WANNEROO SAFETY ENHANCEMENT OPTIONS IDENTIFICATION AND ASSESSMENT

Barbagallo Raceway, Western Australia

The Report was obtained by the Department of Sport and Recreation for provision to stakeholders for the purposes of facilitating consultation between stakeholders in relation to safety improvements at the track as a result of prior safety incidents. It is not the work of the Department of Sport and Recreation and the Department of Sport and Recreation takes no responsibility for its contents. In particular, the Department expresses no view in relation to the methodology or conclusions in the report. Recipients should act upon the Report as they think appropriate after taking independent legal and professional advice as to the process of and reasoning in the Report and the conclusions reached in it.

Disclaimer added to report by the Department of Sport and Recreation 9 December 2016.

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1. EXECUTIVE SUMMARY

1.1 A report dated 4 November 2016 was presented to WA Department of Recreation & Sport. Following the release of the report to affected stakeholders, a process of meeting with them individually and attending a combined forum with them to address their issues with content of the report was undertaken. As a result of those consultations, this report has been produced.

1.2 The racing circuit at Barbagallo Raceway was built in the late 1960's, with the first event being conducted in February 1969.

1.3 The WA Sporting Car Club (WASCC) has remained the developer and operator of the facility from the outset, with major financial assistance being provided by the WA Government.

1.4 The WA Sporting Car Club (WASCC) is the major car-racing club in Western Australia, and is involved in the direct organisation of major race meetings and race-tuning days throughout the year.

1.5 In addition to the car activities at the circuit, motorcycle racing occurs on a regular basis.

1.6 The circuit is also made available for non-race activities such as social car club meetings, testing and motorcycle ride days.

1.7 The Barbagallo circuit is currently homologated to FIA (CAMS) Grade 3 level and to Motorcycling Australia National level.

1.8 A review of the circuit compliance with the design guidelines set down by the sporting controlling bodies was conducted, and safety enhancement options were identified and assessed. The opinions expressed in relation to safety issues and possible enhancements to mitigate the potential for injury are those of the author.

1.9 The run-offs available at a number of turns do not meet the ideal requirements normally associated with the current level of homologation.

1.10 A targeted risk assessment of the non-compliant items at the circuit has indicated HIGH and EXTREME risk levels at various locations.

1.11 Turn 3 is associated with a HIGH level outcome for cars and an EXTREME level outcome for motorcycles.

1.12 Run-off deficiencies for cars at Turn 1 (exit), Turn 5 and Turn 7 (exit) are associated with LOW level outcome risk.

1.13 Run-off deficiencies for motorcycles at Turn 1 and Turn 5 are associated with HIGH level outcome risk while deficiencies at Turn 6 and Turn 7 are associated with EXTREME level outcome risk.

1.14 There are other non-compliant items at the circuit, such as the type of kerbs installed and the track width, which are considered non-critical but should be upgraded.

1.15 Non-compliant sections of poor transition from the track surface into the run-off areas should be immediately addressed through a more rigorous maintenance program.

1.16 The planned barrier installation between the run-off zone for Turn 4 and the back straight (Turn 6 to Turn 7) should be given high priority.

1.17 In its current layout and barrier design, the circuit is associated with a significant number of critical risk items that render it unsafe for motorcycle racing due to an unacceptable risk of serious injury.

1.18 Many of the safety issues associated with the insufficient run-offs can be overcome for the short to medium term, without altering barrier alignments, through designed placement, alignment and construction of appropriate energy absorbing devices.

1.19 However, Turn 3 requires re-alignment of the barrier or of the circuit to reduce the risk of rider injury to an acceptable level.

1.20 The simplest and most cost effective long-term solution to the problems at Turn 3, Turn 5 and Turn 6 would be re-alignment of sections of the track at a cost of around $350,000, but that would involve reducing the length of an already short circuit and would remove the more interesting driving/riding elements.

1.21 Upgrading of and slightly lengthening the circuit to conform to FIA/CAMS and MA requirements is likely to cost in the order of $1.7 - $2.5M for a 2.5 to 3 kilometre circuit.

1.22 Establishment of a basic level new circuit elsewhere, exclusive of land value, is likely to cost in the order of $5.5M - $6.5M for a 2 – 3 km track length.

2. BACKGROUND

2.1 The racing circuit at Barbagallo Raceway was built in the late 1960's, with the first event being conducted in February 1969. Originally known as Wanneroo Park Circuit, the facility has undergone constant development and has been renamed to Barbagallo Raceway. The track length is 2.4 kilometres.

2.2 The WA Sporting Car Club (WASCC) has remained the developer and operator of the facility from the outset, with major financial assistance being provided by the WA Government. WASCC leases the property from the Shire of Wanneroo

2.3 The WA Sporting Car Club (WASCC) is the major car-racing club in Western Australia, and is involved in the direct organisation of 9 major race meetings throughout the year (for a total of 15 race days, including the V8 Supercar event) and offers Race Tuning days to its members on 16 occasions throughout the year.

2.4 WASCC makes the circuit available to other organisations during the year, including other CAMS affiliated car clubs, recreational car clubs, and private bookings.

2.5 In addition to the car activities at the circuit, motorcycle racing occurs on a regular basis, with the Motorcycling WA affiliated club, Motorcycle Racing Club of WA, being the major hirer for two-wheeled racing events. MRCWA conducts 8 major race meetings throughout the year (incorporating 12 race days including the WA round of the Australian Superbike Championships), and a further 14 tune/ride/coaching days at the circuit.

2.6 When considering race and tune days, motorcycle utilisation of the circuit equates closely to the car utilisation. Hence, as with all other major permanent circuits in Australia, the circuit must be designed to minimize the risk of injury to both car competitors and motorcycle competitors.

2.7 This report has been prepared following a request by Western Australian Department of Sport & Recreation for a review of the race circuit compliance with relevant safety guidelines and identification and assessment of appropriate safety enhancement options.

2.8 The issue of safety cannot be separated from injury causation, which is a technical issue. Consequently, the report focuses on the technical issues at hand.

2.9 In addressing the compliance with relevant safety guidelines, the author has not considered social, financial or political issues which may be taken into account when a circuit is licenced by the appropriate sporting body. It is the author's opinion that the licensing process is an entirely different process to one which involves reviewing whether, on technical grounds, the guidelines set down by the sporting authority intending to minimise the risk of injury to participants (ie safety guidelines) have been complied with.

2.10 The author has undertaken to identify areas of significant potential injury to competitors as a basis for assessing whether the non-compliance with the ideal recommendations of each sporting body (CAMS and MA) is a significant factor.

2.11 Where it has been perceived by the author that engineering intervention is required, a number of possible enhancement options have been presented. Those options are simply provided as an insight into what could be undertaken and to promote discussion amongst the stakeholders as to how an enhancement might be achieved, should it be deemed necessary by them. That applied, similarly, for the presentation of circuit extensions.

