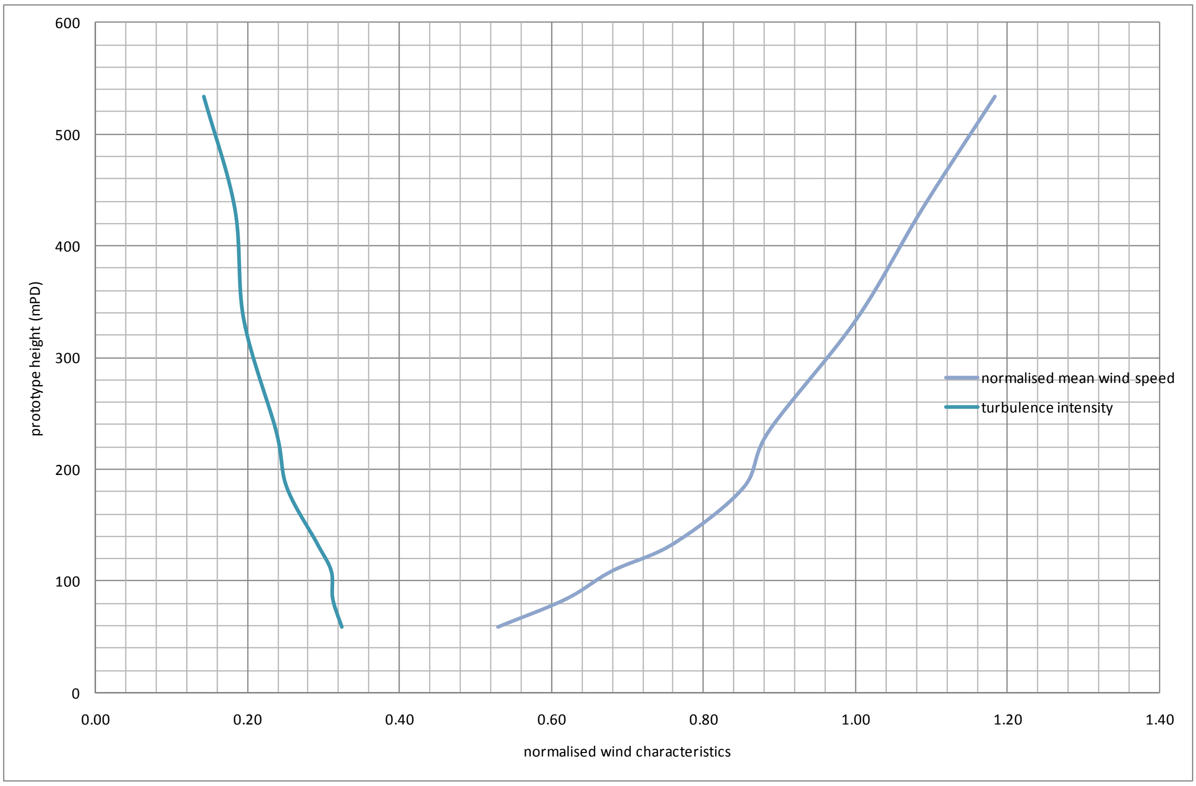


Figure 35: Approach condition W0

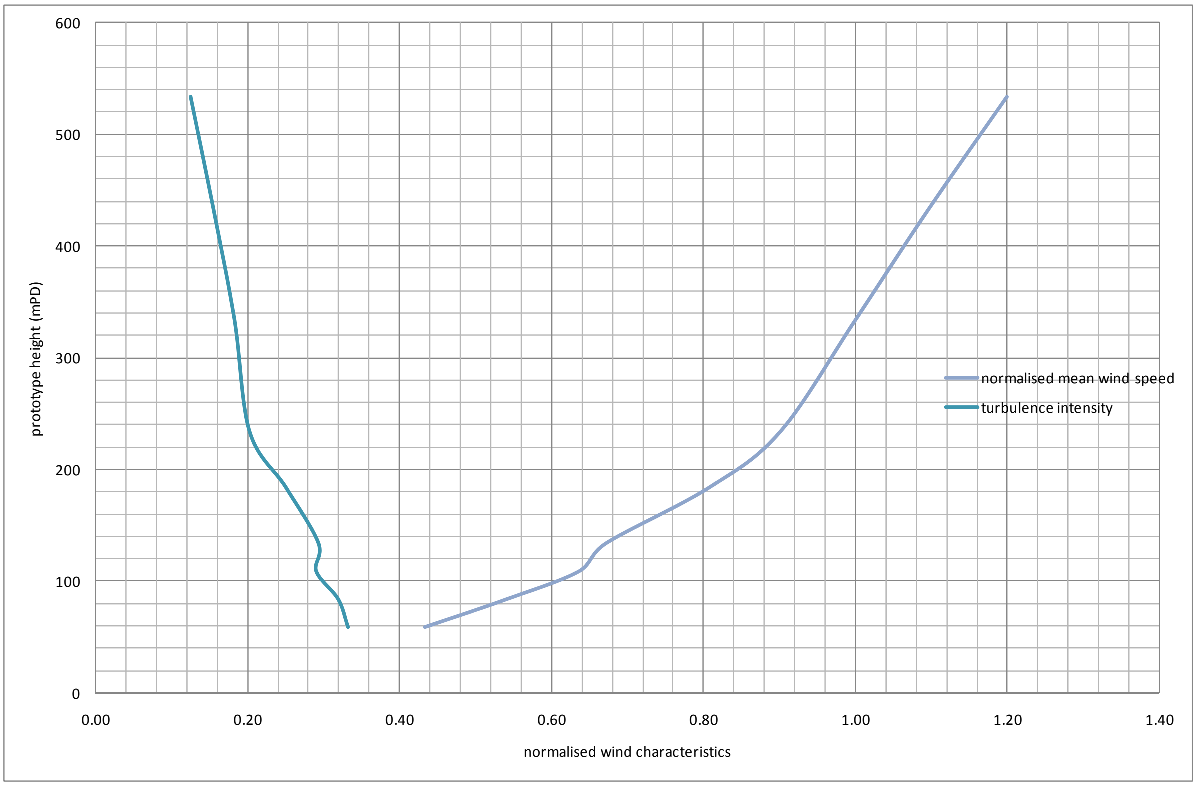


Figure 36: Approach condition W22

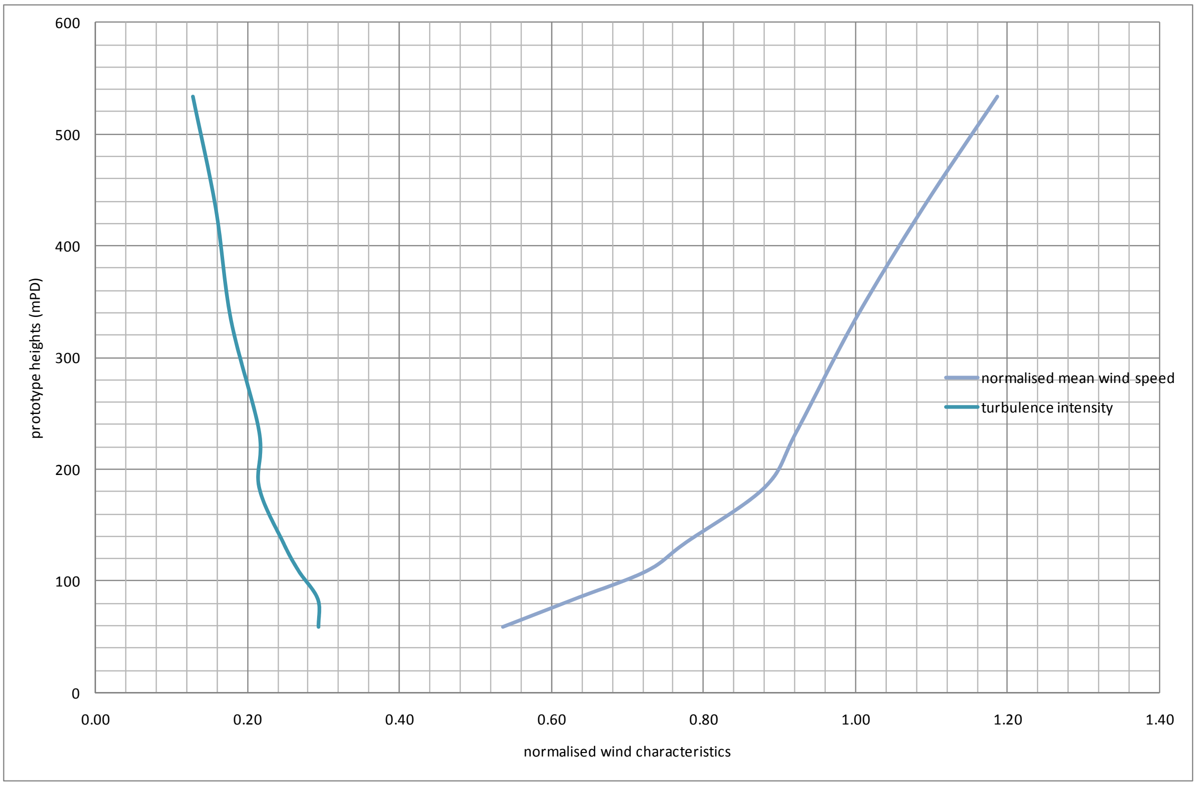


Figure 37: Approach condition W45

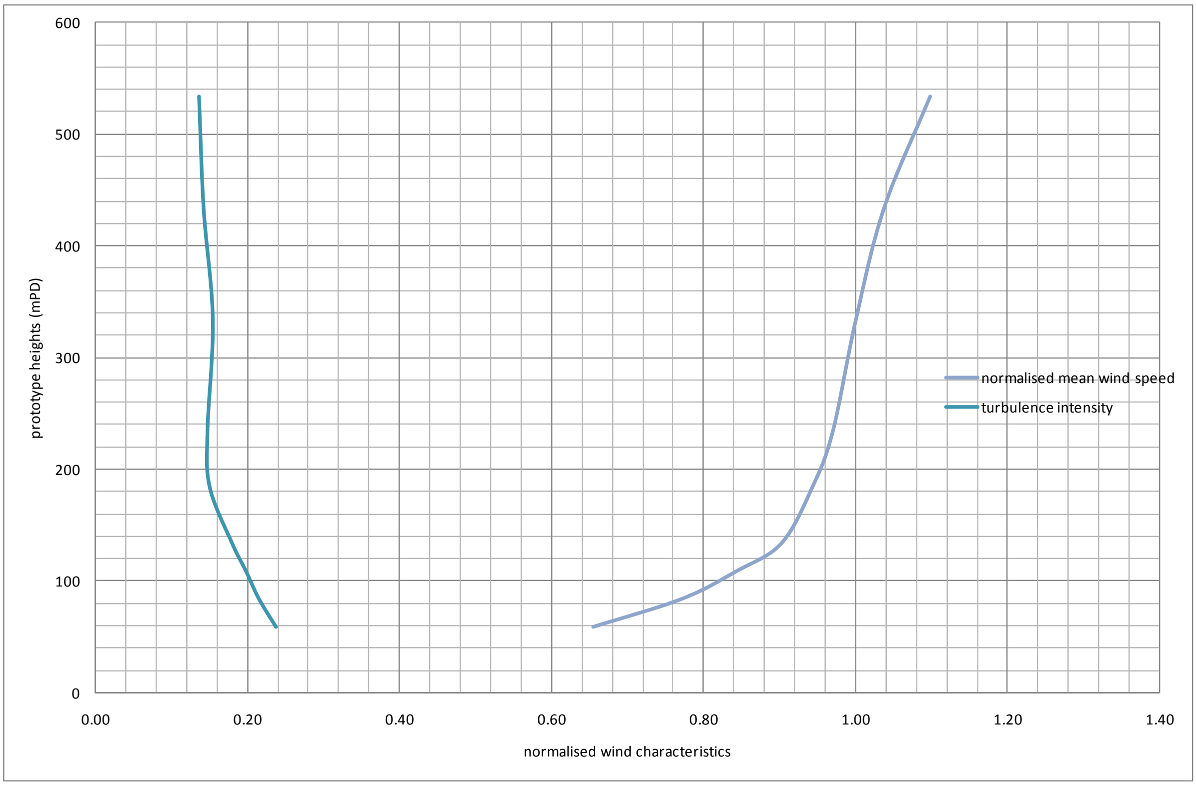


Figure 38: Approach condition W67

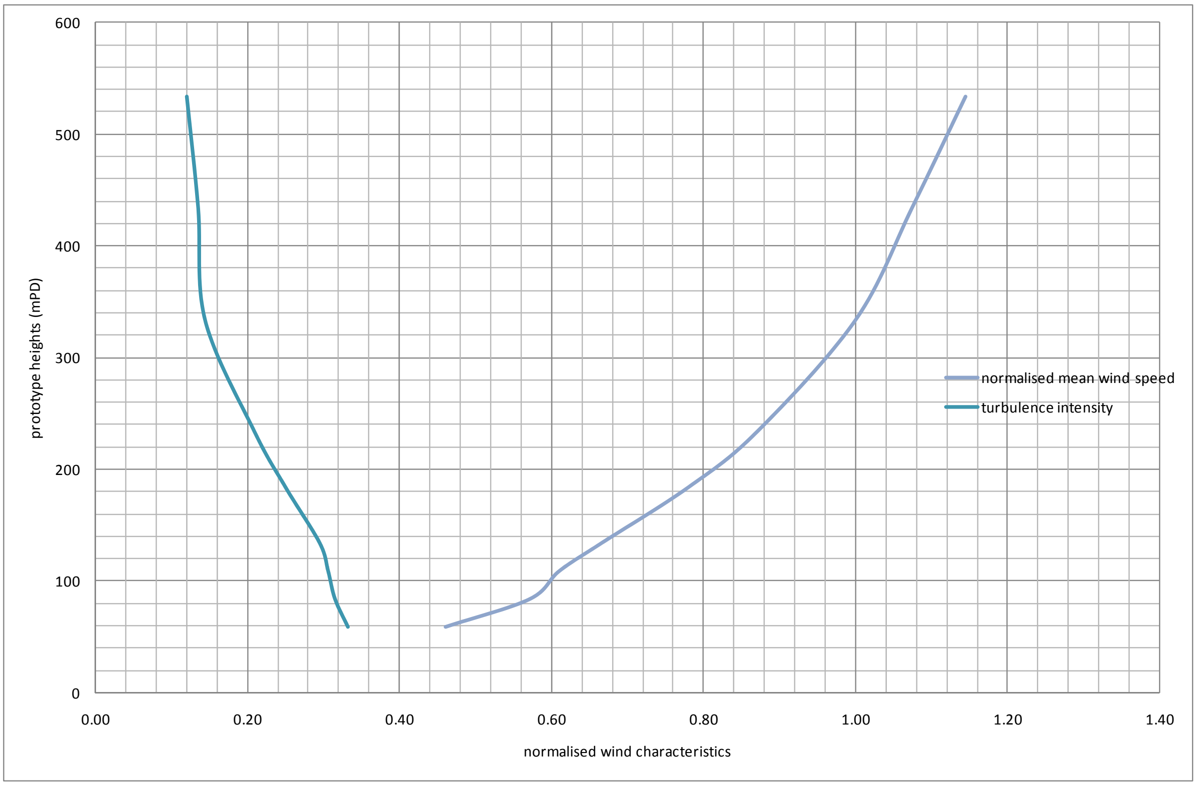


Figure 39: Approach condition W33

