APPENDIX O WIND ANALYSIS

BRISBANE BAYLANDS SPECIFIC PLAN

Brisbane, California

Wind Assessment

Project #2301053

August 23, 2023

SUBMITTED TO

ESA | Environmental Science Associates
575 Market Street, Suite 3700
San Francisco, CA 94105
T: 415.896.5900

Paul Mitchell
pmitchell@esaassoc.com

Terri Avila
tavila@esaassoc.com

SUBMITTED BY

Kamran Shirzadeh, M.E.Sc., E.I.T.,
Technical Coordinator
Karman.Shirzadeh@rwdi.com

Hanqing Wu, Ph.D., P.Eng.,
Senior Technical Director / Principal
Hanqing.Wu@rwdi.com

Dan Bacon
Senior Project Manager / Principal
Dan.Bacon@rwdi.com

RWDI
600 Southgate Drive
Guelph, Ontario, Canada N1G 4P6
T: 519.823.1311 x2245
F: 519.823.1316

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained to conduct a wind assessment to investigate the effect of proposed and future developments on and around the Baylands Specific Plan Area on wind-related recreational activities (e.g., wind/kite-surfing) at shorelines of the San Francisco Bay (Area of Interest shown in Image 1). The site plan of the proposed developments is outlined in the Image 2. The foreseeable future developments are located to the north and northeast of the project site (Baylands North and Candlestick Point State Recreation Area).

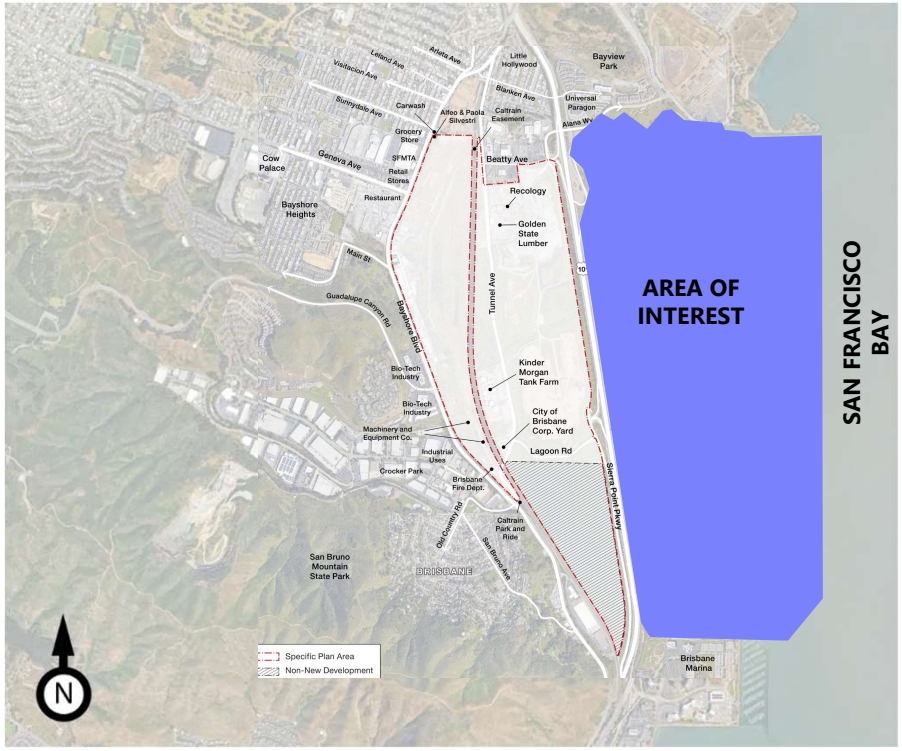

Image 1: Aerial View of the Existing Site and Surroundings
Source: Google™ Earth and ESA

Image 2: Baylands Specific Plan Area Site (Courtesy of ESA)

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2. BACKGROUND

2.1 Overview

This quantitative assessment was based on Computational Fluid Dynamics (CFD) simulations of wind flows on a virtual model of the project and surroundings using *Orbital Stack*, an in-house CFD tool.

The assessment is based on the following:

- A review of the regional long-term meteorological data from San Francisco International Airport;
- 3D models received on May 18, 2023;
- Our engineering judgment, experience, and expert knowledge of wind flows.

2.2 CFD in Wind Assessment

Computational Fluid Dynamics (CFD) simulations were undertaken in order to predict the flow of wind in and around the site. Of the 16 major wind directions, three directions were simulated in order to understand the range of possible flow conditions on the site. These inflow directions were chosen for simulation because they represent the dominant prevailing wind patterns that may influence the area of interest.

The flow conditions were solved using a Large Eddy Simulation (LES) approach. This technique allows for the prediction of mean wind flows as well as the effect of transient phenomena (i.e., gusts). Simulations were run for a sufficiently long duration to acquire statistically significant predictions of both mean and fluctuating wind velocity components. The speeds calculated were then combined into an equivalent mean value and normalized by the reference speed (a wind speed measured at a high elevation that is not affected by ground level structures), into a 'velocity ratio' which is used in later analysis.

Wind speeds from the long-term meteorological data were applied to the velocity ratios produced from the CFD simulations to generate a map of average wind speeds over the area of interest. This approach was taken because it enabled us to present the results in a recognizable format, using values that may be more-easily interpreted by a wider audience.

3. METHODOLOGY

3.1 Simulation Model

CFD simulations were completed for three configurations:

- **Existing:** Existing site and surroundings (Image 3A),
- **Project:** Proposed Brisbane Baylands development with the existing surroundings (Image 3B), and
- **Cumulative:** The Project with the addition of other reasonably foreseeable developments (Image 3C).

The computer models of the assessed configurations are shown in the following images. All models include the terrain and building features present in an area spanning approximately 3.5 miles from south to north and 3 miles from west to east. The level of details was chosen based on the expected influence the terrain and built environment may have on wind conditions at the area of interest. Beyond these detailed models, the effects of terrain were considered by applying appropriate input conditions (wind profile and turbulence conditions for each wind direction). These input conditions represent the atmospheric boundary layer appropriate for the given upwind conditions from the site.

3. METHODOLOGY

Image 3A: Computer Model – Existing Configuration – Existing Site and Surroundings

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Image 3B: Computer Model – Project Configuration – Proposed Brisbane Baylands Development with the Existing Surroundings

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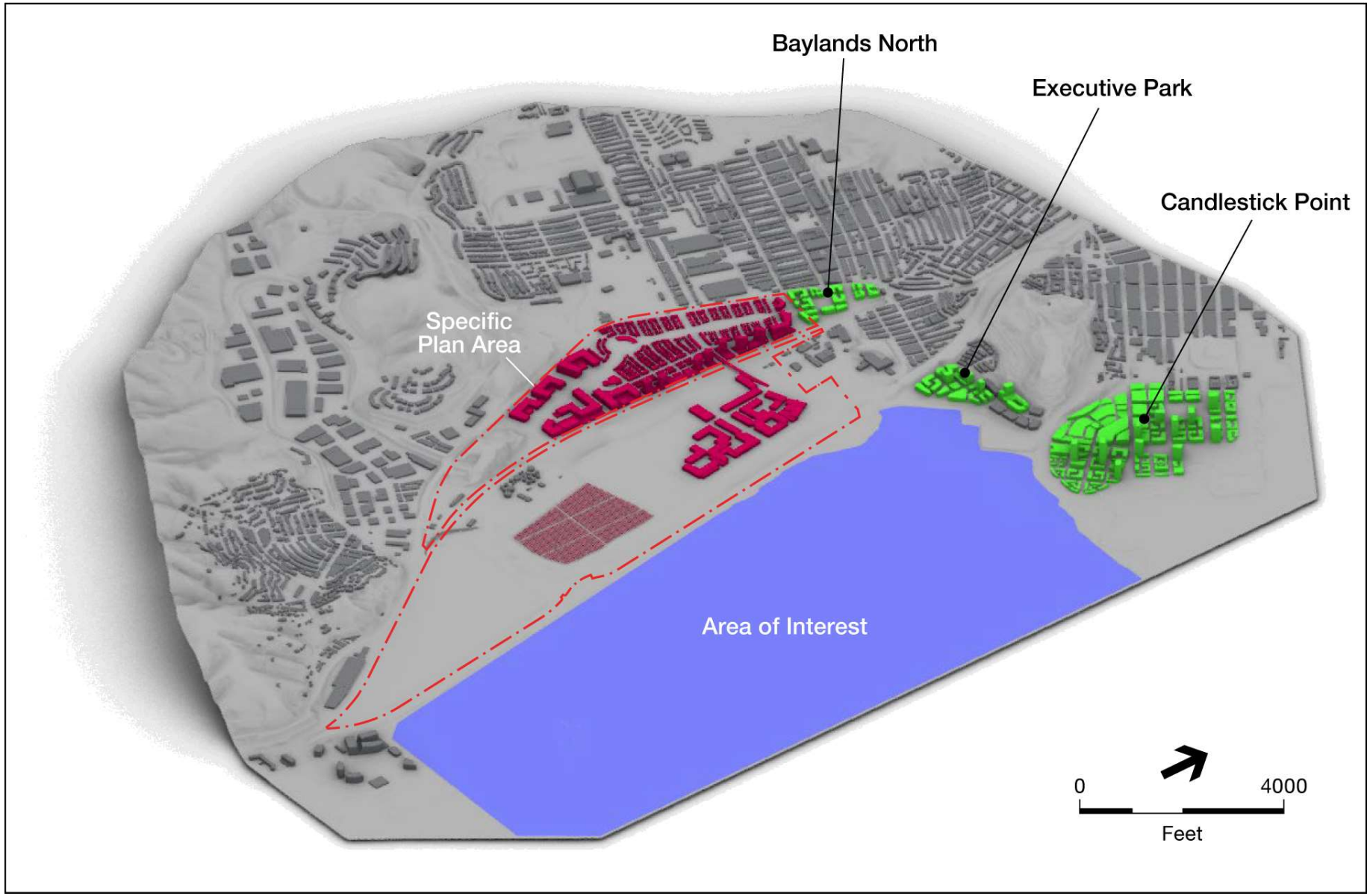

Image 3C: Computer Model – Cumulative Configuration – The Project with the Addition of Other Reasonably Foreseeable Developments

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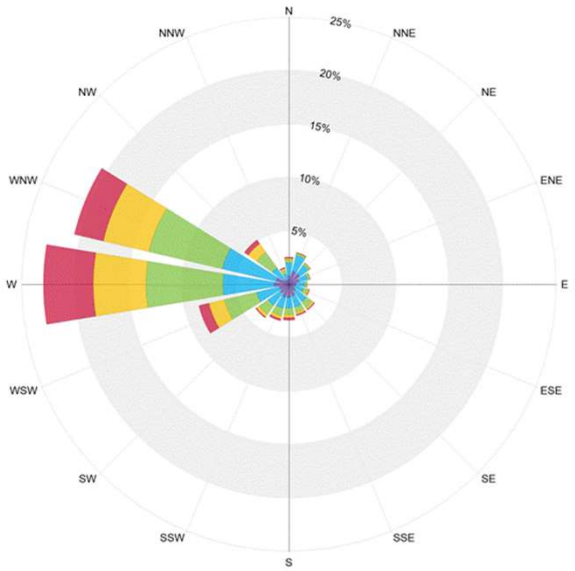
3. METHODOLOGY

3.2 Wind Climate

Long-term Wind statistics recorded at San Francisco International Airport between 1992 and 2022, were used as a reference for wind directionality and speed in the area. Image 4 graphically depicts the directional distributions of wind frequencies and speeds on an annual basis. Winds from west-southwest through northwest are most frequent in the area.

Given the location of the proposed and future developments relative to the area of interest, west (W, 270°), west-northwest (WNW, 292.5°) and northwest (NW, 315°) winds have the highest potential for wind impact. Therefore, these three wind directions were simulated using CFD and are considered the worst-case scenario for potential impact on water-related recreational activities. West-southwest winds, although more prevalent than northwest winds, were not simulated because the Project site and future developments are not generally upwind from the area of interest for winds from this direction.

The average free stream velocity at an elevation of 2000 feet above grade for the three wind directions considered in this study is approximately 25.7 mph. This reference wind speed was used to estimate the value of the average wind speed and fluctuations over the area of interest.



Wind Speed (mph)	Probability (%)
Calm	10.4
1-5	15.4
6-10	26.1
11-15	24.7
16-20	13.5
>20	9.9

Image 4: Directional Distribution of Winds Recorded at San Francisco International Airport (1992 to 2022)

3. METHODOLOGY

3.3 Criteria

As most of water-related recreational activities rely on wind for lift/drag force for propulsion, which is proportional to the second power of wind speed, strong and consistent (low fluctuations/turbulence) winds are often preferred for wind- and kite-surfing enthusiasts as they allow for greater exhilaration and better maneuverability. To RWDI's knowledge, there are no specific criteria on wind conditions for water-related recreational activities. For this reason, this study focuses on the change in average wind speeds and turbulence levels relative to the existing conditions.

3.3.1 Average Wind Speed

The instantaneous wind speed for a specific period of time can be decomposed into an average value over that period and a fluctuating component for each instance of time. See the equation below:

$$S(t) = \bar{S} + s'(t)$$

Instantaneous Speed — Average Speed — Fluctuating Component

The average wind speed is selected to represent the Existing, Project and Cumulative wind conditions. The total run time for simulations was around one hour for each angle considered. The time steps varied throughout the simulation runs but remained below one second.

3.3.2 Wind Fluctuation

Another metric that is considered in this study is the Root Mean Square (RMS) of the fluctuating component of the wind which represents the average amount of wind speed fluctuations during the simulation period.

$$RMS(s') = \sqrt{\frac{1}{n}\sum_{t} s'^{2}\,(t)}$$

Total Number of Values

In this study the average wind speeds and fluctuations at the area of interest are compared to the existing conditions.

4. RESULTS

4.1 Overview

The results of the simulations are presented in Images 5.1 through 6.3 for the average changes in wind speeds and wind fluctuations for the three wind directions considered.

The results are presented as color contours depicting the predicted average changes for the Project and Cumulative configurations compared with Existing configuration (i.e., Project/Cumulative - Existing). The positive and negative values show increased and decreased wind speed/fluctuation compared to the existing condition. The featured horizontal presentation plane height is at 5-feet above the area of interest. This height is considered representative of the elevation of a windsurfer's sail. In addition, as it is near sea level, this height is also conservative, as it would be the height at which nearby landside development would have the greatest effect on wind conditions in the Bay.

Additional horizontal presentation planes at 10-feet, 16-feet, 32-feet, and 82-feet above the area of interest have also been considered for post-processing. The absolute average wind speeds and average wind fluctuations for all the configurations simulated can be found in Appendix A and Appendix B, respectively on all five presentation planes and the three wind directions. In the existing site, the average wind speeds at 5-feet above the water at shorelines near the project area are expected to be around 7-9 mph which then can go up to 9-11 mph further away from land in case of westerly winds; the average wind fluctuations are around 2 mph.

4.2 Discussion

In the Project and Cumulative configurations, the overall wind conditions at the area of interest would remain comparable to the existing conditions. With the addition of the Project, average wind speeds are expected to be slightly reduced in the vicinity of the shorelines downwind of project site. The exact intensity and extent of the influenced areas depends on the wind direction.

The expected changes in case of the most prevalent west (W) winds can be seen in Image 5.1. As can be seen in the left figure, the Project is expected to reduce the average wind speeds by 1 to 2 mph about 300 yards downwind of the project site at the area of interest. The impact of the Project would dissipate further downstream. The Cumulative (right figure) is expected to have minimal impact on the area of interest for west winds.

Similarly, in the case of west-northwest (WNW) winds (see Image 5.2), Project (left figure) would reduce the average wind speeds by 1 to 1.5 mph about 300 yards downstream over the area of interest. The Cumulative developments (right figure) are expected to have an added wind reduction, especially downwind of Candlestick Point and Executive Park at the northern part of the area of interest.

4.2 Discussion– Continued

During northwest (NW) winds (see Image 5.3), the Project (left figure) would result in some moderate decrease in wind speeds farther from shore, particularly in the southern part of the area of interest. However, this decrease in wind speed would be small and on the order of 1 to 1.5 mph. Similar to the case of WNW winds, the Cumulative project would have relatively higher impact on the northern part of the area of interest. The blockage caused by these future buildings would redirect the winds and, as a result, localized areas of increased and decreased wind speeds can occur downwind of these developments. However, as NW winds are less frequent and usually occur about 5 percent of the time (see Image 4 on page 8) the predicted conditions in this case are of less significance.

As for turbulence, the wind fluctuations are expected to increase to a small degree, with the greatest effect anticipated downwind of the Project's tallest buildings and those closest to the shoreline similar to influenced areas presented for average wind speeds (about 300 yards downstream). In case of W winds (see Image 6.1), average wind fluctuations would increase for about 0.5 to 1 mph close to the shoreline; the Cumulative would not have additional effect on the area of interest. For both WNW and NW winds (see Images 6.2 and 6.3), the Project's effect on turbulence would be comparable to W winds but would occur closer to the shoreline and extend further south. Similar to the average wind speed, the Cumulative would have relatively higher turbulence impact at the northern part of the area of interest in case of WNW and NW winds, but the increase would remain lower than 1 mph.

Similar wind impact patterns would occur at higher elevations than those described above; however, as winds are stronger at higher elevations, the impacted areas would be relatively smaller when compared to lower elevations.

4.3 Summary & Conclusion

Based on the foregoing, our findings are summarized as follows:

- Wind conditions around the majority of the area of interest is not expected to be influenced by the Project. The average changes are expected to be small, and it is not expected to substantially degrade the existing wind-related recreational resource offshore from the project site and adjacent to Candlestick Point State Recreation Area.
- For the Cumulative developments, as shown in the right-hand figures in Images 5.1 through 6.3, there would be some additional decrease in wind speeds and increase in turbulence in the case of WNW and NW winds. However, the area affected would be limited to the northern tenth part of the area of interest, closest to the Candlestick Point development.
- Wind impact patterns at higher elevations would exhibit similarities to the ones presented in the body of report. Nevertheless, due to the increased strength of winds at higher altitudes, the affected regions would be comparatively smaller compared to lower elevations.

