BOUNDARY RISK ASSESSMENT

ROMAN FIELDS HOUSING DEVELOPMENT

ADJACENT TO PORTSMOUTH GOLF COURSE

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LABOSPORT

BOUNDARY RISK ASSESSMENT – ROMAN FIELDS HOUSING DEVELOPMENT (PORTSMOUTH GOLF COURSE)

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APPROVED BY		David James Managing Director

SUMMARY	A new housing development is being planned for land adjacent to Portsmouth Golf Course. There is a possibility that balls may surpass the boundaries of the golf course and present a risk to the residents and properties within the new development. Labosport Ltd has reviewed the site to ascertain the risk of balls landing in areas past the boundaries; and to advise on the type and level of mitigation recommended to provide a suitable level of protection.

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Section 1 – Introduction

Introduction
To assess the potential risk of golf balls surpassing the boundaries of Portsmouth Golf Course and entering the proposed development, Labosport Ltd has reviewed the site to ascertain the risk of balls landing in areas past the boundaries; and to advise on the type and level of mitigation recommended to provide a suitable level of protection. A sophisticated trajectory model was developed using data from published studies on golf ball aerodynamics and measured data on golf ball launch dynamics. The model was used to simulate ball trajectories for relevant shots at specific locations at the golf course where potential risks were identified. The height of the ball as it surpassed the site boundary was calculated for each scenario. This report forms the basis of a risk assessment and a recommended mitigation strategy to minimise potential risks. Note: This is a desk-based study. Labosport have not visited Portsmouth Golf Course to survey the site. All measurements have been provided by the client, and Labosport cannot be held accountable for any errors that may arise from this information.

Previous Work
Labosport Ltd have undertaken this type of sports boundary risk assessment for over 5 years when there have been perceived problems with balls exceeding the boundary, or the potential influence of a new adjacent development to an existing club. Through this work, Labosport Ltd have developed significant expertise that supports our judgements in these matters.

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Section 2 – Golf Ball Trajectory Model

Trajectory Model Overview

A sophisticated three-dimensional trajectory model was developed to analyse the trajectory of the golf ball. The model was built in the numerical programming software 'Matlab' and incorporated aerodynamic drag and lift forces, and the complexities arising from the ball's spin rate.

The model used published aerodynamic coefficients taken from wind tunnel studies on golf balls at different velocities and spin rates (Bearman, P. W. & Harvey, J. K. (1976) – Golf Ball Aerodynamics - Aeronautical Quarterly, Volume 27, Issue 2, May 1976, pp. 112-122).

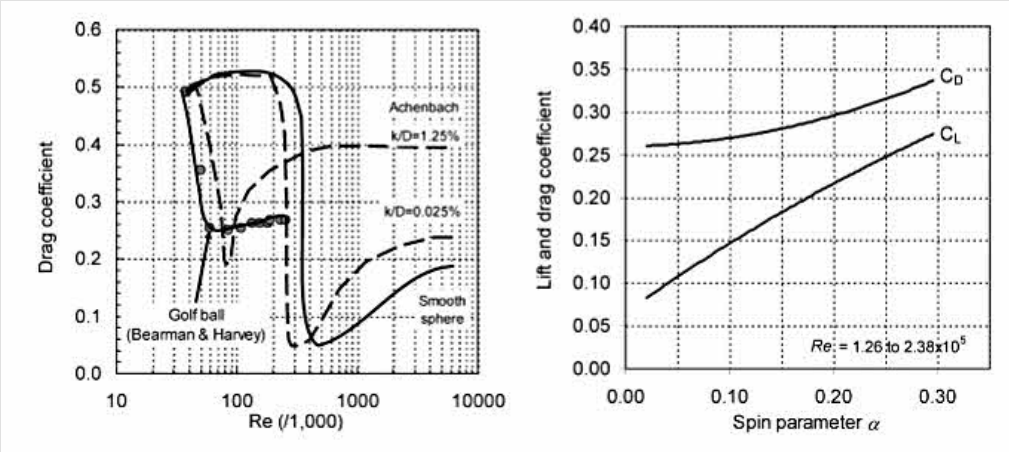

Figure 1 (a) Drag coefficient for a golf ball compared to rough and smooth spheres; (b) Lift and drag coefficients for a spinning golf ball with spin parameter $\alpha = \omega r/U_\infty$ (Bearman & Harvey, 1976).

The aerodynamic forces of drag (F_D) and lift (F_L) are proportional to the ball's velocity relative to the air flow, frontal area, air density and the drag coefficient respectively lift coefficient. The forces are defined as:

=

=

with C_D and C_L are the non-dimensional drag and lift coefficients, ρ the air density in kg/m^3, V the air stream velocity in m/s and A the frontal area of the ball in m^2.

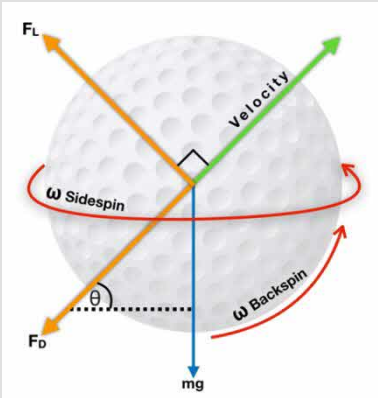

Figure 2. A free body diagram for the golf ball trajectory model showing the aerodynamic drag and lift forces.

