Mandurah greyhound track upgrade
Report 5 – Review of track Designs 3 and 4

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For Racing and Wagering Western Australia

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Executive summary

This is the fifth report in a series of reports prepared by UTS for Racing and Wagering Western Australia.

The purpose of this Report was to review two additional proposed designs for the Mandurah greyhound track and should be read in conjunction with Report 4.

Two different designs were evaluated. These designs were:

- Design 3: 70.9 m bends, 59.8 m transitions, 7.0 m wide; and
- Design 4: The optimum drop-on box position on the Back Straight.

Of the three Mandurah greyhound track configurations that have been reviewed, Design 3 is the safest and preferred design. Design 3 has four starts at 303.0 m, 403.0 m, 498.0 m and 697.5 m, with a possible drop-on box start on the Back Straight.

The analysis of the drop-on boxes located on the Back Straight concluded the optimum location is around 340 m to 350 m. This location provided a lower jerk_{max}, the centrifugal acceleration was smoothed and there was reduced predicted race congestion.

-/The analysis also concluded that a drop-on start should be no less than340 m *.

Contents

1 Introduction

1.1 General

This is the fifth report in a series of reports prepared by UTS for Racing and Wagering Western Australia (RWWA).

This report is a supplementary report to Report 4 and should be read in conjunction.

As stated in Report 4, the Mandurah greyhound track is located at Kanyana Park, approximately 65 km south of Perth in close proximity to the majority of greyhound trainers. The existing track has four starts, namely: 302 m, 405 m, 490 m and 647 m.

1.2 Design constraints

The design constraints are the same as those stated in Report 4.

2 Design 3: 70.9 m bends, 59.8 m transitions, 7 m wide

2.1 Design 3: Track shape

The Design 3 proposal is an oval shaped track with two 70.9 m semicircular bends joined to two 15.7 m straights by four 59.8 m. This design has approximately 2.1 m and 4.2 m longer circumference compared to Design 1 and Design 2 respectively. The Design 3 track has four starts, namely: 303.0 m, 403.0 m, 498.0 m and 697.5 m.

Figure 1 is the David Allan Consulting Engineer Pty Ltd plan for the Design 3 Mandurah greyhound track dated 23 February 2021.

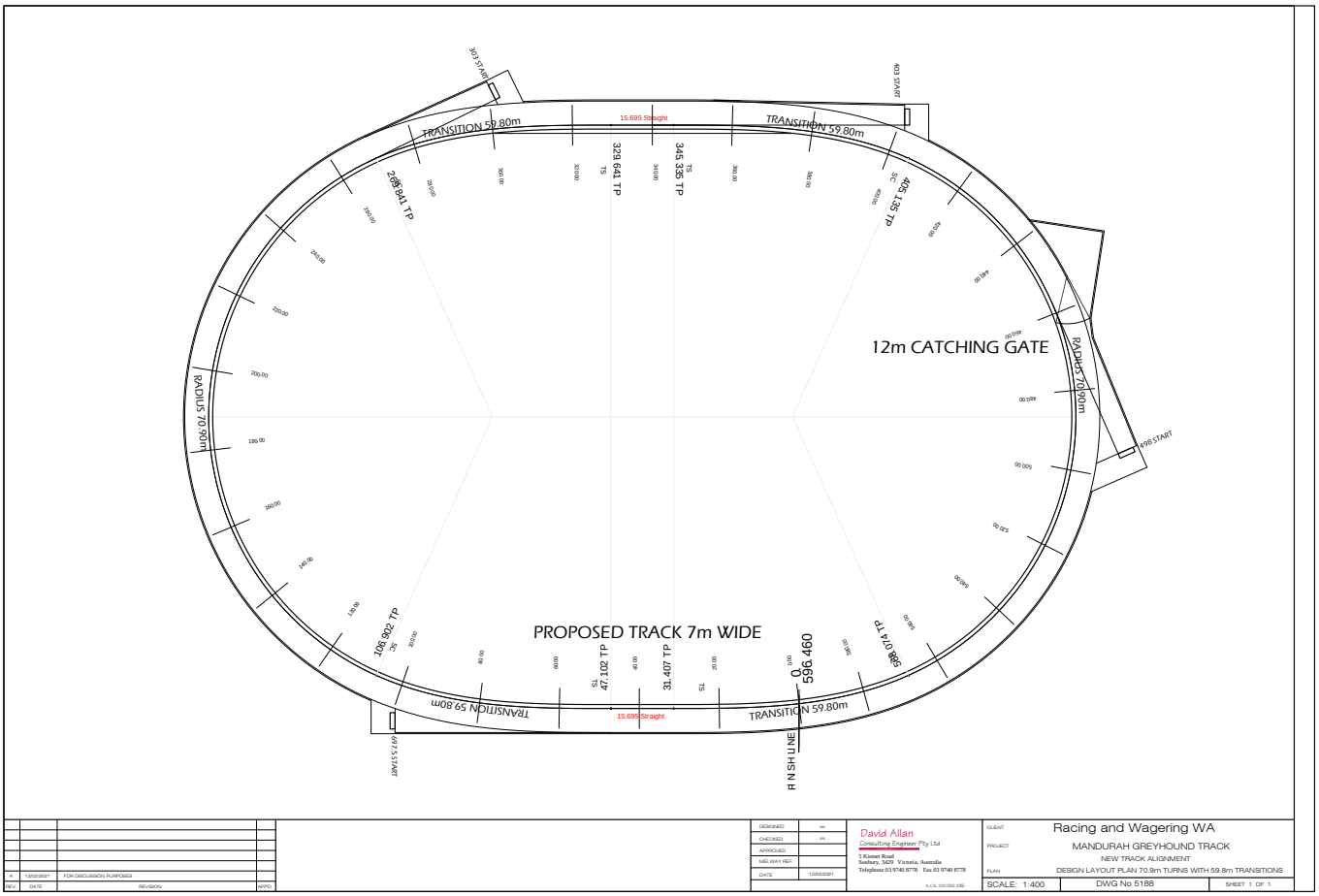

Figure 1: Design 3 Mandurah greyhound track plan (70.9 m bends, 59.8 m transitions) David Allan Consulting Engineer Pty Ltd (23 February 2021).

2.2 Design 3: Curvature for each starting distance

Figure 2 shows a plan view of the Mandurah greyhound track with fundamental track dimensions and the curvature lines.

The length of the transition from both straights to both bends is 59.8 m. This is depicted by the red curvature lines in Figure 2.

