

# Calf Heath Reservoir Wind Assessment

The West Midlands Rail Freight Interchange Order 201X

RWDI: May 2019

Four Ashes Limited

# REPORT WEST MIDLANDS INTERCHANGE



**BIRMINGHAM, UK**  
**WIND ASSESSMENT**  
PROJECT #: 1901388  
23 MAY, 2019

## SUBMITTED TO

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# 1. INTRODUCTION

RWDI was instructed by Ramboll on behalf of Four Ashes Limited, to assess the wind conditions in-and-around the proposed development of the West Midlands Interchange. The objective of this analysis was to provide initial estimates of the effects of the potential development on the sailing conditions at the nearby Calf Heath Reservoir. This assessment is based on the following:

1. A review of regional long-term meteorological data for the area;
2. Layouts of the proposed development (two configurations) as provided by Ramboll to RWDI on 8 February (Figure 1);
3. Our engineering judgement and knowledge of wind flows around buildings<sup>1,3</sup>; and,
4. The use of the Computational Fluid Dynamics (CFD) software *OpenFOAM* for visualizing wind flow patterns.

This approach provides an estimation of potential wind conditions and identifies anticipated areas of accelerated or lower wind speeds.

The effects of the predicted changes in wind conditions is being assessed separately by Wolfson Unit.



Figure 1: Location of Proposed Development

1. H. Wu and F. Kriksic (2012). "Designing for Pedestrian Comfort in Response to Local Climate", *Journal of Wind Engineering and Industrial Aerodynamics*, vol.104-106, pp.397-407.
2. H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004), "Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions", *ASCE Structure Congress 2004*, Nashville, Tennessee.
3. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), "Experience with Remedial Solutions to Control Pedestrian Wind Problems", *10th International Conference on Wind Engineering*, Copenhagen, Denmark.

## 2. BUILDING AND SITE INFORMATION



The proposed development will be located southwest to the Calf Heath Reservoir. The Interchange will include a number of large low-rise warehouse buildings. As part of the development there will be an earth bund 7-8 m in height which will separate the development from the south end of the reservoir.

As shown in Figure 2a and Figure 2b, there are two development scenarios analyzed in this report. The existing condition will be identified as Configuration 1, and the two development scenarios will be Configuration 2 and Configuration 3.

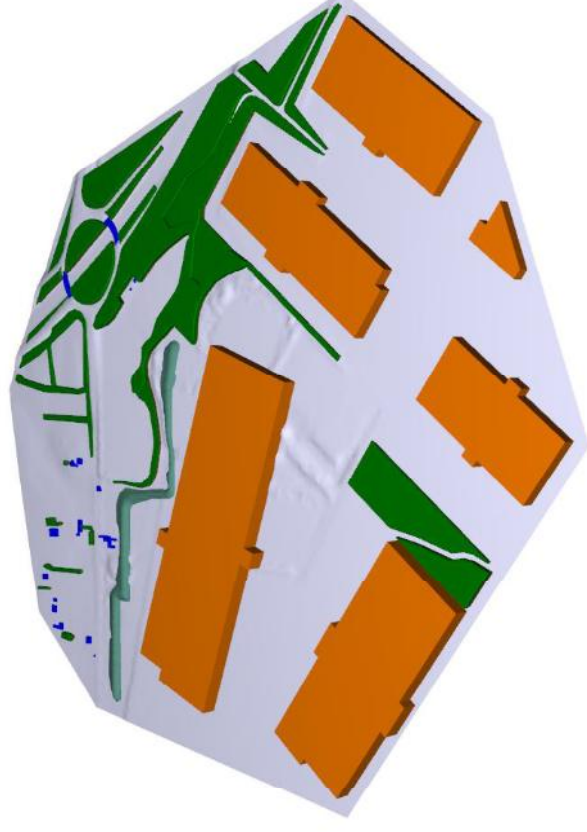
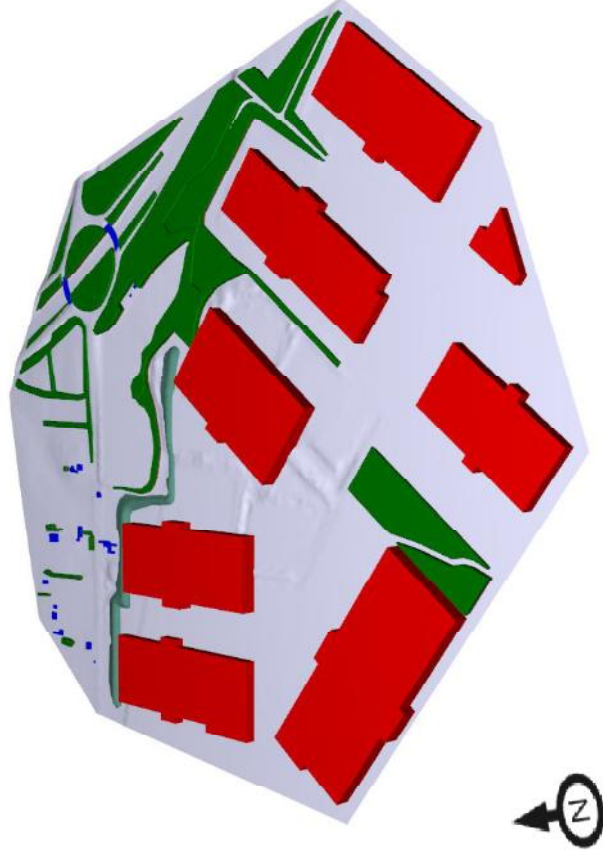


Figure 2a: Models of the two potential development scenarios. (Left Side: Configuration 2, Right side: Configuration 3)

## 2. BUILDING AND SITE INFORMATION



The topography of the site was modelled based upon LiDAR scan data collected by the UK Department for Environment, Food and Rural Affairs in 2015, with building dimensions provided by Ramboll. We note that at this stage of the design, a grading plan has not been developed which would define how the ground will be leveled for construction.

Therefore, in some cases RWDI has had to make assumptions regarding the heights of the buildings relative to the existing topography. All assumptions were made in a conservative fashion (i.e. resulting in taller buildings). We acknowledge that the modelled heights may be in excess of the limits of the parameter plans and understand that the actual design will be compliant. The modeled heights are illustrated in Figure 2b.

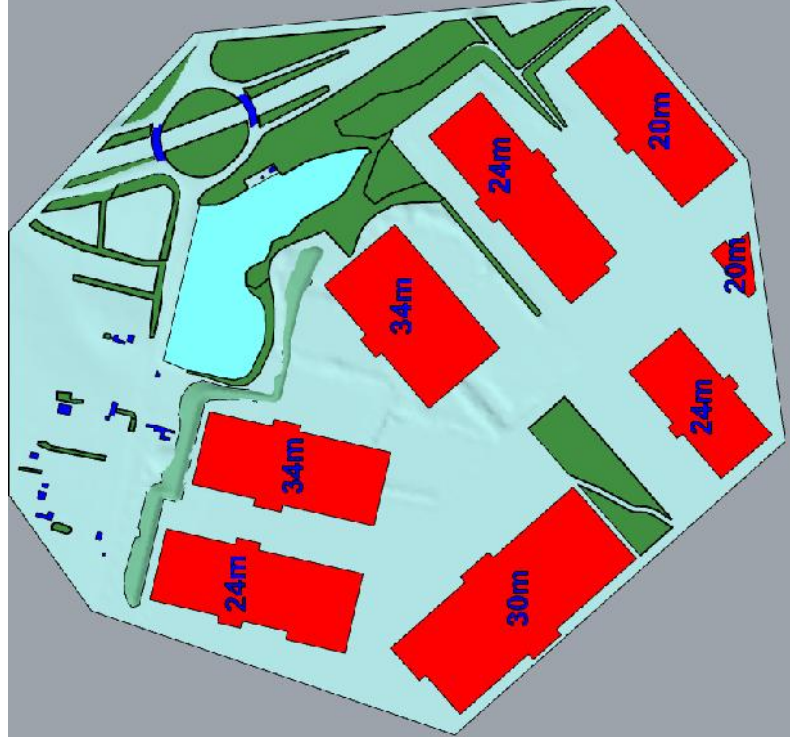


Figure 2b: Building heights modeled in this analysis. (Left Side: Configuration 2; Right side: Configuration 3)

# 3. METEOROLOGICAL DATA



## Meteorological Station Selection

Meteorological data from Birmingham Airport recorded between 1995 and 2015 was used as reference for the local wind conditions. The distributions of wind frequency and directionality is shown in the wind rose at right (Figure 3).

Based on the local wind directionality and the orientation of the surrounding site context, winds from the following directions were selected for the computational simulations:

- South-southeast (**SSE**)
- South (**S**)
- South-southwest (**SSW**)
- Southwest (**SW**)
- West-southwest (**WSW**)
- West (**W**)

These provide a representative sample of the most common wind directions that would be affected by the presence of the proposed development.

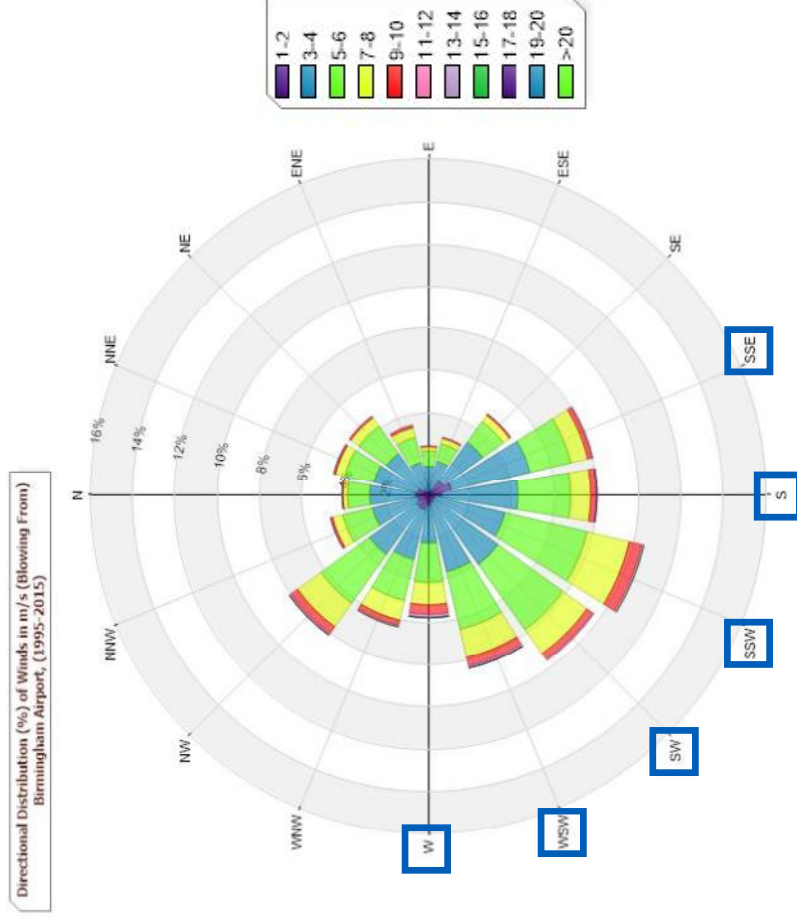


Figure 3: Directional Distribution of Winds Approaching Birmingham Airport (1995 – 2015)

## 4. METHODOLOGY



Wind flows around the proposed development and the surroundings were simulated using *OpenFOAM* computational fluid dynamics (CFD) software. A view of the proposed simulation configuration is illustrated in Figure 4.

For the purposes of this computational study, the 3D model was simplified to include the necessary massing and topography details that would affect the local wind flows in the area on-and-around the site. Landscaping was included in the computer model, the porosity of the tree cover was assumed to be 80%.

Using the meteorological data described on the preceding page, the 80<sup>th</sup> percentile wind speed for each of the studied directions was determined and used as the input conditions for these simulations. In other words, the ambient wind conditions simulated in this report, were chosen to represent a condition that is not expected to be exceeded more than 20% of the time in Birmingham, UK.

These speeds were selected in order to provide a conservative assessment of the impact of the proposed developments on the reservoir, while still modelling wind conditions which can occur with reasonable frequency.

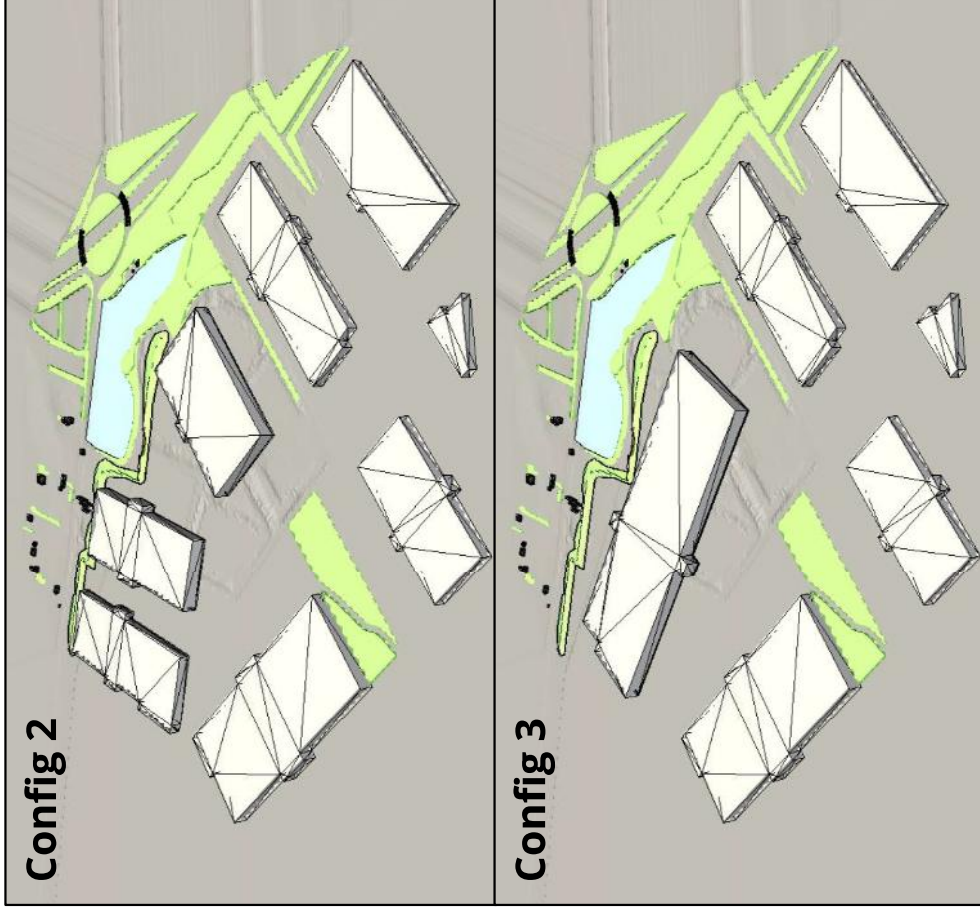


Figure 4: Computer Model of the Proposed Development for OpenFOAM CFD Simulations

## 5. GENERAL WIND FLOW PATTERNS



In the following results and discussion of anticipated wind conditions, reference is made to the following generalized wind flows:

- a) Structures taller than the immediate surrounds tend to intercept stronger winds at high elevations and redirect them to the ground level (see Figure 5a). Such a downwashing flow is often the main cause for wind accelerations around tall structures at pedestrian level.
- b) When winds accelerate around building corners at pedestrian level, a localized increase in the wind activity can be expected in that area (see Figure 5b).
- c) When two buildings are situated side by side, wind flow tends to accelerate through the space between the buildings due to the Channelling Flow (see Figure 5c).

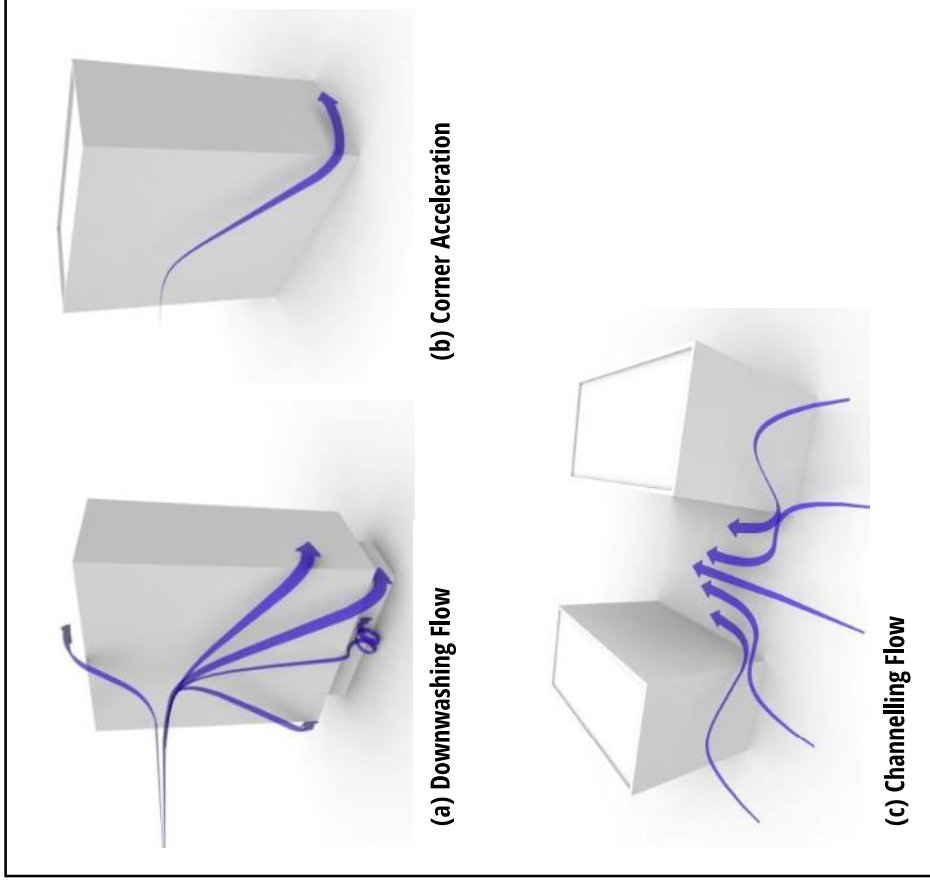


Figure 5: General Wind Flow Patterns



## 6. WIND CONDITIONS



### 6.1 Predicted Wind Conditions

The following pages present the results of RWDI's computational simulations. Wind conditions above the Calf Heath Reservoir at various heights under different wind directions are shown. The results of each of the three configurations are shown side-by-side to facilitate comparisons.

