NATURAL VENTILATION STATEMENT

QUADRANGLE SITE, CASTLECRAG

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Prepared for:

Greencliff Castlecrag Pty Ltd

Level 10/488 Kent Street
Sydney NSW, 2000

DOCUMENT CONTROL

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July 09, 2021	Initial.	0	AFM	TR	TR/BU
July 16, 2021	Results summary table included.	1	AFM	TR	BU
July 23, 2021	Updated treatments.	2	AFM	TR	BU
August 27, 2021	Corrected the terminology for one of the treatments.	3	TR	TR	TR
September 1, 2021	Updated treatments.	4	AFM	TR	AFM/HK

EXECUTIVE SUMMARY

This report presents an opinion on the natural ventilation performance of the various residential apartments of the proposed development located at 100 Edinburgh Road, Castlecrag (also referred to as 'The Quadrangle'), based on our extensive experience in this field and the architectural drawings prepared by the project architect FJMT, received July 07, 2021. It should be noted that no wind tunnel testing has been undertaken for this assessment and, hence, this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection. The results of the assessment have been compared against the wind-driven natural cross ventilation criteria detailed in the Apartment Design Guide (ADG) of the State Environmental Planning Policy No. 65 (SEPP65).

The results of the assessment indicate that a total of 35.8% (19 out of 53) of the residential apartments will meet the "deemed to satisfy" requirements of SEPP65 for natural cross ventilation. This has been achieved through openings on orthogonal or opposite aspects (for example corner or through apartments) with direct exposure to the prevailing winds, and/or windows located in significantly different pressure regions with an overall depth of cross-over or cross-through apartments not exceeding 18m from glass line to glass line.

A further assessment of the current design has been conducted to determine possible design changes that could allow for improved natural cross-ventilation performance, by locating openings in significantly different pressure regions. It has been determined that 13 additional apartments are suitable candidates for treatment options. The results indicate that if the recommended treatments are implemented in all 13 of these apartments, then a total of 60.4% (32 of 53 residential apartments) are expected to satisfy the ADG requirements for natural cross-ventilation. The treatments for these 13 apartments are outlined as follows:

1. G03 - Inclusion of a window opening (elevated to maintain privacy) on the western aspect towards the back of the apartment, to ensure that this will allow airflow through the habitable spaces.

2. G05 - Inclusion of a horizontal plenum enabling ventilation air from the southern façade glass line to the plenum opening on the eastern façade. Note that this treatment requires the eastern façade of the corridor to be set back such that the length of the ventilation flow path does not exceed 18m. Figure A.2 in Appendix A shows the recommended layout for the horizontal plenum, indicating the nature of the set-back required on the eastern façade. The exact dimensions required to satisfy the above mentioned 18m requirement should be determined by the design team.

3. 116, 216 - Inclusion of a 1.2-1.5m wide and full height impermeable wing wall or screen protruding out from approximately the centre of the eastern façade to allow the generation of significantly different pressures on either side of the wall (due to the prevailing southerly winds).

4. 202, 203, 205, 207, 208, 210, 212, 213, 218 - Inclusion of ventilated skylight opening to the roof level, at the rear third of the apartment area (i.e. the front of the apartment is considered to be the perimeter on which the existing operable windows are located). For instance, for apartment 205, the front is the southern aspect, and the skylight should be located close to the northern perimeter of the apartment.

The results of the study are listed in Table 1 below. To ensure effective natural cross-ventilation is displayed within the abovementioned apartments, design detail guidelines for the ventilated skylights for effective natural cross-ventilation are also provided within this report in Section 4.

Note that the minimum effective openable area of the proposed ventilated skylights and habitable room openings (external windows, doors etc.) are assumed to be at least 0.4m^2. Based on our extensive experience and research into natural ventilation characteristics of residential apartment buildings utilising wind tunnel testing as well as full-scale verification testing (Peddie and Rofail, 2011) this is the minimum effective openable area required to generate pressure driven airflow between openings. It has also been assumed that all windows indicated in the architectural drawings are operable.