Due to the complexity of the flight dynamics, the trajectory can only be resolved by using a numerical time step approach whereby the ball conditions are calculated at small timesteps throughout the trajectory. The conditions at time step 1 are used to calculate the conditions at time step 2; the conditions are timestep 2 are used to calculate the conditions at time step 3 and henceforth. A timestep of 0.001 seconds was used to generate high-resolution trajectory data.

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Figure 3. The coordinate system used in the trajectory model.

The trajectory model uses a standard Cartesian coordinate system to define the location of the ball throughout flight. Examples of the trajectory model simulations can be seen in Figure 4.

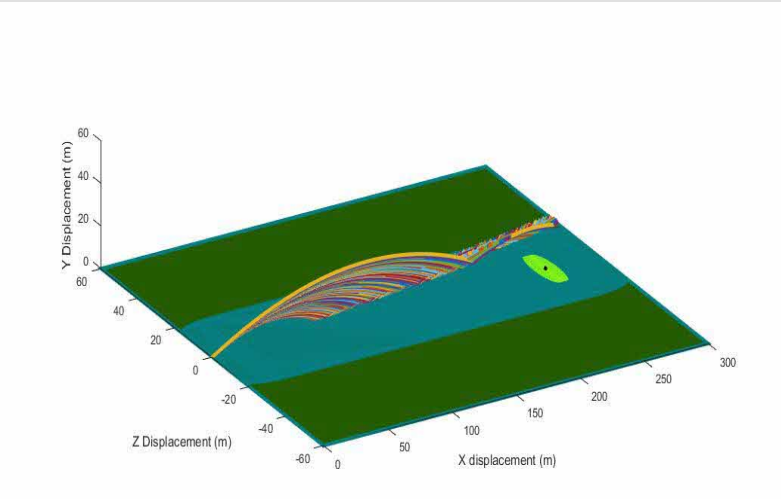

Figure 4. Examples of the trajectory model visualisations in Matlab.

Model Validation

The trajectory model was validated by comparing the TrackMan measured flight distance for an average male amateur with predictions from the trajectory simulations. The trajectory was found to exhibit high accuracy; however, it is not possible to model the full complexity of the real world and the model developed for this project is best regarded as an indicative predictive tool.

TrackMan measured flight distance	Trajectory model prediction (based on initial launch conditions)	Trajectory model accuracy
186.5 metres	187.0 metres	< 0.3%

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Section 3 – Site Specifics

Course Layout

Labosport have been provided with plans that show the proposed housing development and have concluded the possible risks to be located on holes 6 and 7 at Portsmouth Golf Course. The below image shows the orientation of holes 6 and 7 in relation to the proposed development. There is a possibility that erroneous shots may intersect the new properties.

