Northern Suburbs Football Association: Playing field assessments

August 2016

AgEnviro Solutions

Northern Suburbs Football Association:

Playing field assessments

This project was supported by NSW EPA as part of the Waste Less, Recycle More initiative, funded from the waste levy

Report written by AgEnviro Solutions Pty Ltd

Author: Dr Mick Battam, Principal soil scientist AgEnviro Solutions. CPSS. CIAg CID

Reviewer: Steve Garland, Principal horticulturalist. MLArch, Hort Cert, MAILDM.

Report Limitations

This report was written in a certain way, with a certain budget, for a specific intention. Funding for this project was provided by NSW EPA.

The material contained within this report is for use by NSW EPA and Northern Suburbs Football Association in the management and renovation of the sporting fields listed in Section 1 of this report which are located in the Ku-Ring-Gai Council, North Sydney Council and Lane Cove Council local government areas.

Limitations apply and the material contained within the report (including technical information and formats) is not to be used by other persons or organisations other than in the amendment and renovation of the sporting fields listed in Section 1 of this report which are located in the Ku-Ring-Gai Council, North Sydney Council and Lane Cove Council local government areas.

AgEnviro Solutions, Pty Ltd

80 Wild Oaks Rd, The Oaks 2570

0425 363 161

www.agenviro.com

mick@agenviro.com

Executive summary

With the dual objectives of promoting the use of recycled organics and improving turf conditions, NSW EPA has funded AgEnviro Solutions Pty Ltd to assess and provide advice on the amendment of playing fields. This report outlines these findings for 7 sites (10 winter playing fields) nominated by Northern Suburbs Football Association and has been written by Dr Mick Battam.

Playing field usage

Based on sports field usage data provided by the sporting clubs and Council, the amount of wear each field receives was estimated using the foot traffic model developed by Dr Mick Battam. Due to their poor condition the fields can collectively handle the equivalent wear of 100 hours/week of adult soccer, which is much less than the 188 hours/week of equivalent wear they currently receive. Winter use is not distributed evenly, with (Figure E.1):

- elevated to high wear occurring at Bob Campbell Oval and Norman Griffith Oval; and
- elevated wear observed at Primrose Park and Queen Elizabeth II Reserve.

The wear levels on these fields are less intense then those observed in many of the nearby councils and if amended according to the works outlined in this report the collective carrying capacity could be increased to about 250 hours per week. As such, the fields could handle the current usage levels if amended according to the works outlined in this report (Figure E.2).