3. SCOPE OF WORK

3.1 The following tasks were undertaken;

- Identify the current safety measures associated with the existing track
- Identify where the safety requirements set down by the relevant national sanctioning organisations are not met
- Benchmark the current configuration against the FIM Standards for Road Racing Circuits (SRRC)
- Provide a range of options that may enhance the existing safety measures
- Identify site constraints impinging upon safety improvements
- Indicate the comparative costs associated with the suggested safety enhancements
- Identify any conflicts between the safety measures required for the different motor-racing disciplines (cars v motorcycles)
- Provide a conceptual costing for future extension of the circuit and construction of an additional circuit to the north of existing facility
- Stakeholder consultation and forum addressing contents of the report dated 4 November 2016

3.2 During the project phase, consultation with the following bodies occurred;

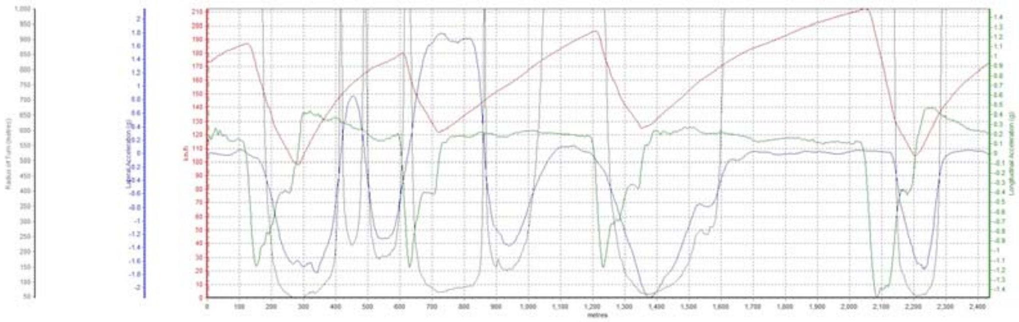
- CAMS
- WA Sporting Car Club
- Motorcycling Australia
- Motorcycling Western Australia
- Department of Sport & Recreation

3.3 In addition to the above bodies, consultation with a number of riders and motorcycle racing officials was undertaken. I was also provided with video footage of motorcycle incidents at the circuit and information presented to the WA Government by Mr Scott Elliott.

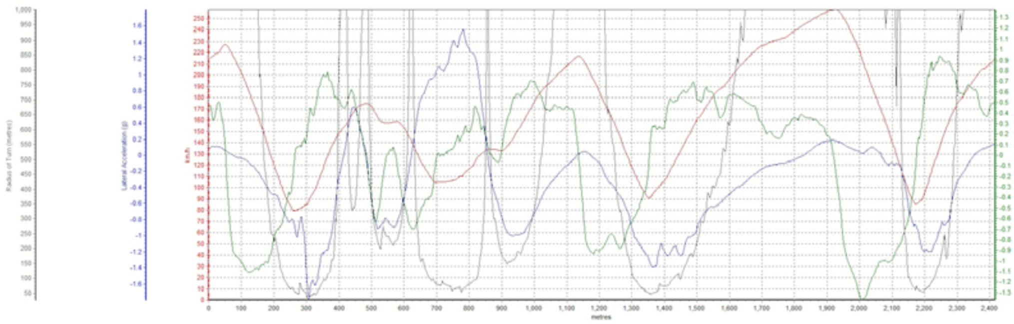
3.4 An inspection of the racing circuit was undertaken on 3 August 2016. In addition to a general inspection of the circuit and barrier lay-out, data was collected from race-vehicles performing race speed laps to determine the respective race lines and speed profiles. Data was collected for the following classes;

- Australian Superbike
- F1000
- Sports Sedan

The following speed profiles were adopted to reflect race conditions on the day of the inspection. The red line represents the speed, the blue line represents the lateral acceleration (an indicator of where a rider/driver initiates a turn) and the green line represents longitudinal acceleration (indicating where braking and acceleration occur). The grey line represents the radius of curvature of the race line adopted by the drivers/riders.



Speed Profile for F1000



Speed Profile for Superbike

The data collected was compared with the lap record times for the circuit, and was adjusted to reflect the likely quickest lap for motorcycles and cars which are ridden/driven on the circuit. The speed profile from the adjusted data was used in determining the appropriate run-off lengths.

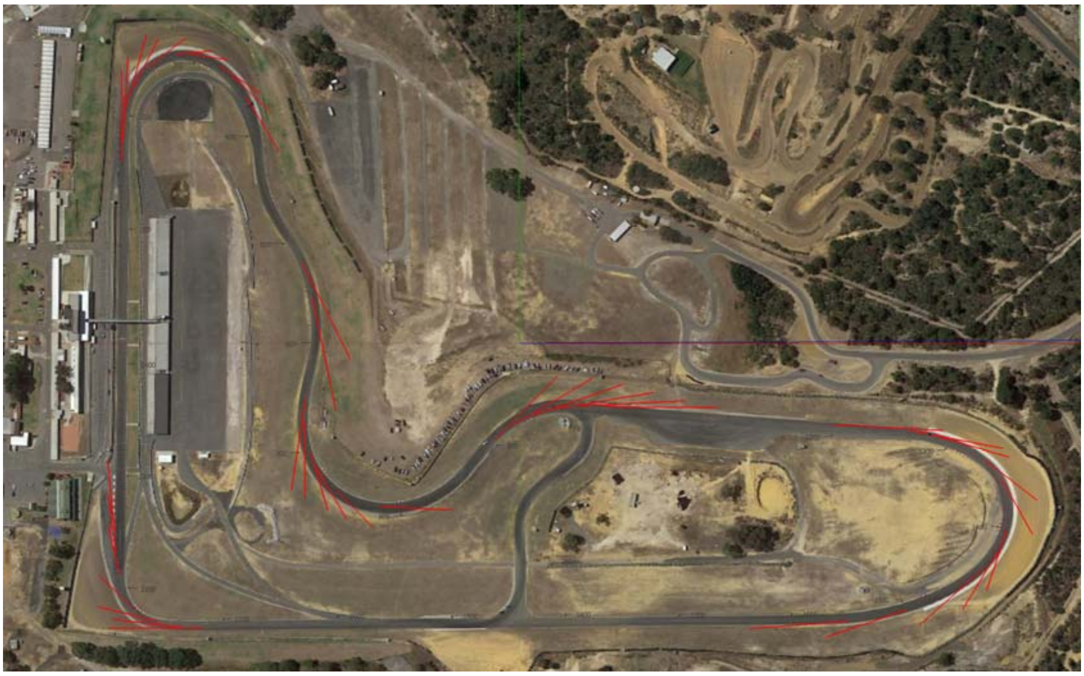
4. CIRCUIT SAFETY COMPLIANCE

4.1 An analysis of the more significant safety items applicable to the circuit, as highlighted by serious racing incidents during the previous 10 years, has been undertaken. Items such as pavement markings, cross-fall and marshal point location were considered to be non-controversial or do not involve major capital cost and are not addressed in this report.

4.2 <u>FIA / CAMS</u>

4.2.1 The run-off requirement for a car circulating at a lap time of 54.3 seconds was determined in accordance with the FIA model (see FIA Internal Guidelines For Motor Racing Course Construction and Safety Edition 7.2 2008). CAMS have adopted the FIA model for new circuits.

4.2.2 The following diagram sets out the national level (CAMS) run-off requirement (larger images can be viewed in the Appendices). I understand that the Barbagallo circuit has been homologated for FIA Grade 3 events, which would require design elements appropriate to the international F3 category (with a weight to power ratio of around 2.3 kg/hp compared with F1000 at around 2.5 kg/hp). Hence, the speed profile used for homologation of the circuit by FIA may show higher speeds than that used for this analysis. However, since F1000 is the fastest category car used in racing at the circuit, I have undertaken the analysis based on the F1000 speed profile.