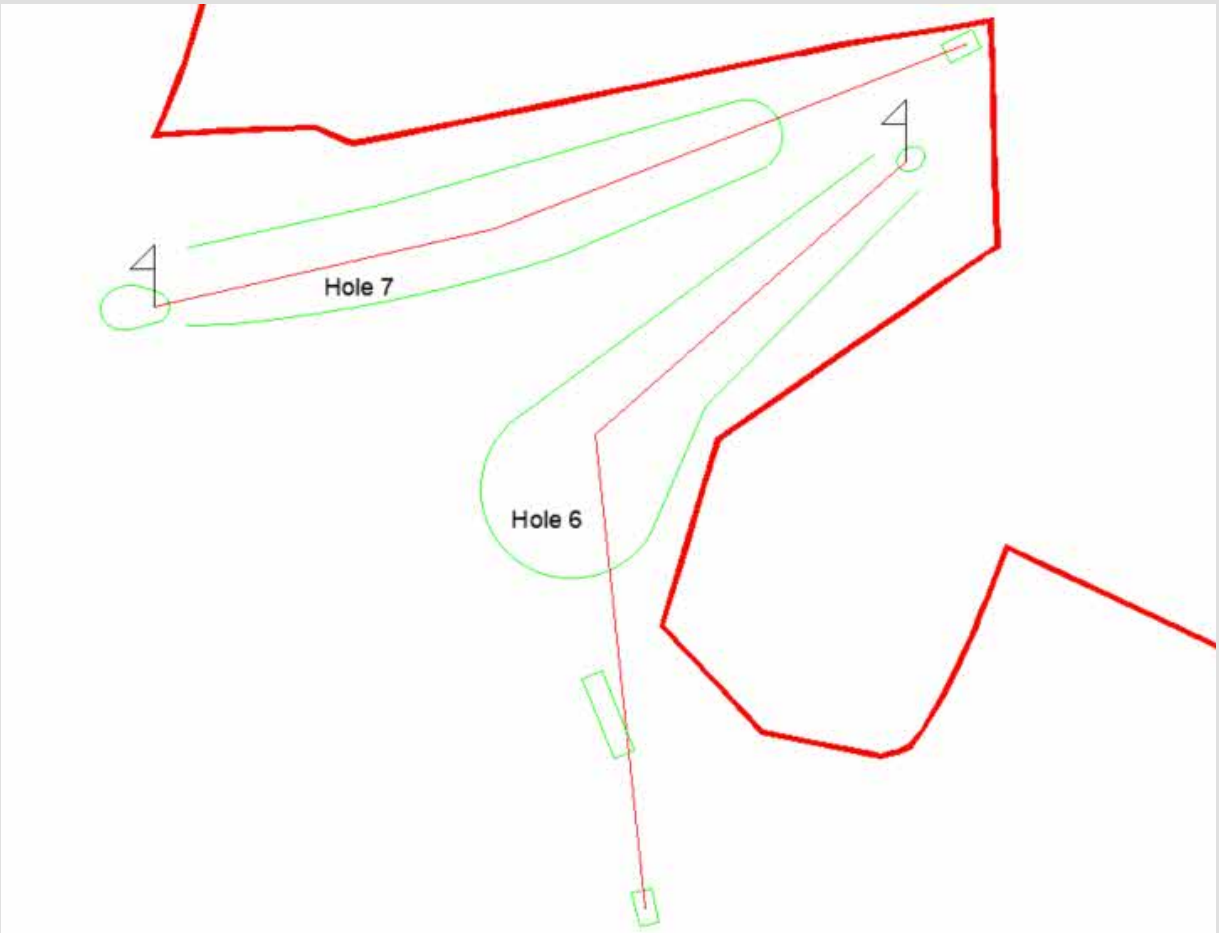

Figure 4. An overview of Holes 6 and 7 in relation to the proposed development boundary

Existing Ball Stop Mitigation

This report does not account for any existing, or planned planting (trees, hedges etc). This trajectory assessment is based on reasonable worst-case scenarios, and it is our informed opinion that planting cannot be relied upon to provide protection against ball trajectories. The planting may not be sufficiently dense to stop the ball, nor homogeneous across the length. The planting may change during the seasons, or indeed be cut back or removed.

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Section 4 – Ball Trajectory Scenarios

Site Measurements and Topography
In the game of golf, a tee shot presents the highest risk to site boundaries as it is the golf shot with the longest and highest trajectory; however, depending on the length of the hole, different clubs with different ball launch characteristics will be chosen. For both holes 6 and 7 a driver would normally be selected. Players aim to launch the ball down the fairway in the direction of the hole, but it is understood that variations in targeting accuracy can result in a range of possible trajectories. In this scenario, a reasonable assumption is that variations in targeting accuracy will be considered with a maximum likely 'error' of ± 20 degrees. In addition to the initial tee shot using a driver, hole 6 analysis will also assess whether there a potential risk with approach shots beyond the green. Based on predicted landing zones of the tee shot and data that suggests an approach shots proximity to the target increases as it is hit from a greater distance, the reasonable worst-case scenario in this location is a golfer hitting a 4-iron from 155 m from the hole. In this scenario, TrackMan data suggests that variations in targeting accuracy should be considered with a maximum likely 'error' of ± 15 degrees. Furthermore, there is a risk that a golfer may miss-hit the ball with excessive club speed. A reasonable worst-case scenario is an initial ball speed that is 10% higher than desired. This increase in ball speed relates to the difference between an average male amateur and a professional player.