4. RESULTS

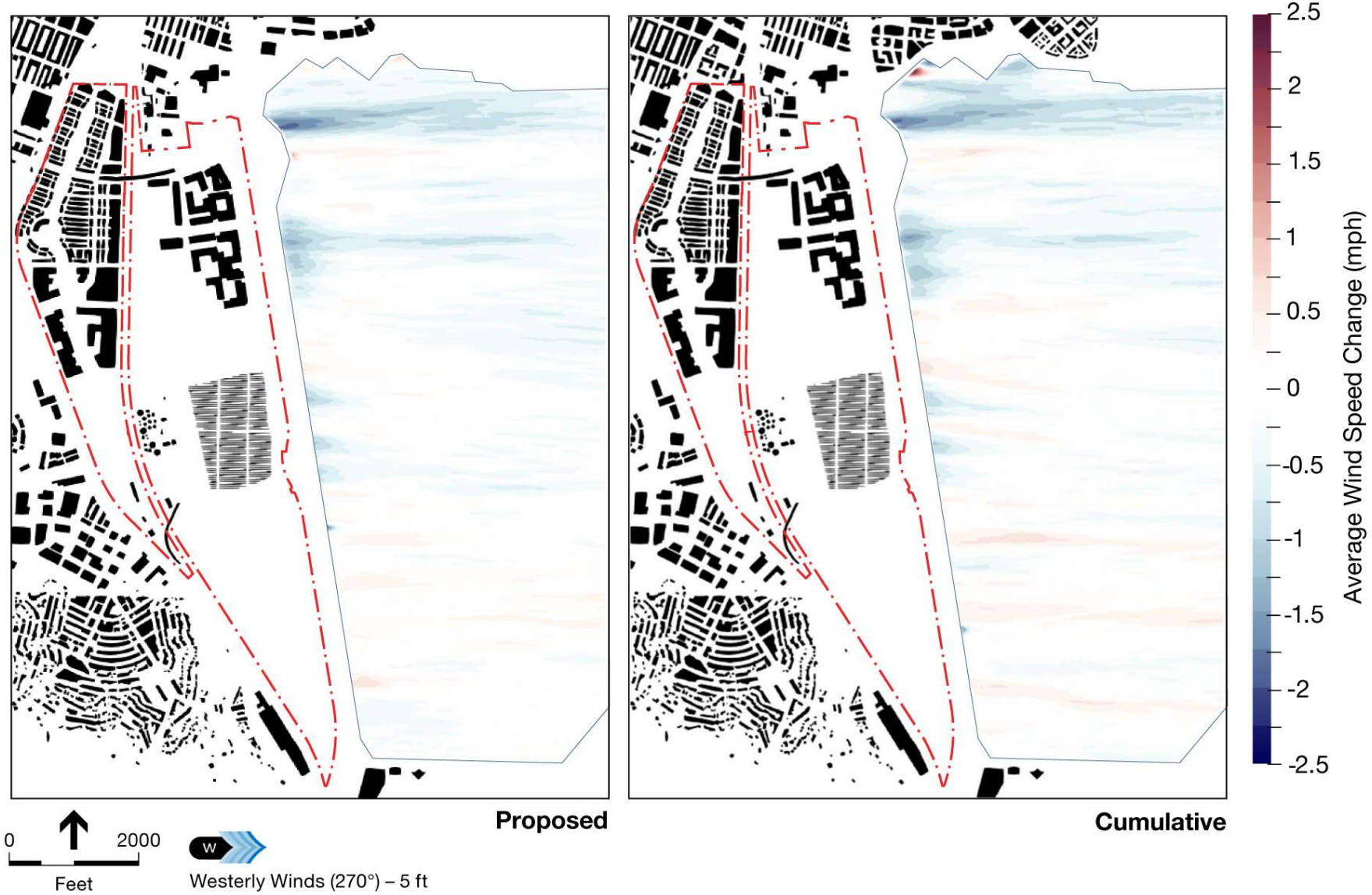


Image 5.1: Predicted Average Wind Speed Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions

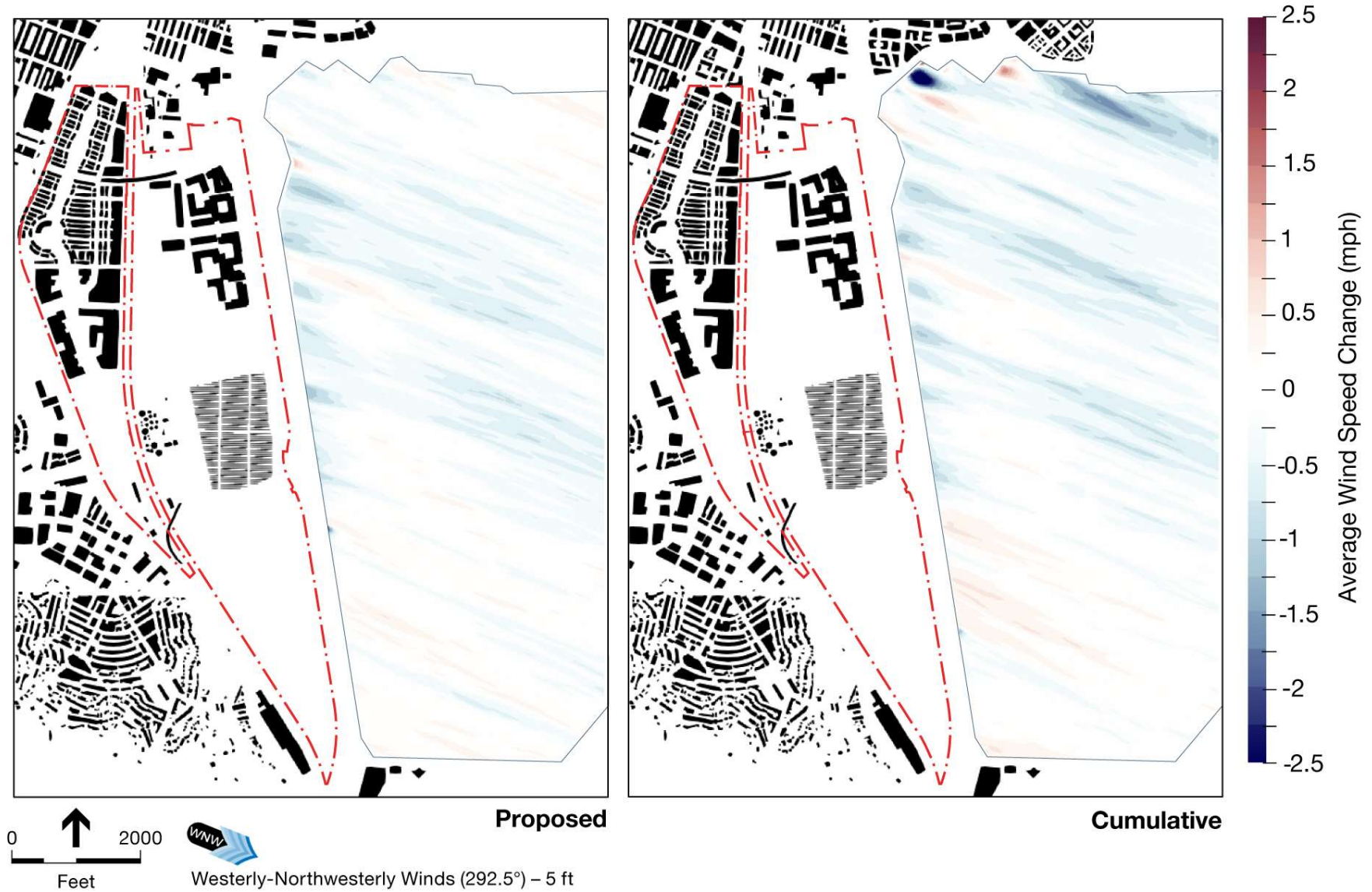


Image 5.2: Predicted Average Wind Speed Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions

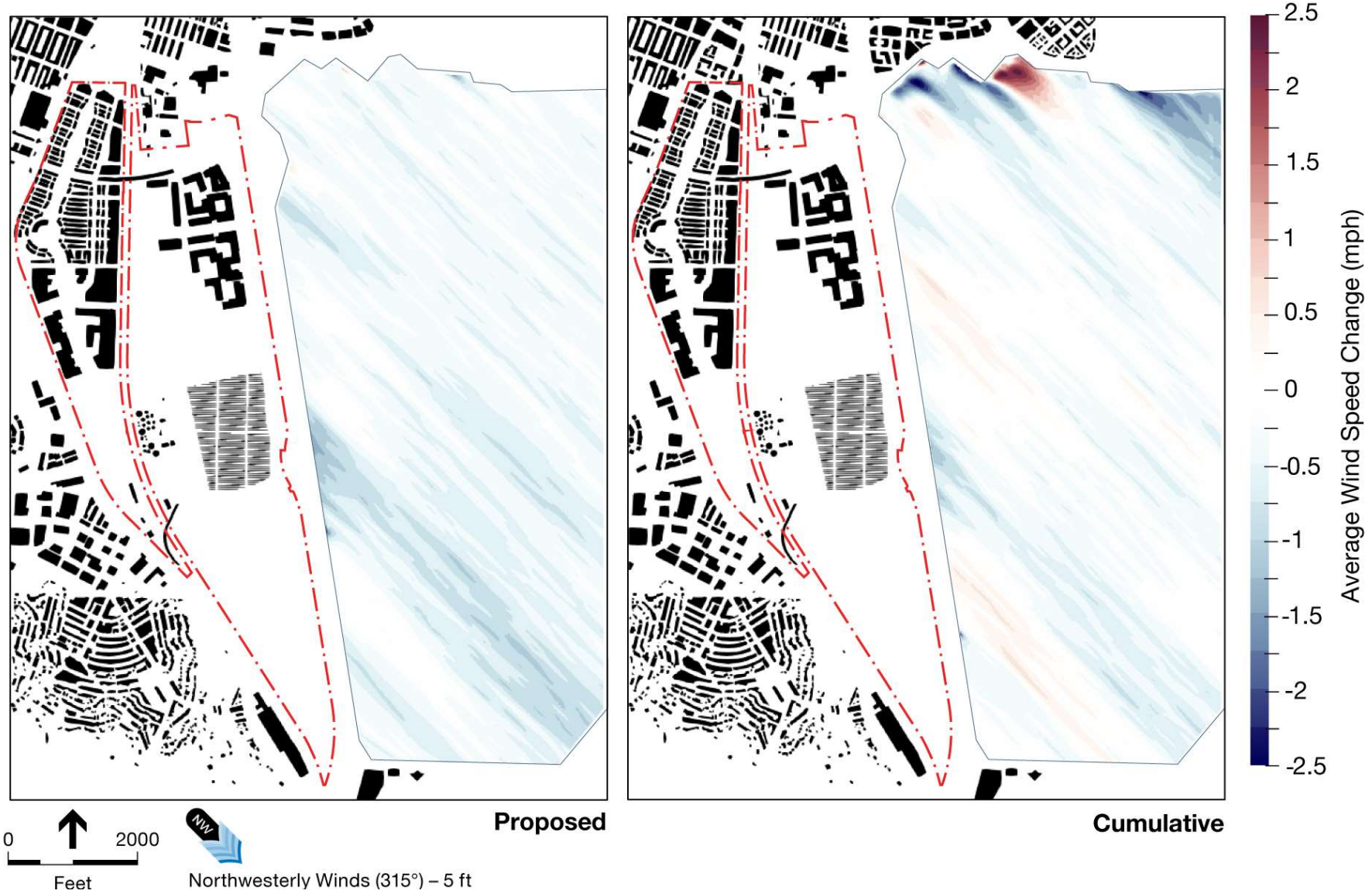


Image 5.3: Predicted Average Wind Speed Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions

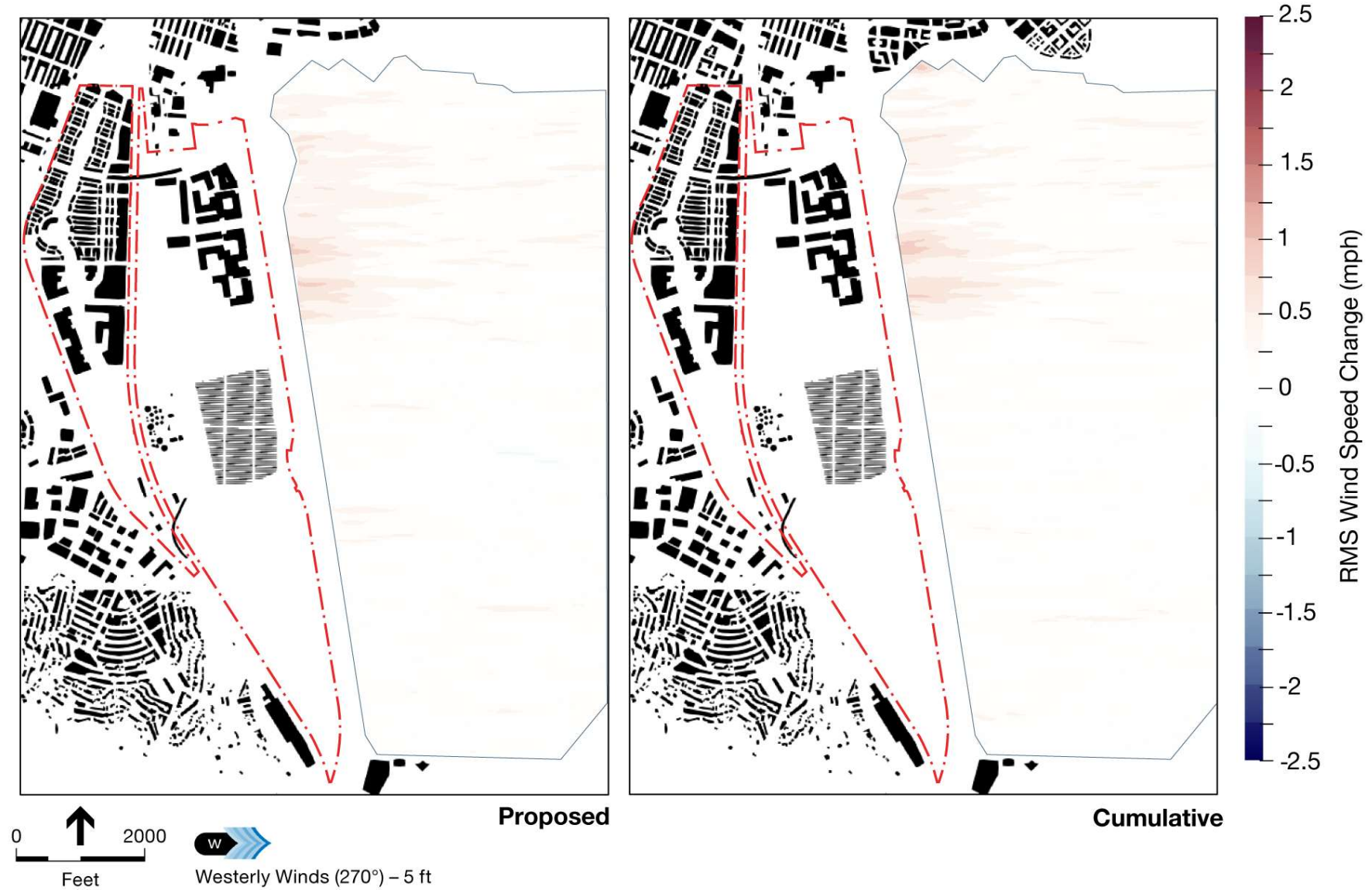


Image 6.1: Predicted Average Wind Fluctuation Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions
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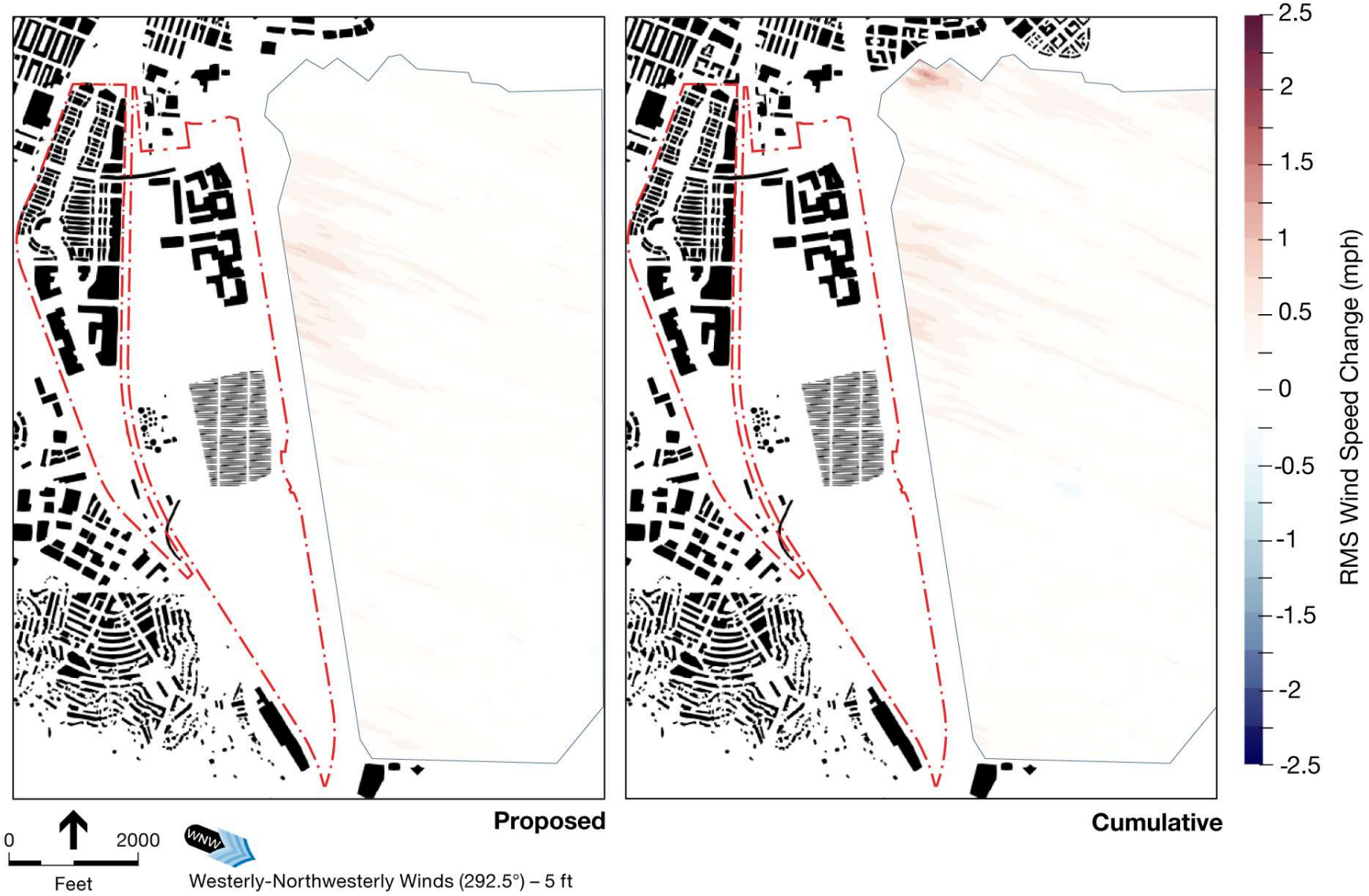

Image 6.2: Predicted Average Wind Fluctuation Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions
RWDI Project #2301053
August 23, 2023

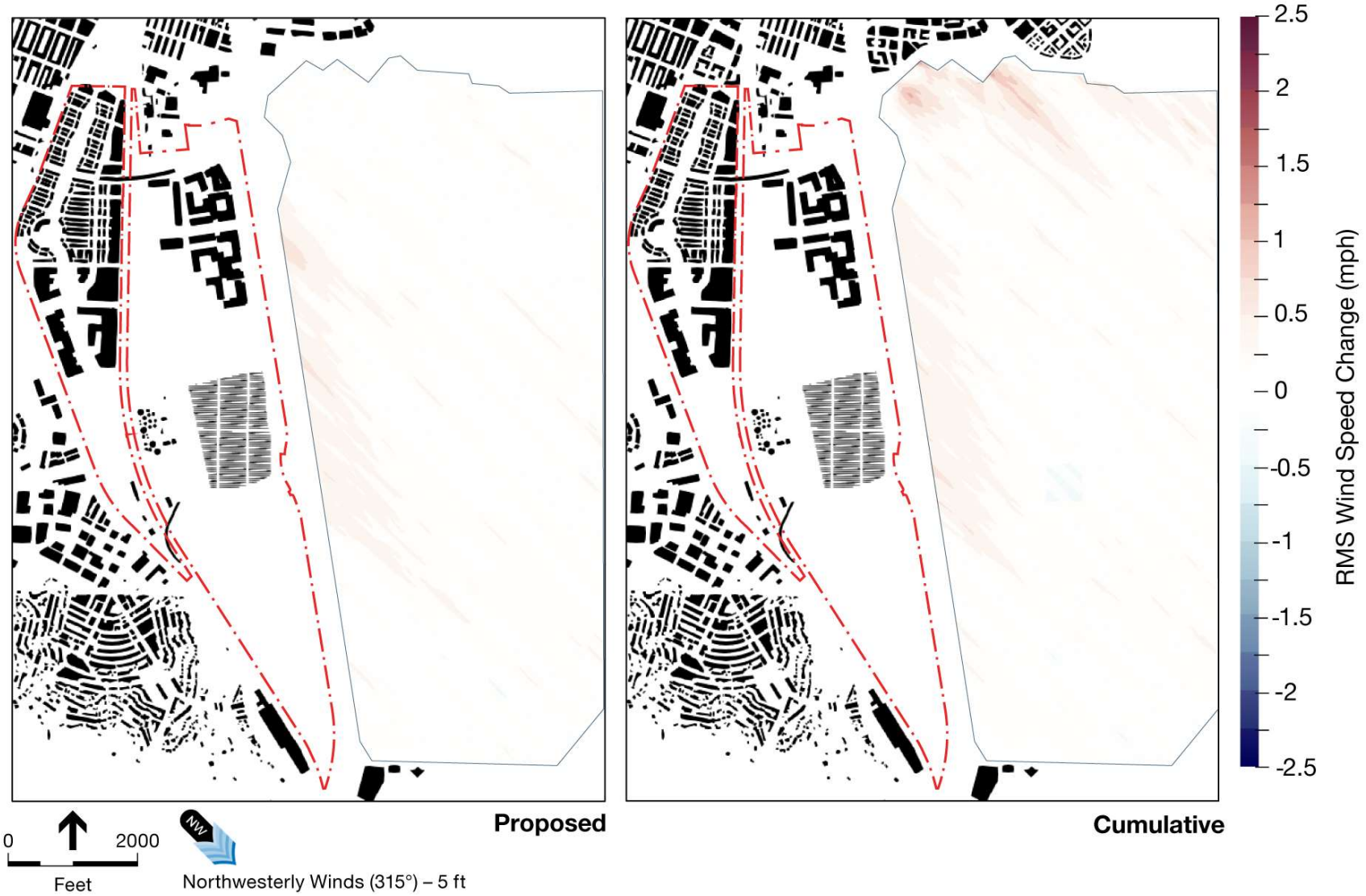

Image 6.3: Predicted Average Wind Fluctuation Changes in Proposed (Left) and Cumulative (Right) Configurations Compared to the Existing Conditions
RWDI Project #2301053
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5. DESIGN ASSUMPTIONS

The findings in this report are based on the building geometries and site plans communicated to RWDI listed below. Should the details of the proposed design and/or geometry of the building change significantly, results may vary.

