Cannington, Mandurah and Northam greyhound racing tracks: Report 1 – A review of the track shapes, cross-falls, race dynamics and injury rates

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Executive summary

The COVID-19 pandemic has created travel restrictions into Western Australia. So as to provide RWWA with timely reporting UTS has decided to stage the delivery of its reporting. This report is the first in a series of reports to RWWA. It presents a review of the track shapes, cross-falls, racing dynamics and the injury rates for the Cannington, Mandurah and Northam greyhound tracks.

Reducing the injury rate within the greyhound industry is analogous to repairing an old rusted leaking roof. Repairing one hole will not stop the water getting in. One needs to remove all the holes to stop the water getting in and this may involve the removal and replacement of the entire roof.

The amount and complexity of work required for each track varies significantly. The following preliminary observations were made:

- The Cannington and Mandurah greyhound tracks require an immediate regrading of their track surface to smooth out the undulating cross-falls[1].
- The Northam greyhound track requires a costly rebuild to bring it up to an optimal racing standard. This is not recommended. Instead it is recommended that temporary works including the construction of inner and outside plinths to allow better track preparation and safer racing to occur.
- The Mandurah greyhound track also requires the installation of three/four clothoidal bends. This will require a temporary track closure. It is recommended that this closure and construction be scheduled for after April 2021. In preparation the Northam greyhound track should be brought up to and kept at a minimally acceptable safe operational state until safe racing recommences at the Mandurah greyhound track.
- In the longer-term it is recommended that RWWA replace the Northam greyhound track with a purpose built greenfield track in a region that is climatically better suited to racing greyhounds. Ideally this site would be co-located near the geographic centre of where the majority of greyhounds are homed and/or trained.

[1]Removing the undulations at all three tracks is only the first of many interventions aimed at reducing the injury rates.

Further recommendations will be presented in future reports. Report 2 will address starting box locations and catching pens. Report 3 will address the track maintenance.

Contents

1 Introduction

1.1 General

UTS was engaged by Racing and Wagering Western Australia (RWWA) to conduct a review of the Cannington, Mandurah and Northam greyhound tracks, operated by the Western Australian Greyhound Racing Association (WAGRA).

1.2 Cannington greyhound track

Cannington track is located within Perth's metropolitan region that has the potential to attract race-side viewers. The track has five starts, namely: 275 m, 380 m, 520 m, 600 m and 715 m.

1.3 Mandurah greyhound track

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

1.4 Northam greyhound track

Northam track is located approximately 90 minutes drive east of Perth in a small town that has few greyhound trainers. The track has four starts, namely: 297 m, 509 m, 588 m, and 721 m.

2 Review of the track shapes, cross-falls and race dynamics

2.1 General

Preliminary site inspections of the three tracks in WA were conducted by Prof David Eager in the company of Mr Tim Beaver, RWWA representative, on 3 and 4 March 2020.

For context, it is our belief that as a general rule, galloping greyhounds do not like sudden changes when galloping at their limit state. These changes can manifest themselves in many different forms. The most commonly known is the abrupt transition at the end of a straight to a semi-circular bend. Other changes include a change to the track running surface such as the traction, hardness, moisture content, shear force and impact attenuation. Changes can include the rate of change in the cross-fall from the straight to the bend or up and down undulations in the track running surface.

For example, the up and down undulations in the track running surface are analogous to road undulations while tailgating the motorist ahead around a tight corner on a wet and slippery road during poor visibility. These unnecessary undulations tend to destabilise the greyhounds while they are being exposed to a constantly changing centrifugal force and the other greyhounds jostling for position in close proximity.

Changes either need to be eliminated or if they can't be eliminated the rate of these change need to be reduced to an acceptable level.

If a change is required it should be done for a reason such as a controlled transition from a straight to the bend. All changes need to be applied gradually. Therefore the ideal track configuration for a 2-turn track is two constant cambered semi-circles joined by two constant cambered straights; these four elements would be joined by four clothoid segments that transition gradually along the lure rail and also the track surface.

2.2 Greyhound racing speed over different distances

Typical greyhound racing speed profiles for three different racing distances are presented in Figure 1[2]. A typical greyhound's racing speed rapidly increases to a maximum speed slightly below 20 m/s at between 90 m and 150 m into a race. For medium length race distances (525 m and 600 m) the greyhound's speed gradually reduces until the end of a race where it is approximately 16 m/s. For the longer length race distance (725 m) the greyhound's speed gradually reduces until the end of a race where it is below 15 m/s.

Data measured at The Meadows greyhound track will be used for the simulation and modelling contained within this Report. Notwithstanding, the simulation and modelling takes account of the specific physical characteristics of the three greyhound tracks.

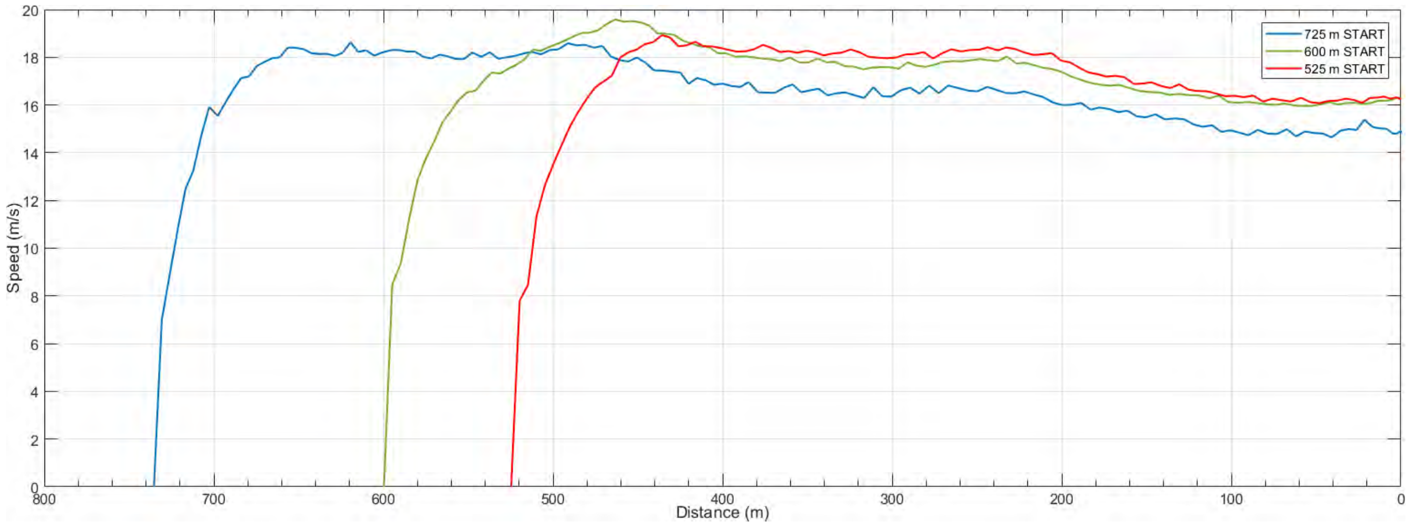


Figure 1: Greyhound average racing speed (m/s) versus race distance (m) where the 0 m distance represents the finish line.

2.3 Greyhound racing curvature, centrifugal acceleration and jerk

The radius of curvature, centrifugal acceleration and jerk for each starting distance were calculated. In making these calculations a typical smoothed greyhound racing trajectory[3] was assumed.

[2]The speed data were measured at The Meadows track (GRV) using position location tracking devices mounted within the greyhound jacket during normal racing conditions.

[3]The smoothed greyhound running trajectory was assumed to be measured 1 m perpendicular to the inside rail of the track.

2.4 Cannington greyhound track

2.4.1 Track shape

Figure 2 is the satellite plan view[4] of the Cannington greyhound track as downloaded on 2 January 2020. The Cannington greyhound track is a typical 2-turn track with two straight starts and two bend starts.

Figure 2: Cannington greyhound track satellite plan view orientated so north is at the top of the plan. Throughout this Report for the Cannington greyhound track the end of the track adjacent the 600 m start will be referred to as the Northern Turn. Conversely, the end of the track adjacent the 380 m start and the Catching Pen will be referred to as the Southern Turn (downloaded 28 July 2020).

[4]The use of satellite imagery introduced errors into the calculations contained herein. It is recommended RWWA arrange for the Cannington greyhound track to be surveyed so that future analysis by UTS is conducted using this survey data.

2.4.2 Track surface cross-fall

Figure 3 is a plan view of the Cannington greyhound track depicting the cross-falls measured at regular intervals (every fifth lure-rail support post). The data were measured on 4 March 2020 using Bosch 1200 mm Digital Spirit Level.

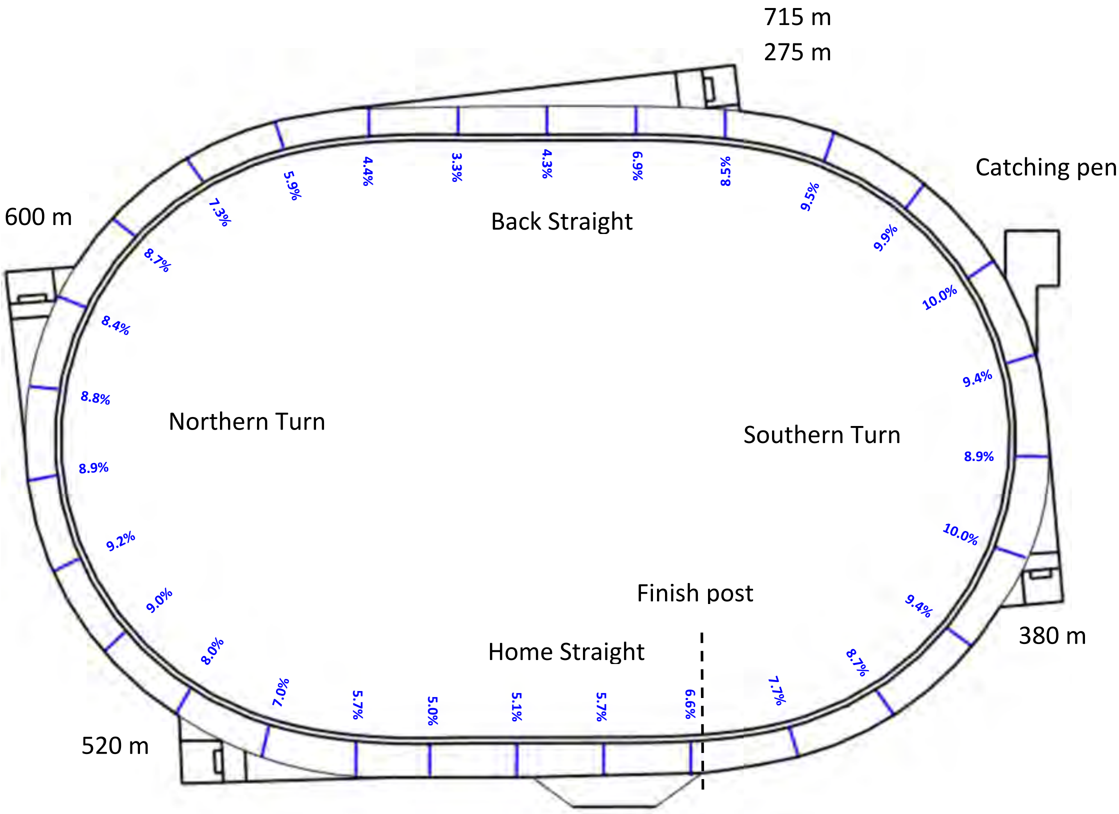


Figure 3: Cannington greyhound track cross-falls (4 March 2020).

The Cannington greyhound track cross-fall readings confirm the following:

- *Home Straight*

  The track surface cross-fall on the Home Straight has a dip in the cross-fall. This dip would introduce a destabilising force where the track surface drops from a cross-fall of more than 6.0% down to 5.0% before its climbs to 6.6% just before the Finish Post.

  UTS recommend removing the dip on the Home Straight so that the straight has a constant 5.5% cross-fall.

UTS also recommends 35 m and 37 m track surface transitions that mirror the track shape curvature at either end of the Home Straight.

- *Northern Turn*

  The track surface cross-fall on the Northern Turn is not constant (7.3%, 8.7%, 8.4%, 8.8%, 8.9%, 9.2%, 9.0%, 8.0%). This inconsistency subjects the greyhounds to changing forces as they negotiate the bend.

  UTS recommend the cross-fall be made a constant 8.5% for the entire bend.

- *Back Straight*

  The track surface cross-fall on the Back Straight drops from 8.5% to 3.3% before it rises to approximately 4.4% before the bend.

  UTS recommend that the dip in the Back Straight be removed by raising the lower portions so that the straight is a constant 5.5% cross-fall.

  UTS also recommends 35 m transitions at either end of the Back Straight.

- *Southern Turn*

  The track surface cross-fall on the Southern Turn undulates (7.7%, 8.7%, 9.4%, 10.0%, 8.9%, 9.4%, 10.0%, 9.9%, 9.5%). This undulation coupled with a non-constant cross-fall is not ideal for racing.

  UTS recommend the undulations on the Southern Turn be removed and the cross-fall be made a constant 8.5% for the entire bend.

Figure 4 is a plan view of the Cannington greyhound track depicting the *proposed* cross-falls measured at regular intervals (every fifth lure-rail support post).

To summarise[5], UTS recommend a constant cross-fall of 5.5% for the straights and a constant cross-fall of 8.5% for the turns. UTS also recommend connecting these with the 35 m long transitions that mirror the track shape curvature[6]. These transitions are highlighted in red within Figure 4.

[5] The recommended cross-falls will need to be confirmed on-site as the RL of the starting box plinths are a limiting constraint and minor adjustments in the cross-falls may need to be made to accommodate these height differences.

[6] The Cannington greyhound track has tight bends as well as short straights which limit the length of the track surface transitions.

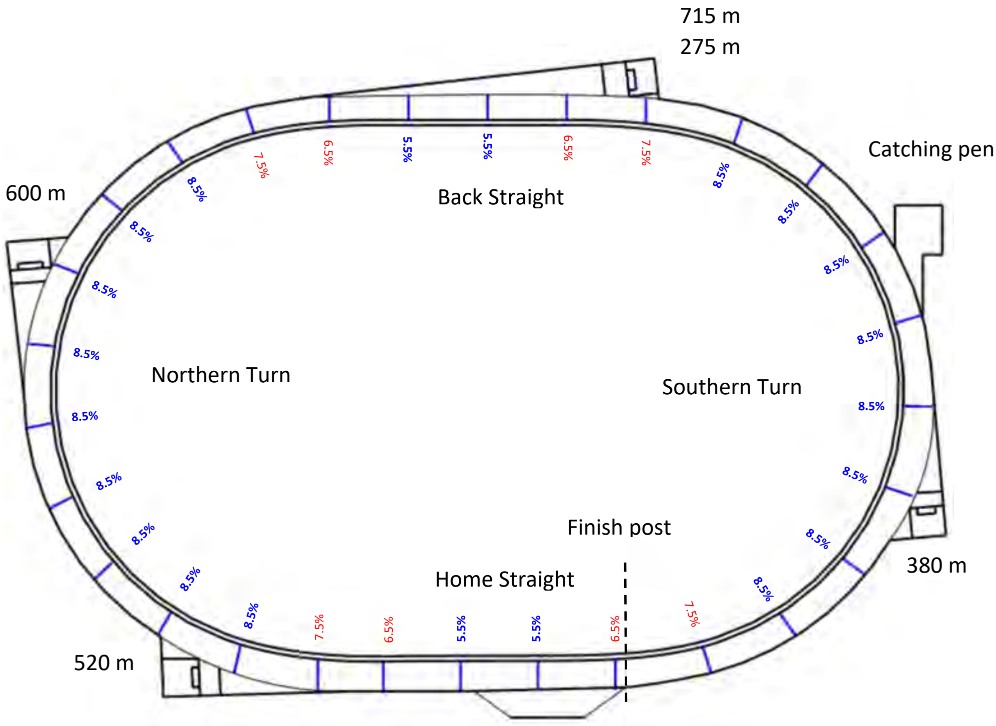


Figure 4: Cannington greyhound track *proposed* cross-falls.
The four track surface transitions are indicated in red.

2.4.3 Curvature for each starting distance

Figure 5 shows a plan view of the Cannington greyhound track curvature lines together with the fundamental track dimensions.

The length of the transition from Back Straight into Northern Turn is approximately 35 m, the length of the transition from Northern Turn into the Home straight is also approximately 35 m, the length of the transition from Home Straight into the Southern Turn is approximately 37 m and the length of the transition from the Southern Turn into Back Straight is approximately 35 m. These transitions are depicted in red within Figure 5.

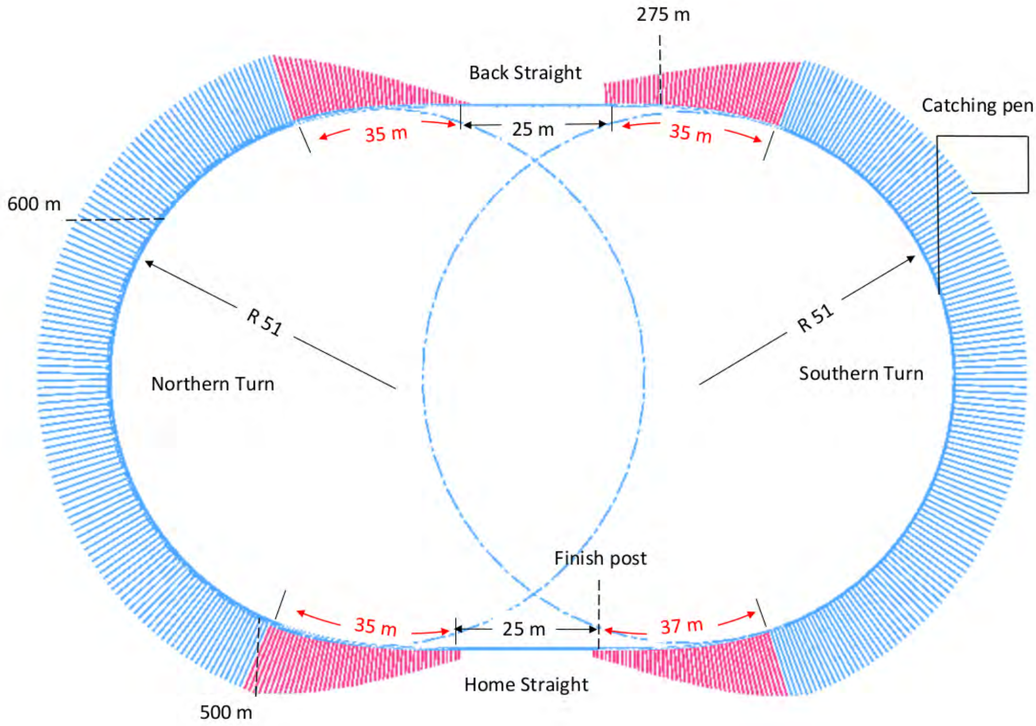


Figure 5: The existing Cannington greyhound track curvature line plot. The lengths of the perpendicular blue lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail. This plot also depicts the existing transitions (with red curvature lines) and their length into and out of both the Southern and Northern Turns. Source: Satellite photo (see Figure 2).

The track path curvature (1/m) for the 275 m (and 715 m), 380 m, 520 m and 600 m starting distances versus race distance (m) measured from the respective starting boxes to the Finish Post for the Cannington greyhound track is given in Figure 6. Figures 7 to 10 contain the curvature data for each individual starting distance for the Cannington greyhound track.

These curvature data plots show where the track is curved and where it is not curved. As can be seen from these graphs the track path for all starting distances[7] has a gradually increasing curvature from the straight to the bend over an approximate 45 m distance.

[7]The measured curvature distances (as marked in red in Figure 5) are less than 45 m as a typical smoothed greyhound racing trajectory was assumed while modelling track paths.

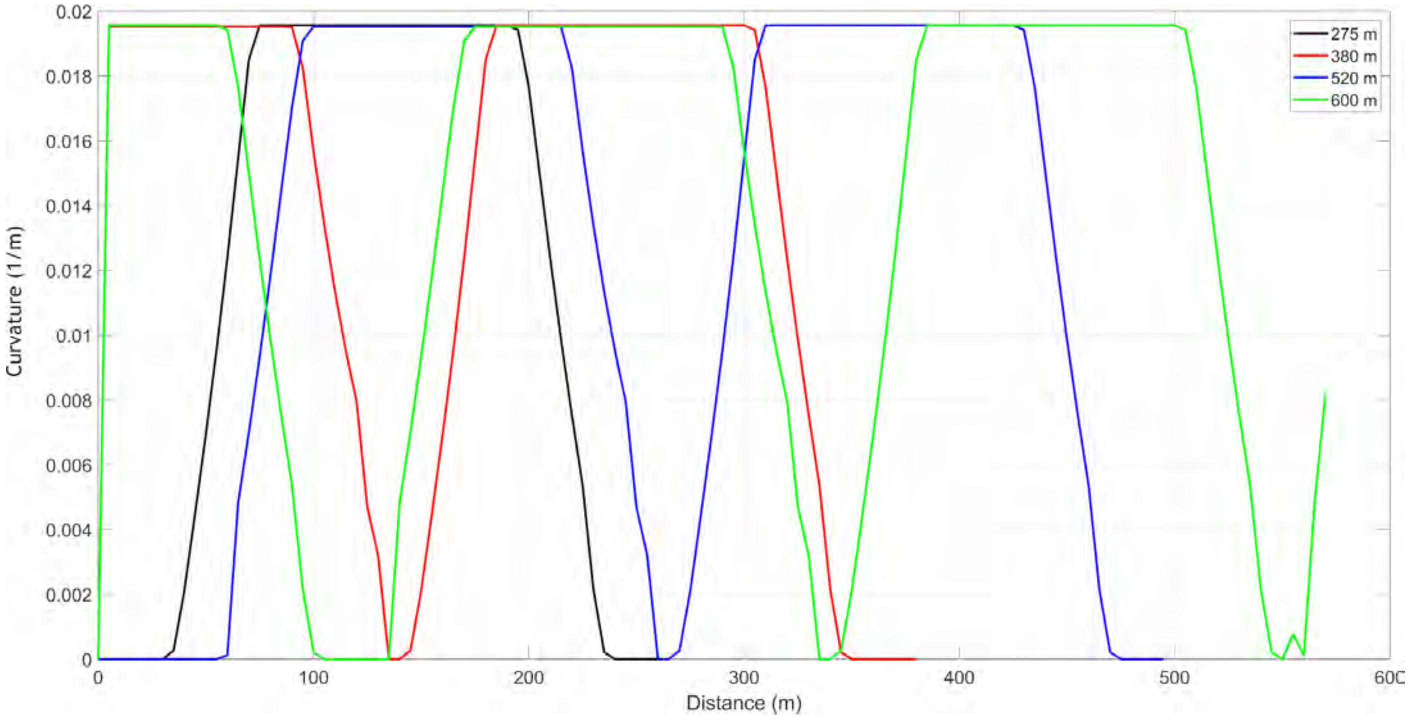


Figure 6: The curvature data for 275 m, 380 m, 520 m and 600 m starting distances at Cannington track. The plots commence at the respective Starting Boxes and end at the Finish Post.

