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Synthetic Track Surfaces Discussion Document

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Objectives

The objectives of this document are:

(i) *Literature review:* Provide a concise summary of the peer reviewed literature describing the hoof / limb interaction on synthetic and turf tracks, the material properties of synthetic and turf track surfaces and the methods used to quantify track surface properties. The literature will also be examined for data on the environmental variables that induce variability in track surface properties and the reported injury rates on synthetic and turf surfaces.

(ii) *Physical description of tracks:* Provide a description of the synthetic tracks in New Zealand including their physical properties, the management techniques employed and the current metrics on the track surface (e.g. Clegg hammer data) over time.

(iii) *Horses and track use:* Provide a description of the current use of the synthetic tracks within New Zealand (racing frequency and pattern of use) with a focus on the demographics of the horse population racing on the synthetic tracks and compare this to the racing population during the same time period on turf tracks. Compare data from official race day reports of injury and fatality on all racing surfaces for the 2020/21 season to completion of the 2023/24 season. This timeframe was selected as it coincides with the first full season of the introduction of racing on synthetic tracks in New Zealand.

Executive summary

Different track surfaces have different hoof loading profiles. Synthetic tracks have a different hoof loading profile than observed with turf tracks, specifically a more acute end to the deceleration of the hoof on impact. In New Zealand, the use of synthetic tracks during winter accentuates the difference in hoof load that horses experience when transitioning from turf to synthetic tracks. On different surfaces the horse can adjust the limb to attenuate load for optimal gallop efficiency. At present we do not have empirical data on how rapidly this fine tuning can occur. To increase the chance of the horse having this "muscle memory", the habituation of horses to different surfaces is required.

Lack of training data, such as the number of horses training on different surfaces and injuries presented, restricted incidence estimates to only those observed on race day. Univariable estimates of race day musculoskeletal injury (MSI) and fracture incidence rates indicate a higher incidence rate on synthetic than turf tracks. The univariable estimates are in a similar range to observations from other jurisdictions for synthetic surfaces. Caution should be applied to the interpretation of these incidence estimates, as a multivariable analysis is required to provide robust estimation of true incidence rate. Multivariable analyses account for all the other variables than also contribute to injury and fracture.

Across the industry, there is a need for awareness that synthetic tracks provide an alternative racing surface that can complement racing in New Zealand, but they do not provide a panacea for injuries. Similar to turf tracks the responsiveness of synthetic tracks can change in relation to environmental factors, such as temperature, and the maintenance and preparation programmes.

Analysis of race-day sectional times demonstrates that horses are running at faster speeds on synthetic tracks than turf tracks. Faster speeds are a risk factor for injury, and preparation of the synthetic surfaces could be altered to reduce the respective speed of horses on the synthetic tracks and thus the injury risk profile.

Reports of a clumping appearance of the cushion and a rising pan indicates the opportunity for greater involvement of the supplier (Martin Collins) to tailor the maintenance and preparation procedures of each track to suit the differing environmental conditions. There was some variation in the recording of maintenance protocols and documentation between tracks. The establishment of a nationwide standardised reporting procedure (Clegg hammer and depth stick) would improve data flow and provide the opportunity to implement a nationwide monitoring programme to proactively monitor and maintain tracks in close collaboration with the supplier (Martin Collins).

Literature Review

Understanding the interaction between loading of the equine limb and track surfaces is essential to minimise musculoskeletal injury (MSI) risk during horse racing. Limb loading refers to the forces exerted on the equine limb during movement and can vary significantly depending on track surface and geometry. There are three main track surfaces used for racing; turf, dirt and synthetic. Each of these surfaces have various measures which quantify the firmness, grip, shear and consistency of surface. On turf tracks these can be classified into a 'track condition score', which indicates different levels of track firmness (fast, good, dead, soft, heavy). Generally, a fast, hard track is associated with a higher risk of MSI (Gibson et al., 2023; Hitchens et al., 2019). On dirt tracks similar qualitative terms are used to describe track variables such as, fast, good, muddy, sloppy, slow and sealed. Synthetic tracks are universally regarded as "fast".

The primary contributors to loading on the distal limb of racehorses are the combination of speed, turn radius, surface type and surface consistency (Parkes et al., 2020). The art of racetrack management is to provide the appropriate balance of these variables so that the loading of the limb is predictable and within the acceptable physiological limits of the horse. It has been proposed that historically, New Zealand flat racing provided a relatively consistent magnitude of limb loading for a horse during a racing preparation, due to tracks with similar configurations (shape, circumference and turn aspect ratio) and limited variation in track condition score, with few tracks reporting the higher risk "fast" track condition score (Gibson et al., 2022; Legg et al., 2025; Rogers et al., 2014).

The majority of the data on track surface and the impact of surface type and going on injury type and risk have originated from outside New Zealand. In the USA, there are three track surfaces used: dirt, synthetic and turf. In many reports, dirt tracks consistently have the highest incidence for injury and fracture compared to the other two surfaces. It is believed that dirt tracks have a different hoof – ground interaction than turf and synthetic tracks (Parkes and Witte, 2015) and this alters the loading of the limb and the associated risk profile for injury (Parkin, 2008). Horses can adjust to different surfaces by fine tuning how the tendons dampen the loading of the limb (Wilson et al., 2001). However, we currently lack data on how quickly a horse can readjust from working, or training, on one type of surface to a different surface (Bardin et al., 2021). Data from a cross-sectional survey of dressage horses indicates that horses habituate to a certain surface and may in the short-term lose the ability to respond positively to different surfaces if variety in training surfaces is not included as part of the routine training programme (Murray et al., 2010).

A meta-analysis of published studies indicated that the difference between surface types may be subtle and also confounded by the variation in going in turf surfaces, with harder, faster tracks having a greater risk profile than softer, slower rated tracks (Hitchens et al., 2019). This pattern of increasing risk of injury with increasing firmness of the track was reported for both turf and synthetic tracks in the UK (Rosanowski et al., 2017a) and turf tracks in New Zealand (Bolwell et al., 2017; Gibson et al., 2022). In Thoroughbred racing, drier, firmer tracks are associated with higher racing speeds (Maeda et al., 2012). Preliminary data from our group examining the last 600m sectional times indicates synthetic tracks in New Zealand are producing race times that reflect a firm turf track (Legg et al., 2024).

Horse – hoof – track interaction

The basic principles of the horse – hoof – track interaction have been described in the racing surfaces white paper (Peterson et al., 2012) and in detail in Parkes and Witte (2015). Briefly, the interaction can be described as consisting of primary impact (initial contact with the surface), secondary impact (slide and stop), support (midstance and vertical ground reaction force) and breakover (rollover - propulsion), as depicted in Figure 1. The Ground Reaction Force (GRF) describes the force of the limb on the ground surface. Ground reaction forces can be described simply as the total force, or as a force vector which describes the force and the primary direction of the force. Acceleration occurs primarily during initial impact (deceleration) and breakover (as the horse pushes off), with surface properties (e.g. firmness and grip) affecting force transfer and propulsion efficiency.

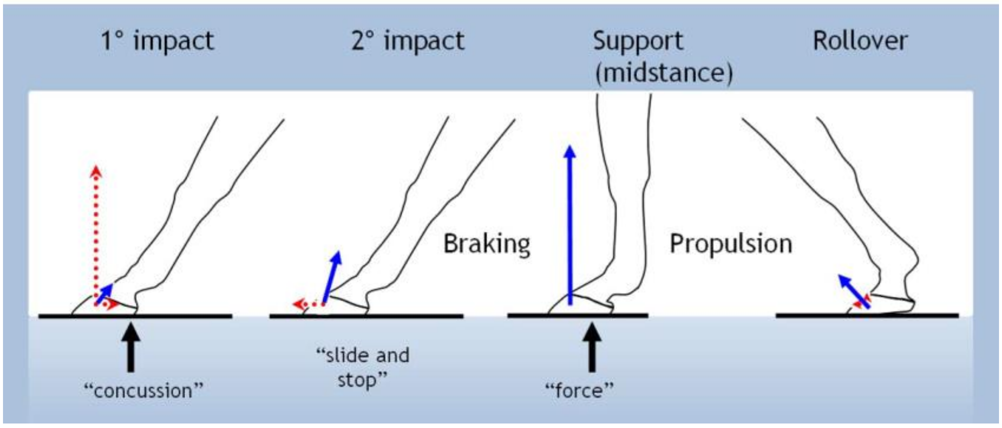


Figure 1. Stages of the horse-hoof-track interaction showing the differences in acceleration (red) and Ground Reaction Force (GRF, blue) between the stages. When the GRF arrow is tilted, that indicates that both vertical and horizontal components of GRF are present. The arrow shows the direction in which the ground is pushing the horse. Modified from Peterson et al. (2012).

In relation to racetrack properties, the primary impact of the hoof is generally affected by the track hardness (vertical hardness of the surface), resulting in high frequency vibration within the hoof and the distal limb at loading. From a functional point of view, secondary impact is of greater importance, as the hoof slides forward and is rapidly decelerated, thus generating a large braking and loading force up the limb. It is during this phase that the limb is most sensitive to rapid abrupt deceleration, or the opposite, where the hoof slips and there is a resultant overextension of the tendons and ligament within the distal limb. The support (midstance) phase represents peak vertical ground reaction force (limb loading) which, in the galloping horse, may be up to 2.4 times the horse's bodyweight. Breakover represents the transition from support to propulsion, with a rapid decrease and change in the direction of force. The force experienced, and the risk of injury, are dependent on the rate of change in direction and magnitude of the force, which in turn depends on the material properties of the surface.

Greater speed is associated with increased track firmness, which is due to the greater traction possible at breakover. However, increased track firmness is also associated with more rapid deceleration of the limb and a reduced and abrupt slide and stop, increasing the concussive forces on the limb. This rapid deceleration of the limb is one of the explanations for the greater odds of fracture being associated with "fast" tracks (Bolwell et al., 2017).

Greater shear resistance can have the same effect as track hardness in promoting rapid deceleration of the limb on impact. In a cross-sectional survey of UK jockeys, synthetic tracks were perceived as providing greater grip than turf tracks, possibly reflecting the greater shear resistance observed with synthetic tracks (Horan et al., 2021a; Horan et al., 2021b; Northrop et al., 2020). This greater shear resistance is reflected in the greater relative speeds on synthetic tracks vs. turf tracks and may be an explanation for the higher incidence rate for injury and fracture on synthetic tracks compared to turf tracks in a UK study (Rosanowski et al., 2017b) and in preliminary data from New Zealand (Gibson et al., 2024).

Racetrack geometry - effect on limb load

To date, there has been limited data published on the impact of track geometry on injury rates. The early literature focused on harness racing and the impact of turn radius, the transition zone and banking on kinematics (trot and pace) and injury rates (Fredricson et al., 2010). A case study investigating the remodelling of one of the Japanese racing association tracks to improve transitions into bends was associated with a reduction of racehorse injuries (Oikawa et al., 1994). This supports anecdotal evidence from the USA on a reduction in injury rates with smoother transitions into bends. A more recent examination of the equine injury database revealed a greater risk of right forelimb fracture with smaller radius turns, and an interaction with straight (home or back straight) length (indicating the effect of speed on the turn radius) (Peterson et al., 2021a).

Galloping on a curve increases the force perpendicular to the direction of motion, and this centripetal force increases with speed and a smaller turn radius. The maximum speed able to be maintained on a turn is dependent on the shear coefficient of the surface; the greater the grip, the faster the speed, which results in greater loads placed on the limb (Parkes et al., 2020).