File Name	File Type	Date Received (mm/dd/yyyy)
20221014-VV 3d Massing	SketchUp	05/18/2023
Height Map from CP-HP Addendum 6	PDF	05/18/2023
Site Plan w-Cumulative - MARKED UP	PDF	05/18/2023
2004.1031CRV - 601 Crescent Way	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 1	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 2	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 4	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 5-6	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 7	PDF	05/18/2023
2018-0118 FINAL PLAN SUBMIT - Parcel 8	PDF	05/18/2023
180615-EP-Blk3-Planning-Re-Submittal#2 - MBH	PDF	05/18/2023
Plans and Graphics - 5 Thomas Mellon Cir - 2015-009690CUA.pdf	PDF	05/18/2023
20221117_Baylands model	Rhino	12/21/2022

Changes to the Design or Environment

It should be noted that perception of wind is subjective and can be sensitive to changes in building design and operation that are possible during the life of a building. In the event of changes to the design, construction, or operation of the building in the future, RWDI could provide an assessment of their impact on the discussions included in this report. It is the responsibility of Others to contact RWDI to initiate this process.

6. STATEMENT OF LIMITATIONS

This report was prepared by Rowan Williams Davies & Irwin Inc. for Environmental Science Associates ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein and authorized scope. The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

The conclusions contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions provided.

APPENDIX A

AVERAGE WIND SPEEDS

AVERAGE SPEEDS

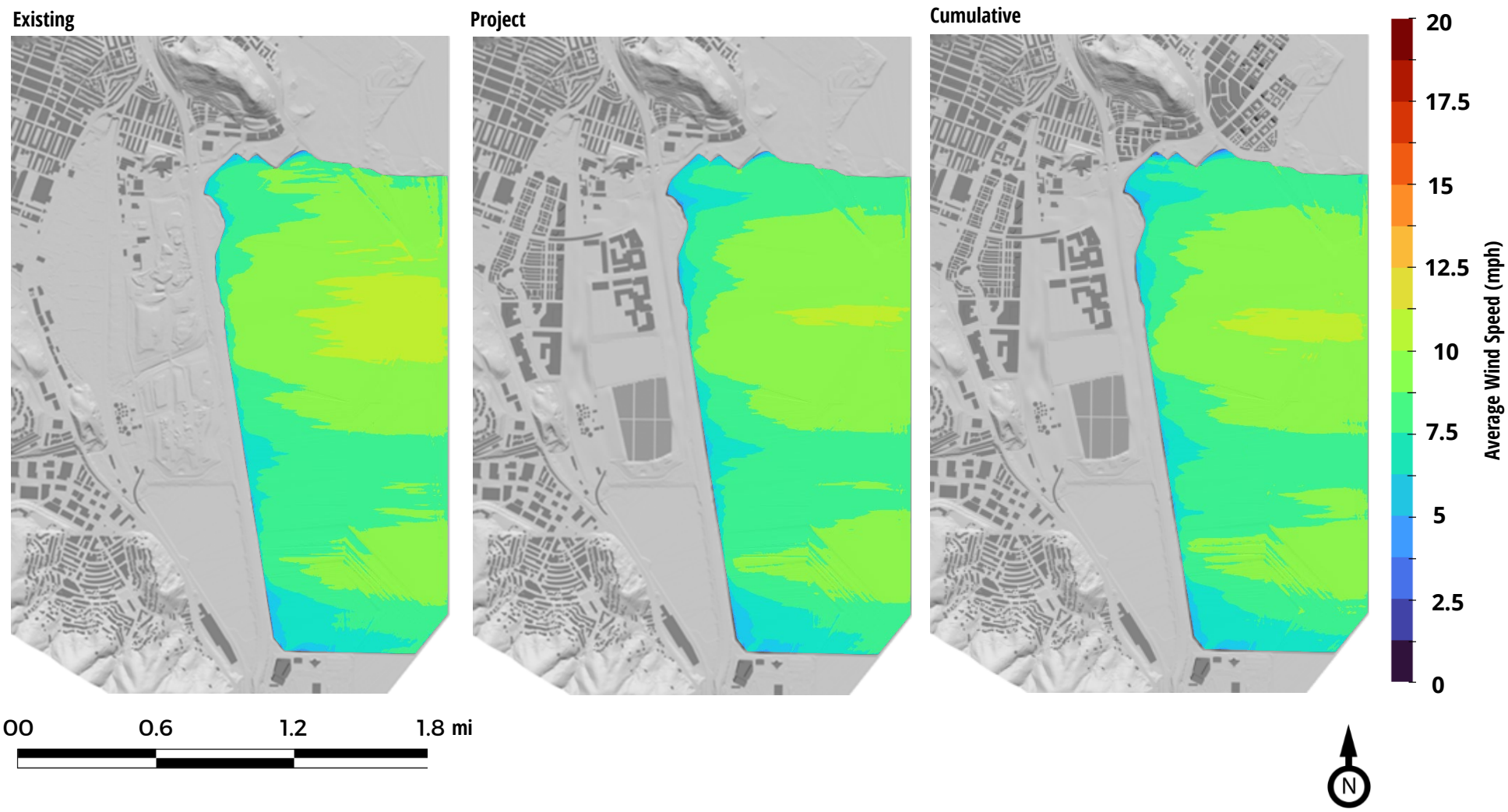

Image A.1.1: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Westerly Winds (270°) – 5 ft

RWDI Project #2301053
June 23, 2023

AVERAGE SPEEDS

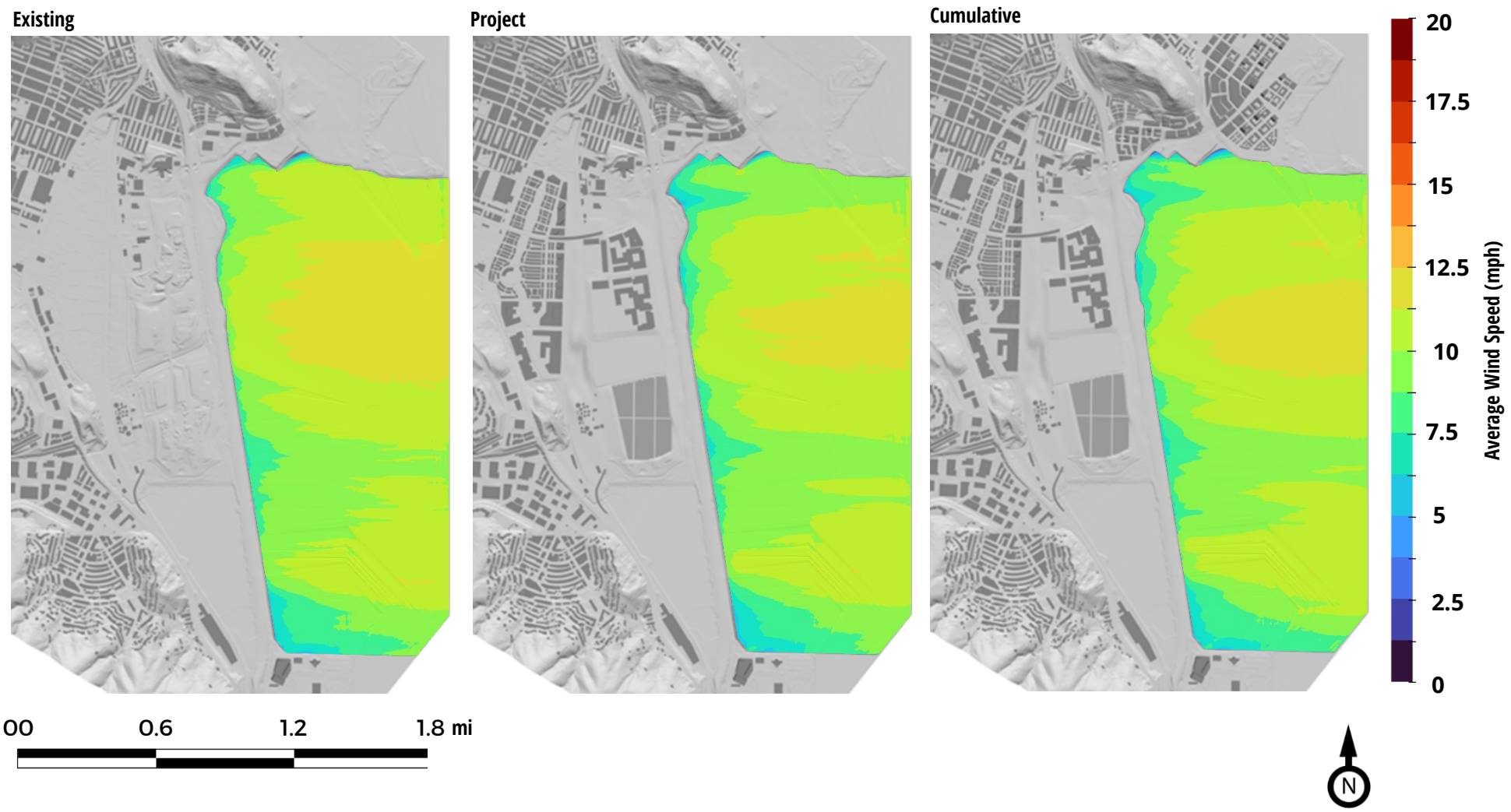

Image A.1.2: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Westerly Winds (270°) – 10 ft

AVERAGE SPEEDS

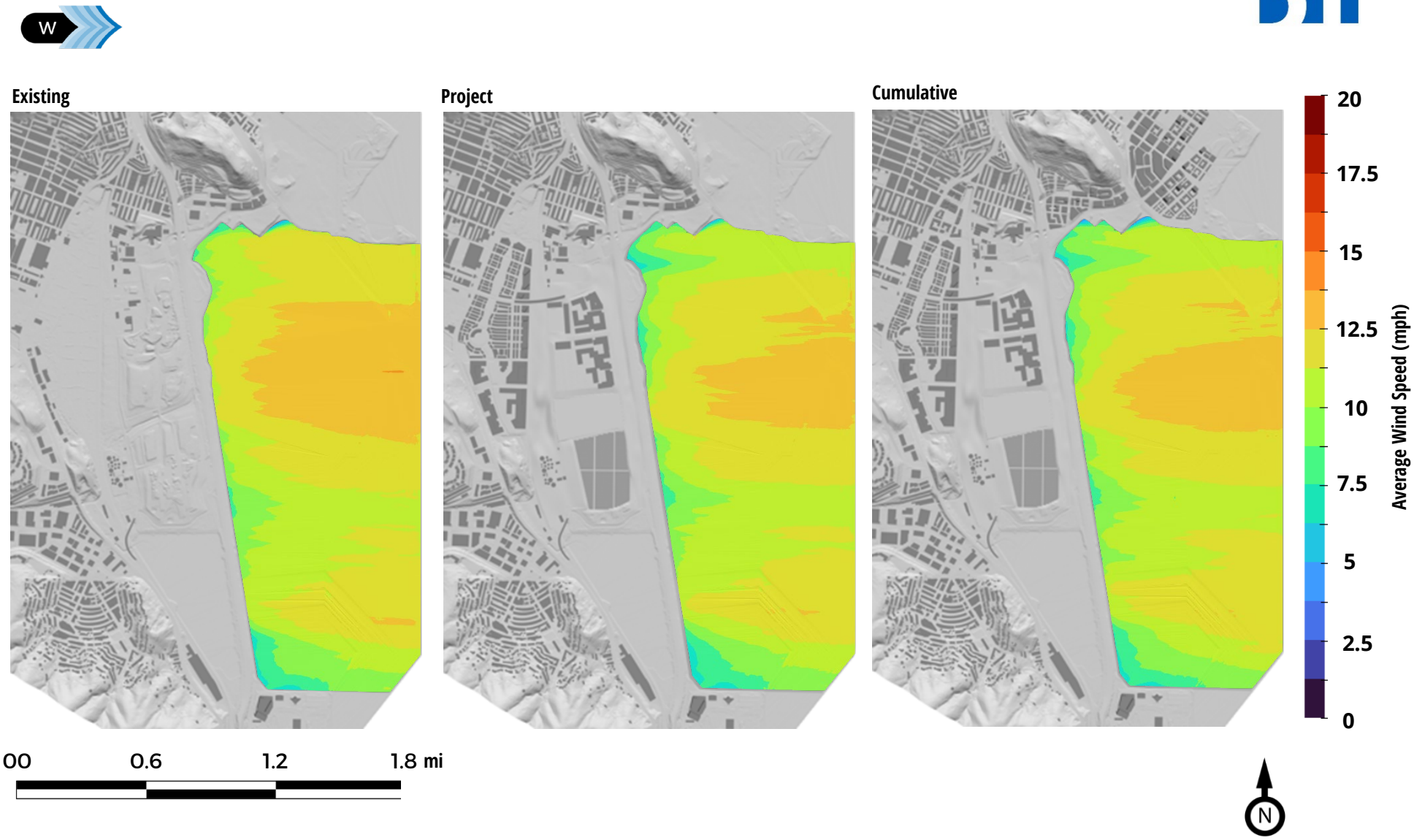

Image A.1.3: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Westerly Winds (270°) – 16 ft

AVERAGE SPEEDS

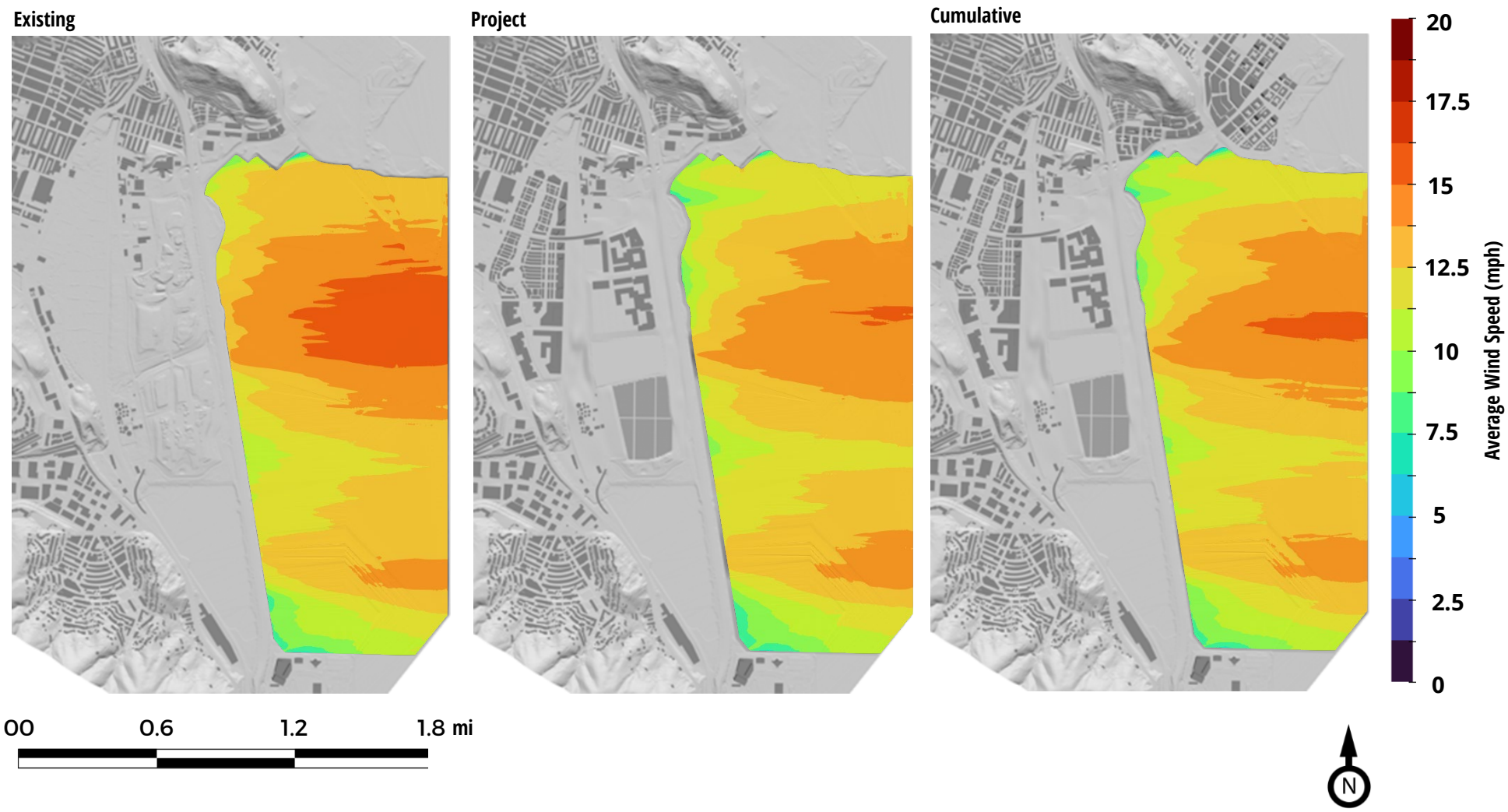

Image A.1.4: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Westerly Winds (270°) – 32 ft