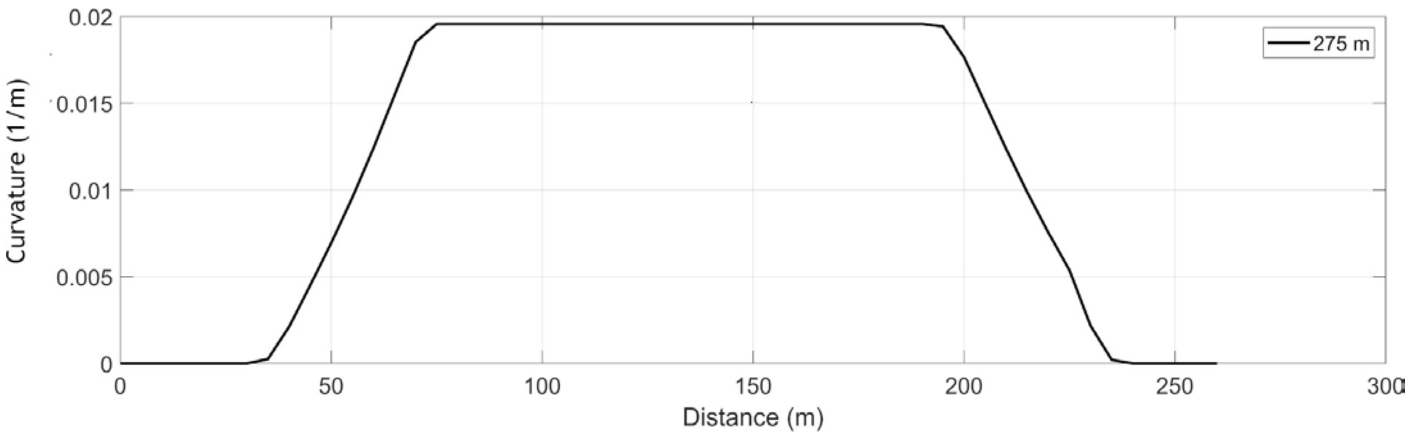


Figure 7: The curvature data for 275 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

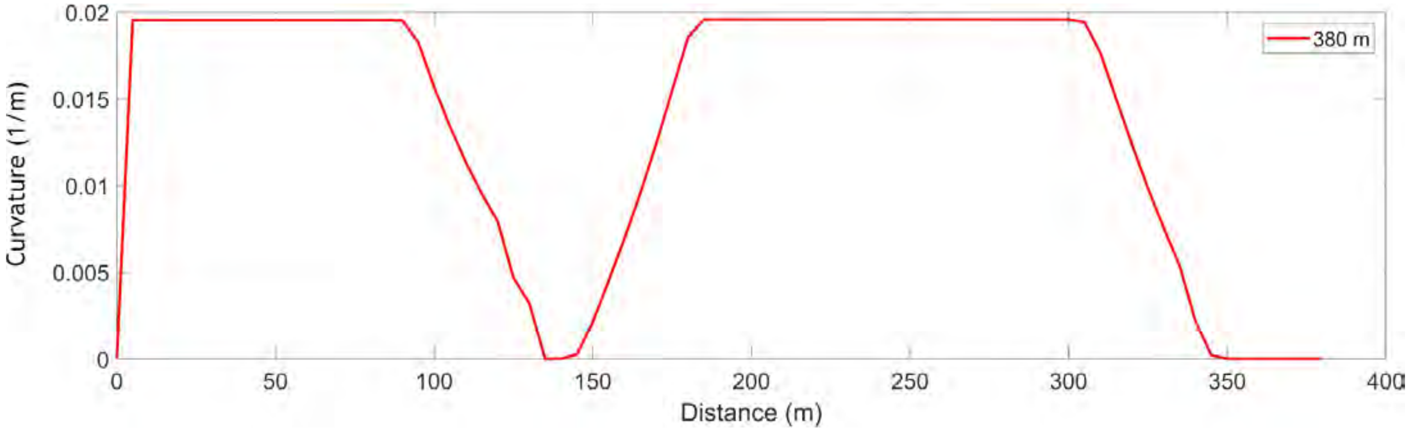


Figure 8: The curvature data for 380 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

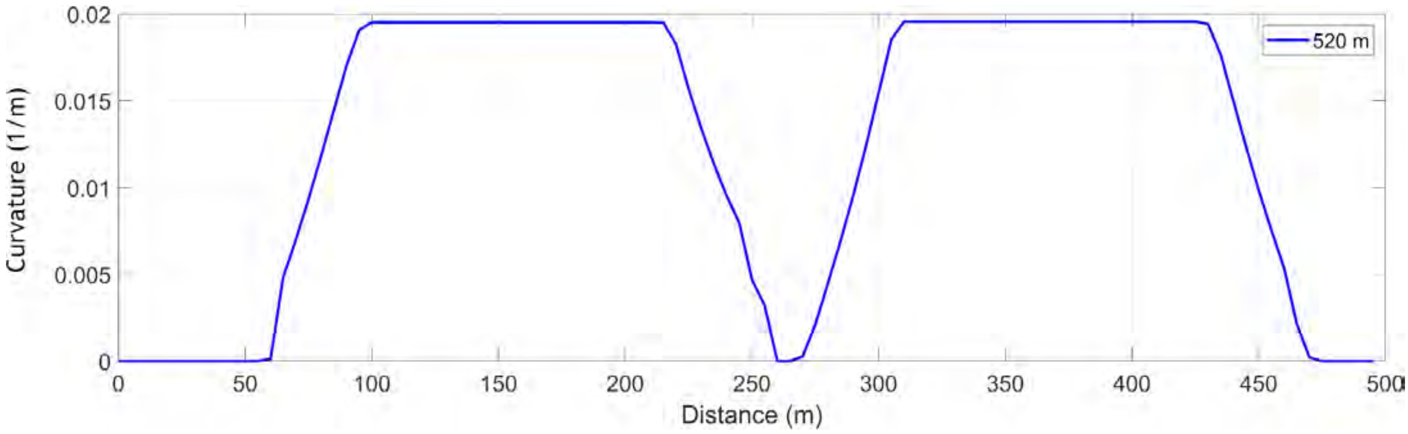


Figure 9: The curvature data for 520 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

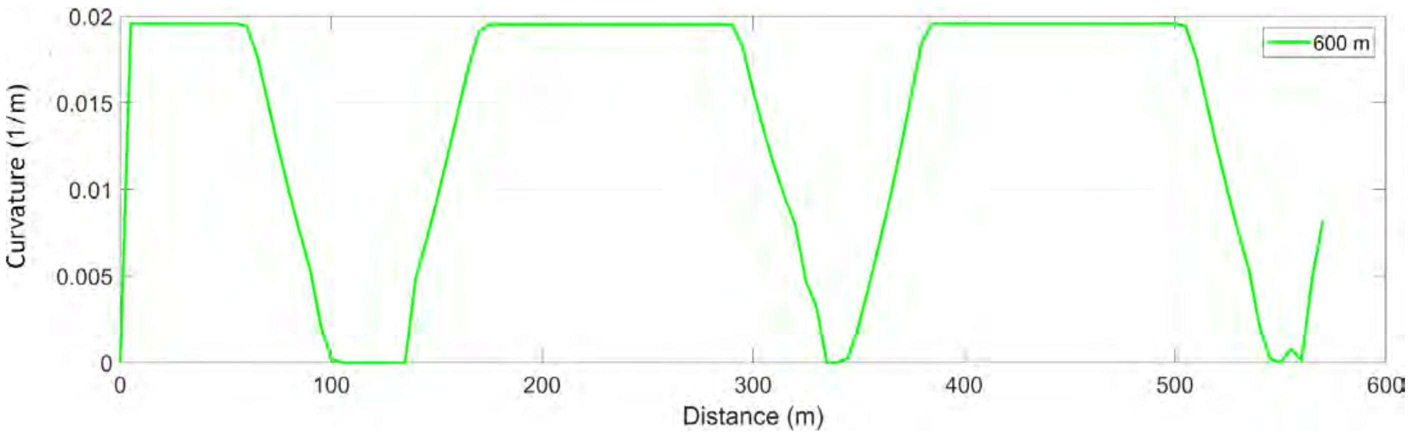


Figure 10: The curvature data for 600 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

2.4.4 Centrifugal acceleration for each starting distance

The centrifugal acceleration (m/s^2) for 275 m (and 715 m), 380 m, 520 m and 600 m starting distances versus track distance (m) measured from the respective starting boxes to the Finish Post for the Cannington track are given in Figure 11. Figures 12 to 15 contain the centrifugal acceleration data for each individual starting distance for the Cannington greyhound track.

The Cannington greyhound track has two tight 51 m turns which result in the greyhounds experiencing elevated levels of centrifugal acceleration.

For the 275 m (and 715 m) and 520 m starting distances the greyhounds experience the highest centrifugal acceleration of approximately 7.5 m/s^2. The greyhounds reach their maximum velocity as they enter the turn.

For the 380 m and 600 m starting distances the greyhounds are accelerating from the boxes and around the turn and reach their maximum velocity as they are coming out of the bend. By the time the greyhounds reach the next turn their velocity has dropped and thus their centrifugal acceleration is lower.

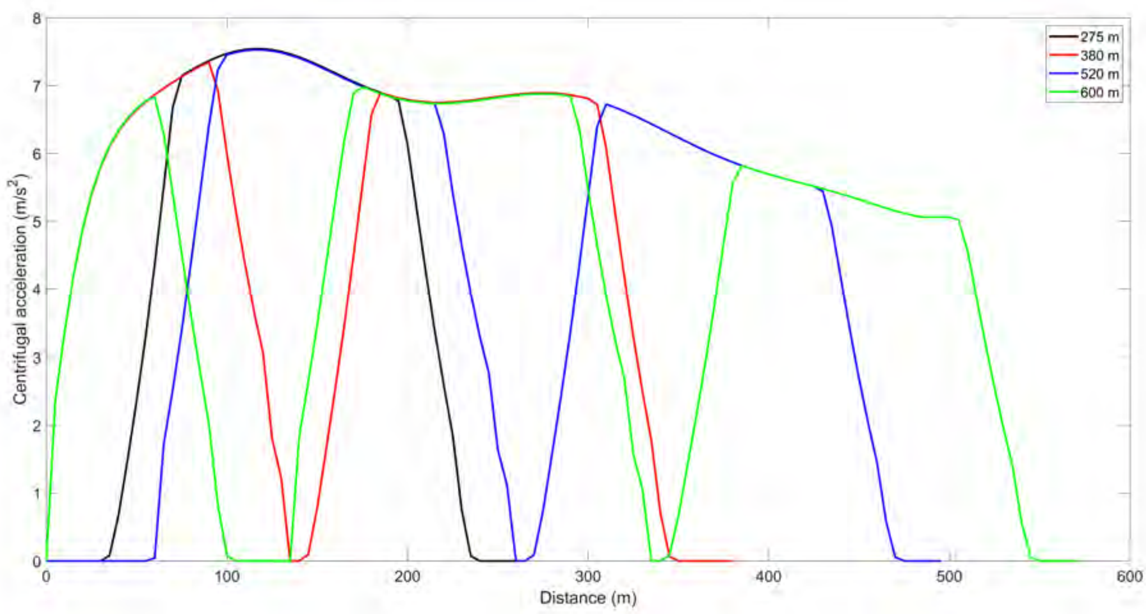


Figure 11: The centrifugal acceleration for 275 m, 380 m, 520 m and 600 m starting distances at Cannington track. The plots commence at the respective Starting Boxes and end at the Finish Post.

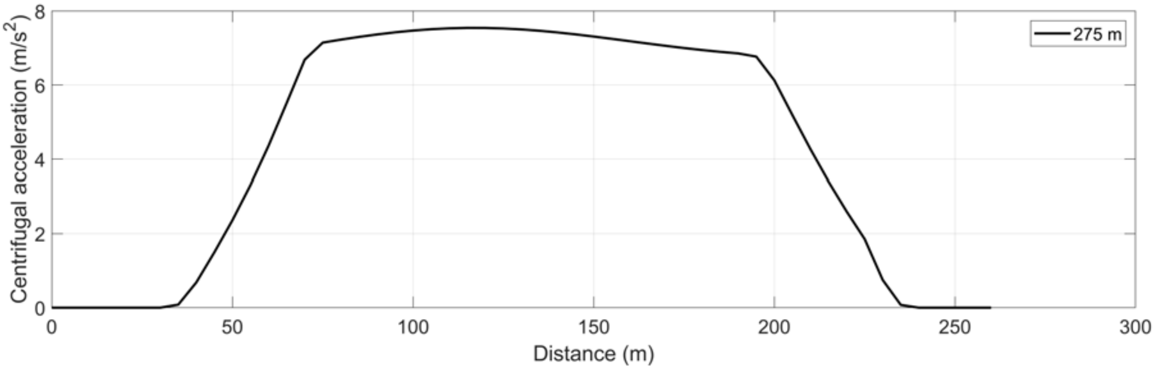


Figure 12: The centrifugal acceleration for 275 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

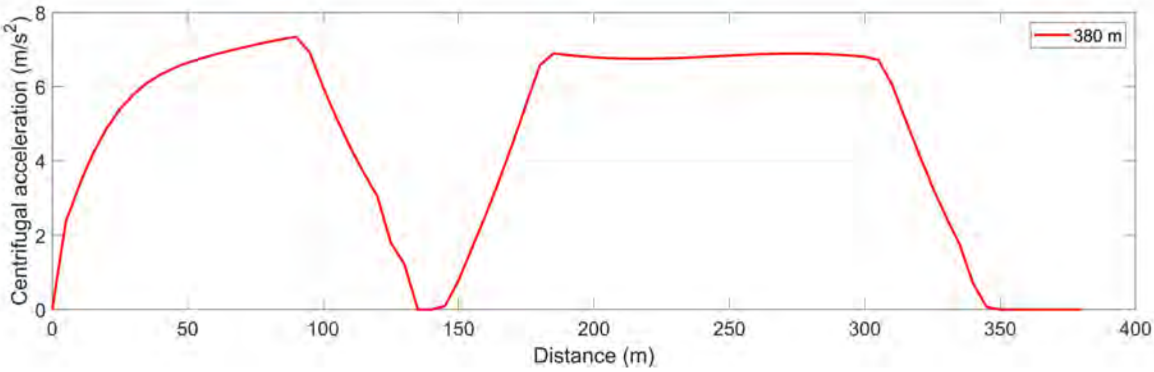


Figure 13: The centrifugal acceleration for 380 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

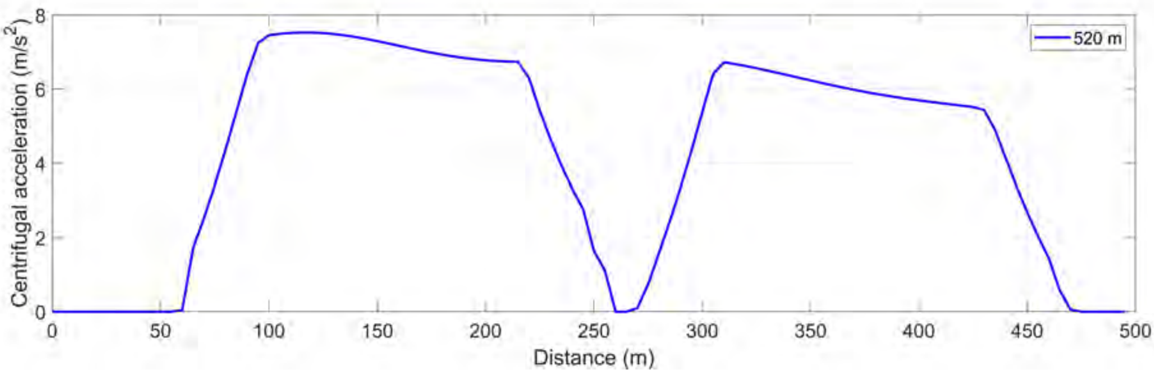


Figure 14: The centrifugal acceleration for 520 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

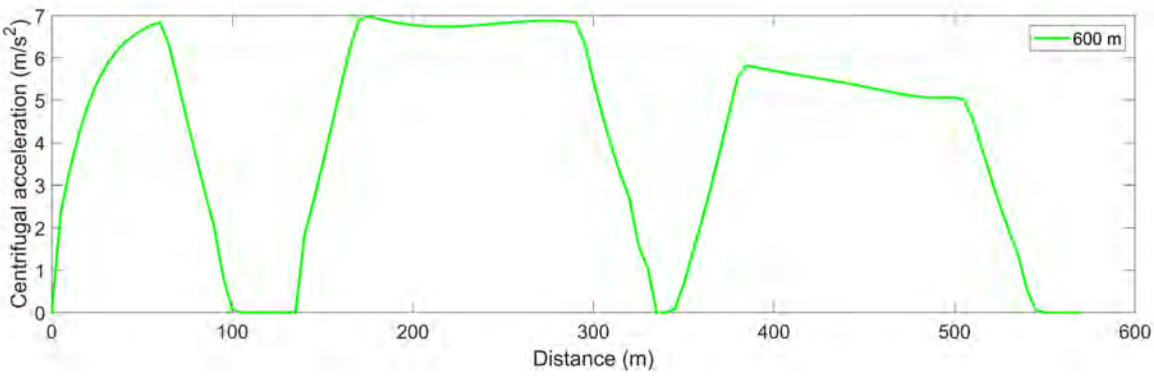


Figure 15: The centrifugal acceleration for 600 m starting distance at Cannington track. The plot commences at the Starting Box and ends at the Finish Post.

2.4.5 Jerk for each starting distance

The jerk (m/s^3) for 275 m (and 715 m), 380 m, 520 m and 600 m starting distances versus track distance (m) measured from the respective starting boxes for the Cannington track is given in Figure 16. Figures 17 to 20 contain the jerk data for each individual starting distance for the Cannington greyhound track.

The 275 m (and 715 m) distance has the lowest $jerk_{max}$ at just over 4 m/s^3 at approximately 70 m into the race. For the 380 m distance it is higher and fluctuates frequently with a $jerk_{max}$ at approximately 5 m/s^3. The magnitude of the calculated $jerk_{max}$ for 520 m is not smooth as the race starts (>6 m/s^3) suggesting the lack of a correctly built transition onto the track. Of all the racing distances the 600 m distance has the highest jerk (>7 m/s^3) at approximately 130 m into the race. For all racing distances, with the exception of the 275 m, the value of jerk is higher than the minimum recommended value of 4 m/s^3 and well short of the preferred 'greenfield' track design value of 2 m/s^3.

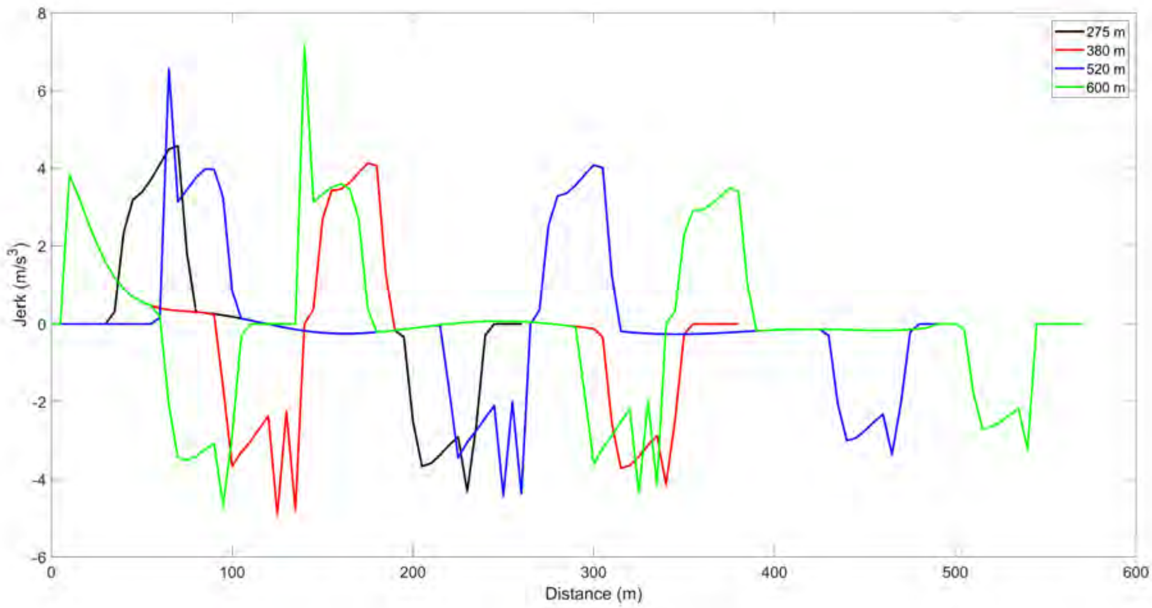


Figure 16: The jerk for 275 m, 380 m, 520 m and 600 m starting distances at Cannington greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

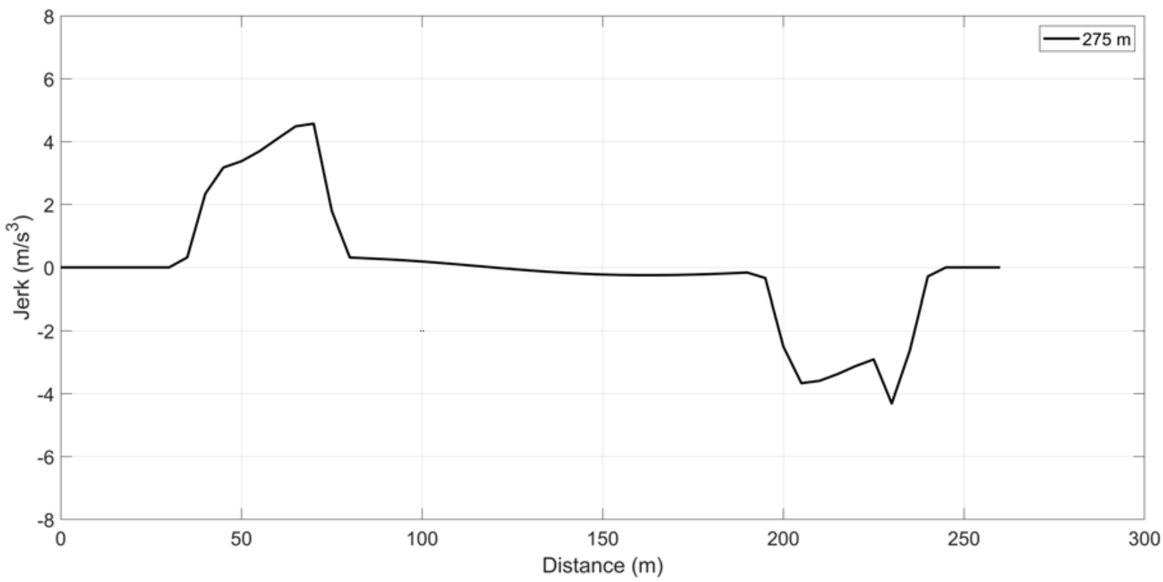


Figure 17: The jerk for 275 m starting distance at Cannington greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

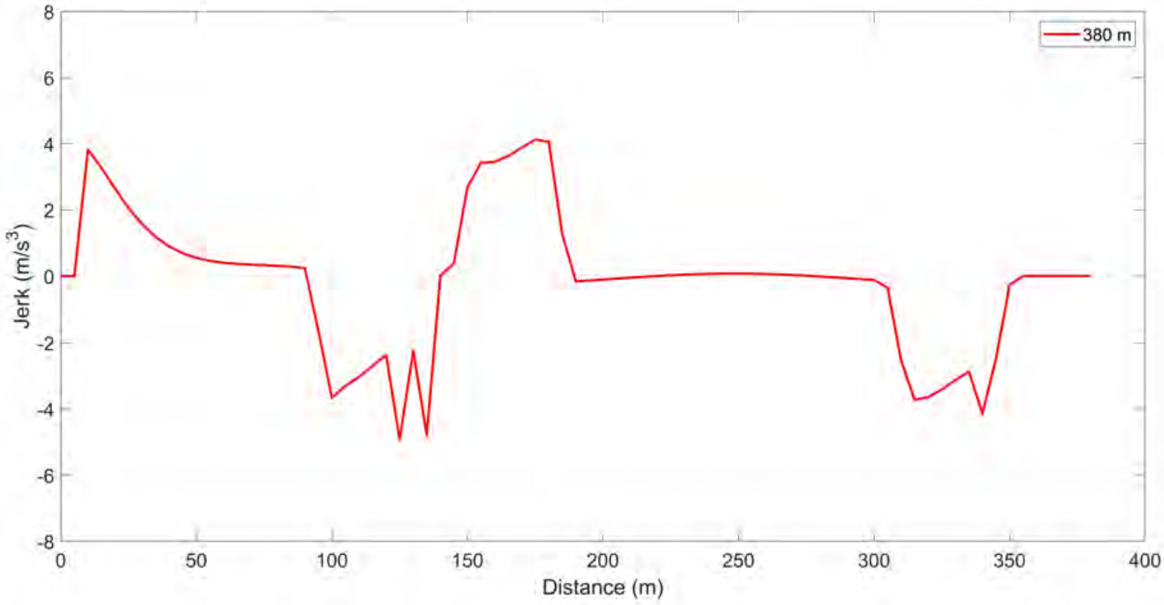


Figure 18: The jerk for 380 m starting distance at Cannington greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

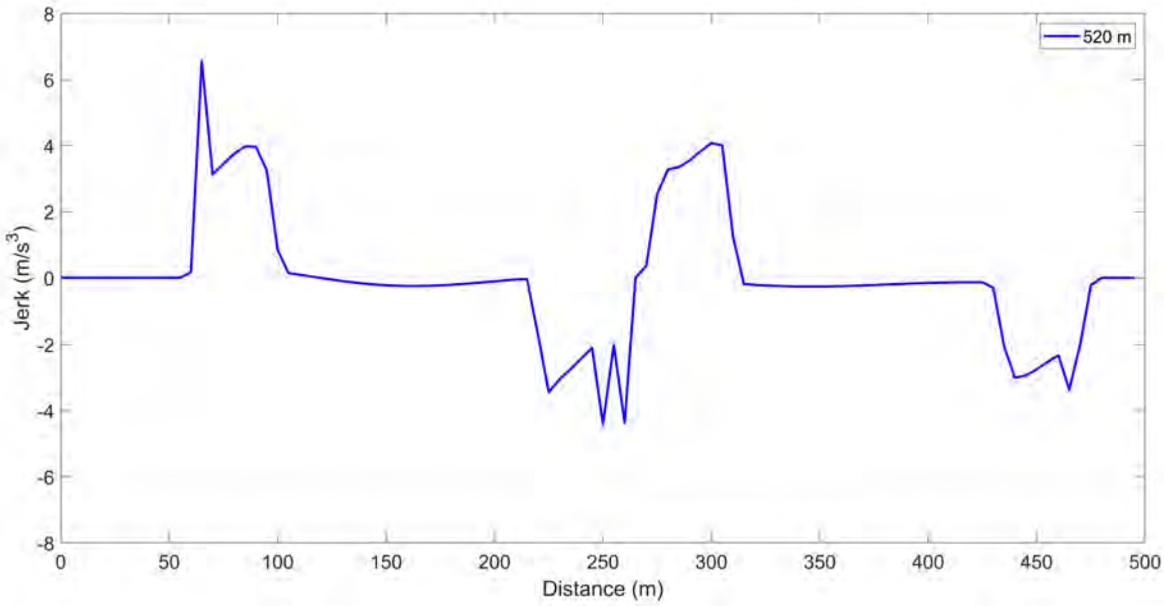


Figure 19: The jerk for 520 m starting distance at Cannington greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

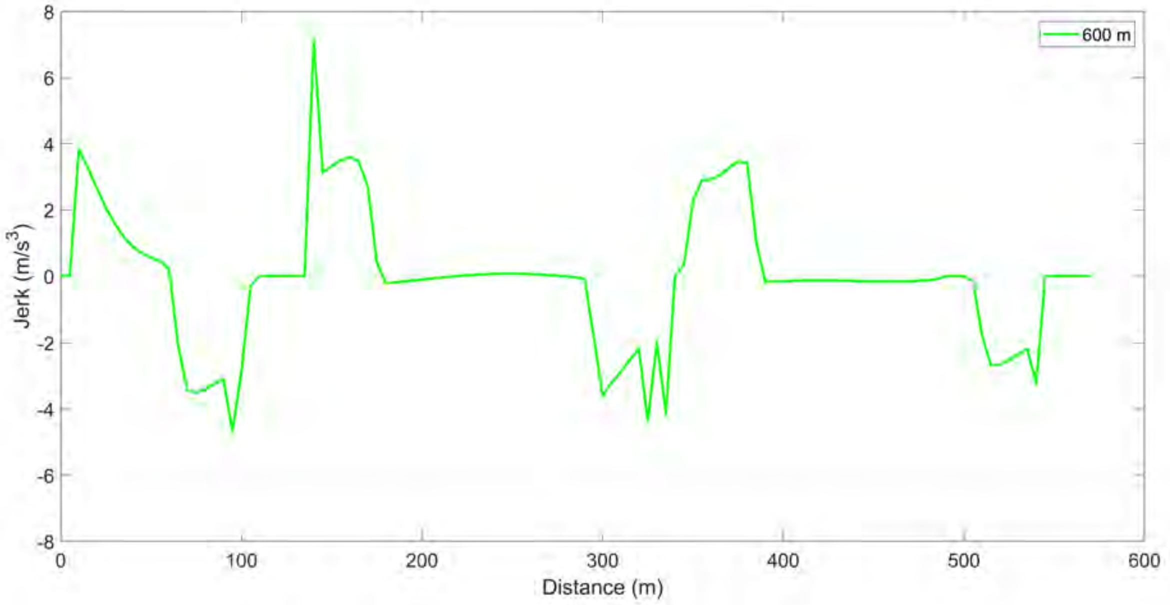


Figure 20: The jerk for 600 m starting distance at Cannington greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

2.5 Mandurah greyhound track

2.5.1 Track shape

Figure 21 is the satellite view of the Mandurah greyhound track.

