

Appendix B
Pedestrian Wind Study, 1979 Mission Street

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1979 Mission Street
San Francisco, CA

Final Report

Pedestrian Wind Study

RWDI # 1402356
June 29, 2015

SUBMITTED TO

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1979 Mission Street – San Francisco, California
Pedestrian Wind Study
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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by Maximus-BP 1979 Mission Street, LLC to conduct a Pedestrian Wind Study for the proposed project at 1979 Mission Street in San Francisco, California. The purpose of the study was to assess the wind environment around the development in terms of pedestrian comfort and hazard relative to wind metrics specified in the San Francisco Planning Code Section 148. The study objective was achieved through wind tunnel testing of a 1:300 (1" = 25') scale model for the following three development configurations:

- A – Existing:** all existing buildings on-site and in the surroundings including buildings under construction;
- B – Existing plus Project:** proposed 1979 Mission Street project present with surrounding buildings that are existing and under-construction; and,
- C – Project plus Cumulative:** proposed 1979 Mission Street project with surrounding buildings that are existing and under-construction, as well as approved proposed buildings.

The development site is located on the northeast corner of the intersection of Mission and 16th Streets in the Inner Mission neighborhood. The site abuts the northern and eastern boundaries of the street-level plaza and northeast entrance of the 16th Street Mission Bay Area Rapid Transit District (BART) Station.

Maximus-BP 1979 Mission Street LLC ("Applicant") is proposing to demolish two existing one-story commercial buildings and construct a five-story to ten-story mixed use building with approximately 34,198 gross square feet ("gsf") of ground floor retail use, 331 dwelling units consisting of 291,027 gsf and 63,687gsf of parking/loading/building services at the ground floor and basement level (the "Project"). There will be 22 off-street parking spaces for retail use, 133 off-street parking spaces for the residential use and 4 car-share spaces, for a total of 163 spaces plus three freight loading spaces. The Project will provide 162 Class 1 secured bicycle parking spaces on-site and 30 Class 2 bicycle spaces on Mission and Capp Streets.

The test model was constructed using the design information and drawings listed in Appendix A. This report summarizes the methodology of the wind tunnel studies for pedestrian wind conditions, describes the wind comfort and wind hazard criteria associated with wind force, as used in the current study, and presents the test results. The placement for wind measurement locations was based on our experience and understanding of pedestrian usage for this site, and was reviewed by the project team and the City of San Francisco prior to the wind tunnel test.

2. PRINCIPAL RESULTS

The results of the tests are discussed in detail in Section 5 of this report and are summarized as follows:

- Existing wind speeds on the Project site are generally acceptable with those at 28 out of 50 locations exceeding the comfort criterion of 11 mph. Existing winds at one location on 16th Street exceed the wind hazard criterion.
- Wind comfort conditions at grade level for the Existing plus Project configuration and the Project plus Cumulative configuration are predicted to remain generally similar compared to the Existing configuration, with a reduction in the total number of locations exceeding the 11 mph criterion.
- In both the Existing plus Project and Project plus Cumulative configurations, winds at all locations are predicted to meet the wind hazard criterion, with average wind speeds similar to that in the Existing configuration.

3. METHODOLOGY

3.1 Wind Tunnel Testing

As shown in Figures 1a through 1c, the wind tunnel model included the Project site and all relevant surrounding buildings and topography within a 1125 foot radius of the study site. The mean speed profile and turbulence of the natural wind approaching the modelled area were simulated in RWDI's boundary-layer wind tunnel. The model was instrumented with 50 wind speed sensors to measure mean and gust wind speeds at a full-scale height of approximately 5 ft above local grade. Two of these measurement locations on the site (Locations 11 and 16) were covered by the existing building in the Existing configuration. These locations would be accessible to pedestrians with the proposed Project completed, and have been presented for the Existing plus Project and Project plus Cumulative configurations. These measurements were recorded and analyzed for the west-southwest, west, west-northwest and northwest wind directions, as per the City of San Francisco pedestrian wind tunnel testing methodology.

3.2 Local Climate

Average wind speeds in San Francisco are the highest in the summer and lowest in winter. However, the strongest peak winds occur in winter. Throughout the year the highest wind speeds occur in mid-afternoon and the lowest in the early morning. Westerly to northwesterly winds are the most frequent and strongest winds during all seasons. Of the primary wind directions, four have the greatest frequency of occurrence and also make up the majority of the strong winds that occur. These winds include the northwest, west-northwest, west and west-southwest.