AVERAGE SPEEDS

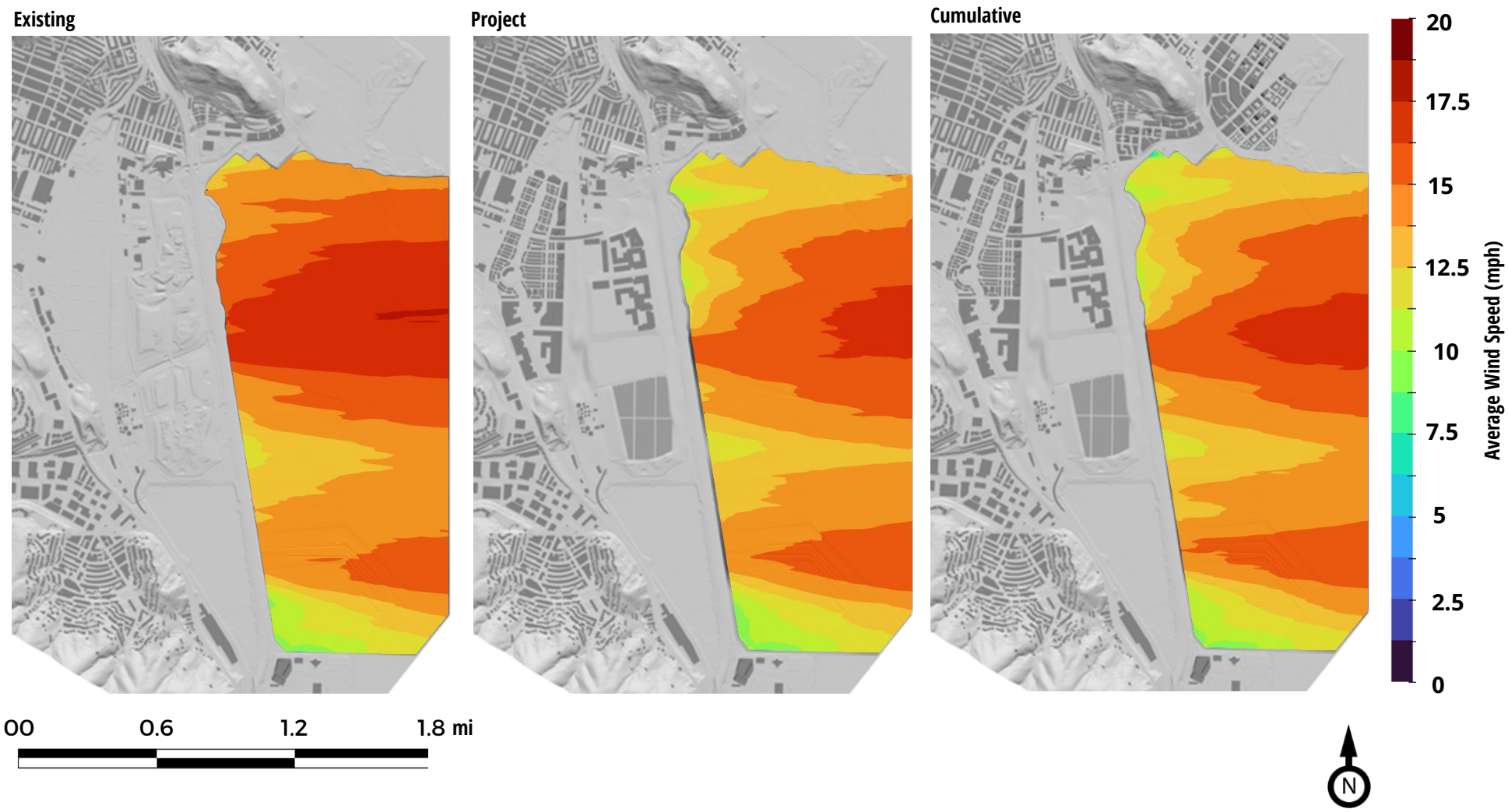

Image A.1.5: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly Winds (270°) – 82 ft