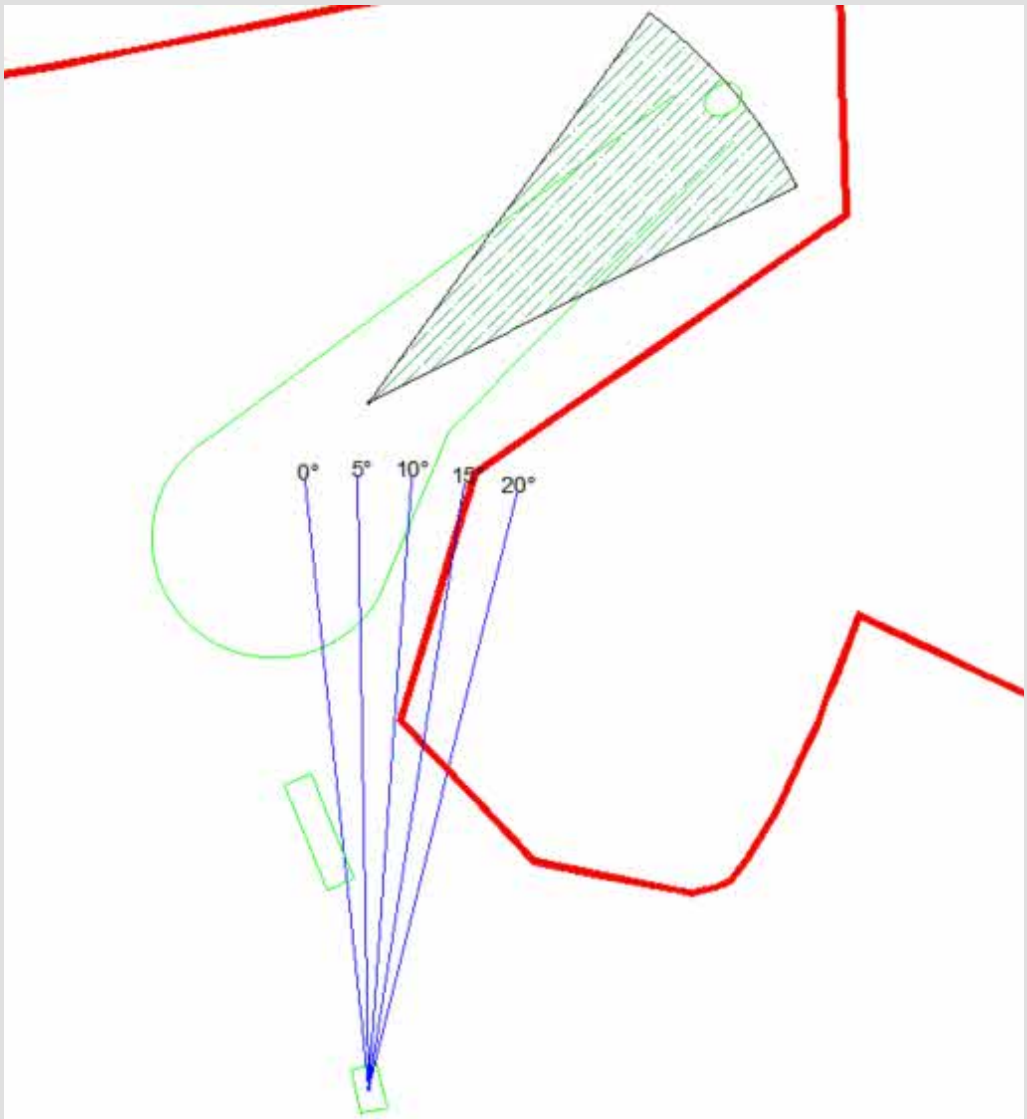

Figure 5. The potential effects of targeting errors on Hole 6 at Portsmouth Golf Course

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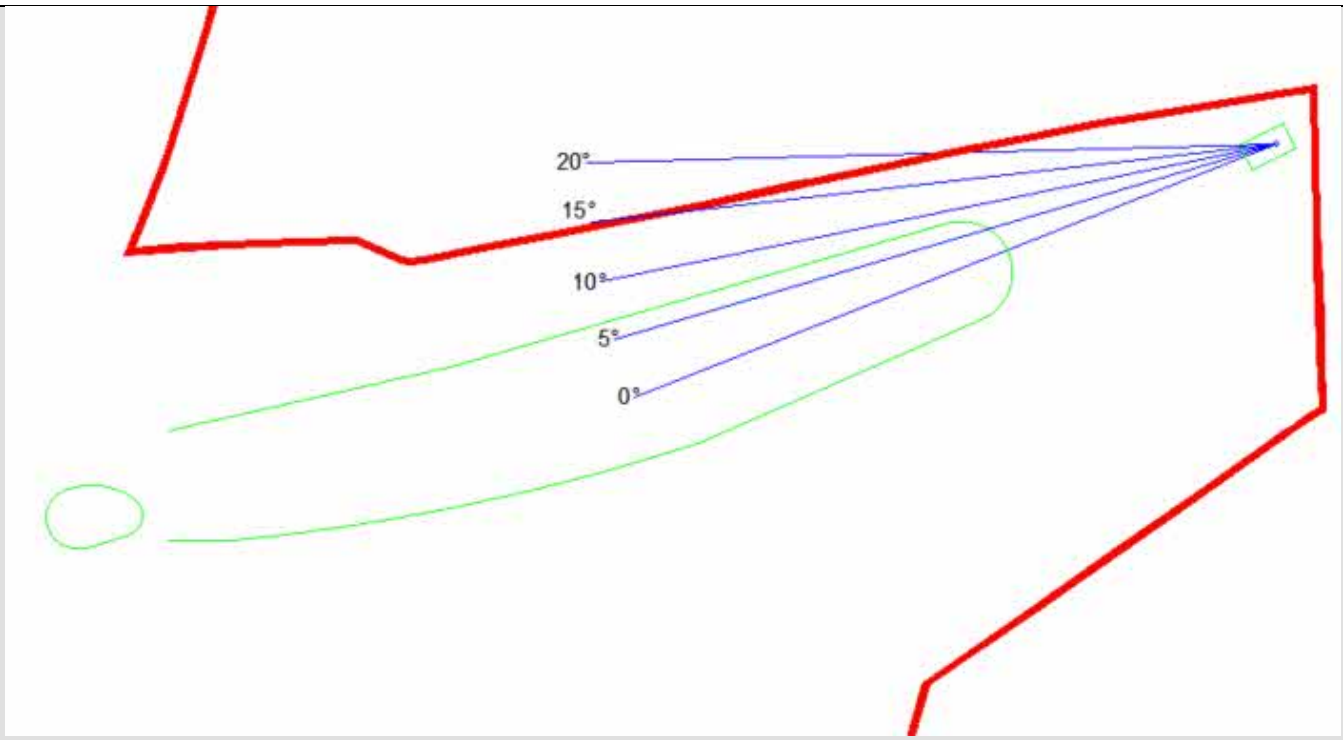

Figure 6. The potential effects of targeting errors on Hole 7 at Portsmouth Golf Course

Golf Shot Launch Conditions

In the game of golf, the ball can be launched with a wide range of initial conditions (speeds, angles and spin rates). Nonetheless, previous researchers have made accurate measurements of ball speeds and spin rates using high speed video, Doppler radar and similar technologies.

Portsmouth Golf Course attracts all levels golfers including advanced/professional players. Reasonable worst-case scenarios consider ball trajectories from advanced/professional players. TrackMan provide gold standard ball launch monitoring systems and have collected an expansive datasets on players to define both professional players and recreational players. The table below presents launch conditions for an average professional player that will be used in the trajectory model simulations.