Data describing the speed, direction, and frequency of occurrence of winds were gathered at the old San Francisco Federal Building at 50 United Nations Plaza (at a height of 132 ft.) during the six-year period, 1945 to 1950.

3.3 Pedestrian Level Wind Criteria

This Project is located in an area that is not subject to the San Francisco Planning Code Section 148, Reduction of Ground-level Wind Currents in C-3 Districts. However, the proposed Project is subject to the California Environmental Quality Act (CEQA). Therefore, the potential for the Project to result in hazardous winds in the Project vicinity must be assessed. Planning Code Section 148 specifies the wind hazard criterion used by the San Francisco Planning Department to identify significant wind impacts. This analysis is performed using the wind testing analysis and evaluation methods to determine conformity with Planning Code Section 148 (see Appendix B). A brief description of the hazard criterion is provided below. The comfort criteria have also been included for information purposes.

The Planning Code defines wind speeds in terms of equivalent wind speeds, and average wind speed (mean velocity), adjusted to include the level of gustiness and turbulence. The equivalent wind speeds were calculated according to the specifications in the San Francisco Planning Code Section 148, whereby the mean hourly wind speed is increased when the turbulence intensity is greater than 15% according to the following formula:

$$EWS = V_m \times (2 \times TI + 0.7)$$

where

<i>EWS</i>	= equivalent wind speed
<i>V_m</i>	= mean pedestrian-level wind speed
<i>TI</i>	= turbulence intensity

Comfort Criteria

The comfort criteria are that wind speeds should not exceed, more than 10% of the time, 11 mph in substantial pedestrian use areas, and 7 mph in public seating areas.

Hazard Criterion

The hazard criterion of the Planning Code requires that buildings not cause equivalent wind speeds to reach or exceed the hazard level of 26 mph as averaged from a single full hour of the year.

The comfort criteria are based on wind speeds that are measured for one minute and averaged. In contrast, the hazard criterion is based on winds that are measured for one hour and averaged. When stated on the same basis as the comfort criteria winds, the hazard criterion speed is a one-minute average of 36 mph.



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3.4 Cumulative Buildings

Proposed buildings in the surrounding area that have been approved by the city were modeled in accordance with the information received on March 18, 2015 from the City of San Francisco Planning Department. These buildings were included in the Project plus Cumulative configuration; the sites are shown in Image 1 and listed in the following table.