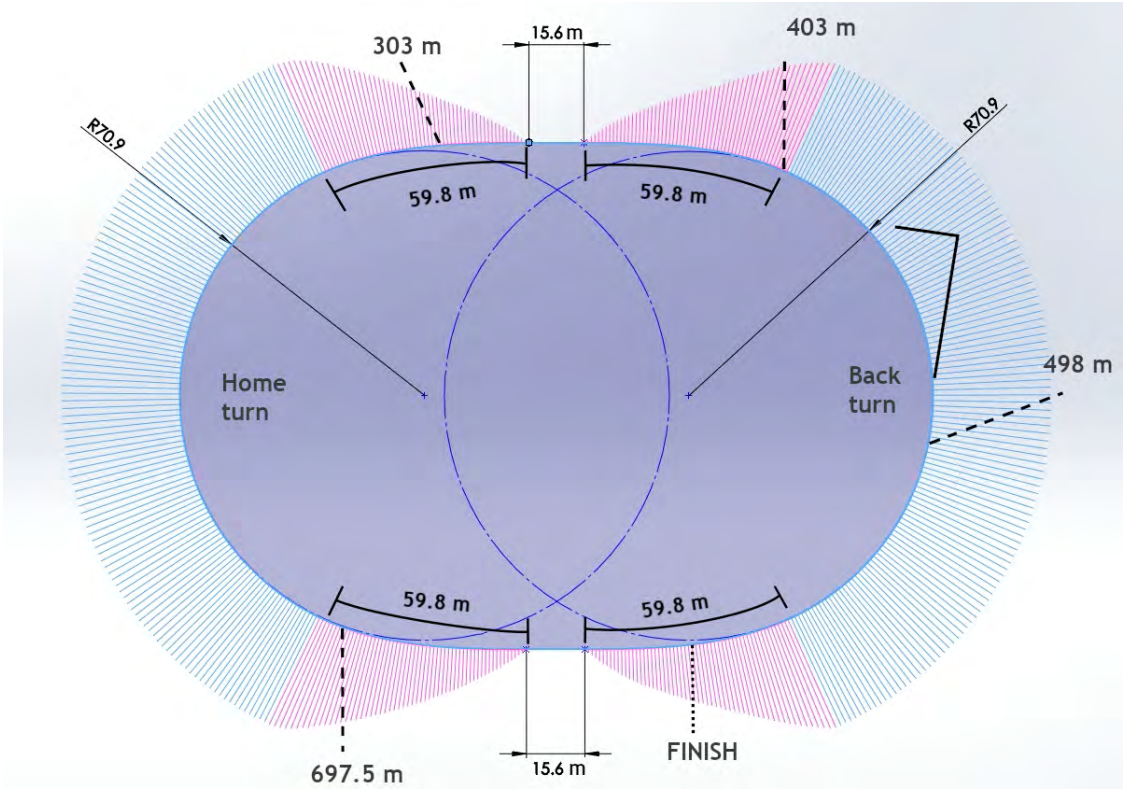

Figure 2: Design 3 Mandurah greyhound track curvature line plot (70.9 m bends, 59.8 m transitions). The lengths of the perpendicular blue lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail.
Source: David Allan Consulting Engineer Pty Ltd.

The curvature plots for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track are given in Figure 3. In the curvature plot figure the bends can be seen to have the highest curvature values while straight track segments have zero curvature values. Also, there is a linear change in track curvature from straight to bend track segments and vice versa.

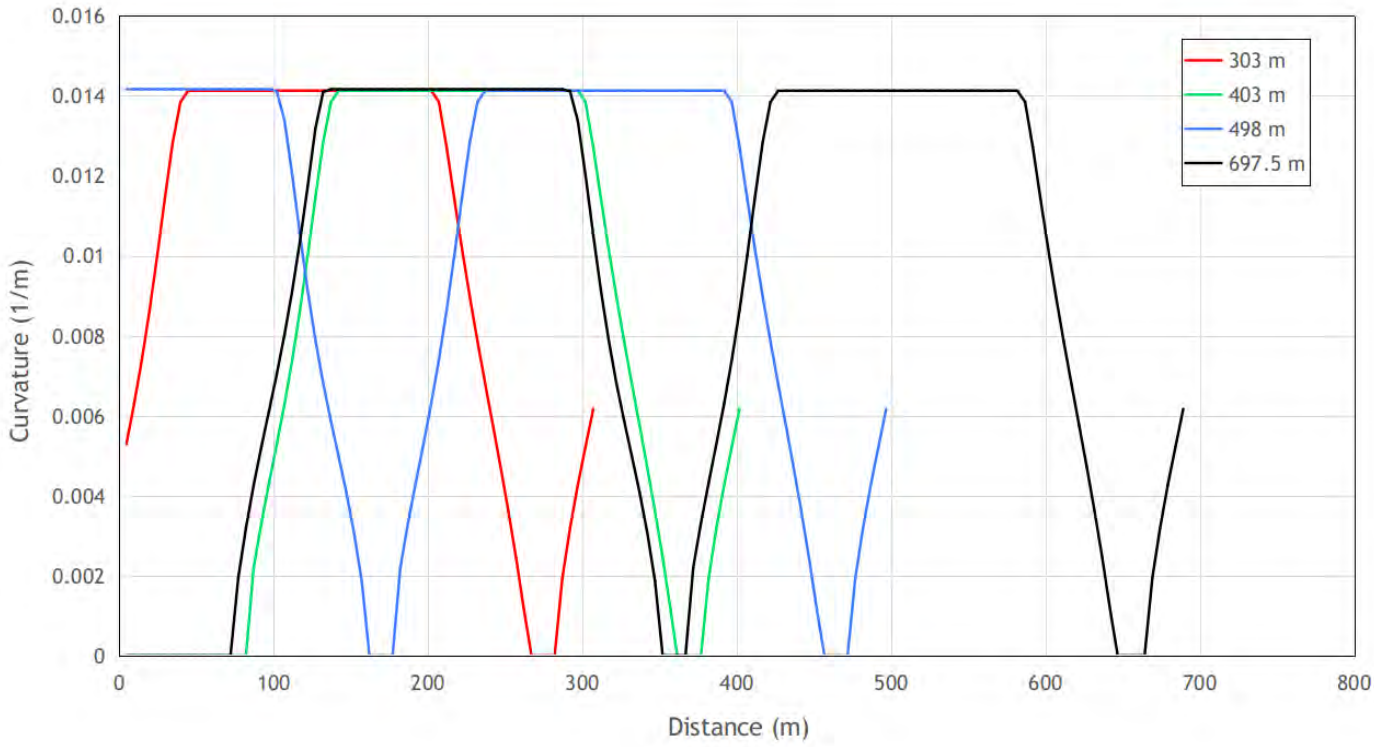

Figure 3: The curvature plots for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.3 Design 3: Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track is given in Figure 4.

The maximum acceleration for all starting distances is lower than both Design 1 and 2.

For Design 3 the 303.0 m distance (red plot) has the maximum centrifugal acceleration among all distances and is around 5.4 m/s^2.

For Design 3 the 403.0 m distance (green plot) maximum centrifugal acceleration is around 5.3 m/s^2.

For Design 3 the 498.0 m distance (blue plot), the maximum centrifugal acceleration is around 5.3 m/s^2.

For Design 3 the 697.5 m distance (black plot), the maximum centrifugal acceleration is around 5.4 m/s^2.

For all starting distances, the increase in centrifugal acceleration before the Finish Post is because the 50 m transition commences before the Finish Post. The magnitude varies according to the predicted velocity as the greyhounds pass the Finish Post.

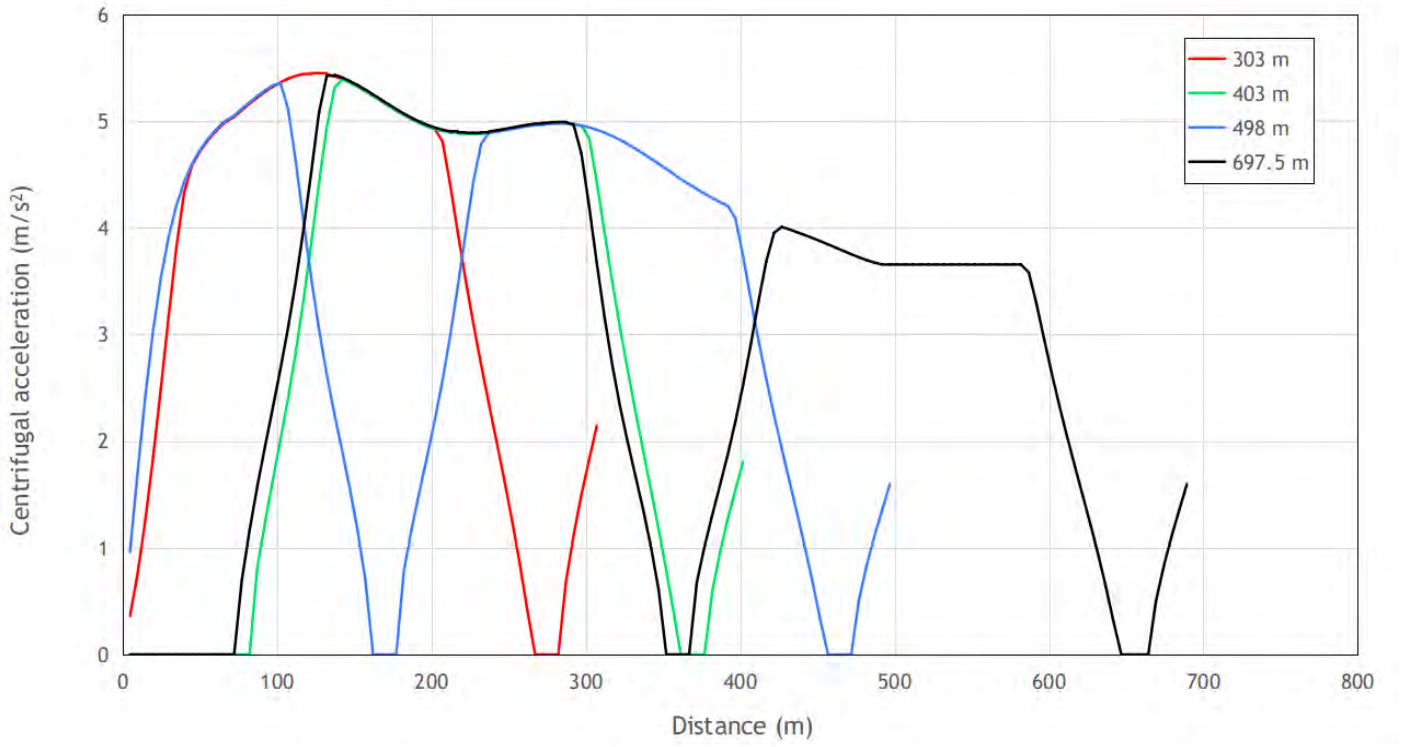

Figure 4: The centrifugal acceleration plots for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.4 Design 3: Jerk for each starting distance

The jerk for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track is given in Figure 5.