Run-off lengths appropriate for F1000 speed profile

4.2.3 The FIA run-off model assumes either full bitumen/concrete run-off length or a combination of bitumen (on track trajectory) and gravel trap arrestor bed. In the event that the run-off area does not incorporate an approved arrestor bed, the run-off requirement would be longer.

4.2.4 From analysis of the F1000 speed profile, the circuit has less than minimum ideal run-off at the following locations;

- T1 exit at driver's left
- T3 over entire bend at driver's left
- T5 first half of bend at driver's left
- T7 final exit sector at driver's left

4.2.5 The following items were also noted in relation to the CAMS safety requirements (see CAMS Track Operator's Safety Guide June 2012);

- exit kerbs on driver's left at T5 and T7 non-ideal
- run-off areas at T1, T4, T6 & T7 not in-plane with the track and/or verge
- run-off area at T4 slopes downwards in excess of 3% (measured value reaches 10%)
- width of track only 9 metres
- arrestor beds constructed with sand rather than “river stone”

4.3 FIM/MOTORCYCLING AUSTRALIA

4.3.1 The FIM standards for road-racing circuits (see FIM Standards For Road Racing Circuits (SRRC) 2015) provide no guidance as to what constitutes an appropriate run-off length for a particular speed. The homologation process involves submission of a track layout which is then analysed by an FIM contractor who undertakes a "simulation". The results of the simulation remain the property of FIM, and any run-off requirements arising out of the simulation are presented to the circuit operator by FIM.

4.3.2 Unlike FIA (which also conducts "simulations" to determine the run-off envelope at bends of a circuit) and CAMS, FIM do not indicate the underlying principles for determining the appropriate run-off lengths. While the FIM standard does address some other important safety issues with distinct recommendations, unless WASCC wish to pursue FIM homologation of the circuit, I see no benefit in relating to their SRRC standards. The Motorcycling Australia standards cover those other issues. I have analysed the safety measures in relation to the Motorcycling Australia Venue Standards Edition 1 (December 2006 - 2012).

4.3.3 The run-off requirement for a national level Superbike circulating at 55.5 seconds is given below. The blue line, based on the existing formula for run-off (see Figure 4 of the Standard), indicates the run-off length requirement where no arrestor bed is installed. The current Standard allows that length to be shortened by up to 50% where an appropriate arrestor bed is employed.

Run-off lengths appropriate for national Superbike speed profile

4.3.4 Historically, the main aim of run-off lengths was to enable drivers and riders who leave the track sufficient room to brake and avoid colliding with a barrier put in place to protect spectators or other competitors (in the event that the off track excursion could result in another section of the track being crossed). It is now known that a fallen rider sliding over a bitumen surface and/or a grassed/compacted earth surface will decelerate at a lower level than an upright rider can achieve on his motorcycle. Since a common feature of motorcycle racing incidents involves a rider falling to the track (low side on entry to and up to the apex of a bend; high side in exit sector), it is appropriate to consider run-off lengths in relation to fallen riders.

4.3.5 The green run-off lengths presented in the diagram above represent the distances required to enable a fallen rider to come to rest, taking into account whether or not sliding occurs across an arrestor bed or not. It should be noted that the green run-off lengths are not based on a model currently adopted by MA, but the model has been used recently in the design of a race circuit which has received approval for construction by FIM after their "simulation" process. As can be seen, the "green line model" is a more conservative model than is currently adopted by MA, and as such, will also provide a degree of protection against sliding motorcycles having sufficient energy to tumble and rise over the first line of protection (barrier at end of run-off area) and place spectators at risk.

4.3.6 From the analysis of the national Superbike speed profile, the circuit has less than the minimal ideal run-off at the following locations;

<u>Based on current MA model</u>

- T1 exit sector
- T3 whole of bend riders left
- T5 entry sector
- T7 exit sector

(Note that the straight-ahead run-offs at T1, T6 and T7 become compliant due to the installation of an arrestor bed)

<u>Based on recommended "green line model"</u>

- T1 straight ahead
- T1 exit sector
- T3 whole of bend
- T5 2/3rds of bend from entry
- T6 straight ahead
- T7 exit sector

4.3.7 The following items were also noted in relation to the MA Venue Standards Edition 1;

- non-compliant kerbs at T5 & T7
- slope of run-off at T4 exceeds 3% downwards
- width of track between T6 & T7 at 9 metres for a speed of 270 kph
- width of track in start/finish straight at 9 metres for a speed of 235 kph
- run-off areas at T1, T4, T6 & T7 not in-plane with the track and/or verge
- transition from verge to arrestor bed too abrupt
- arrestor beds constructed with sand rather than "river stone"

4.3.8 The sand arrestor beds have proved to be very effective deceleration devices. As with gravel beds, it is desirable that, in the event of a high energy (speed) excursion, a car enters the "sand trap" with minimal lateral velocity (ie straight ahead movement) to minimise the risk of a roll-over, and in that case, the deceleration level experienced by the vehicle has minimal effect on the stability of the vehicle.

4.3.9 For motorcycling, the entry situation is similar to that for cars. Riders tend to maintain an upright, straight-ahead posture when entering an arrestor bed, knowing that control of the motorcycle is about to be compromised. The rate at which the motorcycle is decelerated has a direct effect on the stability of the motorcycle and the rider's ability to maintain control. There is evidence that high speed entries into the sand arrestor beds at Barbagallo are difficult to control, but it is unclear as to whether or not the level of difficulty is greater than for similar speed entries into gravel beds. Riders in Western Australia do not indicate any issue with the use of sand instead of gravel in the arrestor beds.

5. RISK ASSESSMENT

5.1 Risk assessments were conducted on each of the issues discussed in Section 4 above. The standard 4x4 matrix for Targeted Risk Assessment, as adopted by both CAMS and Motorcycling Australia, was employed to analyse each of the issues.

5.2 The following Table sets out the results of the Targeted Risk Assessment. In reaching a decision in relation to the likely outcome in the event that an impact with a barrier occurs, an estimate of the likely impact speed was conducted and, taking into account the angle of impact, the likelihood of a fatal injury/serious injury was assessed.

5.3 For perceived motorcycle incidents, the Targeted Risk Assessment is mostly driven by the severity of the likely outcome, no matter how low is the probability of the event occurring. Given how exposed riders are to serious injury, an "extreme" risk is a common result when applying the Targeted Risk Assessment matrix. A less than 5% risk of a serious/fatal injury was adopted as the cut-off for the "Major" consequence in the TRA matrix.

5.4 When assessing the appropriateness of the run-off, consideration was given to both the existing MA model and the "green line model". Both have been included in Table 1 below.

5.5 The risk assessment in relation to non-compliant material in the arrestor beds (indicated with *) took into account the anecdotal evidence from riders and officials, and recognised that there is no supporting scientific evidence that sand arrestor beds are significantly more hazardous than river-stone beds.