Figure 21: Mandurah greyhound track satellite plan view orientated so north is at the top of the plan. Throughout this Report for the Mandurah greyhound track the turn adjacent the kennel block and the catch pen will be referred to as the Northern Turn (downloaded 28 July 2020).

Figure 22 is the David Allan Consulting Engineer Pty Ltd *for construction* plan[8,9] of the Mandurah greyhound track dated 21 May 2018.

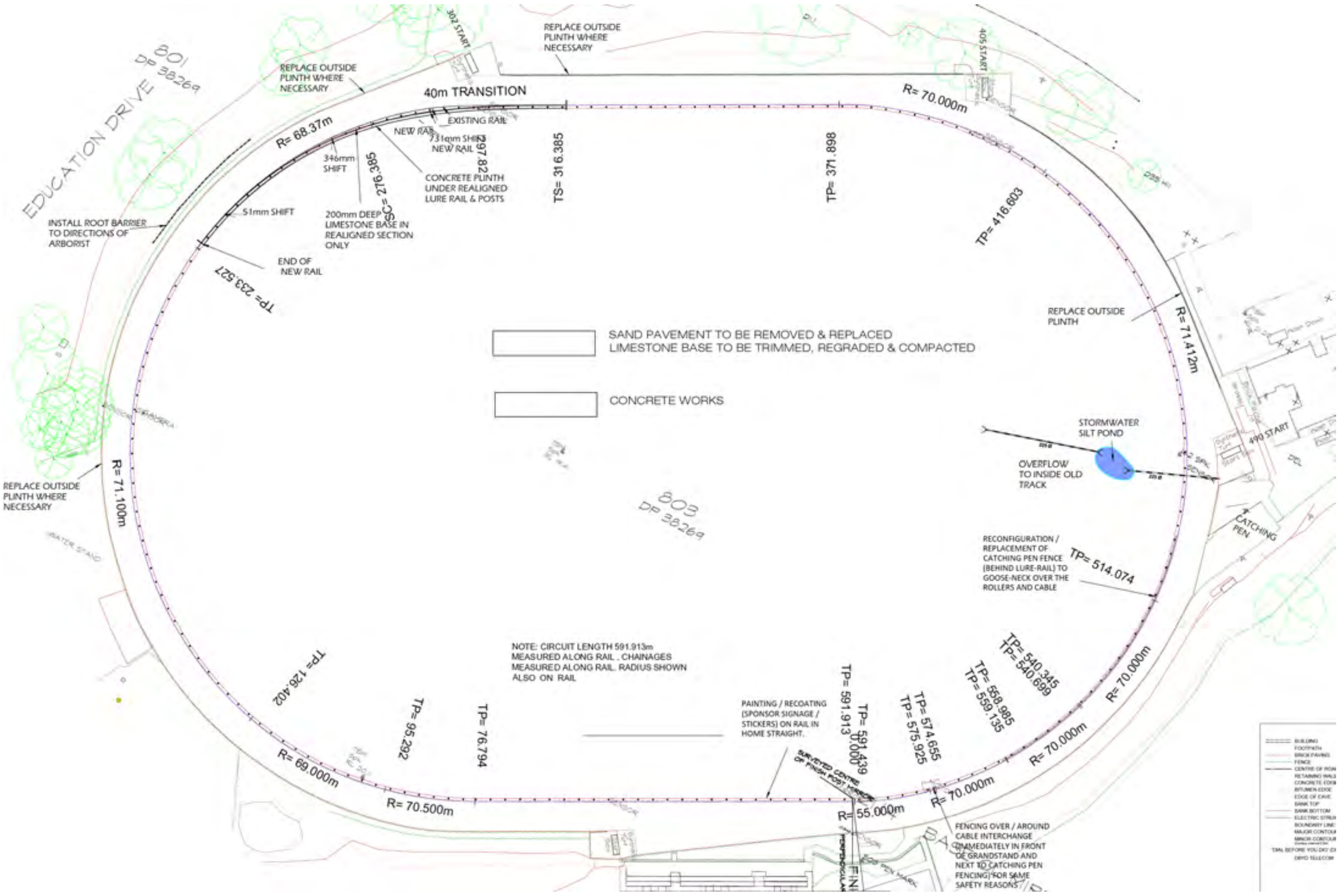


Figure 22: Mandurah greyhound track David Allan Consulting Engineer Pty Ltd *for construction* plan depicting the location and dimension of the 40 m transition that was added to the turn exiting the Back Straight and 55 m radius transition after the Finish Post (21 May 2018).

[8] This plan includes the location and dimension of the 40 m transition that was added to the turn exiting the Back Straight and 55 m radius transition after the Finish Post that were used to generate the curvature line plot, curvature graphs, centrifugal acceleration graphs and jerk graphs.

[9] The use of the *for construction* plan introduced errors into the calculations contained herein. It is recommended RWWA arrange for the Mandurah greyhound track to be surveyed so that future analysis by UTS is conducted using the *as installed* survey data.

2.5.2 Track surface cross-fall

Figure 23 is a plan view of the Mandurah greyhound track depicting the cross-falls measured at regular intervals (every fifth lure-rail support post). The data were measured on 3 March 2020 using Bosch 1200 mm Digital Spirit Level.

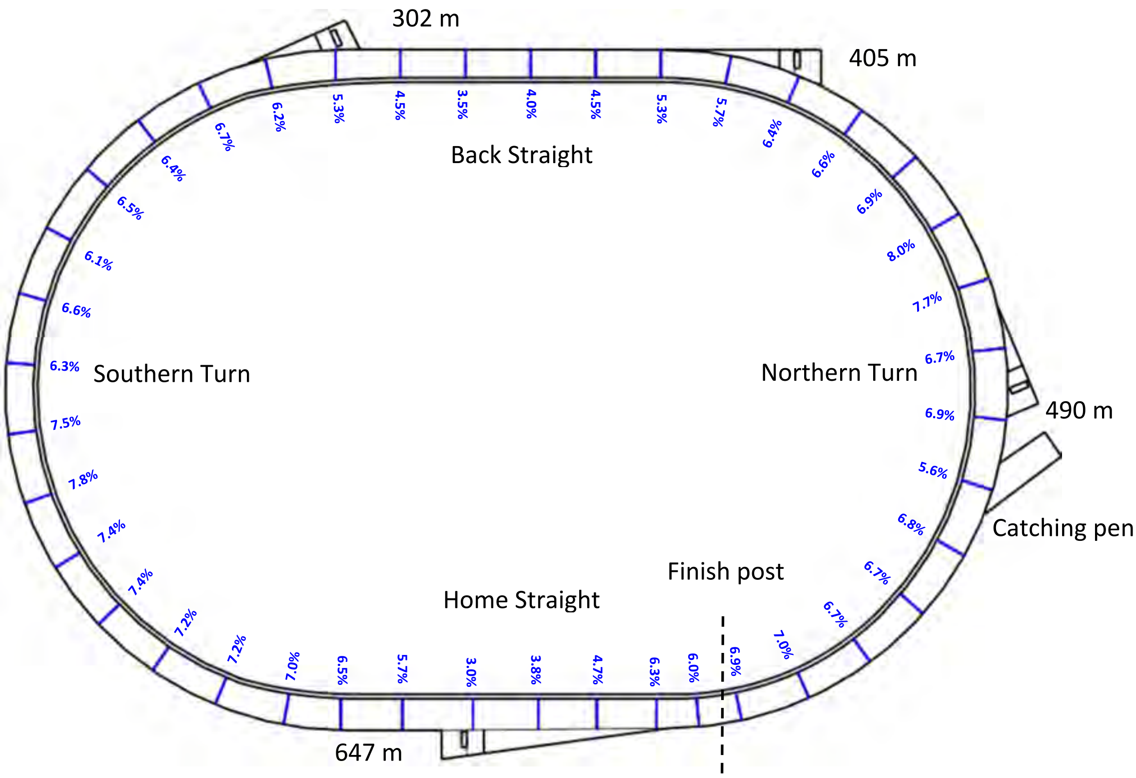


Figure 23: Mandurah greyhound track cross-falls as of 3 March 2020.

The Mandurah greyhound track cross-fall readings confirm the following:

- *Home Straight*

  The track surface cross-fall on the Home Straight dips from 6.5% to 3.0% and rises to 6.0%.

  UTS recommend removing the dip on the Home Straight so that the straight has a constant 5.3% cross-fall.

  UTS also recommends the introduction of transitions at either end of the Home Straight as shown in Figure 24.

- *Northern Turn*

  The track surface cross-fall on the Northern Turn undulates (6.9%, 7.0%, 6.7%, 6.8%, 5.6%, 6.9%, 6.7%, 7.7%, 8.0%, 6.9%, 6.6%, 6.4%). This undulation coupled with a non-constant cross-fall is not an optimal racing surface..

  UTS recommend the 5.6% dip be removed and the cross-fall be made a constant 7.0% for the entire Northern Turn.

- *Back Straight*

  The track surface cross-fall on the Back Straight drops from 5.3% to 3.5% before it rises to 5.3%.

  UTS recommend removing the dip on the Back Straight so that the straight has a constant 5.3% cross-fall.

  UTS also recommend the introduction of transition(s) at either end of the Back Straight as shown in Figure 24.

- *Southern Turn*

  The track surface cross-fall on the Southern Turn undulates (6.2%, 6.7%, 6.4%, 6.5%, 6.1%, 6.6%, 6.3%, 7.5%, 7.8%, 7.4%, 7.4%, 7.2%, 7.2%, 7.0%).

  UTS recommend the 5.6% dip be removed and the cross-fall be made a constant 7.0% for the entire Southern Turn.

Figure 24 is a *proposed* plan view of the Mandurah greyhound track depicting the cross-falls measured at regular intervals (every fifth lure-rail support post).

To summarise[10], UTS recommend a constant cross-fall of 5.3% for the straights and a constant cross-fall of 7.0% for the turns. UTS also recommend connecting these with transitions which are at least 50 m in length. These transitions are highlighted in red within Figure 24.

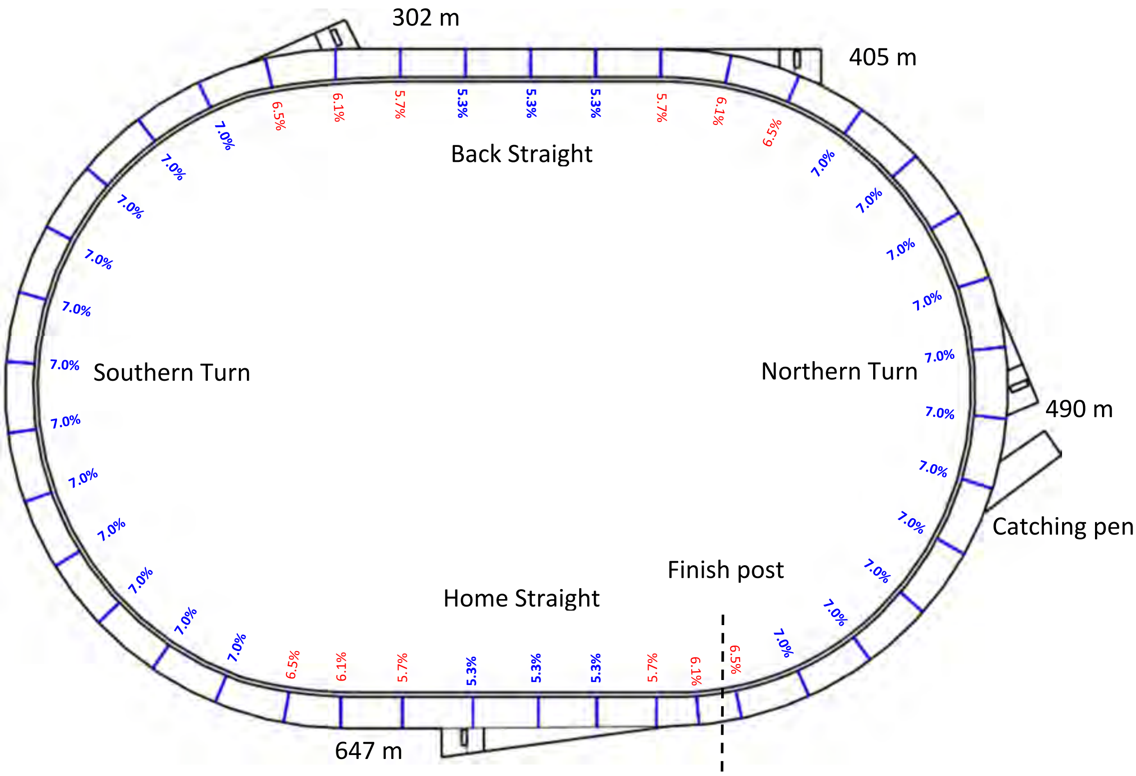


Figure 24: Mandurah greyhound track *proposed* cross-falls.

[10]The recommended cross-falls will need to be confirmed on-site as the RL of the starting box plinths are a limiting constraint and minor adjustments in the cross-falls may need to be made to accommodate these height differences.

2.5.3 Curvature for each starting distance

Figure 25 shows a plan view of the Mandurah greyhound track with fundamental track dimensions and the curvature lines. As can be seen from this diagram there is almost no smooth transition from the home straight to the bend after the Finish Post and from this bend and into the Back Straight.

The length of the transition from the Back Straight to the Southern Turn is approximately 40.0 m as is depicted by the red curvature lines in Figure 25.

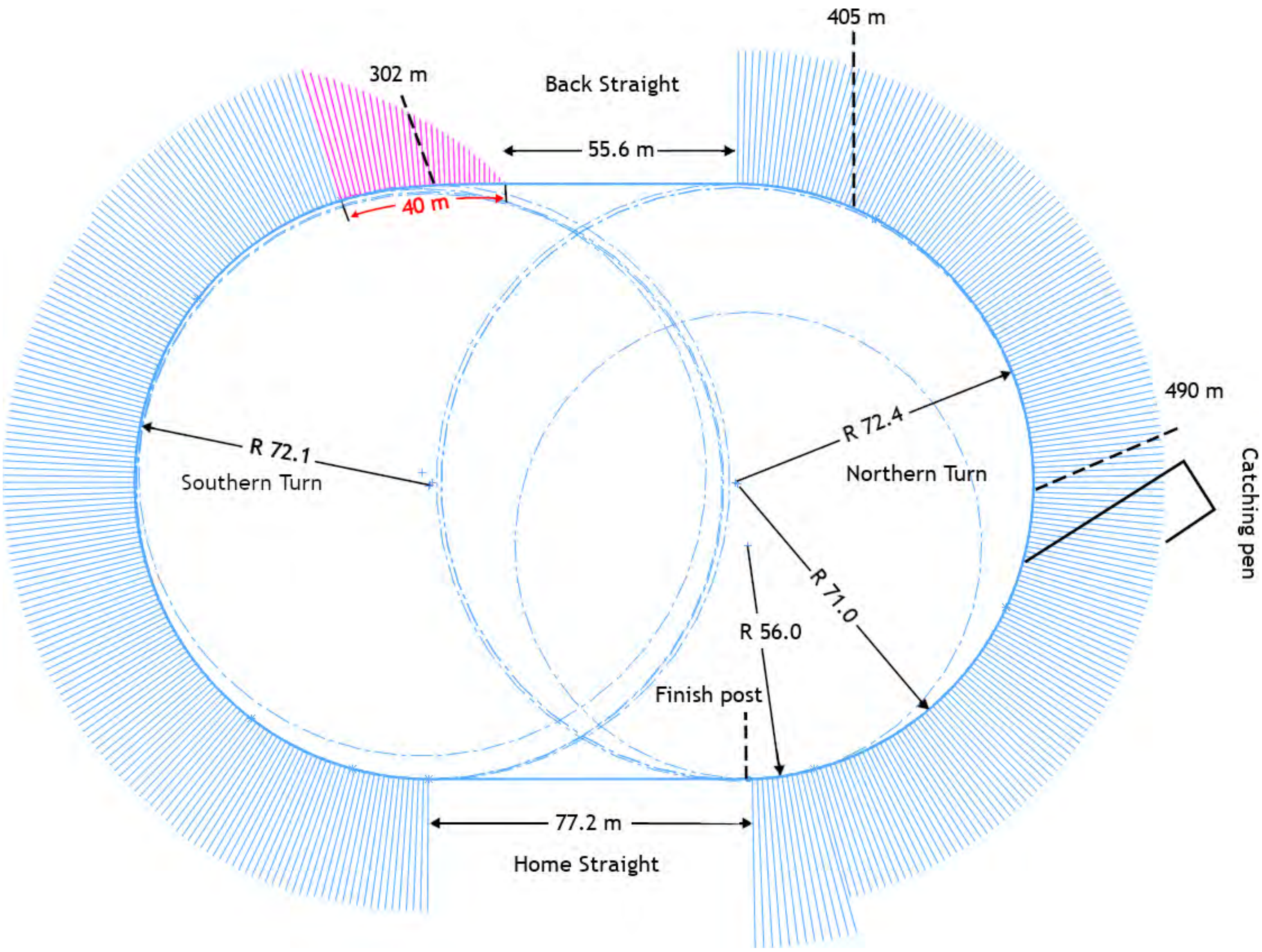


Figure 25: The existing Mandurah greyhound track curvature line plot. The lengths of the perpendicular blue lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail. This plot also depicts the transition (with red curvature lines) between the Back Straight and the entrance to the Southern Turn. More importantly, it depicts the lack of any meaningful transitions into or out of the Northern Turn and out of the Southern Turn. Source: DA survey plan photo (see Figure 22).

The curvature data for 302 m, 405 m and 490 m starting distances versus track distance measured from the respective starting boxes for the Mandurah track are given in Figure 26.

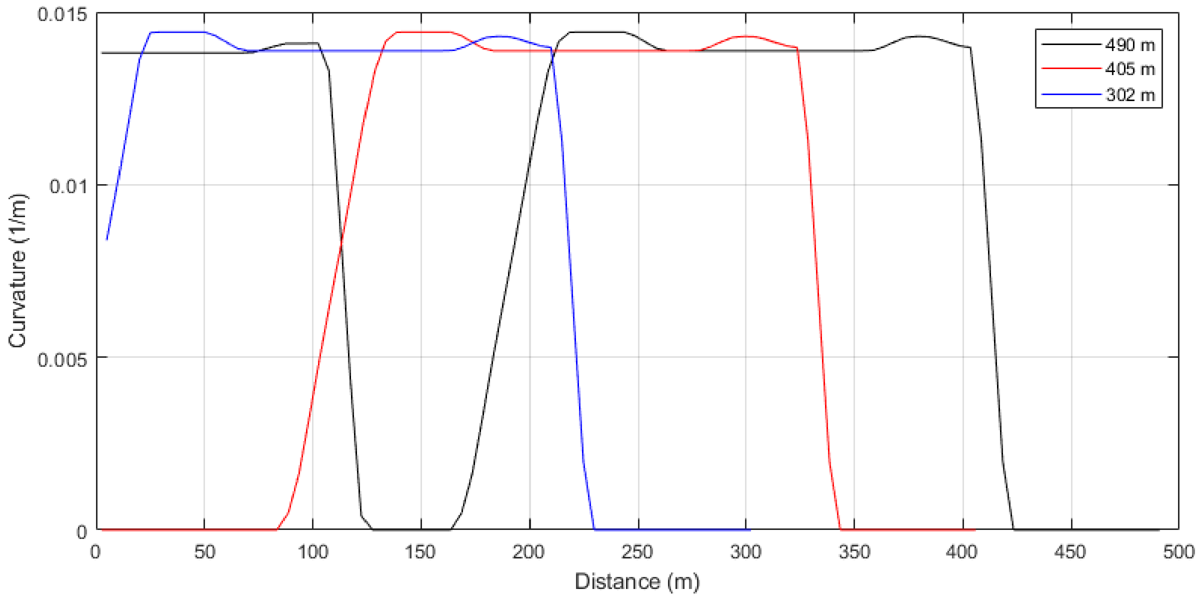


Figure 26: The curvature data for 302 m, 405 m and 490 m starting distances at Mandurah track. The plots commence at the respective Starting Boxes and end at the Finish Post.