Considering the size of craft using the reservoir (Length < 4.5 m, per email received on 8 February 2019), wind speeds at various heights (3m, 6m, 9m, and 12m) above the lake are shown to illustrate the effect of the potential development on the sailing condition.

It is important to recognize that the predicted wind conditions on the subsequent pages are referenced in comparison to the 80<sup>th</sup> percentile ambient wind conditions that were simulated for the purposes of this study. Thus we would expect winds to be higher than shown approximately 20% of the time.

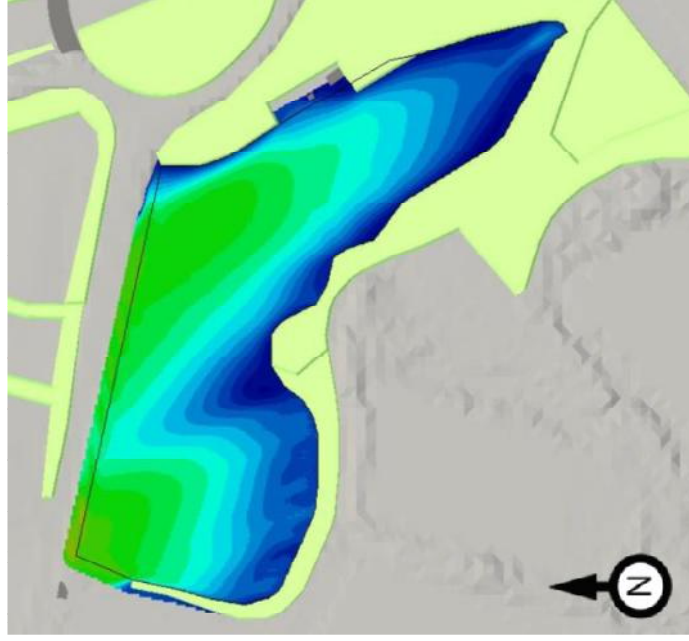
The results here are intended to demonstrate comparatively whether/where the new development would cause the wind to speed up or slow down.

## 6. WIND CONDITIONS

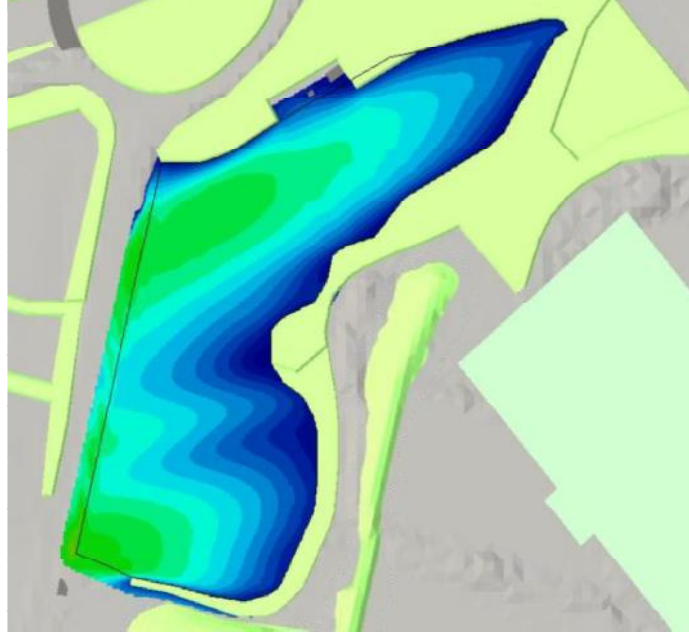


### 6.2 Predicted Wind Conditions: South – Southeast (SSE) Wind at 3m

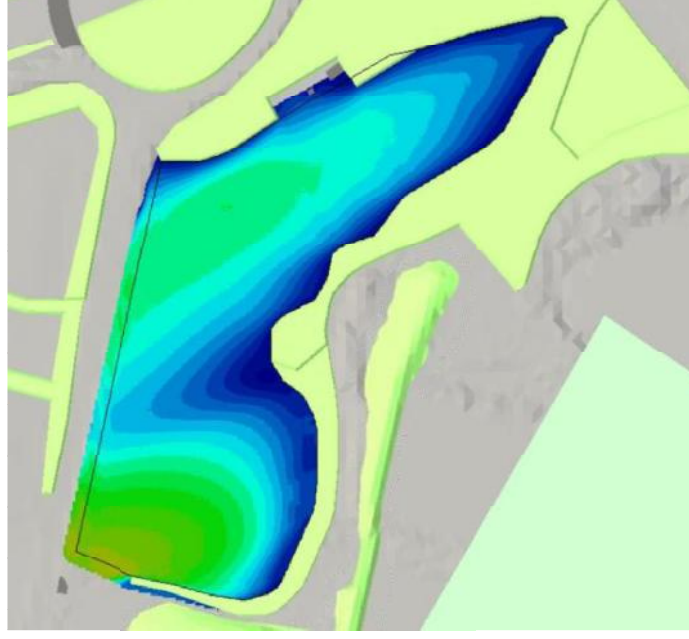
Config 1



Config 2



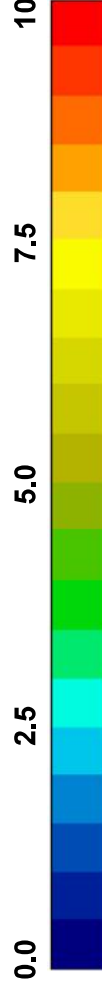
Config 3



Under SSE wind, winds on the south and east areas of the reservoir are slowed. Under Configuration 3, a zone of slightly increased speeds is predicted in the northwest of the reservoir.



Wind Speed (m/s)



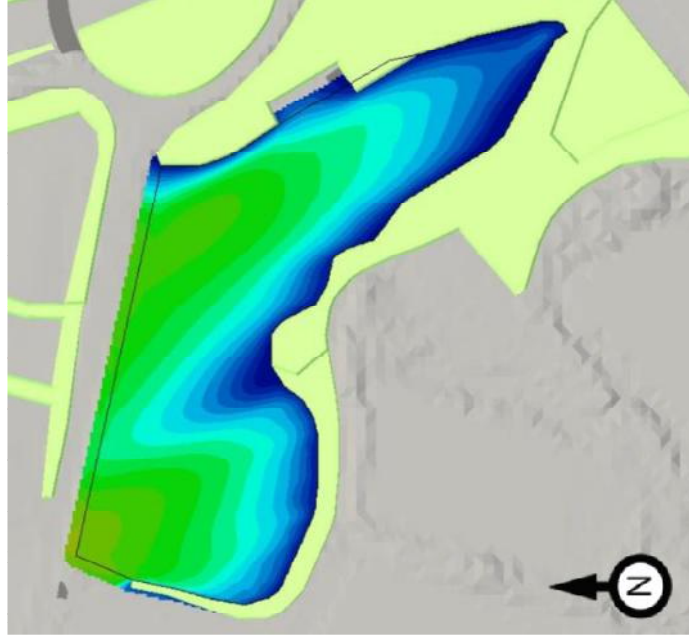
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

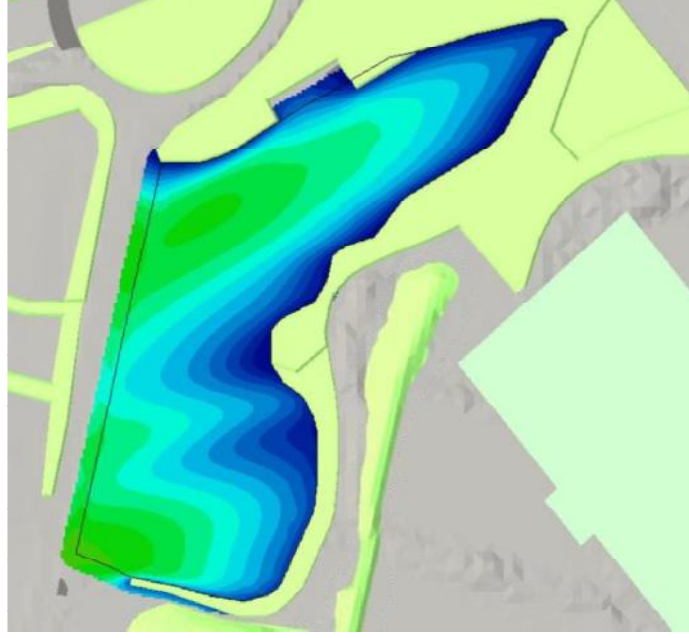


## 6.2 Predicted Wind Conditions: South – Southeast (SSE) Wind at 6m

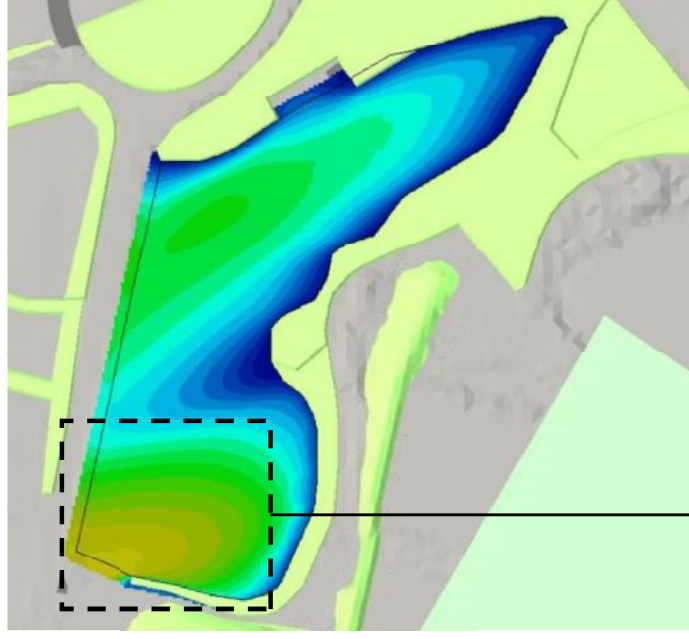
Config 1



Config 2

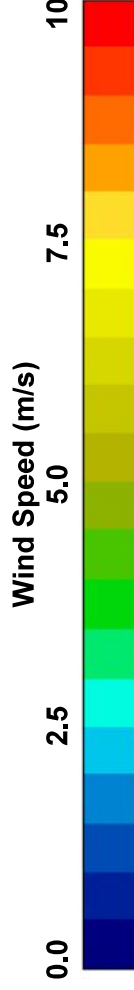


Config 3



Wind speeds under Configuration 2 are predicted to generally decrease on the order of 0.5-1m/s

At 6m above the lake, the northwest corner of the reservoir is expected to experience a higher wind speed of approximately 6.5 m/s



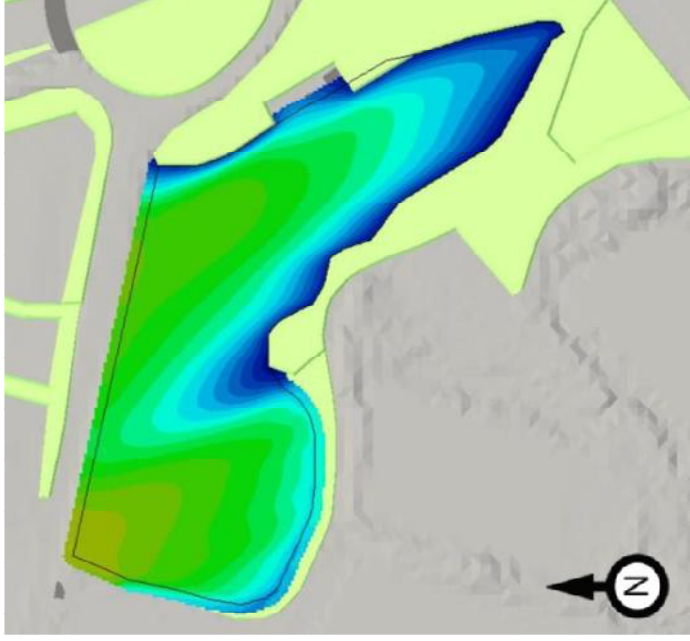
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

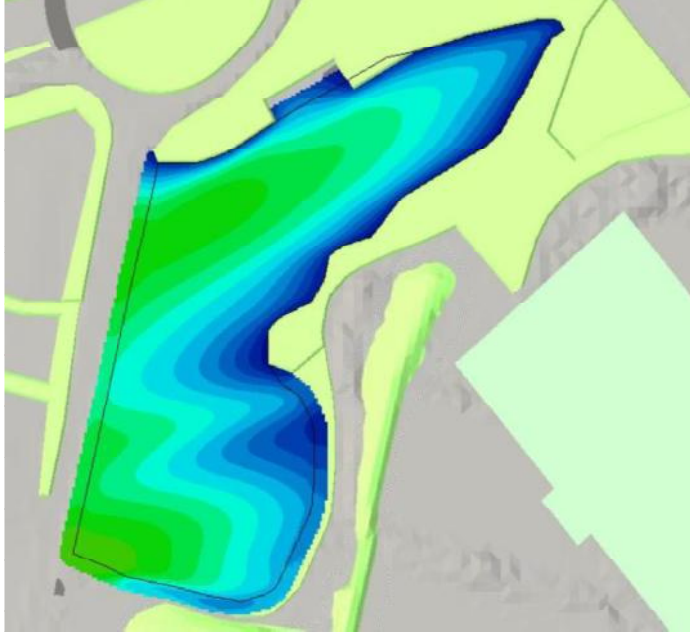


## 6.2 Predicted Wind Conditions: South – Southeast (SSE) Wind at 9m

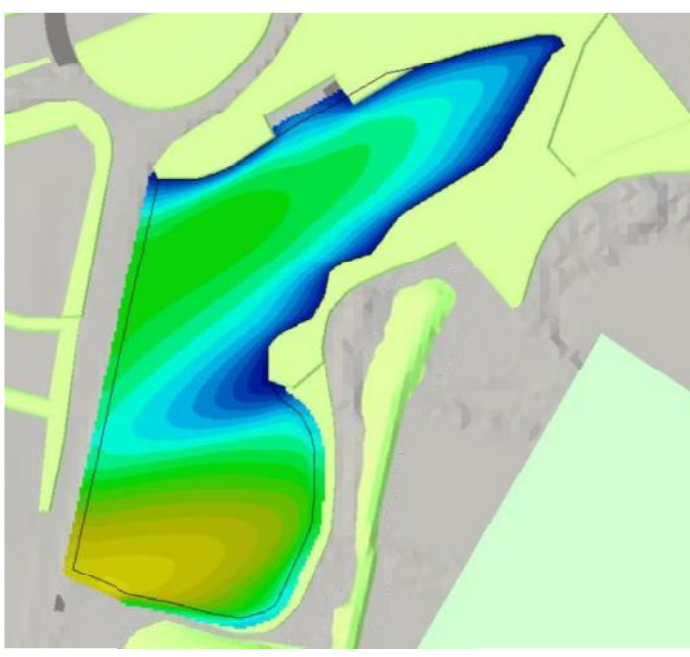
Config 1



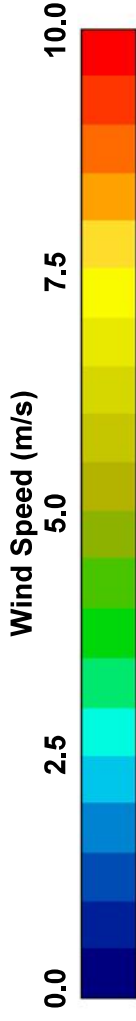
Config 2



Config 3



The change in wind speeds noted at 3m and 6m persist at 9 m for both configurations



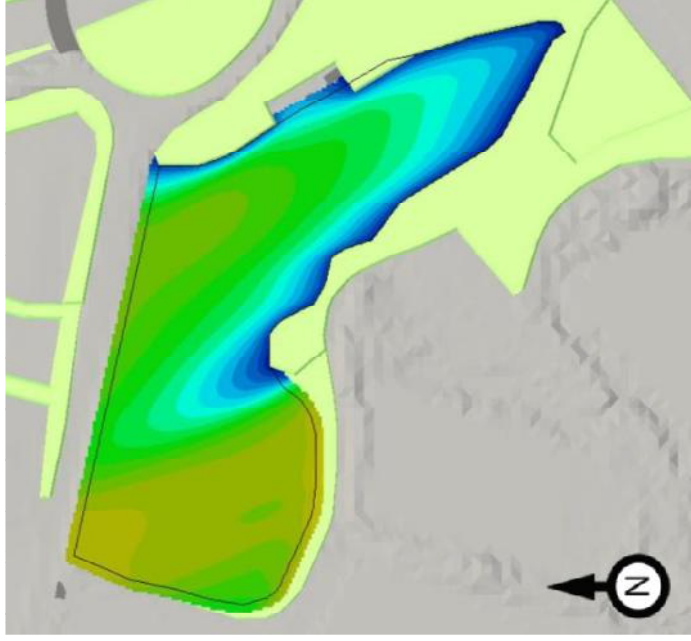
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