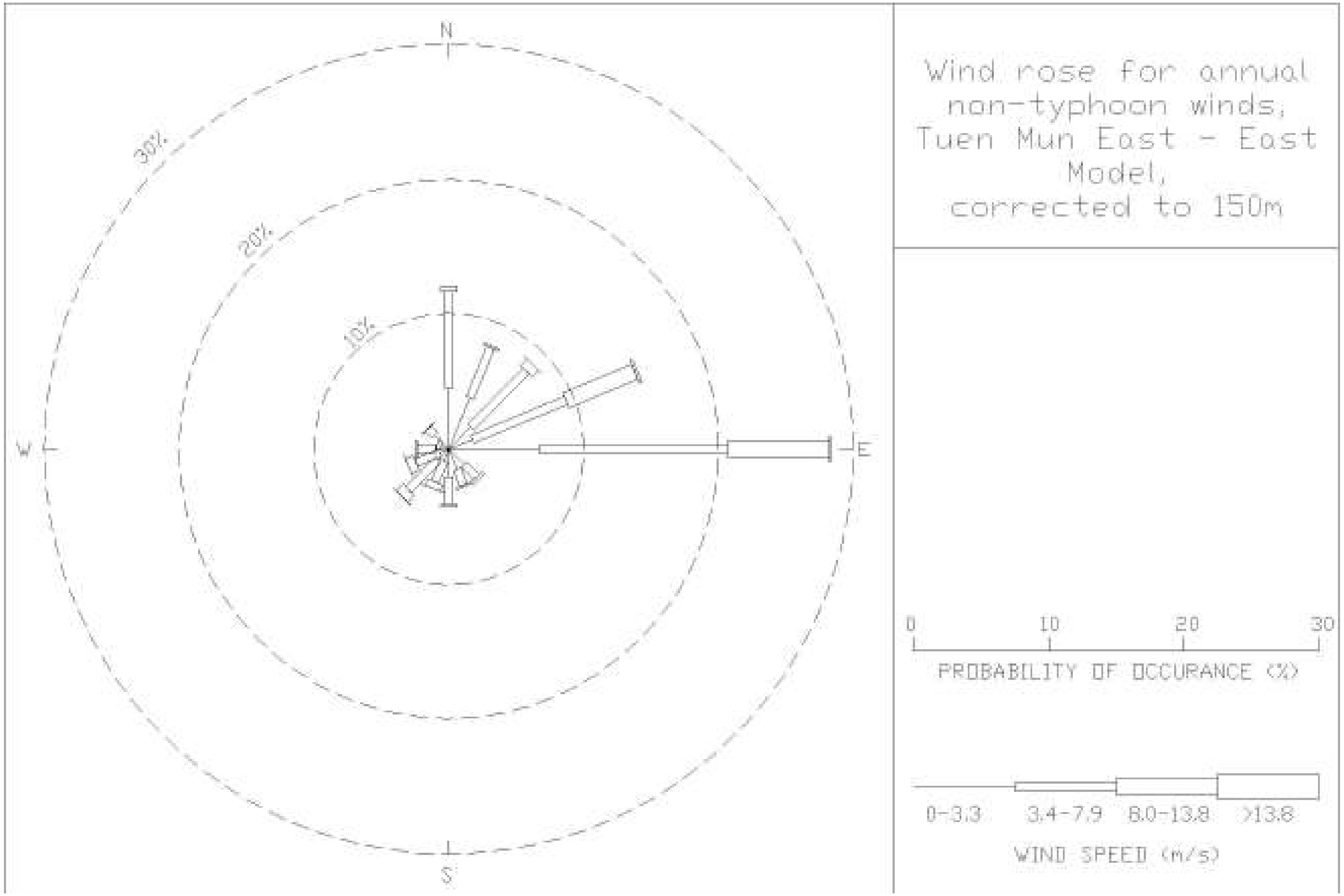


Figure 40: Wind rose for annual non-typhoon winds at Tuen Mun East – East Model, corrected to 150 m

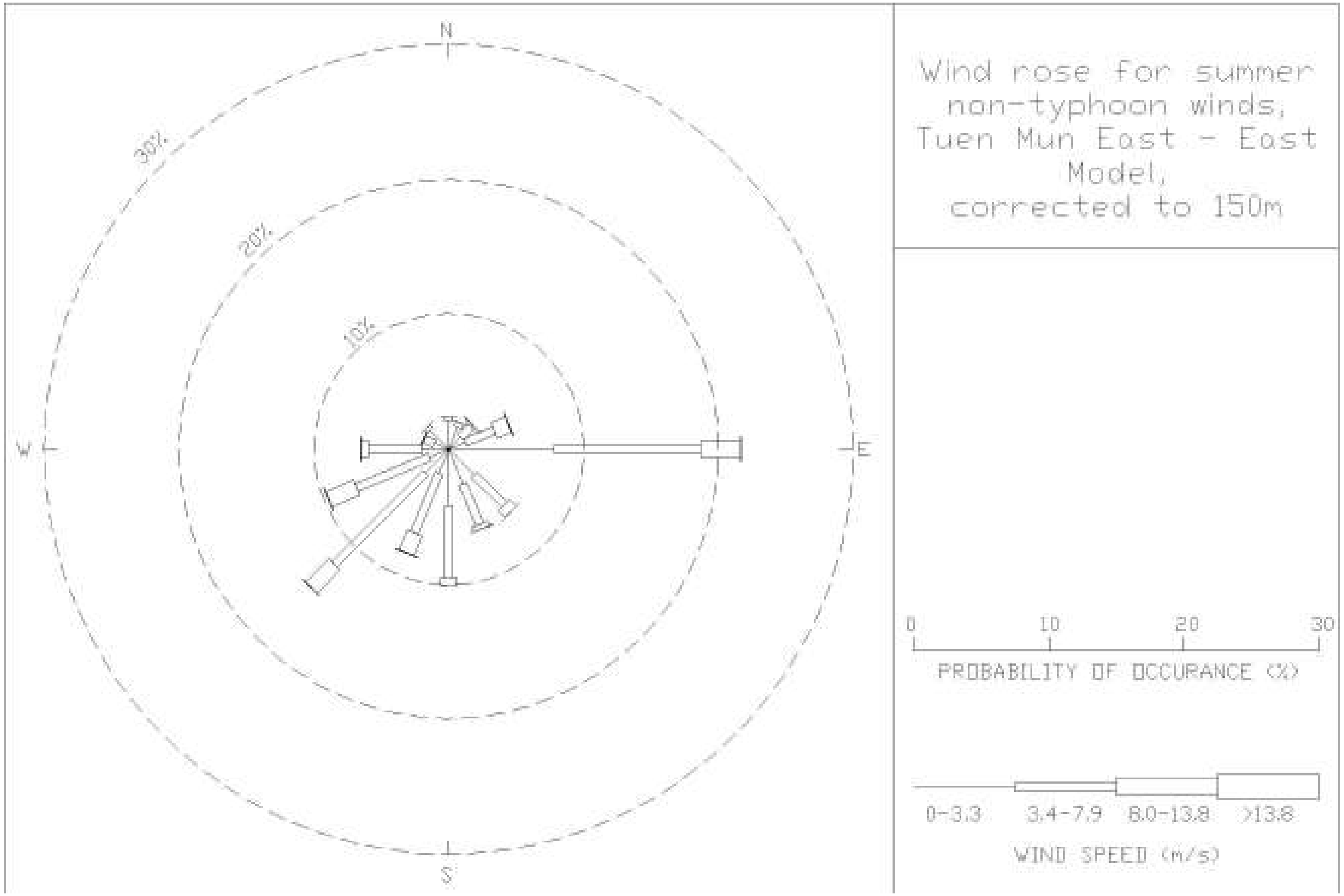


Figure 41: Wind rose for summer non-typhoon winds at Tuen Mun East – East Model, corrected to 150 m

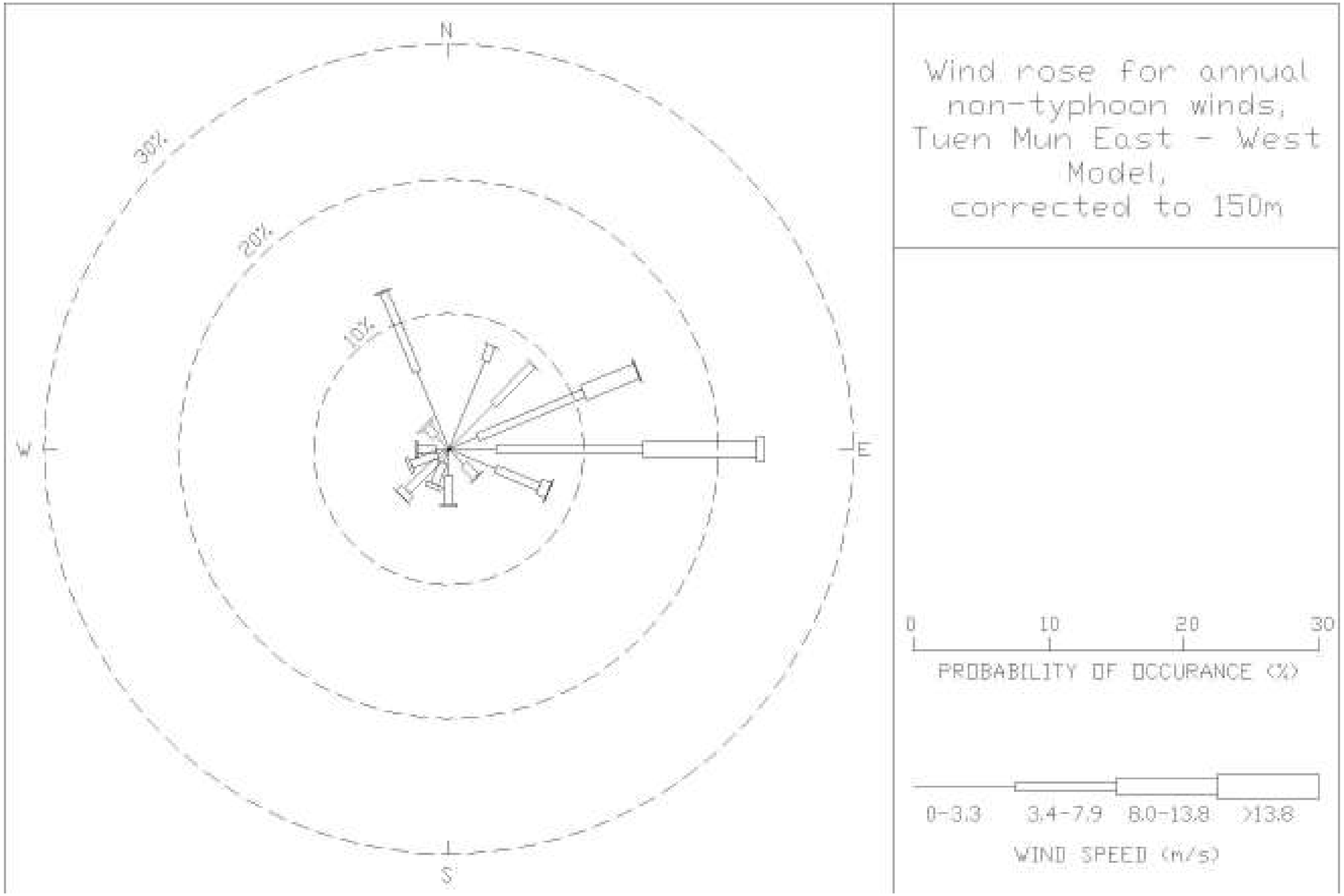


Figure 42: Wind rose for annual non-typhoon winds at Tuen Mun East – West Model, corrected to 150 m