The limbs of the horse adapt their structure according to the magnitude and direction of the load they are exposed to. The most dramatic example of this is the change in bone geometry and density of the mid diaphysis of the third metacarpal (midshaft of the cannon bone) associated with the introduction of gallop work. If the gallop work is introduced on a consistent surface and track configuration, the bones in the lower limb remodel in a specific pattern (Firth et al., 2005). This specificity means that the horse becomes highly adapted to gallop on that surface and with that turn radius (as turn radius dictates load and direction of load on the limb).

Differences in track configuration, such as tighter turns (reduced track turn radius) may provide loading outside the plane of principle loading (to which the horse has adapted). Loading trabeculae (as found in the equine metacarpal condyle) at angles outside the principal physiological loading angle results in a significantly reduced fatigue life of the equine limb with cyclic loading (Martig et al., 2014). This physiological effect may explain why different surfaces, track configurations and track consistencies can independently and synergistically contribute to fracture risk (Peterson et al., 2021a).

Synthetic track composition

Synthetic tracks are composed of mixed fibres and silica sand which are given a wax coating. The application of the wax coating is used to create particle cohesion. The synthetic material is supported on an engineered foundation formed of porous asphalt and gravel to aid drainage. In New Zealand this is called the *Polytrack*. The depth of the synthetic surface above the asphalt base for the synthetic tracks in California is 26 ± 3cm (Setterbo et al., 2013). The depth of synthetic tracks can vary depending on the preparation of the surface and associated level of compaction. Across a number of racing jurisdictions; Australia, France and Singapore for example, the depth of the synthetic surface is reported to be between 13 – 15 cm (Reid Sanders *pers. comm*). All three New Zealand tracks are built with a 15cm depth of *Polytrack* surface on top of a porous Asphalt base.

In an early study, both ambient and track surface temperature were found to be associated with race and workout times, with the authors proposing that at lower temperatures the wax was more viscous, and this provided a firmer racing surface (Peterson et al., 2010). Subsequent studies confirmed this and identified that the material properties of the surface changed with decreasing temperature, with an increase in surface hardness (impact firmness), shear resistance (rotational grip) and horizontal grip, due to the greater viscosity of the wax binder (Northrop et al., 2020). Within this study, the material was sourced from commercial racetracks in the UK and there were significant differences between tracks in the response to temperature, possibly due to differences in the fibres used and the sand particle size distribution.

The basic structure of any synthetic surface is presented in Figure 2. The upper layer acts as the cushion and then there is some consolidation of the material to form an intermediate layer (pan) which sits on top of the base (porous asphalt). Segregation or settling of materials in the top layers can occur over time without appropriate maintenance. Once segregation of material starts to occur, the surface responds to load in a heterogeneous rather than homogenous manner. With waxed surfaces this segregation can result in the fibres being the predominant material in the cushion and an increasing depth of consolidated sand and wax material acting as a hard, highly compacted base surface rather than an intermediate layer. A schematic example of this is presented in Figure 3, which shows the direction of travel of surface material due to the camber of the turn. Consolidation of material can inadvertently occur if maintenance equipment is not adjusted to reflect the camber of the turn, leading to increased depth of material on the inside of the track and a 'rising' pan (Figure 3).

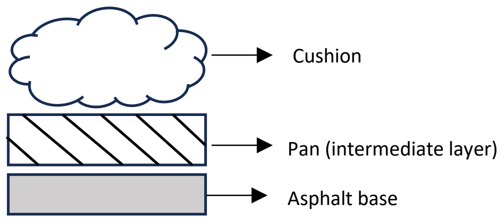


Figure 2. Three-layer structure of a synthetic track. The cushion layer on top represents the loosely compacted *Polytrack* material. The second layer (pan) consists of the same *Polytrack* material but has greater compaction, acting as an intermediate layer. The bottom layer is the porous asphalt base.

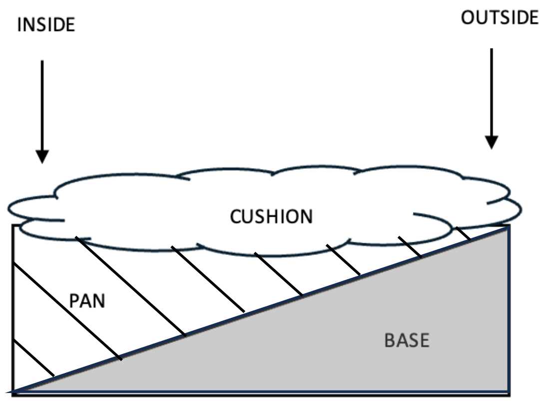
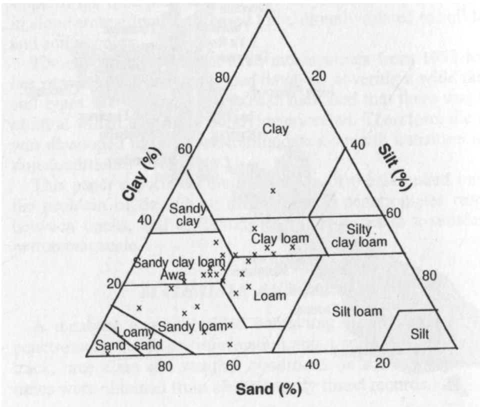


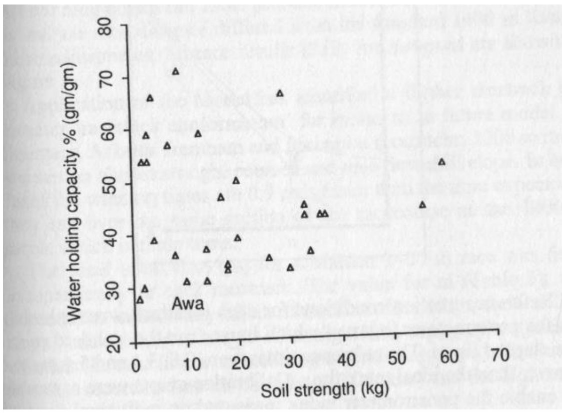
Figure 3. Depiction of the camber on the turn of a synthetic track, showing movement of the material from the outside to the inside of the turn due to segregation of material, and the presentation of a rising pan.

Material properties of turf and synthetic tracks

There are limited studies describing the material properties of turf tracks, though fortunately what is published has focused on New Zealand tracks. The material properties of turf tracks are well described by the penetrometer developed nearly 30 years ago (Thomas et al., 1996). The practical application of the penetrometer has been well demonstrated and generates a reading that reflects the horse hoof – ground interaction based on the soil type and turf grass species used in New Zealand (Murphy et al., 1996). Within this study, the authors also presented data on the soil textures and the soil strength and water holding capacity on a sample of 29 New Zealand racetracks, providing a robust platform for turf racetrack maintenance and monitoring.



A) Soil textures on 29 New Zealand racetracks



B) Soil strength and water holding capacity on the 29 New Zealand racetracks

Figure 4. **A)** Soil texture and **B)** soil strength data from 29 New Zealand turf race tracks (data from (Murphy et al., 1996).

The Orono Biomechanical Surface Tester (OBST) is a device used in the USA and UK to evaluate several material properties of racetrack surfaces. It replicates the mechanical loading and impact characteristics of the horse's hoof during gallop and collects information on surface hardness, cushioning, moisture content and consistency and has been used on both turf and synthetic tracks. The material properties of standard synthetic and turf racetrack surfaces from OBST tests are described in Table 1.

Table 1. Published material properties from OBST testing of synthetic and turf racetrack surfaces.

Parameter	Synthetic+	Turf *
Cushioning (kN)	8.2 ± 0.9	13.5 ± 2.0
Impact firmness (g)	41.5 ± 10.6	-84.1 ± 14.9
Grip horizontal (mm)	9.1 ± 1.6	6.5 ± 5.5
Rotational grip (mm)	32.0 ± 2.1	N/A
Responsiveness	N/A	0.58 ± 0.04
Volumetric moisture content (%)	4%	32.6 ± 9.9%
Surface depth (cm)	26 ± 3**	N/A
Harrow depth (cm)	5**	N/A

+ Mean ± SD of values obtained using the first drop (i.e. fresh surface) of an OBST on 5 different waxed synthetic samples at 20 °C representing UK synthetic racetracks (Northrop et al., 2020) *Mean ± SD of values obtained using an OBST on 15 different soil preparations representing USA turf racetracks (Schmitt et al., 2023).

**(Setterbo et al., 2013)

Synthetic surface preparation

Preparation and maintenance of a synthetic racetrack requires daily monitoring and attention. Synthetic surfaces are harrowed daily to ensure the cushion remains soft and consistent. Typical preparation of synthetic tracks in California involves harrowing to a depth of 5 cm (Setterbo et al., 2013). The harrow is dragged across the surface to break up compacted areas and redistribute the surface materials evenly. Power harrowing is less frequent and uses rotating blades to crumble and mix the pan and cushion material to a specific depth, helping to mix and aerate the materials of the synthetic track, which creates a uniform level surface and improves drainage. Regular grading, or re-levelling of the track is also required to maintain the slope and drainage properties of the surface.

Consistency in surface response is an essential component of any track material as it is believed that the ability for a horse to produce stride to stride modification of the limb stiffness may be limited (Wilson et al., 2001). On synthetic surfaces, superficial harrowing of up to 10 cm tyne depth has been found to reduce the maximum vertical load on the horse's limb, and hoof deceleration by approximately 10%, as well as providing a more consistent surface (Tranquille et al., 2015). However, this positive effect may be short lived due to rapid re-compaction from subsequent horse traffic (Tranquille et al., 2015). This is consistent with published data describing an association of increased variance in the vertical forces on the limb with rough (non-prepared/harrowed) training surfaces (Kai et al., 1999).

Despite the positive effects of harrowing on hoof impact, the later stance phases of the hoof may be affected by the material properties of the track surface itself. Preparation of an arena surface (similar to a synthetic track) by either rolling (to compact the surface) or harrowing resulted in no significant differences in hoof displacement in the craniocaudal (slip), mediolateral or vertical directions, from impact to mid-stance or mid-stance to toe-off (Northrop et al., 2013). This result indicates that these properties are defined more by the inherent material properties of the track surface rather than by surface preparation.

Within New Zealand, turf tracks are prepared so they produce a track condition of a good 3 (penetrometer reading 2.3-2.5) for race day (New Zealand Thoroughbred Racing, 2013). At present, the synthetic tracks are prepared according to manufacturer's specifications for racing or training. At the time of this report the minimum venue guidelines were under review and the revised version will contain NZTR / manufacturers guidelines for synthetic tracks.

Measurement of racetrack surfaces

Turf tracks

In New Zealand, the penetrometer is the preferred device for the measurement of turf track condition. The penetrometer values have a strong relationship with the material properties of the turf track and race times (Legg et al., 2025; Legg et al., 2024; Murphy et al., 1996). The relationship between track properties and speed (last 600m sectional times) demonstrates a curvilinear relationship (Figure 5), with a near flat relationship between speed and track condition score between 1 and 3 and then after TCS 3 a linear decrease in speed with increasing TCS value. New Zealand currently is the only jurisdiction that uses the quantitative values from a measurement device to set the definition of going (Blanco et al., 2023).