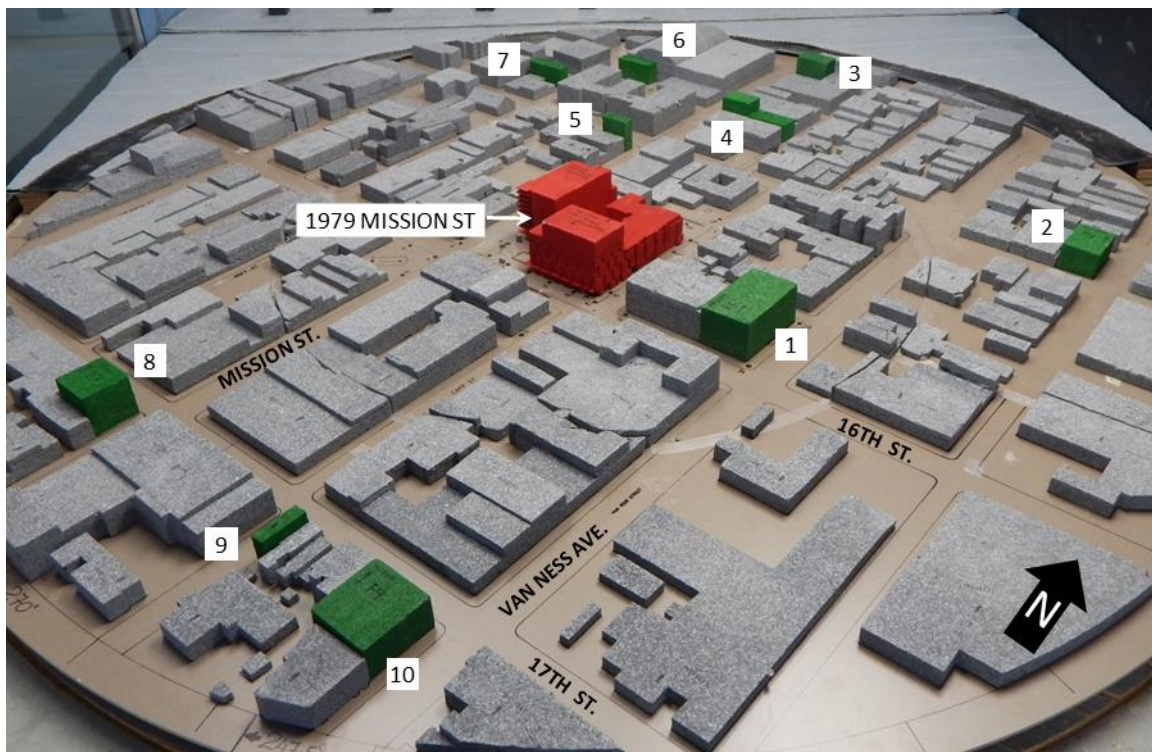


Image 1: Cumulative buildings (numbered 1 - 10)

1	490S VAN NESS AVE.	6	49 JULIAN ST.
2	1450 15 TH ST.	7	80 JULIAN ST.
3	1801 MISSION ST.	8	2100 MISSION ST
4	1863 MISSION ST.	9	3249 17 TH ST
5	1900 MISSION ST.	10	600 VAN NESS AVE.

4. TEST RESULTS

This section presents the results of the wind tunnel measurements analyzed in terms of equivalent wind speeds as defined by the equation in Section 3.3. The text in the report simply refers to the data as wind speeds.

Figure 2 depicts the wind speed measurement locations on and around the Project site. Table 1, located in the tables section of this report, presents the wind comfort results for the three configurations tested. For each measurement point, the measured 10% exceeded (90th percentile) equivalent wind speed and the percentage of time that the wind speed exceeds 11 mph are listed. The point is marked as a comfort exceedance if the 11 mph threshold is exceeded. A letter “e” in the last column of each configuration indicates a wind comfort exceedance.

Table 2 presents the wind hazard results, and lists the predicted wind speed to be exceeded one hour per year. The predicted number of hours per year that the Section 148 wind hazard criterion (one minute wind speed of 36 mph) is exceeded is also provided. A letter “e” in the last column of each configuration indicates a wind hazard exceedance.

4.1 Wind Comfort Conditions

For the Existing configuration, in the vicinity of the Project site, wind conditions are found to be generally acceptable with wind speeds averaging 12 mph for all measurement locations at grade level. Winds at 28 out of 50 locations exceed the Planning Code's 11 mph pedestrian-comfort criterion.

In the Existing plus Project configuration, the taller proposed building would shelter areas to the east of the site from the prevailing westerly winds. Overall wind comfort conditions are expected to remain similar to those in the Existing configuration and wind speeds would continue averaging at 12 mph. The number of locations where wind speeds would exceed the 11 mph criterion is predicted to decrease to 22 from 28 in the Existing configuration.

With the addition of proposed Projects in the surrounding area, in the Project plus Cumulative configuration, average wind speeds are predicted to remain at 12 mph. Winds at 22 of the 50 locations are predicted to exceed the comfort criterion.

4.2 Wind Hazard Conditions

Of the 50 locations tested for the Existing configuration, winds at one location on 16th Street, southeast of the Project site, currently exceeds the hazard criterion (Location 41 in Table 2 and Figure 2). When the Project is added to the site, in the Existing plus Project configuration, the winds at this location would no longer exceed the wind hazard criterion. No new locations of wind hazard exceedance would be created and speeds would continue averaging at 23 mph, similar to the Existing Configuration. In the Project plus Cumulative configuration, the average wind speed is predicted to be 22 mph, with wind speeds at all locations below the hazard criterion. (see summary in Table 2).