AVERAGE SPEEDS

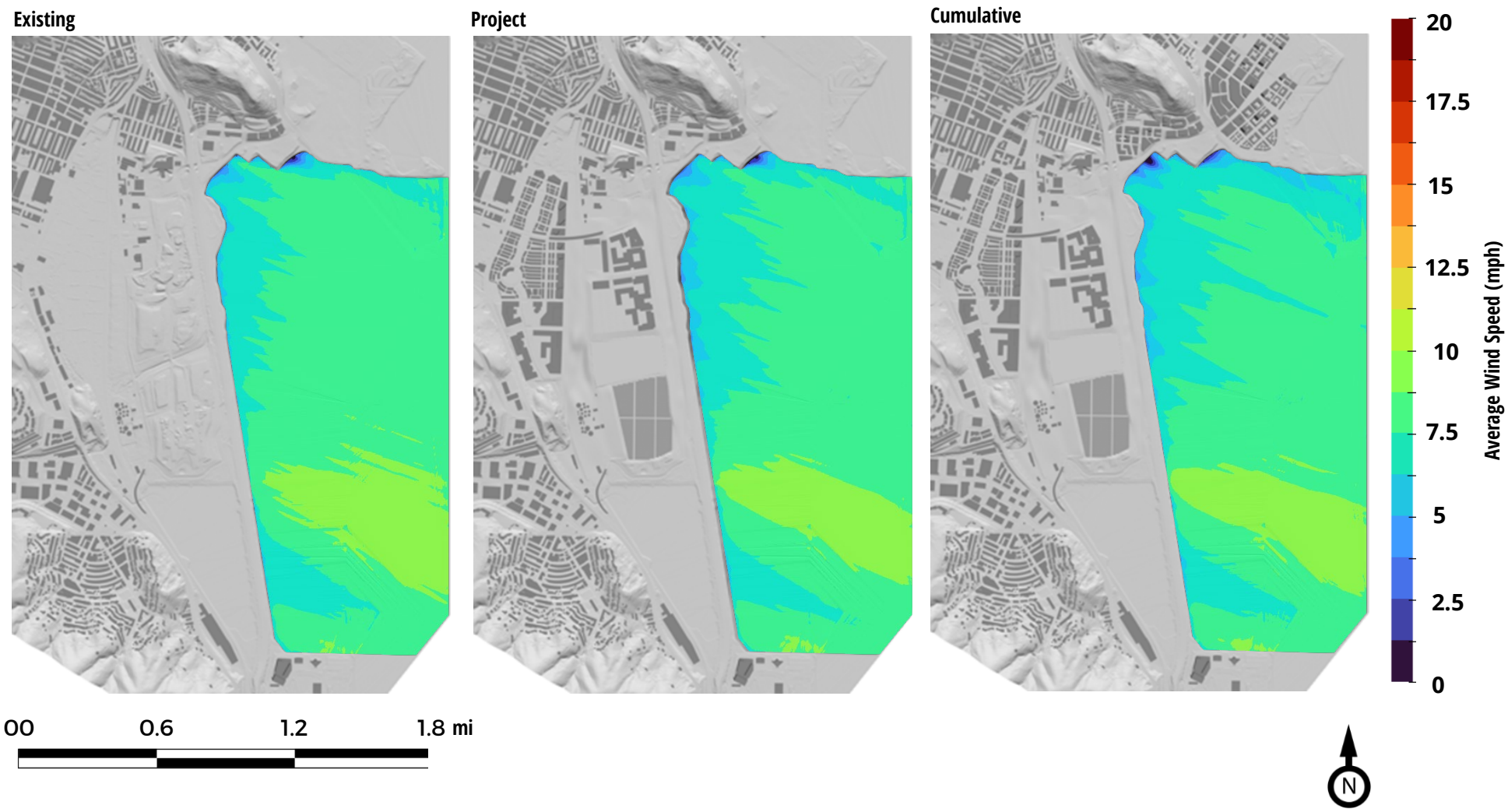

Image A.2.1: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

West-Northwesterly Winds (292.5°) – 5 ft

AVERAGE SPEEDS

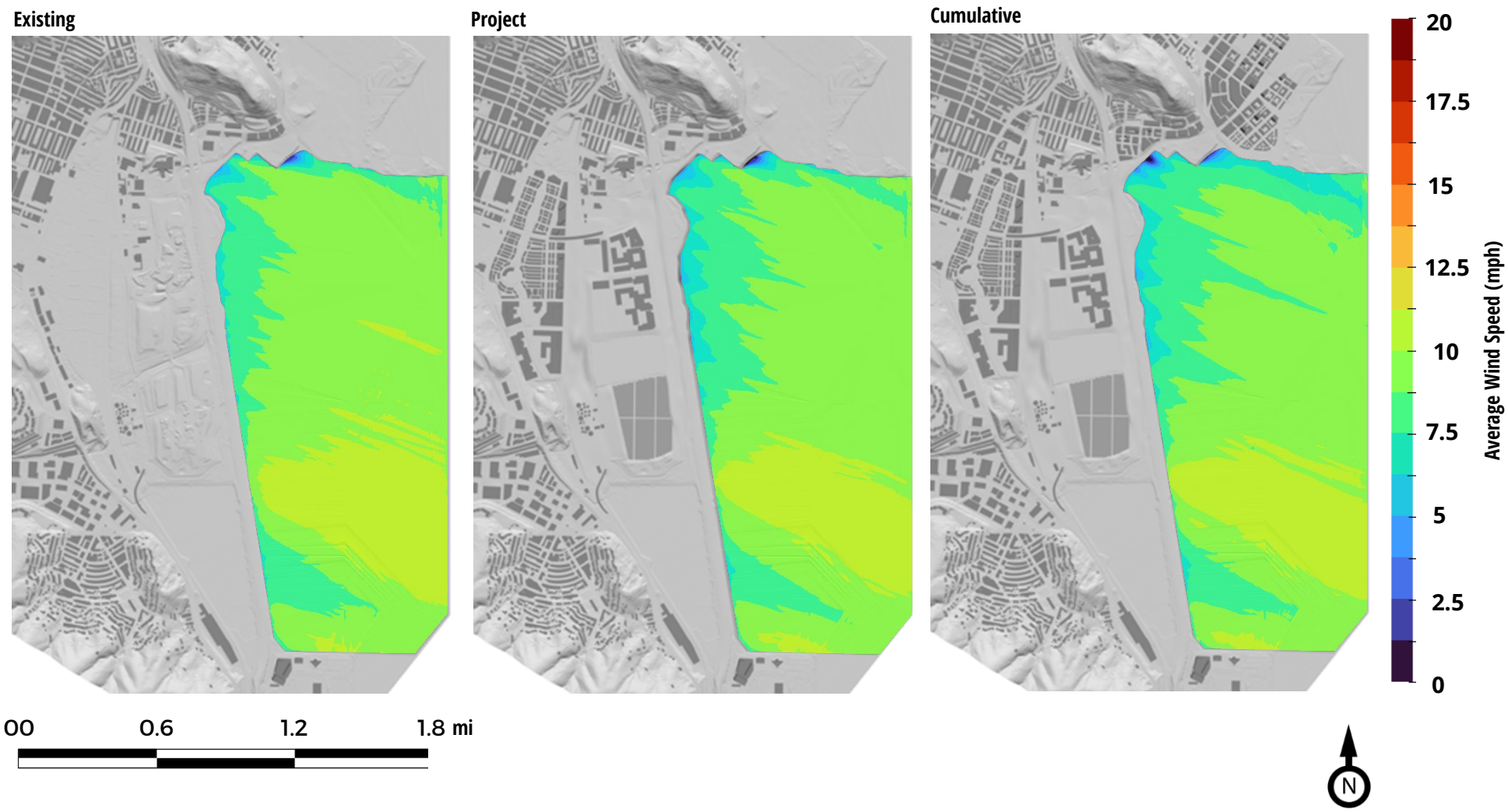

Image A.2.2: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

West-Northwesterly Winds (292.5°) – 10 ft

AVERAGE SPEEDS

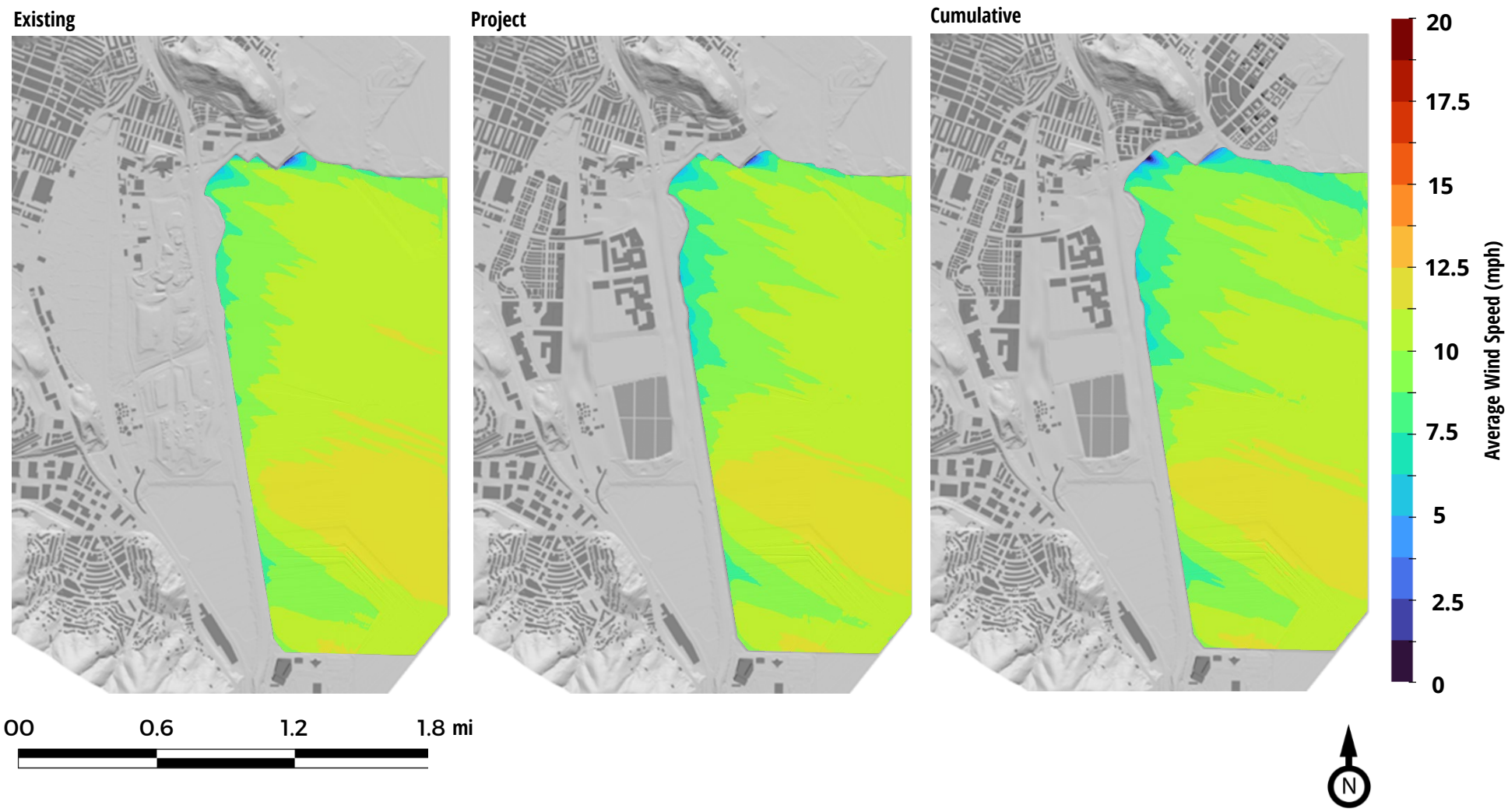

Image A.2.3: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

West-Northwesterly Winds (292.5°) – 16 ft

AVERAGE SPEEDS

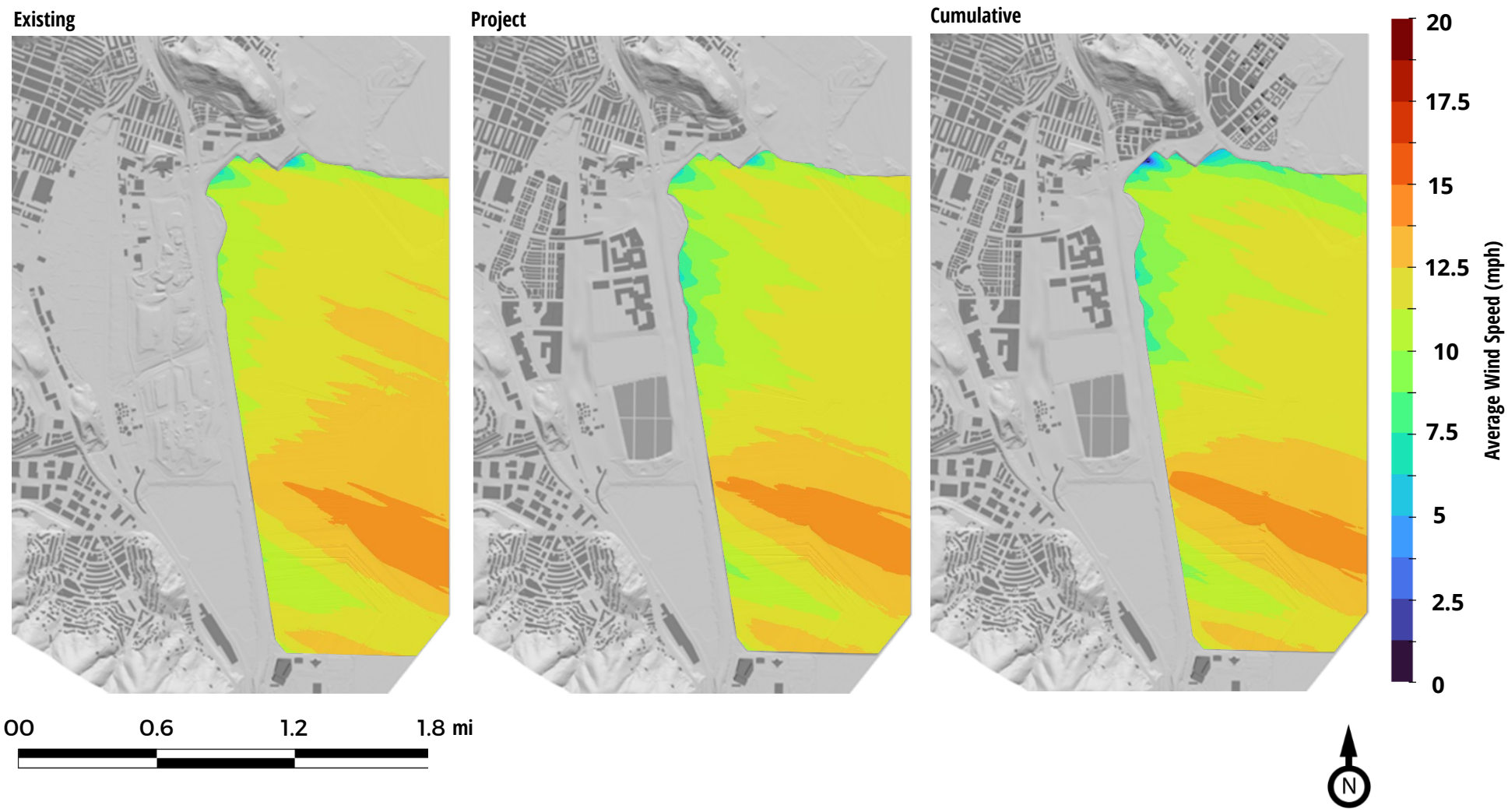

Image A.2.4: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

West-Northwesterly Winds (292.5°) – 32 ft

AVERAGE SPEEDS

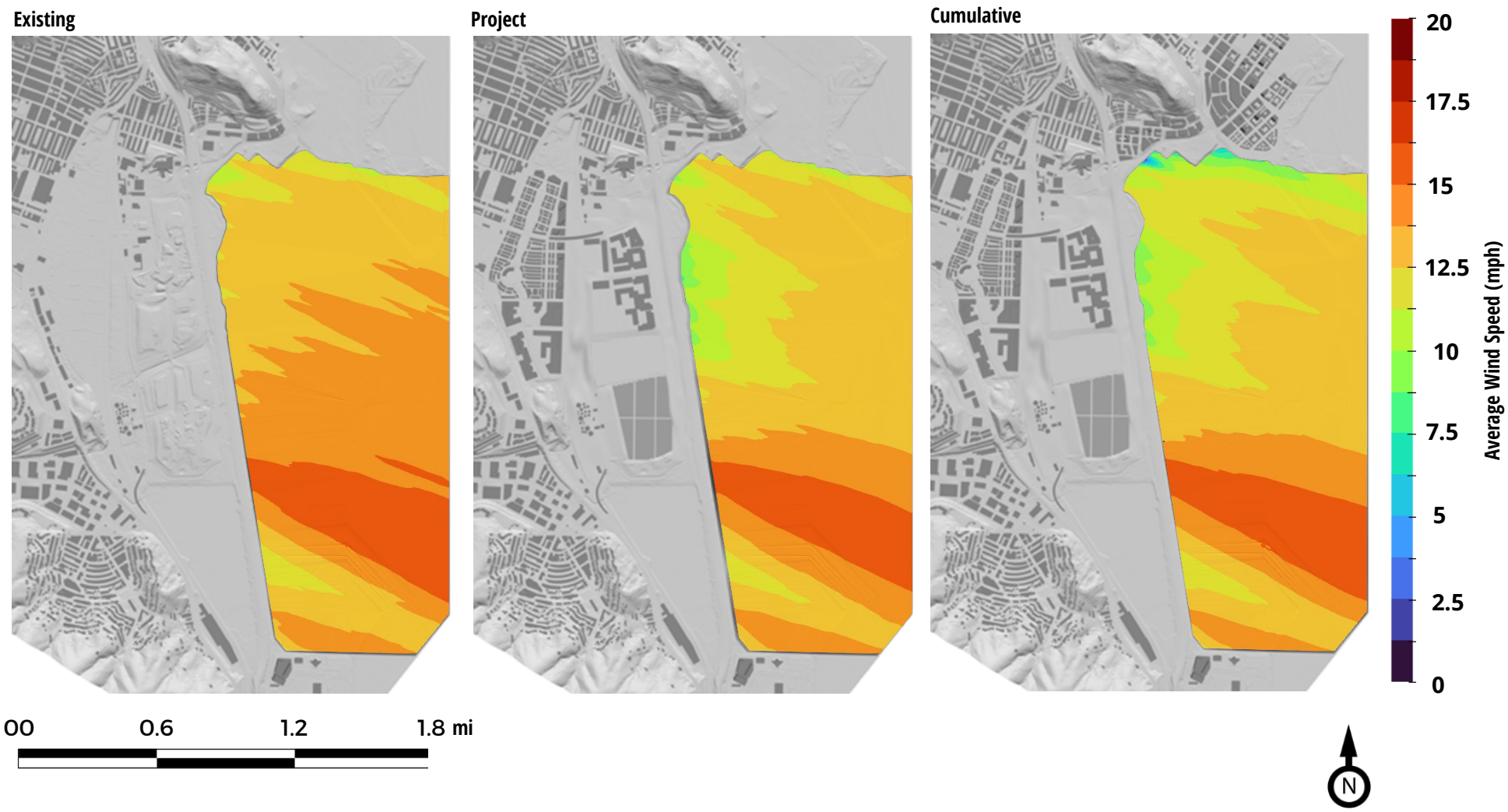

Image A.2.5: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

West-Northwesterly Winds (292.5°) – 82 ft

AVERAGE SPEEDS

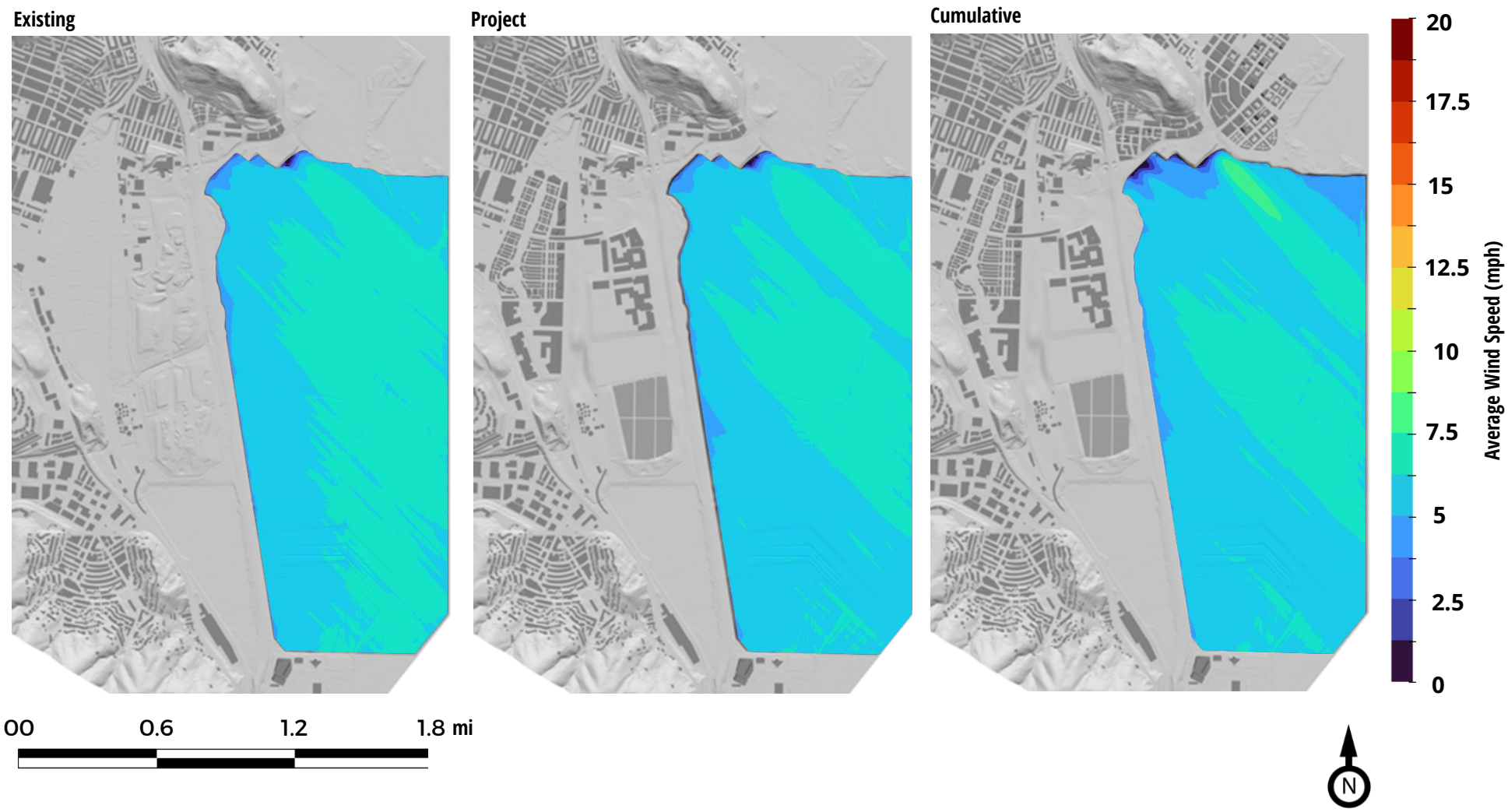

Image A.3.1: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Northwesterly Winds (315°) – 5 ft

RWDI Project #2301053
June 23, 2023

AVERAGE SPEEDS

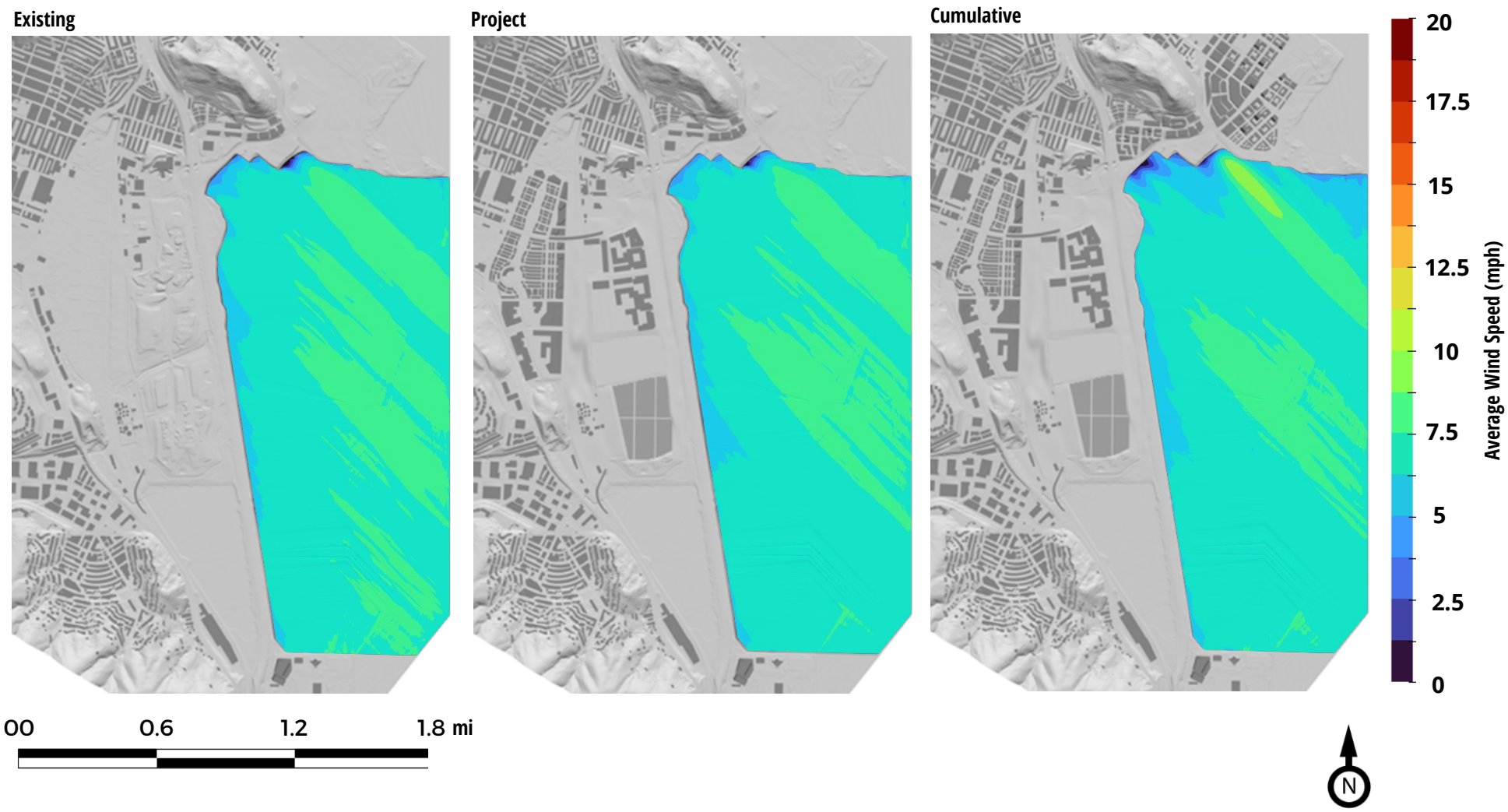

Image A.3.2: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Northwesterly Winds (315°) – 10 ft

AVERAGE SPEEDS

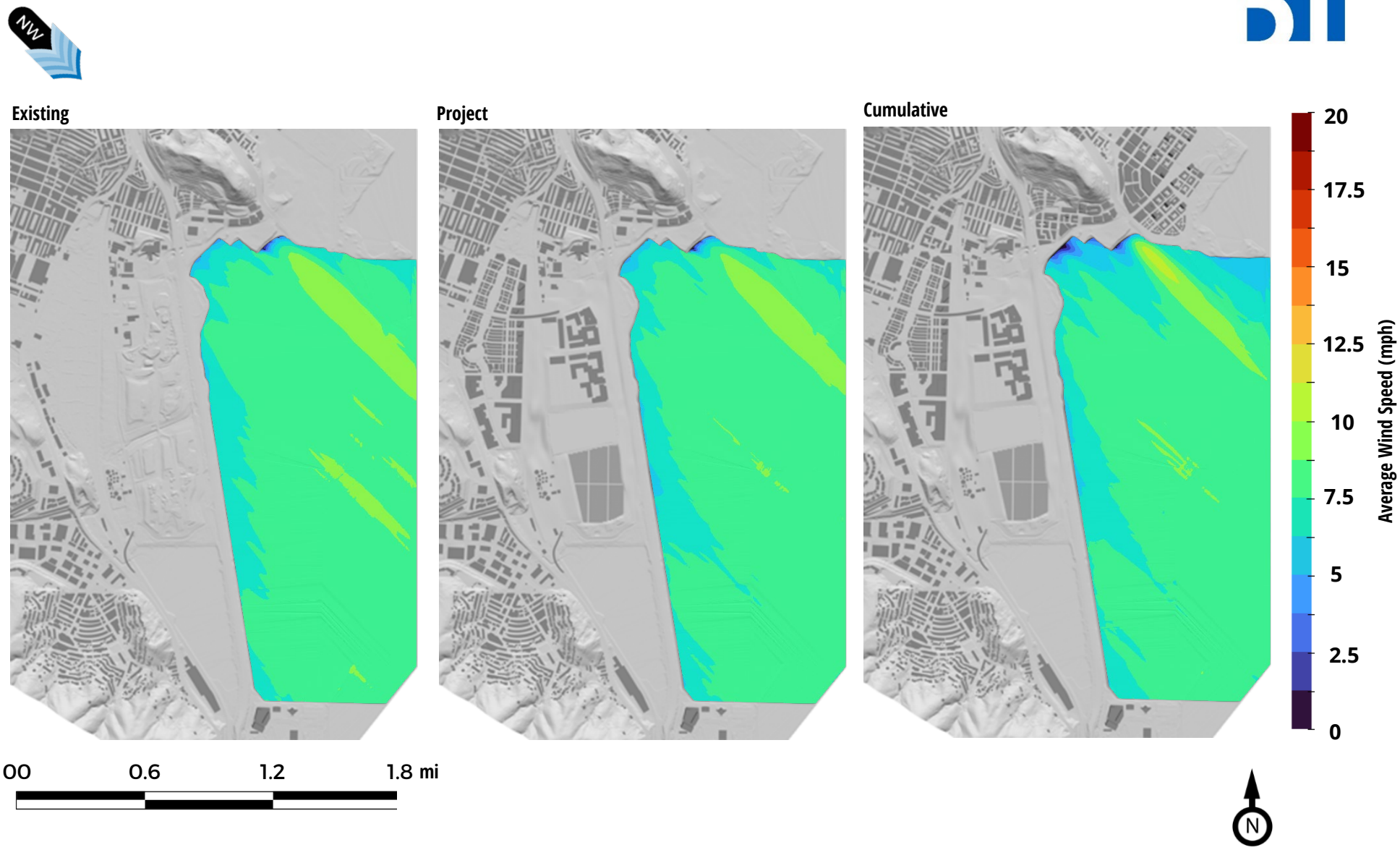

Image A.3.3: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Northwesterly Winds (315°) – 16 ft

AVERAGE SPEEDS

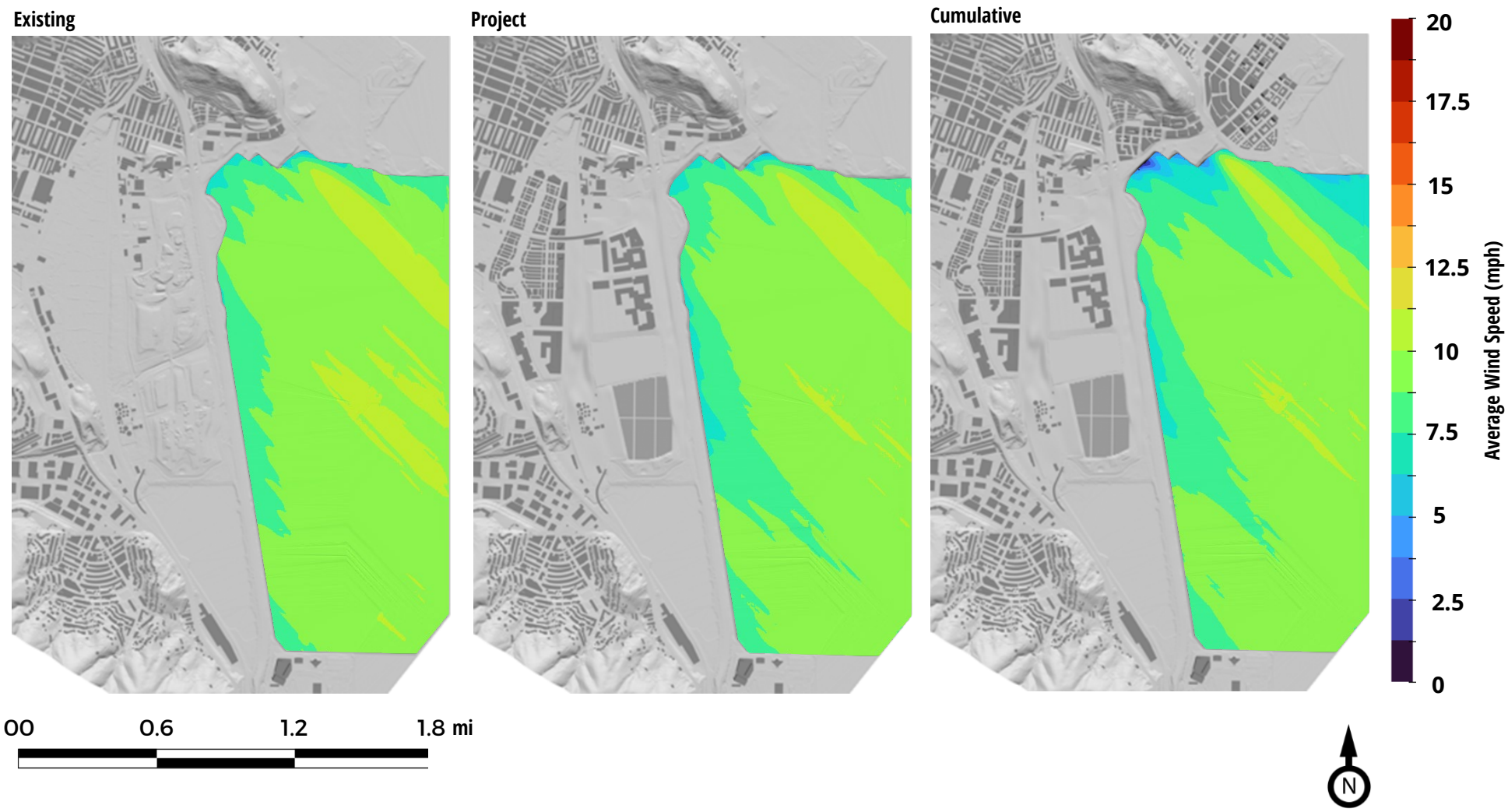

Image A.3.4: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Northwesterly Winds (315°) – 32 ft

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AVERAGE SPEEDS

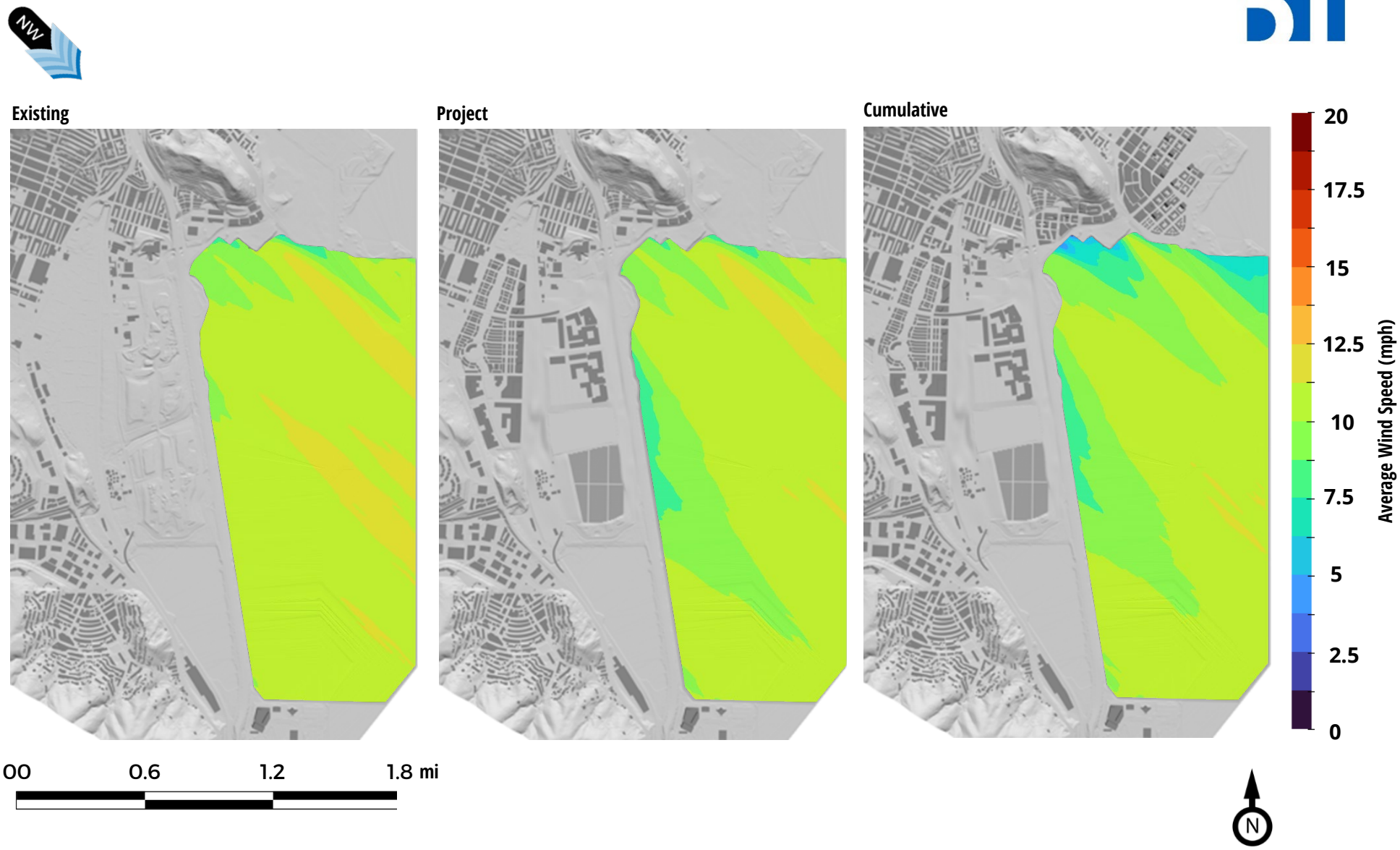

Image A.3.5: Predicted Average Wind Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Northwesterly Winds (315°) – 82 ft