Additionally, each habitable room should have an unobstructed opening size of at least of 5% of the floor area served by the opening, in accordance with Objective 4B-1 of the ADG. For example, a bedroom with a floor area of 12m^2 should have an effective opening size of around 0.6m^2.

CONTENTS

1 REGIONAL WIND CLIMATE

The Sydney region is governed by three principal wind directions, and these can potentially affect the subject development. These winds prevail from the north-east, the south, and the westerly cooler winds. This is based on an analysis of wind data obtained by the Bureau of Meteorology from Kingsford Smith Airport between 1995 and 2016. Directional plots of the daily average winds when temperatures are between 20-29.5°C; which is the thermal comfort range for this region is shown in Figure 1 below (when occupants tend to open windows for ventilation). These plots have been produced based on an analysis of the recorded wind speed data obtained from Sydney Airport from 1995 to 2016, corrected to open terrain at 10m.

Natural ventilation for a residential apartment is most beneficial during the warmer times of the year, when the occupants of the apartment are most likely to open the windows and/or doors and also when the cooling effect of airflow through the apartment is most effective. An analysis of the Bankstown wind climate data within the thermal comfort zone range indicates that more than half of the wind events occur from the north-north-easterly to south-south-easterly directions, where the north-easterly to east-north-easterly and south-easterly to east-south-easterly winds are the most dominant.

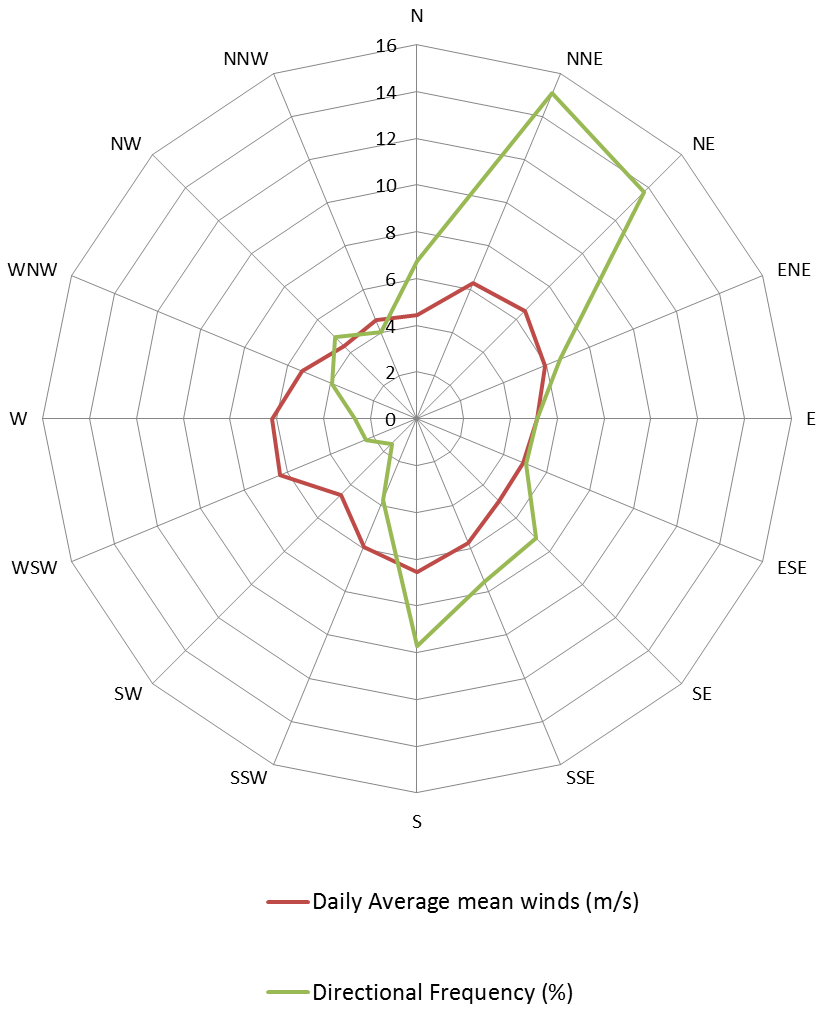

Figure 1: Daily average hourly mean wind speeds, and frequencies of occurrence, for the Sydney region for outdoor temperatures between 20-29.5°C

2 NATURAL CROSS VENTILATION OF DEEMED TO SATISFY APARTMENTS

Natural ventilation of indoor areas can be used to improve both the level of occupant comfort and the air quality of an internal space. Natural ventilation is beneficial in improving occupant comfort during the warmer months of the year when the occupants will generally have windows and doors open, while during the winter months it is considered primarily beneficial for air quality purposes only.