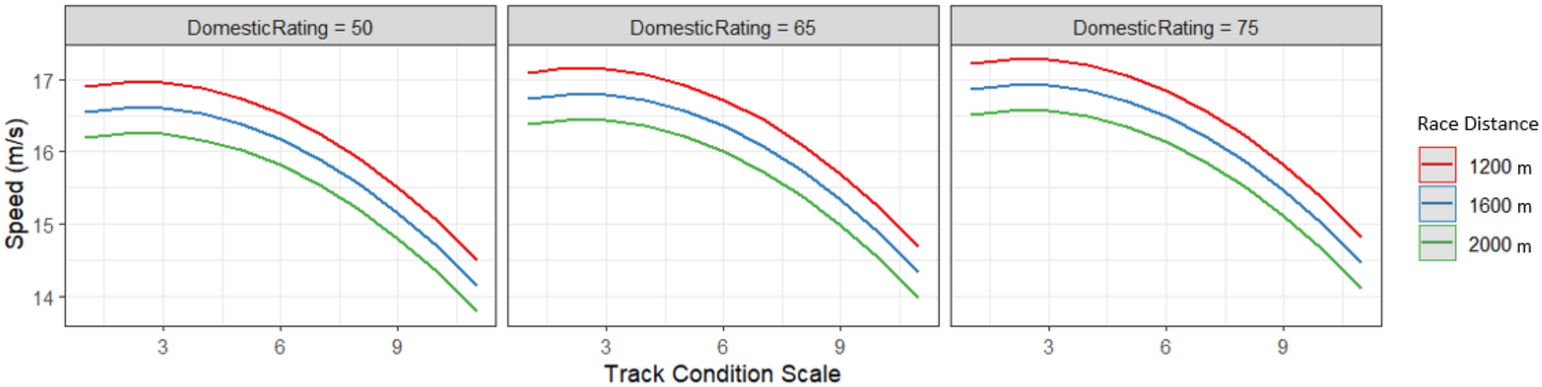


Figure 5. Predicted values of speed (m/s) for Thoroughbred horses in flat races with respect to Track Condition Score (TCS), Race distance (m) and Domestic Rating (Legg et al., 2025).

In the USA, the Orono Biomechanical Surface Tester (OBST) is used to measure track properties pre-race meeting and as part of the daily racetrack monitoring during a meeting. This is part of the safety regulations adopted by the Horseracing Integrity and Safety Authority (HISA) (Schmitt et al., 2024). In a recent comparison of devices for race day characterisation of North American turf racing surfaces, the penetrometer compared favourably against the more expensive and complicated Orono Biomechanical Surface Tester (OBST) which is currently used as part of the HISA racetrack safety programme in the United States (Schmitt et al., 2024). Both the OBST and the penetrometer provide quantitative metrics on the soil surface that the hoof interacts with, however, the grass canopy provides another layer of complexity to the hoof – surface interaction. Early data indicates that it is the root structure rather than the turf canopy that increases resistance to shear, with up to a three-fold increase in resistance to shear being attributed to root structure (Zebarth and Sheard, 1985). Currently, it appears that most measurement devices are not able to robustly describe this turf component (Blanco et al., 2023).

Despite the complex shear interaction, the association of going descriptions with the quantitative measurement of track properties obtained with the penetrometer is unique to New Zealand (Rogers et al., 2014) and has a robust relationship with the sectional times for the last 600m in races (Legg et al., 2025). The routine use of the penetrometer has permitted the estimation of track-based risk factors using a quantitative metric rather than a qualitative scale (Bolwell et al., 2017; Gibson et al., 2023). Modelling of the last 600m sectional times with turf track condition score has revealed a curvilinear relationship, which indicates that with increasing track firmness above TCS 3 there is no increase in speed but an increase in the risk for MSI and fracture (Legg et al., 2025).

Synthetic tracks

Daily maintenance measurement of synthetic tracks according to the HISA Maintenance Quality programme requires measurements of the temperature of the track using a probe pressed 2 inches into the surface, and cushion depth (using a ruler from the compressed top surface until resistance is felt) at each quarter marker pole (Anonymous, 2023). In New Zealand, and a number of other racing jurisdictions, the cushion or going of the synthetic tracks are reported with the use of the Clegg hammer (Setterbo et al., 2013). Within the literature, a single Clegg hammer drop value does not appear to relate well to other measures of track condition (track-testing device or Orono Biomechanical Surface Tester) (Setterbo et al., 2013). The initial Clegg hammer impact deceleration value (CIV) across synthetic tracks was consistently lower than the 4 subsequent CIV's (3.0 (SE 0.2) vs. 4.3 (SE 0.3) – 5.9(SE 0.3)(Setterbo et al., 2013). Therefore, the third Clegg hammer drop value offers a more consistent reading and has a greater correlation with other measures of track properties. Comparison of Clegg hammer readings with data from a triaxial piezoelectric accelerometer fitted to the front hooves of trotters demonstrated good agreement between the Clegg hammer readings and the vertical deceleration peak (Crevier-Denoix et al., 2016). This indicates that Clegg hammer measurements reflect the initial impact absorbing capacity of the surface. However, this represents only a minor part of limb loading and not the aspects of hoof loading that are associated with limb injury.

In part due to temperature altering the material properties of the wax within the synthetic surface, there is an association of synthetic track temperature (at 100mm depth) with horse velocity. This relationship of track surface temperature and velocity is stronger than is observed with values obtained from the Clegg hammer (Peterson et al., 2010). This result demonstrates that on synthetic surfaces the Clegg hammer does not provide an accurate reflection of speed, which is the best holistic measure of how the horse (hoof) is interacting with the surface. Therefore, other quantitative measures (such as temperature and depth recordings) are required to characterise the synthetic surface interaction with the hoof.

Published fracture and injury rates

The differences in the interaction between the hoof and the surface are reflected by differences in the type and location of injuries and fracture site observed in horses racing on the different racetrack surfaces. On turf tracks, the most common presentation for fracture is the proximal phalanx and the lateral condyle of the third metacarpal bone, whereas on synthetic (and dirt) tracks, proximal sesamoid fractures are more common. The differences in location of fracture type with different surfaces reflects the differences in firmness of the surfaces (compliance), the relative shear and grip of the surface and the timing of these during the different stages of limb contact.

In the UK, it is reported that synthetic surfaces are associated with a higher fracture rate than turf surfaces (Parkin et al., 2004). Synthetic tracks also record a higher rate of soft tissue injures (flexor tendon and suspensory ligament) than turf tracks (Parkin et al., 2004; Williams et al., 2001). In a more recent study focusing on just synthetic surfaces in the UK, the incidence rate for fatality was 0.90 / 1,000 starters and for distal limb fracture was 0.95 /1,000 starters (Rosanowski et al., 2017c).

The most comprehensive records of fatal injuries in Thoroughbred racing are associated with the USA equine industry database. The incidence rate for fatal injuries on different track surfaces for 2009-2023 are presented in Figure 6. The 15-year average values are presented in yellow. Synthetic surfaces in USA racing had a lower incidence of fatal injuries than turf or dirt surfaces.

Surface	2009			2010			2011			2012			2013			2014			2015		
	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts
ALL	790	395897	2	727	387671	1.88	713	379285	1.88	709	369565	1.92	643	339104	1.9	583	308923	1.89	500	306654	1.63
Turf	88	45456	1.94	81	50701	1.6	77	50054	1.54	94	53991	1.74	71	51463	1.38	88	50366	1.75	70	56198	1.25
Dirt	617	293306	2.1	585	286584	2.04	586	283531	2.07	570	271851	2.1	524	248418	2.11	455	225201	2.02	397	222405	1.79
Synthetic	85	57135	1.49	61	50386	1.21	50	45700	1.09	45	43723	1.03	48	39223	1.22	40	33356	1.2	33	28051	1.18

	2016			2017			2018			2019			2020			2021			2022			2023			2009-2023		
	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts	Fatal injuries	Starts	per 1000 starts
ALL	483	314459	1.54	493	305929	1.61	493	293555	1.68	441	288565	1.53	333	236561	1.41	366	264200	1.39	328	262761	1.25	336	253640	1.32	7938	4706769	1.69
Turf	65	59629	1.09	79	58259	1.36	65	54323	1.2	87	55878	1.56	59	46380	1.27	63	50479	1.25	45	45278	0.99	50	44305	1.13	1082	772760	1.4
Dirt	385	225898	1.7	384	220428	1.74	394	211535	1.86	329	205882	1.6	254	170569	1.49	285	188979	1.51	271	187918	1.44	257	179547	1.43	6293	3422052	1.84
Synthetic	33	28932	1.14	30	27242	1.1	34	27697	1.23	25	26805	0.93	20	19612	1.02	18	24742	0.73	12	29565	0.41	29	29788	0.97	563	511957	1.1

Figure 6. Fatal injuries in USA horse racing for different racetrack surfaces (Turf, Dirt and Synthetic) from 2009-2023.

Australia represents the closest analogue to the racing that occurs in New Zealand. Rates for MSI and fracture in all racing published from Australia demonstrate a similar pattern to New Zealand. At present there are no published values permitting comparison of injury or fracture rate between turf and synthetic surfaces in Australia.

Literature review summary

Surface type, consistency and track geometry (including turn radius and camber) have a large impact on limb loading and risk of injury in racehorses galloping at high speeds. Consistency of track surface and the adaptation of the horse's limb to certain surfaces (through training on specific surfaces) reduce the risk of injury. Synthetic tracks, made from mixed fibres and silica sand coated with wax, vary in firmness and grip with temperature changes and preparation methods, all of which affect the hoof-surface interaction. Effective track management aims to maintain predictable and safe conditions by ensuring consistent surface properties and considering track geometry to minimise injury risks.

New Zealand Synthetic Tracks

New Zealand has recently introduced racing on three synthetic tracks, located at Awapuni, Cambridge and Riccarton. The three synthetic tracks in New Zealand have different dimensions and configurations (Table 2). The Cambridge track was built over the site of a previous track and has a square egg shape with an 1880 m circumference. Riccarton is also an egg style configuration (1914 m circumference) built within the existing turf track, and Awapuni has the classic oval shape (1556 m circumference), also built within an existing turf track (Figure 7).

To describe the flattened arc of the turns, an aspect ratio for each turn was calculated. The aspect ratio was the ratio of the true radius of the turn divided by half the distance between the two straight sections of track. A higher aspect ratio means a wider, more gradual turn, while a lower aspect ratio indicates a sharper, tighter turn.

Table 2. Physical properties of the three synthetic tracks (Awapuni, Cambridge and Riccarton) and the average dimensions of turf tracks in New Zealand

Track properties	**Awapuni Synthetic**	**Cambridge Synthetic**	**Riccarton Synthetic**	**Turf oval (average)***	**Turf egg (average)***
Circumference (m)	1556	1880	1914	1800 (1600-1800)	1800 (1600-1876)
Back straight length (m)	318	188 & 94	56 & 272	400 (350-450)	350 (250-350)
Home straight length (m)	318	251	363	363 (350-425)	350 (300-400)
Average track width (m)	16	~est 16	~est 16	N/A	N/A
Aspect ratio of turn into home straight	1.02	1.05	0.98	1.19 (1.13–2.24)	1.22 (1.15–1.3)
Aspect ratio of turn into back straight	1.02	0.94 & 1.59	0.88 & 2.50	1.17 (1.12–1.29)	1.36 (1.06–1.54)
Turn radius to home straight	146	177	165	145 (124-164)	144 (92-192)
Turn radius to back straight	146	172 & 150	120 & 250	148 (131-161)	152 (105-202)
Camber on home straight turn	6%	6%	6%	Est 2 – 6%	
Camber on back straight turn	3%	5% & 5%	4% & 3%	N/A	N/A
Camber transition home straight	2-6% & 6-2%	2-6% & 6-2%	2-6% & 6-2%	N/A	N/A
Camber transition back straight	2-3% & 3-2%	2-5% & 5-2%	2-4% & 4-2% & 2-3% & 3-2%	N/A	N/A
Crossfall home straight	2%	2%	2%	N/A	N/A
Crossfall back straight	2%	2%	2%	N/A	N/A
Est. median centrifugal forces of turn into home straight (N)+	772	636	683	771 (695–908)	662 (557–893)
Est. median centrifugal forces of turn into back straight (N)+	772	655 & 751	939 & 451	798 (695–908)	979 (586–1,224)

*(Rogers et al., 2014)

+ Based on a 440kg racehorse.