Holes 6 and 7 Tee Shot Scenario – Driver (professional)

	Imperial	Metric
Ball Speed	167 mph	74.7 m/s
Launch Angle	10.9 degrees	0.19 radians
Spin rate	2686 rpm	281 rad/s

Hole 6 Approach Shot Scenario – 4 Iron (professional)

	Imperial	Metric
Ball Speed	158 mph	70.63 m/s
Launch Angle	9.2 degrees	0.16 radians
Spin rate	3655 rpm	343 rad/s

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Section 5 – Estimated Ball Height

Estimated Ball Height (Using the Projection Modelling Tool)
<u>Hole 6</u> Trajectory scenarios for both the tee shot (driver) and approach shot (4-iron) are considered for hole 6. It can be seen that tee shot (driver) trajectories with a targeting error of 15-20 degrees will intersect the boundary.

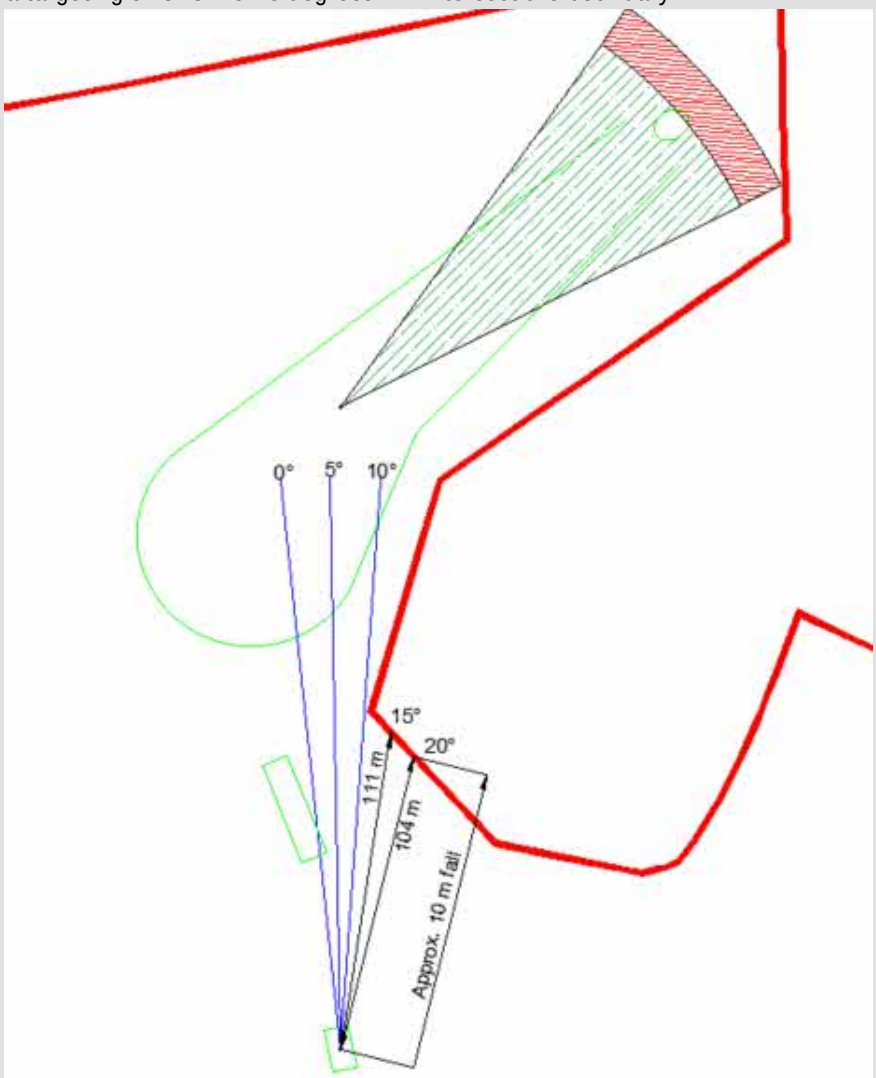

Figure 7. Measured distances for the different trajectory angles from Hole 6 tee box to the boundary of the adjacent property

With a targeting error of 20 degrees, the distance to the boundary of the property boundary is 104 metres with a 10 metre fall in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 29.5 metres as it intersects the site boundary.

With a targeting error of 15 degrees, the distance to the boundary of the property boundary is 111 metres with a 10 metre fall in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 31.2 metres as it intersects the site boundary.

With a targeting error of ±15 degrees and a 10% increased launch speed on the 4-iron approach shot, the trajectory model predicts that the ball will return to the ground before it intersects the proposed boundary of the new development. However, it is important to not that these results are based on the selected reasonable worst-case scenario, and if the ball is launched from different locations, the ball may surpass the boundary.

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Hole 7

Trajectory scenarios for the tee shot (driver) has been considered for hole 7. It can be seen that tee shot trajectories with a targeting error of 20 degrees will intersect the boundary.