The predominant wind directions for the Sydney region have been analysed in Section 1 of this report, and from this analysis only the north-easterly and southerly winds should be considered as contributors to natural ventilation for occupant comfort purposes, since these are the predominant wind directions during the warmer months of the year. The westerly winds are predominant during the cooler winter months and would be beneficial for air quality purposes only.

The NSW State Environmental Planning Policy No. 65 (SEPP65) states that, for a development to be considered naturally ventilated, at least 60% of the individual apartments in the first nine storeys of the building must be considered to be naturally cross ventilated. Apartments at ten storeys or greater are deemed to be cross ventilated only if any enclosure of the balconies at these levels allows adequate natural ventilation and cannot be fully enclosed. To be considered to be naturally cross ventilated, the overall depth of a cross-over or cross-through apartment must not exceed 18m, measured glass line to glass line. Examples of apartments which are classified as being naturally ventilated by SEPP65 are shown in Figures 1 below, which also show the flow paths for natural cross ventilation through the apartments.

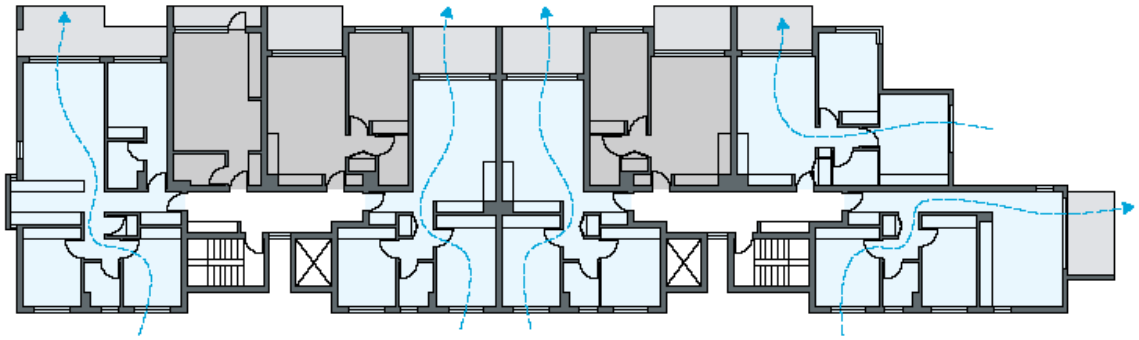

Figure 1a: Examples of apartments achieving effective natural cross ventilation
(from apartment design guide, floor plan of a typical residential building)