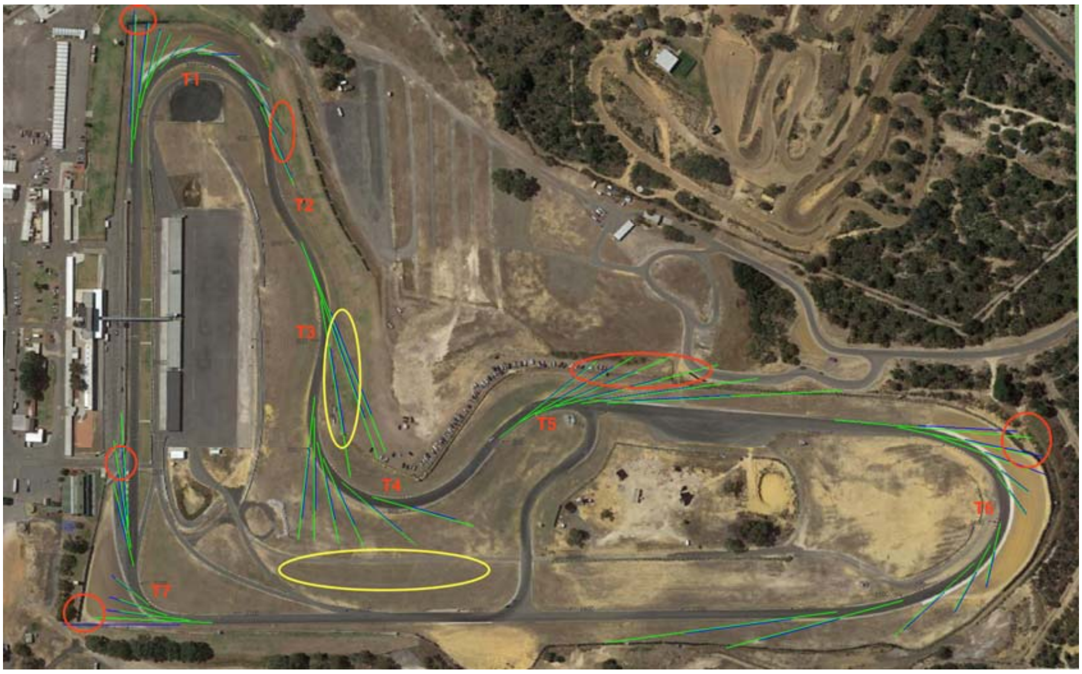
TABLE 1 Risk Factor From The Targeted Risk Assessment Matrix

ITEM	CARS	BIKES	
		MA MODEL	GREEN LINE MODEL
RUNOFFS			
T1 straight ahead	x	HIGH	HIGH
T1 exit	LOW	HIGH	HIGH
T3	HIGH	EXTREME	EXTREME
T5	LOW	HIGH	HIGH
T6	x	EXTREME	EXTREME
T7 straight ahead	x	EXTREME	x
T7 exit	LOW	MEDIUM	EXTREME
OTHER			
Kerb @ T5	LOW	HIGH	
Kerb @ T7	LOW	MEDIUM	
Track edges/transition	MEDIUM	EXTREME	
Track width T6 - T7	LOW	LOW	
Track width T7 - T1	LOW	LOW	
Slope run-off T4	EXTREME	EXTREME	
Arrestor bed material	LOW	LOW*	

6. MAJOR ISSUES

6.1 The following diagram illustrates the areas where the risk assessment is above "low". The areas in red are specific to bikes and the areas in yellow are applicable to both codes. It is considered that those areas require an engineering approach to minimizing the risk of injury to drivers, riders, officials and spectators at those locations. The issue relating to the track edges and transition into the arrestor beds is essentially a maintenance issue that needs to be more rigorously applied and monitored.

6.2 It is obvious from a risk assessment that the highlighted safety issues are much more critical from the perspective of motorcycle competitors than they are for the car drivers. That is not surprising given the speeds involved, the reduced deceleration applying to a fallen rider compared with that which a driver can achieve in his/her car, and the exposure to injury when an impact with a barrier does occur.



Areas deemed in need of engineering solutions

7. PERCEIVED ENHANCEMENTS & COST GUIDE

7.1 The following perceived enhancements represent a considered guide to minimizing the risk of injury at each location where alteration to the existing infrastructure is warranted. Should an option be adopted, the solution should under-go a detailed engineering design process. The following solutions are based on the current fastest speed profiles for cars and motorcycles. In the case of motorcycles, the current MA guidelines have been used as the reference. For major capital works to be undertaken so that speed increases over the next 20 years are catered for, the run-off lengths should be increased by at least 6% (that allows for a 3% reduction in lap times over that period). I have included that factor in the following. The suggested barrier re-alignments are summarised diagrammatically at the end of this section.

7.2 T1

To reduce the potential for injury to a much lower level, the concrete barrier at the straight-ahead alignment should be moved further to the north by a distance of 10 metres, and the new wall angled back to the existing wall over a distance of 40 - 50 metres.

The requirement to change the barrier alignment at T1 entry can be avoided by installing an FIM homologated energy absorbing barrier, such as Airfence Evo. Approximately 12 metres of Airfence Evo would be required to overcome the deficiency in run-off length determined using the current MA model.

At the exit, the existing wall should be relocated 5 metres east of its current alignment over a distance of approximately 100 metres to just south of the exit marshal post.

The run-off length requirement can be reduced by introducing an FIM homologated energy absorbing barrier, such as Airfence Evo, angled to the direction of impact to reduce the normal impact velocity into the absorber. If approximately 35 metres of Airfence were installed, the barrier would not have to be re-aligned for motorcycles. However, that may not solve any issue that might exist for Grade 3 homologation which would be based on higher car speeds at T1 than has been analysed here.

7.3 T3

This is the most critical of all the nominated risk areas; for both motorcycles and cars. It should be considered as extremely high priority. The fact that the solution would require either re-alignment of the track layout or a major realignment of the barriers is a direct reflection of the severity of the outcome of any event occurring at this location.

Should it be decided to realign the first line of protection (barriers) along driver's left, a significant spectator area will be affected. The amount by which the barriers need to be shifted can be reduced by incorporating an arrestor bed between the track and the new barrier alignment. In that case, the barrier alignment need only be shifted east by a distance of approximately 30 metres. The actual design should follow an alignment that minimises the possibility of an errant car or bike travelling across the track at Turn 4.

A new barrier approximately 350 metres in length would need to be constructed.

Given the relatively narrow angle of impact likely in the event of a fall by a rider, the run-off re-alignment can be further reduced by installing an FIM homologated energy absorbing barrier, such as Airfence Evo, angled to the direction of impact to reduce the normal impact velocity into the absorber. However, the use of Airfence, for example, would not avoid the necessity to realign the concrete barrier.

Alternatively, the current track alignment could be altered so that a fall is extremely unlikely and any off track excursion has almost no direction towards the nearby barrier. Such a change would result in the loss of the appeal of the sweeping bends, but may be preferred by WASCC (see this option layout in Section 8).

7.4 T5

The barrier realignment in this area is also extensive, and can be reduced by employing an arrestor bed. Without the arrestor bed, the barrier realignment would result in the loss of the current hill-climb circuit layout. With the arrestor bed, the barrier would need to be realigned approximately 13 metres north of the existing alignment, angling back towards the track and meeting the current alignment at the track access point. Approximately 200 metres of new barrier would be required.

Realignment of the barrier could be avoided with the use of an FIM approved energy absorbing device such as Airfence Evo in conjunction with an approved arrestor bed. Approximately 110 metres of Airfence would be required.

7.5 T6

The alignment of the barrier needs to be altered to provide a further 25 metres of straight-ahead run-off distance. Given the manner in which the run-off area at T6 has been built-up substantially, any significant increase in the run-off length would require a major land build-up operation east of the current barrier alignment.