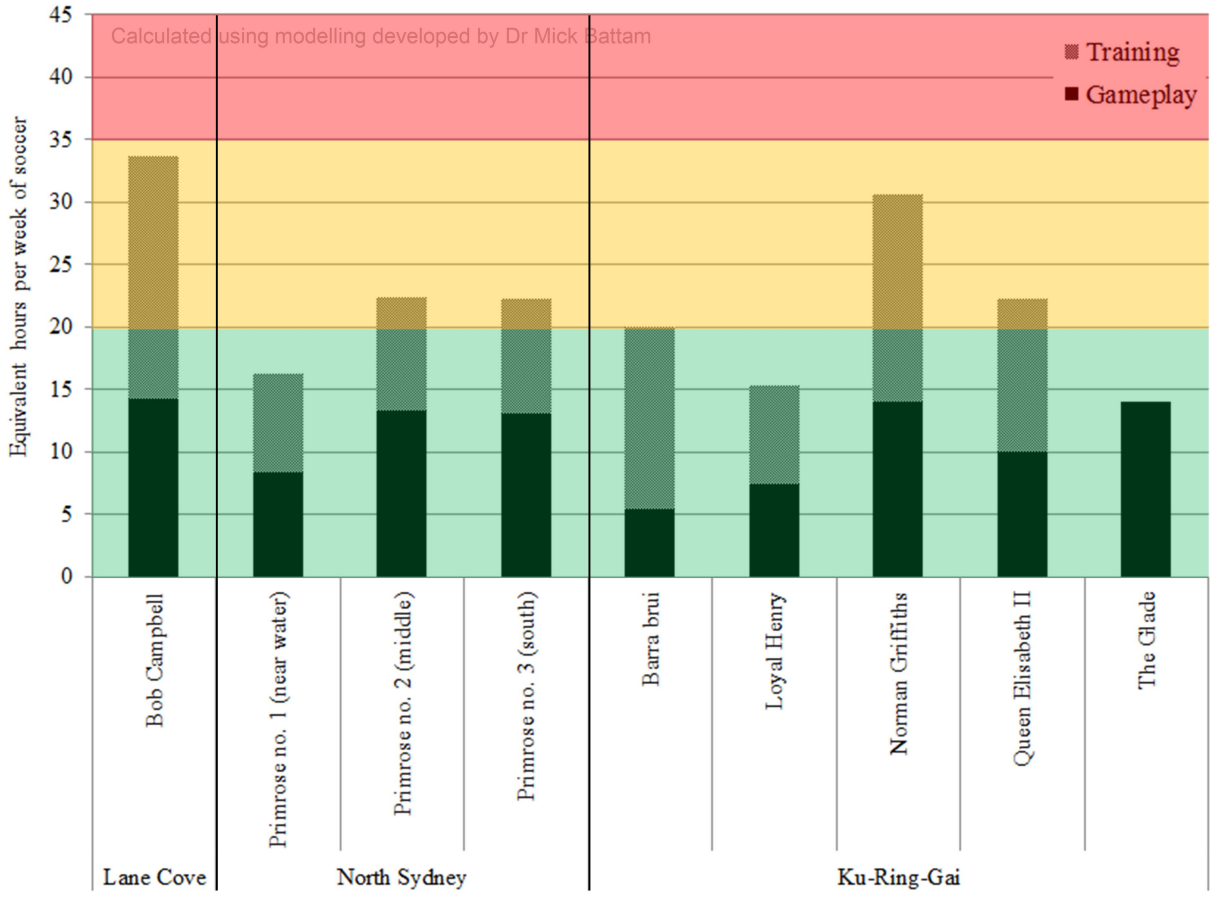


Figure E-1 Normalised winter sport usage levels for each site, with the shading indicating low to moderate (green), high (orange) and intense (red) levels of wear.

Condition of the fields

The playing fields were inspected in July to August 2016. Most sites displayed low levels of traction and were struggling to maintain grass cover across large sections of the field, with major problems at:

- Barra Brui Oval (waterlogging, layered soil that is too sandy);
- Loyal Henry Park (uneven, layered soil and run-on);
- Norman Griffith Oval (wrong turf type, waterlogging and layered soil);
- Primrose Park (run-on, uneven cross-fall and layered soil); and
- Queen Elizabeth II Reserve (waterlogging, layered soil that is too sandy).

Less extensive problems were also observed at Bob Campbell (wrong turf cultivar and layered soil) and The Glade (shallow and receives run-on).

Table E-1 Summary of August 2016 playing field assessments.

Field	Key issues	Turf cover			Evenness			Hardness			Traction		
		Goals	Infiel	Wings	Goals	Infiel	Wings	Goals	Infiel	Wings	Goals	Infiel	Wings
Barra Brui	Layering												
Bob Campbell	Turf type, layering & shade												
Loyal Henry	Run-on, infertile soil, uneven & turf type												
Norman Griffith	Turf type, soil & layering												
Primrose no. 1 (near water)	Turf type, layering & uneven cross-fall												
Primrose no. 2 (middle field)	Turf type, layering, run-on & uneven cross-fall												
Primrose no. 3 (southern field)	Turf type, layering & uneven cross-fall												
Queen Elizabeth II	Turf type & layering												
The Glade south	Shallow, run-on & slope length												
The Glade mini	Shallow, run-on & slope length												

Major issue **Intermediate issue**

Renovation works

Based on the factors limiting turf performance the following renovation practices are recommended for the playing fields involved in this study (details in Table 4-1):