The 303 m starting distance has the highest jerk for this track configuration. The jerk_{max} of approximately 2.6 m/s^3 occurs as the greyhound leave their respective boxes and enter the bend. Nevertheless, this high jerk is lower than the Designs 1 and 2 and appears to be the best that can be achieve within the project constraints.

The jerk_{max} for the 498.0 m starting distance (blue plot) is high at the start as the greyhounds exit the boxes. This high jerk is lower than the Designs 1 and 2.

The jerk_{max} for the 403.0 m starting distance is approximately 2.0 m/s^3.

The jerk_{max} is below 2.0 m/s^3 for the 697.5 m starting distance. The 697.5 m starting distance is the safest start for this track design.

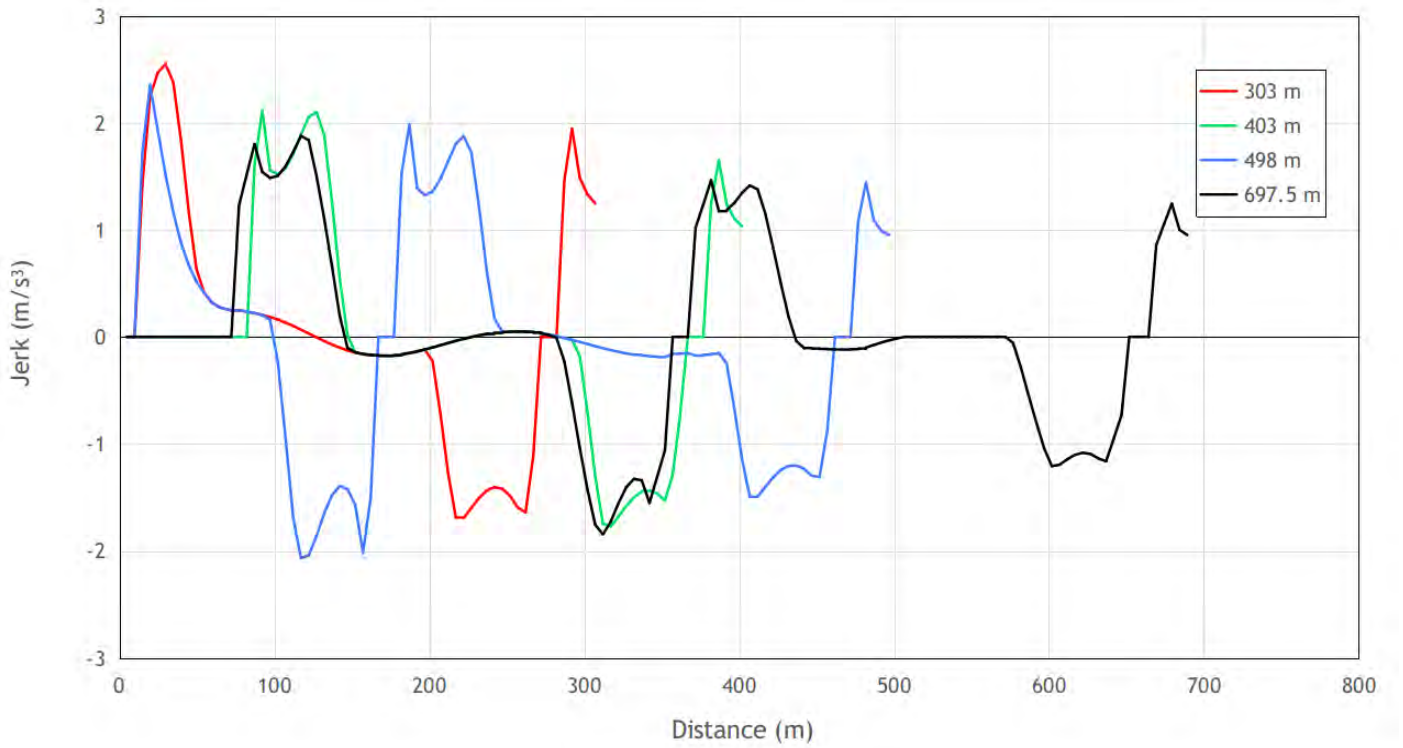

Figure 5: The jerk plots for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.5 Design 3: Starting box simulations

Figures 6 to 9 show simulated greyhound paths of a single greyhound and corresponding turning tendency for the 303.0 m, 403.0 m, 498.0 m and 697.5 m starting box locations and alignments.

The turning tendency sequence is denoted by the perpendicular arrows. The highest turning tendency was observed for 498.0 m distance followed by 697.5 m, 403.0 m and 303.0 m starting box locations and alignments.

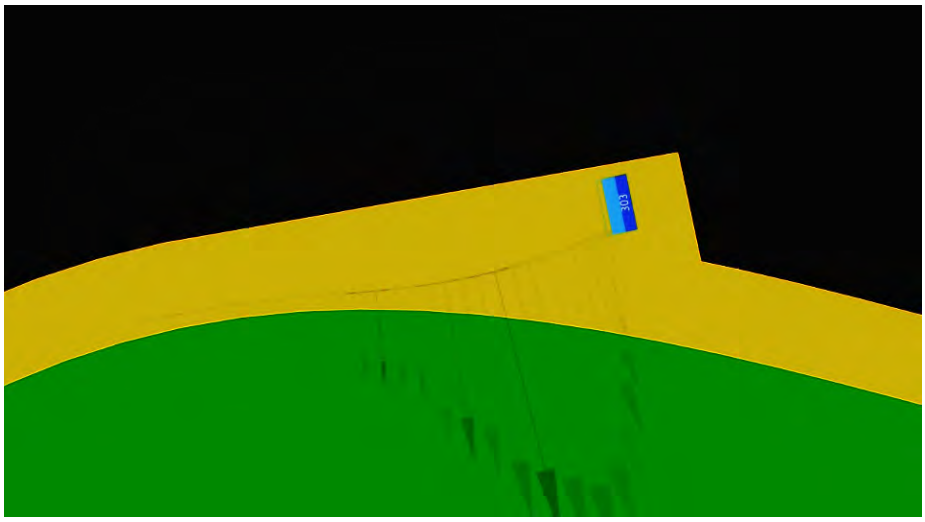

Figure 6: Simulation of greyhound path for the 303.0 m starting distance at proposed Design 3 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