The run-off length can be reduced by introducing an FIM homologated energy absorbing barrier, such as Airfence Evo, angled to the direction of impact to reduce the normal impact velocity into the absorber. Approximately 35 metres of Airfence could be employed so that the barrier need only be moved 5 metres towards the east.

The current tyre barrier should be replaced by a concrete barrier over the entire length of Turn 6 or the existing large tyres should be faced with an appropriate material to produce a smooth face which will not deform to produce pocketing between the large tyre profiles (proper engineering at Turn 6 could enable the existing structure to remain and minimize the cost of upgrading in this area). The first quadrant of the barrier from the straight-ahead location should be protected by a tyre bundle energy absorber faced with conveyor belt.

An alteration to the radius of Turn 6 should also be considered as an alternative to increasing the run-off length. A tighter radius, beginning slightly further up-hill will reduce the entry cornering speed and increase the run-off length available without having to change the barrier location.

7.6 T7

Due to the high speed along the preceding straight and the low cornering speed at T7, the ideal run-off for straight-ahead extends past the existing barrier alignment. While the introduction of a sand-trap makes the run-off compliant, it will not necessarily prevent a fallen rider from striking the barrier with a significant risk of serious injury (note, however, that the "green line model" suggests that a change to the entry run-off area at Turn 7 is not required).

If the current MA model for run-off requirement is adopted, an increase in the straight-ahead run-off length of 15 metres is required. A decision to change the barrier alignment at T7 to mitigate potential injury can be avoided by installing an FIM homologated energy absorbing barrier, such as Airfence Evo. Approximately 12 metres of Airfence Evo would be required to overcome the deficiency in run-off length determined using the current MA model.

In the exit area of T7, the current barrier alignment is hazardous to fallen riders and to riders who may be forced to change line due to problems of another competitor or due to their own mistake. Re-alignment of pit wall, the pit entry lane and associated barrier is required. Based on the "green line model", an approved energy-absorbing device will not overcome the issues associated with the current design (especially with respect to bikes and riders being redirected out onto the track into the path of on-coming riders).

7.7 T4

There is a need to install a barrier between the run-off zone for Turn 4 and the straight between T6 and T7. I understand that such a barrier is already planned and is a requirement associated with the V8 Supercars and the FIA Grade 3 track licence.

The run-off zone at T4 slopes significantly downwards, reaching 10% in some places. For upright riders attempting to retain control and steer to the left to avoid running too far from the track (and also to avoid running across the infield and crossing onto the straight between T6 and T7), they are presented with a steep off-camber situation. Turning and braking in such a situation is significantly compromised. Any barrier installed should take into account the more difficult control situation for riders over that of similarly placed drivers into account.

It is recommended that the barrier be placed south of the infield access road as a matter of priority.

7.8 Kerb T5

The kerb at T5 consists of high section of concrete formed in a wave shape in the Wilson kerb style. Such kerbs are acceptable to CAMS, but not MA, on the exits. Putting aside the effect on a fallen rider, should a rider, under acceleration, be slightly unstable and run wide onto the kerb, a major loss of control could readily occur. Even if a fall does not immediately follow, the excursion off the track could lead to an impact with the concrete barrier beyond. The kerb is contrary to the intent of the Track Standards to provide a smooth run-off area for errant riders.

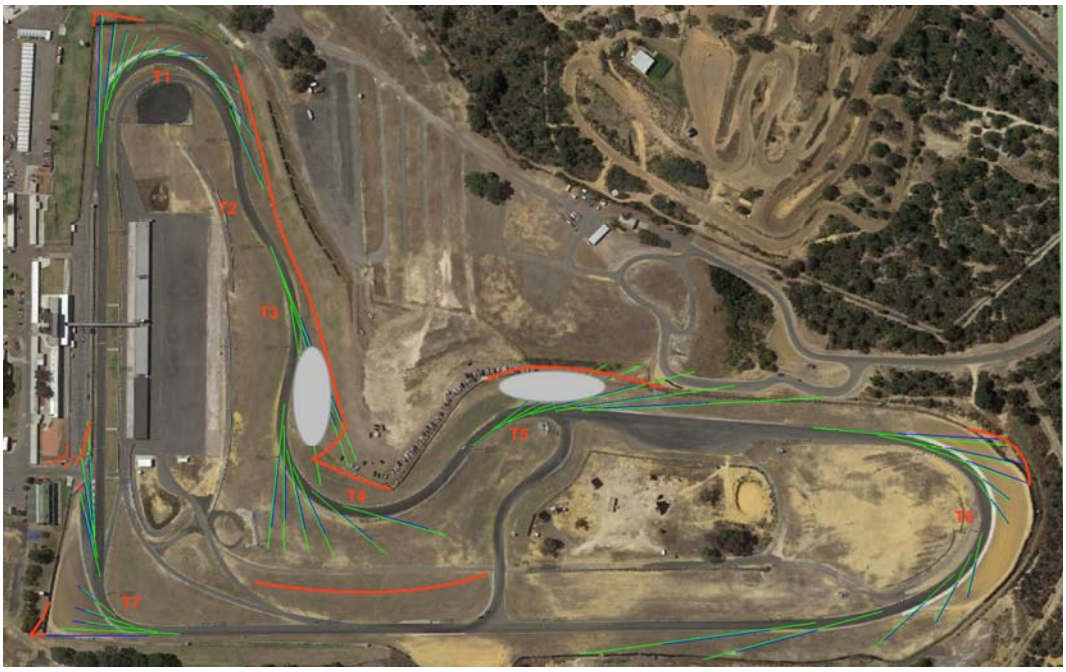
The kerb should be replaced with an acceptable type such as Melbourne kerb, not the Morgan Park type.

7.9 Kerb T7

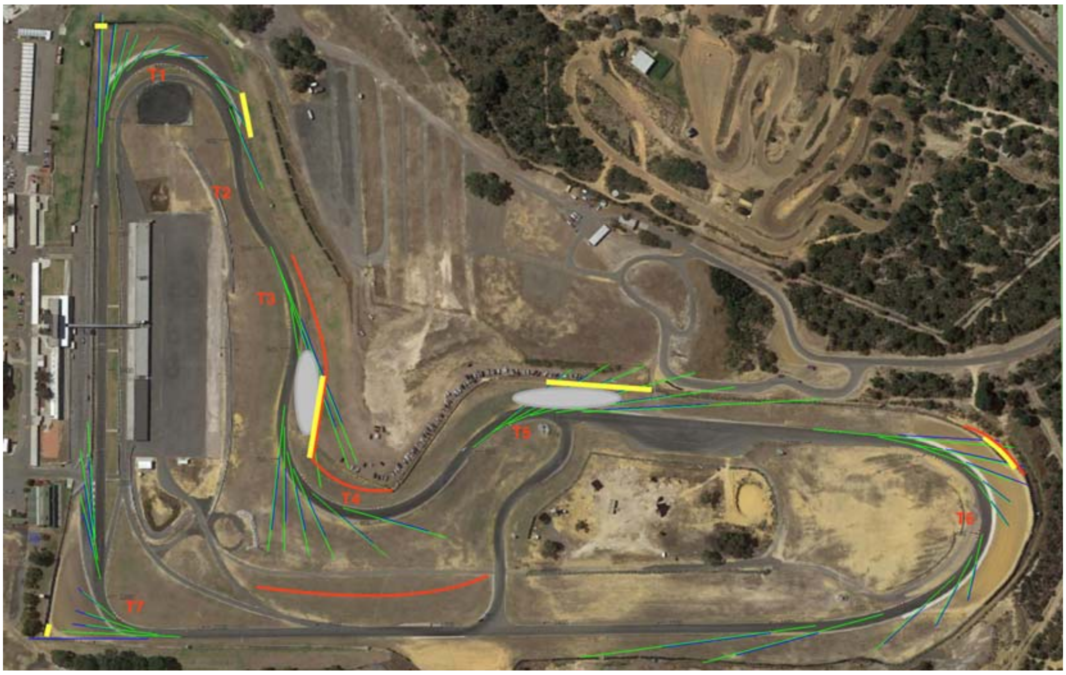
The kerb at T7 is non-compliant with the ideal exit kerbs recommended by CAMS and MA but provides a profile which can be used by riders to assist with their turns while under acceleration (similar to a "berm" in off-road riding). However, should a mistake be made while undertaking the turn, the current kerb will increase any instability and could result in a significant off-track excursion or fall.