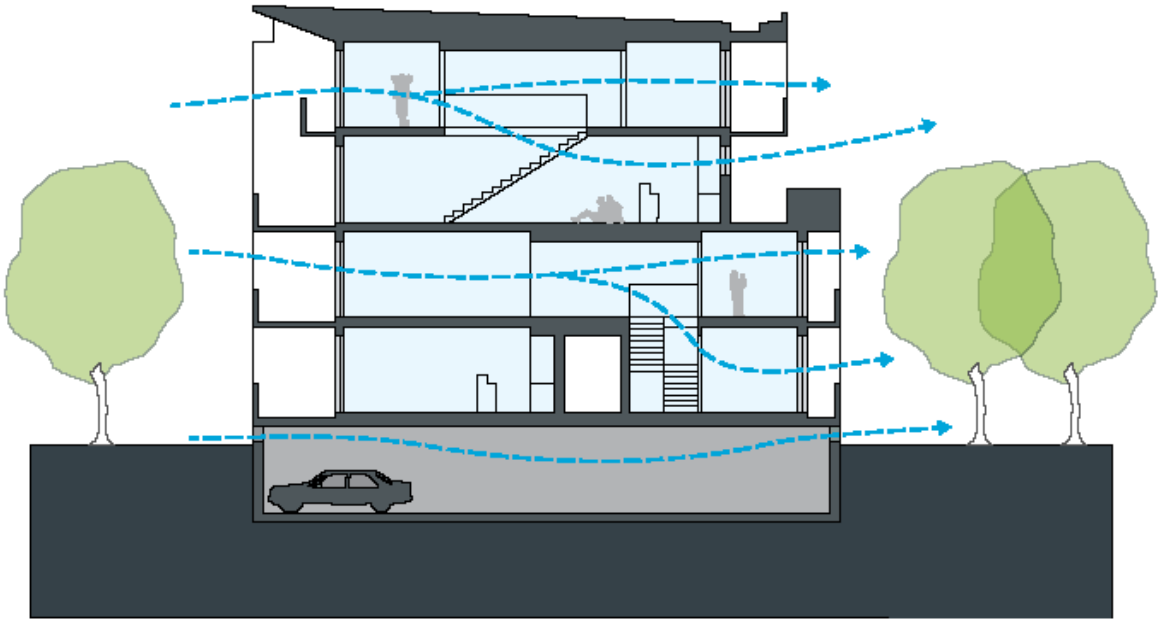

Figure 1b: Examples of apartments achieving effective natural cross ventilation
(from apartment design guide, section elevation of a typical residential building)

Apartments have been considered to have dual aspects if the two openings are able to be located on aspects which are less than 135° in plan orientation from each other. Openings which are located on aspect orientations greater than this are more likely to have similar pressures at the opening, and their performance cannot be considered to satisfy based on the SEPP65 guidelines. These apartments may still be considered to be naturally ventilated, but will require further analysis, as outlined in Section 3.

The Apartment Design Guide does provide design guidance for the layout and design of single aspect apartments to maximise natural ventilation. While these are not considered naturally cross ventilated, they allow for site restraints for design excellence in single aspect apartments. The design allows for the inclusion of ventilated skylights and wing walls to ensure effective natural ventilation.

It is important that the naturally cross ventilated flow path does not flow through a bathroom in order to avoid issues with odours.

It should be noted that deviations in the apartment layout shown in SEPP65 can have the potential to provide effective natural ventilation through the apartment. However, due to the complicated nature of flow paths driven by pressure differentials at different openings of an apartment, the effectiveness of natural ventilation for apartments which are outside of those presented in Figures 1 should be demonstrated by means of a detailed wind tunnel study. A comparison between the predicted natural ventilation characteristics of an apartment obtained from wind tunnel testing with the observed full-scale characteristics of the same apartment have been published in the paper titled ‘Designing for Natural Ventilation for Tall Residential Buildings’ by Peddie and Rofail (2011), which demonstrates close agreement.

3 RESULTS AND DISCUSSION

The results of the assessment indicate that a total of 35.8% (19 out of 53) of the residential apartments will meet the "deemed to satisfy" requirements of SEPP65 for natural cross ventilation. This has been achieved through openings on orthogonal or opposite aspects (for example corner or through apartments) with direct exposure to the prevailing winds, and/or windows located in significantly different pressure regions with an overall depth of cross-over or cross-through apartments not exceeding 18m from glass line to glass line. This is also summarised in Table 1. It is important that the naturally cross ventilated flow path does not flow through a bathroom in order to avoid issues with odours.

A further assessment of the current design has been conducted to determine possible design changes that could allow for improved natural cross-ventilation performance, by locating openings in significantly different pressure regions. It has been determined that 13 additional apartments are suitable candidates for treatment options. The results indicate that if the recommended treatments are implemented in all 13 of these apartments, then a total of 60.4% (32 of 53 residential apartments) are expected to satisfy the ADG requirements for natural cross-ventilation. The treatments for these 13 apartments are outlined as follows:

1. G03 - Inclusion of a window opening (elevated to maintain privacy) on the western aspect towards the back of the apartment, to ensure that this will allow airflow through the habitable spaces.