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5. APPLICABILITY OF RESULTS

The results presented in this report pertain to the model of the proposed 1979 Mission Street Project constructed using the architectural design drawings listed in Appendix A. Should there be design changes that deviate from this list of drawings, the results presented may change. Therefore, if substantial changes in the design are made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

TABLES



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Table 1: Wind Comfort Results

References	Existing			Existing plus Project				Project plus Cumulative			
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Exceeds	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Speed Change Relative to Existing (mph)	Exceeds	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Speed Change Relative to Existing (mph)	Exceeds
1	13	21	e	13	20	0	e	13	19	0	e
2	12	17	e	11	7	-2		11	10	-2	
3	15	25	e	11	10	-3		13	18	-2	e
4	16	29	e	18	38	2	e	16	31	1	e
5	13	20	e	18	37	5	e	17	34	4	e
6	13	19	e	16	28	3	e	15	26	2	e
7	11	10		16	28	5	e	15	27	5	e
8	10	6		11	10	1		11	10	1	
9	10	7		8	2	-2		7	0	-3	
10	11	10		11	10	-1		10	6	-1	
*11	n/a	n/a	n/a	14	20	n/a	e	14	21	n/a	e
12	15	26	e	19	42	4	e	20	45	5	e
13	12	15	e	11	10	-1		10	8	-2	
14	10	5		9	2	-1		8	2	-1	
15	10	7		9	4	-1		9	2	-2	
*16	n/a	n/a	n/a	5	0	n/a		5	0	n/a	
17	11	10		7	1	-4		7	1	-3	
18	10	7		8	2	-2		10	5	-1	
19	12	14	e	9	3	-3		9	2	-3	
20	12	12	e	9	4	-2		9	2	-3	
21	13	19	e	14	24	1	e	13	18	0	e
22	9	4		9	4	0		9	2	-1	
23	7	1		6	0	-1		6	0	-1	
24	15	27	e	15	27	0	e	15	24	0	e
25	10	6		13	19	3	e	14	20	4	e
26	9	3		14	23	5	e	14	21	5	e
27	8	2		13	19	5	e	12	16	4	e
28	11	10		12	12	0	e	11	10	0	
29	12	14	e	11	10	-1		11	10	-1	
30	8	1		8	1	0		8	1	0	
31	13	21	e	13	20	0	e	13	19	-1	e
32	11	10		12	13	1	e	11	10	1	



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Table 1: Wind Comfort Results

References	Existing			Existing plus Project				Project plus Cumulative			
Location Number	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Exceeds	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Speed Change Relative to Existing (mph)	Exceeds	Wind Speed Exceeded 10% of Time (mph)	Percent of Time Wind Speed Exceeds 11 mph (%)	Speed Change Relative to Existing (mph)	Exceeds
33	11	10		11	10	0		11	10	0	
34	12	17	e	12	16	0	e	12	16	0	e
35	18	39	e	17	37	0	e	17	34	-1	e
36	11	10		13	20	2	e	13	20	2	e
37	14	23	e	18	38	4	e	18	39	5	e
38	11	10		9	5	-2		9	4	-2	
39	13	19	e	9	6	-4		11	10	-2	
40	12	13	e	12	12	0	e	13	17	1	e
41	17	34	e	10	5	-8		10	5	-8	
42	12	14	e	10	8	-1		11	10	-1	
43	14	21	e	11	10	-3		11	10	-3	
44	13	19	e	10	7	-2		14	20	1	e
45	13	20	e	11	10	-2		11	10	-2	
46	13	21	e	8	3	-5		7	1	-6	
47	12	13	e	9	4	-3		8	2	-4	
48	15	29	e	15	28	0	e	14	24	-1	e
49	12	15	e	13	17	1	e	13	16	1	e
50	11	10		10	7	0		10	5	-1	
Average mph, Average % and Total exceedances	12	15	28	12	14	0	22	12	14	0	22

***NOTE:**

Data from sensors 11 and 16 are not available for the Existing configuration as the sensors were within the footprint of the existing building model.



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Table 2: Wind Hazard Results