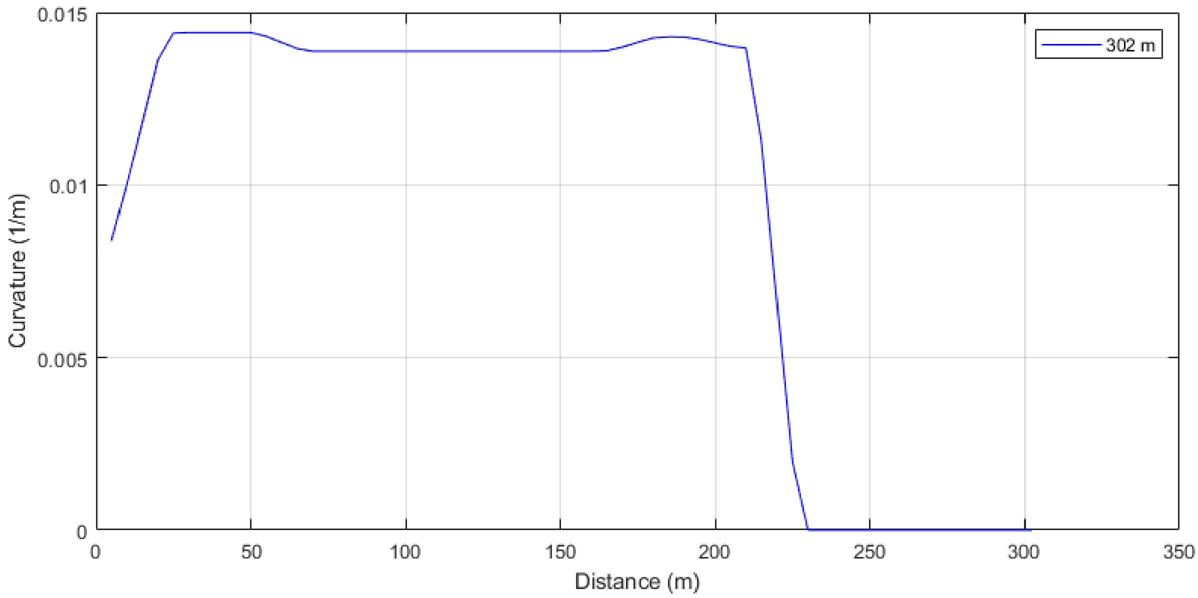


Figure 27: The curvature data for 302 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

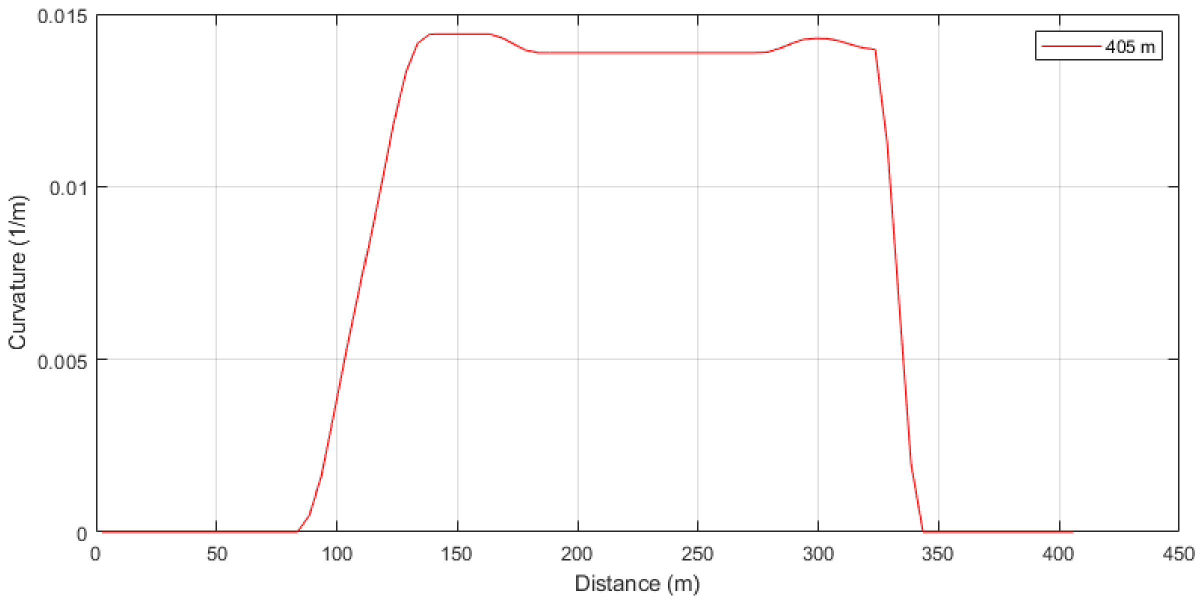


Figure 28: The curvature data for 405 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

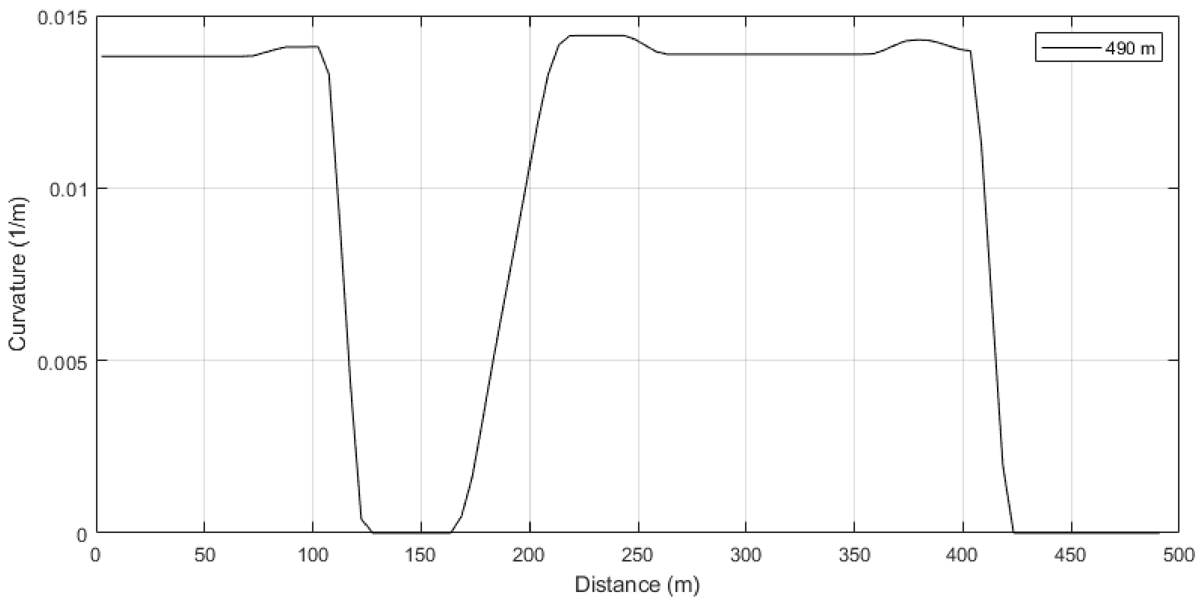


Figure 29: The curvature data for 490 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

2.5.4 Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration (m/s^2) for 302 m, 405 m and 490 m starting distances versus track distance (m) measured from the respective starting boxes for the Mandurah track is given in Figure 30. Figures 31 to 33 contain the centrifugal acceleration data for each individual starting distance for the Mandurah greyhound track.

Although the initial centrifugal acceleration calculated for 405 m is the lowest among all distances, it increases sharply and reaches a peak as greyhounds approach the first bend. The 490 m distance has the highest initial acceleration which reduces as the race continues. The 302 m distance has the lowest initial centrifugal acceleration which also reduces as the race continues.

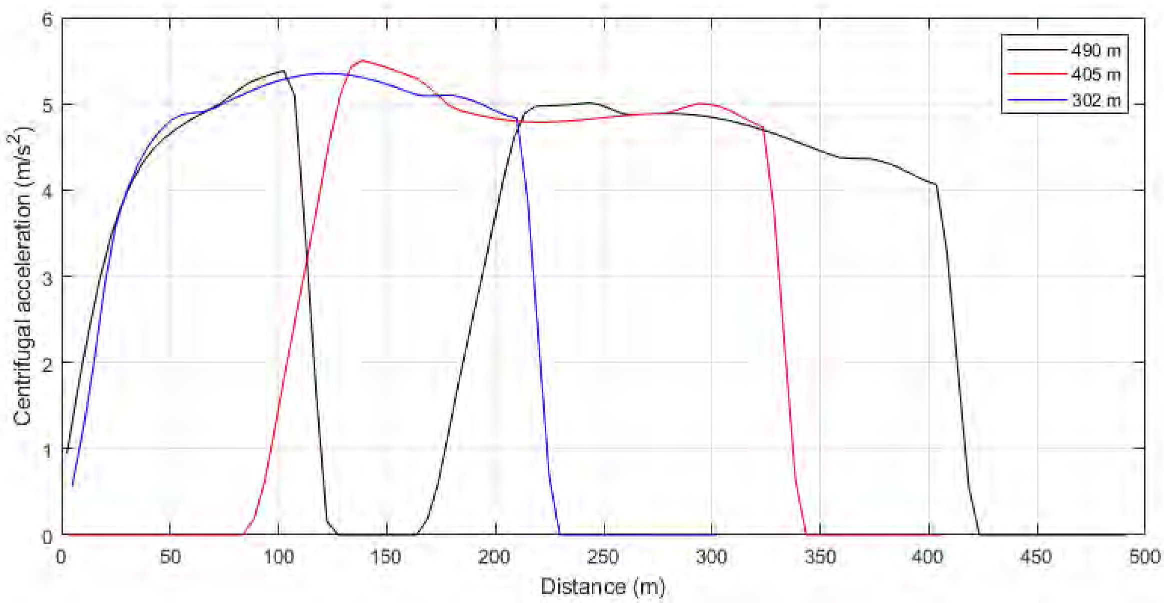


Figure 30: The centrifugal acceleration for 302 m, 405 m and 490 m starting distances at Mandurah track. The plots commence at the respective Starting Boxes and end at the Finish Post.

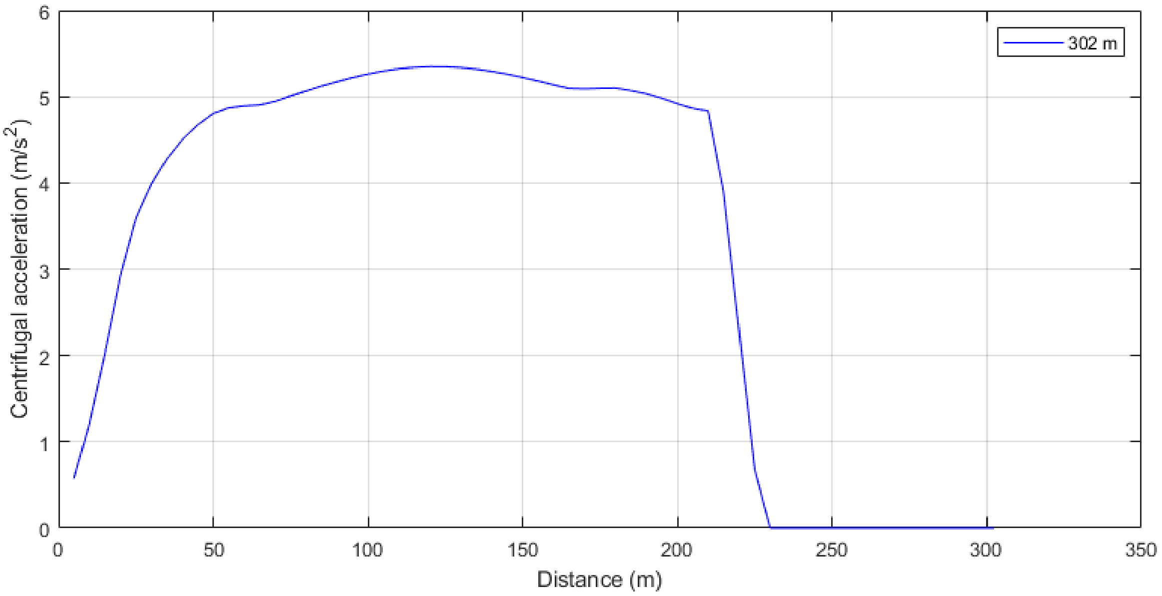


Figure 31: The centrifugal acceleration for 302 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

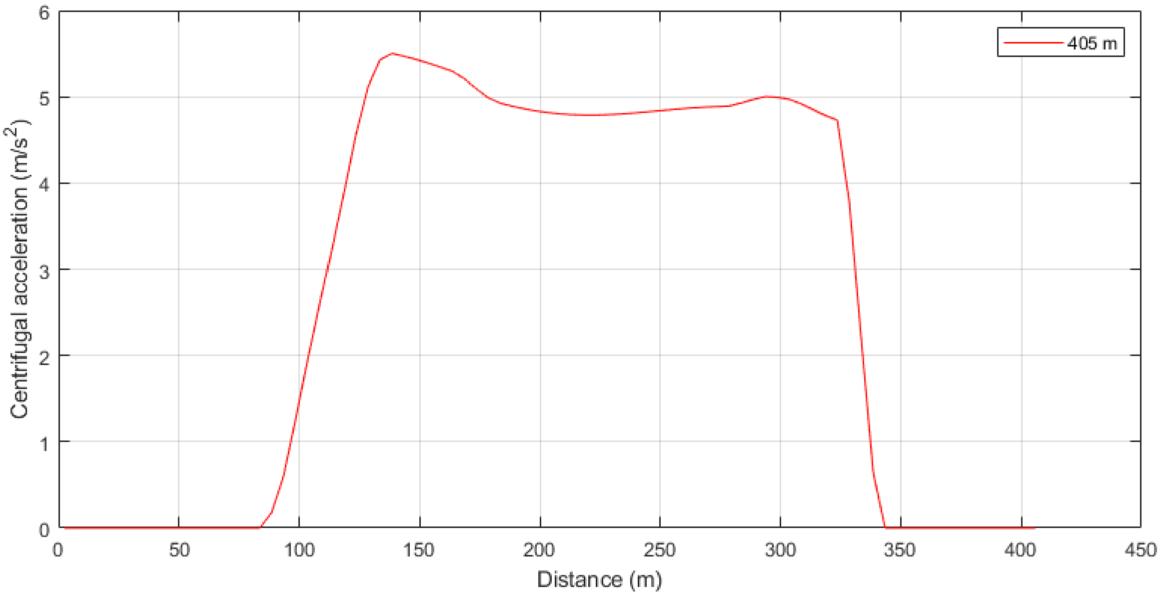


Figure 32: The centrifugal acceleration for 405 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

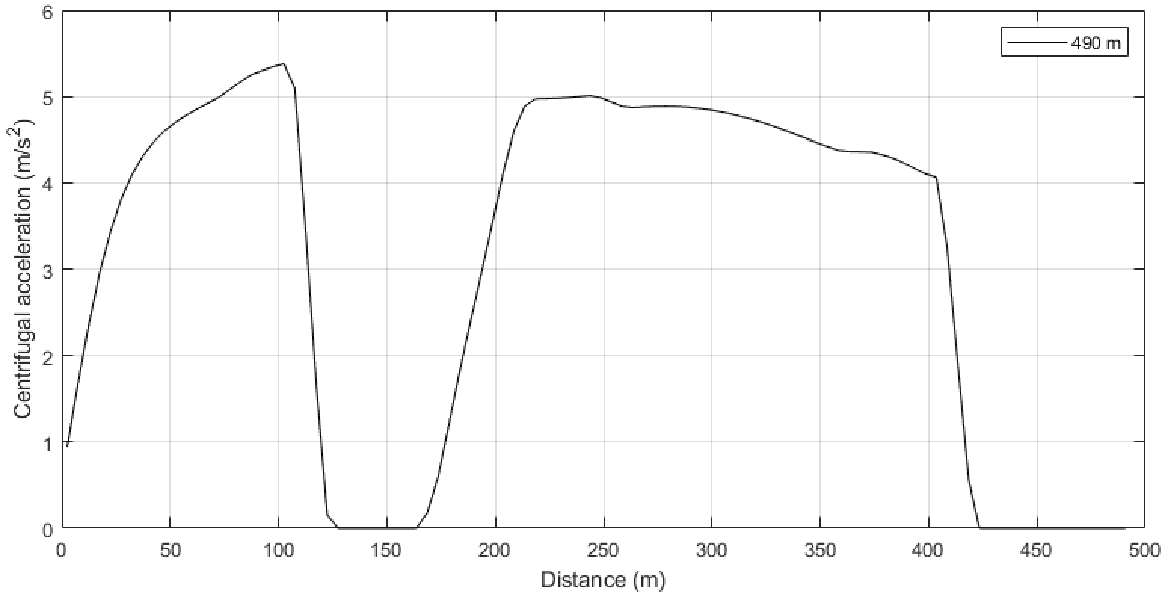


Figure 33: The centrifugal acceleration for 490 m starting distance at Mandurah track. The plot commences at the Starting Box and ends at the Finish Post.

2.5.5 Jerk for each starting distance

The jerk for 302 m, 405 m and 490 m starting distances versus track distance measured from the respective starting boxes for the Mandurah track is given in Figure 34. Figures 35 to 37 contain the jerk data for each individual starting distance for the Mandurah greyhound track.

The 405 m distance has the lowest jerk with a peak of under 3 m/s^3 immediately after the Starting Boxes and the maximum of approximately –6 m/s^3 at the Southern Turn exit. The magnitude of the calculated jerk for 302 m distance is high at the start suggesting a lack of minimum transition from the Starting Boxes to the Southern Turn. For the same reason (lack of an adequate transition) the calculated jerk$_{max}$ for the 490 m distance is high (over 6 m/s^3).

For all racing distances at the Mandurah greyhound track the jerk$_{max}$ is higher than the minimum recommended value of 4 m/s^3 and well short of the preferred 'greenfield' track design value of 2 m/s^3.

It is recommended that the jerk$_{max}$ values for the Mandurah greyhound track be lowered by the installation of clothoid transitions at each of the four bends.

It is recommended that UTS work with David Allan Consulting Engineering Pty Ltd to design a track shape with optimum transitions so as to reduce the jerk$_{max}$ at the Mandurah greyhound track to reasonably practicable levels for all starting distances.

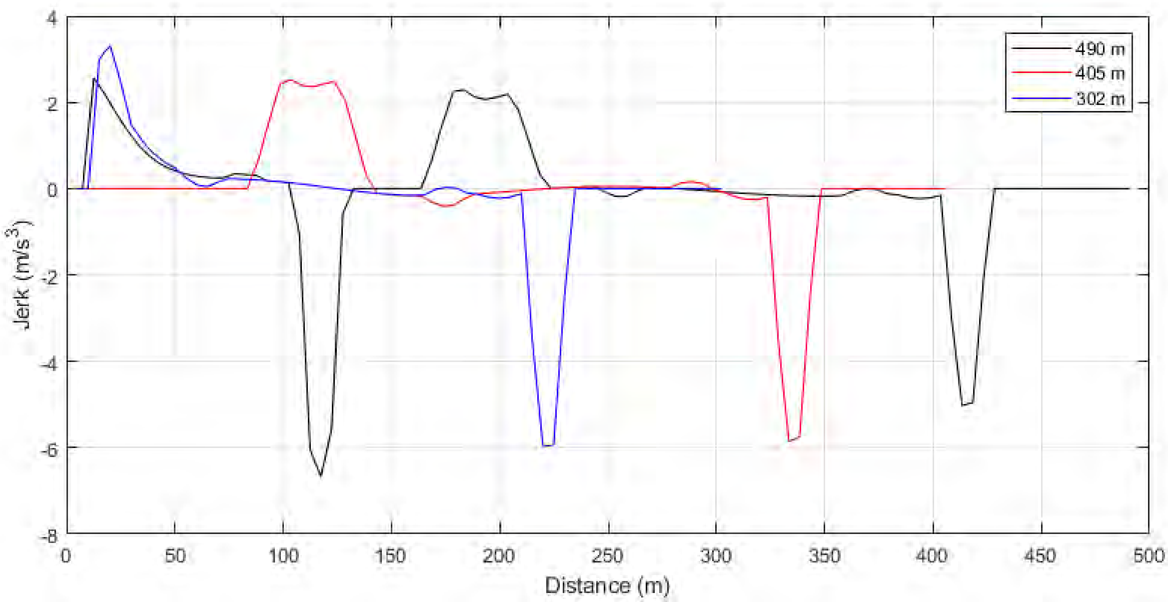


Figure 34: The jerk for 302 m, 405 m and 490 m starting distances at Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

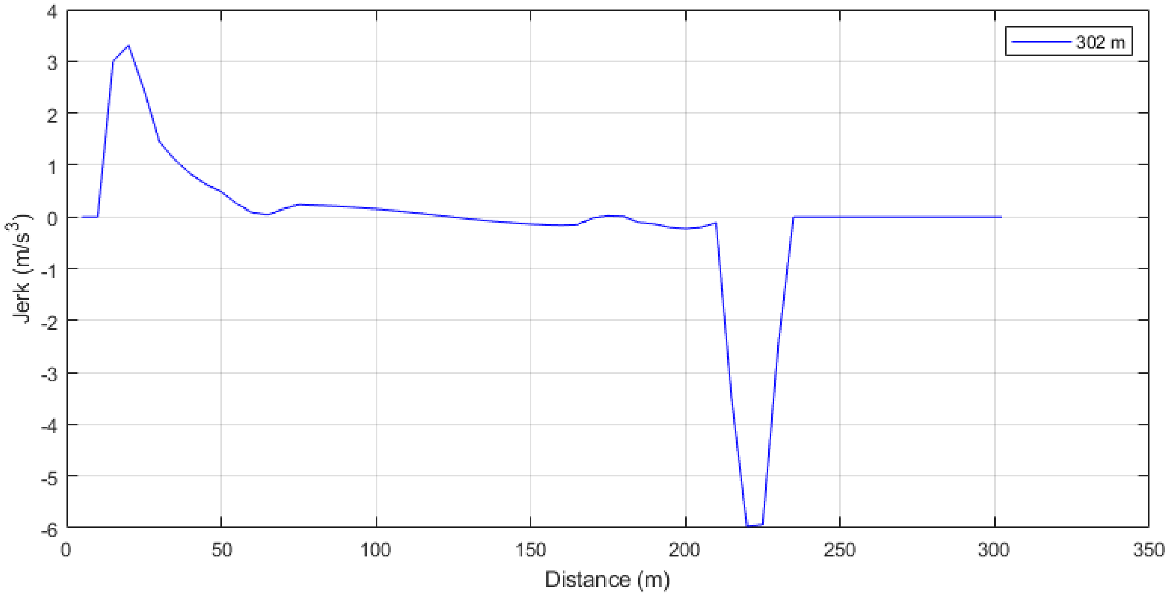


Figure 35: The jerk for 302 m distance at Mandurah greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

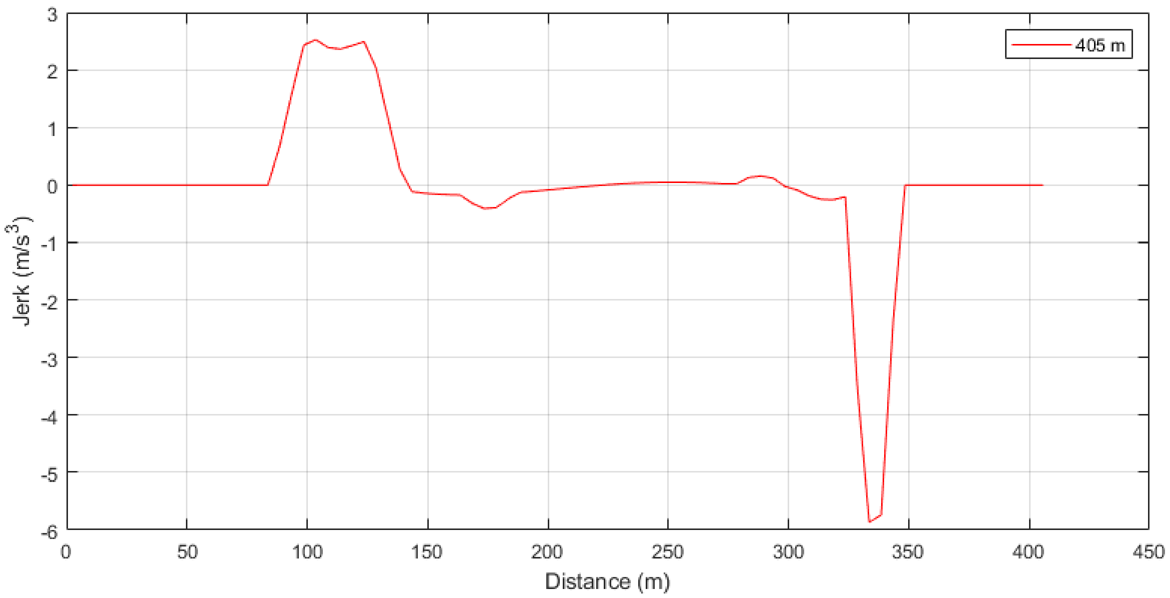


Figure 36: The jerk for 405 m distance at Mandurah greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

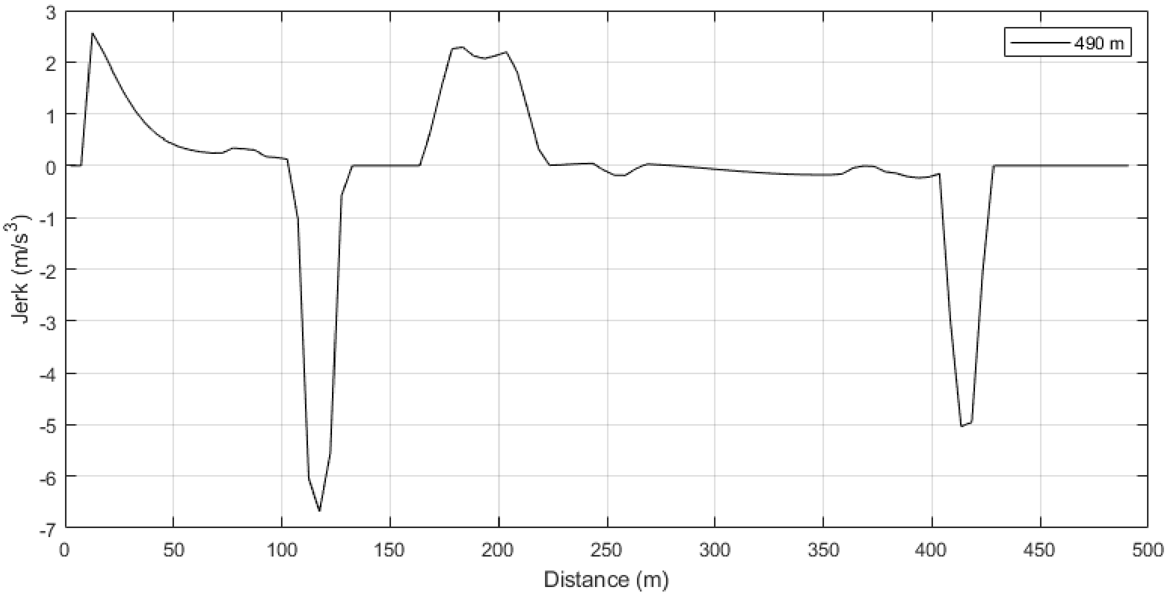


Figure 37: The jerk for 490 m distance at Mandurah greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

2.6 Northam greyhound track

2.6.1 Track shape

Figure 38 is the satellite plan view[11] of the Northam greyhound track.