APPENDIX B

AVERAGE WIND FLUCTUATIONS

AVERAGE WIND FLUCTUATIONS

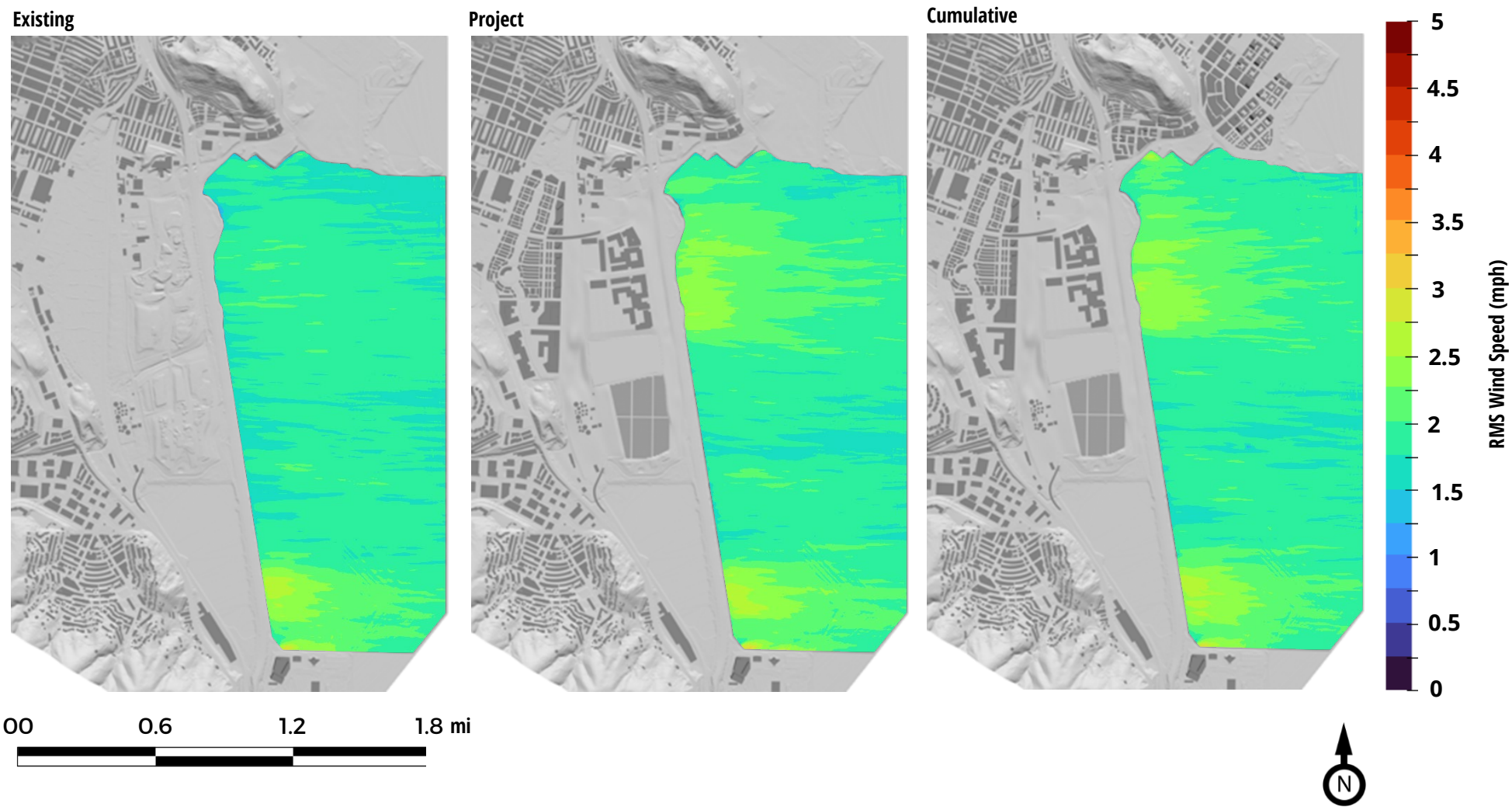

Image B.1.1: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly Winds (270°) – 5 ft

AVERAGE WIND FLUCTUATIONS

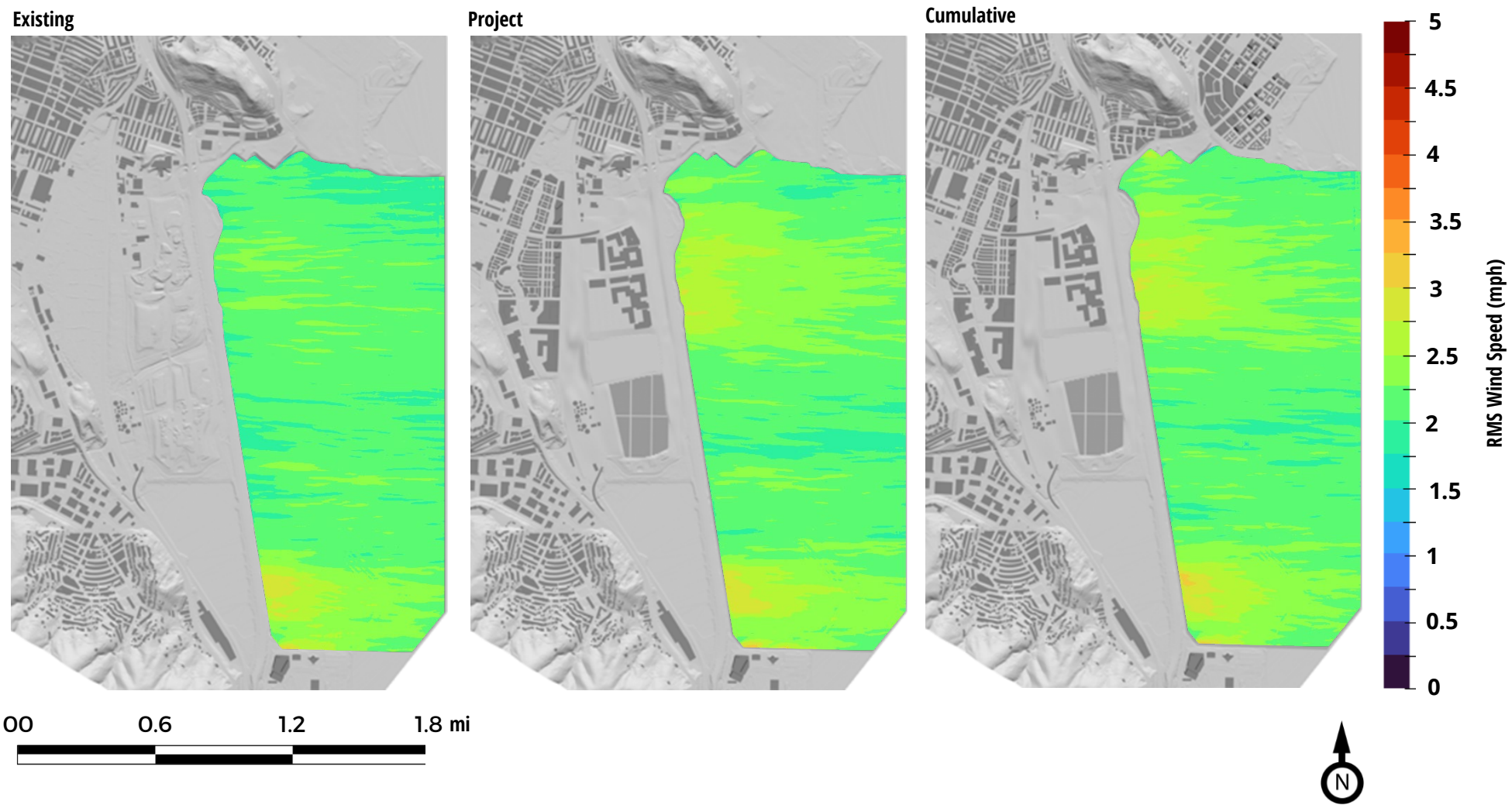

Image B.1.2: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly Winds (270°) – 10 ft

RWDI Project #2301053
June 23, 2023

AVERAGE WIND FLUCTUATIONS

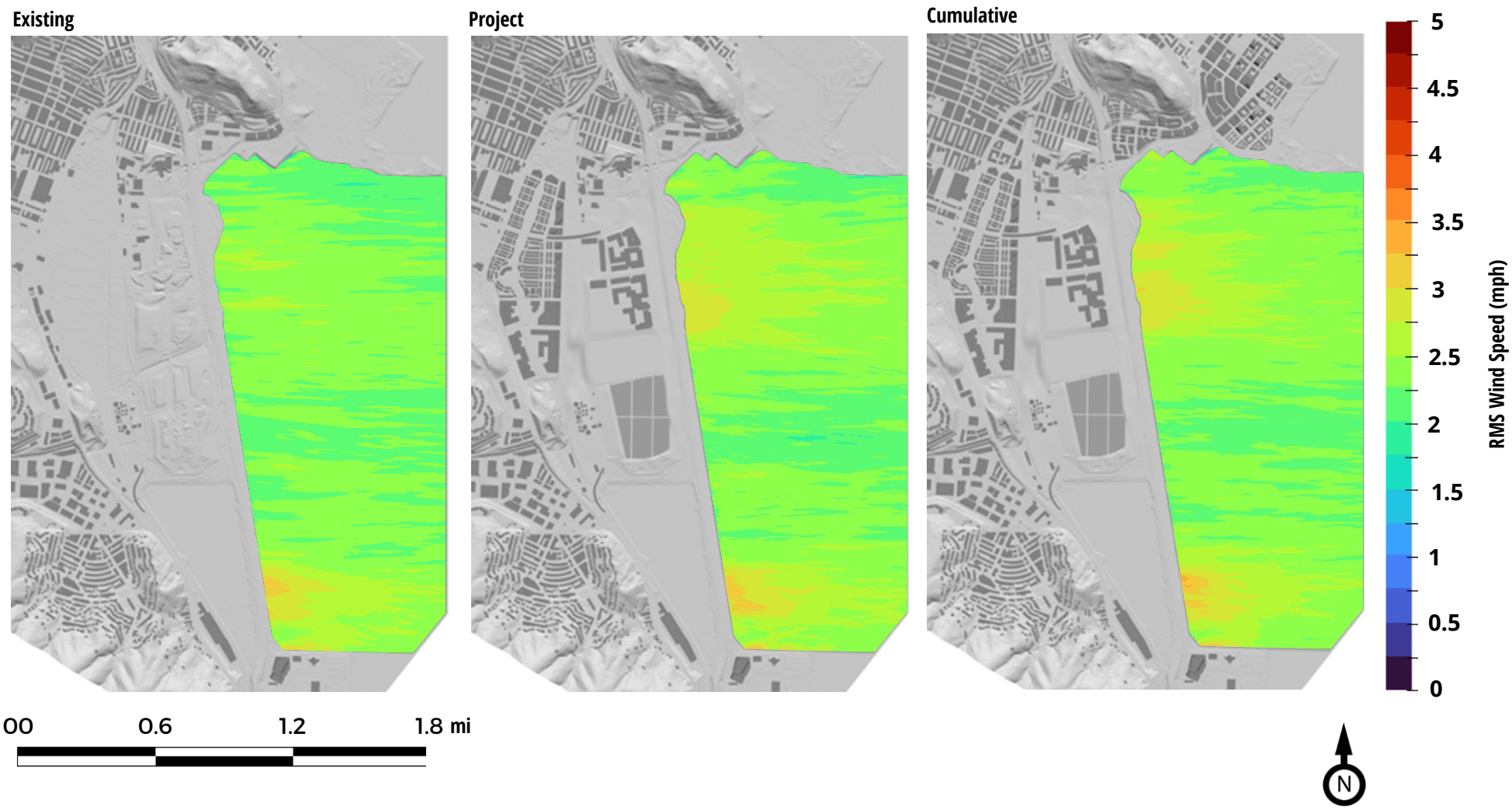

Image B.1.3: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly Winds (270°) – 16 ft

AVERAGE WIND FLUCTUATIONS

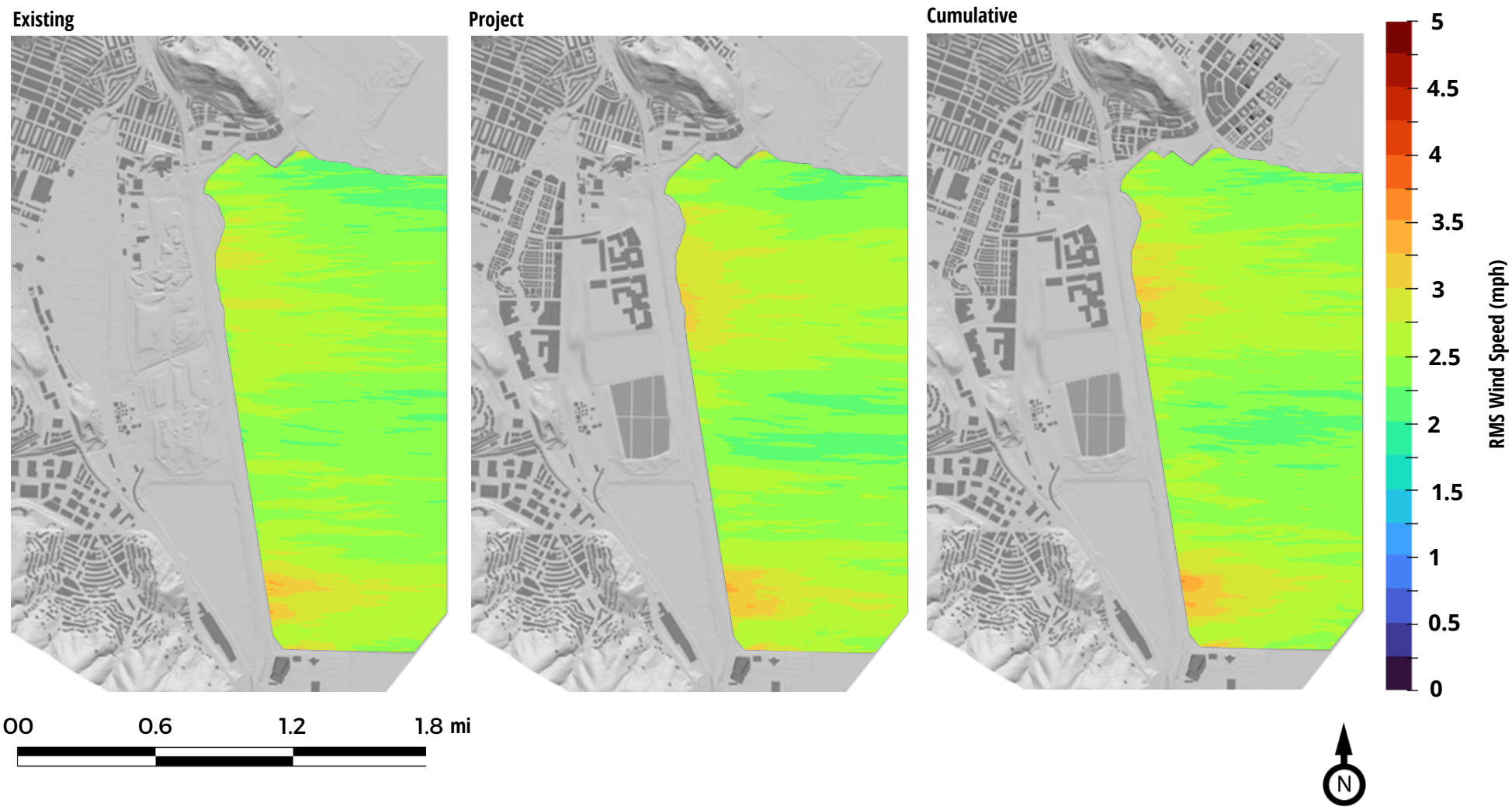

Image B.1.4: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly Winds (270°) – 32 ft