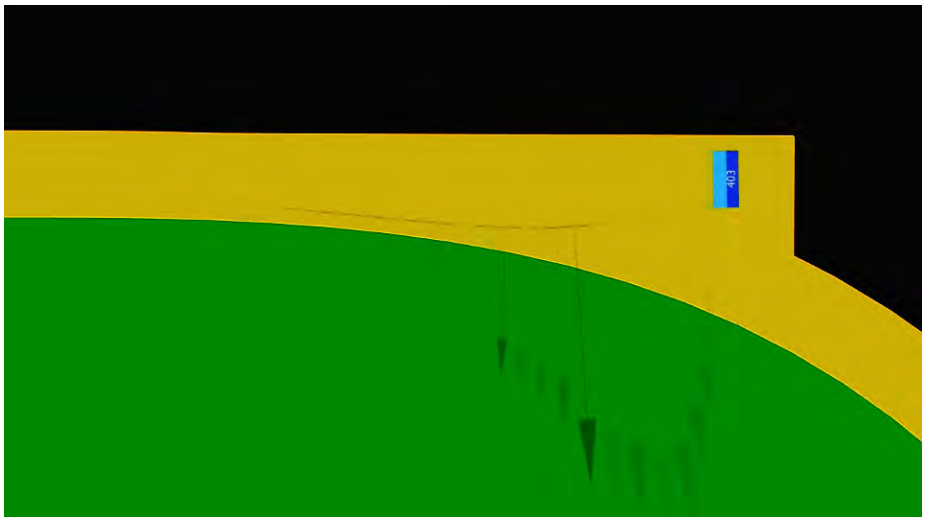

Figure 7: Simulation of greyhound path for the 403.0 m starting distance at proposed Design 3 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

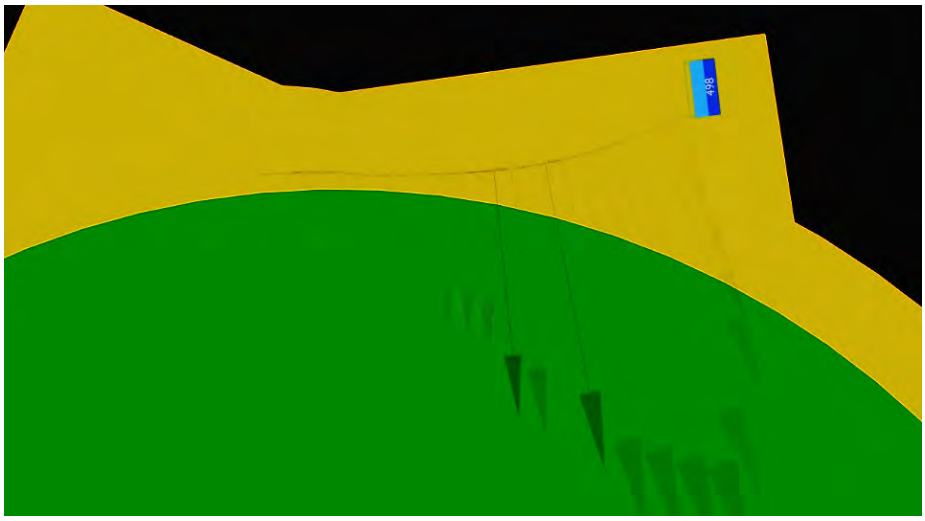

Figure 8: Simulation of greyhound path for the 498.0 m starting distance at proposed Design 3 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

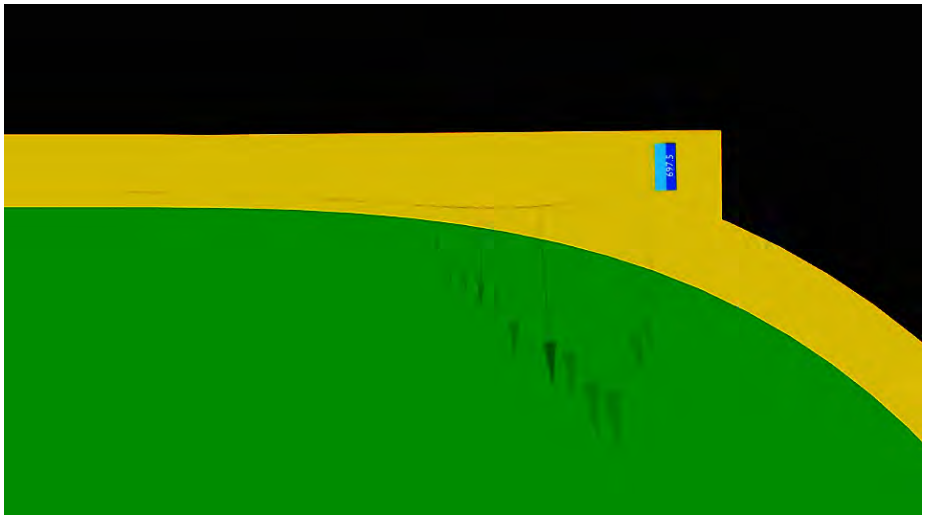

Figure 9: Simulation of greyhound path for the 697.5 m starting distance at proposed Design 3 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

Figure 10 depicts turning radius versus run distance of a greyhound for the 303.0 m, 403.0 m, 498.0 m and 697.5 m starting box locations and alignments. The plots provide an insight with respect to the small turning radius the racing greyhound has to make when moving from boxes to the track. The 303.0 m, 403.0 m, and 697.5 m starting box locations and alignments had similar turning radius performance for up to a distance of around 16.0 m from the respective boxes where the smallest turning was observed for the 303.0 m box location and alignment of about 51.5 m radius. The 498.0 m starting

box locations and alignments had the lowest turning radius performance among all the distances starts where the smallest turning observed was about 40 m radius. Thus, the turning radius immediately after leaving the boxes is much lower than the bend radius of approximately 70.9 m.

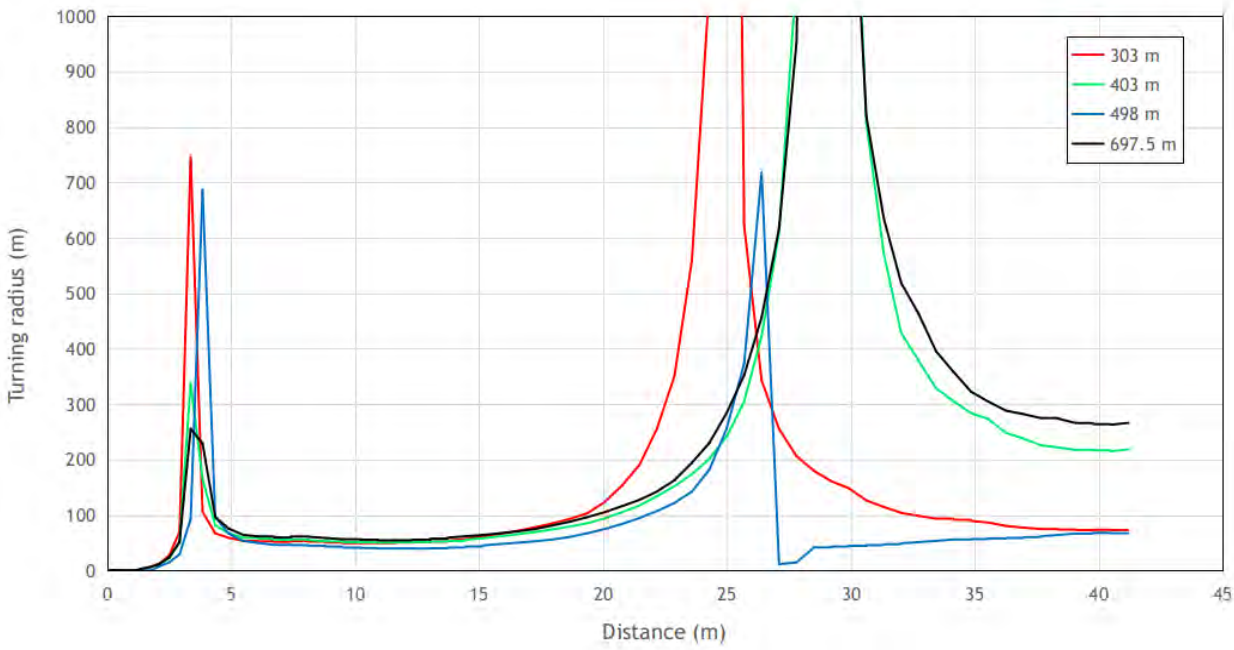

Figure 10: Greyhound turning radius for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances at proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

Figure 11 illustrates yaw rate (rad/s) plotted against the distance out of the box for the 303.0 m, 403.0 m, 498.0 m and 697.5 m starts. For all race distances starting box locations and alignments showed a continuous turning except the 498 m starting distance boxes location and alignment. The peak turning occurred from around 10 m to 15 m for all distances. The 303.0 m required minimum initial turning of about 2.0 rad/s and after that, the greyhound yaw rate went through a 0.6 rad/s change over the 29.0 m run distance. For the 403.0 m and 697.5 m distances starting box alignments, the yaw rate was similar and less than that of the 303 m start after the initial spike where after the initial turning phase the greyhound yaw rate went through 0.43 rad/s and 0.39 rad/s changes respectively. Finally, among all the distances box alignments the 403 m and 697.5 m distances were found to be most optimal.