Figure 38: Northam greyhound track satellite plan view orientated so north is at the top of the plan. Throughout this Report for the Northam greyhound track the end of the track adjacent the 509 m start will be referred to as the Northern Turn. Conversely, the end of the track adjacent the 297 m start and the Catching Pen will be referred to as the Southern Turn (downloaded 28 July 2020).

Northam greyhound track satellite plan view orientated so north is at the top of the plan. Throughout this Report for the Northam greyhound track the end of the track adjacent the 509 m start will be referred to as the Northern Turn. Conversely, the end of the track adjacent the 297 m start and the Catching Pen will be referred to as the Southern Turn (downloaded 28 July 2020).

[11] The use of satellite imagery introduced errors into the calculations contained herein. If RWWA intend to retain the Northam greyhound track is recommended they arrange for this track to be surveyed so that future analysis by UTS is conducted using this survey data.

2.6.2 Track surface cross-fall

Figure 39 is a plan view with the cross-falls at 10 m intervals marked for the Northam greyhound track.

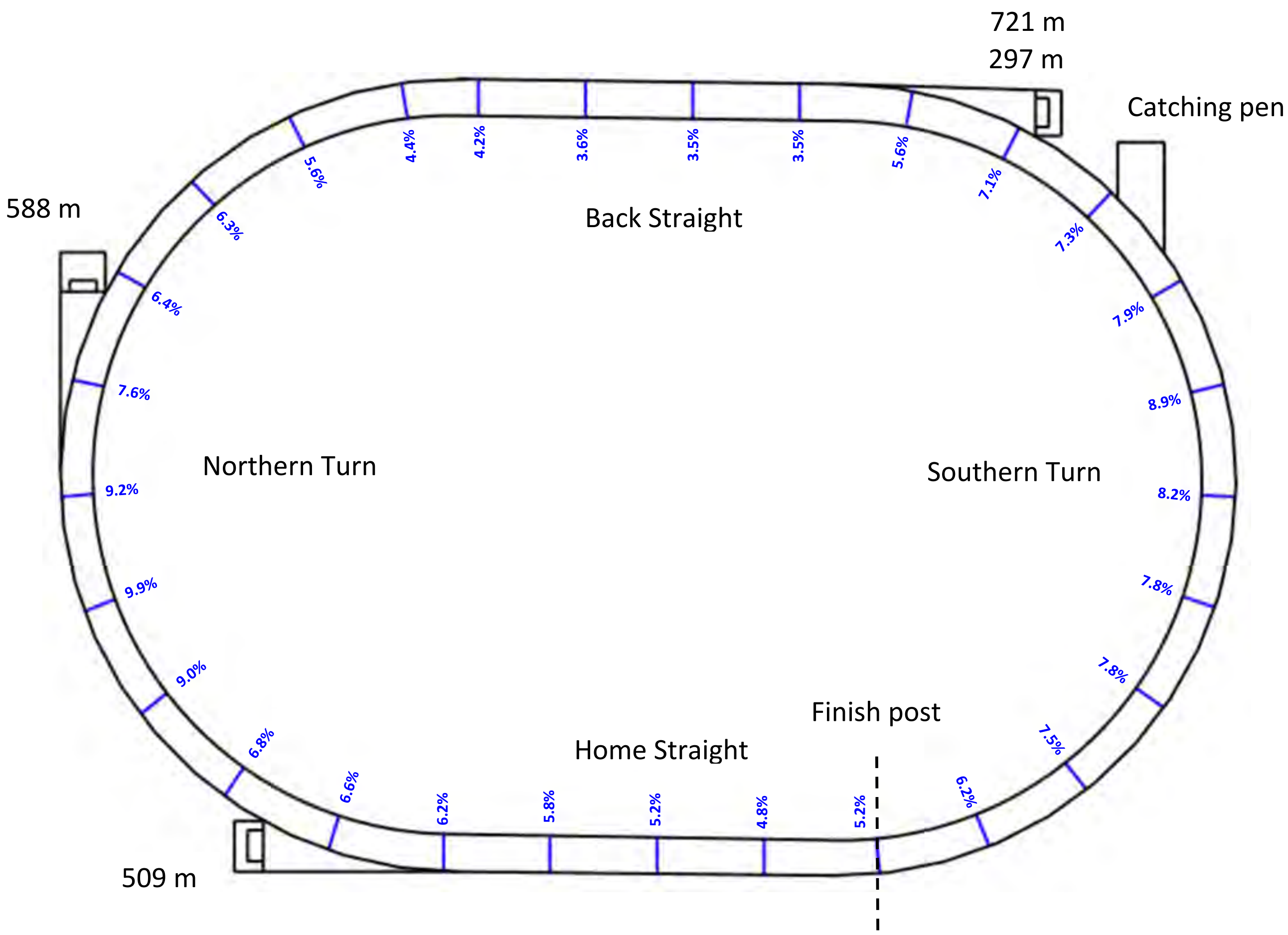


Figure 39: Northam greyhound track cross-falls as of 13 May 2020.

The Northam greyhound track cross-fall readings confirm the following:

- *Home Straight*

  The track surface cross-fall on the Home Straight steadily decreases from 6.2% to 4.8% along its length.

  UTS recommend 5.5% cross-fall along the Home Straight.

  UTS also recommend track surface transitions of no less than 25 m at either end of the Home Straight.

- *Southern Turn*

  The track surface cross-fall on the Northern Turn builds up to 8.9% just beyond the apex of the turn, thereafter it steadily reduces.

  UTS recommend a constant 8.5% cross-fall for the entire Northern Turn.

- *Back Straight*

  The track surface cross-fall on the Back Straight is approximately 3.5%.

  UTS recommend 5.5% cross-fall along the Back Straight.

  UTS also recommend track surface transitions of no less than 25 m at either end of the Back Straight.

- *Northern Turn*

  The track surface cross-fall on the Southern Turn builds up to 9.9% just beyond the apex of the turn, thereafter it steadily reduces.

  UTS recommend a constant 8.5% cross-fall for the entire Southern Turn.

  UTS recommend minimum temporary remediation should include the establishment of inside and out side plinths. These plinths can be traditional concrete plinth or a less expensive timber or steel rail plinth. The establishment of a plinth will allow the track curator to more easily maintain the track and control the effects of sand movement onto and across the track.

Figure 40 is a plan view of the Northam greyhound track depicting the *proposed* cross-falls measured at regular intervals (every tenth lure-rail support post).

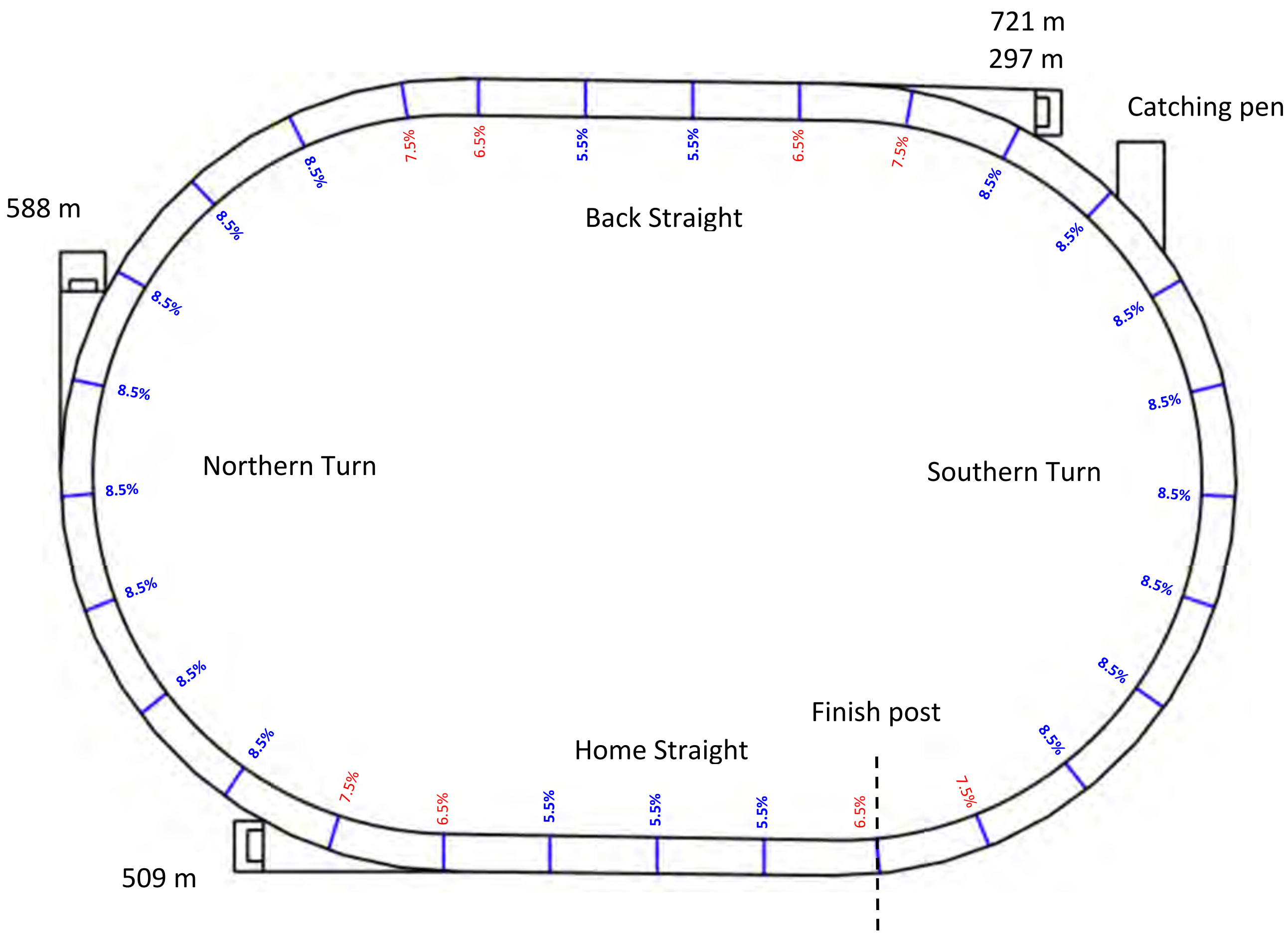


Figure 40: Northam greyhound track *proposed* cross-falls.

To summarise[12], UTS recommend cross-falls of 5.5% for the straights and 8.5% for the turns. UTS also recommend connecting these with the transitions with a length no less than 25 m. These transitions are highlighted in red within Figure 40.

[12]The recommended cross-falls will need to be confirmed on-site as the RL of the starting box plinths are a limiting constraint and minor adjustments in the cross-falls may need to be made to accommodate these height differences.

2.6.3 Curvature for each starting distance

Northam greyhound track with fundamental track dimensions and the curvature lines[13].

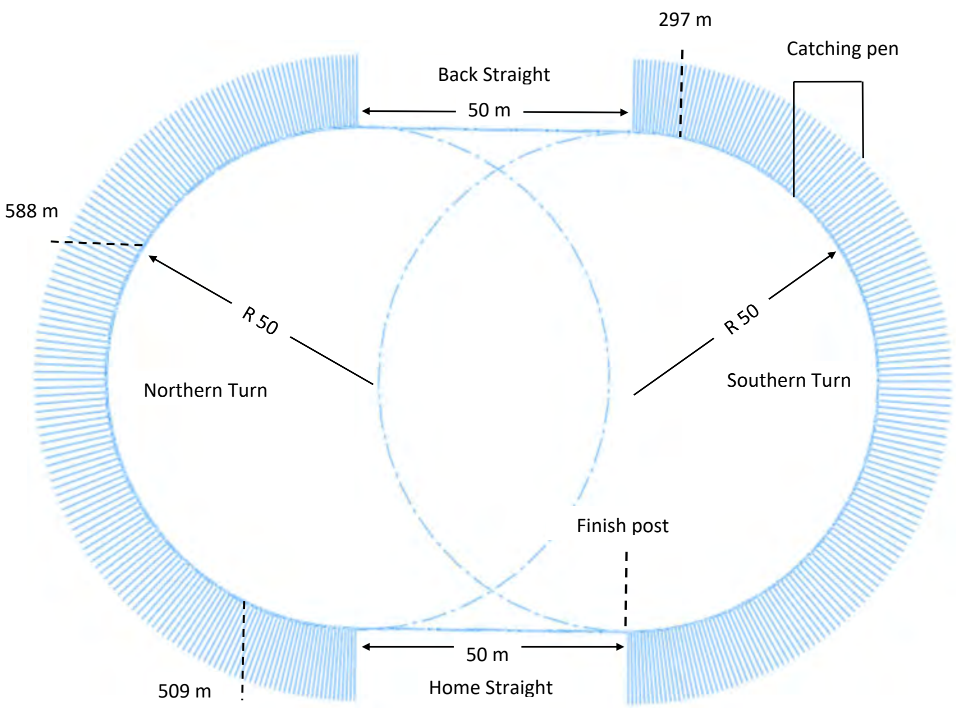


Figure 41: The existing Northam greyhound track curvature line plot. The lengths of the perpendicular blue lines are proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail. This plot visually depicts the lack of any transitions between the two Straights and the two Turns. There are four distinct step changes in the curvature where there ought to be gradual transitions into and out of each turn. Source: Satellite photo (see Figure 38).

The curvature data for 297 m (and 721 m), 509 m and 588 m starting distances versus track distance measured from the respective starting boxes for the Northam track are given in Figure 42.

The curvature data as shown in the graphs indicate the track path is mostly either fully curved or fully straight without any gradual curve development for all race distances.

[13]For comparison Figure 41 should be compared with Figure 5 which has track curvature transitions with a minimum length of 35 m.

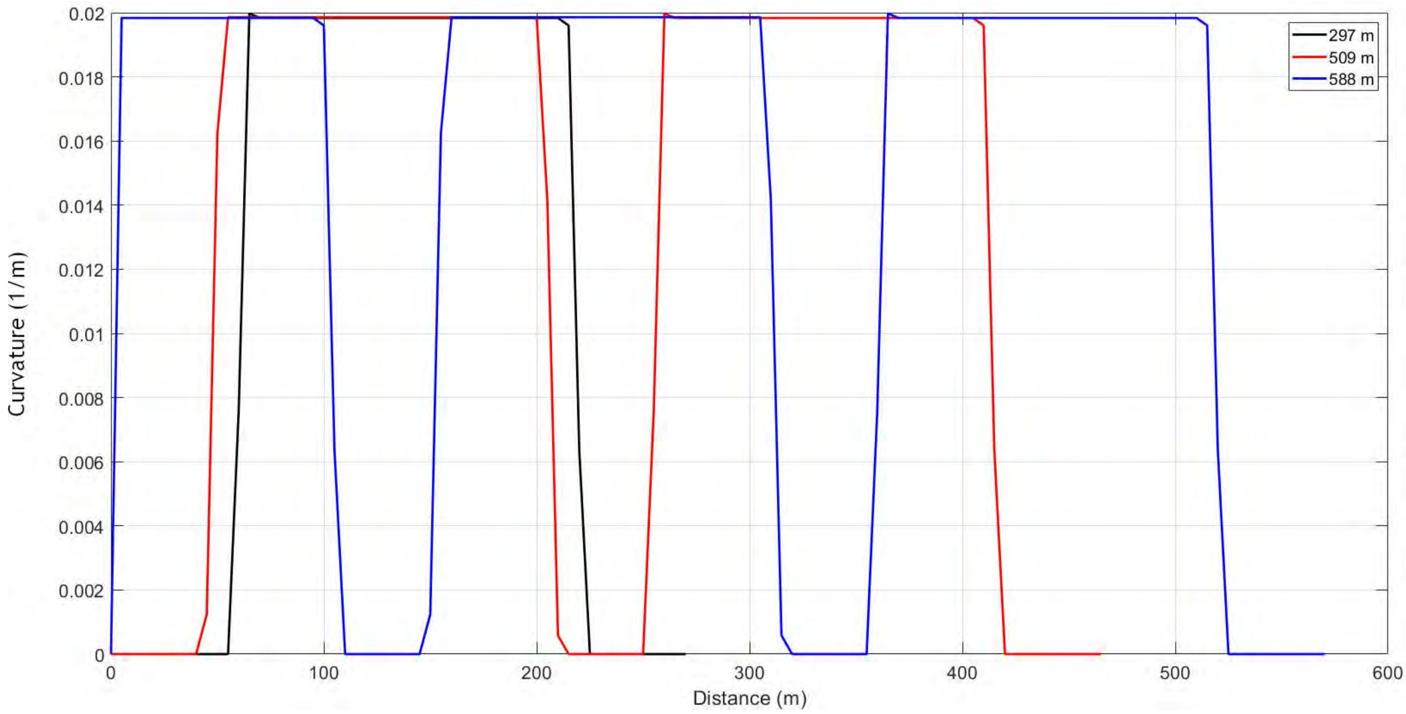


Figure 42: The curvature data for 297 m, 509 m and 588 m starting distances at Northam track. The plots commence at the respective Starting Boxes and end at the Finish Post.

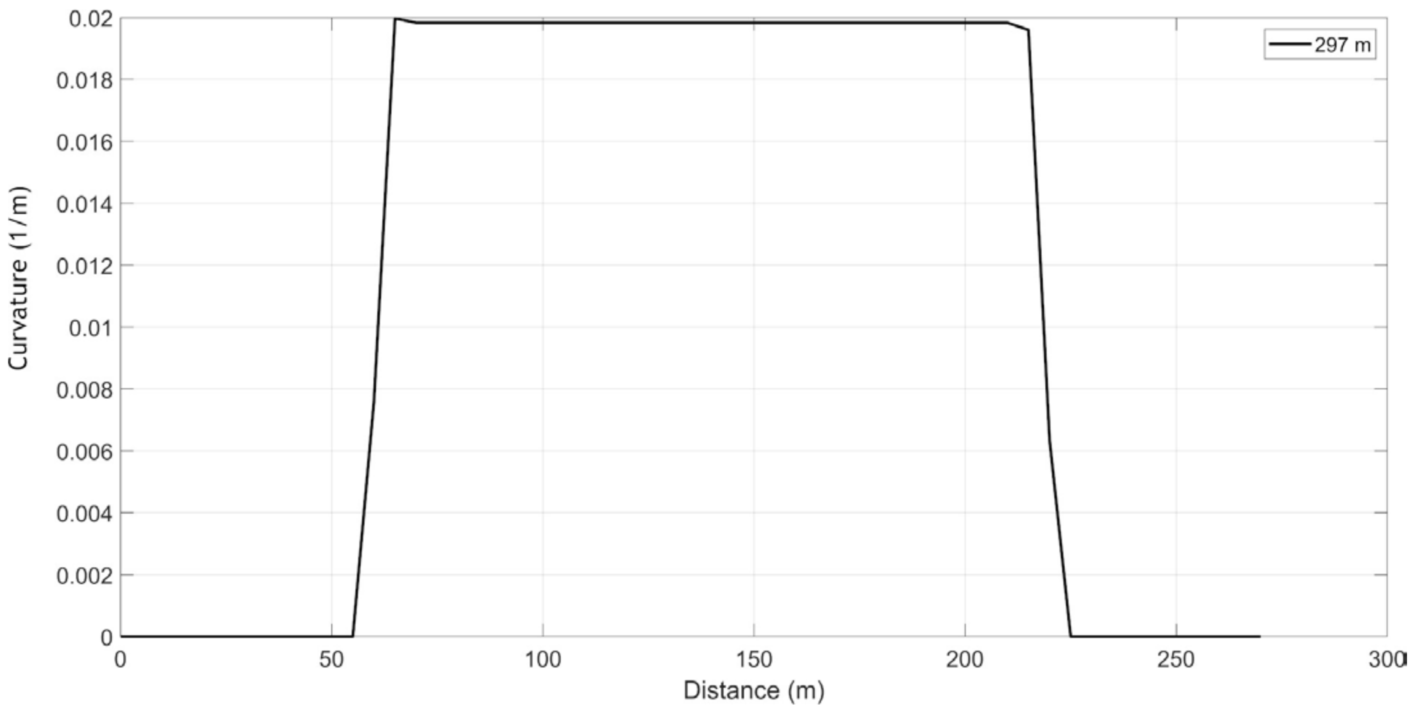


Figure 43: The curvature data for 297 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

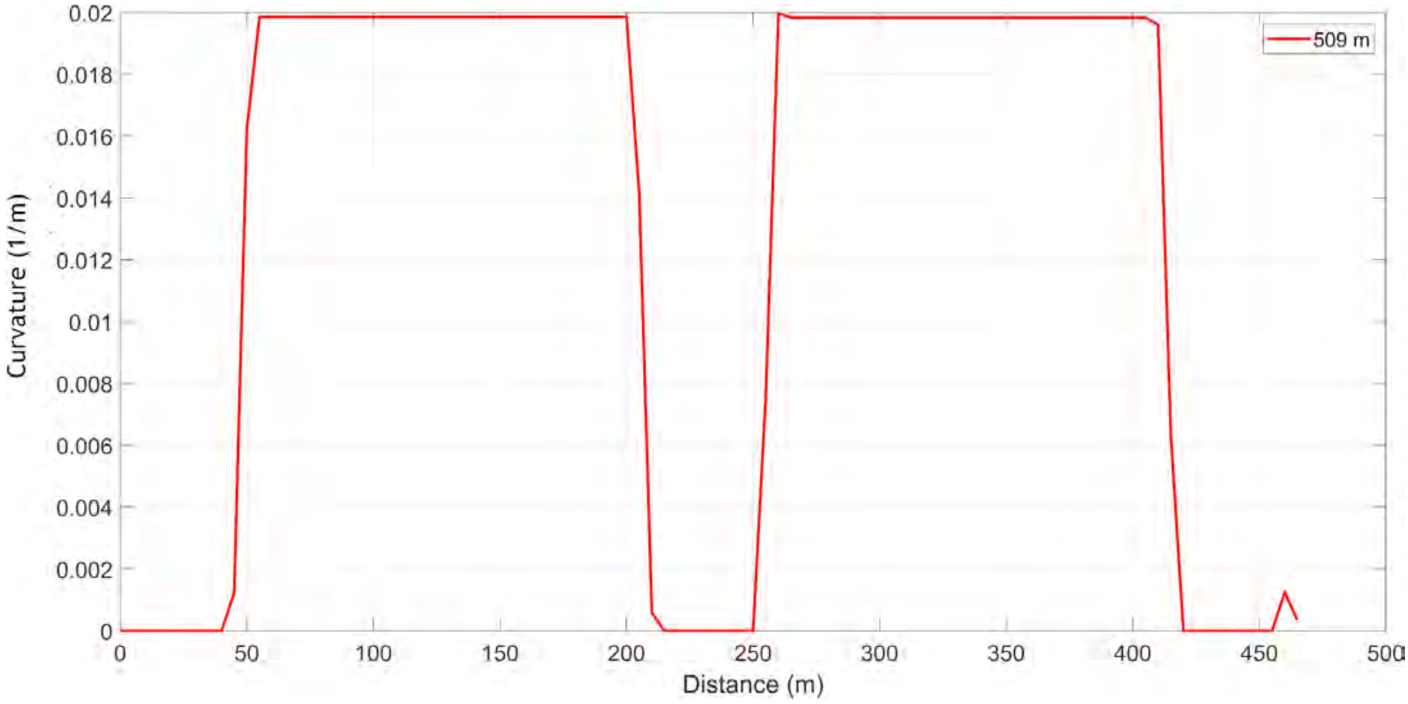


Figure 44: The curvature data for 509 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

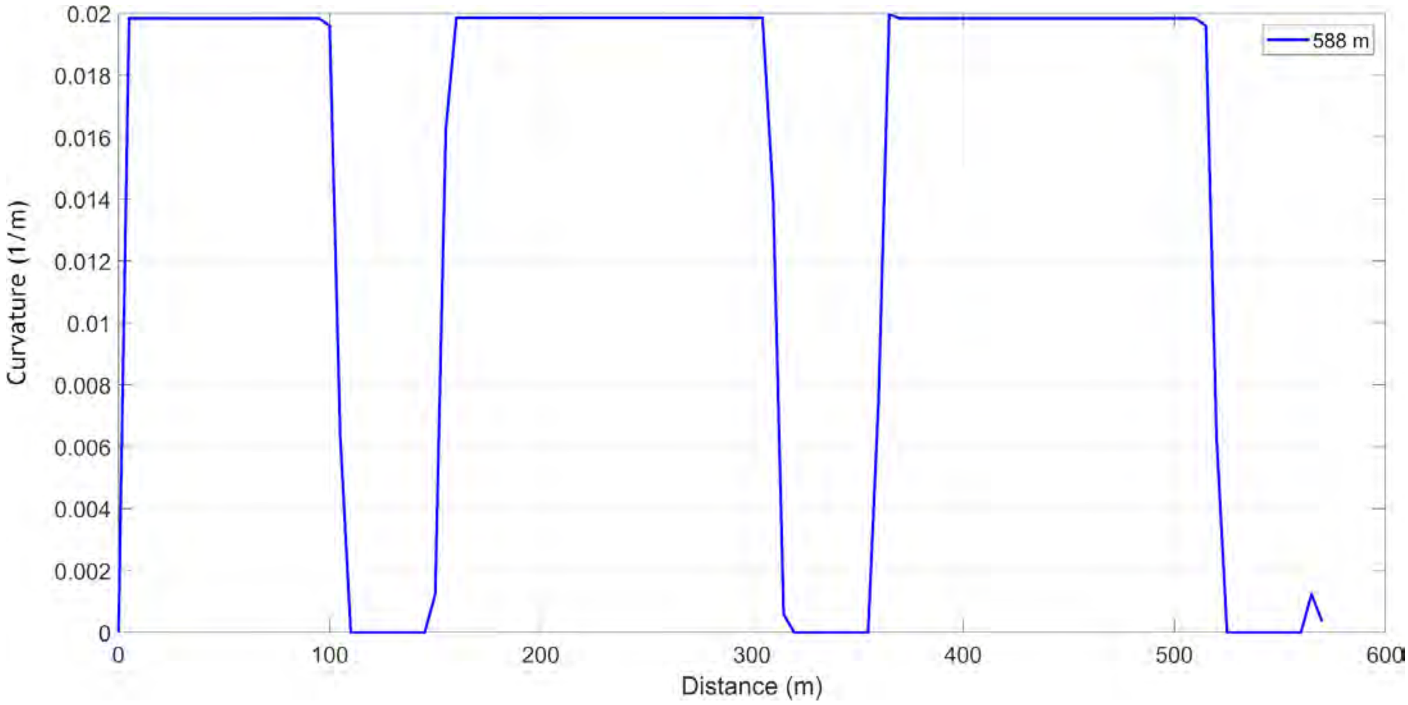


Figure 45: The curvature data for 588 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

2.6.4 Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration (m/s^2) for 297 m (and 721 m), 509 m and 588 m starting distances versus track distance (m) measured from the respective starting boxes for the Northam track is given in Figure 46. Figures 47 to 49 contain the centrifugal acceleration data for each individual starting distance for the Northam greyhound track.