References	Existing			Existing plus Project				Project plus Cumulative			
Location Number	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Exceeds	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Hours Change Relative to Existing	Exceeds	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Hours Change Relative to Existing	Exceeds
1	23	0		25	0	0		24	0	0	
2	23	0		19	0	0		19	0	0	
3	27	0		21	0	0		23	0	0	
4	31	0		35	0	0		32	0	0	
5	27	0		36	0	0		34	0	0	
6	23	0		32	0	0		29	0	0	
7	21	0		35	0	0		35	0	0	
8	20	0		19	0	0		19	0	0	
9	19	0		16	0	0		13	0	0	
10	23	0		22	0	0		19	0	0	
*11	n/a	n/a	n/a	28	0	n/a		27	0	n/a	
12	28	0		35	0	0		36	0	0	
13	21	0		24	0	0		22	0	0	
14	19	0		17	0	0		17	0	0	
15	21	0		20	0	0		18	0	0	
*16	n/a	n/a	n/a	12	0	n/a		12	0	n/a	
17	21	0		14	0	0		15	0	0	
18	21	0		15	0	0		18	0	0	
19	23	0		16	0	0		16	0	0	
20	22	0		16	0	0		15	0	0	
21	23	0		27	0	0		25	0	0	
22	18	0		17	0	0		15	0	0	
23	13	0		11	0	0		11	0	0	
24	26	0		28	0	0		26	0	0	
25	18	0		24	0	0		25	0	0	
26	17	0		28	0	0		25	0	0	
27	16	0		27	0	0		24	0	0	
28	21	0		25	0	0		22	0	0	
29	21	0		20	0	0		19	0	0	
30	14	0		14	0	0		14	0	0	
31	24	0		23	0	0		23	0	0	
32	20	0		22	0	0		21	0	0	
33	20	0		20	0	0		20	0	0	



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Table 2: Wind Hazard Results

References	Existing			Existing plus Project				Project plus Cumulative			
Location Number	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Exceeds	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Hours Change Relative to Existing	Exceeds	Wind Speed Exceeded 1 hr/year (mph)	Hours per Year Wind Speeds Exceed Hazard Criteria	Hours Change Relative to Existing	Exceeds
34	22	0	e	21	0	0		21	0	0	
35	31	0		30	0	0		28	0	0	
36	18	0		24	0	0		25	0	0	
37	25	0		36	0	0		35	0	0	
38	21	0		19	0	0		19	0	0	
39	23	0		21	0	0		25	0	0	
40	22	0		26	0	0		27	0	0	
41	38	2		19	0	-2		19	0	-2	
42	20	0		22	0	0		22	0	0	
43	28	0		21	0	0		21	0	0	
44	23	0		20	0	0		32	0	0	
45	24	0		22	0	0		22	0	0	
46	24	0		17	0	0		16	0	0	
47	24	0		18	0	0		17	0	0	
48	29	0		29	0	0		26	0	0	
49	25	0		25	0	0		25	0	0	
50	21	0		20	0	0		18	0	0	
Average mph, Total hours and Total exceedances	23	2	1	23	0	-2	0	22	0	-2	0

***NOTE:**

Data from sensors 11 and 16 are not available for the Existing configuration as the sensors were within the footprint of the existing building model.