A B C

Figure 7. Racetrack shape and turn radii for A) Awapuni, B) Cambridge and C) Riccarton synthetic racetracks.

The dimensions of the Riccarton and Cambridge synthetic tracks are close to the industry average for turf tracks in New Zealand (Table 2). However, all the synthetic tracks appear to have shorter straights, ride as if they have tighter turns (lower aspect ratio) and have a reduced width compared to traditional New Zealand turf tracks. Despite the synthetic tracks having lower aspect ratios for some of the turns, the resultant estimated centrifugal force was similar to the average value for New Zealand turf tracks, due to similarity in the absolute radius of the turn. Although there is limited data published for comparison of track dimensions, turn radius on USA dirt racetracks can range from as little as 50 m up to >130 m (Peterson et al., 2021b). Data from a subset of the tracks used in the Peterson et al. (2021b) study are presented in Table 3 and Table 4. Based on these data, the New Zealand synthetic tracks have a turn radius similar to those in the upper quartile of racetracks in the USA.

Table 3. Turn radius and circumference of racetracks in America. (Kaleb Dempsey, *pers. com*).

Track	Turn Radius (m)	Circumference (m)
Arlington park	152	1609
Golden Gates Fields	122	1609
Presque Isle Downs	122	1609
Santa Anita (synthetic)	76	1287
Gulfstream Park (synthetic)	144	1673
Turfway Park	122	1609
Woodbine	122	1609
Average	**123**	**1609**
Standard deviation	**24**	**161**

Table 4. Average turn radius comparison between dirt, turf and synthetic tracks in America. (Kaleb Dempsey, *pers. com*).

Descriptor	Dirt	Turf	Synthetic	All
Sample size	124	45	12	181
Average radius (m)	103.7	99.8	129.4	104.4
Standard deviation	29.2	15.7	9.1	16.3

Data on the camber (banking) of the turns on the synthetic tracks appears to be within the industry standards. Synthetic tracks have a similar issue as dirt tracks, where the camber and cross fall can result in the movement of material from the outer track towards the inside rail. This is a key focus of the track management with dirt tracks in the USA. There is generally limited data published or easily accessible internationally on the level of banking on turns for gallop race tracks (Peterson et al., 2021b).

Properties of NZ synthetic surfaces

All synthetic surfaces in New Zealand are from one provider (Martin Collins – *Polytrack*). The surface profiles of the three NZ synthetic surfaces are outlined in Table 5. The surface depth of the three synthetic tracks in New Zealand is 15 cm which is the same depth as synthetic racetracks in Singapore, Australia and Chantilly in France.

Table 5. Surface profiles of the three NZ synthetic racetracks.

Parameter	**Awapuni Synthetic**	**Cambridge Synthetic**	**Riccarton Synthetic**
Surface depth (cm)	15	15	15
Porous Asphalt (cm)	6	*6	*6
Gravel drainage	8 to 10 cm	*8 to 10 cm	*8 to 10 cm
Volumetric Moisture content (%)	2.6%	*2.6%	*2.6%

Footnote: * data provided verbally

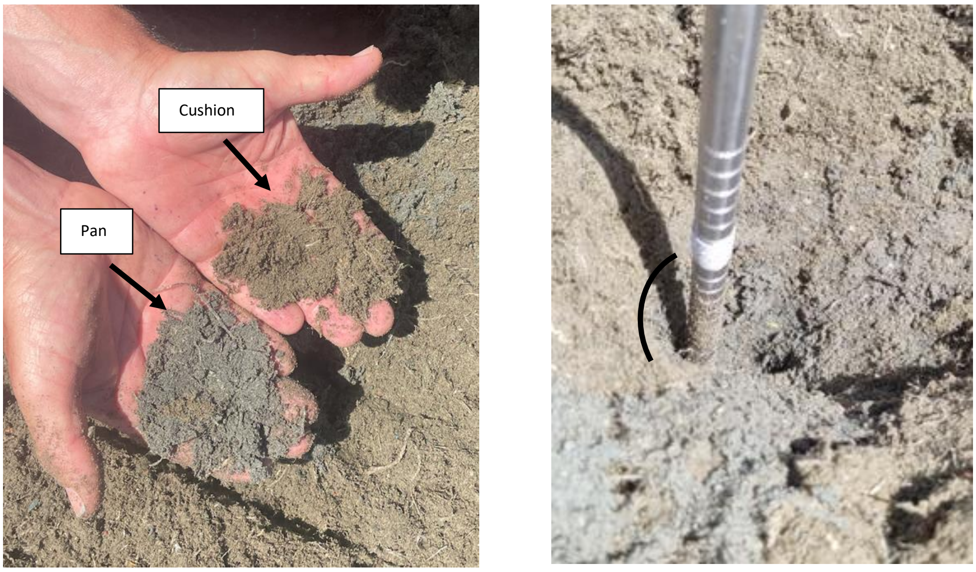
Visual parameters of NZ Synthetic tracks

All three New Zealand tracks were prepared according to the same preparation protocol (sand type and size and relative composition of material components). There are some differences in the appearance of the tracks due to sourcing sand from different quarries. The following figures are photographs from the New Zealand synthetic racetracks to provide visual parameters. Figure 8 illustrates the different colour gradients of the three New Zealand synthetic tracks.

A **B** **C**

Figure 8. Different colour and composition of the three synthetic tracks in New Zealand. **A)** Awapuni **B)** Cambridge **C)** Riccarton.

Within the tracks there is some variation in colour of the *Polytrack* material. The upper cushion layer tends to have a lighter colour in comparison to the pan which is more compacted and darker in colour (Figure 9).



A **B**

Figure 9. Photos of the **A)** colour difference and **B)** colour gradient from the cushion to the pan layer at the Awapuni Racetrack.

Clumping of the cushion layer

At some tracks there have been reports of the cushion appearing to clump or provide the appearance of clumping, even after track maintenance (Figure 10). In association with the reported clumping of the top cushion layer there appears to have been a “rising pan”. This presentation indicates that there has been some separation of the material components of the track and consolidation of the wax and sand components in the base layer. Drivers for this can be temperature changes and the grooming equipment not penetrating the top layer of the pan. Once consolidation of the pan has started it can be difficult for the tynes of the grooming equipment to obtain sufficient penetration to break up the consolidated pan. Within the maintenance protocol it is recommended to alternate the level of the tynes to minimise the chances of this occurring. Given the environmental differences between the three synthetic tracks, a tailored approach for each track should be developed to minimise the chance of clumping and a rising pan occurring. A more robust monitoring protocol and close liaison with Martin Collins is recommended.

A **B** **C**

Figure 10. **A)** hoofprints on a freshly groomed surface **B)** suggested clumping of the cushion layer **C)** water retention on a synthetic track indicating capping / consolidation of pan

Monitoring Pan depth – use of the depth stick

The rising pan issue identified could be empirically measured using the depth stick which is utilised by Martin Collins to measure the depth of the pan (Figure 11). The advantage of the depth stick is that it provides a repeatable metric (depth of the pan). Additionally, pushing the stick over provides a qualitative measure of how tightly the pan is binding. The specifications for the depth stick are provided in Appendix 3. Obtaining these additional measurements will help establish how the pan depth changes in response to track temperature, different grooming techniques and the impact of the camber. To reduce the risk of camber impacting cushion and pan depth, it is important that grooming equipment is adjusted to account for both the camber on the turns and cross fall on the straights (Figure 12).

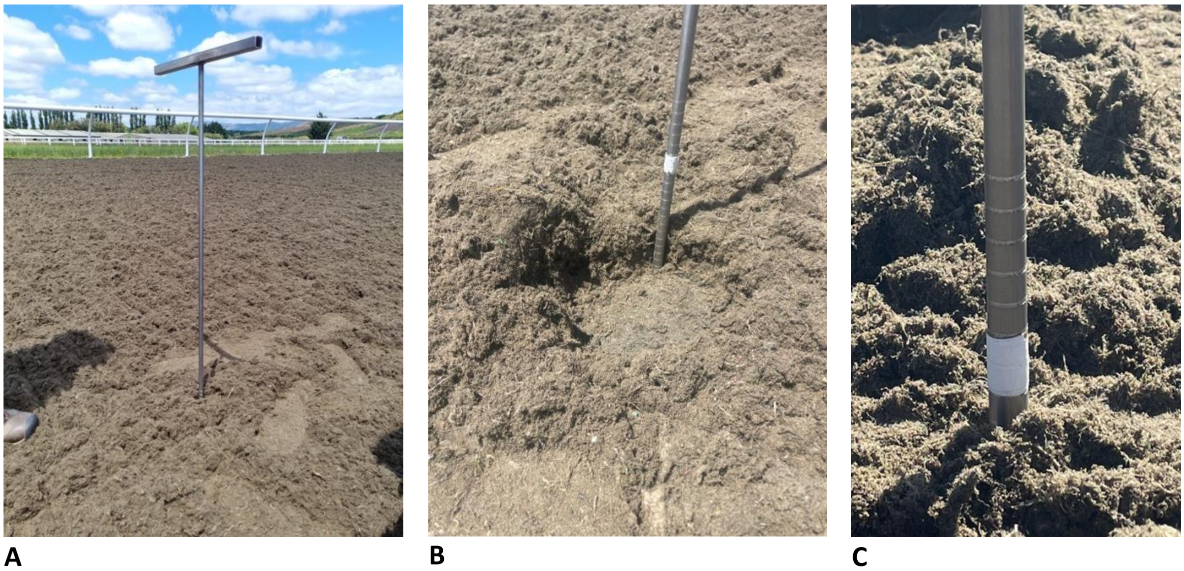


Figure 11. **A)** Depth stick measuring the cushion layer **B)** depth stick showing pan level once cushion has been removed **C)** Depth stick with marker at 150mm showing where to take the measurement.

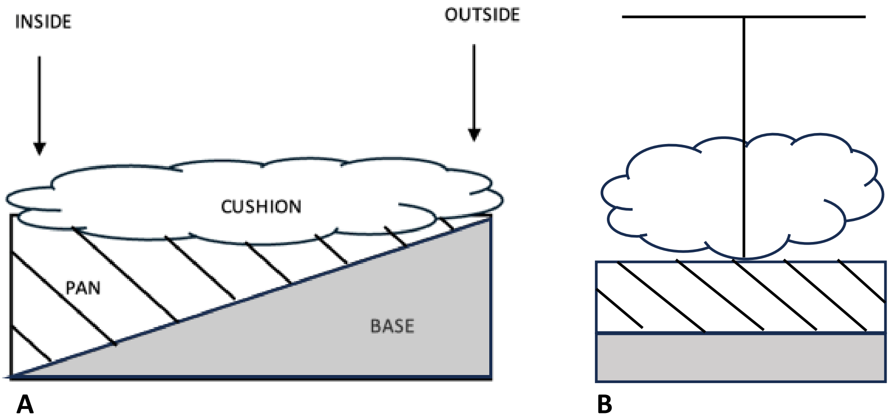


Figure 12. **A)** Depiction of the camber on the turn of a synthetic track, showing movement of the material outside to the inside of the turn. This highlights the importance of measuring cushion height and pan depth. **B)** Recording the cushion depth using the depth stick.