The Northam greyhound track has two tight 50 m turns which result in the greyhounds experiencing elevated levels of centrifugal acceleration.

For all starting distances the greyhounds experience a maximum centrifugal acceleration exceeding 7.5 m/s^2.

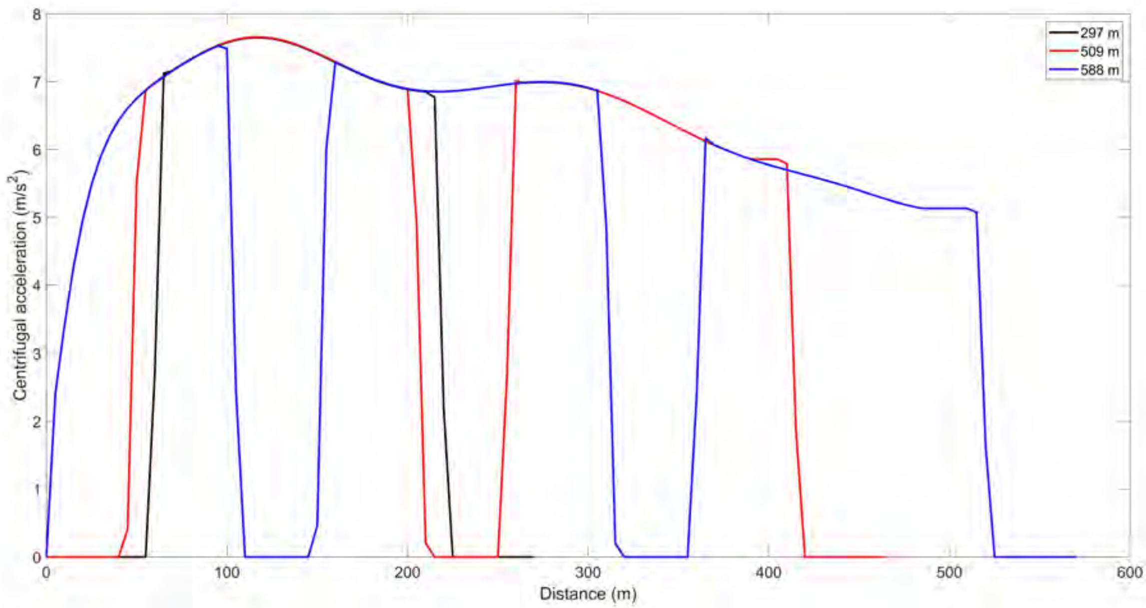


Figure 46: The centrifugal acceleration for 297 m, 509 m and 588 m starting distances at Northam track. The plots commence at the respective Starting Boxes and end at the Finish Post.

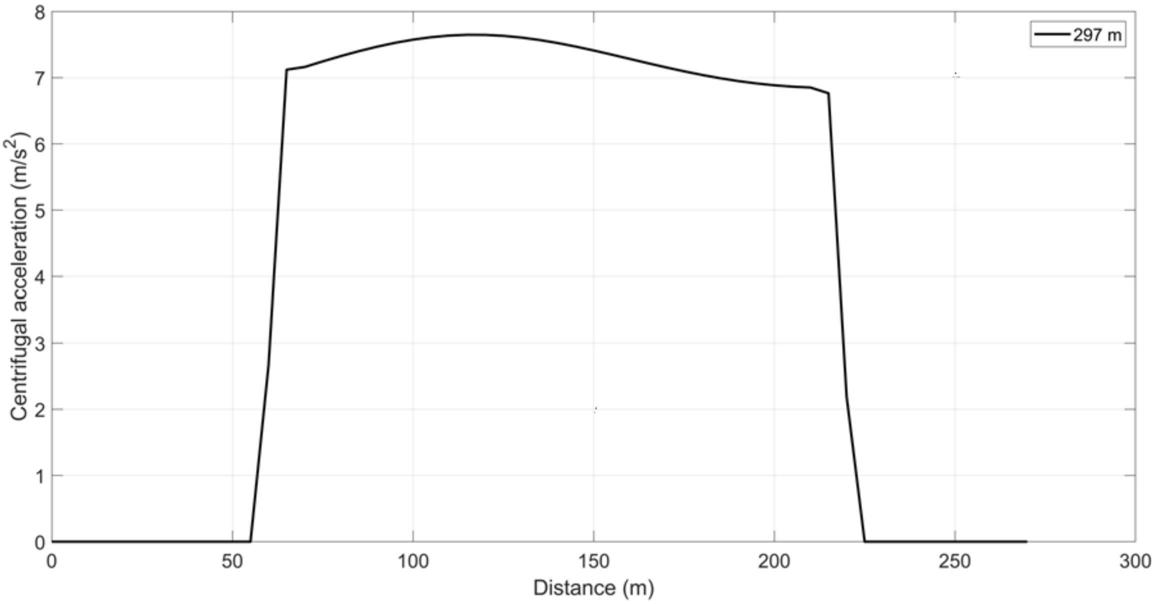


Figure 47: The centrifugal acceleration for 297 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

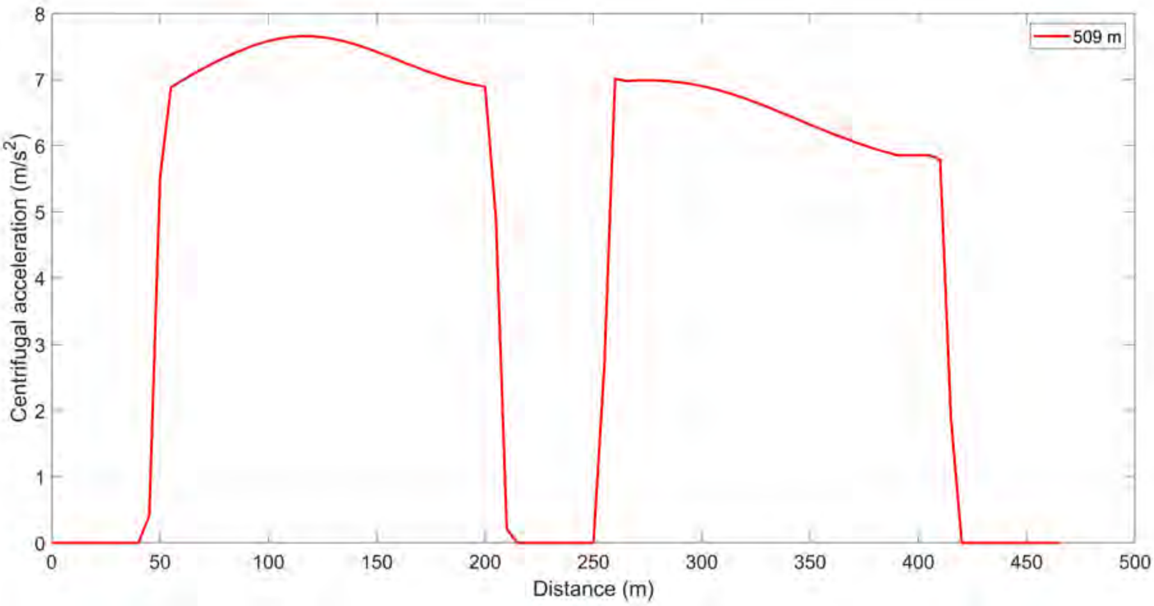


Figure 48: The centrifugal acceleration for 509 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

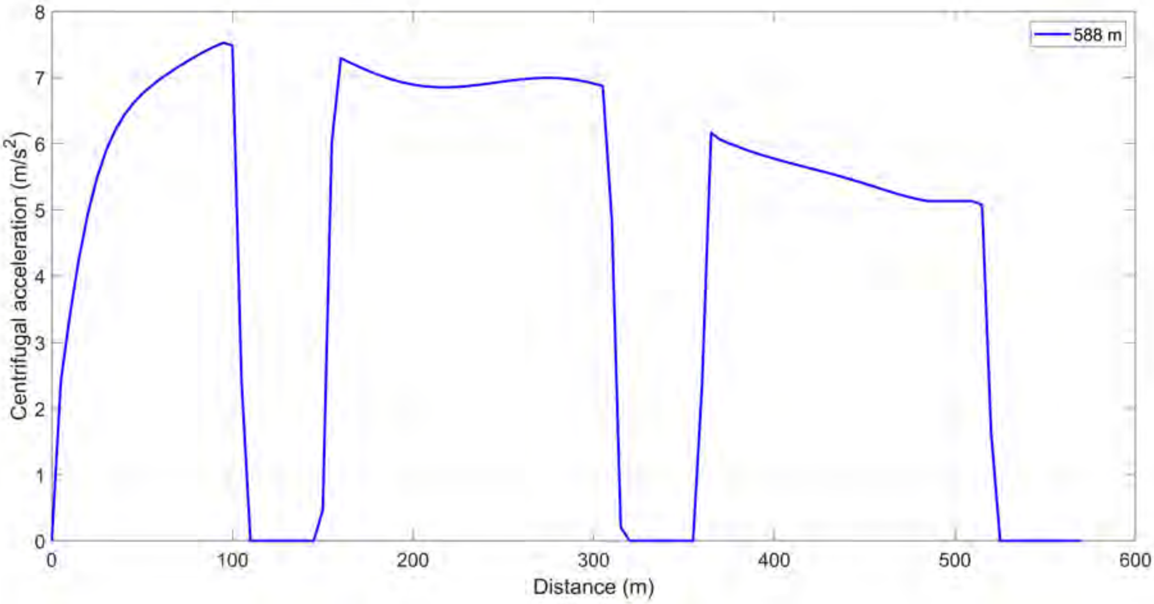


Figure 49: The centrifugal acceleration for 588 m starting distance at Northam track. The plot commences at the Starting Box and ends at the Finish Post.

2.6.5 Jerk for each starting distance

The jerk for 297 m (and 721 m), 509 m and 588 m starting distances versus track distance measured from the respective starting boxes for the Northam track is given in Figure 50. Figures 51 to 53 contain the jerk data for each individual starting distance for the Mandurah greyhound track.

The jerk plots show that the Northam greyhound track path lacks any track curvature transition which manifests as extremely high and unacceptable jerk values for all starting distances regardless of starting distance location.

$Jerk_{max}$ exceeding 10 m/s^3 are unacceptable as they subject the greyhound to an unacceptable level of risk. To lower the $Jerk_{max}$ is it recommended that four transition bends are installed between the semicircles and the straights.

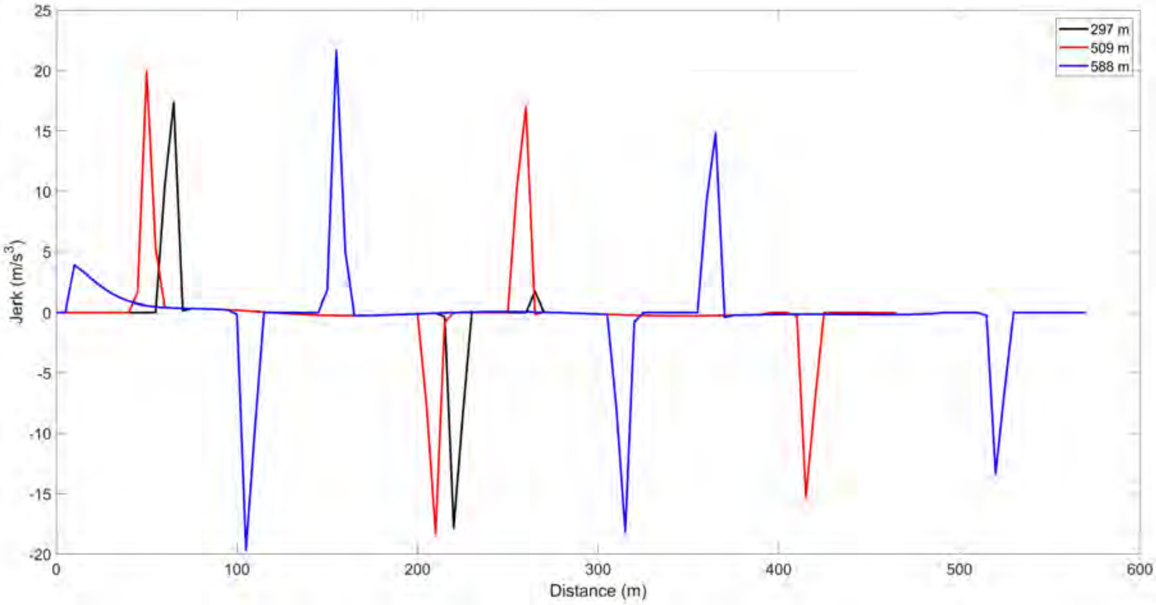


Figure 50: The jerk for 297 m, 509 m and 588 m starting distances at Northam greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

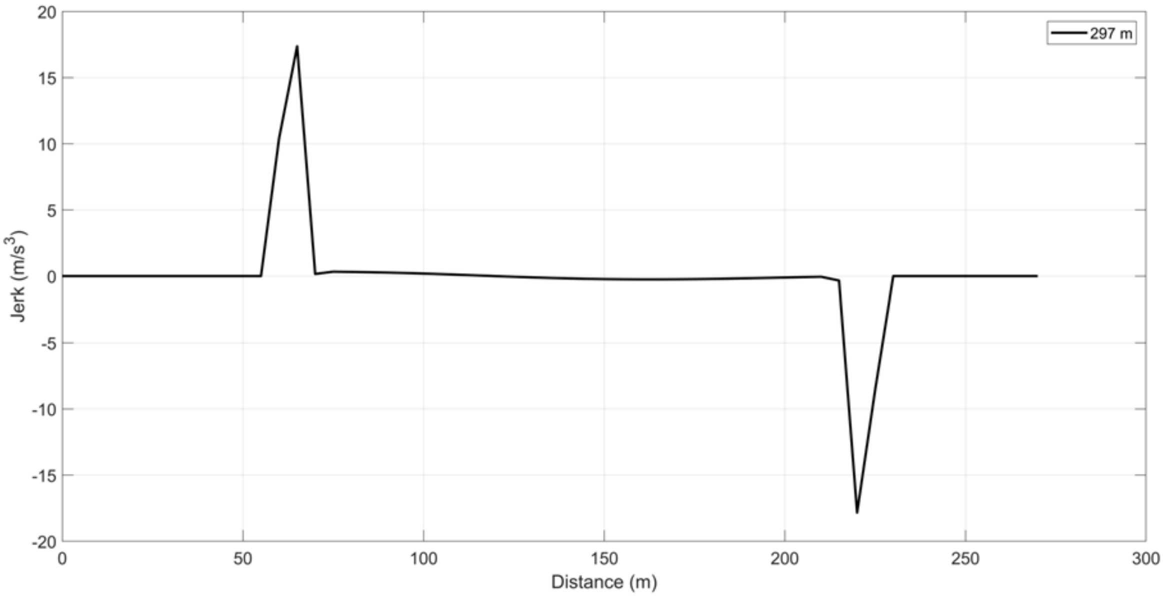


Figure 51: The jerk for 297 m starting distance at Northam greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

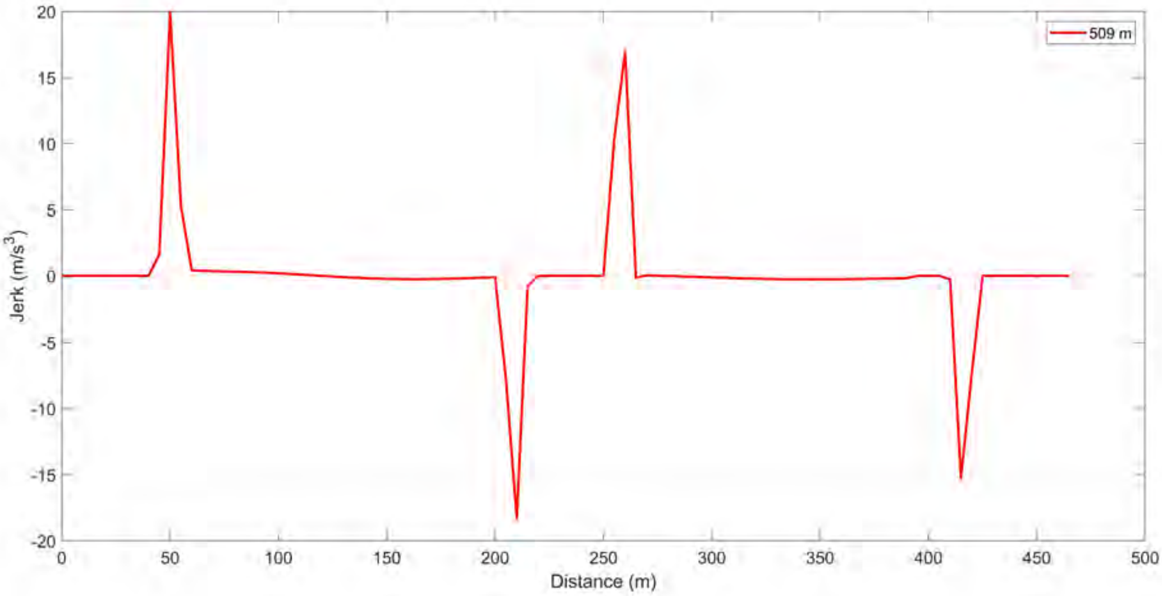


Figure 52: The jerk for 509 m starting distance at Northam greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

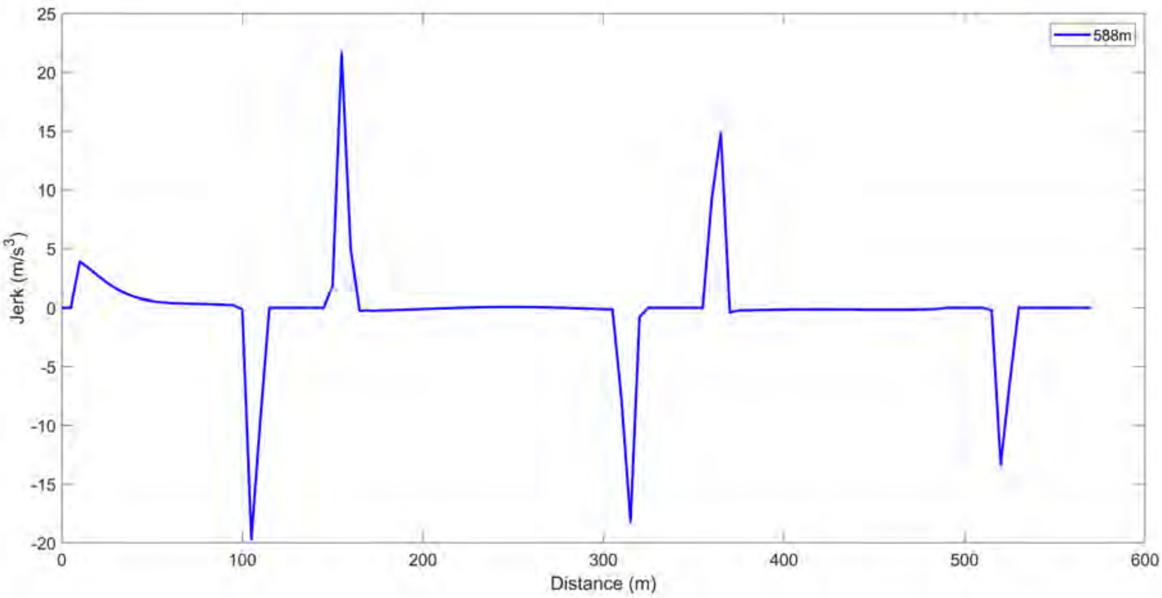


Figure 53: The jerk for 588 m starting distance at Northam greyhound track. The plot commences at the Starting Box and ends at the Finish Post.

3 Review of injury rates

3.1 Injury rates from 1 January 2016 to 30 June 2020

UTS was provided with the racing injury data for the Mandurah, Cannington and Northam greyhound tracks for the period from 1 January 2016 to 30 June 2020. Injury rates for each track are presented quarterly on a track by track basis.

The injury data presented in this report have been *normalised* per 1000 starts. Normalising the injury data allows direct comparison from race to race, meet to meet, track to track and quarter to quarter as it takes account of varying race numbers.

The variations in the quarterly injury rates do not appear to be consistent. This inconsistency suggests that there are multiple factors affecting the injuries. It was expected that relatively higher injury rates would be observed in the hot and dry season (Q1 and Q4). Among a number of factors the hot and dry air results in a higher evaporation rate which can affect the track surface condition.

3.1.1 Cannington greyhound track 28 days or greater stand-down

Figure 54 is a plot of 28 days or greater major injuries at the Cannington greyhound track normalised per 1000 starts presented quarterly over the period of 1 January 2016 to 30 June 2020.

The injury rates over the hotter and drier summer months are generally higher than the cooler wetter winter months during the 18 quarters reviewed.

The two highest rates of injury occurred over the most recent summer period. Another observation is that the highest rates of injury in both Q1 and Q2 belongs to the most recent year.