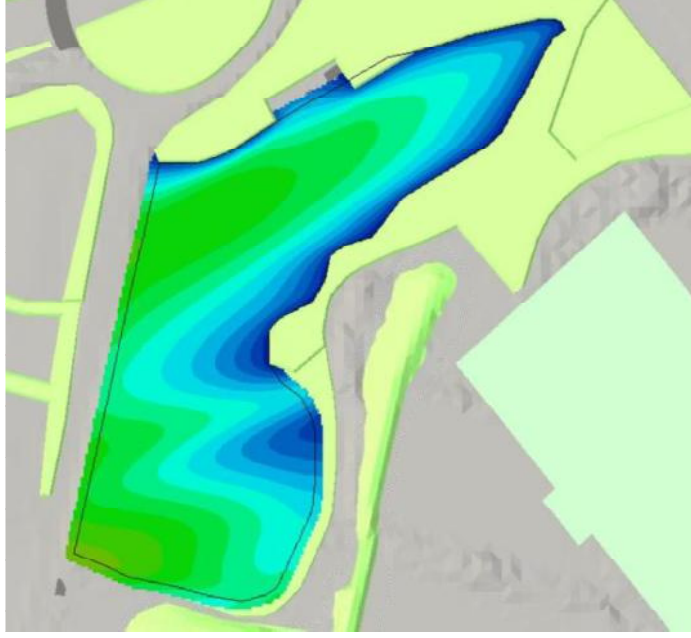


## 6.2 Predicted Wind Conditions: South – Southeast (SSE) Wind at 12m

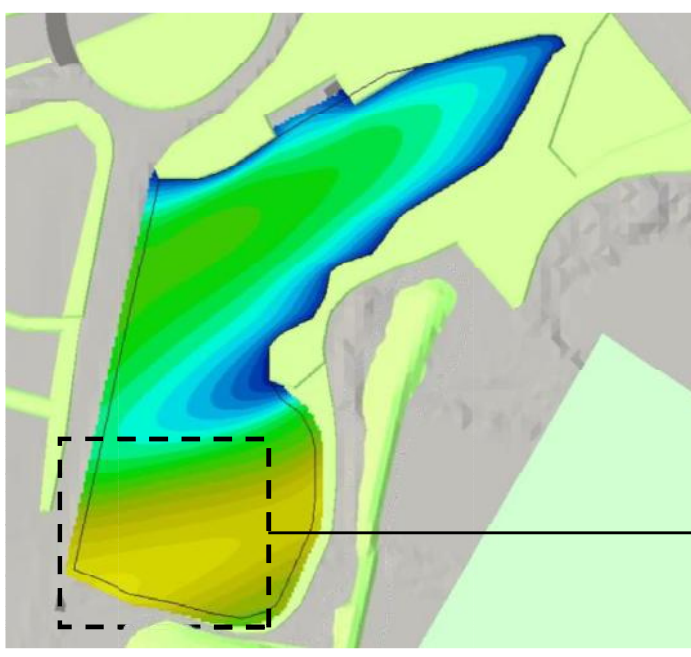
Config 1



Config 2



Config 3

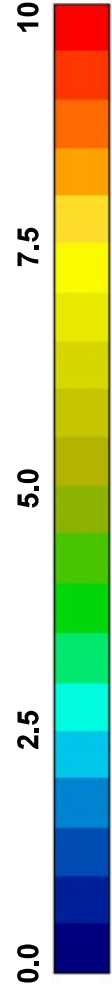


At 12 m above the lake we still see a slower zone in the west of the reservoir, but in the east the effect is less noticeable.

This zone is now predicted to be significantly faster than the existing condition



Wind Speed (m/s)



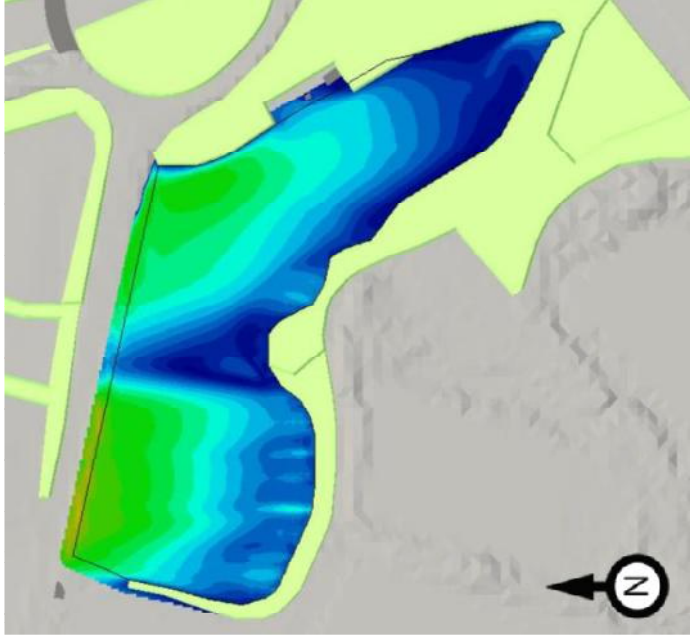
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

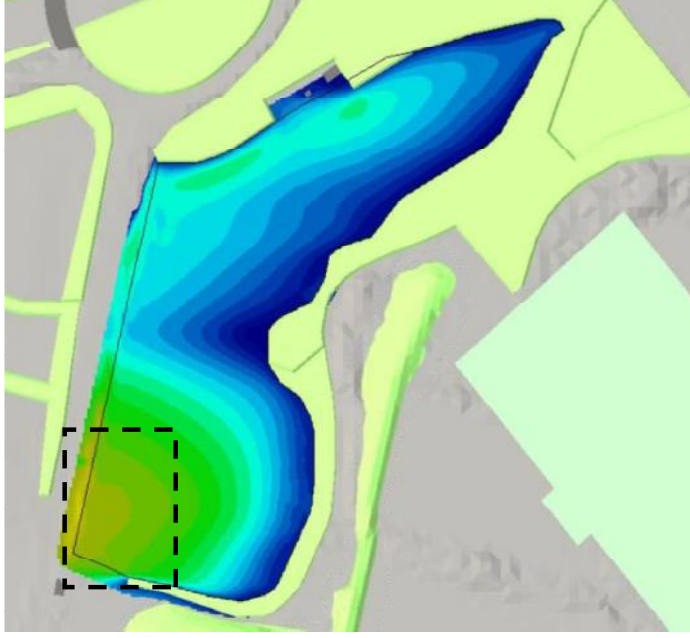


## 6.2 Predicted Wind Conditions: South (S) Wind at 3m

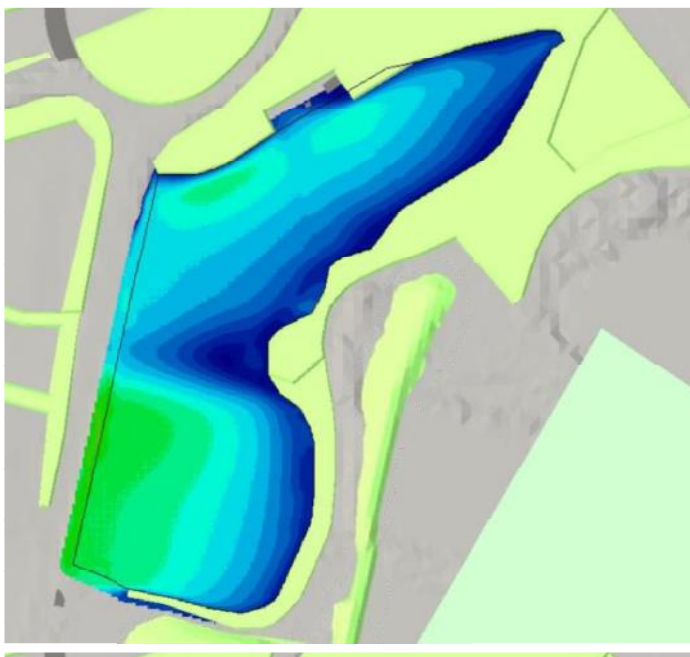
Config 1



Config 2



Config 3

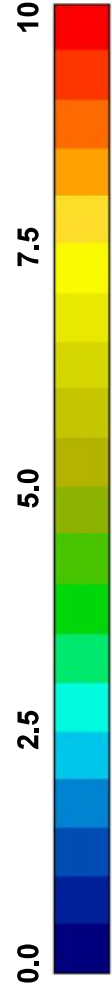


The northwest corner of the reservoir is expected to experience a higher wind speed, while other areas will experience a lower wind speed.

In general, wind speeds above the lake have decreased in Config 3, with the east side seeing a greater slow-down.



Wind Speed (m/s)



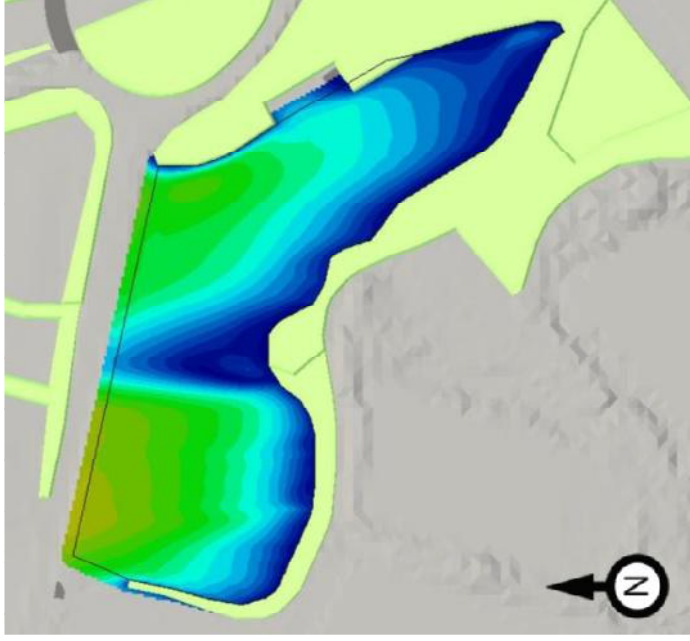
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

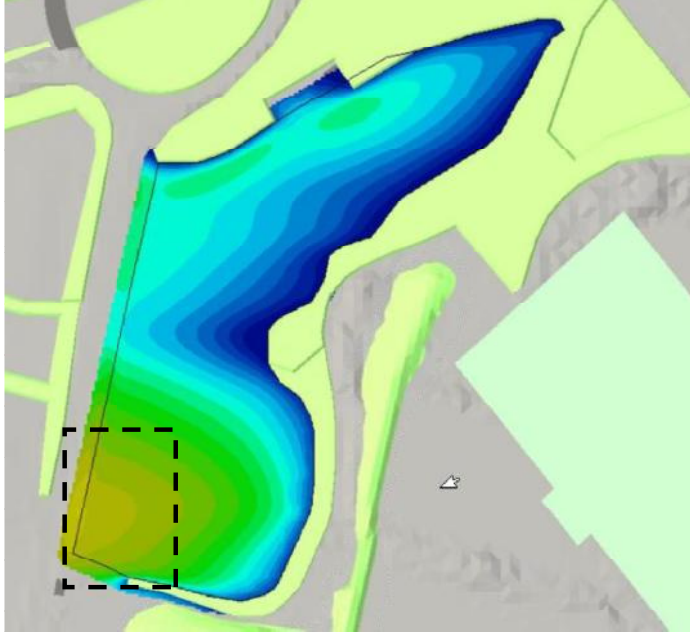


## 6.2 Predicted Wind Conditions: South (S) Wind at 6m

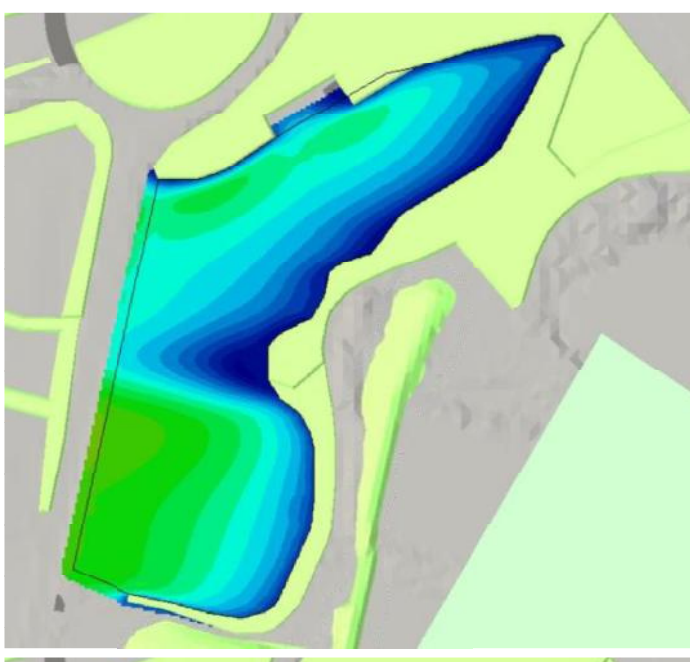
Config 1



Config 2



Config 3

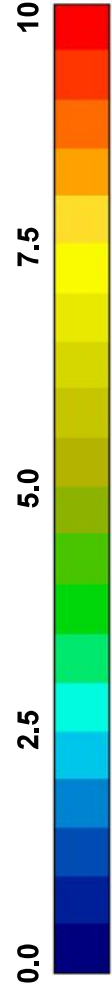


The zone of acceleration in the northwest corner is slightly larger at 6m, pushing into the centre of the reservoir

In general, wind speeds above the lake have decreased in Config 3, with the east side seeing a greater slow-down.



Wind Speed (m/s)



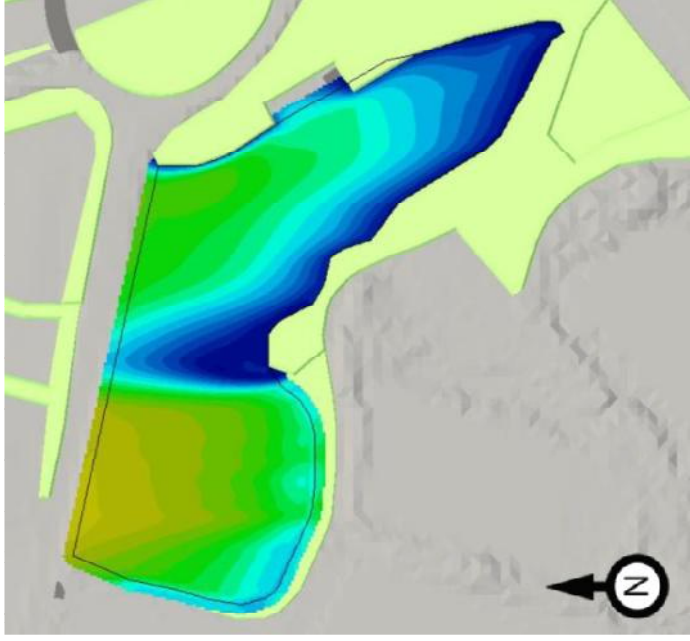
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

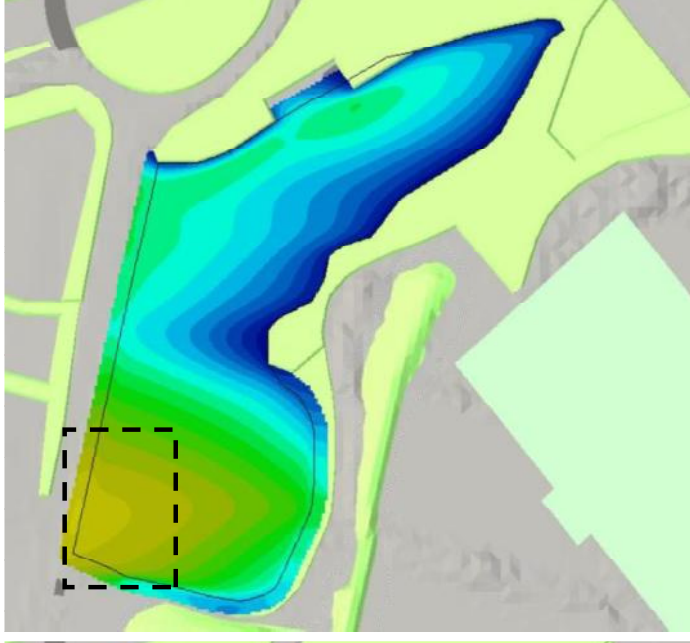


## 6.2 Predicted Wind Conditions: South (S) Wind at 9m

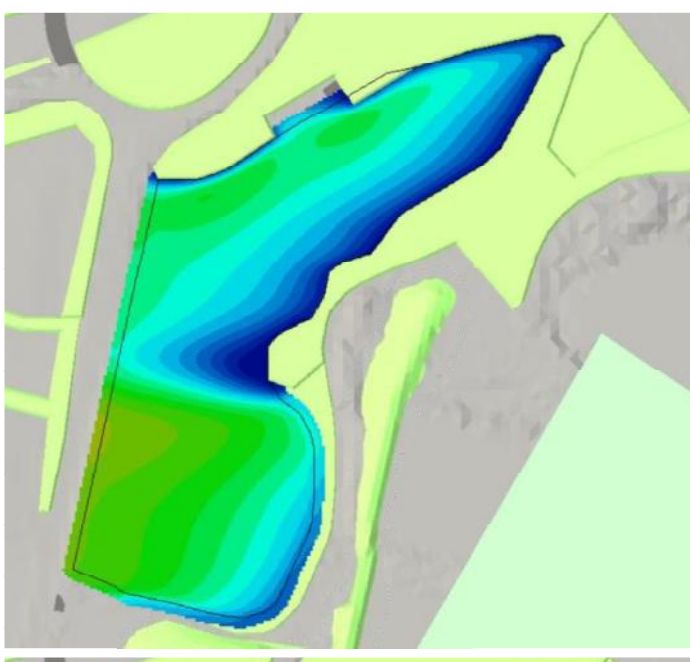
Config 1



Config 2



Config 3



The zone of acceleration in the northwest corner is slightly larger at 6m, pushing into the centre of the reservoir. Though wind conditions are generally similar to Config 1.