Similar to the Clegg hammer readings, the pan depth recordings should be taken at every 100 m mark around the entirety of the track (including the chute and back turn) with the inside, middle and outside positions remaining the same.

For simplicity and ease of recording, the recommendations for the pan depth follow the same pattern as the Clegg hammer:

- Weekly cushion and pan depth recordings on the inside of the track.
- Monthly cushion and pan depth recordings on the inside, middle and outside of the track.
- Cushion and pan depth recordings day prior to a race meeting on the inside, middle and outside of the track.
- Cushion and pan depth recordings prior and post power harrowing on the inside, middle and outside of the track.

Temperature

Previous studies have shown that synthetic tracks vary in firmness and grip with temperature changes. Currently there is no data being recorded on the synthetic track surface temperature in New Zealand. New Zealand has a temperate climate and does not have the extremes other racing jurisdictions, such as North America experience. Staff at Awapuni have identified seasonal changes in track responsiveness to grooming which may be associated with temperature changes. As part of the quality assurance programme, it would be valuable to have regular metrics on the track surface temperature. This data would enable us to corelate changes in temperature with track responsiveness, allowing track staff to respond with the appropriate maintenance strategy. Additionally, it would align with HISA protocols which require track temperature recordings to be taken daily.

The current understanding and knowledge of the temperature gradient of the synthetic track at Awapuni is shown in Figure 13. Measurements were taken at 2cm intervals until the base was reached. The temperature at the top of the synthetic surface (39°C) was greater than the ambient air temperature at the track of 23°C. The temperature within the synthetic cushion steadily decreased with increasing depth, with the temperature plateauing at 26°C in the pan.

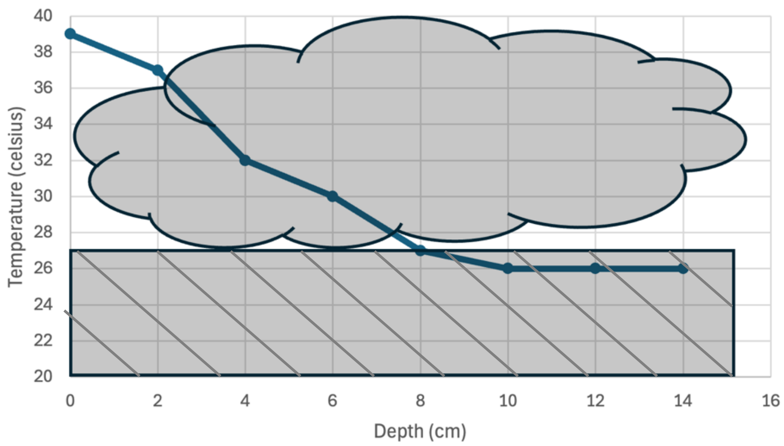


Figure 13. Temperature (°C) of the Awapuni Synthetic racetrack. Recording at 2cm intervals from the surface of the track to the asphalt base. Measurements were taken on the 7/02/25, with ambient air temperature of 23°C.

Clegg Hammer

At present, the primary device in New Zealand used to describe the track properties is the Clegg hammer. When using the 3rd drop of the Clegg hammer, it appears to have some repeatability and association with other measurement techniques to quantify track surface hardness. However, the Clegg hammer does not provide a metric that consistently reflects the material properties of the track. The current recommendation is to continue to use the Clegg hammer, but to actively investigate the use of more precise measurement tools such as the OBST to ensure measurements are in line with current industry best practice. Table 6 shows the difference between the readings from the three Clegg hammer drops and the importance of using the third drop due to the large variation between drops.

Table 6. Variation in the three Clegg hammer drops for the inside (close to inside rail), middle (middle of track) and outside (close to outside rail) of the Synthetic track. Values denote the difference between drops.

Difference between drops	Inside	Middle	Outside
Clegg 1 – Clegg 2	-17.94	-19.83	-17.82
Clegg 2 – Clegg 3	-14.29	-14.31	-14.36
Clegg 1 – Clegg 3	-32.52	-34.14	-32.18

Awapuni staff informally reported a firm spot at the 500m mark, corresponding to the apex of the home straight turn. This increased firmness in the home straight could be due to substrate movement on the cambered turn (Figure 3) or due to the use of grooming and harrowing devices that were not tilted appropriately to account for the higher surface camber of the turn (6° vs 2° on the straight). It is likely that this is a combination of both factors, resulting in a rising pan, which would record firmer clegg hammer measurements. While the back straight turn has a lower camber than the home straight turn, if measurements were made on the back straight turn, this may assist in understanding the drivers of increased firmness on the home straight turn. Therefore, we recommend continuing the Clegg hammer readings around the entirety of the track.

The following recommendations are designed to meet the contractual obligations set by Martin Collins whilst aligning with the standards required by HISA. These recordings will capture the data required for robust understanding of material property changes over the changing seasons and track response to grooming.

- Weekly Clegg hammer recordings on the inside of the track.
- Monthly Clegg hammer recordings on the inside, middle and outside of the track.
- Clegg hammer recordings a day prior to a race meeting, on the inside, middle and outside of the track. (HISA requirement).
- Clegg hammer recordings prior and post power harrowing on the inside, middle and outside of the track.

The recommended recordings should be taken at every 100m mark around the entirety of the track (including the chute and back straight turn). Inside recordings are approximately 2 meters off the inside rail, middle recordings in the middle of the track and the outside recording approximately 2 meters off the outside rail.

Preparation and management protocols

The key to all racing surfaces is consistency, and this includes synthetic tracks. The ability to obtain consistency depends on documentation of processes, obtaining meaningful metrics, and review of observations (monitoring processes). With synthetic tracks, the primary factors affecting the spatial consistency are compaction (cultivator vs harrow), grading and segregation of material. Across time periods or seasons (temporal), variables such as degradation of wax and fibre, weather and temperature can affect how the track responds to management strategies and use (Peterson, 2014).

The required inputs into quality management of racetrack surfaces can be summarised in the diagram below (Figure 14).

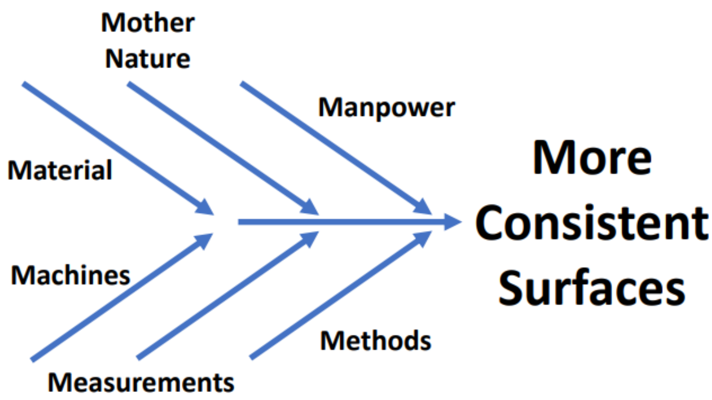
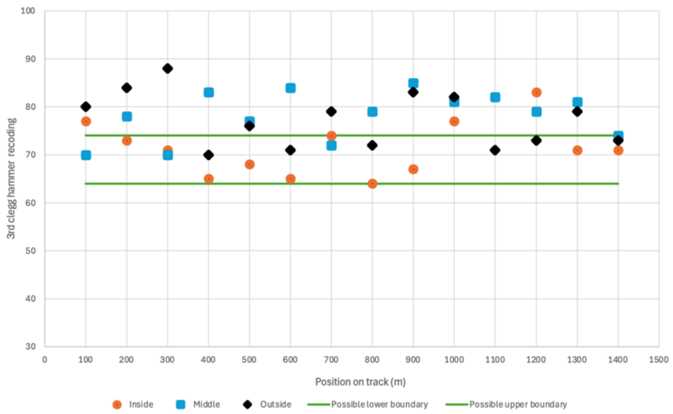


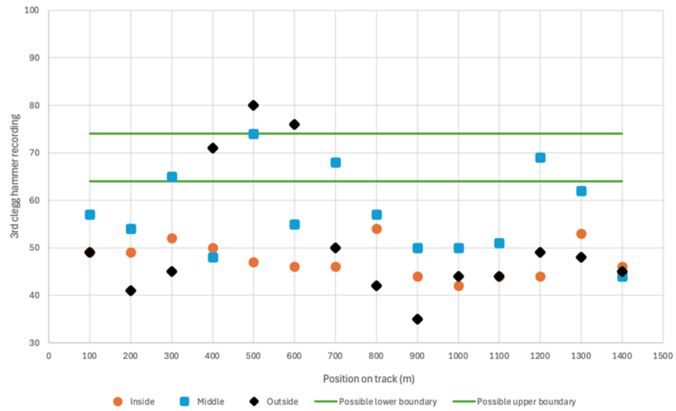
Figure 14. Inputs into quality management of racetrack surfaces, modified from Peterson (2018).

As can be observed from Figure 14, there are multiple inputs into surface management, some of which are unique to the track's location or the track surface material. It is this variation that limits the establishment of a set protocol to optimise track surfaces in different locations. The objective of any management protocol should be to achieve the optimal racing and training surface, as defined within the literature, to optimise horse – surface interaction and have the lowest injury risk profile. Therefore, location and weather conditions need to be considered in track management guidelines or protocols. Good documentation of management protocols is key to the maintenance and improvement of racetrack surface quality, and is essential to maintain safety, performance and cost to all users.

The impact of power harrowing is depicted in Figure 15. The green lines denote possible upper and lower boundaries for Clegg hammer recordings and provide a simple visual representation of consistency around the track. Ideally all measures should be between the green lines.



A



B

Figure 15. Inside (against inside rail), mid (middle of track) and outside (close to outside rail) Clegg hammer readings (3rd drop) at different track positions against the possible upper and lower boundaries of track condition (green lines). A) Pre power harrow, B) Post power harrow.

In the USA, translation of these input parameters into quantifiable tasks or descriptors has resulted in the generation of the following tables (Table 7 - 9) relating to the design and setup of a track, the seasonal or race day variables and the daily tracking and measurements (Peterson, 2018). The monitoring of racetrack maintenance is the most difficult to document due to variation in management systems and staff level and compliance.

Table 7. Design documentation and setup of a racetrack, modified from Peterson (2018).

Variable	**Turf**	**Synthetic**
Equipment planning	Equipment documentation	Equipment documentation
Protocols	Turf calendar	Vendor manual
Composition	Moisture targets and consistency	12 Tests 4 Samples Temperature curves
Layout of Track	Turn radius and banking	Turn radius and banking
Design of the Surface	Turf species, root depth, profile	Depth, base type
Planning	Irrigation plan	
Weather	Installation of on-site or selection of off-site station	

Table 8. Race day or seasonal testing of racetrack surface conditions, modified from Peterson (2018).

Variable	**Turf**	**Synthetic**
Cushioning	Equine Dynamic Impactor (EDI) / Penetrometer	Orono Biomechanical Surface Tester (OBST)
Response		OBST
Firmness	EDI / Penetrometer	
Profile		Ground Pen. Radar
Moisture	High resolution mapping	
Composition & Consistency	Penetration and turf survey	6 Tests 4 Samples

Table 9. Daily tracking and measurements of racetrack maintenance and surface, modified from Peterson (2018).

Variable	**Turf**	**Synthetic**

Equipment movement	Daily log	Daily log GPS if available
Weather data & evaporation	Weather station	Temperature
Moisture	TDR	Track surface temperature
Cushion depth		Manual Measure (depth stick)
Firmness	Penetrometer	

Within New Zealand we are fortunate that all synthetic surfaces are from the one provider (Martin Collins – *Polytrack*), and this provides consistency in the point of contact, material used and ability to implement consistent management strategies. The management protocols for synthetic racetrack surfaces in New Zealand, as proposed by Martin Collins are summarised in Table 10.