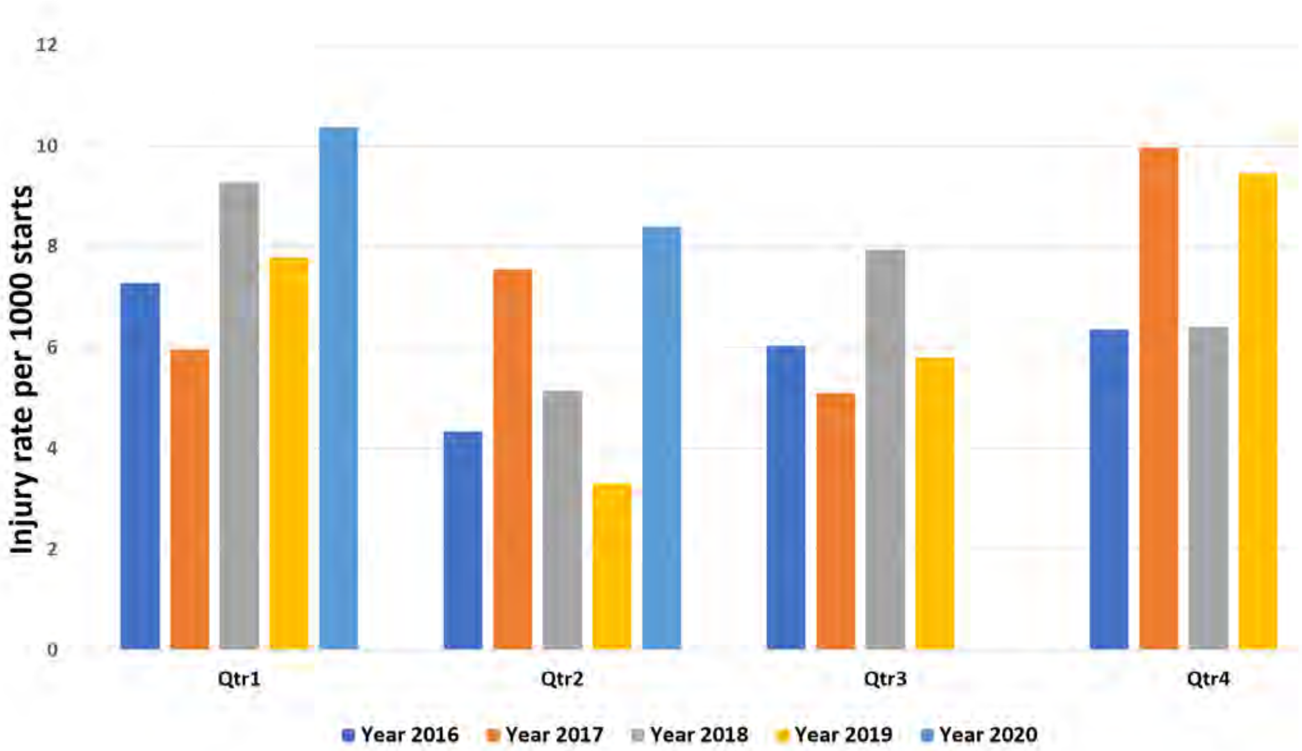


Figure 54: 28 days or greater major injuries at the Cannington greyhound track normalised per 1000 starts presented quarterly over the period of 1 January 2016 to 30 June 2020.

3.1.2 Mandurah greyhound track 28 days or greater stand-down

Figure 55 is a plot of 28 days or greater major injuries at the Mandurah greyhound track normalised per 1000 starts presented quarterly over the period of 1 January 2016 to 30 June 2020.

The first quarter of 2020 (Jan-Mar) and the second quarter of 2019 (Apr-Jun) have the highest injury rate during the 17 quarters reviewed[14].

The high injury rate recorded in the second quarter of 2019 broke the *on average* summer trend. Future research will be directed to understanding the underlying causes of the increased injury rate within the second quarter of 2019 so that systems and procedures can be put in place to ensure these circumstances are not repeated.

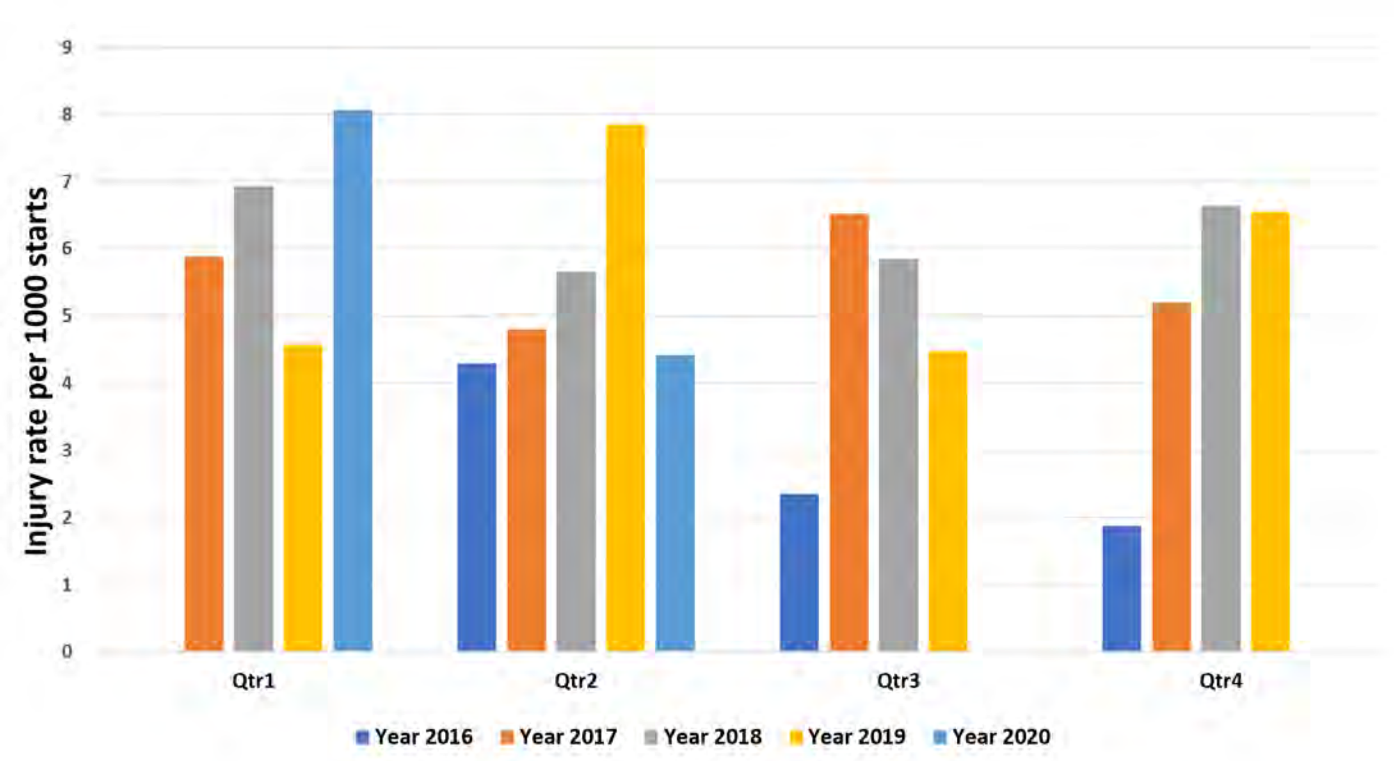


Figure 55: 28 days or greater major injuries at the Mandurah greyhound track normalised per 1000 starts presented quarterly over period of 1 January 2016 to 30 June 2020.

[14]No injury data was provided for the first quarter of 2016 for the Mandurah greyhound track.

3.1.3 Northam greyhound track 28 days or greater stand-down

Figure 56 is a plot of 28 days or greater stand-down injuries at the Northam greyhound track normalised per 1000 starts presented quarterly over period of 1 January 2016 to 30 June 2020.

The second quarter of 2018 and 2019 recorded the highest injury rate of the 12 quarters reviewed[15].

The high injury rate recorded in the second quarters of 2018 and 2019 broke the *on average* summer trend. It is concerning that the normalised injury rate per 1000 starts exceeded 13 within Q2 2018. The equivalent injury rate at both Cannington and Mandurah was less than 6.

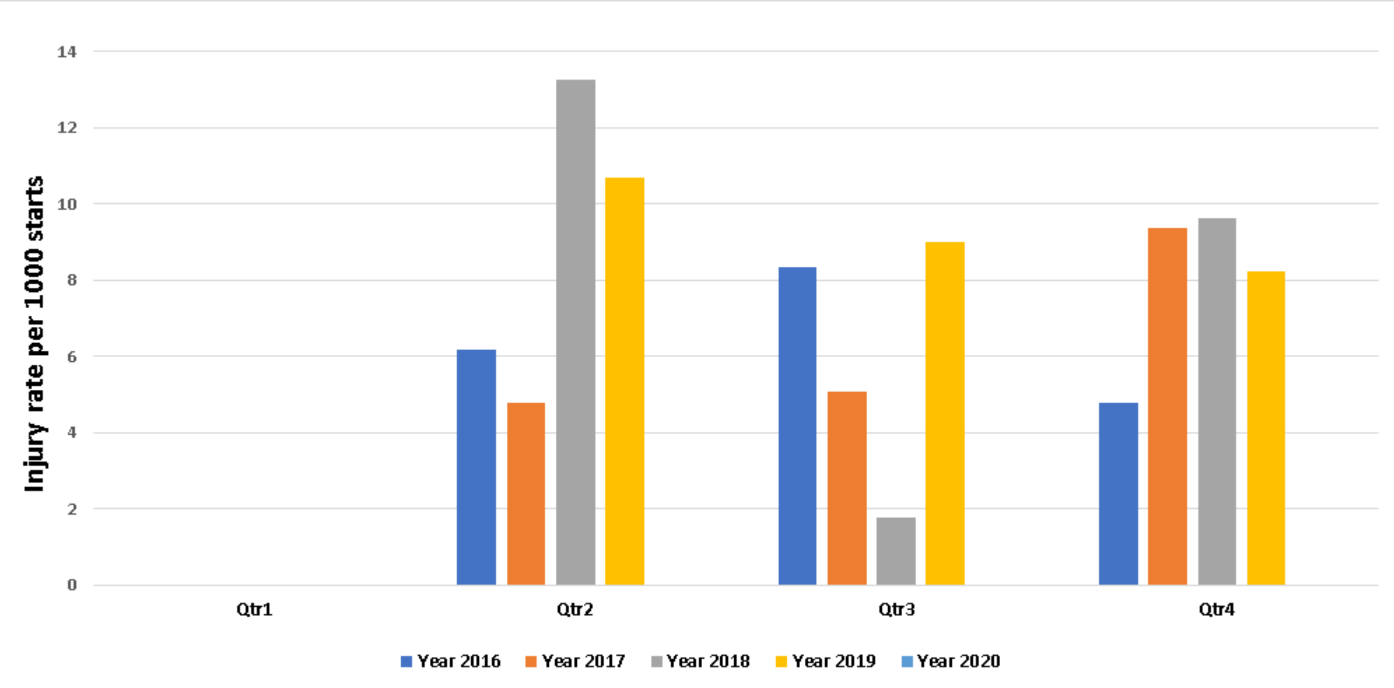


Figure 56: 28 days or greater major injuries of the Northam greyhound track normalised per 1000 starts presented quarterly over period of 1 January 2016 to 30 June 2020.

[15] Racing does not occur at Northam greyhound track over the summer period due to the potential environment stress this could place on the greyhounds. Northam was also closed for racing for 2020.

3.2 RWWA greyhound track incident location *heat maps*

3.2.1 Background

The incident location *heat maps* show the approximate locations on each track for each race distance where clusters of injuries occurred. All the data reported herein is for the first lap with the exception of the injuries that occurred within the catching pens[16]. The diameter of the circle is proportional to the rate of injuries recorded at each specific location.

The plots include data from 1 January 2016 and to 30 June 2020. It is worth noting with *heat maps* that not all injury locations can be mapped. The primary reason for this are the injury was not attributable to the track.

The data included in the plots includes injuries where a stand-down period of 10 days and greater injuries (MED, MAJ and CAT). These injuries range in severity from a Grade 2 muscle injury, joint/ligament sprain, bone fracture to injuries that require the greyhound to be retired or euthanased.

[16]The number of injuries that occurred on the second lap were much less then those on the first lap and were manually omitted for clarify.

3.2.2 Cannington greyhound track incident location *heat maps*

Figure 57 is the injury location *heat map* for the 275 m race distance. During the reporting period there were 8383 starts and 252 injuries were reported for the 275 m race distance. Of the 252 injuries 57 (22%) were recorded with a known track location. The normalised injury rate for Cannington 275 m distance was 30 per 1000 starts. This injury rate is far greater than all the other Cannington greyhound track racing distances. It is recommended that the underlying cause of this high injury rate be identified and appropraite action taken.

The greatest number of injuries (16) occurred on the home straight. The location with the second greatest number of injuries (14) was as the greyhounds entered the first bend. The location with the third greatest number of injuries (13) was as the greyhounds exited the first turn. Other injury locations include: soon after the start (6); catching pen (3); entering the turn after the finish (2); at the finish (1); and back straight (1).

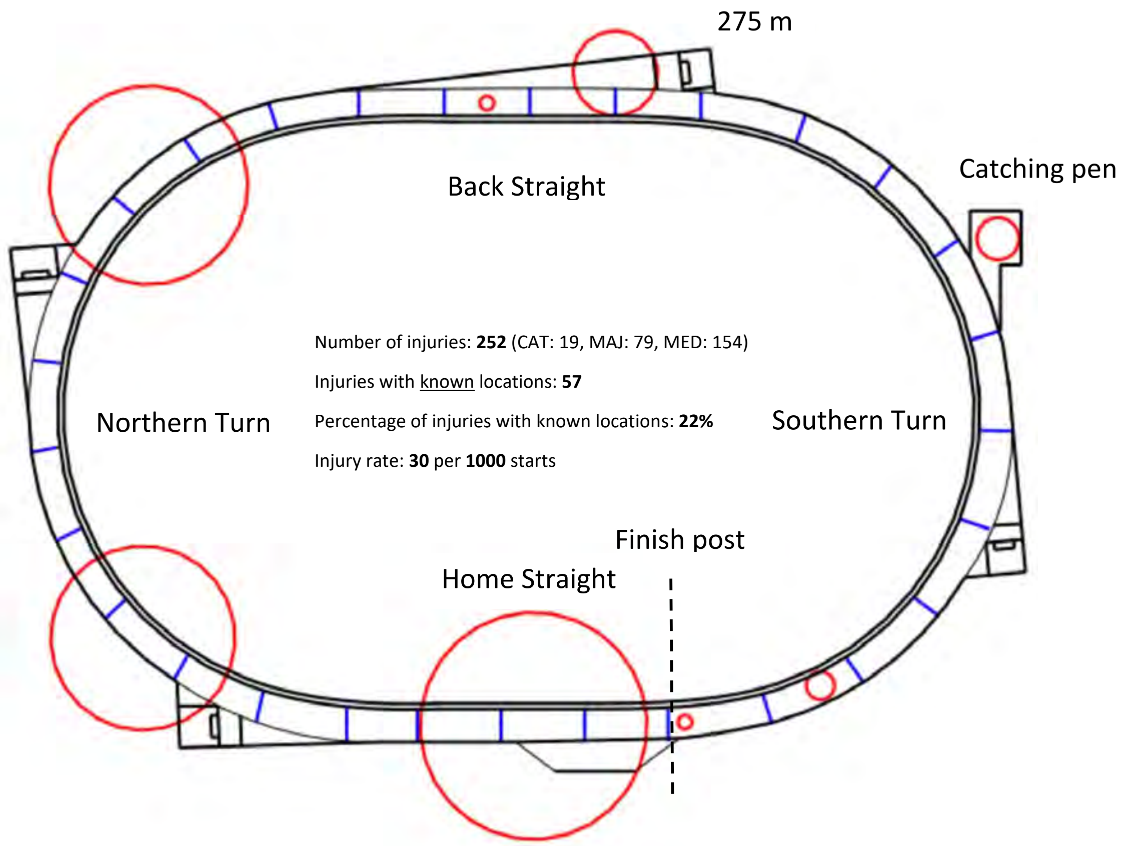


Figure 57: Cannington greyhound track injury location *heat maps* for the 275 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 58 is the injury location *heat map* for the 380 m race distance. During the reporting period there were 16,180 starts and 343 injuries were reported for the 380 m race distance. Of the 343 injuries 140 (41%) were recorded with a known track location. The normalised injury rate for Cannington 380 m distance was 21 per 1000 starts.

The greatest number of injuries (50) occurred soon after the the start being a location which coincides the greyhounds entering the first turn. This *hot spot* occurs where the greyhounds are experiencing their maximum acceleration while also being subjected to congestion and unbalancing forces. Locations where the second greatest number of injuries occurred were turn off back straight (21) and back straight (21). The location with the third greatest number of injuries (19) was as the greyhounds exit the second turn. The location with the fourth greatest number of injuries (18) was as the greyhounds exit the first turn. The location with the fifth greatest number of injuries (8) on the home straight. Other injury locations include: catching pen (1); soon after the finish (1); and entering the turn after the finish (1).

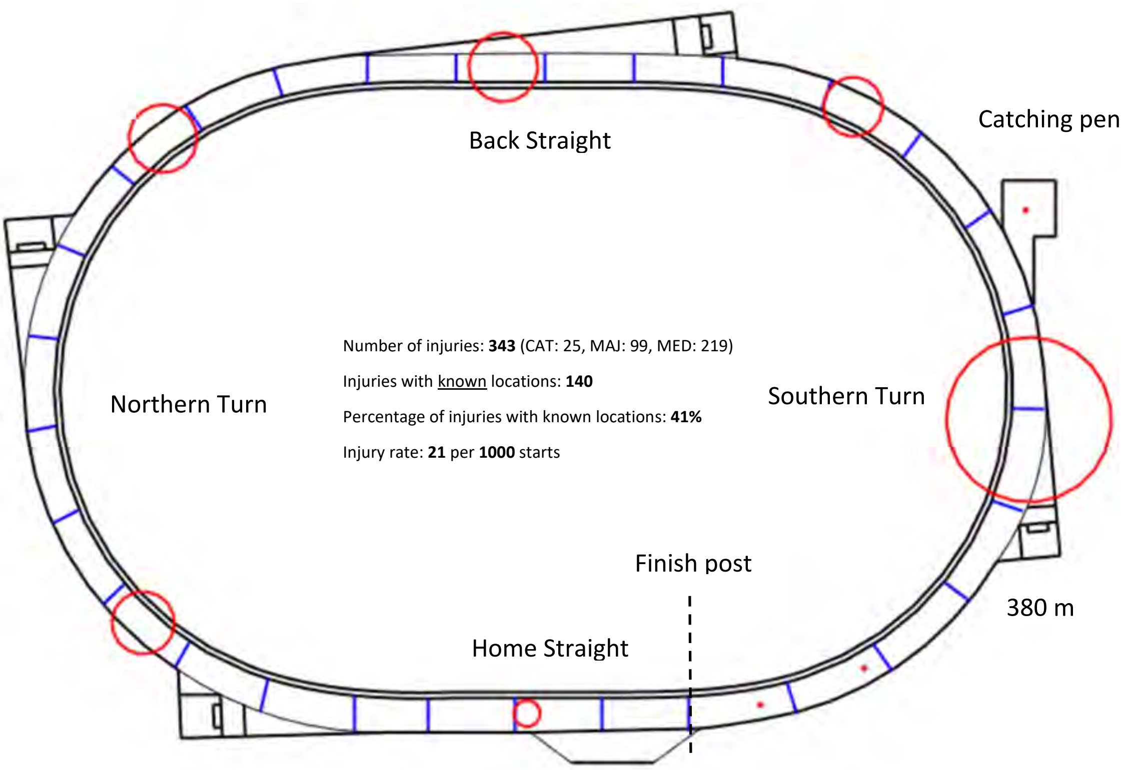


Figure 58: Cannington greyhound track injury location *heat maps* for the 380 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 59 is the incident location *heat map* for the 520 m race distance. During the reporting period there were 19,410 starts and 408 injuries were reported for the 520 m race distance. Of the 408 injuries 142 (35%) were recorded with a known track location. The normalised injury rate for Cannington 520 m distance was 21 per 1000 starts.

The greatest number of injuries (31) occurred as the greyhounds enter the first turn after the start. The location with the second greatest number of injuries (27) was as the greyhounds enter the second turn after the start. The location with the third greatest number of injuries (22) was as the greyhounds exit the first turn. The location with the fourth greatest number of injuries (16) on the back straight. The location with the fifth greatest number of injuries (14) was soon after the start. The location with the sixth greatest number of injuries (13) was as the greyhounds exit the second turn. The location with the seventh greatest number of injuries (9) was on the home straight. Other injury locations include: soon after the finish (4); and catching pen (1). All the reported injuries above occurred on the first lap of the race. There were a total of five injuries on the second lap of the race at and home straight.

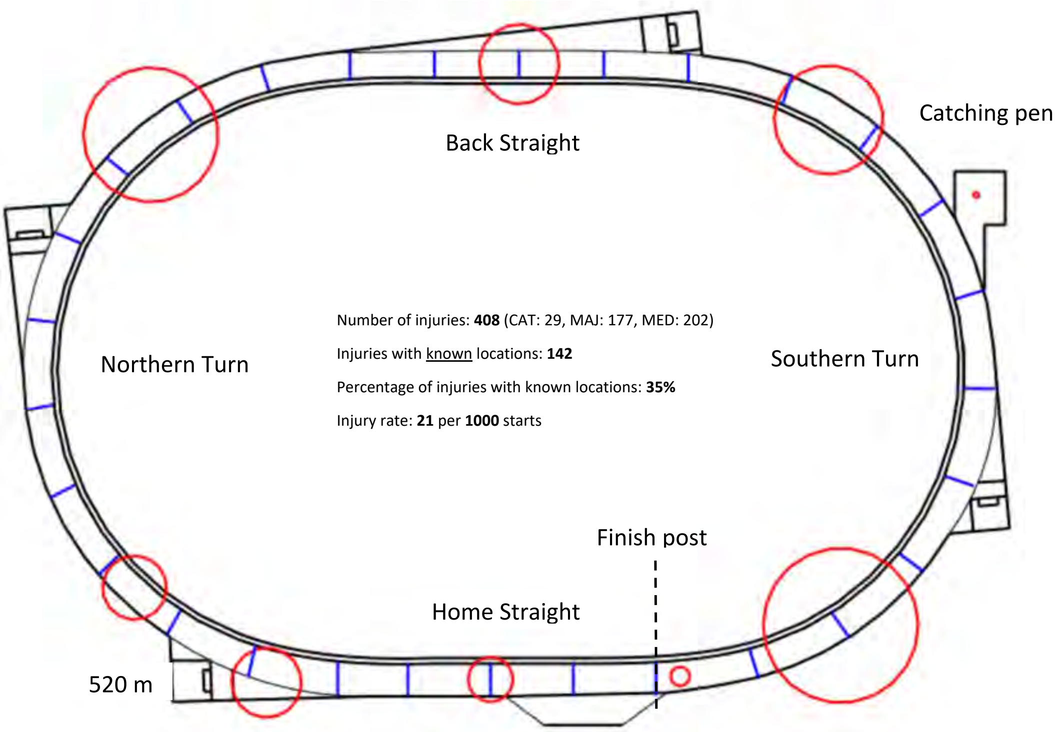


Figure 59: Cannington greyhound track injury location *heat maps* for the 520 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 60 is the incident location *heat map* for the 600 m race distance. During the reporting period there were 2645 starts and 56 injuries were reported for the 600 m race distance. Of the 56 injuries 20 (36%) were recorded with a known track location. The normalised injury rate for Cannington 600 m distance was 21 per 1000 starts.

The greatest number of injuries (5) occurred on the home straight immediately after the start. This location coincides with where the greyhounds are at their maximum speed. Other injury locations include: exiting the first turn after the start (4); entering the third turn after the start (4); soon after the start (3); and entering the second turn (1). All the reported injuries above occurred on the first lap of the race.