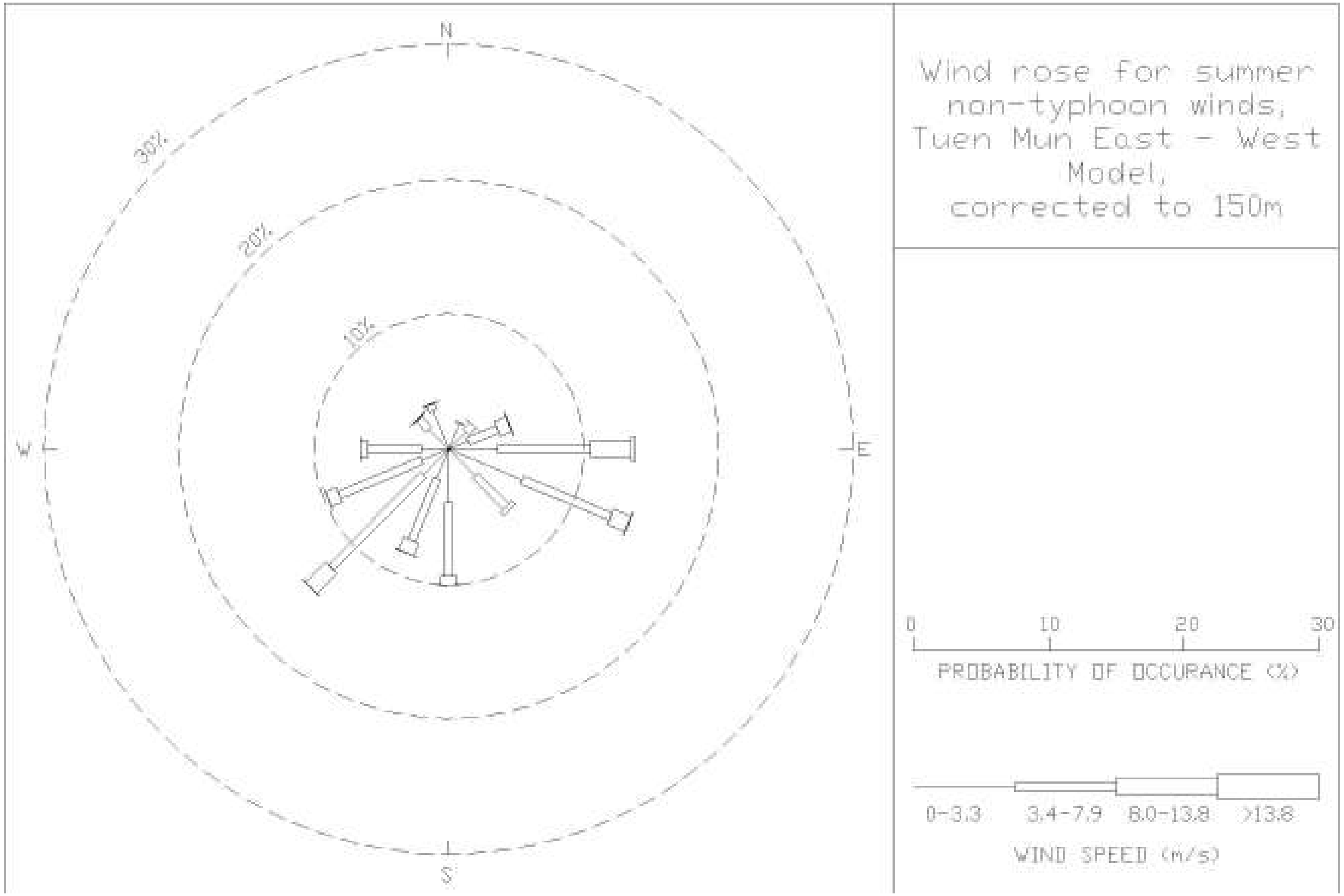


Figure 43: Wind rose for summer non-typhoon winds at Tuen Mun East – West Model, corrected to 150 m

APPENDIX A

APPENDIX A
TABULATED WIND ROSE DATA

Table A1: Wind rose data for annual non-typhoon winds at Tuen Mun East – East Model, corrected to 150 m

	Percentage Occurrence (%) for wind speed ranges:				
Wind Directions	< 3.3	3.3 < 7.9	7.9 < 13.8	> 13.8	Total
0.0°	4.49%	7.28%	0.36%	0.00%	12.13%
22.5°	4.11%	3.98%	0.16%	0.00%	8.26%
45.0°	2.31%	5.81%	0.69%	0.01%	8.82%
67.5°	1.89%	7.52%	5.51%	0.22%	15.15%
90.0°	6.74%	13.96%	7.47%	0.15%	28.31%
112.5°	0.00%	0.00%	0.00%	0.00%	0.00%
135.0°	1.63%	1.27%	0.23%	0.00%	3.14%
157.5°	1.60%	1.26%	0.12%	0.00%	2.97%
180.0°	2.03%	2.05%	0.17%	0.00%	4.26%
202.5°	0.94%	1.67%	0.50%	0.01%	3.12%
225.0°	1.11%	3.11%	0.71%	0.01%	4.94%
247.5°	0.71%	1.89%	0.64%	0.01%	3.25%
270.0°	0.97%	1.35%	0.17%	0.00%	2.50%
292.5°	0.62%	0.31%	0.03%	0.00%	0.97%
315.0°	1.47%	0.67%	0.05%	0.00%	2.19%
337.5°	0.00%	0.00%	0.00%	0.00%	0.00%
Total	30.63%	52.13%	16.82%	0.43%	100.00%

Table A2: Wind rose data for summer non-typhoon winds at Tuen Mun East – East Model, corrected to 150 m

	Percentage Occurrence (%) for wind speed ranges:				
Wind Directions	< 3.3	3.3 < 7.9	7.9 < 13.8	> 13.8	Total
0.0°	2.12%	0.34%	0.01%	0.00%	2.47%
22.5°	1.77%	0.35%	0.02%	0.00%	2.15%
45.0°	1.24%	1.12%	0.17%	0.01%	2.54%
67.5°	1.36%	2.24%	1.17%	0.08%	4.85%
90.0°	7.82%	10.88%	2.88%	0.09%	21.67%
112.5°	0.00%	0.00%	0.00%	0.00%	0.00%
135.0°	2.68%	3.13%	0.70%	0.01%	6.52%
157.5°	2.76%	3.22%	0.37%	0.01%	6.36%
180.0°	4.14%	5.34%	0.59%	0.00%	10.07%
202.5°	1.93%	4.74%	1.59%	0.05%	8.30%
225.0°	2.47%	9.55%	2.40%	0.06%	14.48%
247.5°	1.53%	5.85%	2.25%	0.05%	9.68%
270.0°	1.99%	3.97%	0.56%	0.01%	6.55%
292.5°	1.15%	0.80%	0.09%	0.00%	2.04%
315.0°	1.96%	0.32%	0.04%	0.00%	2.32%
337.5°	0.00%	0.00%	0.00%	0.00%	0.00%
Total	34.93%	51.87%	12.84%	0.37%	100.00%

Table A3: Wind rose data for annual non-typhoon winds at Tuen Mun East – West Model, corrected to 150 m

	Percentage Occurrence (%) for wind speed ranges:				
Wind Directions	< 3.3	3.3 < 7.9	7.9 < 13.8	> 13.8	Total
0.0°	0.00%	0.00%	0.00%	0.00%	0.00%
22.5°	7.01%	1.24%	0.01%	0.00%	8.26%
45.0°	4.67%	4.13%	0.03%	0.00%	8.82%
67.5°	2.34%	8.47%	4.27%	0.07%	15.15%
90.0°	3.53%	10.87%	8.41%	0.62%	23.43%
112.5°	3.81%	3.42%	0.76%	0.02%	8.02%
135.0°	1.60%	1.25%	0.12%	0.00%	2.97%
157.5°	0.00%	0.00%	0.00%	0.00%	0.00%
180.0°	1.94%	2.11%	0.21%	0.00%	4.26%
202.5°	1.09%	1.71%	0.32%	0.00%	3.12%
225.0°	1.19%	3.14%	0.61%	0.01%	4.94%
247.5°	0.94%	2.06%	0.24%	0.00%	3.25%
270.0°	1.00%	1.33%	0.16%	0.00%	2.50%
292.5°	0.00%	0.00%	0.00%	0.00%	0.00%
315.0°	1.36%	0.93%	0.22%	0.01%	2.51%
337.5°	6.17%	6.47%	0.12%	0.00%	12.77%
Total	36.66%	47.13%	15.46%	0.75%	100.00%

Table A4: Wind rose data for summer non-typhoon winds at Tuen Mun East – West Model, corrected to 150 m

	Percentage Occurrence (%) for wind speed ranges:				
Wind Directions	< 3.3	3.3 < 7.9	7.9 < 13.8	> 13.8	Total
0.0°	0.00%	0.00%	0.00%	0.00%	0.00%
22.5°	2.06%	0.09%	0.00%	0.00%	2.15%
45.0°	1.80%	0.71%	0.03%	0.00%	2.54%
67.5°	1.56%	2.34%	0.92%	0.04%	4.85%
90.0°	3.63%	6.89%	3.02%	0.25%	13.79%
112.5°	5.88%	7.12%	1.37%	0.03%	14.40%
135.0°	2.77%	3.22%	0.37%	0.00%	6.36%
157.5°	0.00%	0.00%	0.00%	0.00%	0.00%
180.0°	3.93%	5.45%	0.69%	0.01%	10.07%
202.5°	2.32%	4.94%	1.03%	0.02%	8.30%
225.0°	2.67%	9.70%	2.07%	0.04%	14.48%
247.5°	2.15%	6.66%	0.87%	0.01%	9.68%
270.0°	2.06%	3.96%	0.51%	0.01%	6.55%
292.5°	0.00%	0.00%	0.00%	0.00%	0.00%
315.0°	2.10%	1.02%	0.12%	0.01%	3.24%
337.5°	3.05%	0.49%	0.05%	0.00%	3.59%
Total	35.98%	52.57%	11.04%	0.41%	100.00%

APPENDIX B

APPENDIX B
DIRECTIONAL, ANNUAL OVERALL AND SUMMER OVERALL WIND VELOCITY RATIOS OF ALL TEST POINTS

Table B1: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E001 to E020

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	001	0.10	0.27	0.34	0.51	0.46	0.33	0.21	0.23	0.34	0.55	0.45	0.28	0.20	0.14	0.12	0.11	0.36	0.36
E	002	0.13	0.11	0.13	0.35	0.51	0.43	0.38	0.27	0.18	0.34	0.22	0.26	0.16	0.18	0.17	0.13	0.30	0.30
E	003	0.22	0.18	0.23	0.21	0.17	0.39	0.55	0.49	0.43	0.52	0.47	0.33	0.21	0.19	0.16	0.15	0.25	0.34
E	004	0.08	0.09	0.12	0.18	0.17	0.37	0.54	0.53	0.37	0.30	0.22	0.25	0.31	0.30	0.19	0.16	0.19	0.27
E	005	0.07	0.08	0.14	0.19	0.20	0.20	0.22	0.31	0.27	0.25	0.34	0.33	0.14	0.20	0.12	0.13	0.18	0.24
E	006	0.13	0.13	0.24	0.27	0.27	0.23	0.29	0.22	0.25	0.40	0.37	0.52	0.28	0.18	0.14	0.13	0.25	0.30
E	007	0.17	0.16	0.17	0.17	0.22	0.18	0.23	0.38	0.36	0.44	0.18	0.16	0.13	0.16	0.15	0.12	0.20	0.24
E	008	0.13	0.18	0.28	0.33	0.34	0.24	0.29	0.23	0.22	0.29	0.31	0.14	0.15	0.17	0.17	0.16	0.26	0.26
E	009	0.11	0.11	0.15	0.21	0.32	0.45	0.52	0.48	0.41	0.30	0.11	0.09	0.14	0.15	0.10	0.14	0.23	0.26
E	010	0.13	0.12	0.16	0.30	0.36	0.39	0.21	0.21	0.19	0.26	0.34	0.21	0.23	0.13	0.14	0.11	0.25	0.26
E	011	0.18	0.17	0.20	0.17	0.20	0.23	0.29	0.35	0.31	0.30	0.32	0.22	0.20	0.16	0.16	0.13	0.21	0.25
E	012	0.10	0.12	0.15	0.17	0.18	0.25	0.15	0.32	0.18	0.36	0.23	0.29	0.23	0.22	0.16	0.11	0.18	0.22
E	013	0.13	0.17	0.30	0.22	0.31	0.20	0.40	0.44	0.17	0.23	0.27	0.26	0.21	0.20	0.13	0.16	0.25	0.27
E	014	0.08	0.11	0.11	0.11	0.10	0.13	0.25	0.42	0.37	0.31	0.21	0.17	0.28	0.38	0.19	0.18	0.15	0.22
E	015	0.11	0.21	0.22	0.32	0.30	0.40	0.31	0.27	0.26	0.40	0.37	0.38	0.23	0.30	0.17	0.16	0.27	0.30
E	016	0.11	0.20	0.21	0.28	0.25	0.34	0.30	0.16	0.32	0.37	0.59	0.59	0.33	0.36	0.18	0.18	0.26	0.35
E	017	0.15	0.18	0.29	0.21	0.25	0.27	0.28	0.33	0.43	0.49	0.56	0.36	0.29	0.18	0.11	0.15	0.27	0.34
E	018	0.08	0.10	0.13	0.12	0.17	0.29	0.19	0.24	0.24	0.31	0.39	0.34	0.38	0.16	0.13	0.12	0.17	0.25
E	019	0.13	0.22	0.26	0.22	0.15	0.29	0.17	0.20	0.29	0.28	0.44	0.46	0.45	0.39	0.19	0.16	0.22	0.28
E	020	0.12	0.24	0.29	0.33	0.23	0.29	0.25	0.25	0.35	0.45	0.47	0.44	0.37	0.20	0.12	0.09	0.27	0.33