Table 10. Summary table of track management protocols for synthetic tracks as proposed by Martin Collins for the *Polytrack* (source: Martin Collins).

Track staff	**Daily**	**Weekly**	**Monthly**	**Yearly**
Use of Gallop master for track grooming. Speed not to exceed 7km/h when tynes set higher than 2.75.	X			
Manure collected off the track.	X			
Crossing monitored for contamination.		X		
Clegg Hammer & compliance tolerances.			X	
Depth checks & compliance tolerances Propriety synthetic layer 135mm -165 mm Intermediate fibre layer 85mm -115mm.			X	
Completion & submission of maintenance spreadsheet.			X	
Martin Collins Reports on Polytrack to customer.			X	
Inspect track and consult with ground staff (depth checks, sample taking).				Quarterly
Track composition examination (sample examination). Inclusive of the top 50mm and bottom 50mm of the track.				Quarterly
Assessment of samples at NATA laboratory (wax, fibre, and sand percentages). Report to customers.				Quarterly
Re-levelling of the Polytrack surface, inclusive of: deep harrowing; and levelling of the surface.				Every 4 months
Re-levelling of the Polytrack surface Deep harrowing, flipping and levelling (after two years).				X
Annual infiltration testing of the porous asphalt layer of the Polytrack at 200m intervals. If results indicate rate less than 350mm/hr within a tested area than notification to customer in writing and restoration to above 350mm/hr.				Annually (failed test areas re-tested at 6 monthly intervals)
Re-waxing of Polytrack surface.				36 months from initial installation and in 7th year after initial installation (unless agreed otherwise)

Despite the quality assurance protocols proposed Table 10, there is variation in the adherence to the suggested quality assurance programme and the use of metrics to quantify or support subjective evaluation of track consistency and properties. Table 11 summarises the management protocols followed by the track staff for each of the synthetic tracks in New Zealand.

Table 11. Current understanding of management protocols and measurement of parameters at the three New Zealand synthetic tracks (2024).

Track Staff	**Cambridge**	**Awapuni**	**Riccarton**
Grooming (with Gallop Master?)	daily	daily	daily
Manure collected off the track	Yes	Yes	Yes
Crossing monitored for contamination	Yes	Yes	Yes
Use of Clegg Hammer	~ Daily	~ Daily	Daily since January 2025
Measurement of pan depth	Yes – with Depth Stick	Yes- with Depth Stick	Yes
Power harrow	Yes – frequency – every 6 to 8 weeks	Historically ~ every 3 months	Historically every 3 to 4 months
Method of reporting	Recorded on sheet	Recorded on sheet	Recorded on sheet
Martin Collins			
Inspect track and consult with ground staff	*~Quarterly*	*~Quarterly*	*~Quarterly*
Track composition examination (sample examination)	*Planned ~Quarterly*	*Planned ~Quarterly*	*Planned ~Quarterly*
Assessment of samples at NATA laboratory	*Planned ~Quarterly*	*Planned ~Quarterly*	*Planned ~Quarterly*

Use of New Zealand Synthetic racetracks

The synthetic track at Cambridge opened in May 2021. Riccarton Park Synthetic opened one year later in May 2022, and Awapuni synthetic opened the following year, in May 2023. Race data from both synthetic and turf racetracks were compared between the 2021/22-2023/24 race seasons, as these were the seasons with comparable racing on both turf and synthetic racetracks. Table 12 summarises race variables from each of the synthetic tracks with that from comparable turf tracks used over the same period.

During the 2021/22-2023/24 race seasons there were 74,576 race starts, of which 68,366 (91.7%) starts were on turf and 6,210 (8.3%) were on synthetic. The majority (80% of starts) on synthetic tracks were during the winter and autumn seasons (Table 12). Winter is usually when turf racing speeds are slower, due to heavier track conditions. However synthetic tracks are producing similar race speeds to summer turf racing (Figure 16).

During the examined seasons, 7,734 horses had at least one race start, of which 2,210 (28.6%) horses had at least one start on both synthetic and turf racetrack surfaces types. A large proportion of horses (5,398, 69.8%) only started on turf tracks with only 126 (1.6%) horses only starting on synthetic tracks.

Table 12. Thoroughbred flat race and start characteristics (median and IQR) for synthetic (Awapuni, Cambridge and Riccarton tracks) and comparable turf tracks during the 2021/2022 – 2023/24 racing seasons.

Descriptor	**Awapuni**	**Cambridge**	**Riccarton**	**Turf track**

	Synthetic	Synthetic	Synthetic	Good track (whole season)	Autumn/winter
Track variables					
Quantification methods	Clegg	Clegg	N/A	Penetrometer and TCS	Penetrometer and TCS
Clegg or penetrometer	74 [70-77]	73 [69-78]	N/A	2.7 [2.6-2.8]	3.5 [2.8-4.9]
TCS	-	-	-	4 [3-4]	7 [5-10]
Number of races	86	310	255	2,132	2,676
Number of starts	731	2,952	2,527	23,786	28,373
Median starters per race	8.5 [7-10]	10 [8-12]	10 [8-12]	11 [9-13]	11 [9-13]
Ratings of horses	54 [48-62]	52 [47-61]	58 [50-63]	61 [50-67]	60 [50-65]
Horse age (years)	4 [4-5]	4 [3-5]	4 [4-5]	4 [4-5]	4 [3-5]
Race distance (m)	1400 [1200-2140]	1300 [1300-1550]	1400 [1200-1600]	1400 [1215-1600]	1400 [1200-1600]
Previous start on Turf track (n, %)	432 (59.1%)	1,312 (44.4%)	1,256 (49.7%)	22,365 (94.0%)	26,235 (92.5%)
Previous start TCS (if on turf)	7 [5-10]	7 [5-10]	6 [4-8]	5 [4-7]	6 [4-9]
Race Variables					
(All) Speed last 600m (m/s)	16.8 [16.4-17.1]	17.1 [16.6-17.5]	17.1 [16.7-17.4]	16.9 [16.4-17.3]	16.1 [15.2-16.8]
Early day Speed last 600m (first 2 races) (m/s)	16.6 [16.3-16.9]	16.8 [16.4-17.2]	17.0 [16.6-17.4]	16.9 [16.4-17.3]	16.2 [15.3-16.9]
Late day Speed last 600m (Race 6) (m/s)	16.4 [16.0-16.8]	17.6 [17.1-18.0]	17.1 [16.8-17.5]	16.8 [16.4-17.2]	16.0 [15.1-16.7]
Musculoskeletal injury					
MS injury rate (IR per 1,000 starts)	4.10 (0.85-11.99)	3.05 (1.39-5.79)	3.17 (1.37-6.24)	2.56 (1.96-3.29)	1.93 (1.49-2.52)
MS fatality rate (IR per 1,000 starts)	1.37 (0.04-7.62)	0.34 (0.01-1.89)	1.19 (0.25-3.47)	0.50 (0.26-0.88)	0.18 (0.08-0.41)

Horses are running faster on the synthetic tracks than on the turf tracks (Figure 16). During the winter months the horses' transition from a turf track with a track condition score of 7 [IQR, 5-10] to the synthetic tracks. For those horses which had a previous start on a turf track prior to a synthetic track, the turf track was generally rated with a track condition score of 6 or 7. This represents a change in the pattern of how the race is run (more initial speed on synthetics) and a difference in the loading of the limb, particularly in the rate of deceleration of the limb on initial ground contact. This difference in the rate of deceleration associated with a synthetic track versus a soft or heavy turf track may explain the comments from some trainers that horses inexperienced at running on synthetic tracks appeared to jar up. As presented in the literature review, horses can tune / refine the limb tension of the limb based on the surface they are working on. At present we lack empirical data on the number of exposures required for a horse to develop this template. Anecdotal data indicates that 2 -3 runs on the synthetic surface are sufficient for the horse to acclimatise (adapt their gait) to the surface. Because horses naturally run faster on the synthetic surface with longer strides (~20cm longer), it is anecdotally reported that acclimatisation runs should be conducted with the horses "on the bridle". This would provide sufficient load cycles to train the limb without exposure to peak forces.

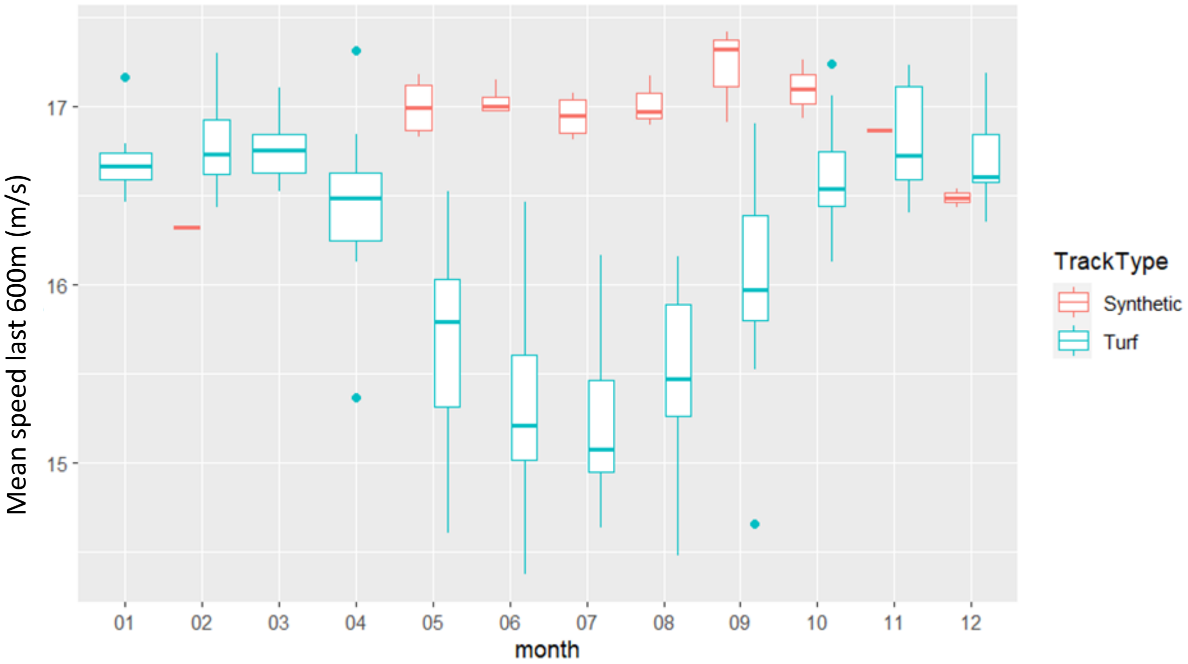


Figure 16. Race speed (m/s) over the final 600m for synthetic and turf tracks according to month of the year for the 2018/19-2023/24 NZ flat racing seasons.

The crude (univariable) estimates of musculoskeletal injury (MSI) and fracture on synthetic tracks appear to be higher than the estimates for turf tracks as well as for turf tracks matched for the same season. Caution should be used when interpreting these incidence rates, as they are univariable estimates and have not accounted for class of horse or other variables known to impact both MSI and fracture rates. The relative number of starts on the synthetic tracks are also relatively low and this is reflected in the wider confidence intervals provided for the estimates. Large confidence intervals reflect the lower certainty in the value being presented and the greater chance for bias in the estimate. At the completion of the current winter season, there should be sufficient data to be able to conduct multivariable analysis of risk factors and provide a more robust comparison of MSI and fracture rates.