FIGURES



Wind Tunnel Study Model Existing

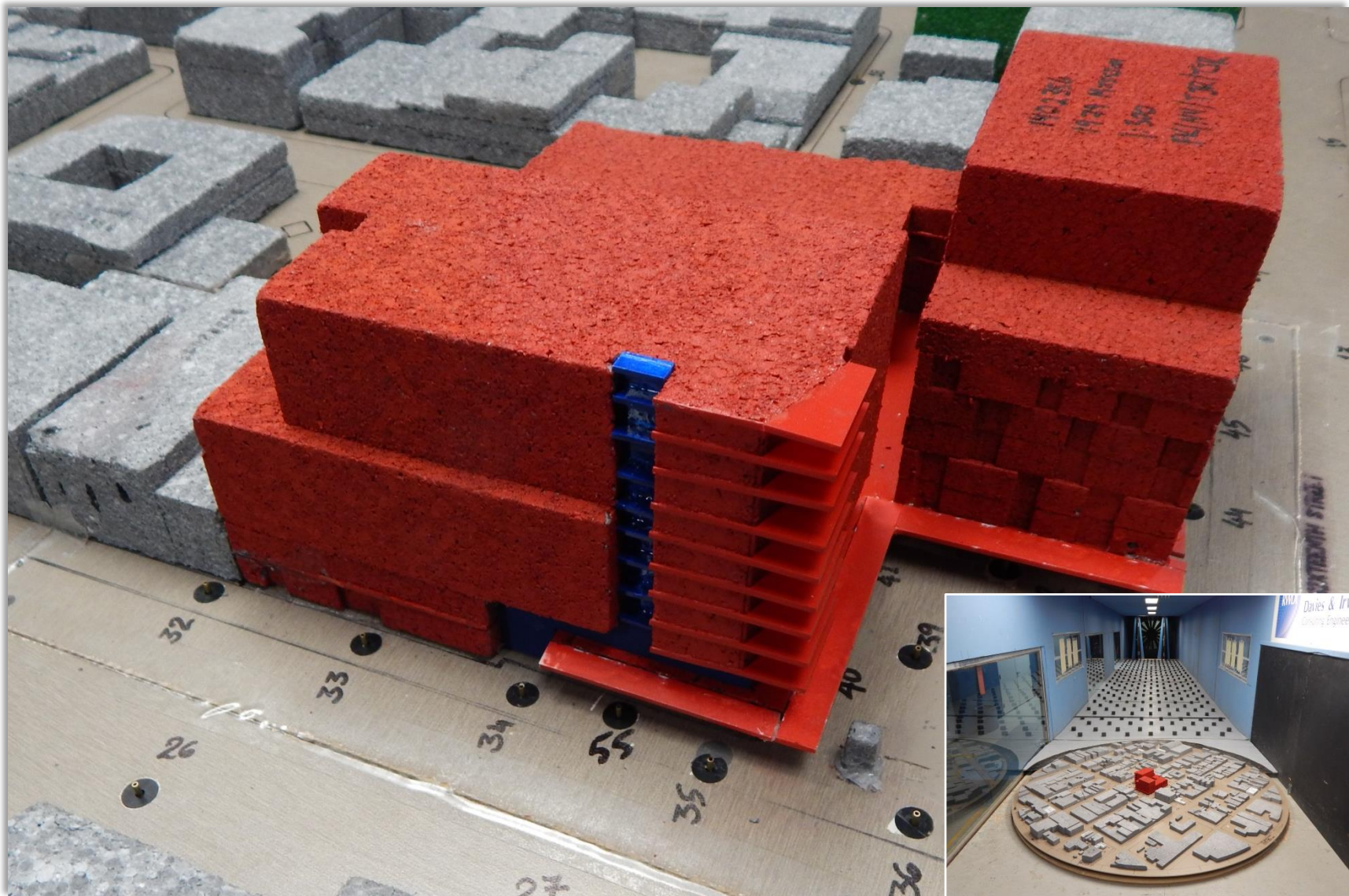
1979 Mission Street – San Francisco, California