Installation of a Melbourne kerb in this location may lead to cars exiting at higher speeds but the suggested changes to the pit entry area should compensate for that. (In addition, penalties for excessive and repeated wide exits over the kerb could apply).

7.10 The new barrier alignments to meet the run-off requirements, without introducing energy absorbing devices, are given below. New arrestor beds are required at T3 and T5, as indicated by the grey ovals. The lengths indicated are not to scale and are shown simply as a representation of where the changes occur. The actual lengths and realigned positions would be subject to a more rigorous design process.



7.11 The alterations required, if appropriate energy absorbing devices are employed, are illustrated below. The required new arrestor beds are also indicated (not to scale, indicative only). Again, the lengths and dimensions of new barriers and energy absorbing devices are not to scale, but are illustrative of the approximate positions. The yellow lines indicate the location of the energy absorbing devices required.



At most locations where it is considered that there is insufficient run-off, the installation of an appropriate energy absorbing device, such as Airfence combined with designed placement (location and angle of approach), could overcome the requirement to alter the barrier alignment in the short term. However, the reduction in impact loading on a fallen rider provided by the installation of Airfence in front of the existing barrier would not be diminished sufficiently in the event of a fall at Turn 3 or the exit at T7.

7.12 A cost estimate of the different treatments has been carried out. The estimates are based on historical costs for works programs at other existing race circuits. A detailed costing would not be undertaken before a final design specification has been undertaken. No costing for T7 exit has been provided as that involves a complete change to pit-lane entry. WASCC and CAMS would need to be strongly involved in that process. The following basic cost structure has been adopted, and it has been assumed that concrete barriers would be installed;

Cost of new concrete barrier (slip form)	= $ 300 /m
Cost of removal of old barrier	= $ 145 /m
Cost of construction of Melbourne kerb	= $ 100 /m
Cost of spectator fencing	= $ 130 /m

A 10% design and contingency cost has been added to cover the cost of engineering design, relocation of CCTV, PA and marshal communications.

ESTIMATED COSTS ($) OF CIRCUIT IMPROVEMENTS

ITEM	NEW BARRIERS	WITH ENERGY ABSORBER (1) (negates barrier change unless otherwise stated)
T1 s/a	23,000	10,800
T1 exit	52,500	31,500
T3	168,000(2)	220,000(3)
T5	84,000(2)	99,000
T6	155,000(4)	76,000(5)
T4 barrier	38,000(6)	38,000(6)
T5 kerb	7,500	7,500
T7 kerb	6,200	6,500
Total	534,200	489,300

T3 gravel bed(7)	50,000
T5 gravel bed(7)	54,000

(1) based on cost of Airfence Evo at $900/m & assumed freight free of charge given the volume of sale
(2) assumed sand arrestor bed. If gravel bed required, add cost shown
(3) includes barrier re-alignment, Airfence and assumes sand arrestor bed
(4) includes earthworks cost to lift area behind barrier by 5m. Rough estimate only of volume of fill as no survey carried out. Based on $30/m^3$
(5) includes reduced volume of earthworks to lift area for barrier alignment
(6) assumes a double row of W-beam, not concrete. Double row to provide safety for marshal attendance/recovery
(7) based on bulk delivery cost of 10mm pea gravel @ $80/m^3$

7.13 While the costs for each method of treatment have been totalled in the above Table, there is nothing to prevent adopting a strategy of choosing the less expensive option from the respective columns. If such a strategy were adopted, the least expensive combination would be $422,300. The costs associated with altering the pit lane entrance are not included.

7.14 A further option to overcome the serious lack of run-off at T3 is to change the track alignment with a new section of track between the exit of T1 and the entry of T4, as shown below and in Section 8 (note that this design is for example only, and there may be more challenging and interesting alternatives that can equally overcome the issue at T3). Through the change, the existing barrier alignment and spectator area can be maintained.

A new section of 12 metre wide track, approximately 225 metres in length, would cost in the vicinity of $113,000, including the cost of the sub-base. At that cost, the new section of track would be suitable for car and bike racing, but not for truck or other heavy vehicle competition or like use.

A re-alignment of the track at T5, as shown below, would reduce the cornering speed and thereby reduce the run-off required so that the area incorporating the hill-climb circuit can be maintained. Some alteration of the barrier alignment would be expected. The cost estimate for the re-alignment at T5 is approximately $78,000.

Similarly, a significant change to the track alignment at the entry to T6 would overcome the deficiency in run-off and avoid comprehensive earth-works immediately to the east of the current barrier alignment. The track re-alignment at T6 would cost in the order of $113,000.

The concept changes are shown below in blue. The cost of each element is less than the alternatives of barrier alignment change and/or energy absorber. However, the overall effect of the changes would be to reduce the track length slightly.