AVERAGE WIND FLUCTUATIONS

W

Existing

Project

Cumulative

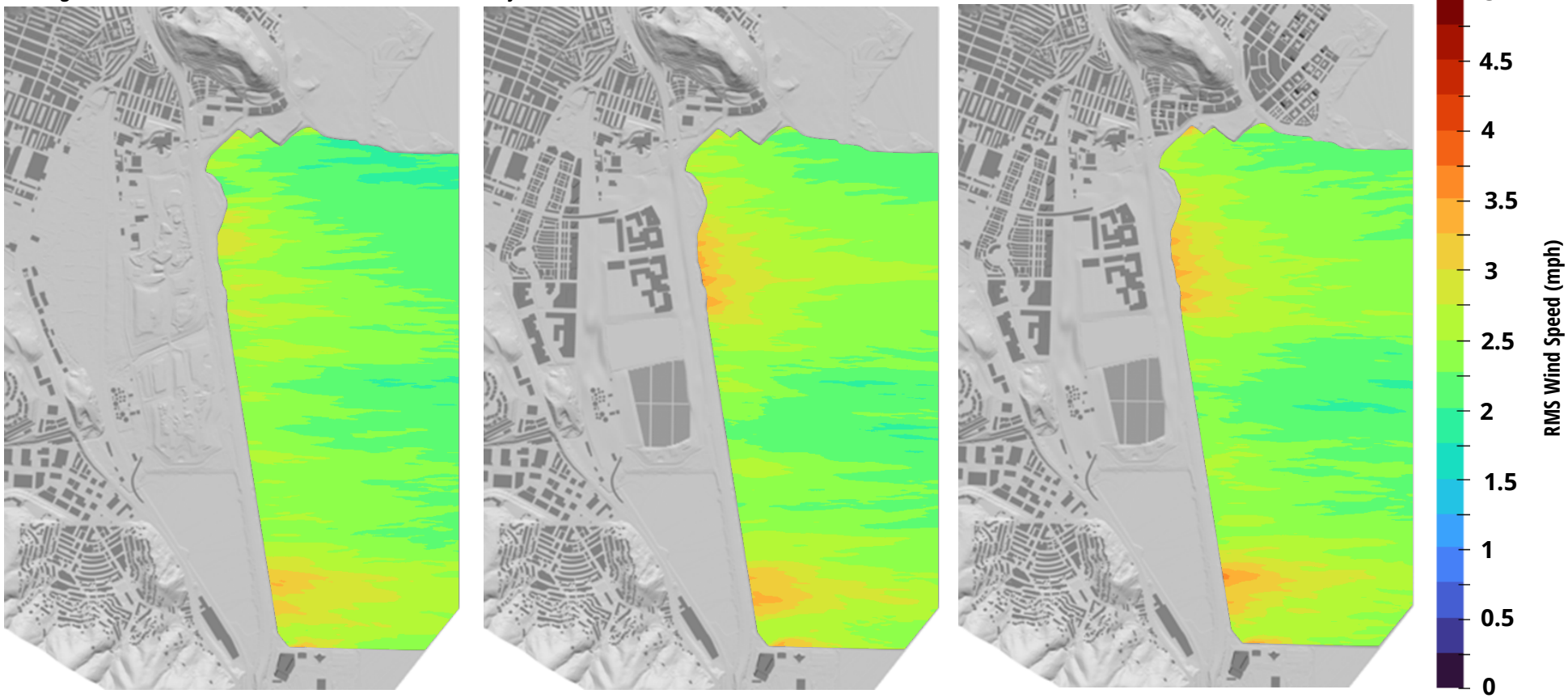

Image B.1.5: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations

Westerly Winds (270°) – 82 ft

AVERAGE WIND FLUCTUATIONS

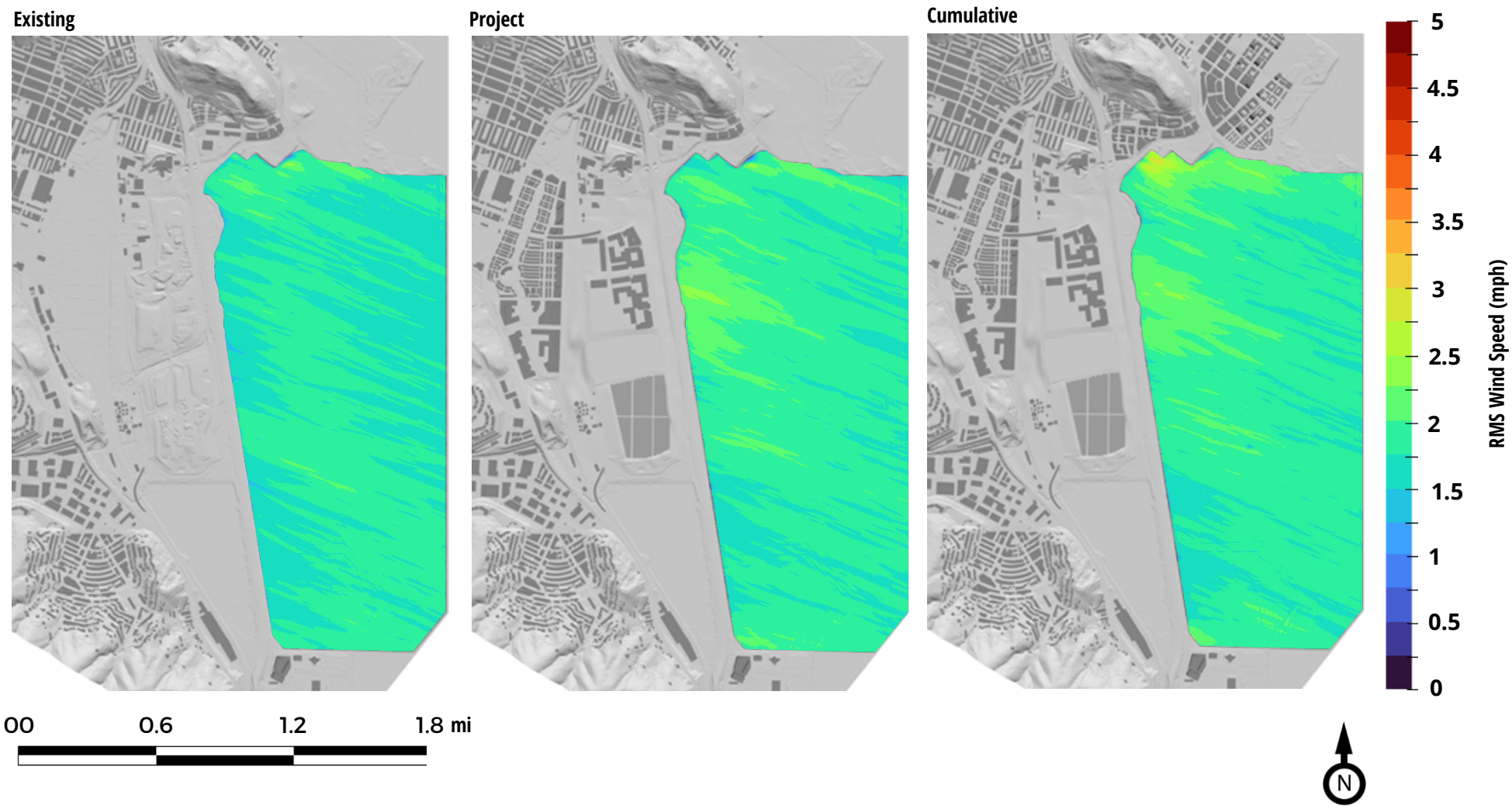

Image B.2.1: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly-Northwesterly Winds (292.5°) – 5 ft

AVERAGE WIND FLUCTUATIONS

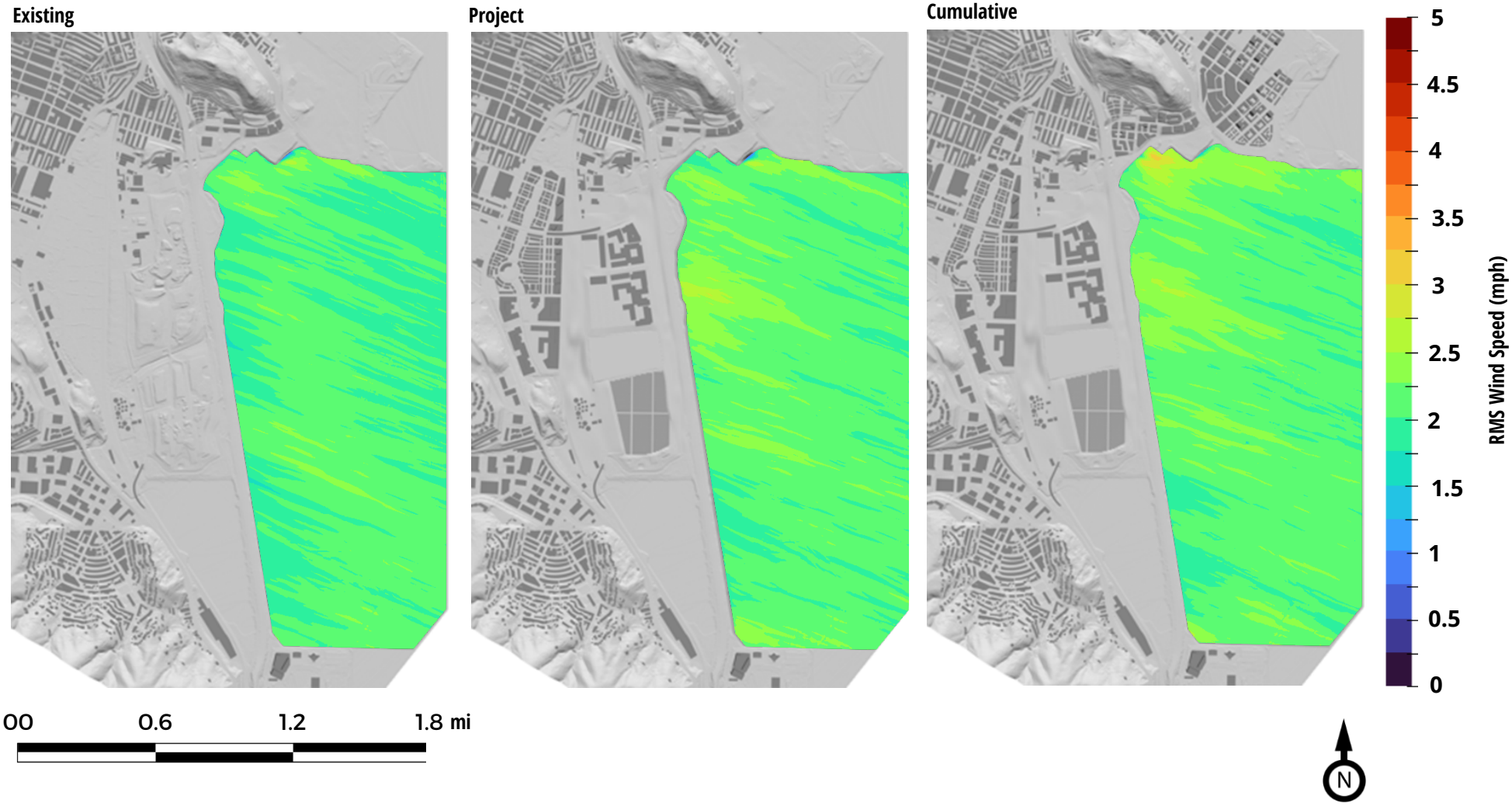

Image B.2.2: Predicted Root Mean Square of the Average Wind Fluctuation in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly-Northwesterly Winds (292.5°) – 10 ft

AVERAGE WIND FLUCTUATIONS

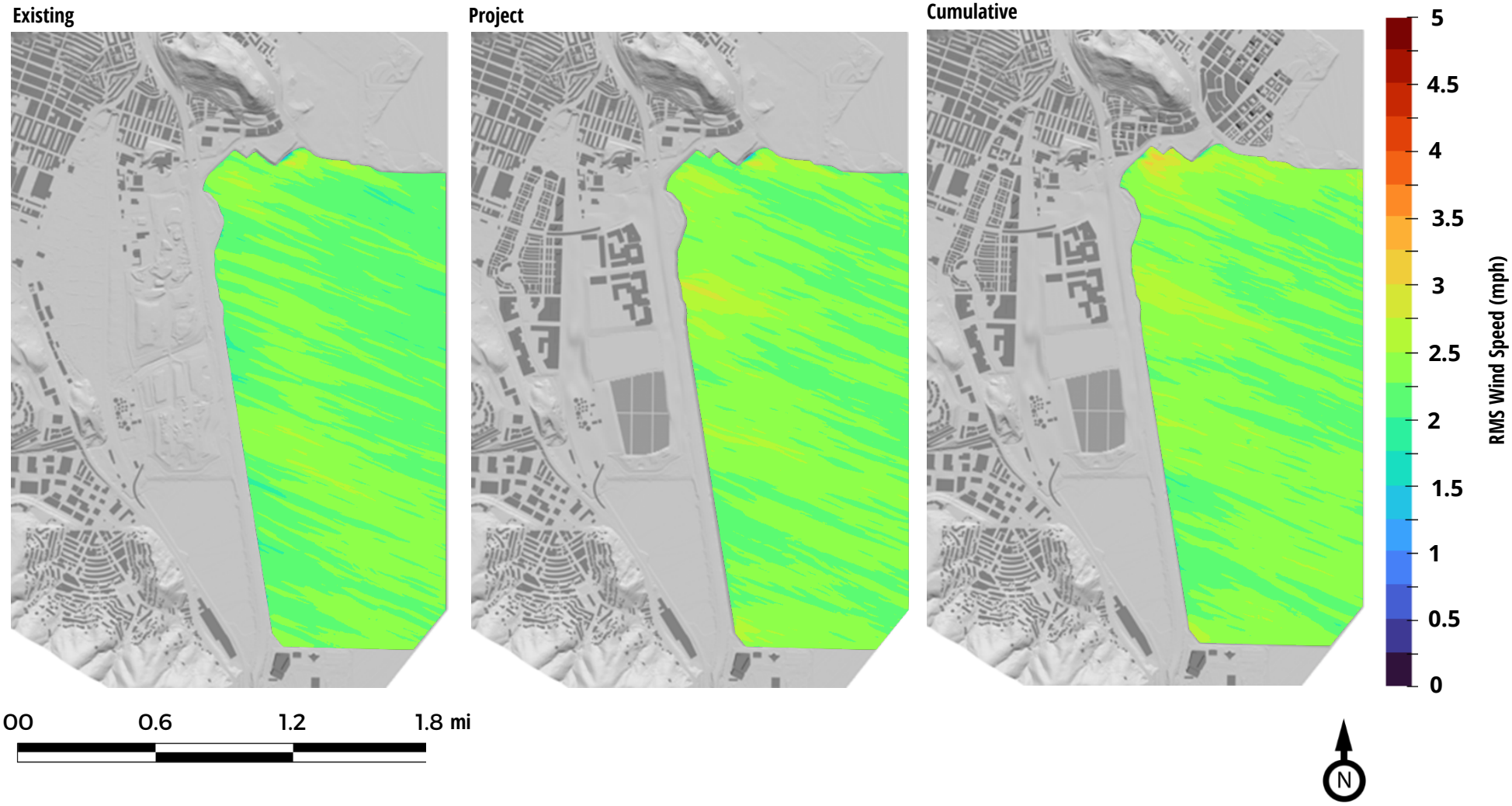

Image B.2.3: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly-Northwesterly Winds (292.5°) – 16 ft

AVERAGE WIND FLUCTUATIONS

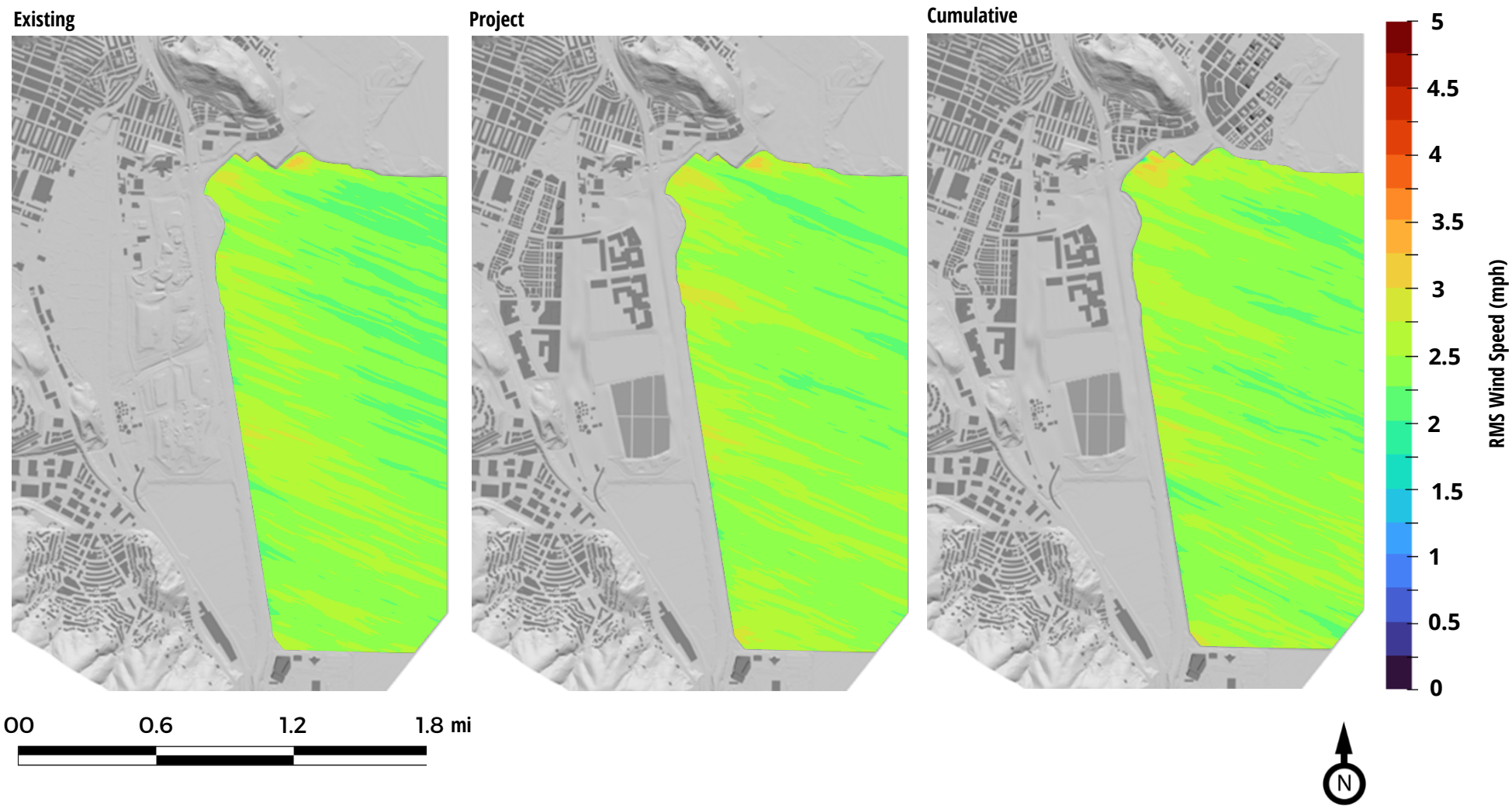

Image B.2.4: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly-Northwesterly Winds (292.5°) – 32 ft

AVERAGE WIND FLUCTUATIONS

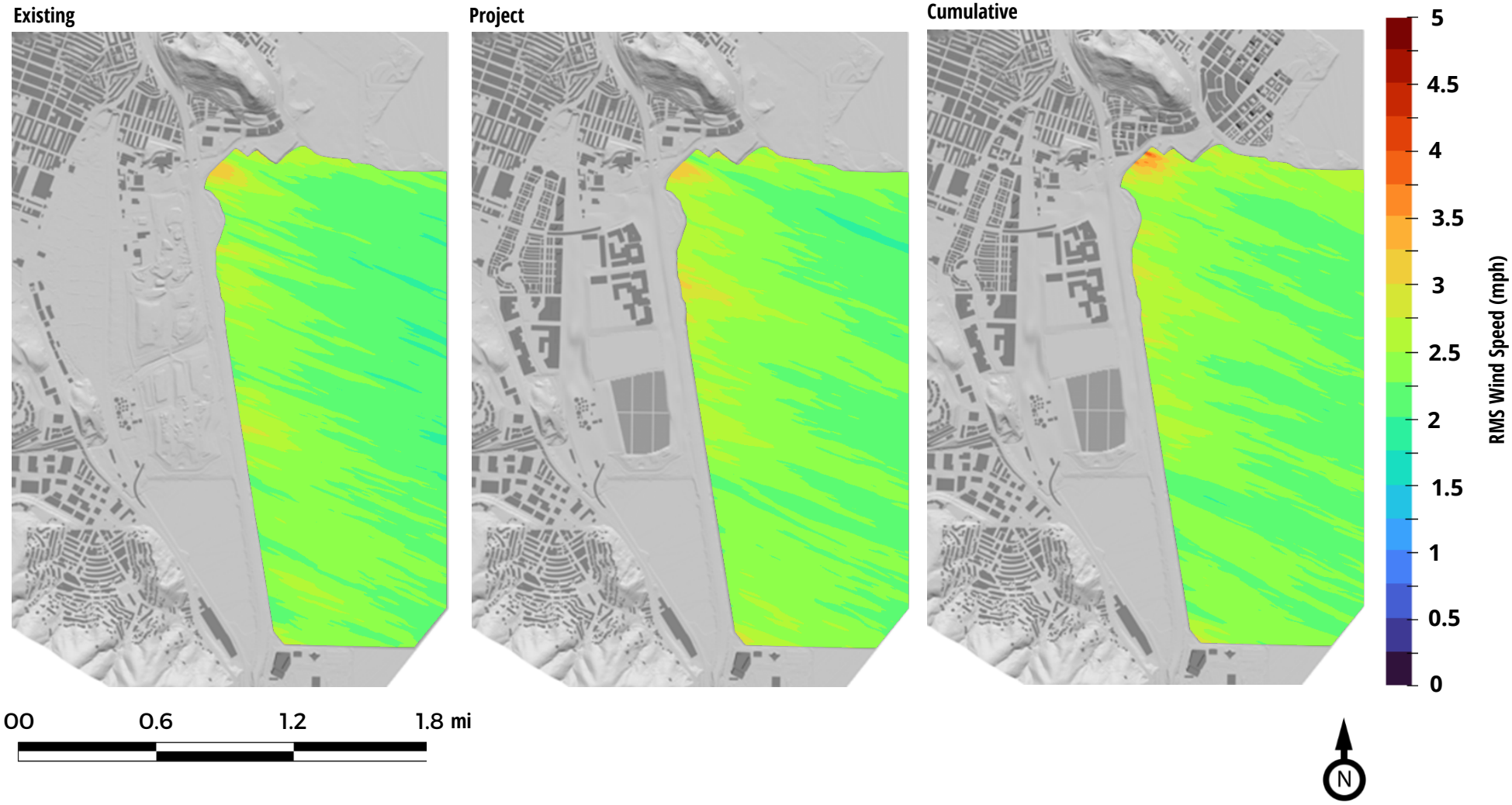

Image B.2.5: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Westerly-Northwesterly Winds (292.5°) – 82 ft