2. G05 - Inclusion of a horizontal plenum enabling ventilation air from the southern façade glass line to the plenum opening on the eastern façade. Note that this treatment requires the eastern façade of the corridor to be set back such that the length of the ventilation flow path does not exceed 18m. Figure A.2 in Appendix A shows the recommended layout for the horizontal plenum, indicating the nature of the set-back required on the eastern façade. The exact dimensions required to satisfy the above mentioned 18m requirement should be determined during the detail design stage.

3. 116, 216 - Inclusion of a 1.2-1.5m wide and full height impermeable wing wall or screen protruding out from approximately the centre of the eastern façade to allow the generation of significantly different pressures on either side of the wall (due to the prevailing southerly winds).

4. 202, 203, 205, 207, 208, 210, 212, 213, 218 - Inclusion of ventilated skylight opening to the roof level, at the rear third of the apartment area (i.e. the front of the apartment is considered to be the perimeter on which the existing operable windows are located). For instance, for apartment 205, the front is the southern aspect, and the skylight should be located close to the northern perimeter of the apartment.

The results of the study are listed in Table 1 below. To ensure effective natural cross-ventilation is displayed within the abovementioned apartments, design detail guidelines for the ventilated skylights for effective natural cross-ventilation are also provided within this report in Section 4.

Note that the minimum effective openable area of the proposed ventilated skylights and habitable room openings (external windows, doors etc.) are assumed to be at least 0.4m^2. Based on our extensive experience and research into natural ventilation characteristics of residential apartment buildings utilising wind tunnel testing as well as full-scale verification testing (Peddie and Rofail, 2011) this is the minimum effective openable area required to generate pressure driven airflow between openings. It has also been assumed that all windows indicated in the architectural drawings are operable.

Additionally, each habitable room should have an unobstructed opening size of at least of 5% of the floor area served by the opening, in accordance with Objective 4B-1 of the ADG. For example, a bedroom with a floor area of 12m^2 should have an effective opening size of around 0.6m^2.

Table 1: Natural ventilation performance

Apartments	Number	Percentage
Total Number of Apartments	53	-
Satisfies SEPP65 (Deemed to Satisfy)		
Without modifications	19	35.8%
With additional windows	1	1.9%
With wing-walls	2	3.8%
With horizontal plenums	1	1.9%
With ventilated skylights	9	17.0%
Total Passing	**32**	**60.4%**

Unit Number	Meets SEPP65 Requirements
101	YES
102	NO
103	NO
104	YES
105	NO
106	YES
107	NO
108	NO
109	YES
110	NO
111	YES
112	NO
113	NO
114	YES
115	YES
116	YES – Vertical Wing-wall
117	YES
118	NO
201	YES

Unit Number	Meets SEPP65 Requirements
202	YES – ventilated skylight
203	YES – ventilated skylight
204	YES
205	YES – ventilated skylight
206	YES
207	YES – ventilated skylight
208	YES – ventilated skylight
209	YES
210	YES – ventilated skylight
211	YES
212	YES – ventilated skylight
213	YES – ventilated skylight
214	YES
215	YES
216	YES – Vertical Wing-wall
217	YES
218	YES – ventilated skylight
G01	NO
G02	NO
G03	YES – Additional Window
G04	YES
G05	YES – Horizontal Plenum
G06	NO
G07	YES
G08	NO
G09	NO
LG01	NO
LG02	NO
LG03	NO
LG04	NO
LG05	NO
LG06	NO
LG07	NO
LG08	YES

4 DESIGN DETAILS

A number of apartments are expected to satisfy the ADG requirements for natural cross-ventilation via locating openings in significantly different pressure regions with the inclusion of the treatment recommendations detailed in Section 3 of this report. To ensure effective natural cross-ventilation is achieved, the following design details are recommended to be incorporated into the final design of the development and are summarised as follows:

4.1 Design details of plenum ducts

Apartment G05 (ground level) of this development rely on a horizontal plenum duct to enable natural cross-ventilation. For the plenum duct to be effective, a number of factors should be considered.