In general, wind speeds above the lake have decreased in Config 3.



Wind Speed (m/s)



\* The wind speed shown here is an estimated value.



# 6. WIND CONDITIONS



## 6.2 Predicted Wind Conditions: South (S) Wind at 12m

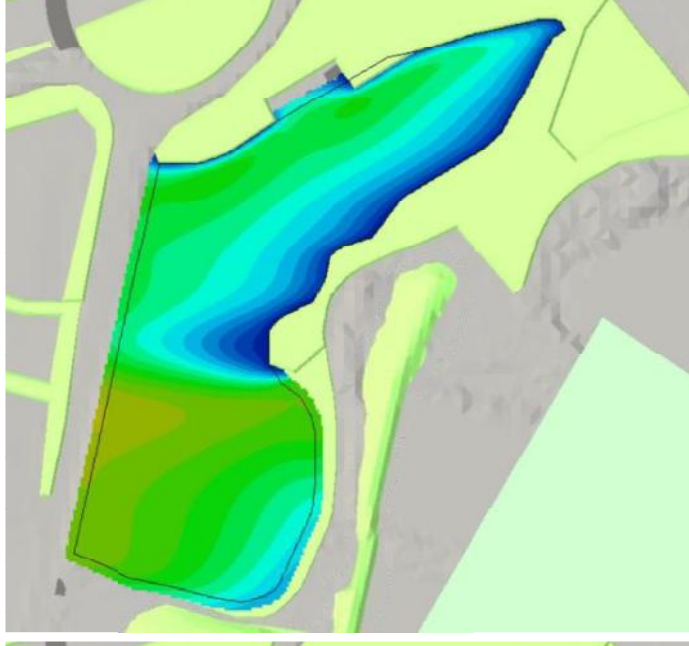
Config 1



Config 2



Config 3



At 12 m the acceleration in the northwest corner is less significant. We also now see a smaller calm zone in the centre of the reservoir.

In general, wind speeds above the lake have decreased in Config 3. The uniformity of the wind speeds across the lake under this configuration is noticeable compared to the existing condition.



Wind Speed (m/s)



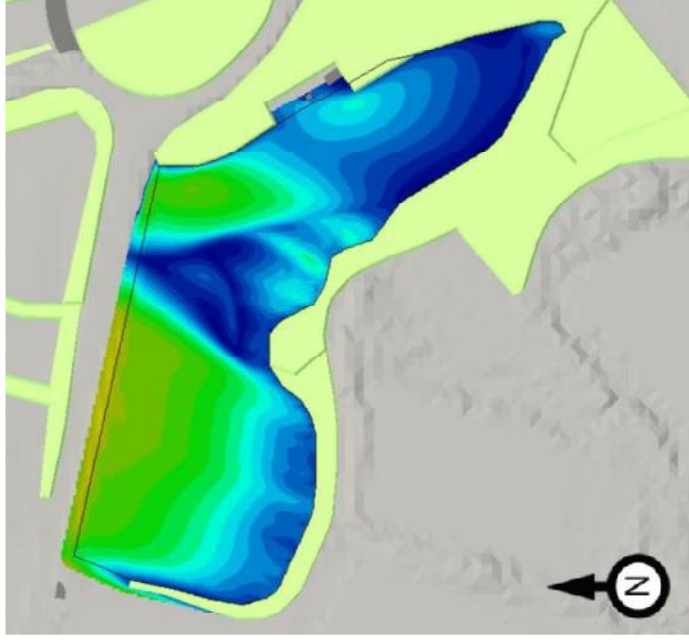
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

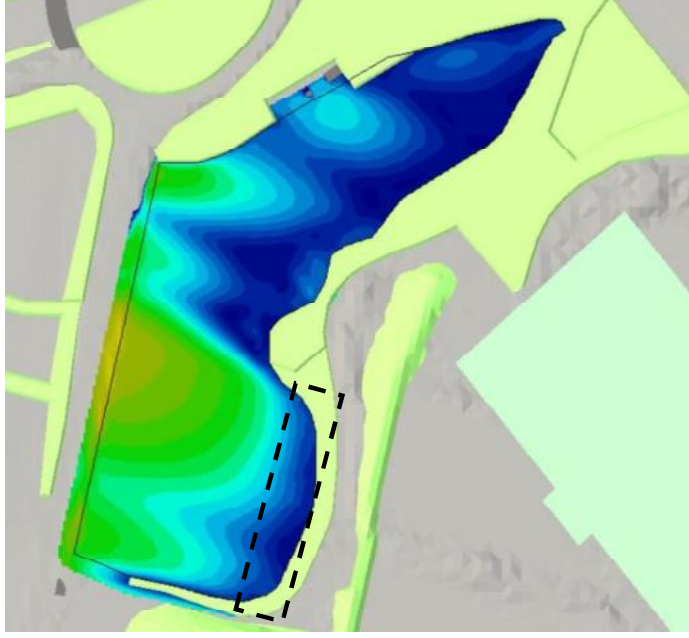


## 6.2 Predicted Wind Conditions: South-southwest (SSW) Wind at 3m

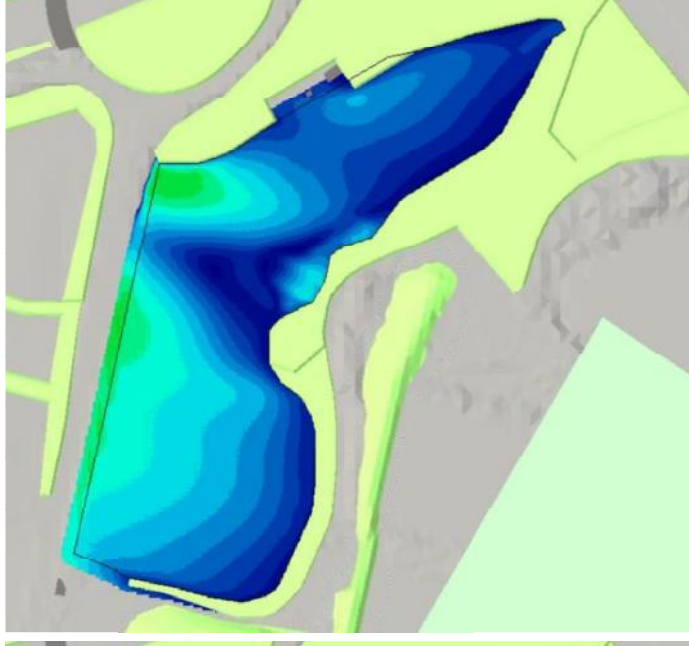
Config 1



Config 2



Config 3

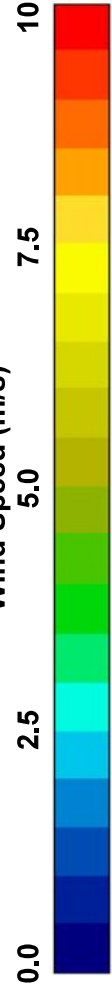


At 3 m the bund creates a significant slow down in the area immediately adjacent to it. Aside from this the change in wind speed under Config 2 is reduced compared to other directions.

SSW are significantly slowed by the Config 3 massing.



Wind Speed (m/s)



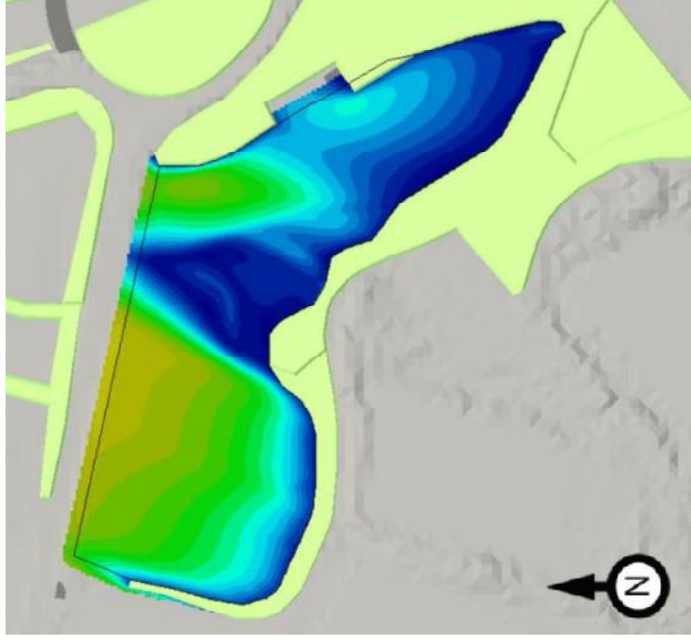
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

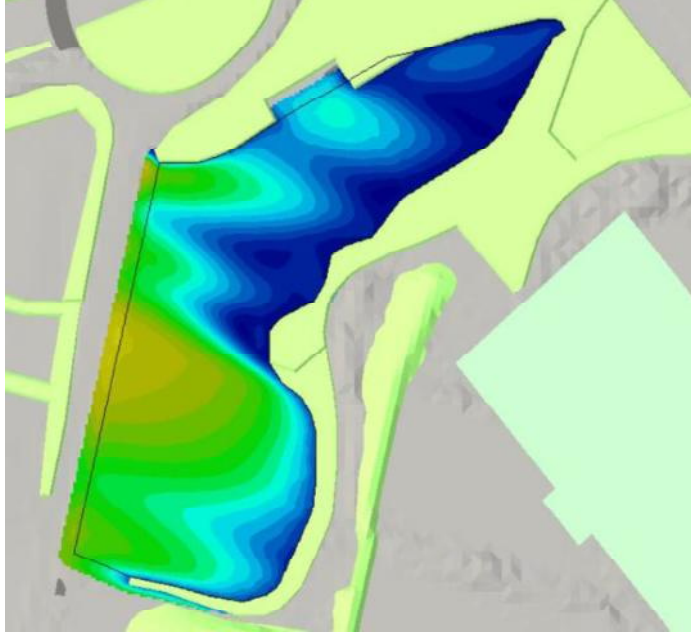


## 6.2 Predicted Wind Conditions: South-southwest (SSW) Wind at 6m

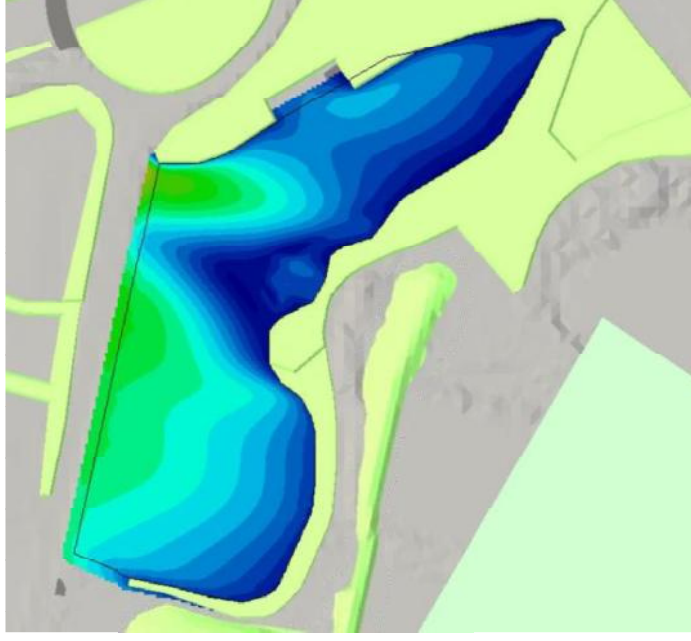
Config 1



Config 2



Config 3

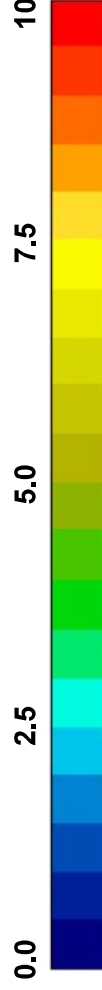


At 6m and above the influence of the bund is less noticeable.

SSW are significantly slowed by the Config 3 massing.



Wind Speed (m/s)



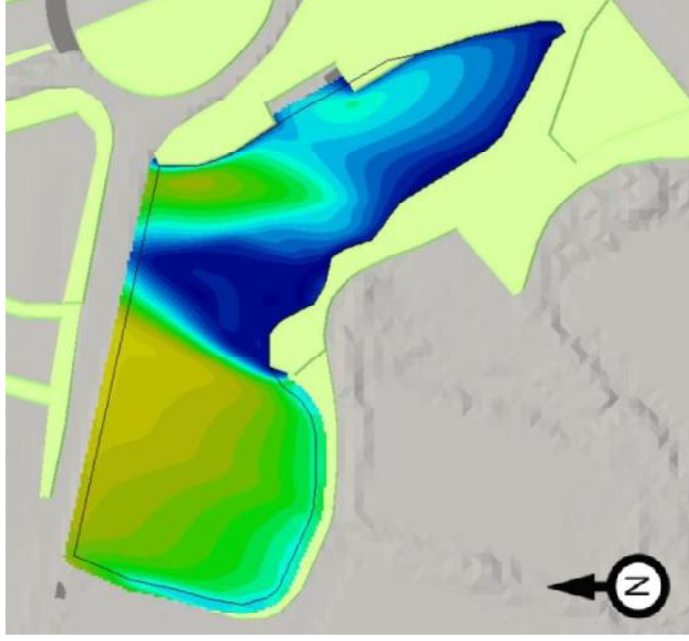
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

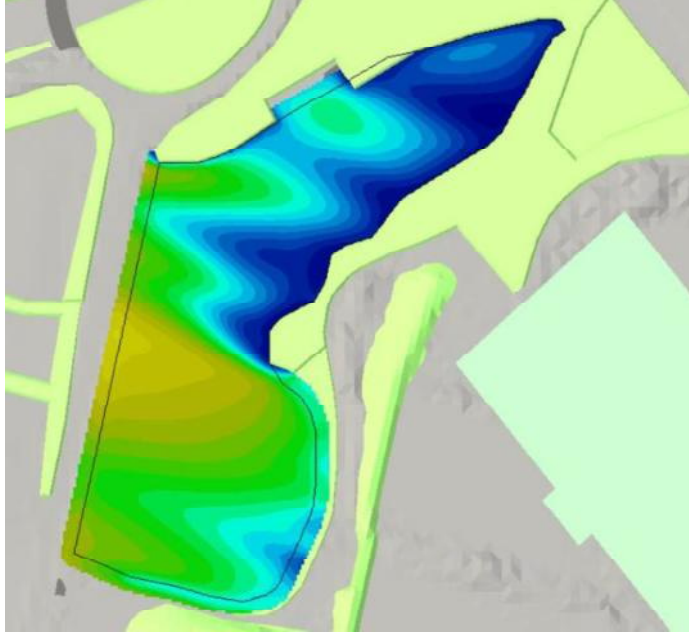


## 6.2 Predicted Wind Conditions: South-southwest (SSW) Wind at 9m

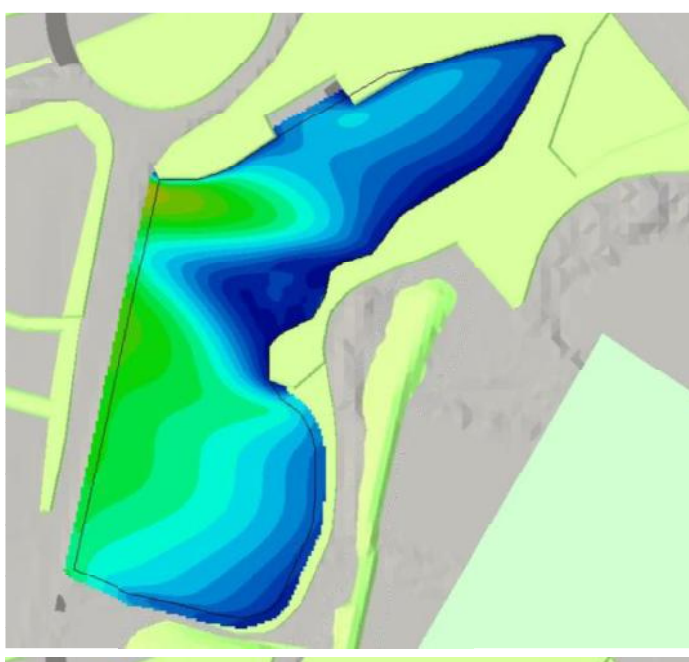
Config 1



Config 2



Config 3

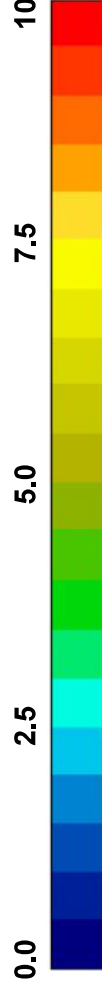


At 6m and above the influence of the bund is less noticeable.