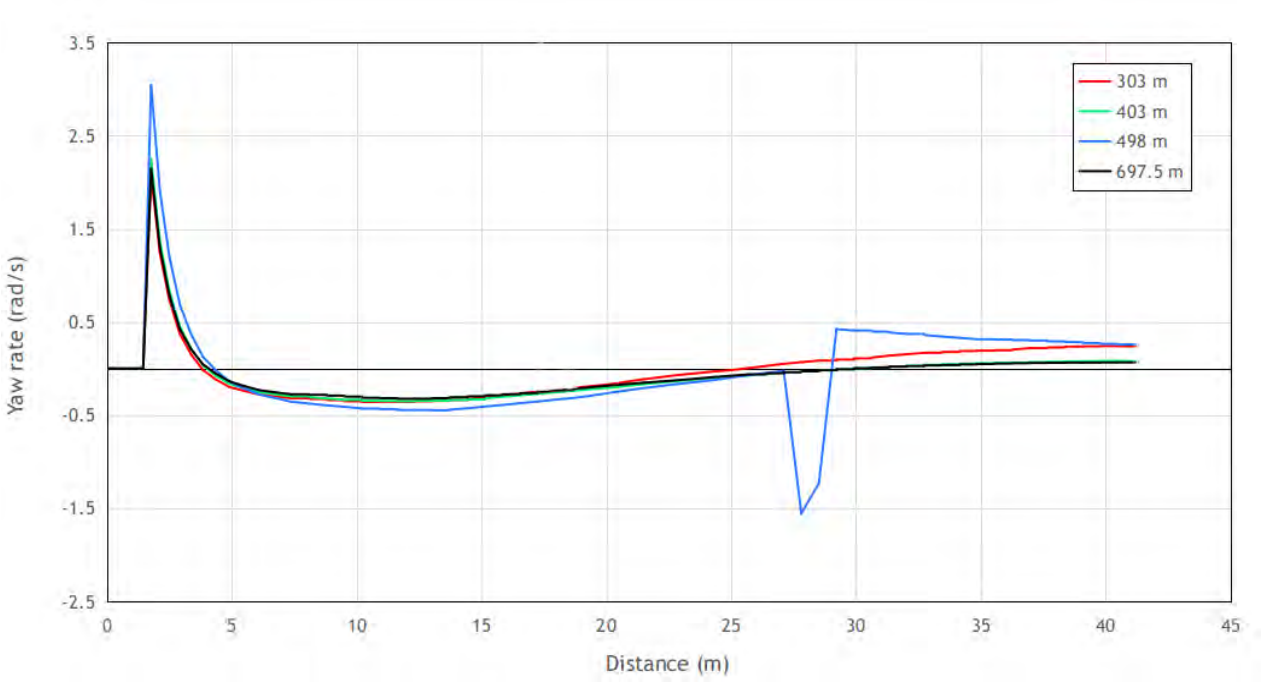

Figure 11: Greyhound yaw rate for the box alignments where a positive value indicates turning anticlockwise and a negative value indicates turning clockwise for 303.0 m, 403.0 m, 498.0 m and 697.5 m starting distances at proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

The current box alignment for 498.0 m starting distance at proposed Design 3 is distant from the track which will introduce greyhound trajectory misalignment with respect to the track which can be seen from Figure 11 above. This can be fixed by bringing the 498.0 m distance starting box closer to the track similar to other starting distances 303.0 m, 403.0 m, and 697.5 m and rotating the box approximately 7.5 degrees as shown in Figure 12. Figure 13 depicts greyhound yaw rate improvements for before and after aligning the 498 m starting distance box closer to the track and rotating approximately 7.5 degrees as shown in Figure 12.

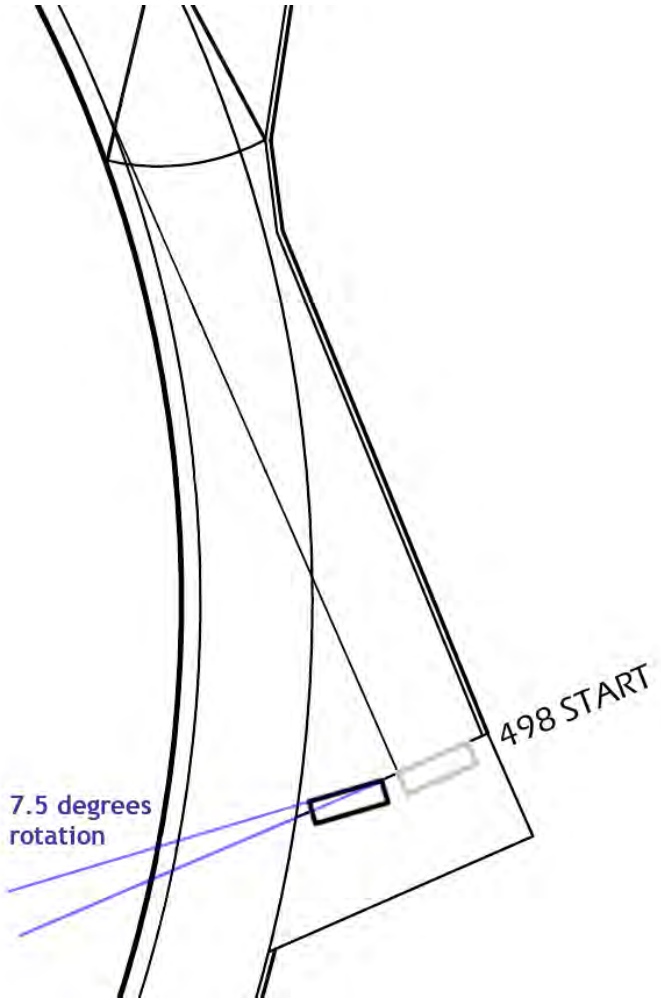

Figure 12: Improved box alignment for 498 m starting distance at proposed Design 3 Mandurah greyhound track where the black box indicates new alignment while the greyed box indicates current alignment from the proposed Design 3 plan.

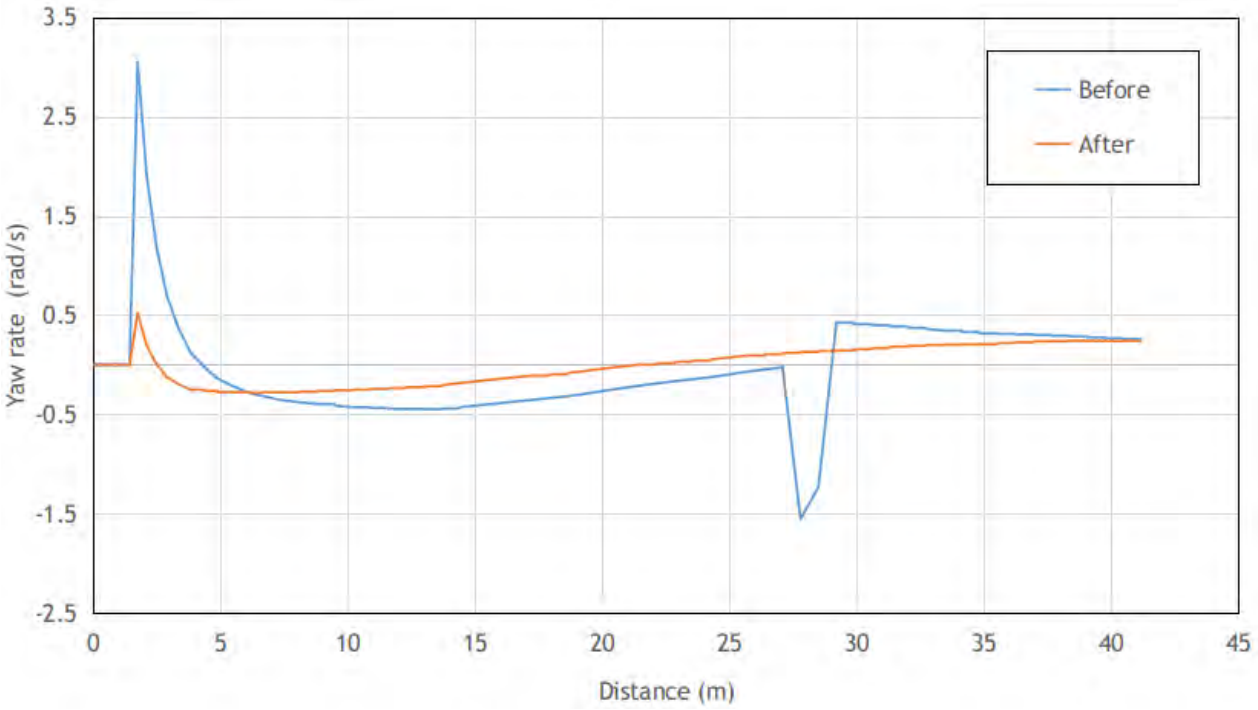

Figure 13: Greyhound yaw rate for 498.0 m starting distance with improved box alignment at proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