- A mark of the proposed location for the plenum duct is shown on Figure A2 in Appendix A. The duct should be located inside the ceiling spaces above the corridor on the Ground Level, and the inlet should be situated in the ear of the apartment. Note that this treatment requires the eastern façade of the corridor to be set back such that the length of the ventilation flow path does not exceed 18m. Figure A.2 in Appendix A shows the recommended layout for the horizontal plenum, indicating the nature of the set-back required on the eastern façade. The exact dimensions required to satisfy the above mentioned 18m requirement should be determined during the detail design stage.

- Natural ventilation is a product of pressure driven flow between two openings, in this case flow between an opening along the external apartment facade, which is more positively pressurised and one on the orthogonal eastern facade, which is negatively or neutrally pressurised.

- The inlet/outlet openings and the plenum duct should have a minimum free area of 0.4m^2 in order to provide effective natural ventilation for a single apartment connected to a single shaft. For example, for a plenum duct with an internal height of 500mm, the width should be at least 800mm. Note that this would be need to be increased accordingly to account for obstructions such as piping within the plenum duct.

- The plenum duct should be a straight duct connecting the inlet/outlet openings with no or minimal bending to prevent pressurisation losses within the duct.

- Obstructions to flow within the duct such as pipes are recommended to be kept to a minimum.

- Provisions should be made for acoustic lining to mitigate the potential noise transfer.

- Provisions should be made for the inclusion of fire dampers in the duct. The design and location of these should be verified by the fire engineer as requirements for access may be stipulated.

- Provisions should be made for the inclusion of operable or one way louvres at the inlet opening in the rear of the apartment to mitigate the potential smell transfer.

- If multiple apartments are connected to a singular plenum duct, it should have an outlet opening and internal plenum duct effective free area of at least 1m^2.

4.2 Design details of the ventilated skylights

Several apartments on ‘Level 2’ of this development rely on ventilated skylights to enable natural ventilation (apartments 202, 203, 205, 207, 208, 210, 212, 213 and 218). For the ventilated skylights to be effective, a number of factors should be considered.

- Similar to the plenum duct, natural ventilation is a product of pressure driven flow between two openings between an opening along the external apartment facade, which is more positively pressurised and an opening (operable skylight) on the roof of the development, which is more negatively or neutrally pressurised.

- The operable skylight should be situated near to the rear of the unit to promote natural cross-ventilation through the whole apartment.

- The effectiveness of the ventilation can be compromised if the skylight opening does not have a sufficient cross-sectional area. It is recommended that the minimum effective openable area of each ventilated skylights should be $0.4m^2$. This recommended free cross-sectional area is based on Windtech’s extensive experience in the field of wind engineering and wind tunnel modelling of similar developments.

5 REFERENCES

ANSI/ASHRAE 55-2010, Thermal Environmental Conditions for Human Occupancy, Atlanta: American Society of Heating, Refrigeration and Air-conditioning Engineers.

ANSI/ASHRAE 62.1-2010, Ventilation for Acceptable Indoor Air Quality, Atlanta: American Society of Heating, Refrigeration and Air-conditioning Engineers.

AS1668.2-2002, The use of ventilation and air conditioning in buildings, Part 2: Ventilation design for indoor air contaminant control (excluding requirements for the health aspects of tobacco smoke exposure), Standards Australia.

Aynsley R.M., Melbourne W. and Vickery B.J., (1977) Architectural Aerodynamics, Architectural Science Series, pp192-203.

State Environmental Planning Policy No. 65 (SEPP65), 2015, "Apartment Design Guide", NSW Department of Planning and Environment.

Peddie K.M. and Rofail A.W., 2011, 'Designing for Natural Ventilation for Tall Residential Buildings', 2011 CTBUH World Conference, Seoul, Korea, October 10-12, 2011.

Peddie K.M. and Rofail A.W., 2010, 'Application of Natural Ventilation for Commercial Developments' 14th Australasian Wind Engineering Society Workshop, Canberra, August 5-6, 2010.