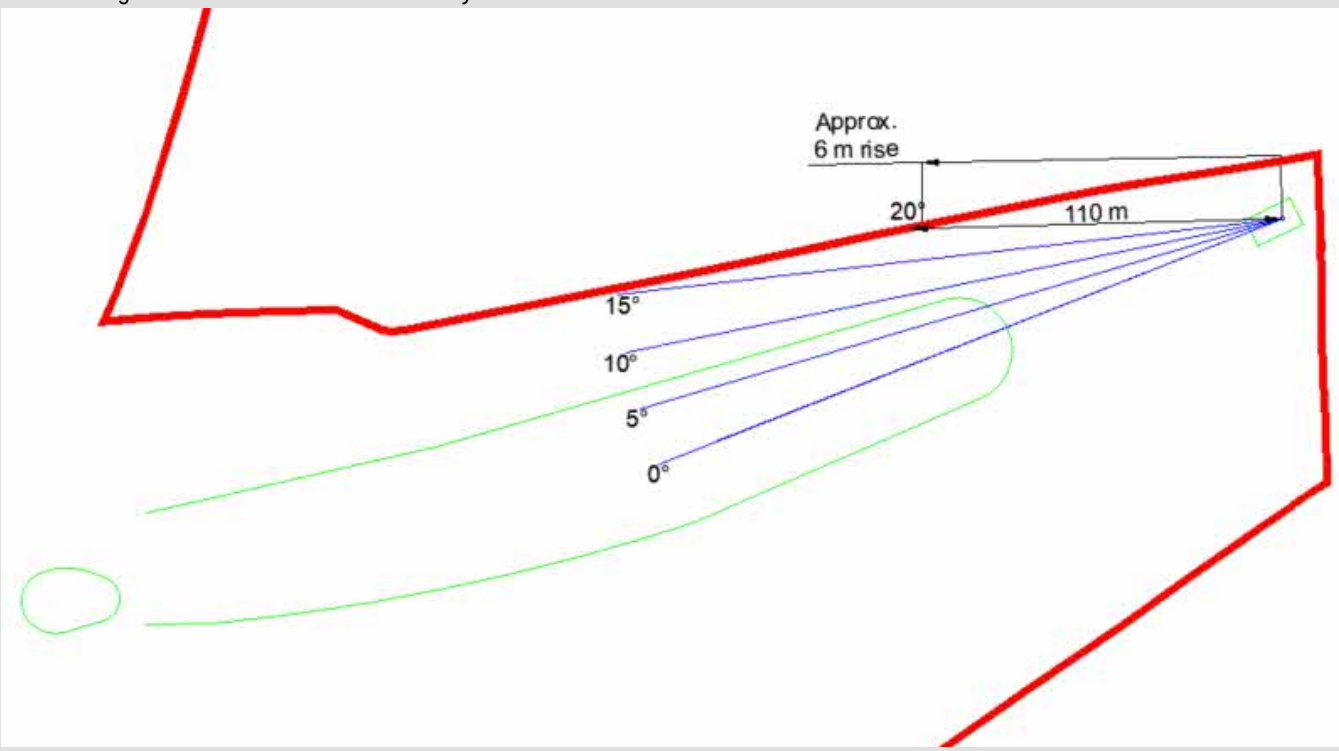

Figure 8. Measured distances for the different trajectory angles from Hole 7 tee box to the boundary of the adjacent property

With a targeting error of 20 degrees, the distance to the boundary of the property boundary is 110 metres with a 6-metre rise in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 20.1 metres as it intersects the site boundary.

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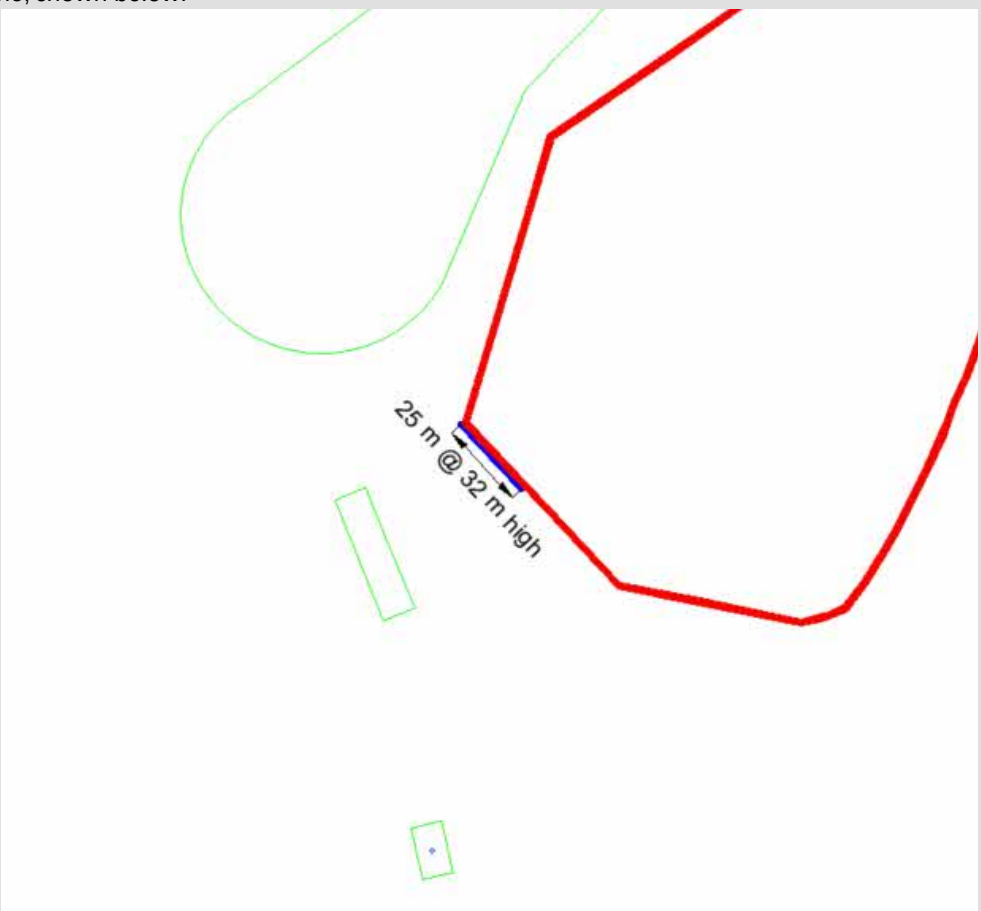
Section 6 – Risk Assessment Discussion