SSW are significantly slowed by the Config 3 massing.



Wind Speed (m/s)



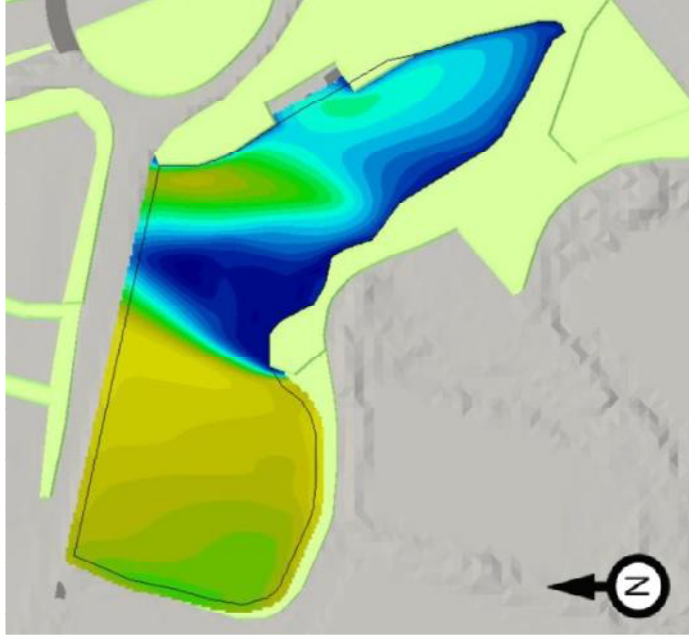
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# 6. WIND CONDITIONS

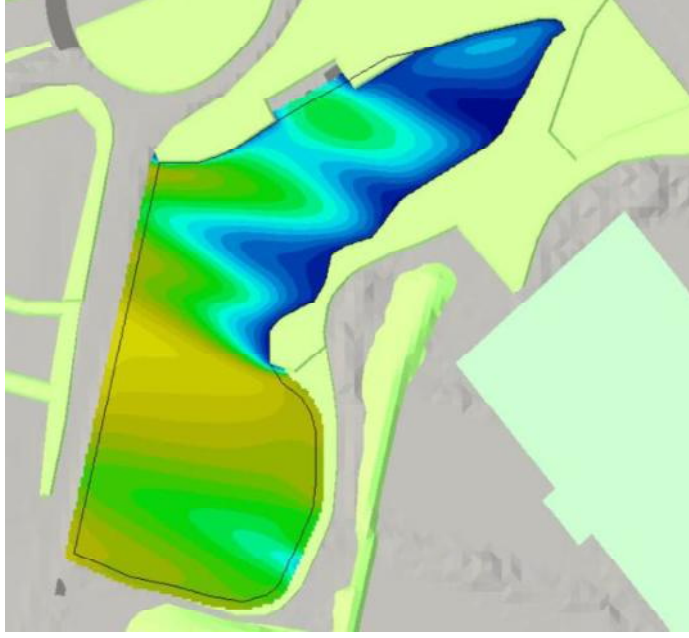


## 6.2 Predicted Wind Conditions: South-southwest (SSW) Wind at 12m

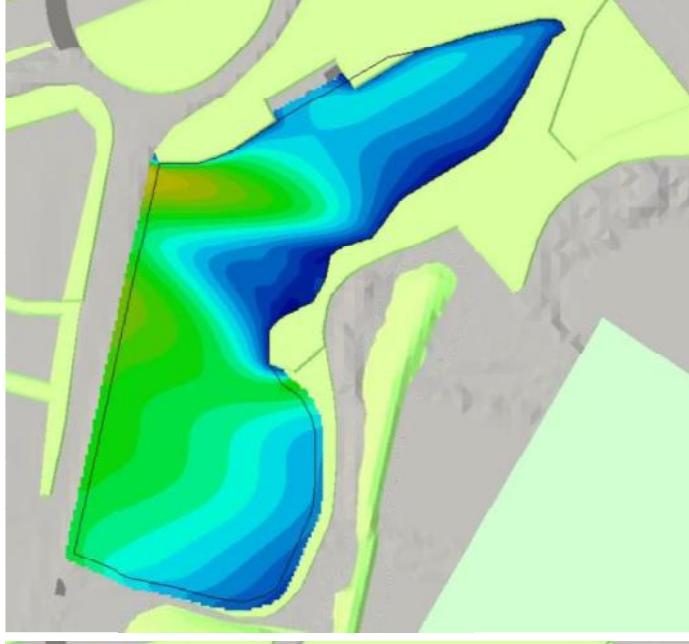
Config 1



Config 2

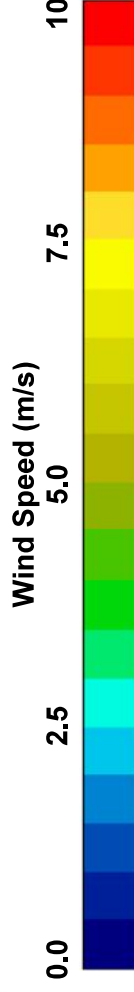


Config 3



At 12 m there is a zone of noticeably slower flow at the west end of the reservoir. A faster moving zone is observed in the east. Large slower speed zone seen in Config 1 has been reduced. Otherwise the flow patterns are generally the same as Config 1.

SSW are significantly slowed by the Config 3 massing.



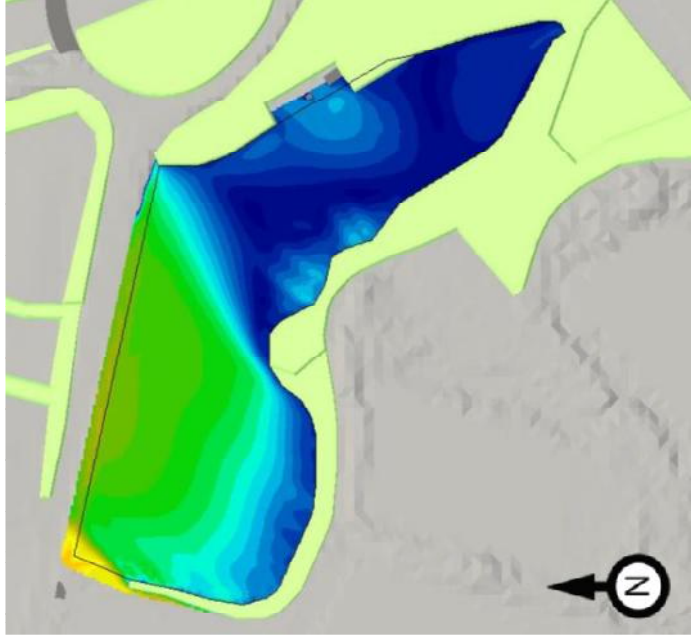
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

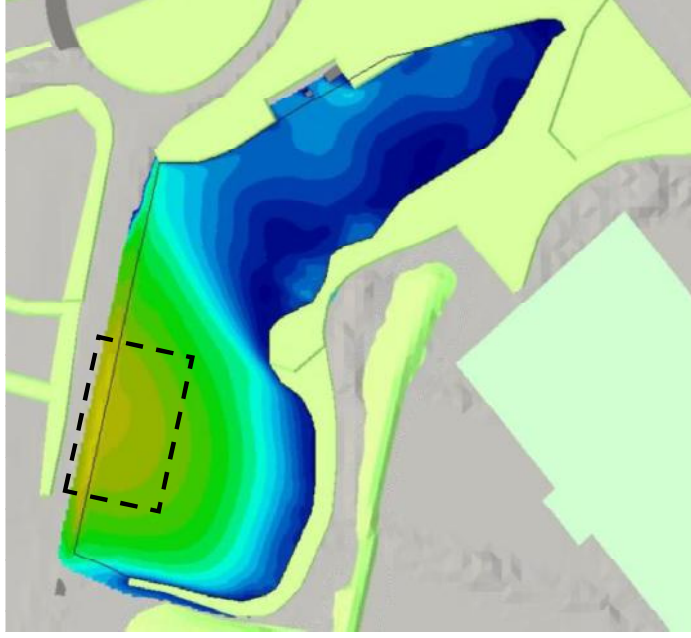


## 6.2 Predicted Wind Conditions: Southwest (SW) Wind at 3m

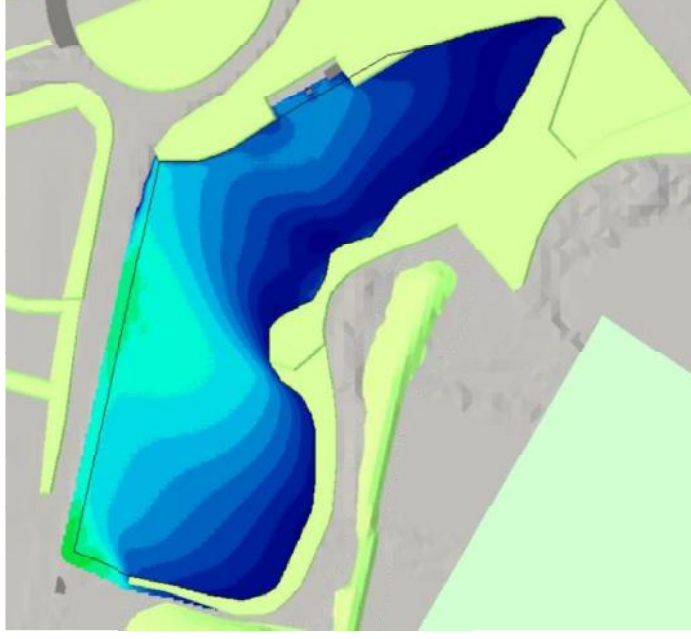
Config 1



Config 2

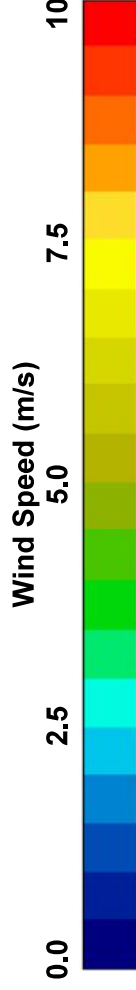


Config 3



The north side of the reservoir is expected to experience higher wind speeds. With the bund providing significant sheltering along the south shore.

Compared to the existing condition, the wind speed in Config 3 has significantly decreased.



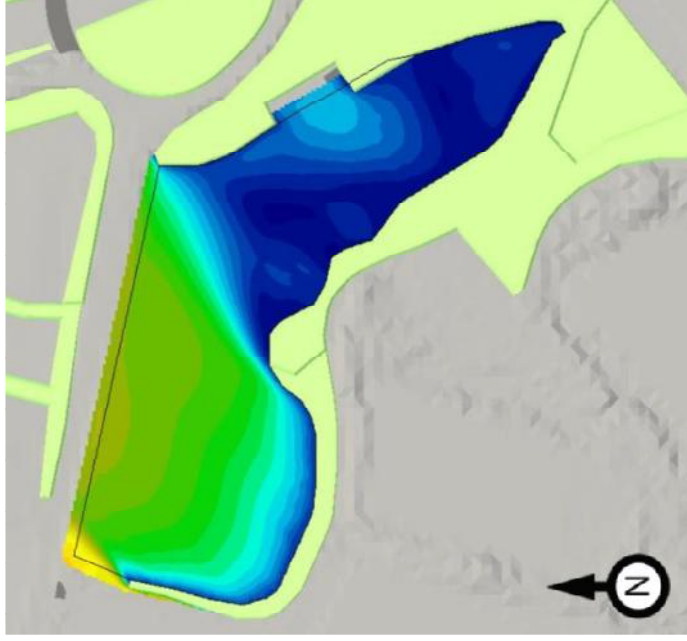
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# 6. WIND CONDITIONS

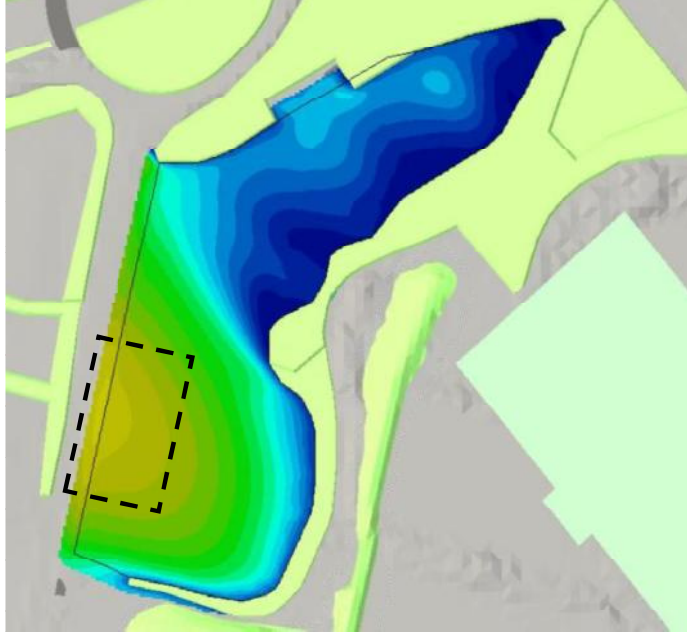


## 6.2 Predicted Wind Conditions: Southwest (SW) Wind at 6m

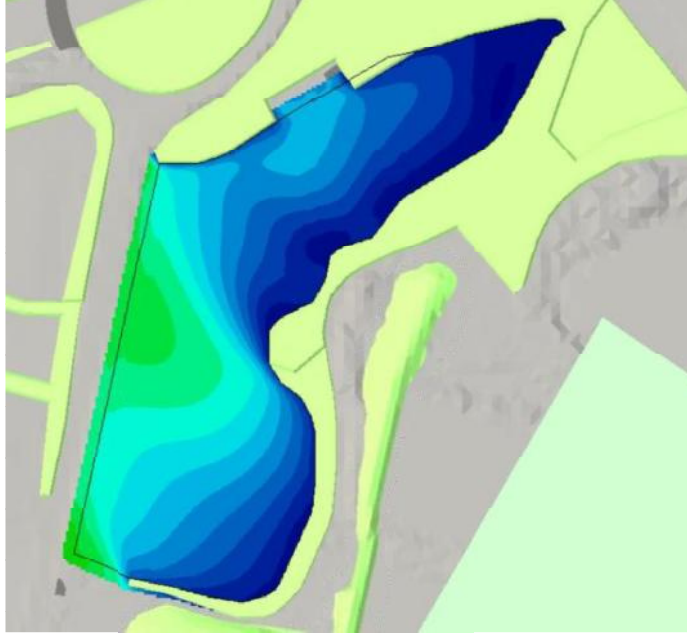
Config 1



Config 2

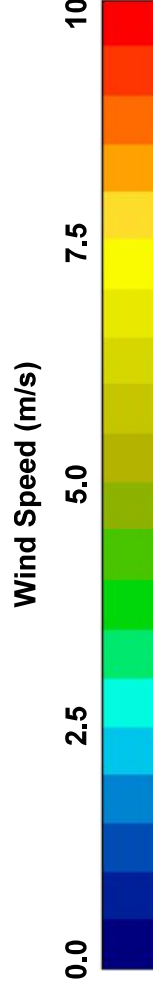


Config 3



The north side of the reservoir is expected to experience higher wind speeds. With the east side not dramatically changed.

Compared to the existing condition, the wind speed in Config 3 has significantly decreased.