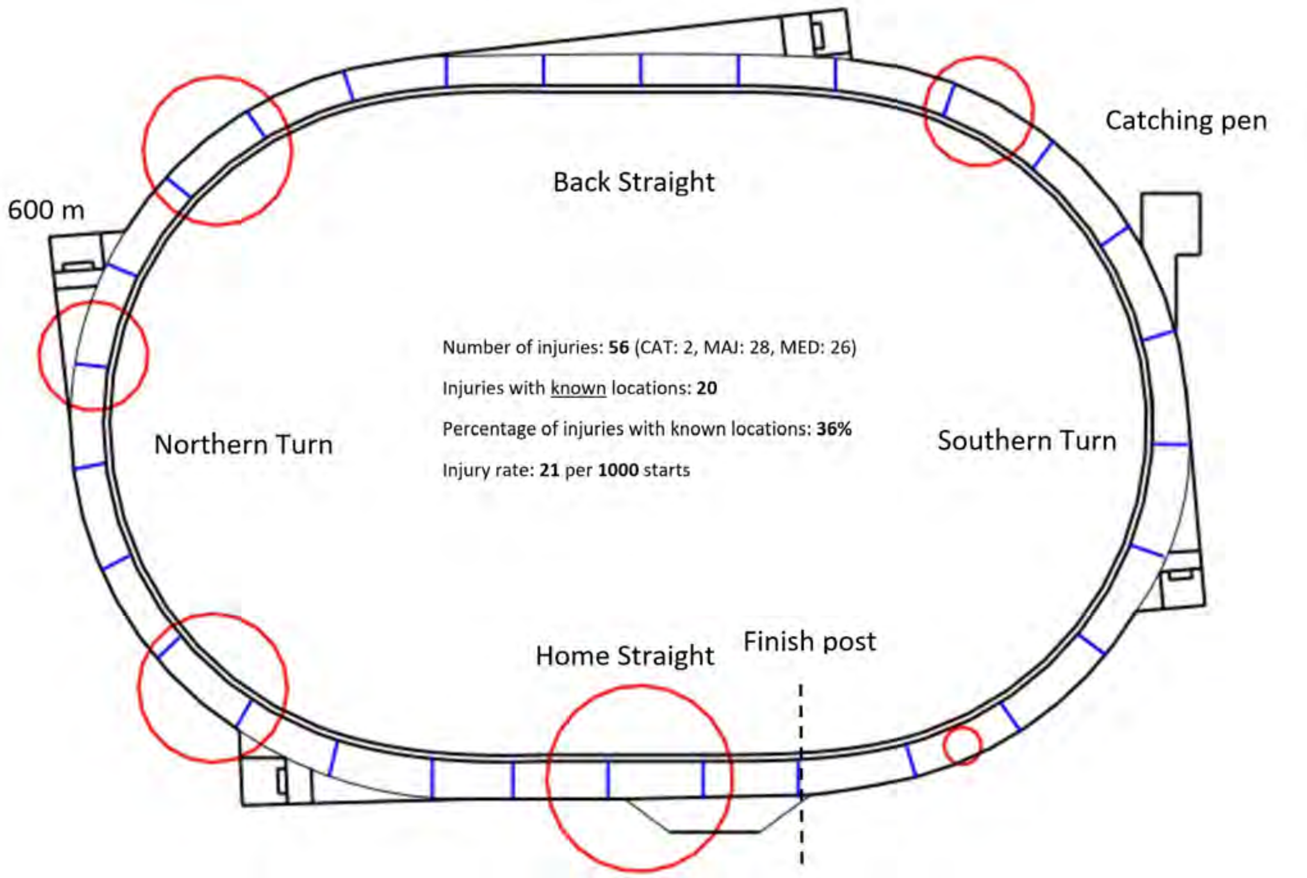


Figure 60: Cannington greyhound track injury location *heat maps* for the 600 m start. The normalised injury rate is depicted by the relative size of the red circles.

3.2.3 Mandurah greyhound track incident location *heat maps*

During the reporting period the Mandurah greyhound track was renovated[17,18]. A transitional clothoidal curvature bend was added between the Back Straight and the Southern Turn (see Figure 22 for details of this renovation). The track incident location *heat maps* for the Mandurah greyhound track are split into *pre-intervention* and *post-intervention*[19]. These two different data sets are used to explore the impact of the transitional curvature bend on the track location of injuries for the three racing distances.

Figure 61 contains the *pre-intervention* and *post-intervention* incident location *heat maps* for the 302 m race distance. During the *pre-intervention* reporting period there were 5885 starts and 95 injuries were reported for the 302 m race distance. Of the 95 injuries 40 (42%) were recorded with a known track location. The normalised injury rate during *pre-intervention* was 16 per 1000 starts. During the *post-intervention* reporting period there were 6520 starts and 156 injuries were reported for the 302 m race distance. Of the 156 injuries 74 (47%) were recorded with a known track location. The normalised injury rate during *post-intervention* was 24 per 1000 starts.

During the *pre-intervention* reporting period the greatest number of injuries (19) occurred soon after the start and entering the first turn. This *hot spot* occurred where the greyhounds are accelerating whilst also being subjected to congestion and unbalancing forces. The second greatest number of injuries (10) was as on the first turn exit. Other injury locations include: first turn (4); catching pen (3); after the finish (2) and home straight (2).

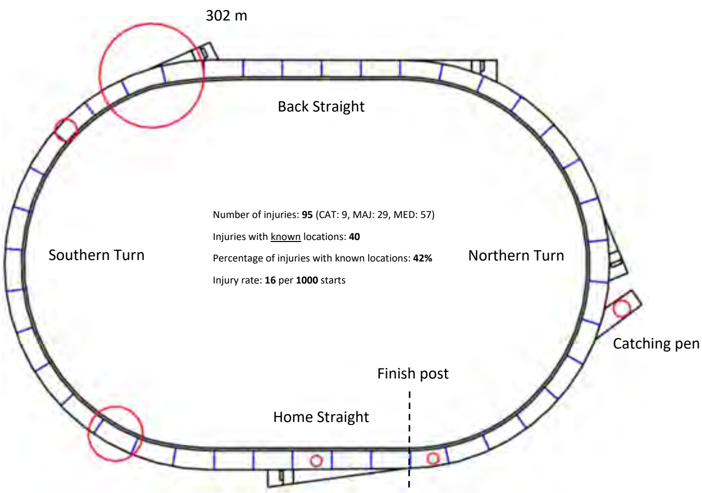
During the *post-intervention* the greatest number of injuries (31) occurred on the first turn exit. This *hot spot* occurred where the greyhounds are experiencing their maximum speed. The second greatest number of injuries (13) occurred on the home straight. The third greatest number of injuries (10) occurred soon after the start. The fourth greatest number of injuries (8) occurred in the catching pen. The fifth greatest number of injuries (7) occurred on the first turn. Other injury locations include: after the finish turn (3); and entering the second turn (1).

[17]The Mandurah greyhound track was closed to racing during a renovation for approximately 8 weeks in 2018. The last race meeting prior to the renovation was 18 May 2018 and the first race meeting after the renovation was 26 July 2018.

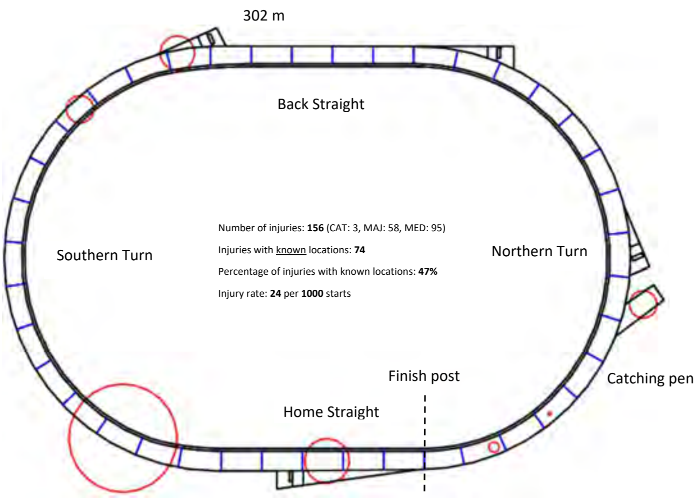
[18]The 2018 RWWA Annual Report states '*The Mandurah greyhound track at Kanyana Park was reopened following an extensive upgrade involving resurfacing of the race track and amendments to the course design generating racing, wagering and animal welfare improvements. The State Government funding component of $150k was supplemented by almost $250k from RWWA's Infrastructure Grants funding pool allowing the eight-week construction program to finish ahead of schedule in July.*'

[19]Several of the injuries were incorrectly labeled in the data set provided to UTS. These injuries have manually been relabeled as unknown injury location.

Comparing the 302 m *pre-intervention* and *post-intervention* data sets the primary *hot spot* moved from soon after the start to the exit of the first bend. The injury rate for the 302 m distance increased by 33% *post-intervention.* This observation was unexpected. This increase suggests there must be other injury contributing factors that have affected the results that need to be identified. These injury factors could include different injury recording policies, changes in track maintenance, changes in staff, changes in the racing age of the greyhounds, changes in the frequency of racing, environmental factors, a combination of one or more of these, or another injury factor.



(a) Pre-intervention



(b) Post-intervention

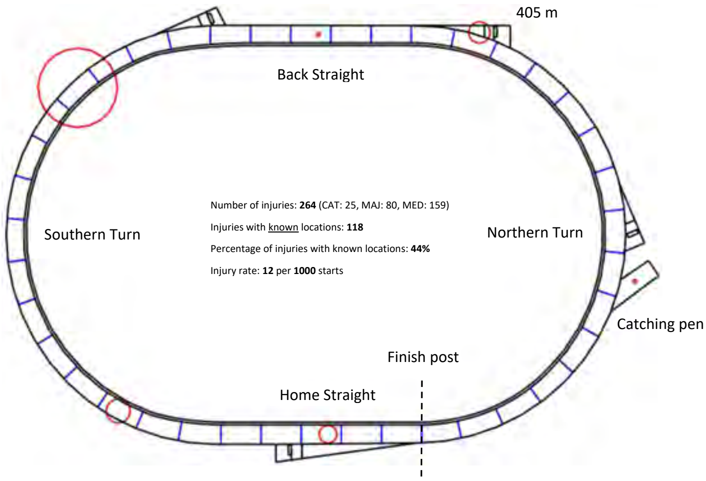
Figure 61: Mandurah greyhound track location *heat map* for the 302 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 62 contains the *pre-intervention* and *post-intervention* incident location *heat maps* for the

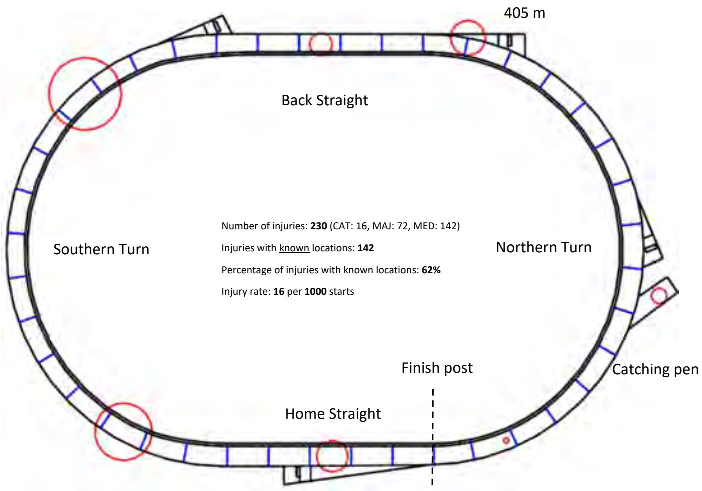
405 m race distance. During the *pre-intervention* reporting period there were 21,812 starts and 264 injuries were reported for the 405 m race distance. Of the 264 injuries 118 (44%) were recorded with a known track location. The normalised injury rate during *pre-intervention* was 12 per 1000 starts. During the *post-intervention* reporting period there were 14,713 starts and 230 injuries were reported for the 405 m race distance. Of the 230 injuries 142 (62%) were recorded with a known track location. The normalised injury rate during *post-intervention* was 16 per 1000 starts.

During the *pre-intervention* reporting period the greatest number of injuries (62) occurred on turn off back straight. The second greatest number of injuries (19) occurred on turn into home straight. The third greatest number of injuries (17) occurred soon after the start. The forth greatest number of injuries (14) occurred on home straight. Other injury locations include: back straight (3) ; and catching pen (3). During the *post-intervention* the greatest number of injuries (46) occurred on turn off the back straight. The second greatest number of injuries (33) occurred on turn into home straight. The third greatest number of injuries (20) occurred soon after the start. The forth greatest number of injuries (18) occurred on home straight. The fifth greatest number of injuries (13) occurred on back straight. Other injury locations include: catching pen (9), turn into back straight (6); and after finish (3).

Comparing the 405 m *pre-intervention* and *post-intervention* data sets the primary *hot spot* location did not change. The injury rate for the 405 m distance increased by 25% *post-intervention*. It is worth noting that the reported injury rates for this distance for both *pre-intervention* and *post-intervention* are within a tolerable level, nevertheless observing an increase in the injury rate was unexpected. This increase suggests there must be other injury contributing factors that have affected the results that need to be identified. These injury factors could include different injury recording policies, changes in track maintenance, changes in staff, changes in the racing age of the greyhounds, changes in the frequency of racing, environmental factors, a combination of one or more of these, or another injury factor.



(a) Pre-intervention



(b) Post-intervention

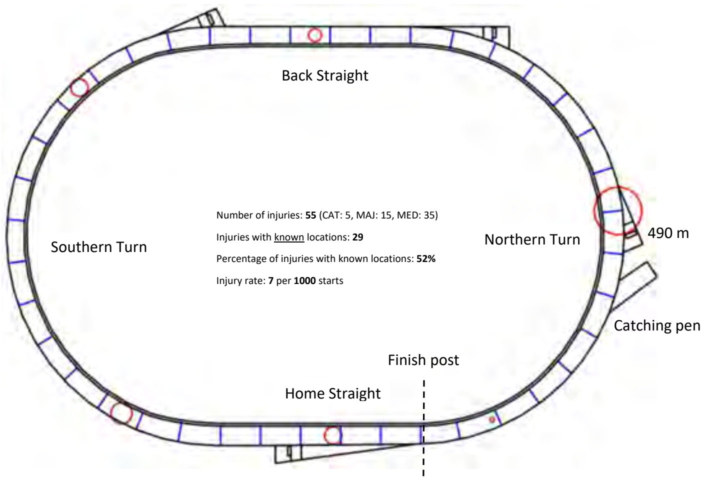
Figure 62: Mandurah greyhound track location *heat map* for the 405 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 63 contains the *pre-intervention* and *post-intervention* incident location *heat maps* for the 490 m race distance. During the *pre-intervention* reporting period there were 7623 starts and 55 injuries were reported for the 490 m race distance. Of the 55 injuries 29 (52%) were recorded with a known track location. The normalised injury rate during *pre-intervention* was 7 per 1000 starts. During the *post-intervention* reporting period there were 5027 starts and 70 injuries were reported for the 490 m race distance. Of the 70 injuries 50 (71%) were recorded with a known track location. The normalised injury rate during *post-intervention* was 14 per 1000 starts.

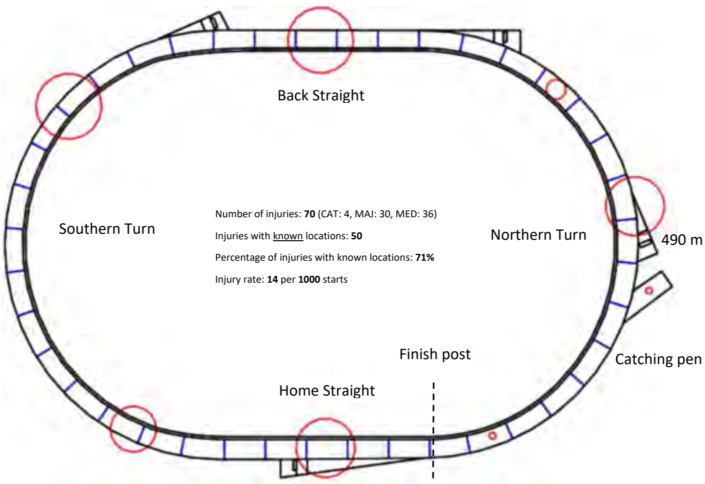
During the *pre-intervention* reporting period the greatest number of injuries (11) occurred soon after the start. Other injury locations include: turn into home straight (5), turn off back straight (5), home straight (4), back straight (3); and after finish (1).

During the *post-intervention* the greatest number of injuries occurred on both turn off back straight (10) and back straight (10). The second greatest number of injuries occurred both on home straight (9) and after the start (9). Other injury locations include: turn into home straight (7), turn into back straight (3), catching pen (1), and after finish (1).

Comparing the 490 m *pre-intervention* and *post-intervention* data sets the primary *hot spot* did not change. The injury rate doubled (increased by 100%) *post-intervention*. Similar to the 405 m distance, the reported injury rates for this distance for both *pre-intervention* and *post-intervention* are within a tolerable level acceptable, nevertheless observing an increase in the injury rate was unexpected. This increase suggests there must be other injury contributing factors that have affected the results that need to be identified. These injury factors could include different injury recording policies, changes in track maintenance, changes in staff, changes in the racing age of the greyhounds, changes in the frequency of racing, environmental factors, a combination of one or more of these, or another injury factor.



(a) Pre-intervention



(b) Post-intervention

Figure 63: Mandurah greyhound track location *heat map* for the 490 m start. The normalised injury rate is depicted by the relative size of the red circles.

3.2.4 Northam greyhound track incident location *heat maps*

Figure 64 is the incident location *heat map* for the 297 m race distance. During the reporting period there were 6615 starts and 161 injuries were reported for the 297 m race distance. Of the 161 injuries 30 (19%)[20] were recorded with a known track location. The normalised injury rate for Northam 297 m distance was 24 per 1000 starts.

The greatest number of injuries (9) occurred as the greyhounds enter the first turn after the start. The location with the second greatest number of injuries (5) was as the greyhounds exit the first turn. The location with equal second greatest number of injuries (5) was on the home straight. Other injury locations include: soon after the start (4); catching pen (3); at the finish post (2); and on the back straight soon after the start (2).

[20] The low number of recorded locations at the Northam track may be a result of inadequate recording.

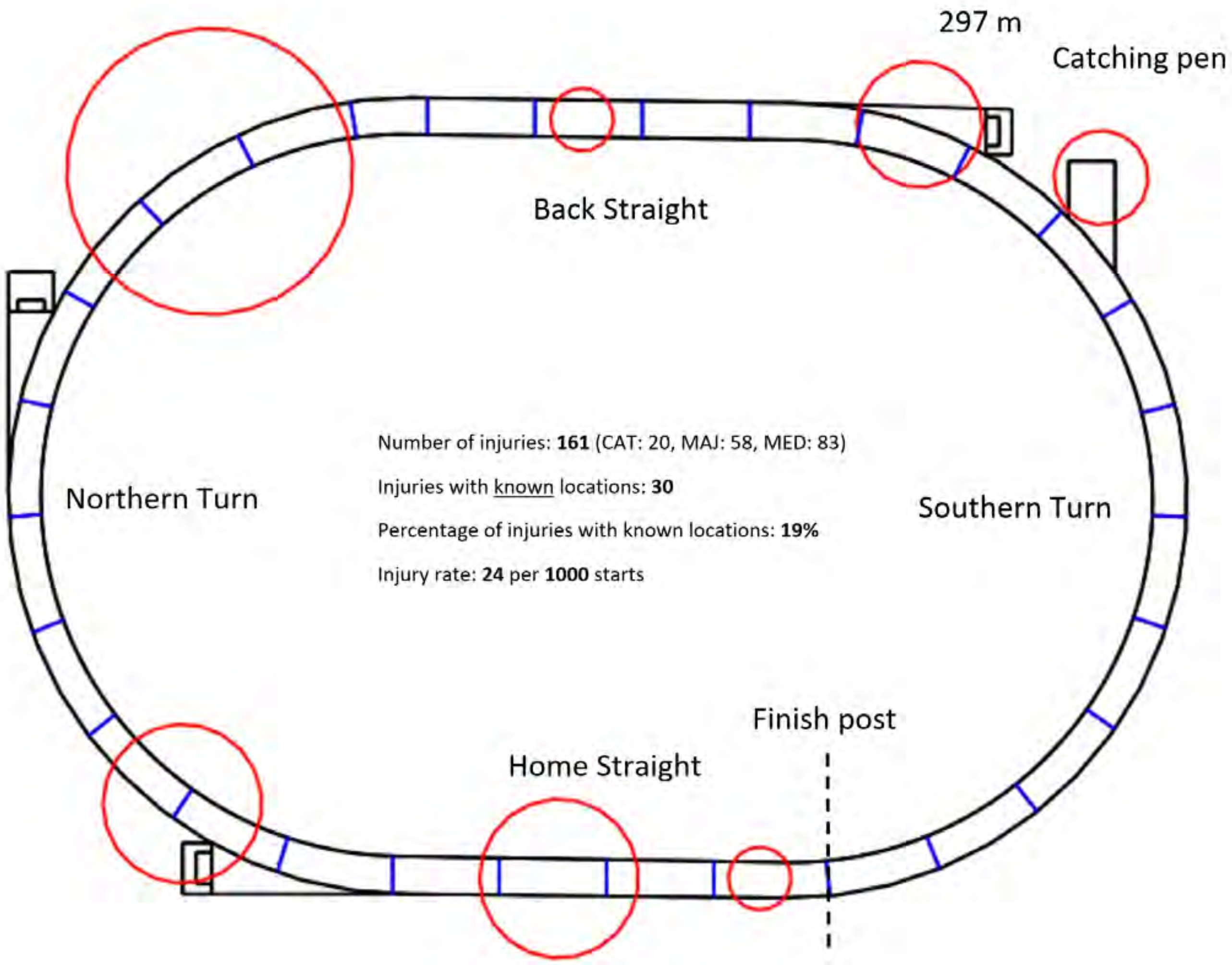


Figure 64: Northam greyhound track injury location *heat maps* for the 297 m start. The normalised injury rate is depicted by the relative size of the red circles.

Figure 65 is the incident location *heat map* for 509 m race distance. During the reporting period there were 4258 starts and 82 injuries were reported for the 297 m race distance. Of the 82 injuries 14 (17%) were recorded with a known track location. The normalised injury rate for Northam 509 m distance was 19 per 1000 starts.

The greatest number of injuries (4) occurred as the greyhounds enter the track soon after the start. The second greatest number of injuries (3) occurs in the catching pens area. Other injury locations include: entering the first turn (2); exiting the second turn (2); the home straight on the second lap (2); and entering the second turn (1). All the reported injuries above occurred on the first lap of the race. There were two incidents occurred on home straight on the second lap of the race.

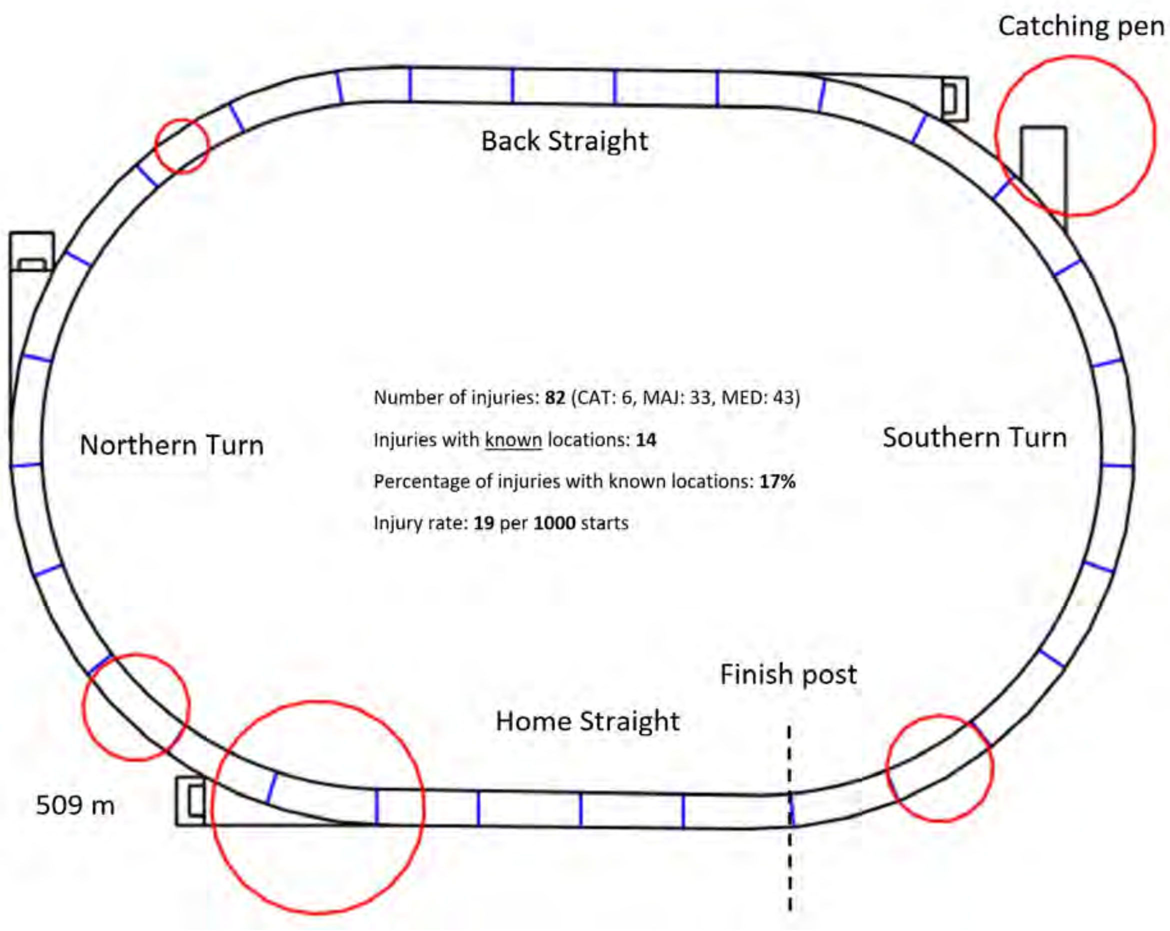


Figure 65: Northam greyhound track injury location *heat maps* for the 509 m start. The normalised injury rate is depicted by the relative size of the red circles.