Figure No. 1a

Project #1402356

Date: June 26, 2015





Wind Tunnel Study Model
Existing plus Project

1979 Mission Street – San Francisco, California

Figure No. 1b

Project #1402356

Date: June 26, 2015





Wind Tunnel Study Model
Project plus Cumulative

1979 Mission Street – San Francisco, California

Figure No. 1c

Project #1402356

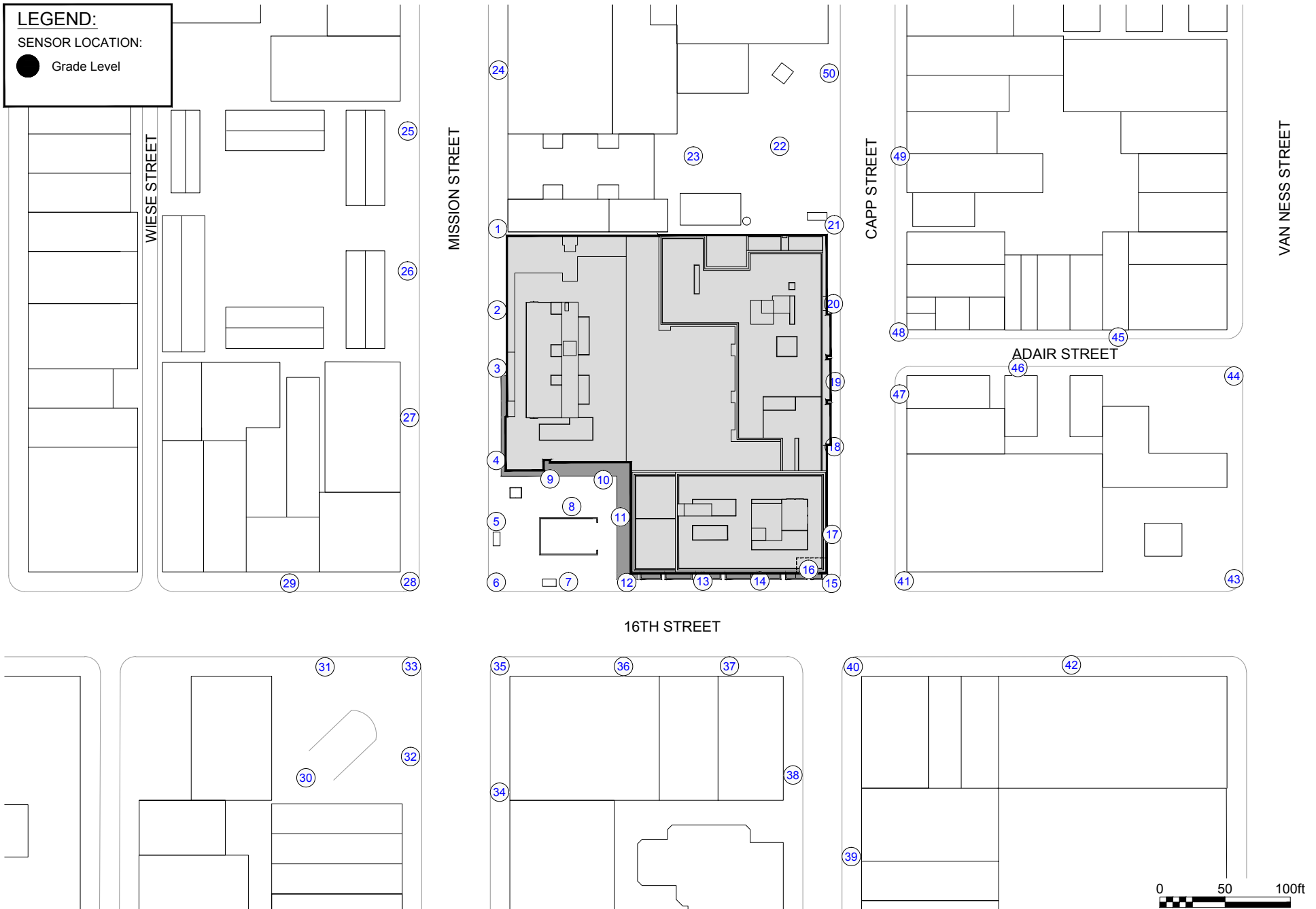
Date: June 26, 2015



LEGEND:

SENSOR LOCATION:

● Grade Level



Pedestrian Level Wind Measurement Sensor Plan

1979 Mission Street - San Francisco, CA



Project #1402356

Drawn by: ARM	Figure: 2
Approx. Scale: 1"=100'	
Date Revised: June 26, 2015	



APPENDIX A

APPENDIX A: DRAWING LIST FOR MODEL CONSTRUCTION

The drawings and information listed below were received from Skidmore Owings and Merrill LLP and were used to construct the scale model of the proposed 1979 Mission Street project. Should there be any design changes that deviate from this list of drawings, the results may change. Therefore, if changes in the design area made, it is recommended that RWDI be contacted and requested to review their potential effects on wind conditions.

Description	File Name	File Type	Date Received (dd/mm/yyyy)
3D Model of proposed building	2015423_1979_Wind-Options.3dm	Rhino	24/04/2015

APPENDIX B

APPENDIX B: SAN FRANCISCO PLANNING CODE SECTION 148

Reduction of Ground-level Wind Currents in C-3 Districts

- a) **Requirement and Exception.** In C-3 Districts, buildings and additions to existing buildings shall be shaped, or other wind-baffling measures shall be adopted, so that the developments will not cause ground-level wind currents to exceed, more than 10 percent of the time year round, between 7:00 a.m. and 6:00 p.m., the comfort level of 11 m.p.h. equivalent wind speed in areas of substantial pedestrian use and seven m.p.h. equivalent wind speed in public seating areas.

When preexisting ambient wind speeds exceed the comfort level, or when a proposed building or addition may cause ambient wind speeds to exceed the comfort level, the building shall be designed to reduce the ambient wind speeds to meet the requirements. An exception may be granted, in accordance with the provisions of Section 309, allowing the building or addition to add to the amount of time that the comfort level is exceeded by the least practical amount if (1) it can be shown that a building or addition cannot be shaped and other wind-baffling measures cannot be adopted to meet the foregoing requirements without creating an unattractive and ungainly building form and without unduly restricting the development potential of the building site in question, and (2) it is concluded that, because of the limited amount by which the comfort level is exceeded, the limited location in which the comfort level is exceeded, or the limited time during which the comfort level is exceeded, the addition is insubstantial.