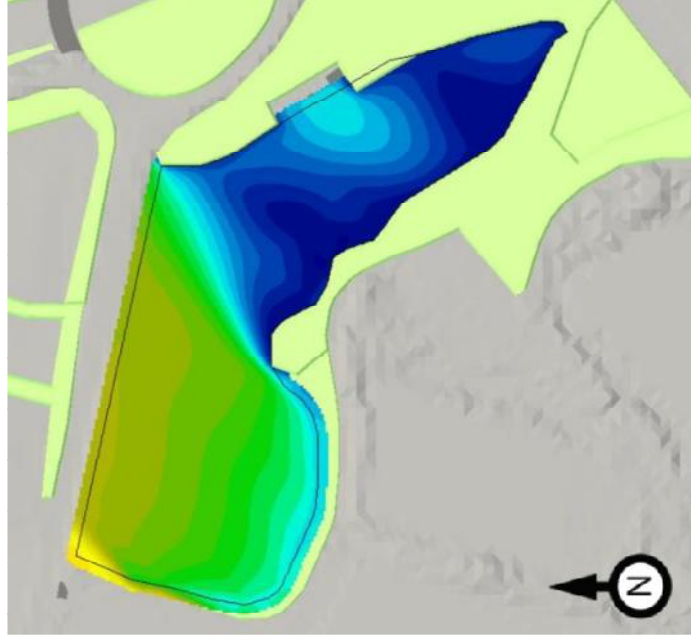
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

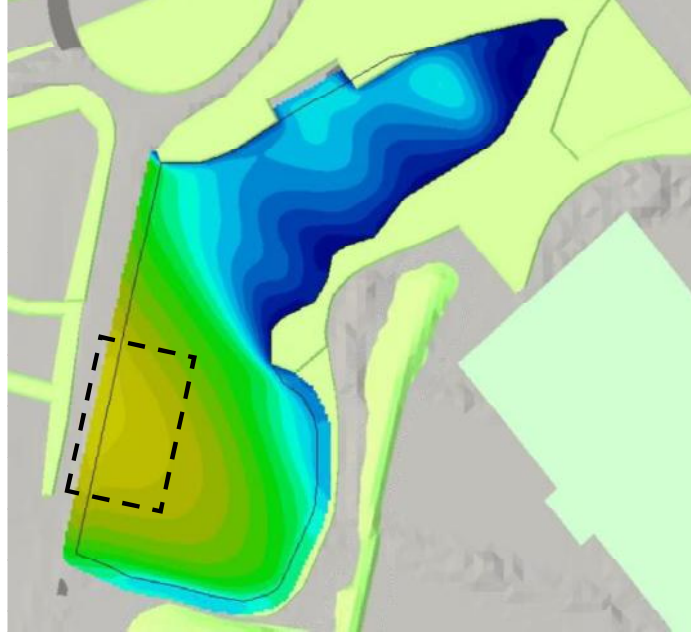


## 6.2 Predicted Wind Conditions: Southwest (SW) Wind at 9m

Config 1

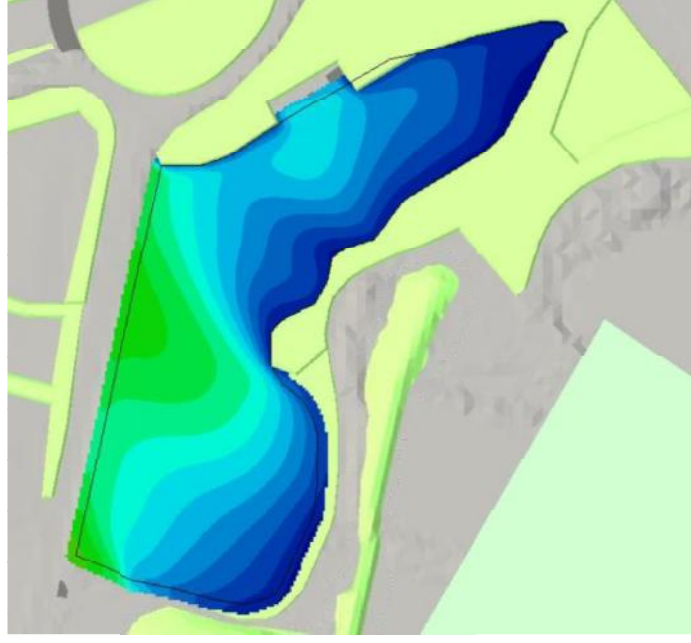


Config 2

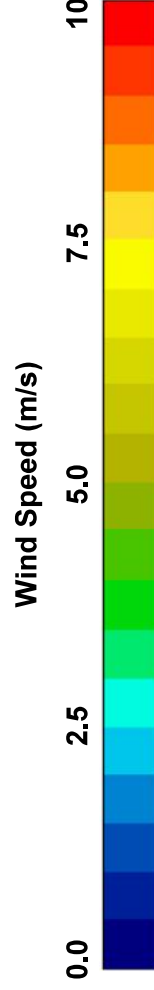


At this height there is a clear increase in wind speeds across much of the reservoir.

Config 3



Compared to the existing condition, the wind speed in Config 3 has significantly decreased.



\* The wind speed shown here is an estimated value.

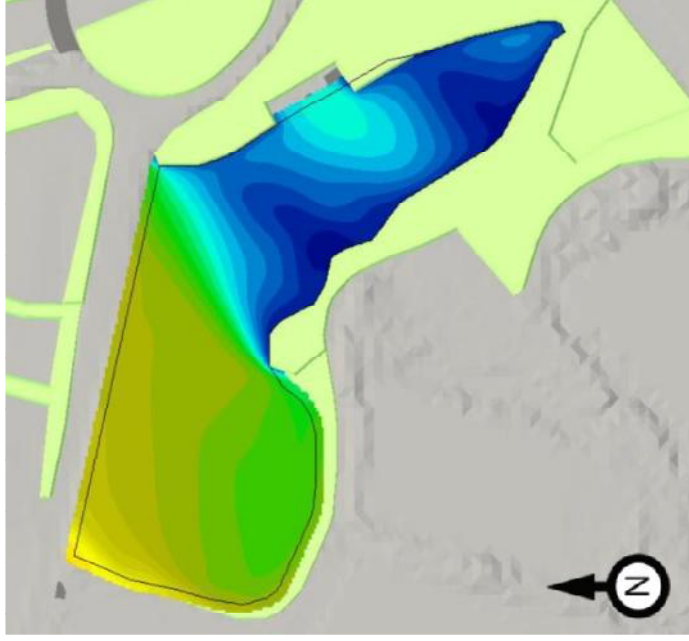


# 6. WIND CONDITIONS

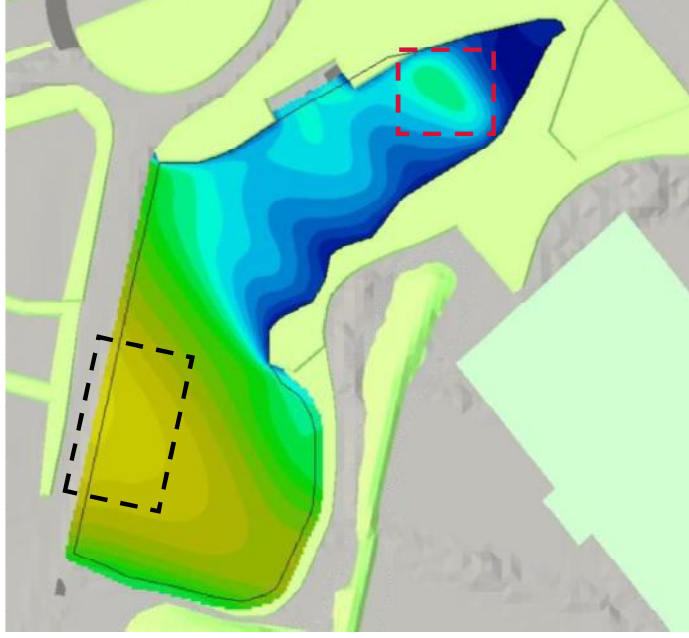


## 6.2 Predicted Wind Conditions: Southwest (SW) Wind at 12m

Config 1

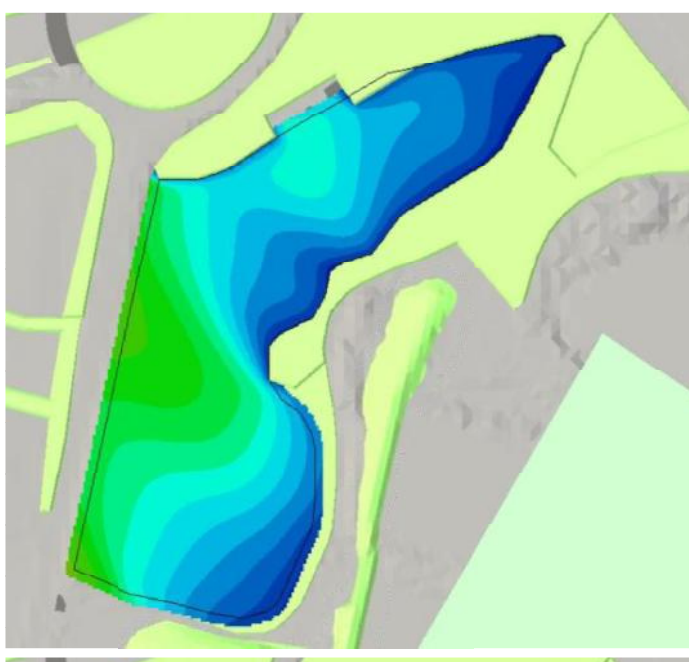


Config 2



At this height there is a clear increase in wind speeds across much of the reservoir but in particular at the northernmost and southernmost ends.

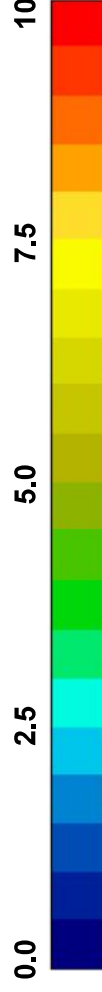
Config 3



Compared to the existing condition, the wind speed in Config 3 has generally decreased. Though uniformity of wind speeds is higher



Wind Speed (m/s)



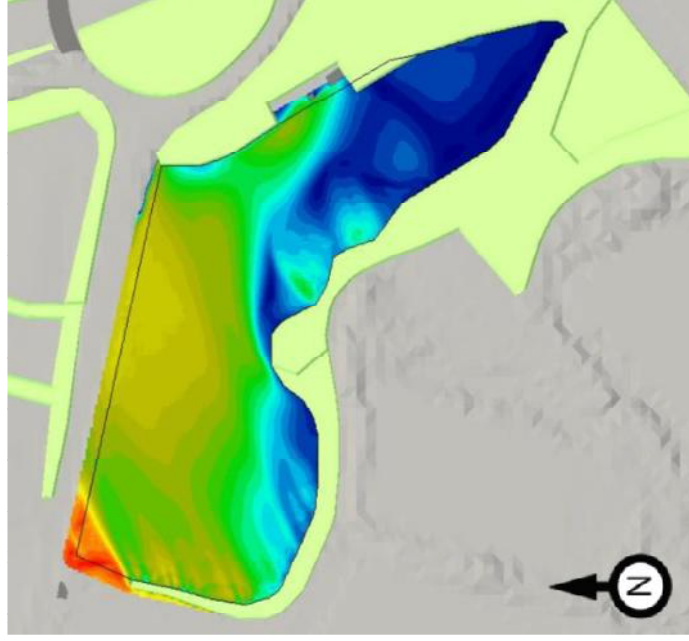
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

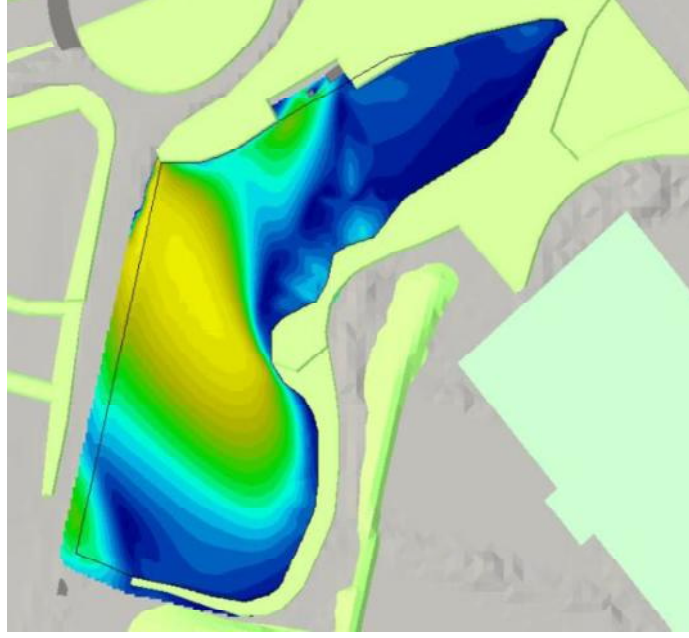


## 6.2 Predicted Wind Conditions: West-southwest (WSW) Wind at 3m

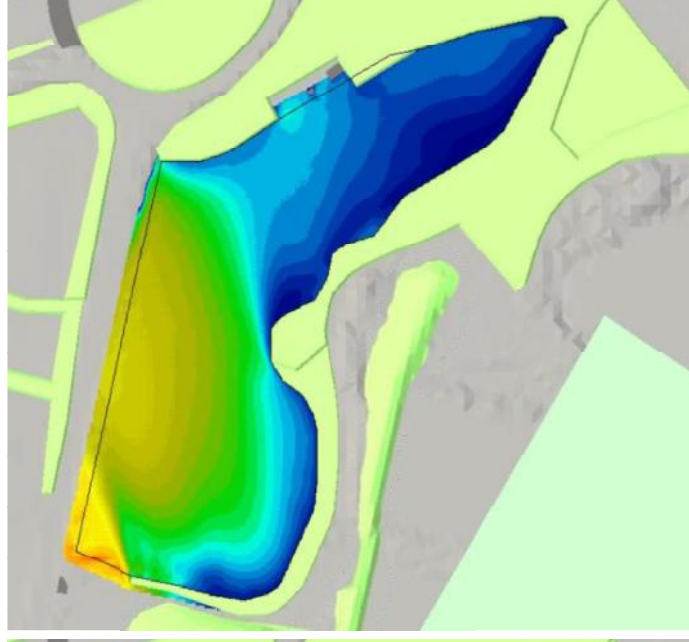
Config 1



Config 2

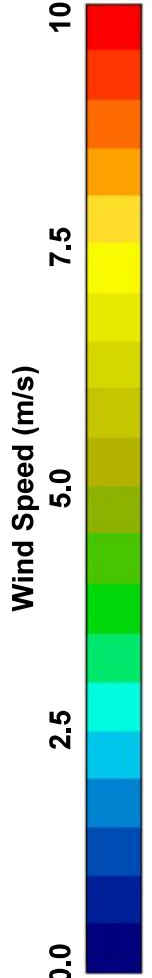


Config 3



The high speed zone in the northwest of the reservoir is calmed under this configuration. There is also a zone of increased speed in the middle of the reservoir predicted.

The higher speed zone in the northwest remains under Configuration 3, but has decreased in magnitude. Otherwise conditions are broadly the same as existing.



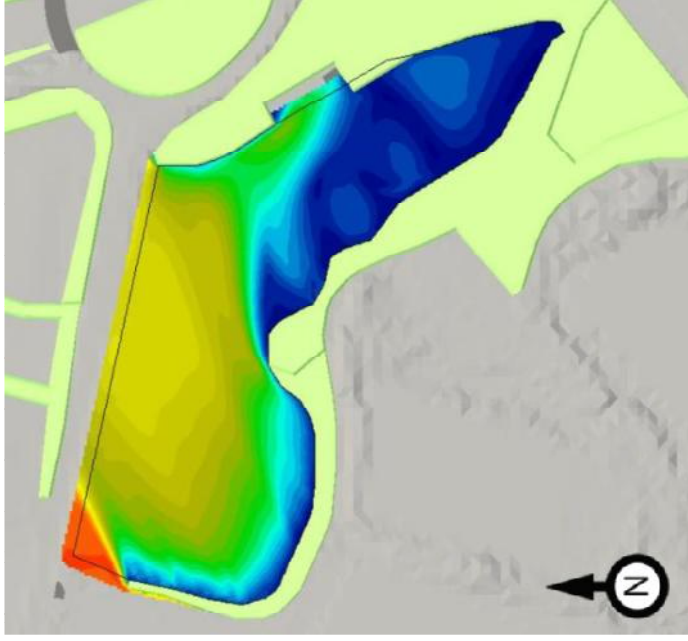
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

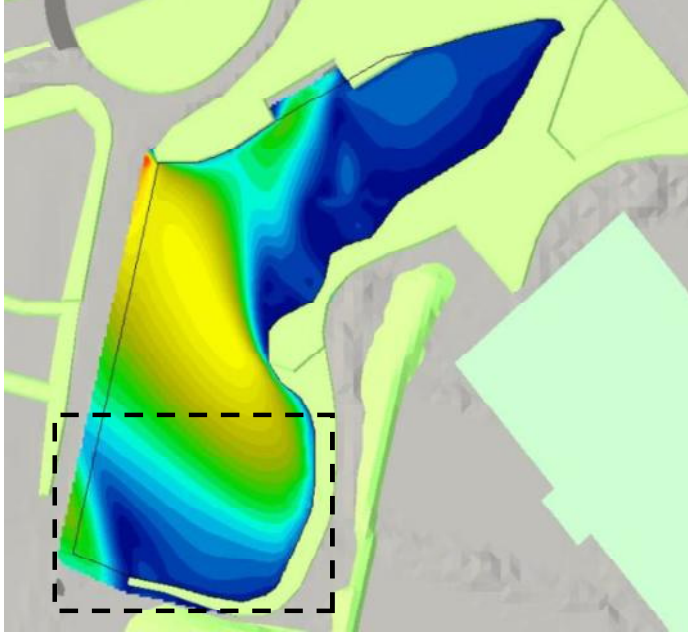


## 6.2 Predicted Wind Conditions: West-southwest (WSW) Wind at 6m

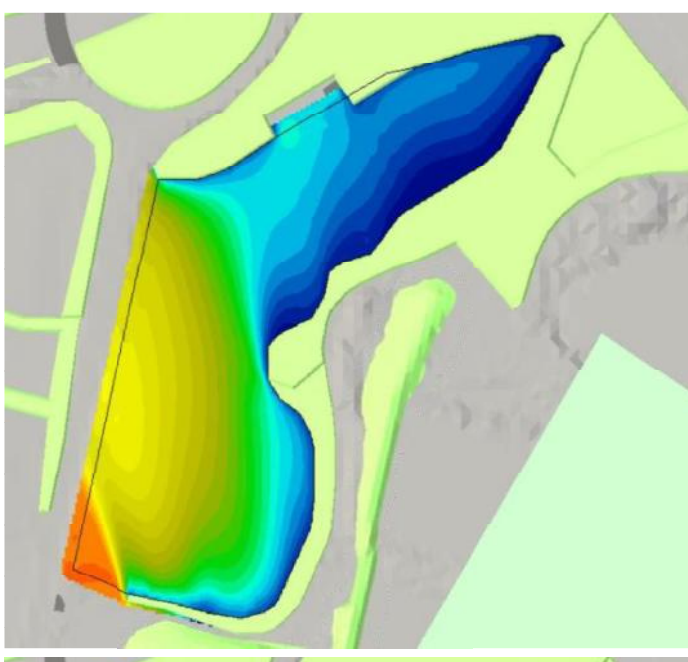
Config 1



Config 2

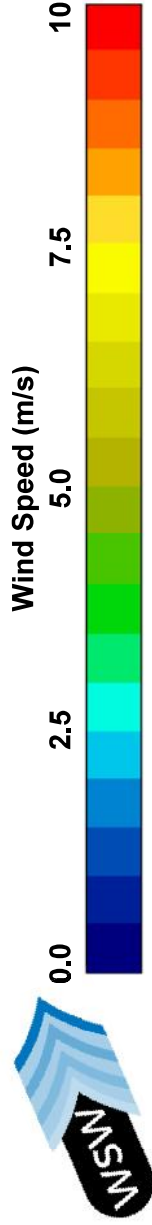


Config 3



At this height there is a clear increase in wind speeds across much of the reservoir but in particular at the northernmost and southernmost ends and a slower zone in the west.