<u>Cost of track re-alignment</u>

T2/T4	$ 113,000
T5	$ 78,000
T6	$ 113,000
Design/contingency	$ 40,000
	$ 344,000

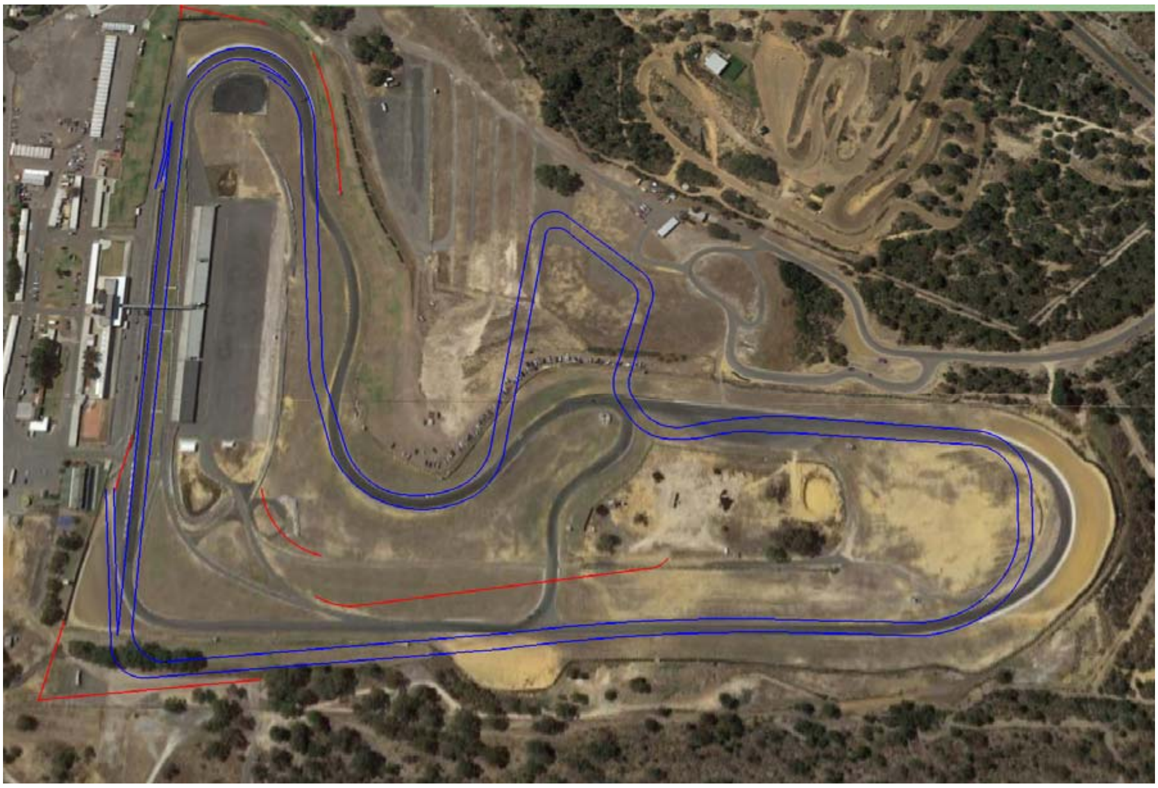
The above total cost of track re-alignment does not cover the other issues such as Turn 1, Turn 4, Turn 7 and the kerbs.

8. OTHER OPTIONS & FUTURE DEVELOPMENTS

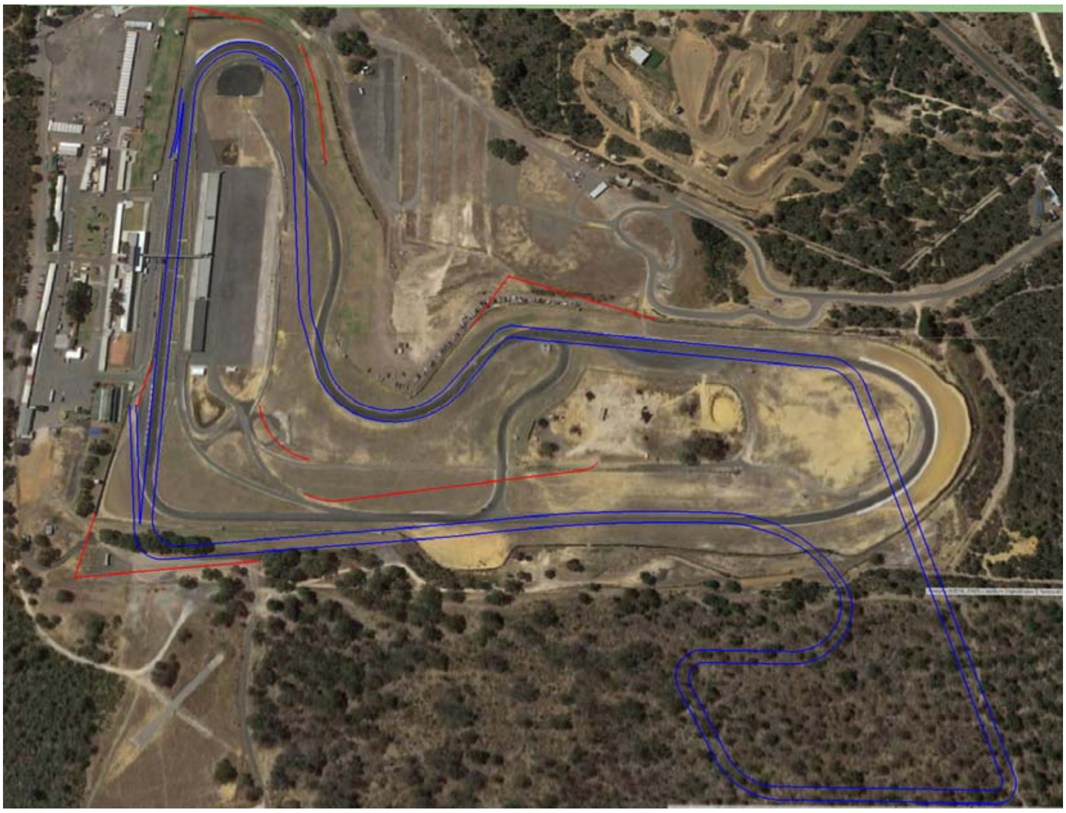
8.1 The long-term business development plan for the Wanneroo site is for the establishment of a motor-racing precinct, with another road-racing circuit situated immediately north of the Barbagallo circuit.

8.2 With the current deficiencies in the circuit and plans for replacing the large tyre barriers with new barriers (either concrete or W-beam are acceptable in places), new barriers and re-surfacing of the track, there is an opportunity to widen the circuit to the CAMS standard level 12 metres, to change the alignment in order to overcome the highlighted run-off deficiencies and to extend the circuit slightly to a length more aligned with other national level circuits (note that there is a down-side to increasing the length; more manpower is then required to run motor-racing events on-going maintenance costs increase and circuit hire costs increase).

8.3 Concept plans for a track extension north or south of the existing property is provided. The concepts are purely for illustration, and do not necessarily reflect an ideal situation. No survey of the area in which the concept layouts are located has been undertaken. It is not known if the areas, part of the existing lease area or Shire of Wanneroo, are available for use or lease, or if the vegetation/fauna in the area is protected (eg, trees forever). Should the change to T7 be adopted, some re-alignment of the pit-entry to the V8 garages may be required due to a possible change in the speed profile in that area.



Concept layout for track extension to 2.5 kms



Concept layout for track extension to 3.0 kms

8.4 Extending the circuit to approximately 2.5 or 3 kms in length and including the alignment changes suggested in 7.12 above to overcome the highlighted safety issues would cost in the order of $1,695,000 and $2,470,000 respectively. A first-order break-down of the costs is given below.

Approximate Costs for Extending & Changing Barbagallo

	2.5 kms	3.0 kms
Engineering - clearing, access etc	$ 150,000	$ 250,000
Sub-base of new track sections and widening	$ 345,000	$ 575,000
New surface and reseal to 12m	$ 625,000	$ 837,000
1st line protection - concrete	$ 255,000	$ 188,000
- W-beam	$ 75,000	$ 155,000
Spectator fencing	$ 50,000	$ 50,000
Perimeter fence extension		$ 150,000
Lines, kerbs, comms, marshal pts	$ 50,000	$ 80,000
Design	$ 70,000	$ 85,000
Contingency	$ 75,000	$ 100,000
	$1,695,000	$2,470,000

PROS	CONS
Solves issues at T3, T5	Cost
Solves issue at T6	Extra marshalling
Current spectator area maintained	Increase maintenance
Add new driving/riding elements	Increase hire cost
Solve issue at exit T7/pit entry	Loss of historical elements
Add another overtaking point	No use during construction
Length more national standard	
Whole track widened to 12m	
Updated circuit to national level	

8.5 The cost of building a new 2 km circuit elsewhere has been estimated on the basis of a generic layout with minimal heavy earth-works required (in line with what would be expected for the site immediately north of the Barbagallo circuit). No attempt to design a circuit layout has been made. It is assumed that the track surface would be 12 metres wide and constructed for motorcycle and car racing but not for truck racing. The cost to build a new 3km circuit equivalent to the result from extending Barbagallo, but not including the infrastructure west of the entire pit straight, would be in the order of $6,500,000. For the following costs, only a basic state-level facility would be provided. Land costs are not included.