Discussion

The introduction of synthetic tracks to New Zealand were potentially viewed as a panacea for a number of industry concerns, including race day abandonments and the ability to provide a consistent racing product during the winter racing season. After a brief honeymoon period, there were comments within the industry in relation to the performance of the synthetic tracks and the rate of injuries. Such a reaction and level of discussion is not unusual for the introduction of a new training or racing surface and the reaction was similar to the response observed with the introduction of a new training surface at the Matamata race track in the 1990's (Perkins et al., 2005a, b).

As presented in the literature review, the dynamics of limb loading and deceleration of the hoof differ between track surfaces and specifically between turf and synthetic tracks. The scheduling of the use of synthetic tracks during winter accentuates this difference with horses transitioning from a slower heavier turf track to a firmer and faster synthetic track. The firmer synthetic track provides a more rapid rate of deceleration and potentially a greater load on the limb due to the greater speed.

Horses have an ability to fine tune the stiffness of the limb in response to the material properties of the surface they are worked on. In addition, some horses have a preference for different surfaces or type of going in a surface. Horses need to habituate to any track surface or change in surface type and this is especially true of synthetic surfaces with horses often requiring a number of training runs prior to racing.

The increased awareness and focus on injury rates are a natural response to any dramatic change in training practice or surface and reflects what epidemiologists refer to as recall bias. At present, the comparison of injury and fracture rates between synthetic and turf tracks has been restricted to univariable analysis, due to the relative low number of horses racing on all three synthetic surfaces and the low incidence rate for fracture within the New Zealand racing population. The crude univariable incidence rates indicate a higher rate of MSI and fracture on the synthetic tracks compared to turf tracks, but the large variation around the estimates demonstrate that caution must be applied when looking at the single point estimates for these values on synthetic tracks. These estimates do not account for a number of the variables that influence MSI and fractures rates, including type and grade of horse, racing history, and race speed (track condition).

New Zealand has an active programme to produce turf tracks with a track condition score of 3 for race day. This represents the optimal track condition for racing while avoiding the high-risk situation associated with firm tracks. Analysis of the last 600m sectional speeds on turf and synthetic tracks indicates that the sectional speeds on the synthetic tracks are closer to those observed with a firm turf track. While there are differences in racing strategy between the turf and synthetic tracks which alter racing speed, alteration in the maintenance of the synthetic surface can reduce the speed of the horses on synthetic tracks. Given the strong evidence for an increased risk of MSI and fractures with firm (faster) tracks, it would be recommended that track managers in consultation with Martin Collins, implement maintenance / preparation programmes that reduce the effective speed of the horses on the synthetic tracks.

In the USA, public concern of injury rates and track preparation in Thoroughbred racing resulted in the establishment of the Horseracing Industry Safety Association (HISA). As a result of the federal intervention, standardised protocols for the maintenance and monitoring of racetracks has been implemented. The implementation of a maintenance recording system provides greater consumer confidence in the consistency of the racing experience. At present within New Zealand, there appears to be some variation between synthetic tracks in the maintenance programmes and the recording or documentation of the processes. It is suggested that the New Zealand industry adopt a nationwide process for the documentation of synthetic track preparation, as outlined in the Appendices. Such a process will permit greater flow of information between the track managers and Martin Collins and greater ability to be proactive to tailor maintenance programmes in the different regions to optimise track performance.

Recommendations – implementation of a track surface quality assurance programme

The non-racing and racing media coverage of the use of synthetic tracks and the perceptions of issues with the synthetic tracks demonstrates the need to have a robust monitoring programme to provide industry confidence and prevent any issues arising.

The recommendations of this report are for New Zealand to adopt an industry wide quality assurance programme for synthetic track maintenance. The proposed model is a monitoring and reporting programme similar to that currently in place in the USA as part of the Horseracing Integrity and Safety Authority (HISA) racetrack reporting programme.

At present the level of recording and use of recorded information to assist with track maintenance and preparation is variable between the three tracks. The current quality assurance programme for racetracks utilised by the Horseracing Integrity and Safety Authority (HISA) is provided in Appendix 1.

Given the structure and pattern of use of the synthetic tracks in New Zealand, there could be some subtle changes to the timing of measurement events within the HISA programme. The use of metrics to define track properties within the racing surface and over time (changing seasons) would greatly improve the ability of track managers to provide a consistent surface.

Having greater consistency in collaboration between the three tracks on managing protocols is required. Reporting using the same structure across the tracks will allow for better data projection and analysis.

Measurement of track consistency

The current recommendation is to use a programme based on the Clegg hammer and the depth stick. As identified in the literature review, the Clegg hammer provides some simple metrics but does not fully describe the range of variables that are of importance when quantifying racetracks. On turf tracks the penetrometer provides a pragmatic and holistic descriptor of the variables of importance with turf racing. At present there is not a simple holistic measuring device similar to the penetrometer to describe synthetic surfaces. It would be advantageous to investigate the use of the OBST which is widely used in the USA to quantify dirt racing surfaces.

The proposed schedule of reporting is described in Table 13. Much of the schedule is based on the original documentation provided in the Martin Collins contract, with additional features from the HISA track management protocols. The recording sheet for the quality assurance programme is provided in Appendix 2.

Table 13. Proposed quality assurance maintenance sheet for New Zealand synthetic tracks.

Activity	Daily	Weekly	Monthly	Other
Weather conditions	X			
Documentation of surface maintenance	X			
Use of gallop master	X			Tyne depth recorded.
Crossing monitoring for contamination		X		
Clegg hammer		Inside	All three positions (inside middle and out)	Pre- and post- power harrowing. Day prior to race meeting
Depth stick		Inside	All three positions (inside middle and out)	Pre- and post- power harrowing. Day prior to race meeting.
Documentation of surface maintenance shared with Massey University			X	
Surface sample collection				Quarterly or 6 monthly as requested by Martin Collins
Power harrow				Based on measurements obtained and consultation with Martin Collins.
Replacement of tynes				Every 6 weeks

Visual presentation of monitoring data

The data collected can be presented in various forms depending on which is the most intuitive for the track managers.

Box and whisker plots

Figure 17 illustrates a box and whisker plot showing the impact of power harrowing on the track responsiveness and is an alternative way of displaying the data to the graphs in Figure 15. Figure 17 clearly shows the changes to the inside, middle and outside 3rd Clegg hammer readings pre- and post-power harrowing. A similar graph could be created after each power harrow to represent an easy visual of the change in the firmness of the track, with ideal ranges for the Clegg hammer recordings presented on the figure.

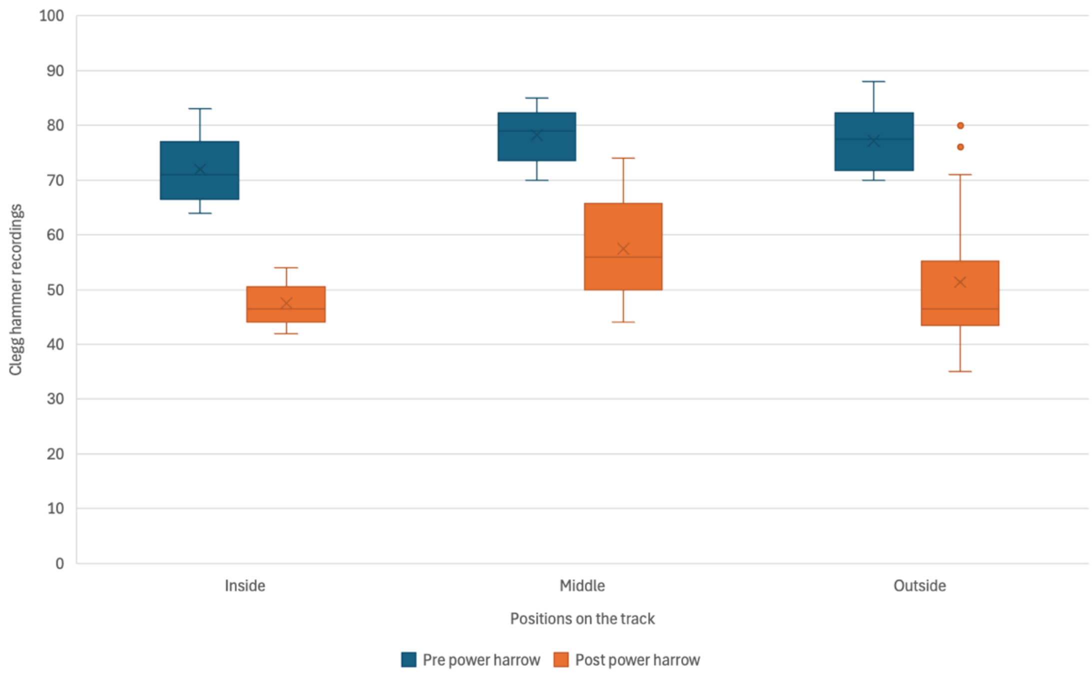


Figure 17. Box and whisker plot showing the pre and post power harrowing Clegg hammer readings (3rd drop) on the inside, middle and outside of the track.

Further detail on the Clegg hammer recordings (3rd drop) at the different locations around the track can be presented as shown in Figure 18. Each position on the track has a box and whisker plot for the inside, middle and outside track positions. This shows relatively small changes between the different positions. However, the inside recording seems to consistently be the lowest (softest) recording with the middle being consistently the highest (firmest) recordings. This could be created at 6-month intervals to check consistency of the track surface.

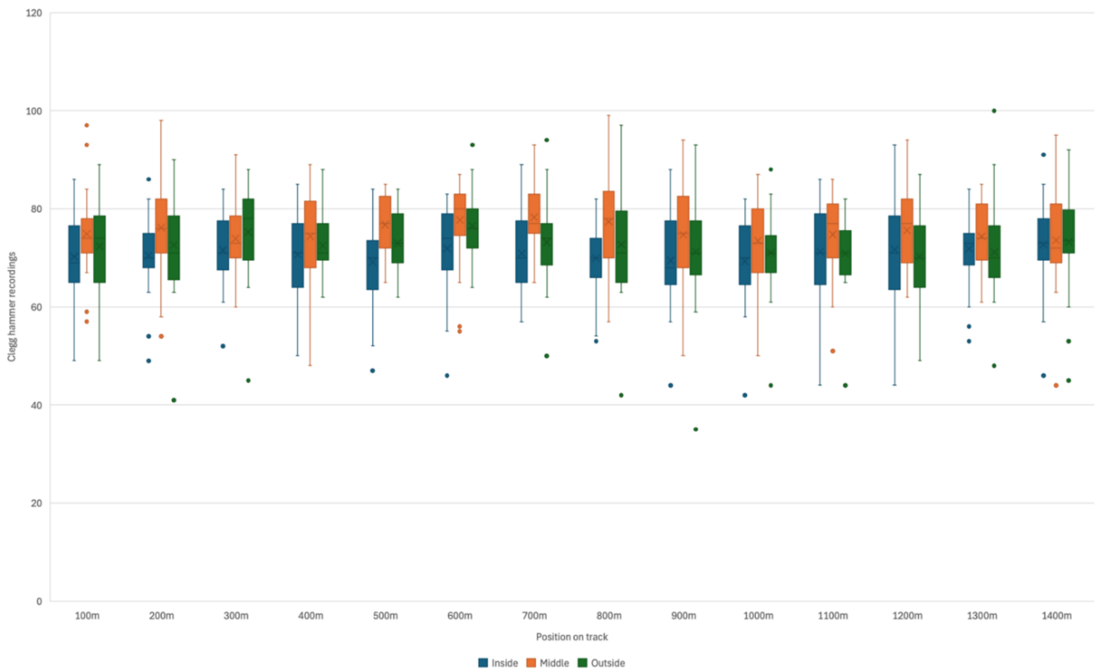


Figure 18. Box and whisker plot depicting the inside, middle and outside 3rd Clegg hammer readings at different positions around the Awapuni Racetrack over a nine-month period.