Compared to the existing condition, the wind speed in Config 3 has generally decreased. Though uniformity of wind speeds is higher



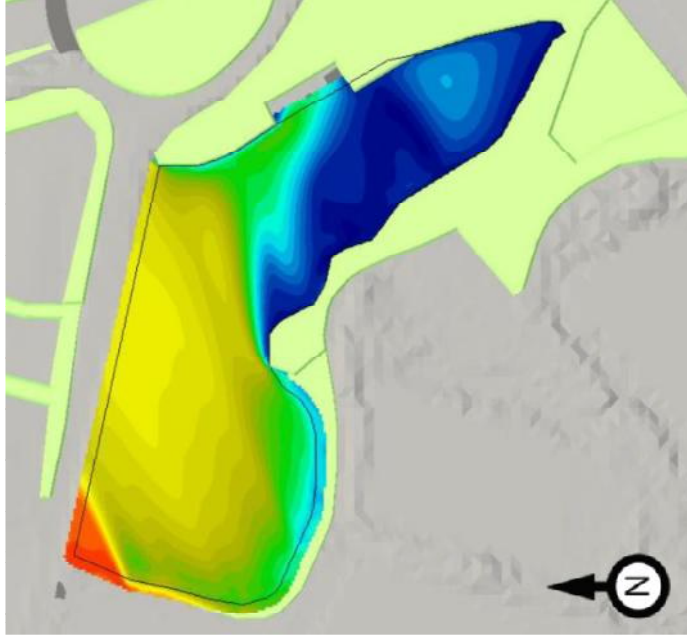
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

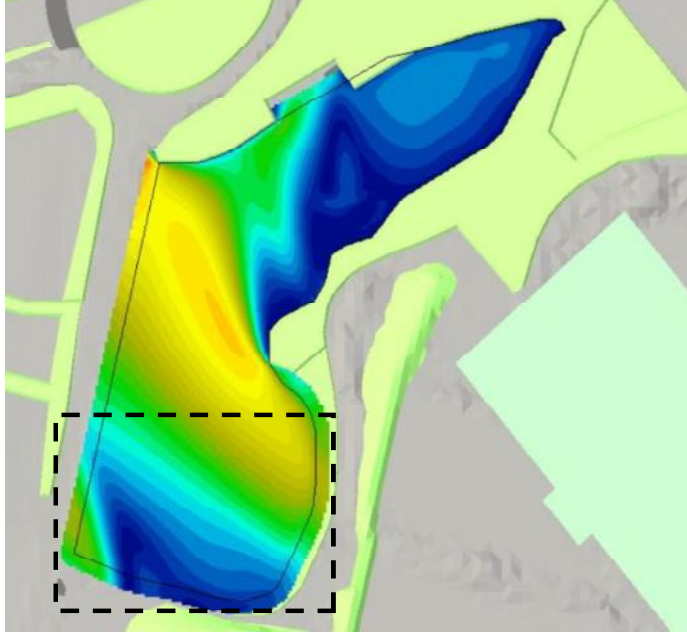


## 6.2 Predicted Wind Conditions: West-southwest (WSW) Wind at 9m

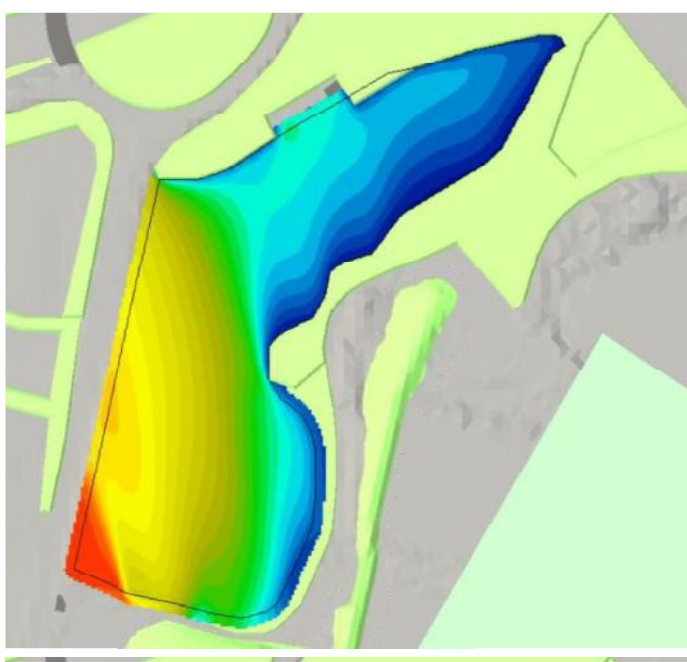
Config 1



Config 2



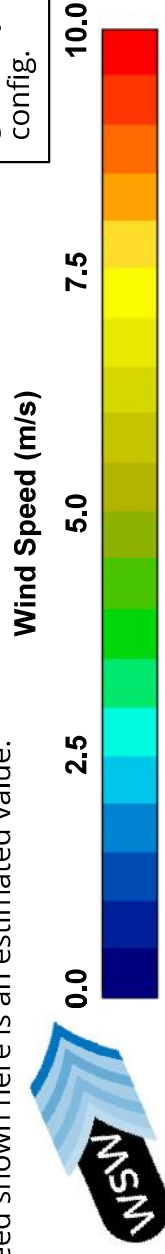
Config 3



The accelerated zone in the centre of the reservoir is larger and faster at 9m and the calmed zone is slightly smaller.

Compared to the existing condition, the wind speed in Config 3 is slightly higher. Though the distribution of the high, moderate and low speed zones is generally the same as the existing config.

\* The wind speed shown here is an estimated value.

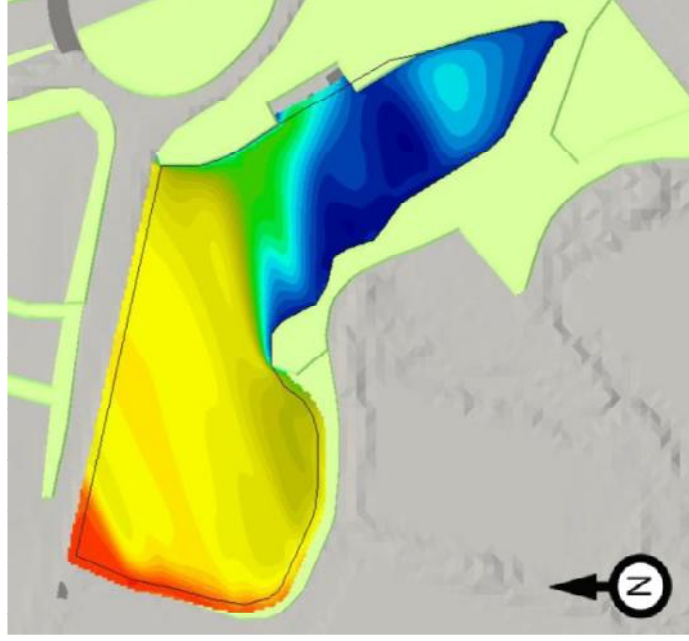


# 6. WIND CONDITIONS

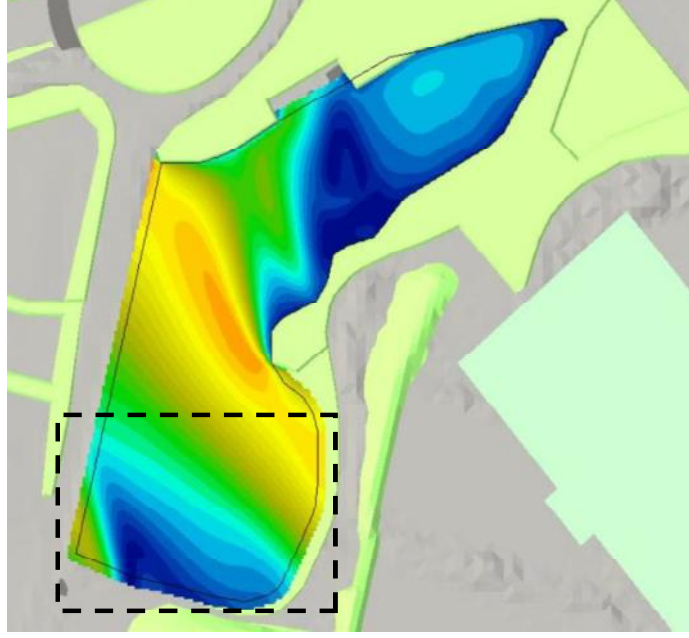


## 6.2 Predicted Wind Conditions: West-southwest (WSW) Wind at 12m

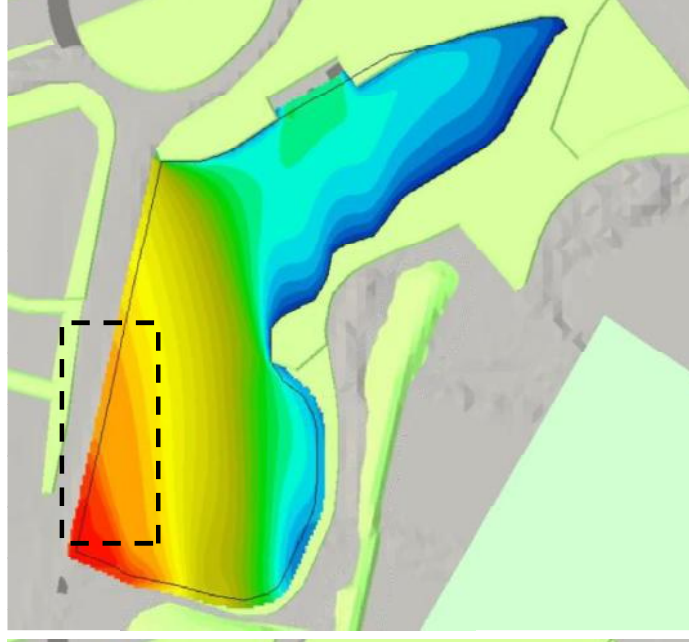
Config 1



Config 2



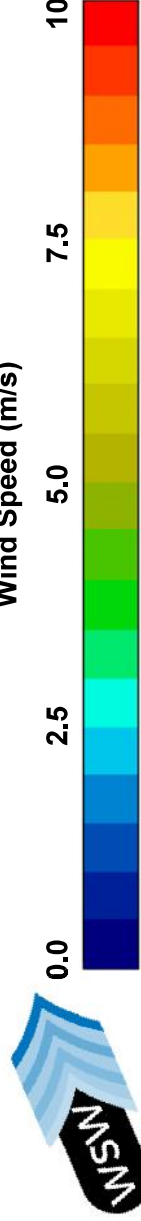
Config 3



The accelerated zone in the centre of the reservoir is larger and faster at 12m, with the west end much calmer.

Compared to the existing condition, the wind speed in Config 3 is slightly higher across the reservoir

Wind Speed (m/s)



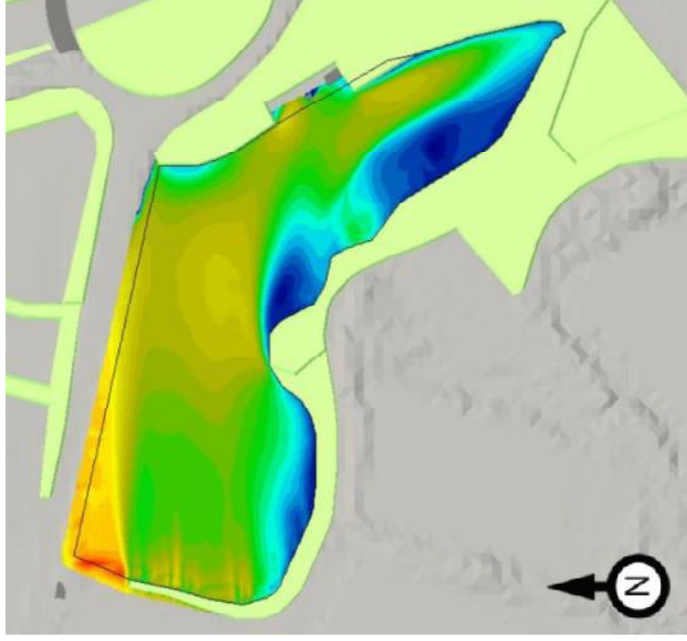
\* The wind speed shown here is an estimated value.

# 6. WIND CONDITIONS

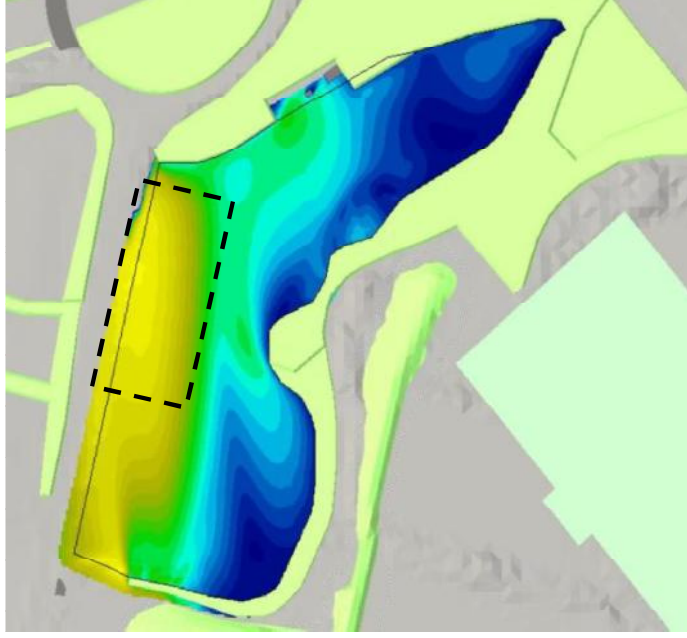


## 6.2 Predicted Wind Conditions: West (W) Wind at 3m

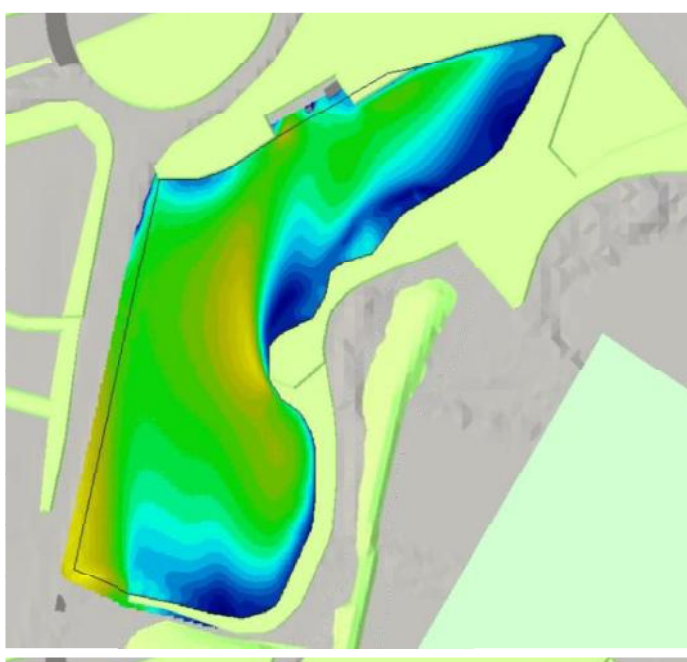
Config 1



Config 2



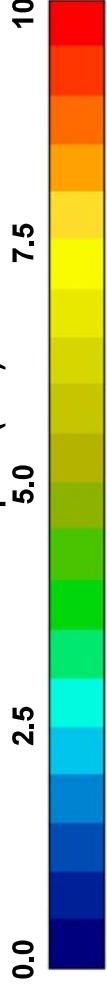
Config 3



The north end sees a more uniform distribution of speeds, though at a higher magnitude compared to the existing condition. The south end of the reservoir is calm

The higher speed zone in the northwest remains under Configuration 3, but has decreased in magnitude. Otherwise conditions are broadly the same as existing.

Wind Speed (m/s)



\* The wind speed shown here is an estimated value.