The construction costs have been divided for a phased program;

	2 km circuit	3km circuit
Phase 1 : Pavement, kerbs, drainage, fencing 1st line of protection, marshal points, lines, run-offs, comms, toilets, lights, control tower, water, electricity, fire-service, design, contingencies	$ 2,035,000	$ 2,800,00
Phase 2 : Pit area pavement, entry roads, run-offs, 1st line of protection, fencing, toilets, office, pit buildings, medical centre, control tower, water, compressed air, electricity, contingencies	$ 3,495,000	$ 3,700,000
	$ 5,530,000	$ 6,500,000

9. SUMMARY AND CONCLUSIONS

9.1 The Barbagallo circuit is currently homologated to FIA (CAMS) Grade 3 level and to Motorcycling Australia National level.

9.2 The run-offs available at a number of turns do not meet the requirements normally associated with the current level of homologation.

9.3 A targeted risk assessment of the non-compliant items at the circuit has indicated HIGH and EXTREME risk levels at various locations.

9.4 Turn 3 is associated with a HIGH level outcome for cars and an EXTREME level outcome for motorcycles.

9.5 Run-off deficiencies for cars at Turn 1 (exit), Turn 5 and Turn 7 (exit) are associated with LOW level outcome risk.

9.6 Run-off deficiencies for motorcycles at Turn 1 and Turn 5 are associated with HIGH level outcome risk while deficiencies at Turn 6 and Turn 7 are associated with EXTREME level outcome risk.

9.7 There are other non-compliant items at the circuit, such as the type of kerbs installed and the track width, which are considered non-critical but should be upgraded.

9.8 Non-compliant sections of poor transition from the track surface into the run-off areas should be immediately addressed through a more rigorous maintenance program.

9.9 The planned barrier installation between the run-off zone for Turn 4 and the back straight (Turn 6 to Turn 7) should be given high priority.

9.10 In its current layout and barrier design, the circuit is associated with a significant number of critical risk items that render it unsafe for motorcycle racing.

9.11 Many of the safety issues associated with the insufficient run-offs can be overcome for the short to medium term, without altering barrier alignments, through designed placement, alignment and construction of appropriate energy absorbing devices.

9.12 However, Turn 3 requires re-alignment of the barrier or of the circuit to reduce the risk of rider injury to an acceptable level.

9.13 The simplest and most cost effective long-term solution to the problems at Turn 3, Turn 5 and Turn 6 would be re-alignment of sections of the track at a cost of around $350,000, but that would involve reducing the length of an already short circuit and would remove the more interesting driving/riding elements.

9.14 Upgrading of and slightly lengthening the circuit to conform to FIA/CAMS and MA requirements is likely to cost in the order of $1.7 - $2.5M for a 2.5 to 3 kilometre circuit.

9.15 Establishment of a basic level new circuit elsewhere, exclusive of land value, is likely to cost in the order of $5.5M - $6.5M for a 2 – 3 km track length.

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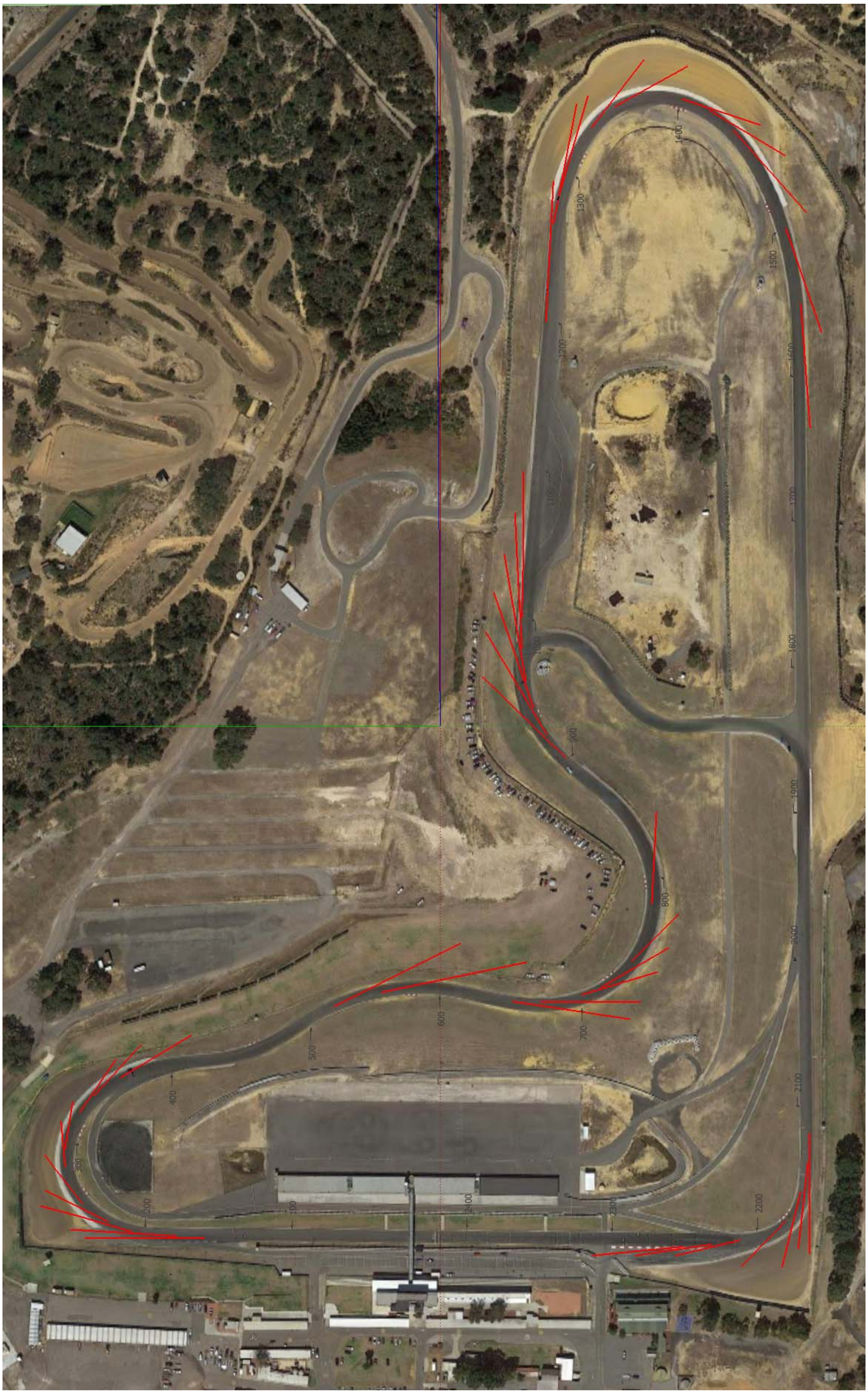
APPENDIX A : DIAGRAM OF CAR RUN-OFF REQUIREMENTS



APPENDIX B : DIAGRAM OF MOTORCYCLE RUN-OFF REQUIREMENTS