AVERAGE WIND FLUCTUATIONS

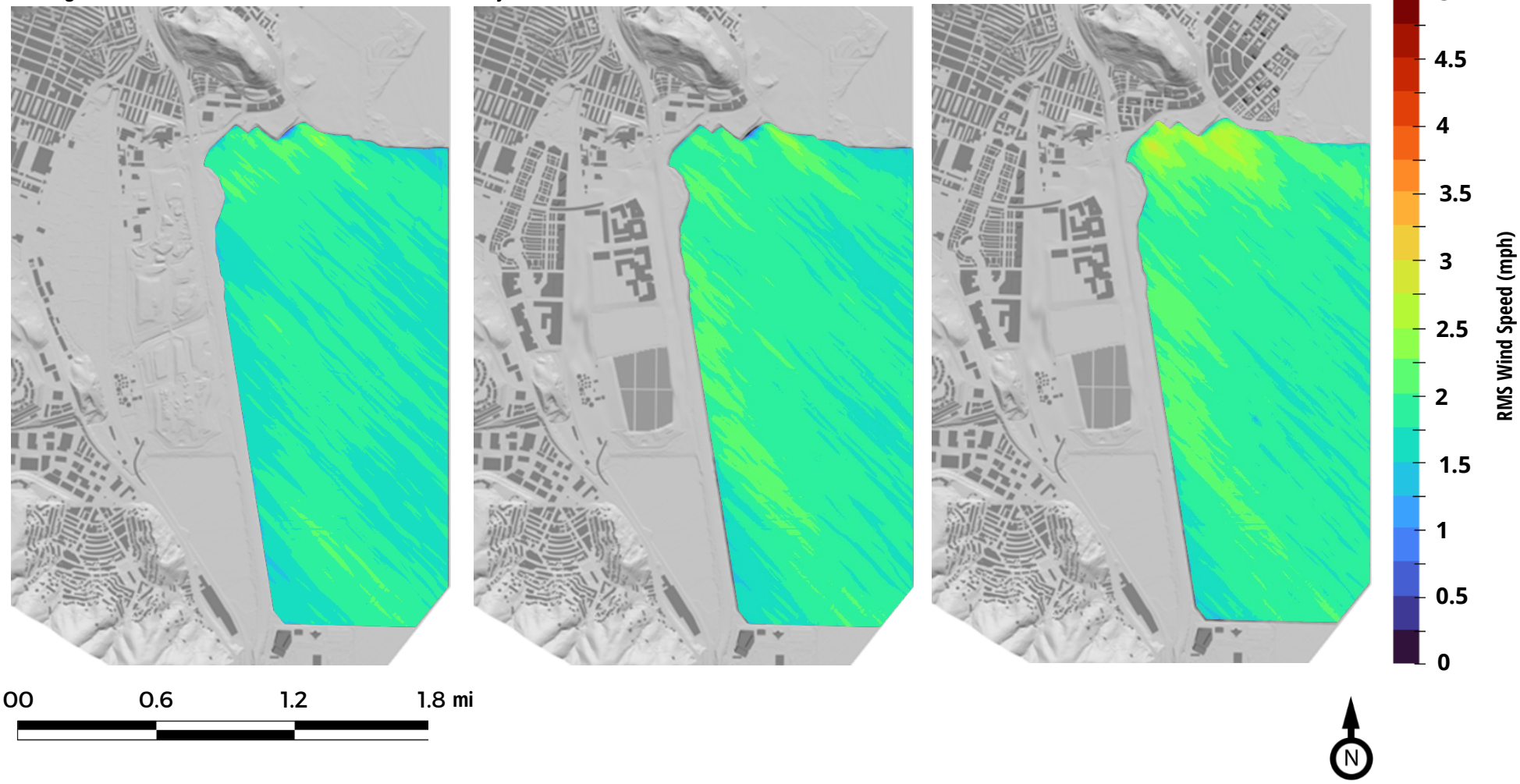

Image B.3.1: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Northwesterly Winds (315°) – 5 ft

AVERAGE WIND FLUCTUATIONS

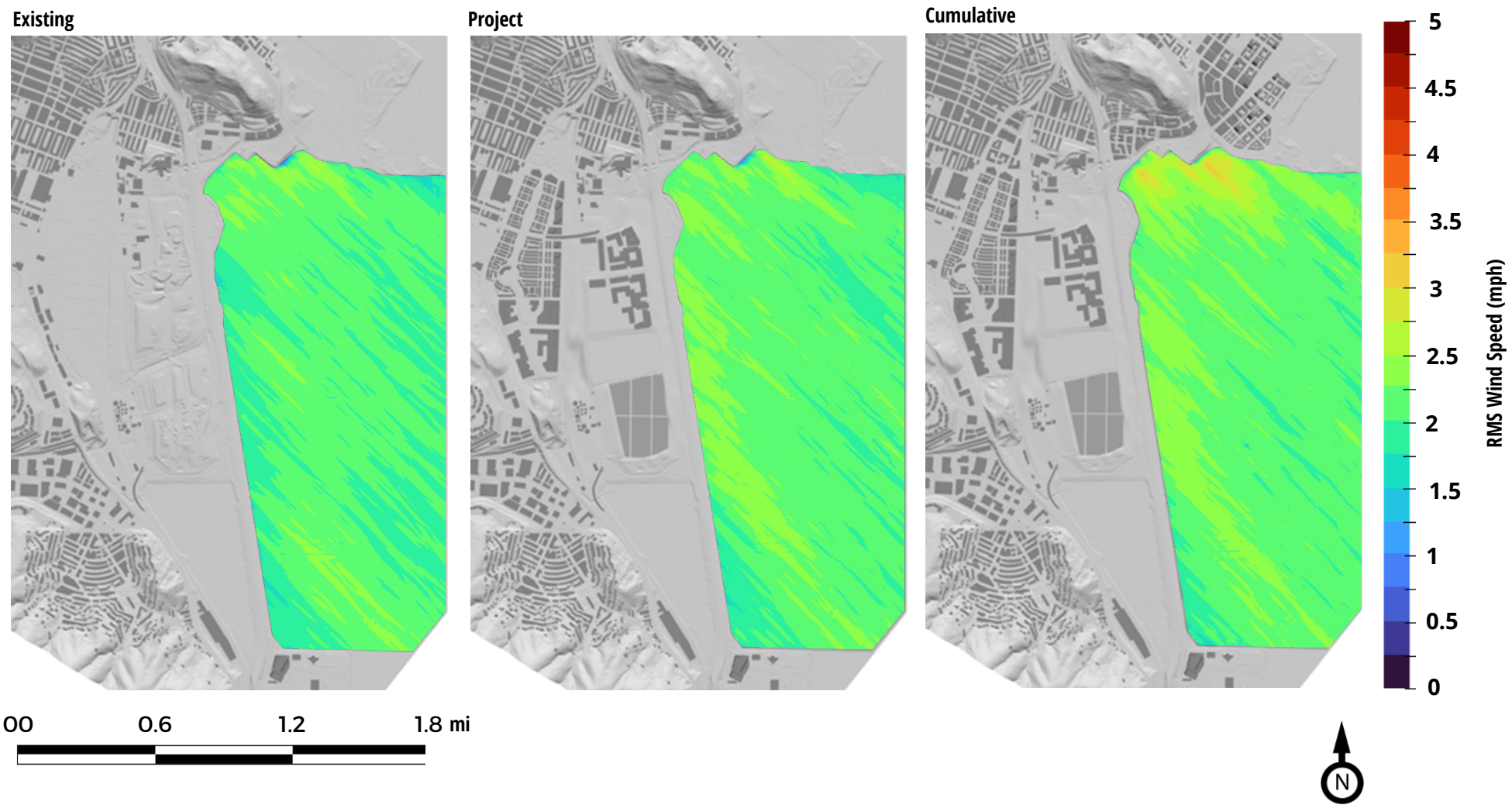

Image B.3.2: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Northwesterly Winds (315°) – 10 ft

AVERAGE WIND FLUCTUATIONS

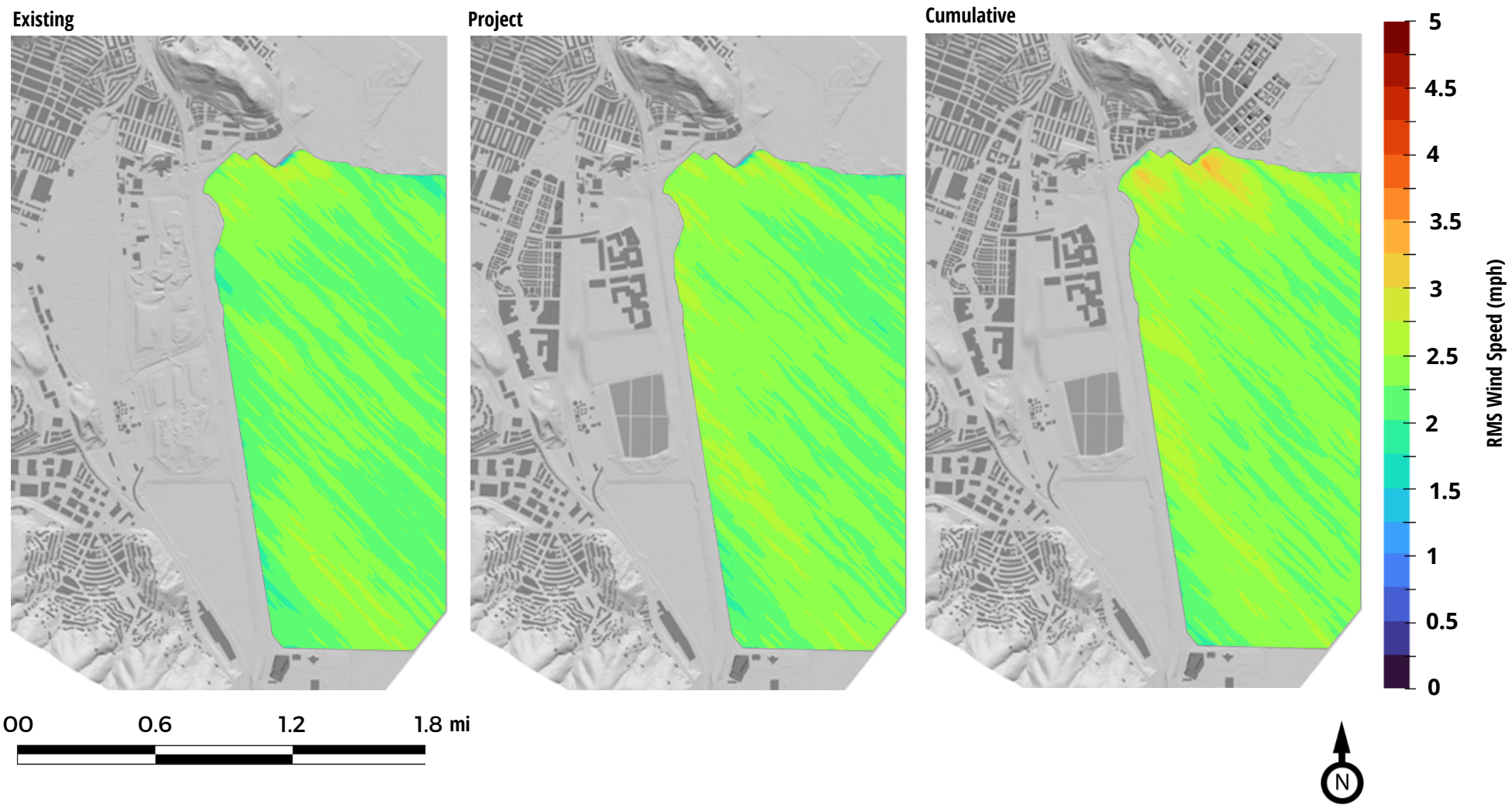

Image B.3.3: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Northwesterly Winds (315°) – 16 ft

AVERAGE WIND FLUCTUATIONS

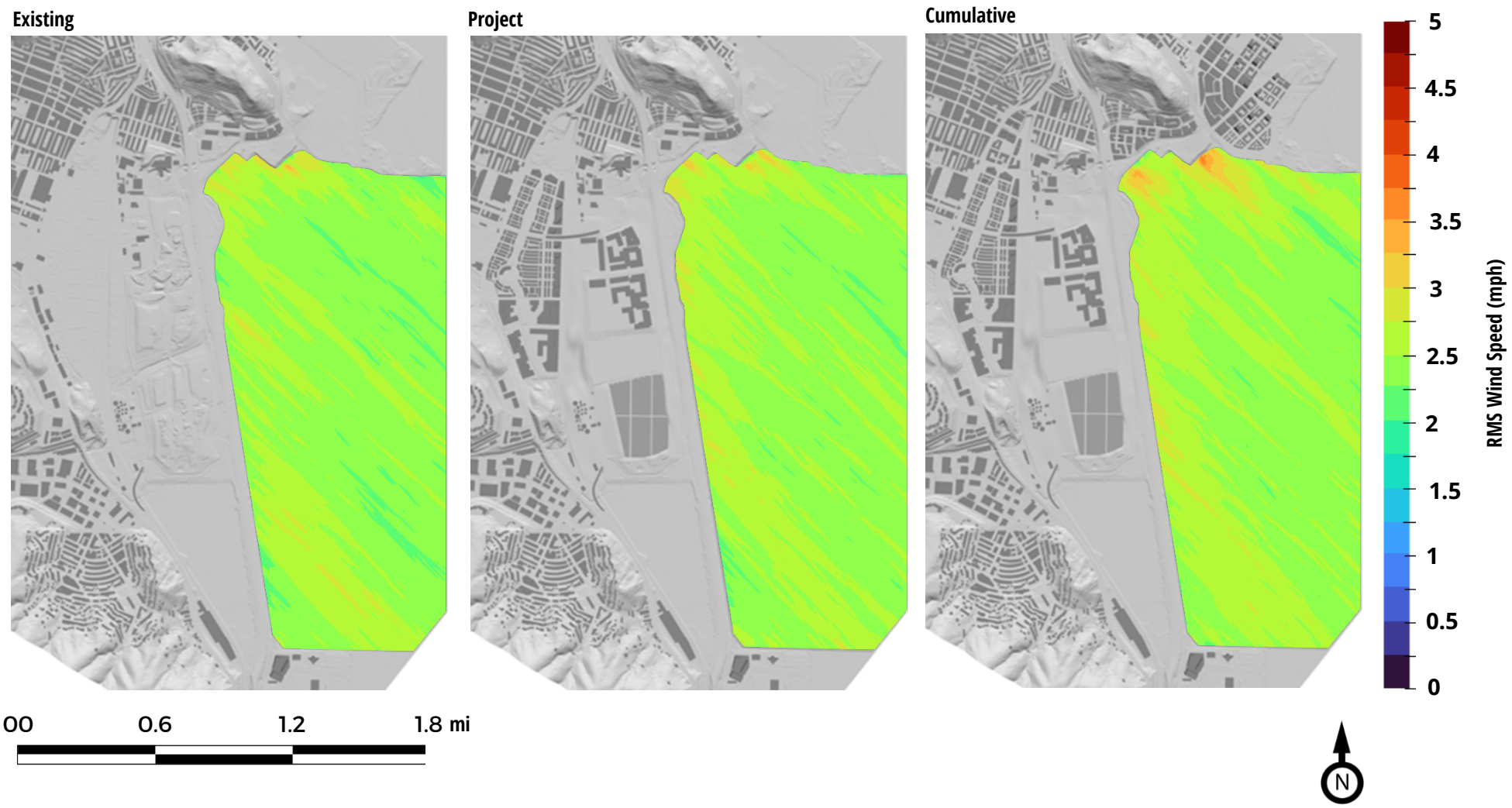

Image B.3.4: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Northwesterly Winds (315°) – 32 ft

AVERAGE WIND FLUCTUATIONS

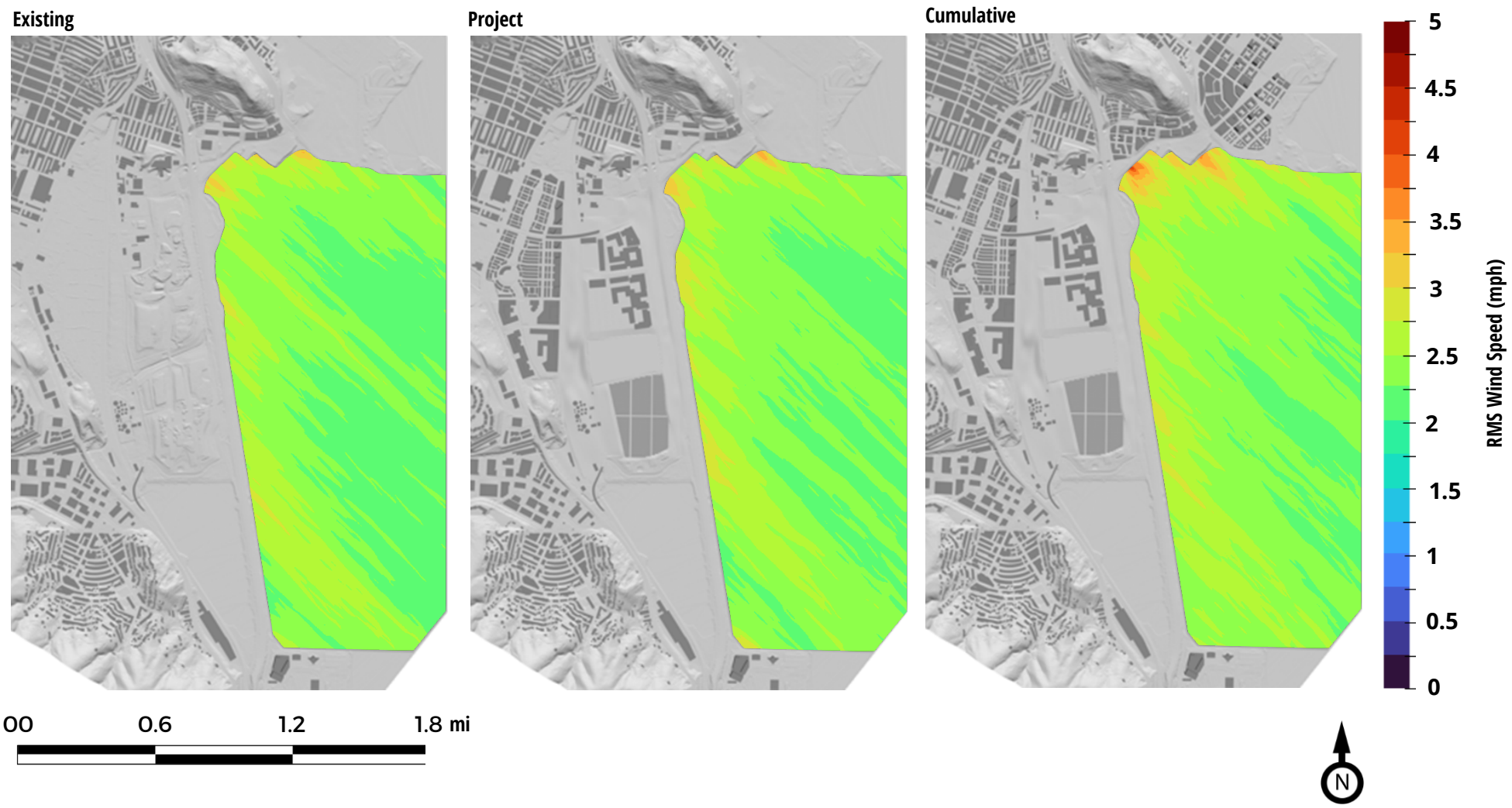

Image B.3.5: Predicted Root Mean Square of the Average Fluctuating Speed in Existing (Left), Project (Middle) and Cumulative (Right) Configurations
Northwesterly Winds (315°) – 82 ft