2.6 Design 3: Track width

The Design 3 track width of 7.0 m is sufficient to allow the greyhounds adequate room to manoeuvre and self-select a running line that limits their exposure to incidents that may result in a serious injury.

3 Design 4: Optimum drop-on box position on the back straight

3.1 Design 4: Track shape

The Design 4 proposal is the Design 3 with the addition of a set of drop-on boxes on the back straight.

3.2 Design 4: Drop-on boxes

Figure 14 is a set of drop-on boxes being install at the Murray Bridge greyhound track.

Drop-on boxes have several advantages over traditional *fixed* boxes.

When installed on a straight section of the track at a minimum distance from the bend the drop-on boxes to allow the greyhounds to exit the boxes and inline with the track and at the same cross-fall as the track surface. The effect of this, on average, is that there is reduced start congestion with cleaner running lines. These clearer running lines, on average, led to fewer injuries and less serious injuries.

Figure 14: Murray Bridge drop-on boxes being installed (11 July 2019.)

3.3 Design 4: Drop-on boxes location simulation

An ideal location for drop-on boxes depends on many factors such as greyhound speed, turning, and race congestion. Greyhound computer race simulations were generated to predict the safest drop-on locations for the proposed Design 3 Mandurah greyhound track on the back straight. The

Figures 15 and 16 show results from computer simulation for greyhound dynamics for the drop-on boxes 330 m, 340 m, 350 m, 360 m, and 370 m starting distances on the back straight at proposed Design 3 Mandurah greyhound track. The results in Figures 15 and 16 show the greyhound dynamics for immediate home turn bend to observe if any of the starting boxes distances has a competitive edge over the others.

As can be seen from Figure 15, the overall greyhound yaw rate after the immediate spike was lower for 360.0 m, and 370 m starting distances compared to other starting distances. The overall yaw rate was highest for 330.0 m starting distance for up-to 80.0 m race distance from the boxes among all other starting distances. A higher yaw rate for 330 m starting distance means greyhounds need to make sharper turns in the transition phase of aligning with the constant band where the yaw rate remains relatively constant. Finally, it can be seen from the figure that the 370.0 m starting distance took the longest run distance for the greyhound to aligning with the constant bend at around 90.0 m race distance from the boxes.

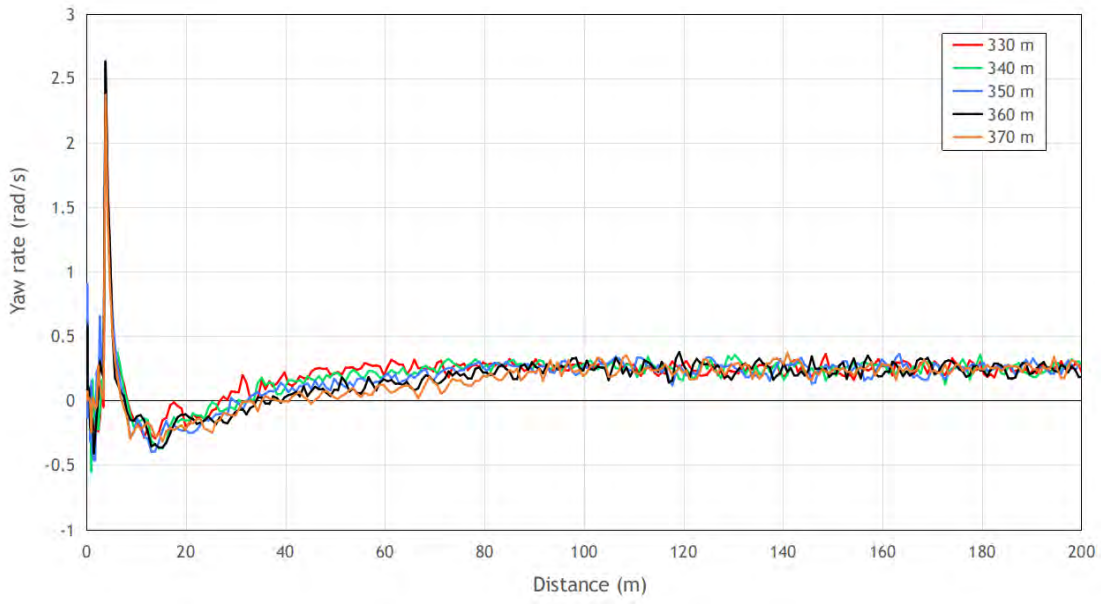

Figure 15: Greyhound yaw rate during racing for 100 simulated races for proposed Design 3 Mandurah greyhound track for various drop-on boxes distances starts.

Simulation peer pressure variable as indicated in Figure 16 roughly measures greyhounds pack congestion during a race where greyhounds pack can be more or less spread-out depending on the greyhounds' location with respect to the track and the greyhound dynamics performance state. A higher peer pressure value indicates greyhounds are more spread out where a lower value indicates there is little room among the greyhounds.

As can be seen from Figure 16, the overall peer pressure does not vary significantly for the 340.0 m starting distance after the immediate spike compared to other starting distances. The overall peer pressure was lowest for the 370.0 m starting distance after roughly 125.0 m run distance among all the starting distances indicating the highest congestion situation. Although the overall peer pressure of the 330 m starting distance improves significantly after roughly 115.0 m run distance from the boxes, this situation is not desirable as it indicates significant changes in the greyhounds' pack formation. Finally, as can be seen from Figure 16, the peer pressure for the 340.0 m and 350.0 m starting distances is relatively stable throughout the run distance indicating both starting distances have a higher prospect of less race-related congestion.

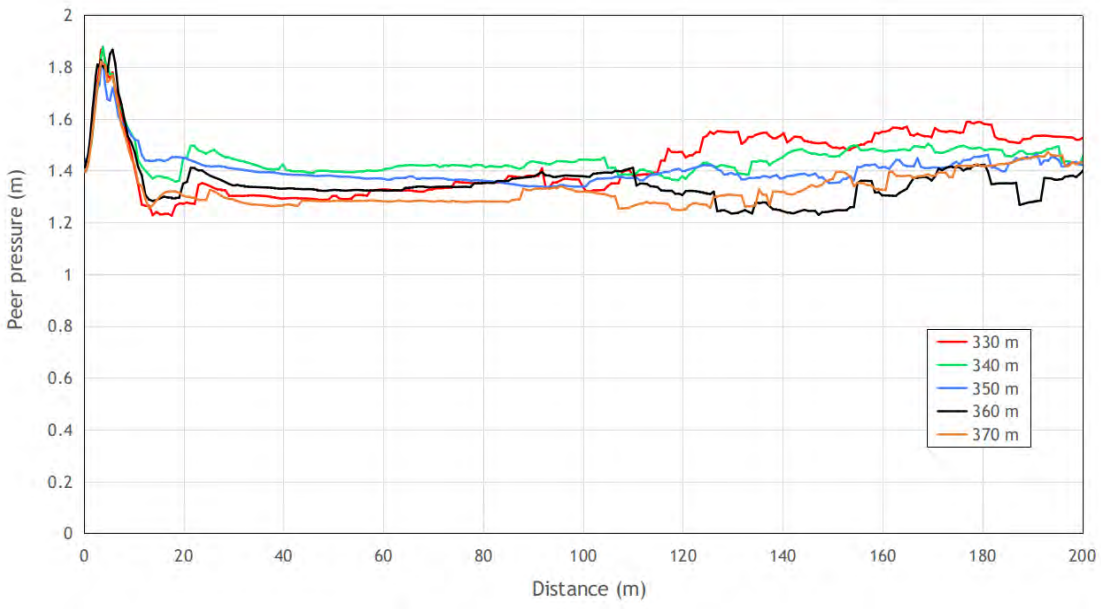

Figure 16: Peer pressure of the greyhound pack during racing for 100 simulated races for the proposed Design 3 Mandurah greyhound track for various drop-on boxes start distances.