- Reconstruction of fields: involving soil amendment and conversion to Santa Anna couch is recommended for Barra Brui, Bob Campbell, Loyal Henry, Norman Griffith, Primrose and Queen Elizabeth II. If these fields are amended and maintained in accordance with the works in this report they should be able to handle current usage;
- Aeration: intense aeration (4 slow passes in a row that is repeated on several occasions) with the vertidrain has been recommended for most sites, especially Barra Brui Oval, Primrose Park and Queen Elizabeth II Reserve. If council does not own a vertidrain then these passes could be performed with the aerovator, but deep aeration should occur at least annually;
- Slicing: has been recommended for The Glade and for ongoing use every 3 years at Bob Campbell Oval, Loyal Henry Park, Queen Elizabeth II Reserve and The Glade. Slicing should extend to the edge of the field, using multiple passes on the edge and in the high traffic areas;
- Drainage structures: to prevent surface water from adjacent areas from running onto the field should be installed at Loyal Henry Park, Primrose Park and The Glade;
- Slit drains: should be considered for installation at Primrose Park, The Glade and possibly Norman Griffiths Oval. These installations must NOT occur (regardless of the claims made by installers) until the surface is even, soil is amended and the site has been converted to a suitable turf cultivar or major problems will persist;
- Turf establishment: should be achieved through sprigging, plugging or the use of washed turf, with traditional sod only to be used if it contains less than 20% fines (silt and clay) in the attached soil layer. This is crucial;
- Topdressing: with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I) is recommended for Primrose Park and The Glade. This topdress should be used to repair holes on other sites. Sand based topdress such as 80:20 must NOT be applied to the fields or ongoing turf patching will be required, with many of the fields marginally too sandy; and
- Trees: were impacting turf performance on 3 sites, but these were generally limited to perimeter areas.

Including the 7 field reconstructions and the installation of an irrigation system at Norman Griffith Oval these works will cost about $1,137,800+GST to perform. **It should be noted that it is usual to recommend the reconstruction of so many fields, but most sites have either been constructed with poor soils that have not been amended and/or using a turf cultivar that is unable to handle the site usage levels**. Once amended the fields should be able to handle the current usage levels so there is minimal need for turf patching (Figure E.2).

The topdress recommended for use on most fields consists of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). Such material is available from several local suppliers, with Sutherland Shire routinely using a slightly heavier version of this mix.

Before amendment	After amendment

Figure E-2: The impact of amendment works on the October condition of Kareela no. 4 sporting field which recieves similar levels of wear to Norman Griffith Oval.

Ongoing management

In addition to regular mowing the following maintenance practices have been recommended:

- Fertilising: the addition of composted garden organics will improve the nutrient holding capacity of the soil. The fields will also require the addition of nitrogen and potassium, with calcium possibly required (confirm via testing) on many sites including The Glade;
- Weed control: weeds were in low numbers during the site inspections, but pre-emergent herbicides may be required at some sites. Hand chipping of Parramatta grass is recommended for Norman Griffith Oval and is crucial given this weed is a trip hazard and currently has no selective herbicide. Weed control should occur on the field surrounds (source of seed);
- Wetting agents: sites should be inspected for the occurrence of water repellency, with routine application recommended for Barra Brui Oval, Loyal Henry Park and Queen Elizabeth II Reserve;
- Irrigation: controllers would ideally operate based on ET monitoring (alternatively use the schedules outlined in this report). Maintenance should occur at least annually (visual inspections performed routinely), with water savings of about 25% likely to be achieved if an irrigation design audit was performed;
- Ryegrass oversowing: may be beneficial at Barra Brui Oval (goal boxes only), Bob Campbell Oval, Primrose Park and Queen Elizabeth II (goal boxes only). Oversowing can assist in improving wear levels, but is far less important than amending the soil and converting the fields to more appropriate turf cultivars;
- Growth regulators (e.g. primo): Barra Brui Oval (goal boxes only), Bob Campbell Oval and Primrose Park; and
- Aeration: should occur routinely using the vertidrain or aerovator, with the earthquake required every 3 years at Loyal Henry Park, Queen Elizabeth II Reserve and The Glade. Aeration must not occur in the 5 month period after applying a pre-emergent herbicide.

Implementing the works outlined in this report will not only reduce irrigation demand, but will result in major improvements in the condition of about 7 fields and significant improvements to the other 3.

Table of Contents

1 Introduction

1.1 Background

With the dual objectives of promoting the use of recycled organics and improving turf conditions, NSW Environment Protection Authority (EPA) has funded AgEnviro Solutions Pty Ltd to assess and provide advice on the amendment of playing fields. This report outlines these findings for 10 playing fields (7 sites) nominated by the Northern Suburbs Football Association. Those located in Ku-Ring-Gai local government area are:

- Barra Brui Oval (Burraneer Avenue St Ives);
- Loyal Henry Park (Thomas Avenue Roseville);
- Norman Griffiths Oval (Prince of Wales Drive West Pymble);
- Queen Elizabeth II Reserve (Bradfield Road Lindfield); and
- The Glade (Koora Avenue, Wahroonga).