Ball Stop Netting Recommendations
This report has been prepared to assess the potential risk of golf balls surpassing the boundaries of Portsmouth Golf Course and to advise on the type and level of mitigation recommended to provide a suitable level of protection. The exact frequency of events resulting in a golf ball being hit into the adjacent area is unknown and impossible to predict with certainty (player skills and many other factors can influence this) hence a proportionate approach needs to be taken to provide safety to these users. In reality, there may be a "freak" shot that will result in a further than expected trajectory, but a balanced risk mitigation strategy needs to be implemented that is proportionate. Indeed, there are risks associated with many everyday activities, but plans need to be developed to reduce risk following good practical health and safety principles including a combination of likelihood and severity. <u>Hole 6 recommendations</u> The analysis shows there is a need for ball stop fencing/netting to protect the proposed property development from ball trajectories of the 6th hole tee shot. It is recommended that fencing/netting with a minimum height of 32 metres would have to be erected at the site boundary line, shown below.    Figure 9. Recommended location of the mitigation on the site boundary adjacent to hole 6 <u>Hole 7 recommendations</u> The analysis shows there is a need for ball stop fencing/netting to protect the proposed property development from ball trajectories of the 7th hole tee shot. It is recommended that fencing/netting with a minimum height of 21 metres would have to be erected at the site boundary line, shown below.

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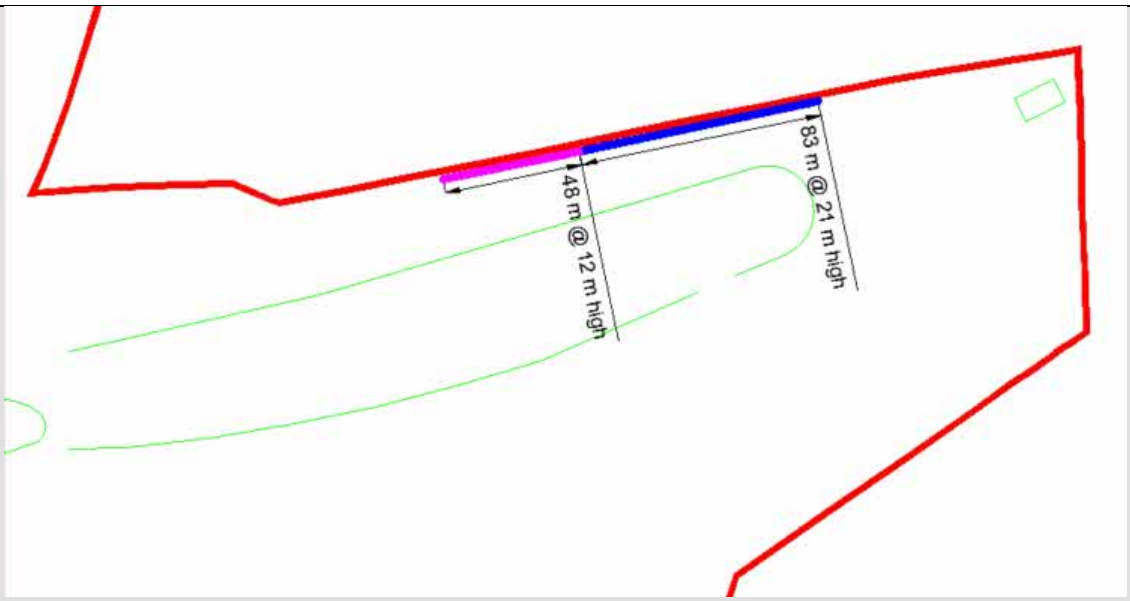

Figure 10. Recommended location of the mitigation on the site boundary adjacent to hole 7

Alternative Ball Stop Netting Locations

It is recognised that it may not be feasible to erect ball stop netting with these heights to protect the boundary, as this scale of mitigation would require significant foundations and would disturb existing mature trees. A more practical approach for both holes 6 and 7 may be to erect a fence/net closer to the teeing areas to catch erroneous balls at the start of their trajectory.