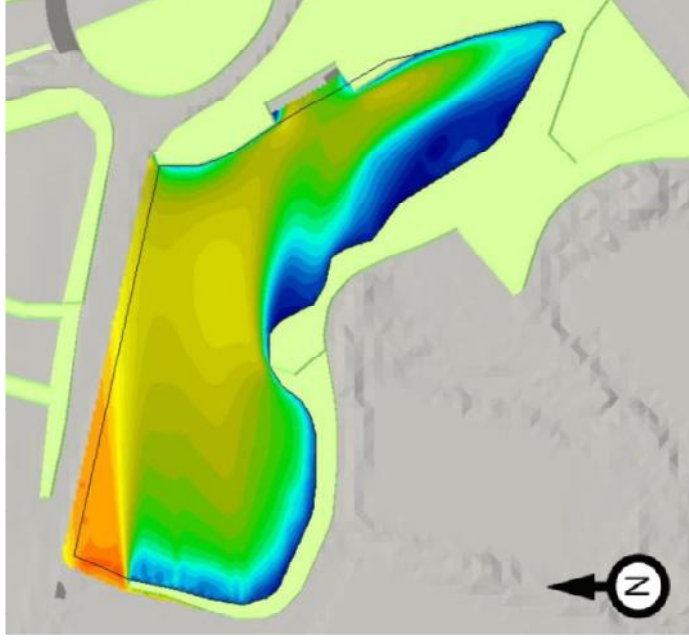


# 6. WIND CONDITIONS

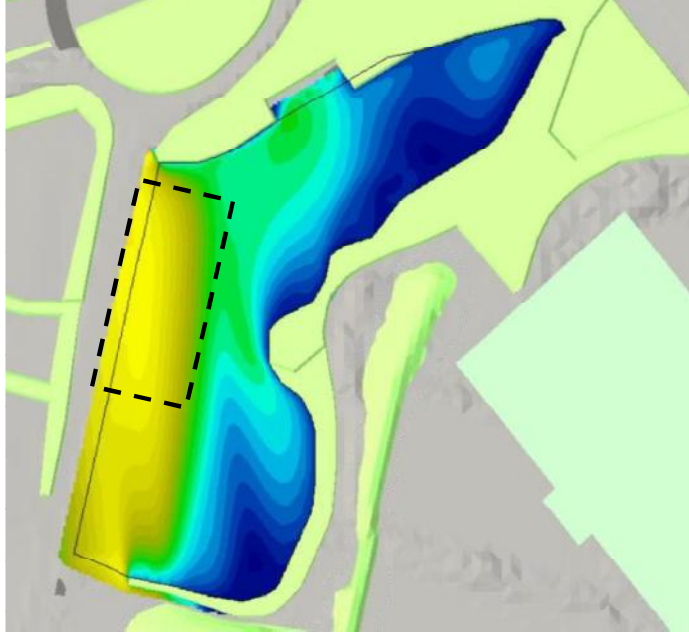


## 6.2 Predicted Wind Conditions: West (W) Wind at 6m

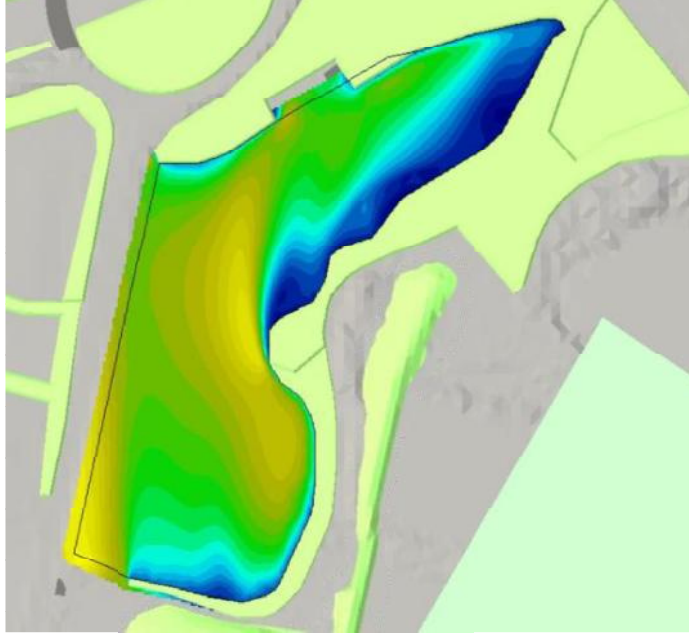
Config 1



Config 2



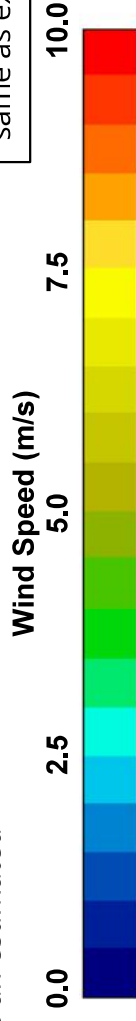
Config 3



The north end sees a more uniform distribution of speeds, though at a higher magnitude compared to the existing condition. The south end of the reservoir is calm

The higher speed zone in the northwest remains under Configuration 3, but has decreased in magnitude along with the south end. Otherwise conditions are broadly the same as existing.

\* The wind speed shown here is an estimated value.

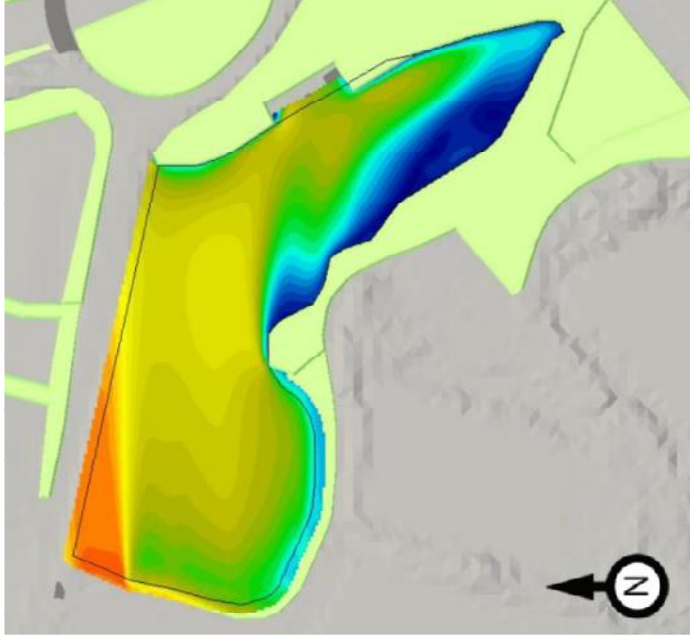


# 6. WIND CONDITIONS

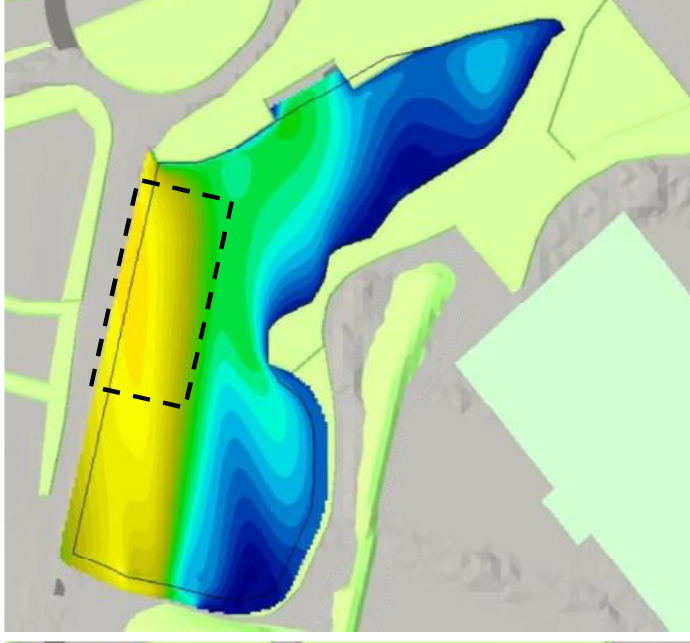


## 6.2 Predicted Wind Conditions: West (W) Wind at 9m

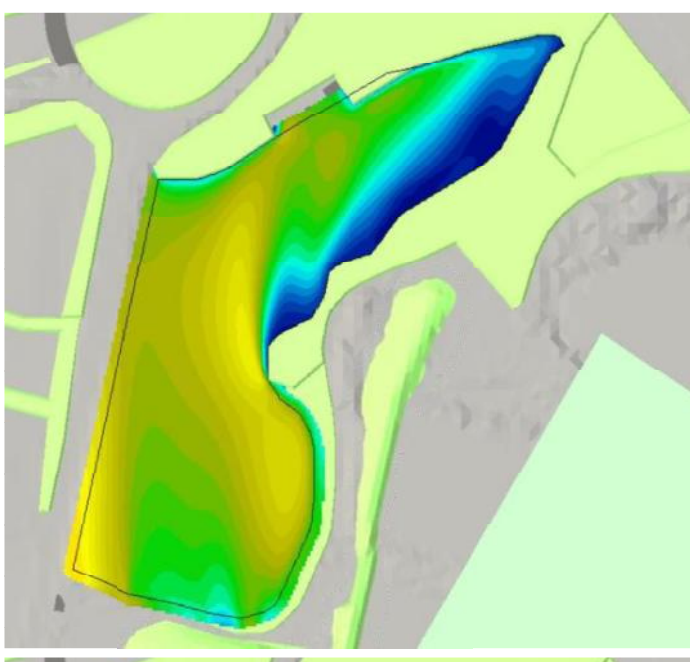
Config 1



Config 2

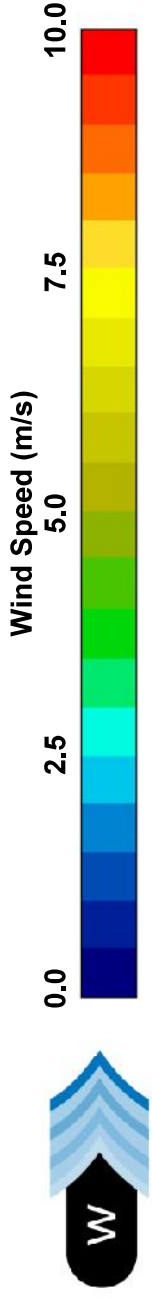


Config 3



The north end sees a more uniform distribution of speeds, though at a higher magnitude compared to the existing condition. The south end of the reservoir is calm. The high speed zone is pushed eastward.

The higher speed zone in the northwest has been distinctly calmed. Otherwise conditions are broadly the same as existing.



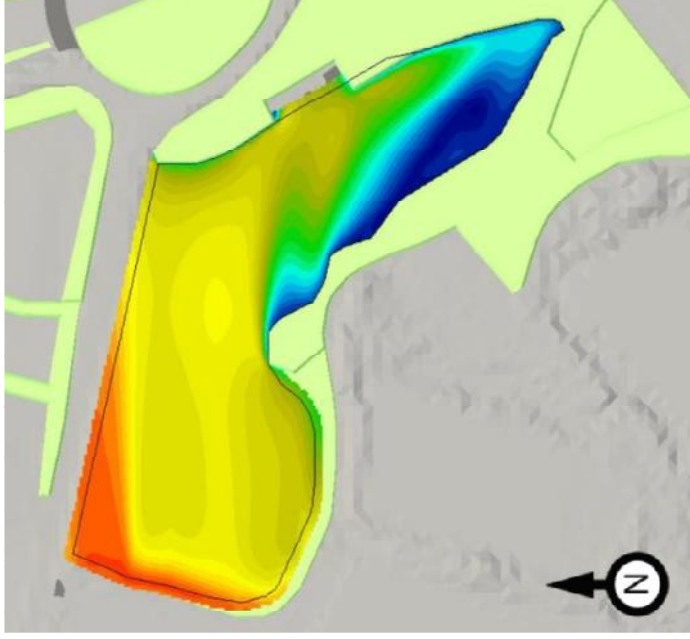


# 6. WIND CONDITIONS

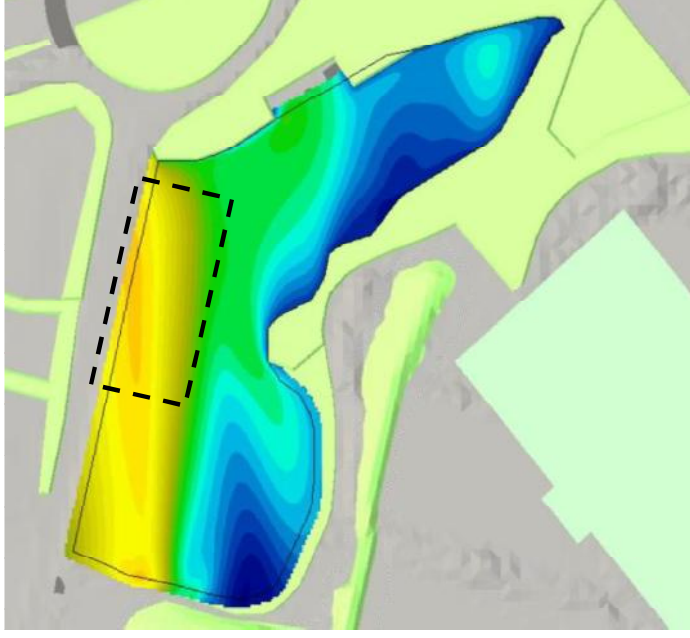


## 6.2 Predicted Wind Conditions: West (W) Wind at 12m

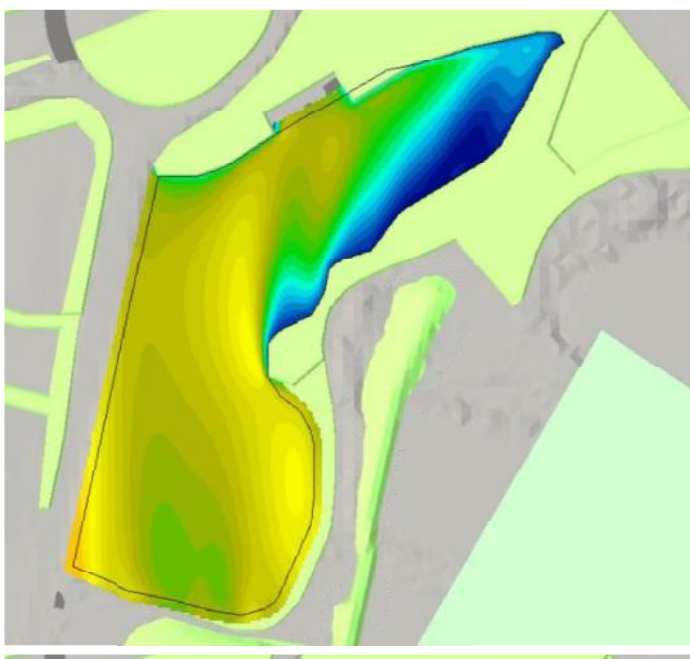
Config 1



Config 2

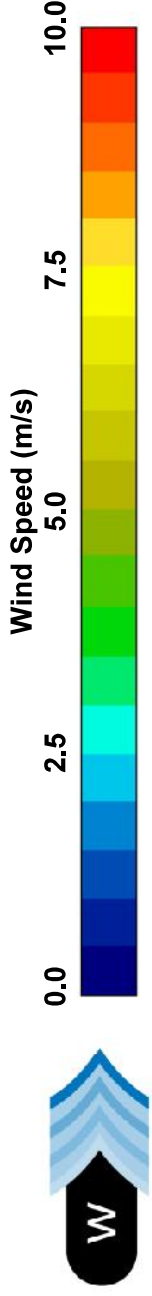


Config 3



The north end sees a more uniform distribution of speeds, though at a higher magnitude compared to the existing condition. The south end of the reservoir is calm. The high speed zone is pushed eastward.

The higher speed zone in the northwest has been distinctly calmed. Otherwise conditions are broadly the same as existing.



\* The wind speed shown here is an estimated value.

# 7. CLOSING



## 7.1 Summary

The bund can have a significant effect on local wind speeds on the areas of the reservoir immediately adjacent to it under many wind conditions for both Configurations. This effect acts to calm wind speeds (compared to existing) and can extend up to 9 m above the water. That said, it does seem to be limiting the effects of wind channeling between the buildings as it flows towards the reservoir in many cases, and under some conditions the redirection and channeling of winds by the proposed warehouse buildings reduces the calming effect of the bund.

Configuration 2 tended to create higher variability in the wind speeds under the more southerly conditions. In particular at the southeastern 'leg' of the reservoir.

The Configuration 3 simulations tended to predict lower gradients (i.e. more uniform speeds) of wind flow compared to Configuration 2 and the existing case. And the patterns of high to low speeds were more consistent with the existing condition.

The results of the CFD simulations show that the wind speeds over the reservoir are affected by the proposed development under both configurations. In some cases localized decreases in wind speed are created, while in others it is an increase (e.g. wind from the southwest being channelled between the buildings in Configuration 2).

This report is intended to provide an assessment of the wind microclimate around the proposed development. These are intended to be used for preliminary feedback and by Wolfson Unit for additional analysis on the possible impact on sailing. Their findings will be issued in a separate report.

## 7.2 Applicability

The assessment presented in this report is for the proposed warehouse buildings, based on the site plans received by RWDI on 8 February, 2019. In the event of any significant changes to the design, construction or operation of the building or addition of surroundings in the future, RWDI can provide an assessment of the impact on the wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.