Table B2: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E021 to E050

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	021	0.15	0.18	0.20	0.20	0.15	0.24	0.29	0.27	0.39	0.46	0.38	0.40	0.33	0.18	0.19	0.17	0.22	0.29
E	022	0.20	0.18	0.31	0.18	0.10	0.11	0.14	0.13	0.10	0.13	0.14	0.19	0.17	0.24	0.24	0.28	0.17	0.15
E	023	0.12	0.14	0.28	0.42	0.38	0.39	0.46	0.43	0.25	0.21	0.18	0.34	0.40	0.35	0.20	0.18	0.30	0.31
E	024	0.12	0.10	0.15	0.14	0.08	0.10	0.13	0.22	0.20	0.15	0.09	0.26	0.34	0.35	0.21	0.21	0.13	0.16
E	025	0.14	0.08	0.10	0.10	0.09	0.20	0.27	0.25	0.32	0.28	0.15	0.34	0.52	0.39	0.22	0.22	0.15	0.22
E	026	0.11	0.11	0.11	0.14	0.22	0.16	0.23	0.39	0.41	0.44	0.38	0.33	0.40	0.21	0.12	0.15	0.21	0.30
E	027	0.09	0.12	0.12	0.18	0.30	0.27	0.34	0.29	0.20	0.18	0.17	0.21	0.26	0.18	0.10	0.08	0.20	0.23
E	028	0.17	0.31	0.32	0.18	0.16	0.18	0.28	0.29	0.26	0.26	0.20	0.32	0.35	0.16	0.16	0.18	0.22	0.24
E	029	0.38	0.21	0.25	0.31	0.27	0.29	0.34	0.45	0.39	0.68	0.58	0.24	0.26	0.49	0.50	0.56	0.33	0.39
E	030	0.13	0.14	0.14	0.12	0.15	0.22	0.40	0.51	0.24	0.28	0.34	0.33	0.26	0.17	0.19	0.23	0.19	0.26
E	031	0.21	0.25	0.28	0.15	0.11	0.12	0.16	0.22	0.39	0.32	0.19	0.18	0.17	0.18	0.19	0.22	0.19	0.20
E	032	0.07	0.06	0.06	0.11	0.12	0.12	0.23	0.34	0.36	0.32	0.19	0.11	0.13	0.09	0.08	0.12	0.13	0.19
E	033	0.07	0.09	0.16	0.17	0.19	0.13	0.23	0.20	0.35	0.24	0.13	0.16	0.13	0.12	0.08	0.09	0.16	0.19
E	034	0.13	0.14	0.10	0.12	0.15	0.11	0.17	0.23	0.38	0.39	0.33	0.28	0.14	0.10	0.10	0.13	0.17	0.23
E	035	0.15	0.13	0.18	0.23	0.22	0.24	0.28	0.30	0.22	0.36	0.12	0.17	0.27	0.22	0.22	0.24	0.21	0.22
E	036	0.10	0.13	0.14	0.31	0.39	0.33	0.42	0.23	0.21	0.24	0.34	0.20	0.14	0.11	0.11	0.14	0.26	0.28
E	037	0.15	0.18	0.14	0.13	0.22	0.31	0.34	0.36	0.33	0.30	0.33	0.14	0.20	0.18	0.24	0.17	0.21	0.25
E	038	0.14	0.12	0.10	0.12	0.10	0.09	0.11	0.16	0.17	0.22	0.19	0.15	0.09	0.09	0.14	0.17	0.12	0.14
E	039	0.17	0.25	0.33	0.29	0.25	0.25	0.23	0.26	0.32	0.19	0.26	0.35	0.28	0.33	0.32	0.24	0.26	0.27
E	040	0.15	0.17	0.22	0.20	0.16	0.14	0.11	0.13	0.15	0.26	0.16	0.22	0.14	0.11	0.17	0.17	0.17	0.17
E	041	0.08	0.13	0.14	0.15	0.14	0.12	0.07	0.08	0.17	0.47	0.44	0.40	0.25	0.12	0.13	0.08	0.16	0.23
E	042	0.12	0.15	0.13	0.21	0.18	0.14	0.11	0.18	0.18	0.15	0.30	0.35	0.20	0.09	0.12	0.11	0.18	0.20
E	043	0.12	0.14	0.22	0.25	0.20	0.14	0.17	0.16	0.11	0.26	0.15	0.12	0.24	0.23	0.25	0.18	0.19	0.18
E	044	0.11	0.09	0.07	0.18	0.24	0.30	0.19	0.27	0.15	0.20	0.21	0.15	0.07	0.13	0.27	0.26	0.17	0.19
E	045	0.20	0.19	0.21	0.13	0.10	0.14	0.22	0.21	0.25	0.14	0.18	0.19	0.20	0.29	0.41	0.35	0.17	0.18
E	046	0.11	0.10	0.12	0.10	0.11	0.18	0.23	0.20	0.17	0.22	0.09	0.07	0.09	0.13	0.12	0.12	0.12	0.13
E	047	0.11	0.12	0.15	0.13	0.12	0.18	0.18	0.27	0.16	0.12	0.13	0.10	0.16	0.16	0.12	0.10	0.13	0.14
E	048	0.07	0.08	0.06	0.08	0.07	0.08	0.10	0.13	0.12	0.22	0.24	0.12	0.15	0.15	0.11	0.09	0.09	0.13

E	049	0.19	0.15	0.19	0.26	0.18	0.27	0.26	0.31	0.21	0.14	0.12	0.10	0.08	0.19	0.20	0.15	0.19	0.17
E	050	0.09	0.09	0.10	0.17	0.18	0.22	0.17	0.11	0.31	0.10	0.16	0.19	0.10	0.12	0.12	0.11	0.15	0.16

Table B3: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E051 to E080

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	051	0.11	0.20	0.28	0.28	0.26	0.26	0.22	0.15	0.16	0.22	0.18	0.18	0.07	0.18	0.17	0.13	0.22	0.20
E	052	0.11	0.08	0.09	0.17	0.23	0.34	0.25	0.27	0.17	0.31	0.17	0.14	0.08	0.25	0.24	0.21	0.17	0.20
E	053	0.07	0.08	0.26	0.33	0.28	0.28	0.21	0.21	0.20	0.30	0.15	0.16	0.09	0.20	0.15	0.12	0.22	0.21
E	054	0.12	0.21	0.39	0.41	0.37	0.41	0.33	0.17	0.15	0.38	0.13	0.30	0.22	0.27	0.27	0.18	0.30	0.27
E	055	0.12	0.19	0.32	0.27	0.22	0.21	0.23	0.19	0.16	0.36	0.12	0.21	0.06	0.08	0.13	0.12	0.21	0.20
E	056	0.18	0.20	0.26	0.32	0.33	0.35	0.44	0.23	0.20	0.26	0.15	0.21	0.08	0.12	0.21	0.18	0.26	0.24
E	057	0.14	0.14	0.18	0.20	0.18	0.24	0.25	0.16	0.28	0.29	0.32	0.31	0.07	0.14	0.21	0.18	0.19	0.23
E	058	0.14	0.20	0.24	0.26	0.24	0.12	0.13	0.16	0.31	0.18	0.28	0.32	0.14	0.21	0.16	0.14	0.22	0.23
E	059	0.13	0.13	0.16	0.21	0.22	0.26	0.39	0.39	0.38	0.18	0.18	0.15	0.14	0.21	0.22	0.24	0.21	0.23
E	060	0.11	0.13	0.14	0.16	0.15	0.13	0.13	0.22	0.19	0.19	0.19	0.26	0.10	0.13	0.15	0.16	0.15	0.17
E	061	0.24	0.25	0.23	0.24	0.23	0.27	0.21	0.27	0.40	0.39	0.26	0.25	0.09	0.24	0.33	0.25	0.25	0.26
E	062	0.17	0.17	0.20	0.16	0.16	0.11	0.12	0.10	0.09	0.13	0.09	0.11	0.04	0.17	0.20	0.23	0.15	0.12
E	063	0.30	0.24	0.19	0.22	0.27	0.33	0.39	0.34	0.29	0.20	0.13	0.14	0.17	0.37	0.35	0.35	0.25	0.24
E	064	0.18	0.24	0.36	0.37	0.35	0.35	0.27	0.12	0.14	0.21	0.37	0.35	0.33	0.36	0.36	0.25	0.30	0.29
E	065	0.16	0.14	0.17	0.28	0.31	0.38	0.33	0.28	0.20	0.17	0.17	0.13	0.21	0.24	0.22	0.18	0.23	0.23
E	066	0.15	0.17	0.16	0.20	0.23	0.33	0.34	0.29	0.14	0.16	0.16	0.10	0.22	0.20	0.25	0.24	0.20	0.20
E	067	0.11	0.12	0.17	0.17	0.17	0.24	0.34	0.25	0.30	0.24	0.34	0.16	0.09	0.08	0.09	0.11	0.18	0.22
E	068	0.15	0.13	0.23	0.24	0.30	0.26	0.32	0.13	0.15	0.13	0.25	0.26	0.28	0.31	0.22	0.15	0.23	0.23
E	069	0.15	0.13	0.15	0.12	0.16	0.18	0.20	0.16	0.19	0.31	0.21	0.16	0.15	0.19	0.20	0.14	0.16	0.18
E	070	0.17	0.14	0.15	0.23	0.30	0.40	0.45	0.32	0.13	0.22	0.23	0.29	0.18	0.26	0.14	0.16	0.23	0.25
E	071	0.12	0.11	0.16	0.24	0.30	0.33	0.43	0.45	0.39	0.26	0.12	0.23	0.15	0.27	0.16	0.23	0.23	0.26
E	072	0.13	0.28	0.32	0.46	0.48	0.44	0.39	0.35	0.37	0.42	0.43	0.25	0.17	0.18	0.12	0.11	0.36	0.37
E	073	0.09	0.17	0.18	0.24	0.25	0.19	0.20	0.23	0.22	0.21	0.17	0.10	0.11	0.10	0.08	0.08	0.19	0.19
E	074	0.11	0.17	0.19	0.24	0.17	0.16	0.21	0.13	0.16	0.22	0.13	0.15	0.15	0.17	0.12	0.12	0.17	0.16

E	075	0.20	0.11	0.16	0.26	0.25	0.28	0.36	0.28	0.29	0.21	0.16	0.23	0.14	0.27	0.18	0.27	0.22	0.23
E	076	0.17	0.15	0.15	0.22	0.31	0.22	0.19	0.11	0.20	0.08	0.09	0.15	0.07	0.22	0.09	0.17	0.20	0.17
E	077	0.17	0.19	0.28	0.32	0.36	0.27	0.31	0.25	0.14	0.31	0.26	0.37	0.29	0.28	0.10	0.19	0.28	0.28
E	078	0.07	0.10	0.11	0.12	0.12	0.12	0.11	0.16	0.13	0.27	0.19	0.17	0.15	0.15	0.11	0.09	0.12	0.15
E	079	0.17	0.29	0.36	0.44	0.38	0.33	0.35	0.14	0.21	0.32	0.17	0.27	0.23	0.22	0.13	0.12	0.31	0.28
E	080	0.16	0.21	0.24	0.23	0.22	0.26	0.22	0.21	0.24	0.24	0.14	0.12	0.11	0.12	0.14	0.17	0.20	0.19

Table B4: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E081 to E110

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	081	0.17	0.28	0.29	0.37	0.30	0.23	0.24	0.29	0.35	0.38	0.32	0.14	0.17	0.13	0.12	0.14	0.28	0.28
E	082	0.13	0.29	0.30	0.41	0.52	0.44	0.41	0.22	0.15	0.19	0.28	0.25	0.21	0.21	0.23	0.10	0.34	0.31
E	083	0.25	0.29	0.22	0.16	0.13	0.15	0.18	0.25	0.31	0.45	0.33	0.24	0.16	0.14	0.15	0.19	0.21	0.24
E	084	0.25	0.31	0.30	0.22	0.11	0.11	0.18	0.28	0.26	0.24	0.19	0.23	0.17	0.20	0.33	0.34	0.21	0.20
E	085	0.15	0.19	0.21	0.18	0.17	0.13	0.08	0.09	0.11	0.21	0.17	0.23	0.18	0.12	0.14	0.12	0.17	0.16
E	086	0.13	0.23	0.31	0.35	0.38	0.35	0.23	0.18	0.16	0.40	0.23	0.33	0.25	0.19	0.21	0.16	0.29	0.28
E	087	0.16	0.19	0.20	0.22	0.26	0.28	0.33	0.21	0.18	0.18	0.10	0.19	0.21	0.14	0.18	0.16	0.21	0.20
E	088	0.17	0.16	0.23	0.28	0.36	0.42	0.38	0.43	0.29	0.20	0.19	0.33	0.29	0.28	0.29	0.18	0.28	0.30
E	089	0.23	0.21	0.20	0.16	0.14	0.16	0.18	0.30	0.22	0.27	0.19	0.32	0.13	0.12	0.17	0.15	0.19	0.20
E	090	0.18	0.21	0.22	0.26	0.25	0.32	0.34	0.22	0.12	0.15	0.15	0.16	0.24	0.25	0.27	0.23	0.22	0.21
E	091	0.14	0.15	0.18	0.19	0.20	0.22	0.25	0.22	0.12	0.14	0.20	0.22	0.28	0.27	0.24	0.21	0.19	0.20
E	092	0.27	0.19	0.19	0.17	0.20	0.29	0.23	0.18	0.14	0.14	0.12	0.16	0.21	0.32	0.34	0.30	0.20	0.18
E	093	0.23	0.19	0.19	0.26	0.28	0.35	0.47	0.40	0.28	0.31	0.16	0.19	0.20	0.38	0.36	0.32	0.26	0.27
E	094	0.10	0.21	0.27	0.32	0.31	0.30	0.23	0.25	0.17	0.17	0.22	0.20	0.29	0.26	0.25	0.16	0.25	0.24
E	095	0.20	0.19	0.26	0.33	0.33	0.26	0.21	0.16	0.15	0.30	0.27	0.33	0.33	0.32	0.31	0.18	0.28	0.27
E	096	0.11	0.13	0.18	0.16	0.18	0.27	0.18	0.12	0.11	0.14	0.21	0.21	0.11	0.17	0.14	0.15	0.16	0.16
E	097	0.19	0.21	0.23	0.12	0.16	0.18	0.13	0.13	0.19	0.22	0.16	0.14	0.10	0.20	0.19	0.18	0.17	0.16
E	098	0.32	0.26	0.37	0.39	0.39	0.30	0.33	0.25	0.22	0.22	0.22	0.30	0.23	0.33	0.27	0.15	0.33	0.29
E	099	0.33	0.24	0.46	0.44	0.30	0.22	0.22	0.29	0.29	0.32	0.25	0.18	0.15	0.22	0.21	0.14	0.32	0.27
E	100	0.14	0.14	0.19	0.28	0.13	0.20	0.25	0.14	0.11	0.16	0.19	0.22	0.18	0.28	0.16	0.19	0.17	0.17