APPENDIX A – WING WALL AND PLENUM DUCT LOCATIONS

Figure A.1: Vertical wing wall treatment for apartments 116 and 216, shown in Level 1 plan (not to scale)

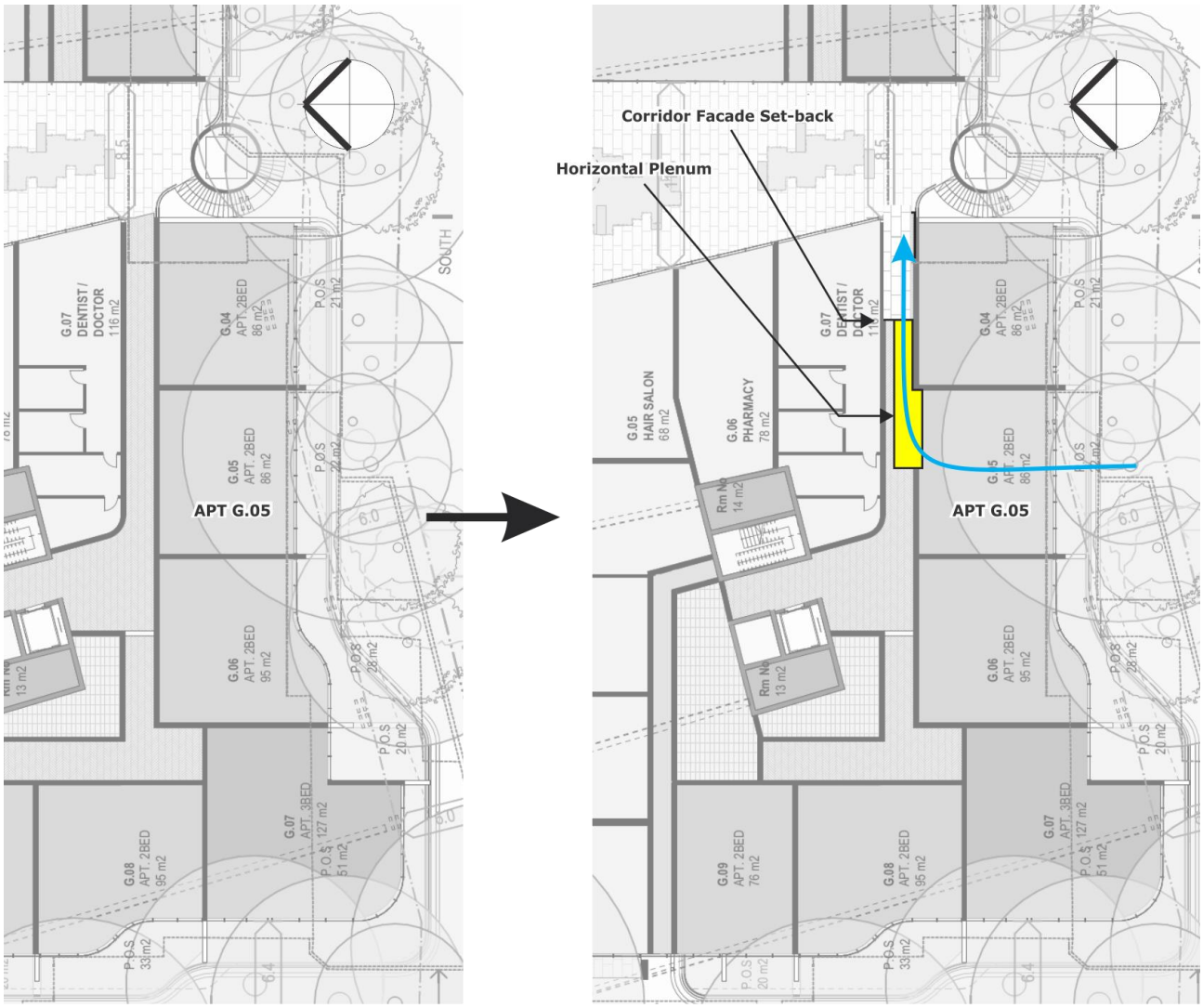

Figure A.2: ‘Horizontal Plenum’ treatment for apartment G05.