Heat maps

Heat maps are a simple visual representation of the consistency around the track using colour to represent the differences in track properties (Figure 19-22). It is important that the track remain consistent for the depth readings and Clegg hammer readings both at the inside, middle and outside of the track width, and at each 100m position around the entirety of the track, including the chute. In the USA HISA uses heat maps to present the OBST data for the racetracks monitored.

The aim in the future would be to colour coordinate the heat maps to represent the ideal measurements so track managers are easily able to identify the red areas (measurements indicating areas of immediate attention required) and green areas (ideal recordings).

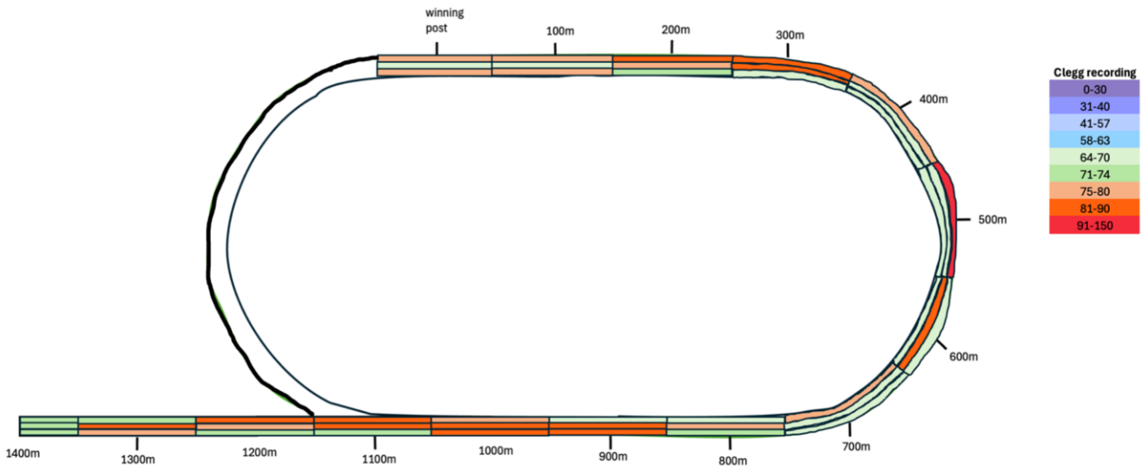


Figure 19. Heat map using Clegg hammer recordings of a racetrack on a single day at different positions around the track. Green colour represents possible ideal recordings, blue is soft and red is hard.

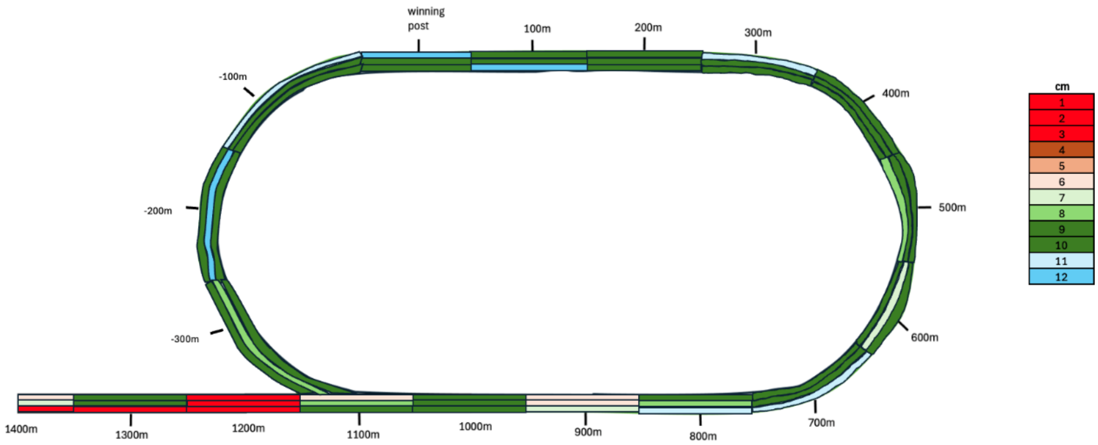


Figure 20. Heat map using cushion depth recordings of a racetrack on a single day at the different positions around the track.

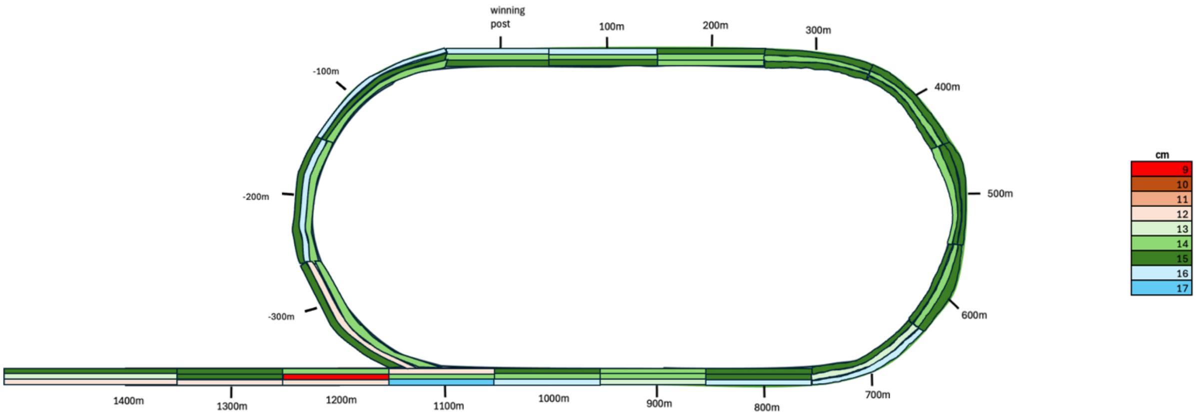


Figure 21. Heat map using base depth recordings of a racetrack on a single day at the different positions around the track.

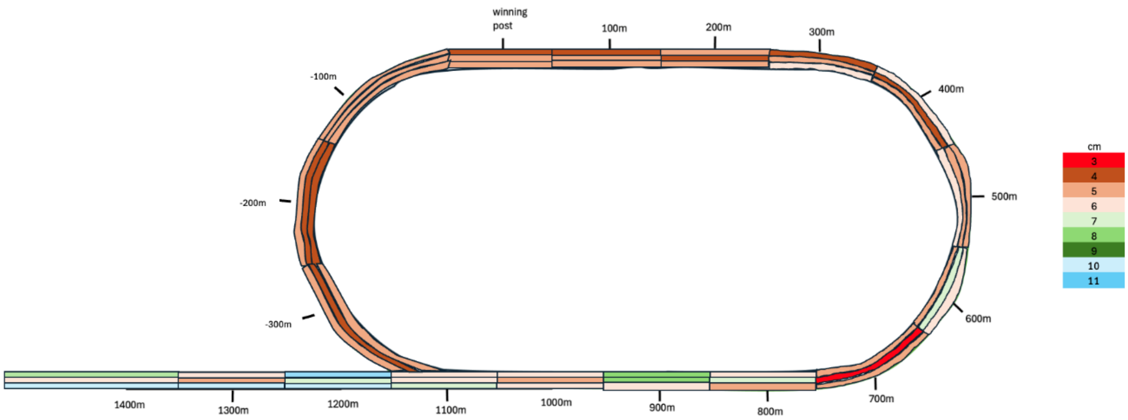


Figure 22. Heat map using pan depth calculated by subtracting the cushion depth from the base depth.

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Appendix 1. HISA quality assurance programme

Activity	**Daily**	**Weekly**	**Monthly**
Temperature	X		
Cushion depth	X		
Weather conditions and precipitation at 15-minute intervals from a national or local weather service.	X		
Documentation of surface maintenance (uploaded weekly).	X		
Sample collection			(1 - 6 months)

HISA requires the collection of three points at each quarter mile marker pole (400m) at locations 5ft (1.5m) from the inside rail.

The surface maintenance logs include recording the equipment used, direction and speed.

HISA has in place a safety director which oversees Racetrack safety, equine safety and risk management and injury prevention. The safety director ensures the Racetracks are implementing the safety standards as set out by HISA, and establishes a protocol for the reporting of health, safety and welfare issues to enable a formal investigation to be conducted and annually review the standard operating procedures and protocols related.

HISA also has Racetrack surface monitoring requirements pre-race meeting. For the synthetic racetracks they require:

- Geometry and slopes of straights, turns and slopes at each distance marker pole.
- Accuracy of distances from the finish line to the marker pole.
- Cushion and base geometries
- Surface material samples.

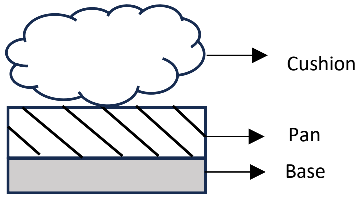
Appendix 2. Recording sheet

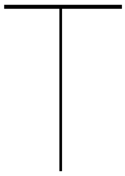
Position on track	**Clegg**			**Base depth**						**Tyne depth**	**Power harrow**	**Comments**
	Inside	*Middle*	*Outside*	*Inside*		*Middle*		*Outside*				
				Cushion	Base	Cushion	Base	Cushion	Base			
Winning post												
-300												
-200												
-100												
1400												
1300												
1200												
1100												
1000												
900												
800												
700												
600												
500												
400												
300												
200												
100												

Appendix 3. Depth stick SOP

Recording type and location

Two measurements are taken using the depth recording stick. The cushion recording and the base recording. Measurements are to be taken at every 100m around the track, including the chute and back straight turn on the inside (2m from the inside rail), middle (middle of track) and outside (2m from the outside rail) of the track.

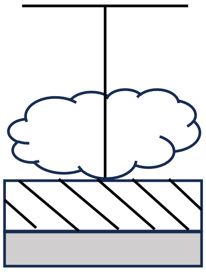




Depth stick.
22cm at top mark.
15cm mark at bottom of white tape.

The cushion recording

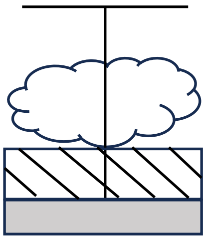
The cushion recording measures the amount of cushion from the surface down to the beginning of the pan. The pan is when the cushion becomes more compact and acts as an intermediate stage between the cushion layer and the asphalt base layer. The cushion recording should be around 10cm.



Depth stick pushed through the cushion to the top of the pan.

The base recording

The base is made of asphalt and is the layer below the pan. The base recoding is the total depth of the cushion and the pan. The base recording should be around 15cm.



Depth stick pushed through the cushion and pan until it hits the base (ashphalt).

The pan recording

To get the pan recording (the depth of the pan) subtract the cushion recording from the base recording.

Standard Operating Procedure (SOP)

1	Turn the depth stick upside down to gently even out a surface.	
2	Gently insert the depth stick point end first into the surface and stop when you feel resistance. Should be a smooth glide down without much pressure until the stick drops/starts resisting.	
3	Holding the stick upright and straight, record the line that is closest to the surface. (Recording in photo would be 8).	 
4	Continue pushing against the resistance until you feel the asphalt base. Lift the stick up and push back down and there should be a dull metallic thud.	
5	Holding the stick upright and straight, record the line that is closest to the surface. Recording in photo would be 14.	 
6	Remove stick and smooth over hole.	