No exception shall be granted and no building or addition shall be permitted that causes equivalent wind speeds to reach or exceed the hazard level of 26 miles per hour for a single hour of the year.

- b) **Definition.** The term "equivalent wind speed" shall mean an hourly mean wind speed adjusted to incorporate the effects of gustiness or turbulence on pedestrians.
- c) **Guidelines.** Procedures and Methodologies for implementing this section shall be specified by the Office of Environmental Review of the Department of City Planning. (added by Ord. 414-85, App. 9/17/85)

APPENDIX C

APPENDIX C: APPROVED SCOPE OF WORK

Wind Climate Model

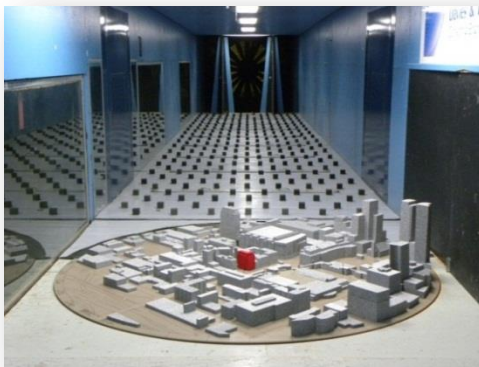
Wind Data: Long-term meteorological data for San Francisco will be used for the Pedestrian Wind Tunnel Study. This data, along with information on the topography surrounding the wind instrument, will be used to establish wind speeds for the area and to develop a mathematical model of the joint probability of wind speed and direction.

Pedestrian Wind Study (Wind Tunnel Testing)

Objective: The proposed Pedestrian Wind Study involves testing a three-dimensional physical scale model of the development and surroundings in a boundary layer wind tunnel to quantitatively measure the wind conditions for pedestrians at important locations around the site.

Proximity Model: A proximity model of the existing buildings and relevant surroundings within a 1600 foot radius of the center of the development site will be constructed at a 1:400 scale (equivalent to 1" = 33').

The buildings immediately surrounding the study site will be modeled in more detail than buildings beyond this radius. The model will incorporate relevant topographic changes as applicable. Surroundings beyond the limits of the proximity model will be appropriately simulated by spires and roughness blocks situated on the wind tunnel floor upwind of the study model. This will provide an accurate representation of the wind speed and turbulence profiles of wind approaching the study model.



Example of scale models in one of RWDI's boundary layer wind tunnels.

Study Building Test Model: To conduct the tests, a 1:400 scale model of the proposed project will be built and added to the proximity model described above. Wind speed sensors that are used to measure the mean and gust wind velocities at a full-scale height of 5 ft above ground, will be installed on the model taking into consideration outdoor pedestrian-use areas around the proposed development.

Wind Tunnel Testing: The test model together with the proximity model will be tested in our boundary layer wind tunnel where the natural wind speed and turbulence levels will be simulated. During the tests, wind speed data will be collected for four wind directions per the City of San Francisco pedestrian wind tunnel testing methodology. We anticipate measuring wind speeds at approximately 50 pedestrian locations which will be provided to you and the Planning Department for review and comment prior to testing.

Test Configurations: Four configurations of the study site and surroundings will be tested for our base studies:

- **Existing:** the existing surroundings, with any buildings currently on site, without the proposed development;
- **Existing plus Development:** the proposed development, along with existing surrounding structures;
- **Existing plus Development plus Cumulative:** the proposed development, along with existing surrounding structures, and future buildings (Cumulative); and,
- **Existing plus Alternative Design:** one alternative design, along with existing surroundings structures.

Analysis: The wind tunnel data will be analyzed together with the area's long term meteorological statistics to predict how often selected wind speed ranges will occur at each location. Results will be reviewed against the City of San Francisco pedestrian wind comfort and safety criteria.

In the event that undesirable conditions are found, we would use our experience and judgment to suggest design concepts to minimize uncomfortable winds. If conditions are particularly severe in critical areas, we may recommend additional testing to develop specific solutions. Additional testing in connection with detailed solution development has not been included within the scope of this proposal.

Report & Deliverables: RWDI will contact you as soon as preliminary results are available to arrange a conference call to discuss our findings. A draft report describing methodology, results and recommendations will be prepared upon completion of the study and sent to SOM and the City for review. Our final report will incorporate all comments and edits from SOM and the City.