Hole 6 – Alternative Netting Location

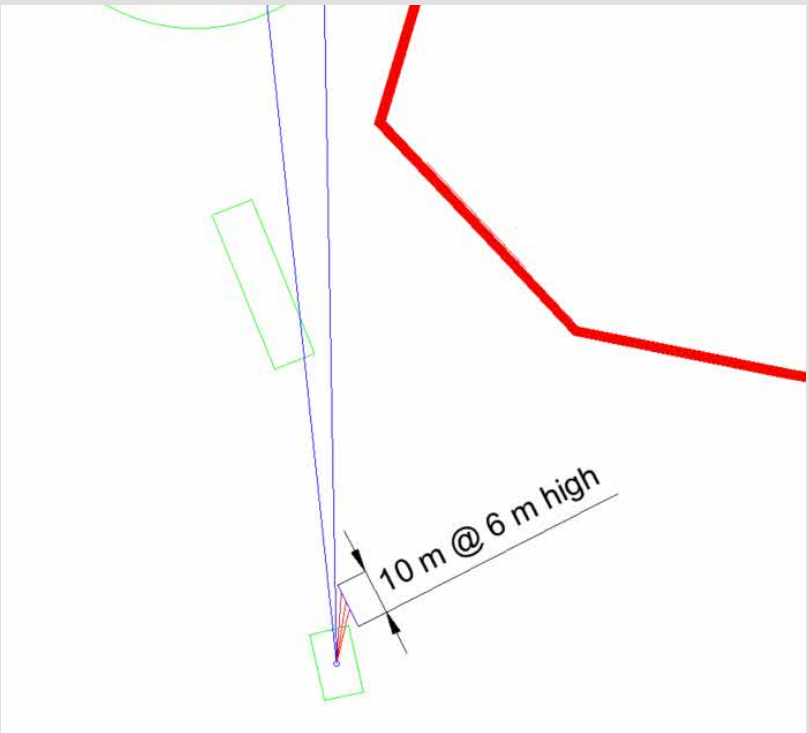

Figure 11. Alternative location of the mitigation on hole 6

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With a targeting error of 20 degrees, the distance to the ball stop netting location is 12 metres with a 2 metre fall in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 4.2 metres as it intersects the site boundary.

With a targeting error of 15 degrees, the distance to the ball stop netting location is 14 metres with a 2 metre fall in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 4.7 metres as it intersects the site boundary.

With a targeting error of 10 degrees, the distance to the ball stop netting location is 16 metres with a 2 metre fall in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 5.1 metres as it intersects the site boundary.

The analysis shows there is a need for ball stop fencing/netting to protect the proposed property development from ball trajectories of the 6th hole tee shot. The recommendation for this alternative location is that a fencing/netting with a minimum height of 6 metres would have to be erected close to the tee box, shown above in figure 11.

Hole 7 – Alternative Netting Location

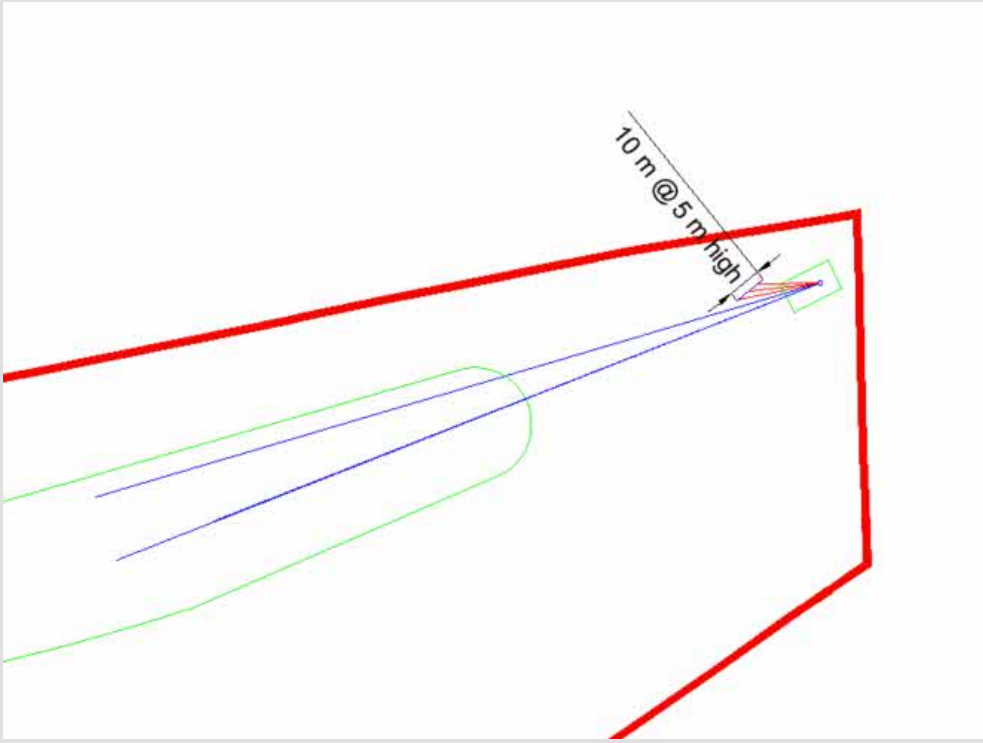

Figure 12. Alternative location of the mitigation on hole 7

With a targeting error of 20 degrees, the distance to the ball stop netting location is 17 metres with no change in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 3.3 metres as it intersects the site boundary.

With a targeting error of 15 degrees, the distance to the ball stop netting location is 20 metres with no change in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 3.9 metres as it intersects the site boundary.

With a targeting error of 10 degrees, the distance to the ball stop netting location is 23 metres with no change in in elevation. The trajectory model predicts that for a Driver, the ball will retain a height of 4.6 metres as it intersects the site boundary.

The analysis shows there is a need for ball stop fencing/netting to protect the proposed property development from ball trajectories of the 7th hole tee shot. The recommendation for this alternative location is that a fencing/netting with a minimum height of 5 metres would have to be erected close to the tee box, shown above in figure 12.

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