E	101	0.13	0.13	0.17	0.31	0.37	0.30	0.36	0.21	0.16	0.18	0.17	0.16	0.16	0.18	0.16	0.17	0.24	0.23
E	102	0.28	0.30	0.22	0.34	0.28	0.41	0.41	0.37	0.46	0.51	0.36	0.24	0.26	0.35	0.31	0.18	0.31	0.34
E	103	0.14	0.12	0.14	0.14	0.33	0.37	0.49	0.36	0.26	0.24	0.20	0.29	0.31	0.38	0.34	0.28	0.24	0.28
E	104	0.10	0.13	0.16	0.11	0.12	0.19	0.27	0.34	0.23	0.16	0.16	0.21	0.12	0.24	0.19	0.16	0.15	0.18
E	105	0.26	0.39	0.43	0.28	0.35	0.37	0.42	0.45	0.46	0.45	0.41	0.32	0.16	0.22	0.27	0.31	0.35	0.37
E	106	0.22	0.27	0.22	0.14	0.16	0.15	0.22	0.26	0.30	0.32	0.29	0.19	0.19	0.23	0.25	0.23	0.20	0.23
E	107	0.28	0.19	0.18	0.24	0.34	0.40	0.46	0.42	0.37	0.27	0.19	0.29	0.40	0.55	0.52	0.42	0.29	0.32
E	108	0.43	0.46	0.29	0.24	0.33	0.24	0.40	0.56	0.62	0.63	0.44	0.50	0.43	0.69	0.69	0.71	0.39	0.46
E	109	0.19	0.21	0.20	0.16	0.28	0.26	0.27	0.28	0.22	0.20	0.15	0.21	0.21	0.35	0.28	0.17	0.22	0.23
E	110	0.48	0.36	0.27	0.21	0.37	0.39	0.52	0.54	0.47	0.42	0.27	0.28	0.34	0.49	0.57	0.61	0.36	0.38

Table B5: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E111 to E140

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	111	0.32	0.30	0.32	0.27	0.32	0.57	0.61	0.41	0.45	0.60	0.55	0.48	0.31	0.37	0.25	0.30	0.35	0.43
E	112	0.46	0.32	0.27	0.30	0.21	0.23	0.44	0.28	0.28	0.33	0.30	0.32	0.55	0.68	0.45	0.34	0.31	0.32
E	113	0.46	0.49	0.35	0.19	0.47	0.45	0.49	0.53	0.43	0.40	0.30	0.30	0.39	0.60	0.63	0.58	0.41	0.41
E	114	0.21	0.14	0.27	0.14	0.27	0.13	0.13	0.17	0.30	0.28	0.24	0.25	0.15	0.25	0.25	0.22	0.22	0.23
E	115	0.42	0.48	0.48	0.30	0.29	0.45	0.57	0.55	0.55	0.49	0.28	0.30	0.39	0.46	0.51	0.48	0.38	0.40
E	116	0.30	0.34	0.40	0.25	0.29	0.15	0.27	0.28	0.25	0.27	0.25	0.21	0.29	0.35	0.38	0.36	0.29	0.27
E	117	0.22	0.31	0.20	0.34	0.19	0.12	0.22	0.24	0.23	0.25	0.16	0.20	0.29	0.32	0.33	0.30	0.24	0.22
E	118	0.52	0.63	0.65	0.40	0.20	0.17	0.14	0.15	0.17	0.20	0.37	0.34	0.49	0.46	0.34	0.35	0.37	0.29
E	119	0.48	0.38	0.24	0.23	0.37	0.31	0.20	0.17	0.31	0.42	0.24	0.32	0.25	0.30	0.26	0.48	0.33	0.30
E	120	0.18	0.19	0.28	0.19	0.26	0.31	0.20	0.14	0.35	0.45	0.30	0.21	0.17	0.20	0.20	0.33	0.24	0.26
E	121	0.41	0.33	0.32	0.20	0.24	0.24	0.25	0.19	0.25	0.38	0.31	0.20	0.26	0.38	0.50	0.53	0.28	0.27
E	122	0.26	0.36	0.40	0.32	0.26	0.30	0.28	0.30	0.20	0.29	0.32	0.33	0.47	0.33	0.28	0.30	0.30	0.30
E	123	0.48	0.33	0.44	0.30	0.25	0.23	0.33	0.25	0.16	0.27	0.18	0.19	0.57	0.68	0.55	0.54	0.32	0.28
E	124	0.29	0.24	0.14	0.20	0.35	0.42	0.47	0.43	0.39	0.22	0.17	0.25	0.28	0.50	0.41	0.37	0.28	0.30
E	125	0.19	0.18	0.16	0.21	0.18	0.21	0.20	0.18	0.17	0.17	0.08	0.09	0.19	0.32	0.24	0.26	0.18	0.16
E	126	0.14	0.15	0.18	0.23	0.17	0.15	0.13	0.12	0.11	0.09	0.11	0.13	0.08	0.21	0.19	0.19	0.16	0.14

E	127	0.29	0.35	0.32	0.36	0.32	0.33	0.30	0.24	0.33	0.24	0.25	0.13	0.15	0.24	0.19	0.25	0.30	0.27
E	128	0.35	0.46	0.33	0.30	0.20	0.20	0.17	0.23	0.39	0.54	0.51	0.25	0.31	0.32	0.34	0.32	0.31	0.33
E	129	0.21	0.28	0.24	0.21	0.22	0.22	0.22	0.18	0.13	0.24	0.35	0.38	0.32	0.26	0.24	0.25	0.23	0.25
E	130	0.16	0.12	0.11	0.16	0.16	0.15	0.18	0.19	0.17	0.11	0.12	0.24	0.34	0.32	0.28	0.26	0.16	0.18
E	131	0.11	0.10	0.10	0.26	0.20	0.19	0.19	0.14	0.11	0.16	0.13	0.13	0.17	0.15	0.11	0.10	0.17	0.16
E	132	0.10	0.11	0.15	0.15	0.11	0.14	0.14	0.14	0.20	0.28	0.23	0.12	0.15	0.18	0.13	0.13	0.14	0.16
E	133	0.10	0.11	0.13	0.18	0.21	0.23	0.21	0.19	0.16	0.20	0.14	0.17	0.18	0.14	0.11	0.09	0.16	0.17
E	134	0.08	0.11	0.09	0.14	0.11	0.10	0.13	0.15	0.15	0.26	0.18	0.17	0.13	0.13	0.12	0.13	0.12	0.15
E	135	0.22	0.26	0.30	0.27	0.24	0.16	0.24	0.32	0.28	0.23	0.28	0.22	0.23	0.22	0.29	0.24	0.25	0.25
E	136	0.33	0.17	0.22	0.29	0.22	0.19	0.28	0.26	0.21	0.29	0.16	0.15	0.34	0.35	0.37	0.36	0.25	0.24
E	137	0.25	0.17	0.27	0.27	0.23	0.19	0.30	0.23	0.22	0.28	0.30	0.17	0.28	0.21	0.19	0.20	0.24	0.25
E	138	0.18	0.17	0.14	0.19	0.28	0.27	0.35	0.22	0.24	0.16	0.22	0.12	0.23	0.19	0.20	0.20	0.22	0.22
E	139	0.13	0.17	0.15	0.15	0.16	0.16	0.20	0.15	0.14	0.10	0.14	0.13	0.18	0.15	0.16	0.15	0.15	0.15
E	140	0.17	0.21	0.20	0.17	0.21	0.20	0.25	0.23	0.25	0.19	0.20	0.26	0.39	0.35	0.29	0.26	0.21	0.23

Table B6: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E141 to E170

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	141	0.18	0.20	0.16	0.15	0.18	0.20	0.25	0.28	0.32	0.28	0.25	0.29	0.33	0.40	0.42	0.38	0.21	0.25
E	142	0.35	0.31	0.15	0.18	0.33	0.38	0.42	0.35	0.36	0.36	0.25	0.31	0.38	0.47	0.42	0.33	0.30	0.32
E	143	0.13	0.11	0.16	0.21	0.34	0.39	0.44	0.30	0.26	0.38	0.40	0.39	0.63	0.65	0.29	0.24	0.27	0.35
E	144	0.10	0.11	0.14	0.22	0.13	0.08	0.11	0.09	0.11	0.12	0.13	0.17	0.12	0.18	0.14	0.12	0.14	0.13
E	145	0.16	0.21	0.17	0.39	0.20	0.18	0.26	0.15	0.19	0.12	0.15	0.19	0.20	0.23	0.18	0.18	0.22	0.19
E	146	0.18	0.21	0.24	0.35	0.30	0.26	0.34	0.18	0.21	0.14	0.26	0.28	0.36	0.27	0.22	0.21	0.27	0.26
E	147	0.27	0.22	0.19	0.17	0.24	0.24	0.38	0.30	0.25	0.23	0.24	0.17	0.33	0.32	0.31	0.29	0.24	0.25
E	148	0.24	0.19	0.32	0.41	0.33	0.28	0.29	0.29	0.24	0.36	0.21	0.16	0.25	0.25	0.30	0.29	0.30	0.27
E	149	0.23	0.19	0.26	0.25	0.23	0.21	0.25	0.28	0.23	0.32	0.27	0.20	0.43	0.37	0.30	0.29	0.25	0.26
E	150	0.30	0.32	0.26	0.26	0.24	0.26	0.32	0.36	0.23	0.21	0.19	0.14	0.38	0.38	0.43	0.40	0.26	0.25
E	151	0.20	0.20	0.35	0.39	0.26	0.23	0.20	0.24	0.19	0.36	0.26	0.21	0.27	0.22	0.22	0.22	0.27	0.26
E	152	0.25	0.22	0.18	0.25	0.20	0.19	0.28	0.27	0.22	0.21	0.26	0.19	0.33	0.32	0.28	0.30	0.23	0.24

E	153	0.17	0.20	0.15	0.29	0.19	0.18	0.28	0.21	0.21	0.14	0.20	0.30	0.30	0.20	0.19	0.19	0.21	0.22
E	154	0.18	0.30	0.26	0.47	0.28	0.22	0.18	0.14	0.26	0.20	0.29	0.36	0.38	0.28	0.18	0.17	0.29	0.28
E	155	0.12	0.08	0.10	0.21	0.31	0.31	0.22	0.17	0.18	0.42	0.39	0.29	0.46	0.17	0.15	0.13	0.23	0.28
E	156	0.15	0.18	0.27	0.23	0.16	0.26	0.29	0.22	0.21	0.19	0.11	0.18	0.10	0.19	0.22	0.20	0.19	0.18
E	157	0.15	0.19	0.23	0.20	0.14	0.26	0.27	0.21	0.21	0.24	0.20	0.24	0.10	0.13	0.13	0.13	0.18	0.19
E	158	0.17	0.20	0.13	0.23	0.22	0.30	0.26	0.20	0.19	0.25	0.21	0.23	0.15	0.16	0.14	0.15	0.20	0.21
E	159	0.25	0.27	0.26	0.15	0.18	0.25	0.14	0.12	0.12	0.12	0.13	0.22	0.34	0.32	0.27	0.23	0.20	0.18
E	160	0.22	0.23	0.34	0.19	0.18	0.20	0.19	0.25	0.25	0.47	0.42	0.27	0.40	0.21	0.17	0.21	0.24	0.28
E	161	0.13	0.15	0.14	0.28	0.22	0.21	0.16	0.13	0.14	0.11	0.16	0.29	0.28	0.22	0.17	0.16	0.19	0.19
E	162	0.10	0.12	0.11	0.16	0.12	0.17	0.15	0.10	0.09	0.07	0.12	0.15	0.18	0.14	0.13	0.14	0.12	0.12
E	163	0.11	0.17	0.14	0.16	0.18	0.23	0.17	0.15	0.25	0.17	0.21	0.19	0.19	0.16	0.12	0.12	0.16	0.18
E	164	0.25	0.25	0.31	0.21	0.19	0.27	0.32	0.30	0.33	0.28	0.20	0.25	0.51	0.60	0.57	0.36	0.26	0.28
E	165	0.25	0.31	0.40	0.33	0.20	0.29	0.31	0.22	0.22	0.24	0.27	0.48	0.56	0.43	0.44	0.27	0.29	0.30
E	166	0.14	0.12	0.13	0.11	0.17	0.22	0.22	0.19	0.23	0.24	0.26	0.29	0.25	0.29	0.26	0.19	0.17	0.21
E	167	0.18	0.21	0.22	0.15	0.08	0.09	0.11	0.14	0.19	0.28	0.23	0.21	0.19	0.21	0.23	0.21	0.16	0.17
E	168	0.31	0.29	0.42	0.44	0.19	0.23	0.19	0.20	0.32	0.35	0.38	0.26	0.27	0.22	0.29	0.33	0.30	0.28
E	169	0.20	0.19	0.20	0.18	0.24	0.25	0.24	0.19	0.15	0.09	0.10	0.13	0.17	0.16	0.26	0.28	0.20	0.17
E	170	0.16	0.19	0.17	0.17	0.13	0.15	0.15	0.17	0.12	0.14	0.12	0.17	0.18	0.17	0.16	0.14	0.15	0.15