3.4 Design 4: Drop-on box versus safest fixed box location comparison

In the previous section, several drop-on boxes for the proposed Design 3 Mandurah greyhound track were analysed. This computer simulation analysis showed the boxes with starting distances 340.0 m and 350.0 m are preferable from race dynamics perspective. Also, out of all fixed location starting distances the 697.5 m distance start is preferable when accessed for centrifugal acceleration and jerk. The Figures 17 to 20 show how the best drop-on boxes start distances (340.0 m and 350.0 m) compare to the best proposed fixed location start (697.5 m). As can be seen from Figure 18, the maximum centrifugal acceleration was similar among the 340.0 m and 350.0 m, and 697.5 m start distances. However, the rise of centrifugal acceleration for the 340.0 m and 350.0 m distances starts was more gradual than the 697.5 m start distance. From Figure 18, it can be seen that the overall jerk was lowest for the 340.0 m start distance compared to other start distances. Likewise, when it comes to race congestion as depicted in Figure 20, the overall change in peer pressure was lower for the 340.0 m start distance compared to other start distances. Also, the 350.0 m start distance performed worst when compared to the other start distances. Finally, it can be said that for the drop-on start 340.0 m race distance performed best compared to all start distances for the proposed Design 3 Mandurah greyhound track.

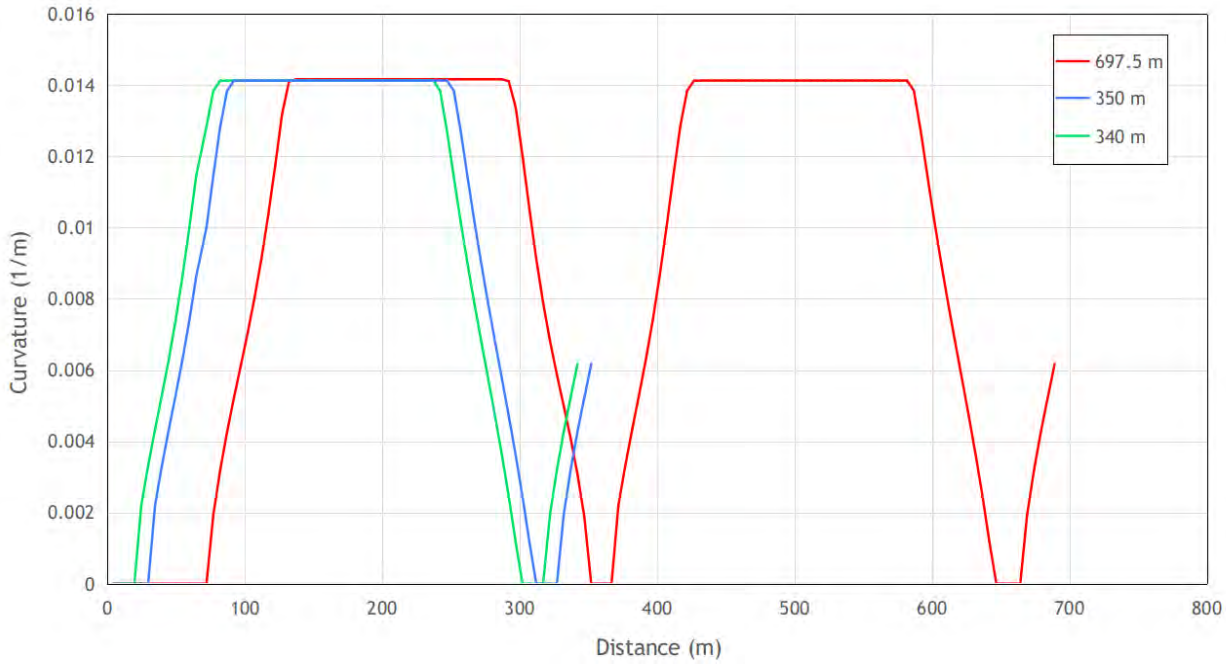

Figure 17: The curvature plots of preferred drop-on boxes and fixed boxes distances starts for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

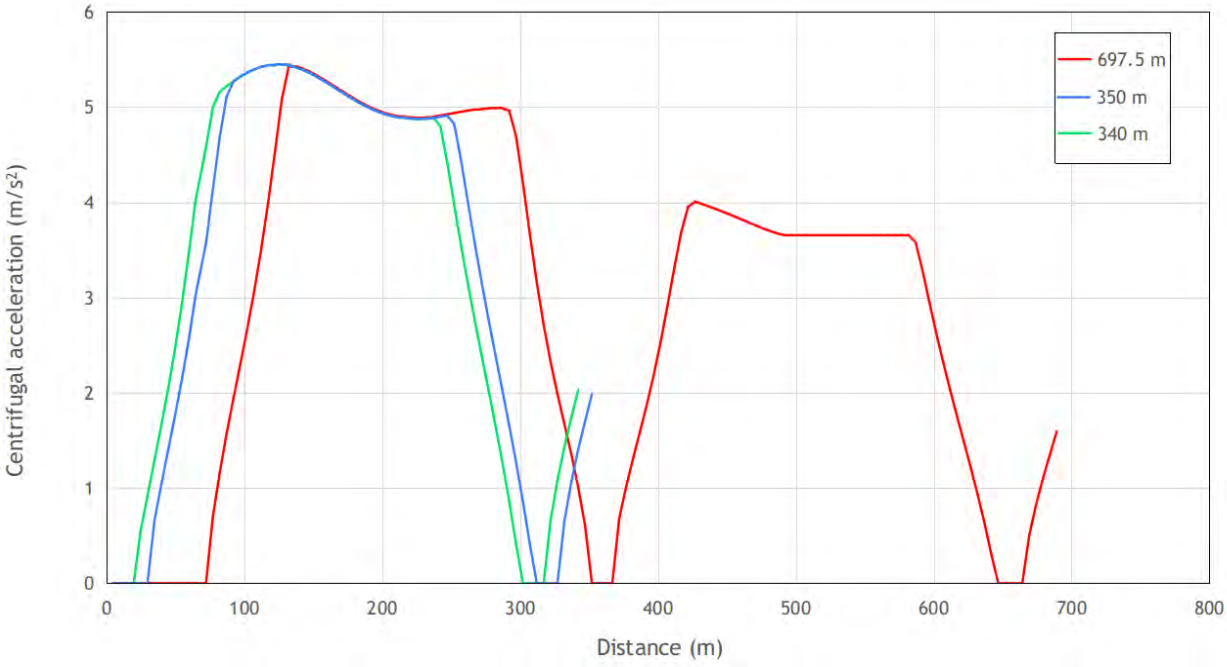

Figure 18: The centrifugal acceleration plots of preferred drop-on boxes and fixed boxes distances starts for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