Those located in Lane Cove Council are:

- Bob Campbell Oval (Cliff Road Northwood).

Those located in North Sydney Council are:

- Primrose Park (Young Street Cremorne).

Techniques for improving the condition of these fields are provided in this report which was written by Dr Mick Battam (AgEnviro Solutions Pty Ltd). Direct comparisons between sport usage levels and playing field carrying capacity are also presented.

1.2 Layout of report

The report provides a summary of the playing usage levels (Chapter 2), condition of the fields (Chapter 3), renovation recommendations (Chapter 4) and maintenance requirements (Chapter 5). The detailed assessment findings for each site are then presented individually in Appendices A to G.

2 Carrying capacity and usage of playing fields

The 7 sites involved in this study occupy a combined area of about 8.2 ha and are divided into 10 fields during the winter sport season. Many of the sites are wind protected and receive late afternoon shade, with the most sheltered microclimates observed at Loyal Henry Park and Bob Campbell Oval.

2.1 Winter wear levels

Foot or vehicle traffic causes injury to turf by tearing leaves, stems, stolons, rhizomes and/or roots. As a result, some regrowth is needed to repair the damaged tissue to maintain the playing surface condition following use. The amount of wear each field receives was calculated with the foot traffic model developed by Dr Mick Battam. This model accounts for playing age and sport type.

During winter these playing fields receive the equivalent of wear of caused by about 188 hours per week of adult soccer. Most of the fields are in poor condition and based on their carrying capacity (100 hours per week) cannot collectively handle winter usage. Wear is not distributed evenly, with:

- elevated to high wear occurring at Bob Campbell Oval and Norman Griffith Oval; and
- elevated wear observed at Primrose Park and Queen Elizabeth II Reserve.

The wear levels on these fields are less intense then those observed in many nearby councils and if amended according to the works in this report the collective carrying capacity could be increased to about 250 hours per week. As such, the fields could handle the current usage levels with amendment. Results for a more intensely used field provided in Figure E.2. Ideally Councils would have wear levels evaluated for all sites so it can be spread evenly (divert training to lesser used fields, with home grounds unchanged).