Table B7: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points E171 to E190

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
E	171	0.17	0.24	0.25	0.37	0.25	0.24	0.26	0.27	0.17	0.25	0.18	0.23	0.24	0.25	0.26	0.19	0.25	0.23
E	172	0.17	0.34	0.47	0.55	0.33	0.32	0.28	0.26	0.22	0.28	0.30	0.37	0.40	0.31	0.21	0.17	0.35	0.32
E	173	0.33	0.38	0.37	0.24	0.20	0.25	0.29	0.30	0.24	0.26	0.15	0.13	0.25	0.32	0.38	0.35	0.26	0.23
E	174	0.20	0.25	0.35	0.39	0.21	0.25	0.14	0.17	0.17	0.17	0.25	0.25	0.43	0.32	0.22	0.19	0.25	0.23
E	175	0.35	0.41	0.40	0.32	0.20	0.18	0.24	0.34	0.31	0.41	0.26	0.14	0.25	0.19	0.24	0.34	0.29	0.27
E	176	0.21	0.33	0.43	0.37	0.26	0.23	0.16	0.17	0.18	0.32	0.23	0.25	0.25	0.20	0.18	0.17	0.28	0.25
E	177	0.40	0.40	0.39	0.34	0.23	0.23	0.21	0.18	0.17	0.19	0.17	0.24	0.27	0.37	0.25	0.34	0.29	0.23
E	178	0.11	0.21	0.46	0.62	0.41	0.29	0.24	0.36	0.28	0.32	0.36	0.48	0.51	0.43	0.25	0.14	0.38	0.38

E	179	0.20	0.18	0.21	0.21	0.23	0.29	0.24	0.28	0.21	0.24	0.23	0.27	0.31	0.35	0.20	0.15	0.22	0.24
E	180	0.23	0.22	0.24	0.21	0.10	0.13	0.16	0.21	0.15	0.14	0.19	0.17	0.17	0.26	0.24	0.23	0.18	0.16
E	181	0.15	0.19	0.23	0.30	0.25	0.30	0.30	0.34	0.29	0.17	0.17	0.30	0.44	0.55	0.34	0.30	0.25	0.27
E	182	0.21	0.25	0.32	0.48	0.49	0.44	0.30	0.20	0.12	0.11	0.16	0.18	0.16	0.55	0.45	0.35	0.34	0.27
E	183	0.24	0.26	0.30	0.36	0.30	0.33	0.26	0.30	0.15	0.15	0.12	0.13	0.14	0.19	0.28	0.35	0.27	0.21
E	184	0.32	0.38	0.39	0.32	0.21	0.26	0.24	0.24	0.14	0.17	0.14	0.18	0.22	0.24	0.27	0.34	0.27	0.21
E	185	0.12	0.16	0.29	0.14	0.16	0.20	0.10	0.13	0.13	0.14	0.13	0.14	0.19	0.22	0.22	0.15	0.16	0.15
E	186	0.32	0.38	0.47	0.43	0.24	0.27	0.15	0.18	0.29	0.44	0.36	0.25	0.34	0.30	0.30	0.35	0.32	0.30
E	187	0.28	0.28	0.25	0.18	0.15	0.26	0.18	0.23	0.17	0.19	0.16	0.15	0.15	0.19	0.30	0.34	0.20	0.18
E	188	0.23	0.17	0.14	0.18	0.26	0.35	0.28	0.24	0.20	0.19	0.20	0.33	0.30	0.39	0.38	0.33	0.23	0.25
E	189	0.14	0.13	0.24	0.40	0.43	0.42	0.37	0.35	0.17	0.16	0.26	0.18	0.29	0.46	0.36	0.25	0.30	0.29
E	190	0.22	0.26	0.34	0.35	0.33	0.25	0.32	0.18	0.15	0.23	0.17	0.21	0.24	0.31	0.30	0.28	0.28	0.25

Table B8: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points W001 to W030

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	001	0.15	0.18	0.11	0.17	0.46	0.52	0.41	0.29	0.28	0.32	0.34	0.33	0.50	0.47	0.32	0.20	0.31	0.37
W	002	0.16	0.16	0.12	0.13	0.31	0.38	0.30	0.20	0.17	0.30	0.33	0.28	0.36	0.26	0.22	0.23	0.24	0.28
W	003	0.18	0.25	0.21	0.20	0.21	0.27	0.26	0.22	0.37	0.38	0.48	0.39	0.47	0.33	0.12	0.21	0.25	0.32
W	004	0.11	0.12	0.08	0.10	0.30	0.37	0.39	0.36	0.35	0.18	0.23	0.13	0.20	0.19	0.16	0.18	0.21	0.25
W	005	0.15	0.14	0.09	0.13	0.26	0.38	0.36	0.32	0.36	0.36	0.33	0.26	0.29	0.28	0.26	0.25	0.24	0.30
W	006	0.17	0.14	0.11	0.15	0.26	0.24	0.26	0.27	0.25	0.23	0.21	0.18	0.26	0.16	0.12	0.21	0.20	0.22
W	007	0.27	0.27	0.18	0.20	0.29	0.53	0.40	0.26	0.24	0.36	0.27	0.30	0.23	0.13	0.19	0.33	0.29	0.32
W	008	0.22	0.16	0.13	0.14	0.18	0.17	0.33	0.19	0.17	0.27	0.43	0.35	0.19	0.20	0.18	0.30	0.21	0.25
W	009	0.15	0.14	0.09	0.09	0.24	0.15	0.18	0.14	0.19	0.22	0.30	0.24	0.26	0.19	0.13	0.17	0.18	0.21
W	010	0.19	0.21	0.15	0.28	0.48	0.42	0.33	0.30	0.49	0.25	0.15	0.15	0.12	0.13	0.14	0.21	0.30	0.30
W	011	0.25	0.23	0.16	0.24	0.36	0.32	0.29	0.29	0.37	0.52	0.29	0.20	0.23	0.16	0.26	0.35	0.30	0.31
W	012	0.25	0.24	0.19	0.17	0.39	0.36	0.36	0.28	0.36	0.37	0.24	0.17	0.16	0.14	0.26	0.32	0.29	0.29
W	013	0.29	0.30	0.26	0.29	0.26	0.37	0.30	0.27	0.44	0.48	0.23	0.15	0.16	0.14	0.26	0.37	0.30	0.30
W	014	0.25	0.35	0.26	0.26	0.22	0.20	0.17	0.14	0.56	0.61	0.37	0.26	0.29	0.19	0.28	0.33	0.29	0.32
W	015	0.23	0.20	0.13	0.19	0.38	0.40	0.36	0.32	0.37	0.21	0.32	0.26	0.26	0.18	0.27	0.34	0.29	0.31
W	016	0.14	0.14	0.18	0.24	0.26	0.24	0.16	0.14	0.19	0.29	0.20	0.14	0.15	0.11	0.17	0.23	0.22	0.21
W	017	0.11	0.12	0.13	0.21	0.44	0.36	0.25	0.23	0.39	0.23	0.35	0.29	0.17	0.12	0.15	0.17	0.27	0.30
W	018	0.27	0.29	0.22	0.28	0.51	0.46	0.29	0.23	0.20	0.22	0.26	0.16	0.17	0.19	0.25	0.36	0.34	0.30
W	019	0.12	0.10	0.09	0.09	0.16	0.18	0.17	0.16	0.21	0.33	0.41	0.29	0.20	0.12	0.13	0.19	0.17	0.23
W	020	0.35	0.32	0.14	0.14	0.31	0.29	0.34	0.26	0.33	0.45	0.32	0.28	0.22	0.11	0.21	0.43	0.29	0.30
W	021	0.15	0.20	0.17	0.17	0.17	0.31	0.30	0.24	0.29	0.27	0.34	0.24	0.16	0.12	0.10	0.14	0.20	0.25
W	022	0.22	0.21	0.13	0.13	0.19	0.24	0.27	0.19	0.18	0.18	0.15	0.21	0.15	0.27	0.15	0.24	0.19	0.19
W	023	0.27	0.31	0.24	0.23	0.27	0.20	0.25	0.30	0.42	0.51	0.36	0.26	0.23	0.11	0.18	0.34	0.28	0.30
W	024	0.32	0.40	0.33	0.35	0.49	0.28	0.13	0.20	0.27	0.23	0.45	0.49	0.31	0.27	0.23	0.33	0.37	0.35
W	025	0.19	0.18	0.13	0.14	0.32	0.20	0.25	0.27	0.33	0.38	0.32	0.16	0.14	0.22	0.23	0.33	0.24	0.26

W	026	0.22	0.23	0.16	0.14	0.20	0.25	0.33	0.41	0.57	0.61	0.57	0.30	0.16	0.22	0.17	0.28	0.26	0.35
W	027	0.30	0.34	0.23	0.19	0.17	0.23	0.29	0.29	0.27	0.33	0.44	0.24	0.31	0.28	0.17	0.30	0.25	0.28
W	028	0.17	0.19	0.17	0.21	0.24	0.18	0.12	0.20	0.26	0.27	0.46	0.41	0.50	0.37	0.18	0.23	0.24	0.29
W	029	0.11	0.15	0.14	0.18	0.20	0.16	0.26	0.12	0.17	0.28	0.31	0.16	0.22	0.17	0.18	0.19	0.19	0.21
W	030	0.14	0.18	0.16	0.17	0.17	0.24	0.34	0.22	0.25	0.40	0.43	0.19	0.21	0.15	0.16	0.21	0.21	0.26

Table B9: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points W031 to W060

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	031	0.18	0.17	0.12	0.13	0.16	0.22	0.29	0.24	0.25	0.30	0.24	0.13	0.17	0.12	0.12	0.24	0.18	0.21
W	032	0.16	0.15	0.13	0.20	0.30	0.24	0.29	0.33	0.45	0.47	0.28	0.14	0.24	0.17	0.20	0.24	0.25	0.28
W	033	0.15	0.19	0.16	0.23	0.45	0.29	0.17	0.20	0.23	0.30	0.33	0.23	0.21	0.15	0.10	0.15	0.27	0.28
W	034	0.18	0.19	0.15	0.18	0.26	0.19	0.17	0.21	0.39	0.43	0.37	0.24	0.20	0.11	0.17	0.23	0.23	0.27
W	035	0.14	0.14	0.15	0.20	0.49	0.37	0.29	0.30	0.34	0.41	0.40	0.28	0.25	0.12	0.12	0.17	0.30	0.34
W	036	0.14	0.13	0.10	0.14	0.22	0.26	0.28	0.28	0.24	0.20	0.20	0.15	0.16	0.13	0.22	0.21	0.19	0.21
W	037	0.10	0.10	0.07	0.08	0.15	0.16	0.20	0.18	0.24	0.26	0.18	0.14	0.15	0.10	0.11	0.15	0.14	0.17
W	038	0.17	0.20	0.16	0.18	0.40	0.37	0.24	0.19	0.14	0.21	0.10	0.14	0.14	0.13	0.13	0.21	0.24	0.22
W	039	0.19	0.22	0.14	0.11	0.18	0.13	0.13	0.13	0.24	0.30	0.21	0.11	0.30	0.16	0.17	0.24	0.18	0.19
W	040	0.17	0.21	0.16	0.15	0.32	0.26	0.28	0.24	0.32	0.27	0.12	0.09	0.17	0.11	0.12	0.19	0.22	0.22
W	041	0.21	0.26	0.21	0.19	0.15	0.18	0.17	0.15	0.22	0.13	0.18	0.13	0.19	0.11	0.13	0.21	0.19	0.17
W	042	0.13	0.16	0.12	0.11	0.16	0.22	0.27	0.19	0.15	0.18	0.23	0.19	0.21	0.18	0.18	0.21	0.17	0.19
W	043	0.17	0.23	0.21	0.25	0.24	0.11	0.15	0.11	0.07	0.22	0.20	0.16	0.15	0.11	0.10	0.15	0.20	0.17
W	044	0.15	0.17	0.12	0.11	0.13	0.16	0.22	0.14	0.11	0.14	0.23	0.10	0.12	0.09	0.11	0.18	0.14	0.15
W	045	0.25	0.22	0.16	0.16	0.14	0.25	0.32	0.25	0.34	0.41	0.19	0.16	0.17	0.16	0.21	0.28	0.21	0.23
W	046	0.18	0.24	0.20	0.20	0.21	0.14	0.16	0.13	0.18	0.20	0.19	0.13	0.18	0.19	0.18	0.22	0.20	0.18
W	047	0.25	0.24	0.15	0.16	0.27	0.29	0.29	0.25	0.36	0.32	0.22	0.20	0.24	0.23	0.30	0.34	0.25	0.26
W	048	0.15	0.16	0.13	0.15	0.26	0.24	0.22	0.24	0.23	0.44	0.28	0.20	0.31	0.15	0.18	0.18	0.21	0.25
W	049	0.19	0.18	0.13	0.17	0.26	0.23	0.22	0.24	0.27	0.22	0.19	0.13	0.19	0.15	0.20	0.26	0.21	0.21
W	050	0.22	0.23	0.21	0.28	0.39	0.32	0.30	0.17	0.24	0.23	0.18	0.12	0.17	0.12	0.23	0.24	0.28	0.25
W	051	0.20	0.18	0.13	0.19	0.27	0.23	0.23	0.25	0.27	0.22	0.14	0.11	0.13	0.11	0.18	0.24	0.21	0.20