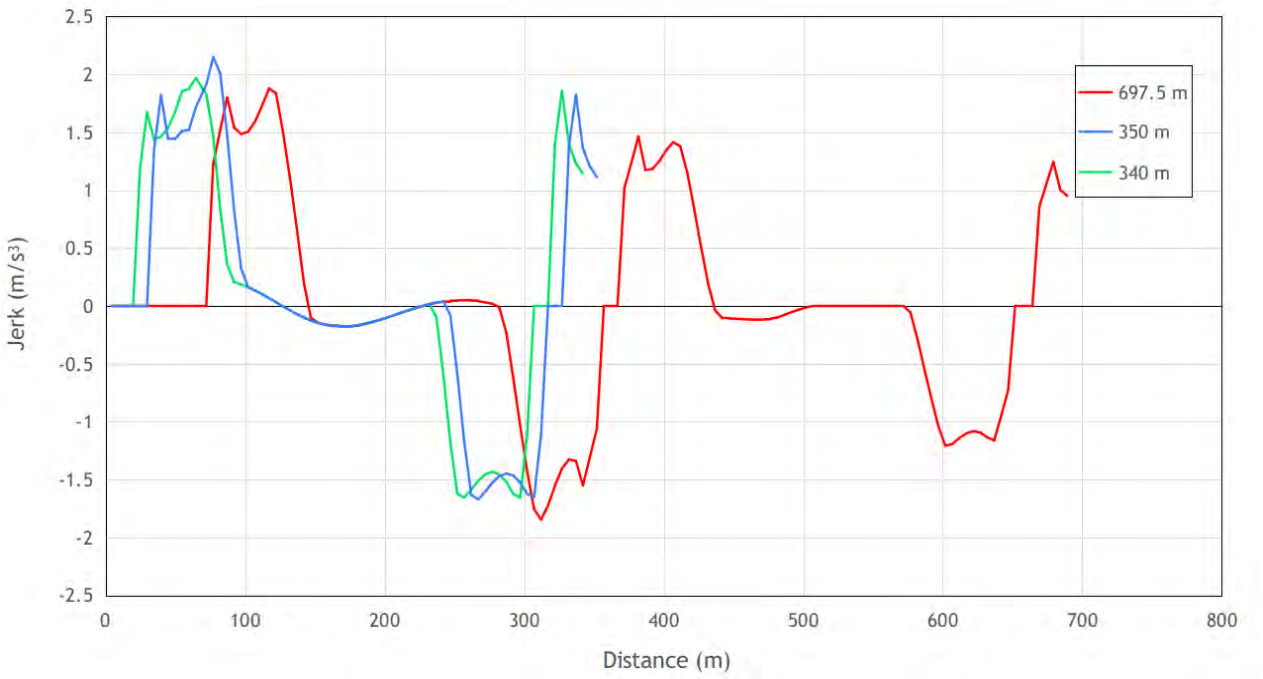

Figure 19: The jerk plots of preferred drop-on boxes and fixed boxes distances starts for proposed Design 3 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

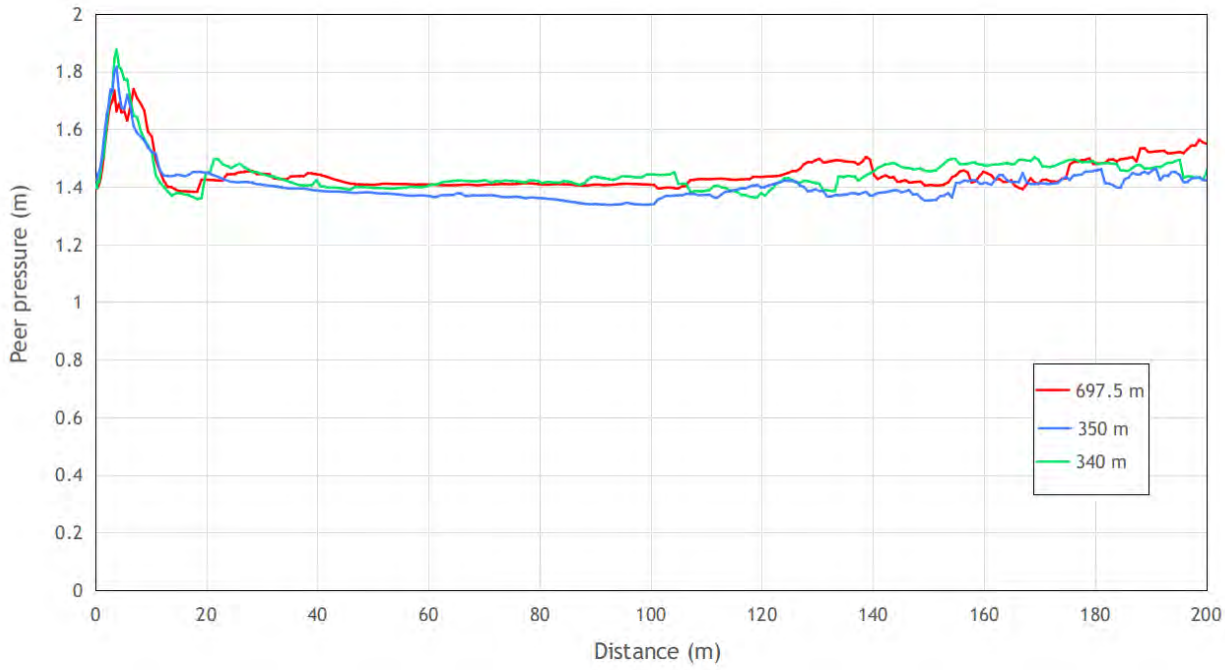

Figure 20: Peer pressure of greyhound pack during racing for 100 simulated races for proposed Design 3 Mandurah greyhound track for preferred drop-on boxes and fixed boxes start distances.

Finally, Figure 21 illustrate greyhound speed estimate for all race distances starts including drop-on boxes at proposed Design 3 Mandurah greyhound track. As can be seen from the plot, the estimate provides an idea of greyhound Finish Post speed for all race distances starts.

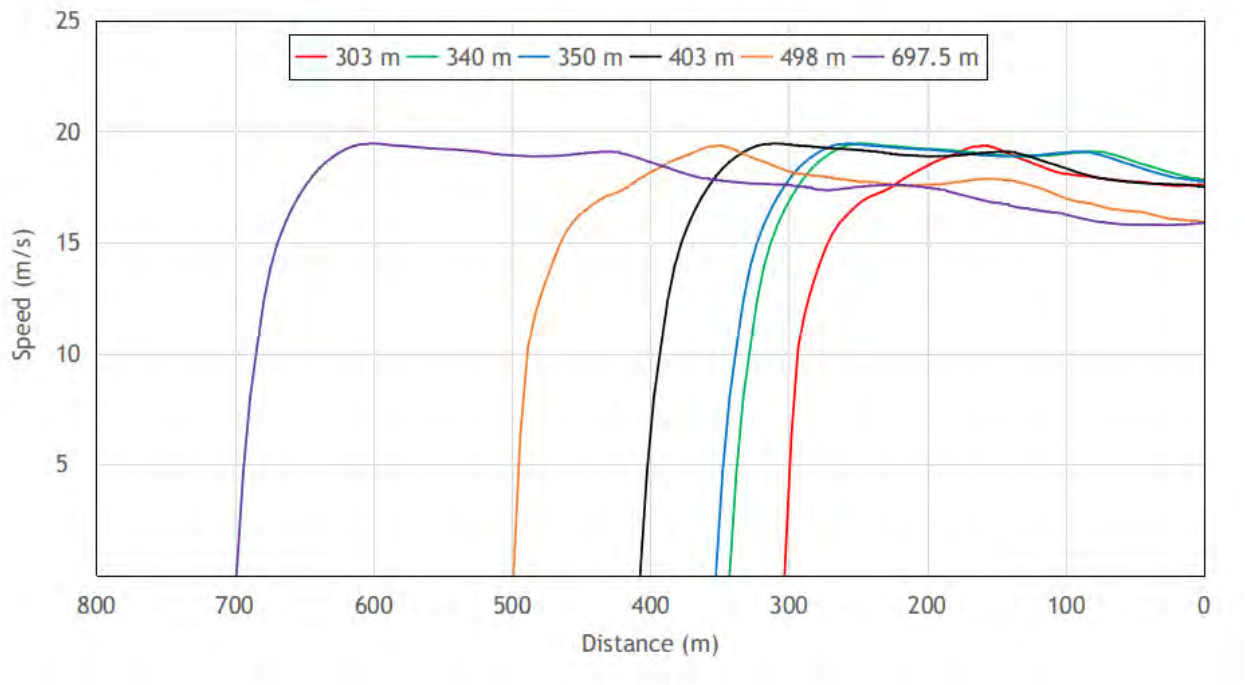

Figure 21: Greyhound average racing speed estimate versus race distance based on track curvature prediction where the 0 m distance represents the finish line at proposed Design 3 Mandurah greyhound track for preferred drop-on boxes and all fixed boxes start distances.