W	052	0.17	0.16	0.12	0.14	0.20	0.19	0.20	0.20	0.23	0.18	0.19	0.19	0.20	0.16	0.25	0.25	0.19	0.19
W	053	0.18	0.22	0.18	0.17	0.18	0.17	0.21	0.22	0.14	0.25	0.13	0.13	0.14	0.15	0.20	0.22	0.18	0.17
W	054	0.12	0.14	0.08	0.09	0.16	0.26	0.32	0.24	0.21	0.14	0.21	0.13	0.17	0.17	0.16	0.20	0.16	0.19
W	055	0.09	0.09	0.07	0.08	0.10	0.10	0.11	0.09	0.13	0.12	0.19	0.10	0.12	0.10	0.09	0.14	0.11	0.12
W	056	0.13	0.15	0.14	0.19	0.28	0.19	0.16	0.13	0.12	0.30	0.23	0.18	0.19	0.13	0.11	0.17	0.20	0.20
W	057	0.11	0.11	0.10	0.12	0.14	0.10	0.13	0.10	0.13	0.12	0.19	0.13	0.13	0.12	0.13	0.16	0.13	0.13
W	058	0.19	0.22	0.17	0.18	0.15	0.10	0.12	0.16	0.12	0.19	0.28	0.15	0.16	0.10	0.16	0.19	0.17	0.17
W	059	0.29	0.27	0.19	0.18	0.27	0.25	0.28	0.29	0.30	0.16	0.13	0.10	0.13	0.10	0.16	0.24	0.22	0.20
W	060	0.22	0.24	0.24	0.33	0.50	0.22	0.15	0.14	0.11	0.15	0.14	0.13	0.14	0.14	0.26	0.27	0.30	0.22

Table B10: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points W061 to W090

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	061	0.24	0.20	0.15	0.18	0.24	0.30	0.30	0.31	0.31	0.31	0.21	0.15	0.24	0.19	0.32	0.31	0.24	0.25
W	062	0.15	0.16	0.15	0.18	0.25	0.26	0.20	0.17	0.13	0.41	0.31	0.17	0.16	0.10	0.15	0.17	0.21	0.23
W	063	0.19	0.17	0.14	0.15	0.32	0.34	0.29	0.21	0.13	0.31	0.24	0.27	0.27	0.15	0.21	0.29	0.24	0.26
W	064	0.17	0.19	0.17	0.20	0.26	0.29	0.26	0.23	0.12	0.39	0.19	0.15	0.16	0.11	0.11	0.19	0.22	0.22
W	065	0.19	0.20	0.16	0.17	0.23	0.27	0.23	0.20	0.17	0.34	0.26	0.27	0.25	0.17	0.13	0.22	0.22	0.24
W	066	0.12	0.11	0.08	0.10	0.19	0.19	0.24	0.10	0.18	0.17	0.28	0.24	0.23	0.17	0.19	0.17	0.16	0.20
W	067	0.18	0.22	0.20	0.18	0.18	0.14	0.23	0.23	0.15	0.29	0.25	0.15	0.11	0.09	0.09	0.15	0.18	0.18
W	068	0.18	0.19	0.15	0.17	0.19	0.19	0.22	0.13	0.10	0.15	0.15	0.13	0.14	0.09	0.11	0.18	0.17	0.16
W	069	0.16	0.16	0.17	0.19	0.25	0.27	0.29	0.25	0.10	0.21	0.09	0.09	0.10	0.08	0.13	0.18	0.19	0.18
W	070	0.22	0.27	0.22	0.22	0.23	0.16	0.21	0.18	0.12	0.29	0.22	0.25	0.30	0.18	0.20	0.23	0.22	0.22
W	071	0.22	0.23	0.21	0.24	0.29	0.15	0.12	0.09	0.09	0.18	0.13	0.16	0.17	0.12	0.22	0.25	0.22	0.18
W	072	0.28	0.25	0.19	0.20	0.26	0.33	0.30	0.28	0.25	0.27	0.20	0.15	0.20	0.12	0.28	0.29	0.25	0.24
W	073	0.25	0.25	0.24	0.28	0.36	0.31	0.37	0.22	0.19	0.34	0.30	0.26	0.25	0.16	0.28	0.28	0.29	0.29
W	074	0.14	0.18	0.19	0.26	0.40	0.23	0.13	0.13	0.12	0.12	0.10	0.08	0.13	0.12	0.19	0.22	0.24	0.19
W	075	0.22	0.21	0.18	0.25	0.41	0.36	0.31	0.35	0.17	0.18	0.18	0.16	0.21	0.23	0.31	0.33	0.29	0.26
W	076	0.15	0.18	0.18	0.21	0.30	0.16	0.10	0.11	0.10	0.17	0.09	0.08	0.13	0.11	0.16	0.20	0.20	0.15
W	077	0.19	0.21	0.21	0.24	0.36	0.23	0.19	0.17	0.10	0.18	0.08	0.09	0.14	0.14	0.23	0.26	0.24	0.19

W	078	0.13	0.15	0.14	0.23	0.39	0.24	0.22	0.17	0.12	0.23	0.13	0.12	0.10	0.08	0.13	0.18	0.23	0.20
W	079	0.18	0.19	0.15	0.18	0.27	0.23	0.25	0.22	0.12	0.19	0.16	0.16	0.19	0.14	0.24	0.23	0.21	0.20
W	080	0.21	0.25	0.22	0.21	0.27	0.22	0.20	0.13	0.08	0.11	0.16	0.15	0.18	0.14	0.17	0.22	0.22	0.18
W	081	0.18	0.15	0.12	0.14	0.24	0.23	0.26	0.19	0.13	0.17	0.20	0.14	0.26	0.20	0.25	0.24	0.20	0.20
W	082	0.19	0.17	0.14	0.13	0.20	0.20	0.22	0.16	0.12	0.16	0.20	0.12	0.18	0.13	0.18	0.19	0.17	0.17
W	083	0.15	0.14	0.14	0.13	0.20	0.13	0.12	0.08	0.08	0.09	0.10	0.11	0.15	0.17	0.21	0.19	0.15	0.13
W	084	0.19	0.16	0.12	0.11	0.20	0.19	0.16	0.15	0.11	0.12	0.18	0.14	0.19	0.12	0.19	0.25	0.17	0.16
W	085	0.15	0.13	0.09	0.07	0.09	0.10	0.13	0.12	0.09	0.10	0.21	0.20	0.22	0.17	0.21	0.25	0.13	0.14
W	086	0.16	0.16	0.15	0.20	0.29	0.20	0.16	0.17	0.11	0.13	0.15	0.14	0.19	0.14	0.17	0.29	0.21	0.18
W	087	0.24	0.21	0.14	0.23	0.30	0.18	0.17	0.23	0.18	0.18	0.20	0.14	0.19	0.14	0.20	0.33	0.23	0.20
W	088	0.23	0.19	0.13	0.17	0.30	0.21	0.24	0.22	0.13	0.14	0.20	0.21	0.25	0.17	0.26	0.34	0.23	0.21
W	089	0.11	0.12	0.11	0.21	0.32	0.19	0.23	0.19	0.23	0.24	0.24	0.30	0.30	0.20	0.13	0.18	0.22	0.24
W	090	0.20	0.17	0.11	0.16	0.24	0.17	0.21	0.15	0.24	0.26	0.25	0.28	0.30	0.21	0.21	0.28	0.21	0.23

Table B11: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points W091 to W120

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	091	0.11	0.10	0.08	0.07	0.10	0.11	0.16	0.15	0.18	0.16	0.32	0.20	0.27	0.18	0.19	0.20	0.14	0.18
W	092	0.13	0.15	0.14	0.12	0.15	0.08	0.07	0.09	0.14	0.25	0.25	0.14	0.16	0.10	0.09	0.14	0.14	0.15
W	093	0.10	0.10	0.10	0.13	0.22	0.13	0.09	0.05	0.12	0.20	0.15	0.11	0.14	0.09	0.13	0.16	0.15	0.15
W	094	0.15	0.17	0.12	0.13	0.12	0.13	0.12	0.10	0.13	0.24	0.27	0.21	0.33	0.17	0.28	0.29	0.17	0.19
W	095	0.13	0.17	0.11	0.10	0.08	0.08	0.09	0.08	0.11	0.15	0.23	0.22	0.35	0.12	0.25	0.27	0.14	0.16
W	096	0.11	0.11	0.08	0.09	0.10	0.09	0.12	0.09	0.17	0.21	0.21	0.24	0.34	0.12	0.28	0.31	0.15	0.17
W	097	0.11	0.10	0.08	0.07	0.08	0.10	0.12	0.07	0.13	0.20	0.19	0.19	0.29	0.12	0.20	0.20	0.12	0.15
W	098	0.20	0.21	0.15	0.11	0.13	0.14	0.16	0.13	0.30	0.25	0.24	0.17	0.26	0.13	0.20	0.30	0.18	0.20
W	099	0.11	0.12	0.07	0.06	0.09	0.09	0.14	0.14	0.35	0.29	0.24	0.16	0.30	0.10	0.25	0.21	0.14	0.19
W	100	0.13	0.13	0.09	0.08	0.14	0.19	0.26	0.13	0.18	0.24	0.17	0.16	0.12	0.10	0.19	0.24	0.15	0.17
W	101	0.16	0.19	0.11	0.09	0.14	0.15	0.25	0.14	0.24	0.13	0.15	0.11	0.16	0.11	0.21	0.32	0.17	0.17
W	102	0.15	0.14	0.09	0.10	0.11	0.13	0.26	0.27	0.22	0.29	0.24	0.23	0.28	0.14	0.32	0.35	0.18	0.20
W	103	0.13	0.12	0.11	0.11	0.16	0.13	0.16	0.33	0.23	0.26	0.25	0.20	0.18	0.12	0.13	0.26	0.17	0.19

W	104	0.18	0.23	0.15	0.11	0.17	0.21	0.13	0.27	0.32	0.31	0.28	0.21	0.23	0.16	0.15	0.30	0.20	0.23
W	105	0.13	0.14	0.11	0.13	0.14	0.19	0.10	0.15	0.18	0.15	0.12	0.12	0.11	0.09	0.11	0.19	0.14	0.14
W	106	0.07	0.08	0.06	0.07	0.11	0.14	0.16	0.12	0.16	0.22	0.21	0.13	0.11	0.08	0.05	0.08	0.11	0.14
W	107	0.13	0.13	0.10	0.10	0.11	0.13	0.13	0.18	0.19	0.28	0.36	0.33	0.40	0.35	0.10	0.18	0.16	0.21
W	108	0.21	0.24	0.17	0.15	0.14	0.14	0.12	0.16	0.29	0.33	0.38	0.32	0.21	0.13	0.16	0.33	0.21	0.24
W	109	0.15	0.17	0.11	0.10	0.18	0.21	0.15	0.17	0.27	0.42	0.40	0.37	0.42	0.25	0.12	0.28	0.21	0.27
W	110	0.21	0.23	0.16	0.13	0.14	0.20	0.12	0.19	0.19	0.24	0.31	0.32	0.39	0.23	0.15	0.37	0.21	0.23
W	111	0.14	0.16	0.13	0.13	0.20	0.19	0.17	0.29	0.37	0.37	0.35	0.27	0.28	0.18	0.10	0.21	0.20	0.25
W	112	0.18	0.19	0.19	0.17	0.27	0.23	0.13	0.22	0.37	0.37	0.39	0.20	0.21	0.15	0.18	0.27	0.24	0.27
W	113	0.21	0.24	0.19	0.16	0.26	0.30	0.18	0.18	0.18	0.32	0.52	0.42	0.46	0.31	0.14	0.37	0.27	0.32
W	114	0.15	0.18	0.13	0.11	0.20	0.20	0.25	0.28	0.29	0.28	0.33	0.30	0.38	0.25	0.11	0.26	0.20	0.25
W	115	0.13	0.13	0.11	0.14	0.18	0.24	0.20	0.25	0.20	0.42	0.56	0.48	0.58	0.38	0.12	0.17	0.21	0.31
W	116	0.11	0.12	0.09	0.10	0.17	0.21	0.31	0.27	0.26	0.20	0.22	0.28	0.41	0.38	0.15	0.17	0.17	0.22
W	117	0.14	0.11	0.10	0.10	0.16	0.20	0.31	0.30	0.35	0.31	0.19	0.16	0.22	0.18	0.14	0.20	0.17	0.21
W	118	0.11	0.12	0.09	0.11	0.14	0.18	0.32	0.28	0.30	0.13	0.16	0.17	0.25	0.22	0.12	0.13	0.15	0.18
W	119	0.12	0.12	0.09	0.10	0.13	0.16	0.25	0.23	0.19	0.19	0.26	0.30	0.34	0.34	0.14	0.17	0.16	0.20
W	120	0.15	0.15	0.10	0.09	0.28	0.29	0.22	0.35	0.37	0.32	0.25	0.26	0.36	0.35	0.30	0.21	0.22	0.27

Table B12: Directional, Annual Overall and Summer Overall Velocity Ratios for Test Points W121 to W124

		Directional Velocity Ratio																Annual Overall Velocity Ratios	Summer Overall Velocity Ratios
		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total	Total
W	121	0.13	0.14	0.11	0.10	0.16	0.27	0.29	0.31	0.32	0.30	0.28	0.26	0.36	0.35	0.26	0.16	0.19	0.25
W	122	0.16	0.16	0.10	0.09	0.13	0.24	0.30	0.32	0.33	0.34	0.34	0.26	0.36	0.37	0.22	0.19	0.18	0.25
W	123	0.18	0.20	0.18	0.21	0.25	0.36	0.26	0.16	0.29	0.44	0.54	0.44	0.51	0.41	0.14	0.25	0.28	0.36
W	124	0.14	0.15	0.17	0.23	0.36	0.24	0.17	0.16	0.24	0.15	0.31	0.18	0.28	0.19	0.27	0.22	0.25	0.25

APPENDIX C

APPENDIX C
QUALITATIVE ASSESSMENT OF REFINED LAYOUT FOR SITE 7

C1. At the request of Scott Wilson Limited, two qualitative assessments on two revised layouts for Site 7 were conducted to assess their air ventilation impact.

C2. The first refined layout for Site 7 (+25mPD Platform) was provided by Scott Wilson Limited in June 2009 as shown in **Figure C1**. The refined layout comprises two parallel rows of four buildings each, aligned from the north-east to south-west with a 30m wide non-building area between the rows of buildings. The row of buildings to the east of the platform has a top elevation of +70mPD while the row of buildings to the west of the platform has a top elevation of +85mPD. Other platforms and buildings in Site 7 remained unchanged.

C2.1. With reference to the results for the tested layout of Site 7, it is expected that the introduction of a north-east to south-west non-building area for the revised layout will facilitate the penetration of south to south-westerly winds into Site 7, although these are likely to be of moderate strength.

C2.2. Easterly winds reaching Site 7 are of low to moderate strength. The small separations between the buildings will impede wind flow, causing areas of low wind speed immediately on the leeward side of the proposed +70.0mPD buildings. However, this may be offset to some extent by the +85mPD buildings conveying some higher level winds to pedestrian level.

C3. The second revised layout for Site 7, as shown in **Figure C2**, was provided by Scott Wilson Limited on 13 October 2009 to incorporating the proposed noise mitigation measures.

<u>+25mPD platform</u>

C3.1. The revised +25mPD platform layout comprises four buildings of height +70mPD, two buildings of height +85mPD, one building of height +67mPD, one building of height +61mPD, one building of height +49mPD, and a club house of 12m height. The south-east to north-west aligned non-building area remains unchanged relative to the layout that was assessed in the Expert Evaluation and Air Ventilation Assessment Initial Study. The following is a summary of the likely effects of the revised +25mPD platform layout:

C3.2. The reduction of the spacing between the two rows of buildings along the south-west to north-east aligned non-building area to 10m is likely to reduce the effectiveness of the varied building height. This is also likely to reduce the penetration of south to south-westerly winds into Site 7.

C3.3. The newly introduced +67mPD building has a width which is approximately three times the width of the north-east and south-west non-building area and, in combination with the newly introduced L-shape club-house, is likely to inhibit the penetration of south to south-westerly winds into Site 7.

C3.4. The +70mPD building at the south-east of the +25mPD platform is likely to shelter the area bounded by the club-house, the new +67mPD building and the +61mPD building from easterly winds.

C3.5. The small building spacings and configuration of the revised layout dated 13 October 2009 will create regions of lower wind flow and poorer air ventilation.

C3.6. As noted in previous assessments for Site 7, the variation of the alignment of the south-east to north-west non-building areas of the +25mPD and +50mPD platforms will limit its effectiveness to convey easterly winds to the +25mPD platform.

+50mPD platform

C3.7. The revised +50mPD platform layout comprises seven buildings of height +70mPD. The south-east to north-west aligned non-building area remains unchanged relative to the layout that was assessed in the Expert Evaluation and Air Ventilation Assessment Initial Study. The five buildings along the south-east to north-west aligned non-building area have been relocated relative to the layout assessed in the Expert Evaluation and Initial Study.

C3.8. Although the Expert Evaluation and Air Ventilation Assessment Initial Study suggested that the previous proposed building configurations and layout are expected to facilitate general wind penetration into this area, the relocation of the five buildings will reduce the width of potential air path along the south-east to north-west aligned non-building area. As a result, the effectiveness of the south-east to north-west aligned non-building area to convey easterly winds to +25mPD platform is likely to be reduced.

+60mPD platform

C3.9. The revised +60mPD platform layout comprises seven three-storey buildings of height +70mPD and a six-storey building of height +63mPD which is located at a ground elevation of +43mPD. Relative to all previously assessed layouts, this revised layout has one additional building at the +60mPD platform while other buildings were relocated. The club-house originally proposed for the +60mPD platform has been replaced by a residential building, and the height of the building with ground elevation +43mPD has increased from +53mPD to +63mPD.

C3.10. In the revised layout, the four buildings located at the northern end of the +60mPD platform are arranged with no separations to effectively form a single continuous building. Similarly, the two buildings located at the south-west of the +60mPD platform have also been rearranged to effectively form a single building. Due to its ground elevation (+60mPD) and relatively low building heights (10m), the +60mPD platform is relatively exposed and the revised layout is not likely to have an overall adverse effect relative to the previous assessed layout. However, some localised effects may occur on the leeward side of the buildings. In particular, the area between the south-west and north buildings on the +60mPD platform will be sheltered from south to south-westerly winds which is likely to result in poorer ventilation conditions during the summer months.

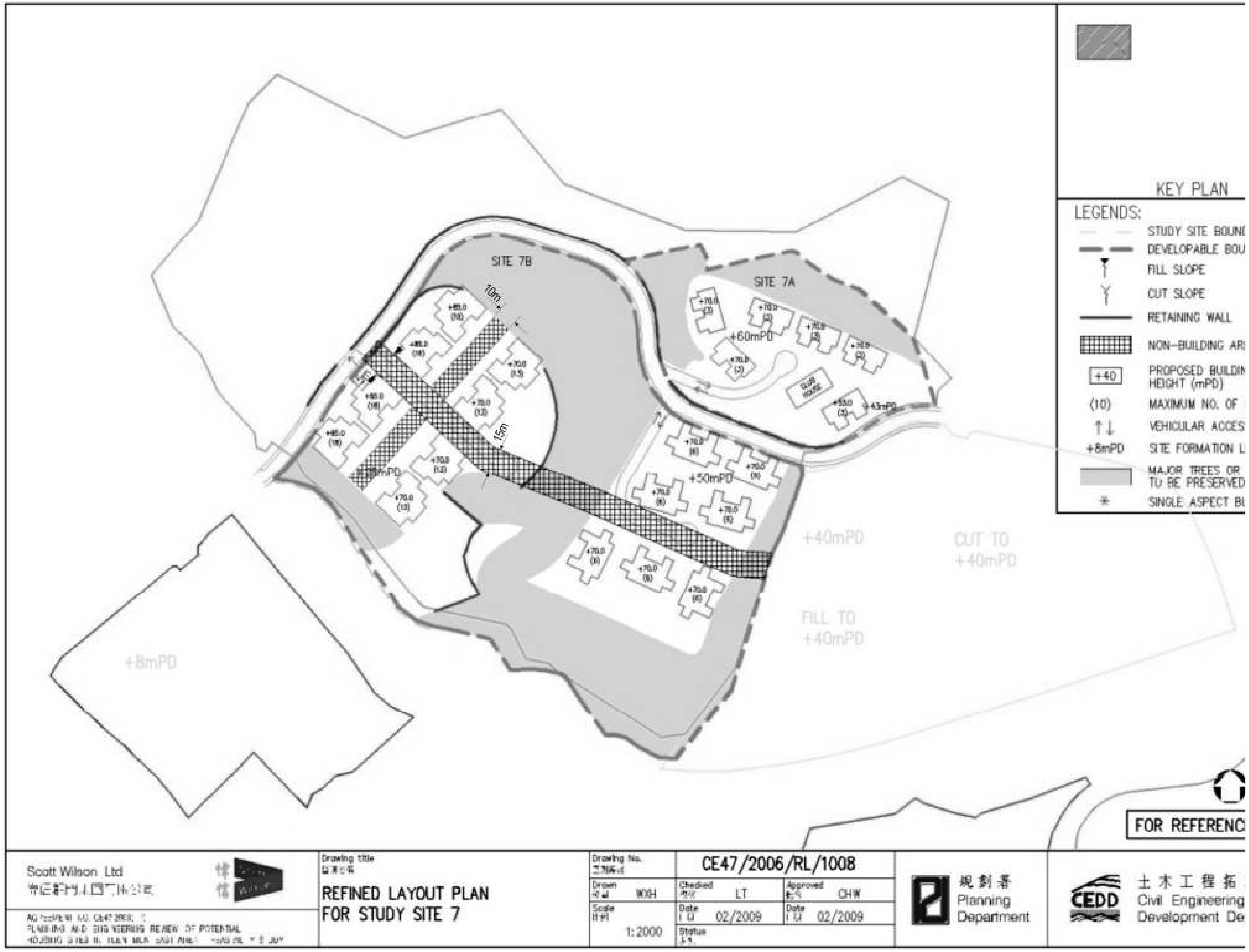


Figure C1: 1st refined layout plan for Site 7

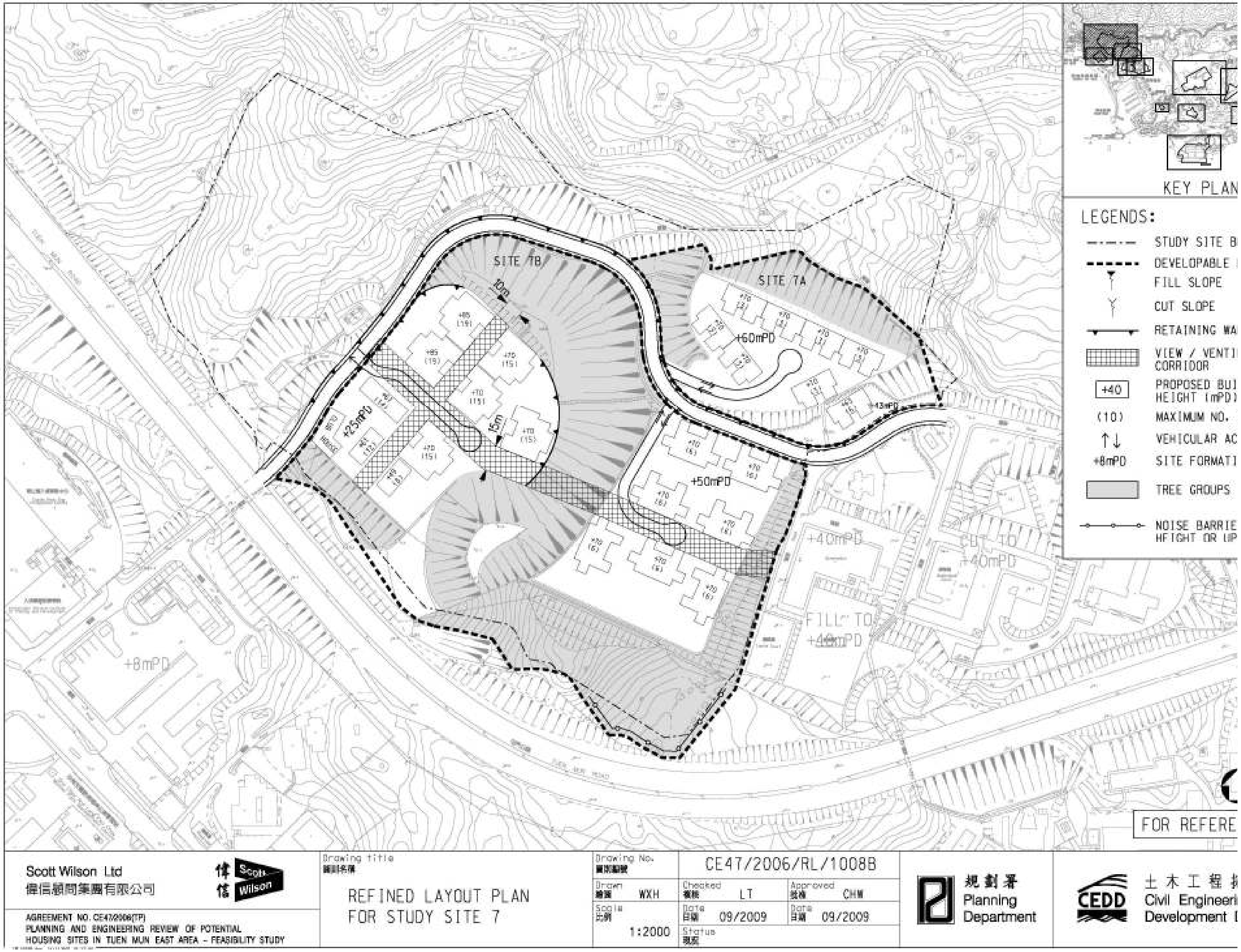


Figure C2: 2nd refined layout plan for Site 7