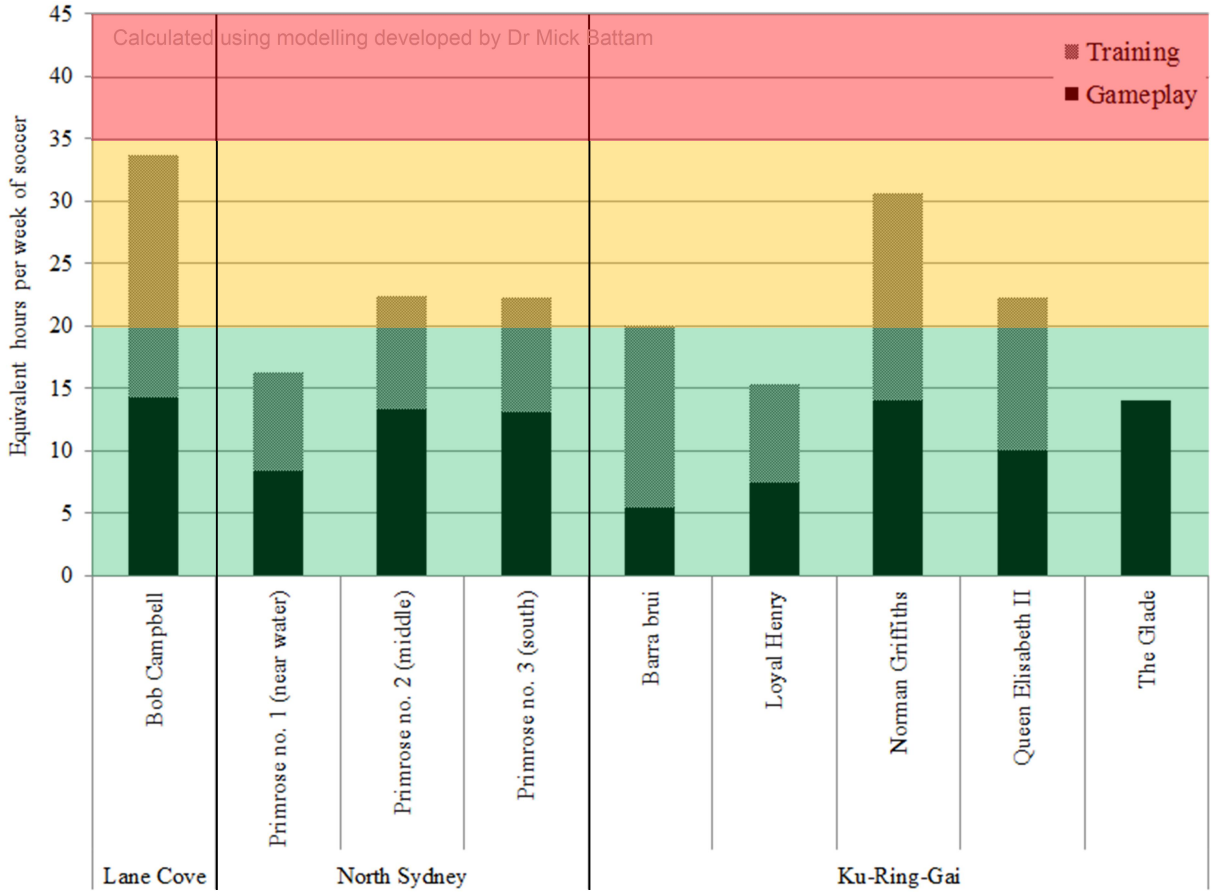


Figure 2-1 Normalised winter sport usage levels for each site, with the shading indicating low to moderate (green), high (orange) and intense (red) levels of wear.

2.2 Summer wear and recovery

The fields are generally used for cricket during the warmer months, with some receiving minimal use. Not only does cricket result in relatively small amounts of wear, but training is mostly conducted off the field (in the nets). Apart from the bowler's run-up, the fields can handle the wear caused by summer sports. However, due to poor soil conditions and/or inappropriate turf cultivars many of the sites are likely to struggle to recover for the damage occurring during the winter sport season.

Techniques for overcoming these problems and improving the condition of these fields are outlined in Chapters 4 and 5.

Figure 2-2: Thin cover on Loyal Henry Park due primarily to poor soil. Acceptable turf cover will not be achieved in this area by the end of summer unless turf patching is performed.

3 Condition of playing fields

Many Councils and/or sporting groups have developed procedures for assessing the condition of playing field. These procedures vary considerably, with more than 65 characteristics commonly used to describe playing fields. Many of these parameters are interrelated such as surface hardness and soil density. Other parameters describe aesthetic characteristics that have minimal impact on play such as turf colour.

A list of parameters that should be measured on playing fields in order of importance has been assembled by a number of industry experts. Those parameters that rank highly on these lists and directly measure playing surface condition include surface hardness, traction (grip) and surface evenness (Aldous 2003; Beard 1973; Holborn 2009 and Otago *et al.* 2007). For each of the 16 playing fields involved in this study these key parameters have been measured or subjectively scored for:

- Outfield areas: along the wings of a field (outfield on a cricket oval);
- Infield areas: such the central playing corridor excluding the centre bounce area; and
- High wear areas: such as the goal box.

The condition of playing fields should be carefully interpreted as it will vary in relation to weather conditions, time of the year and usage patterns. Ideally play would be spread evenly, but due to training patterns it is common for play to be concentrated on one side of the field (or one goal box).

The following assessment was performed by Dr Mick Battam who is a certified professional soil scientist and irrigation agronomist with more than 20 years of experience in sports turf assessment.

3.1 Traction (grip)

Traction refers to the amount of grip that the playing surface provides to players. Low levels of traction are generally associated with sandy soils, waterlogged areas, thin turf and/or root problems. The parameter has been subjectively scored on a scale of 0 (grip) to 5 (minimal grip). Sites with a score of more than 3.5 are regarded as unacceptable, which was observed on all sites, being worst at (Figure 3.2):

- Barra Brui Oval;
- Norman Griffith Oval;
- Queen Elizabeth II Reserve; and
- Primrose Park.

Techniques for improving traction have been encapsulated in the site renovation (Chapter 4) and maintenance practices (Chapter 5).

Figure 3-1: Low levels of traction at Queen Elizabeth Reserve (left) and The Glade (right).

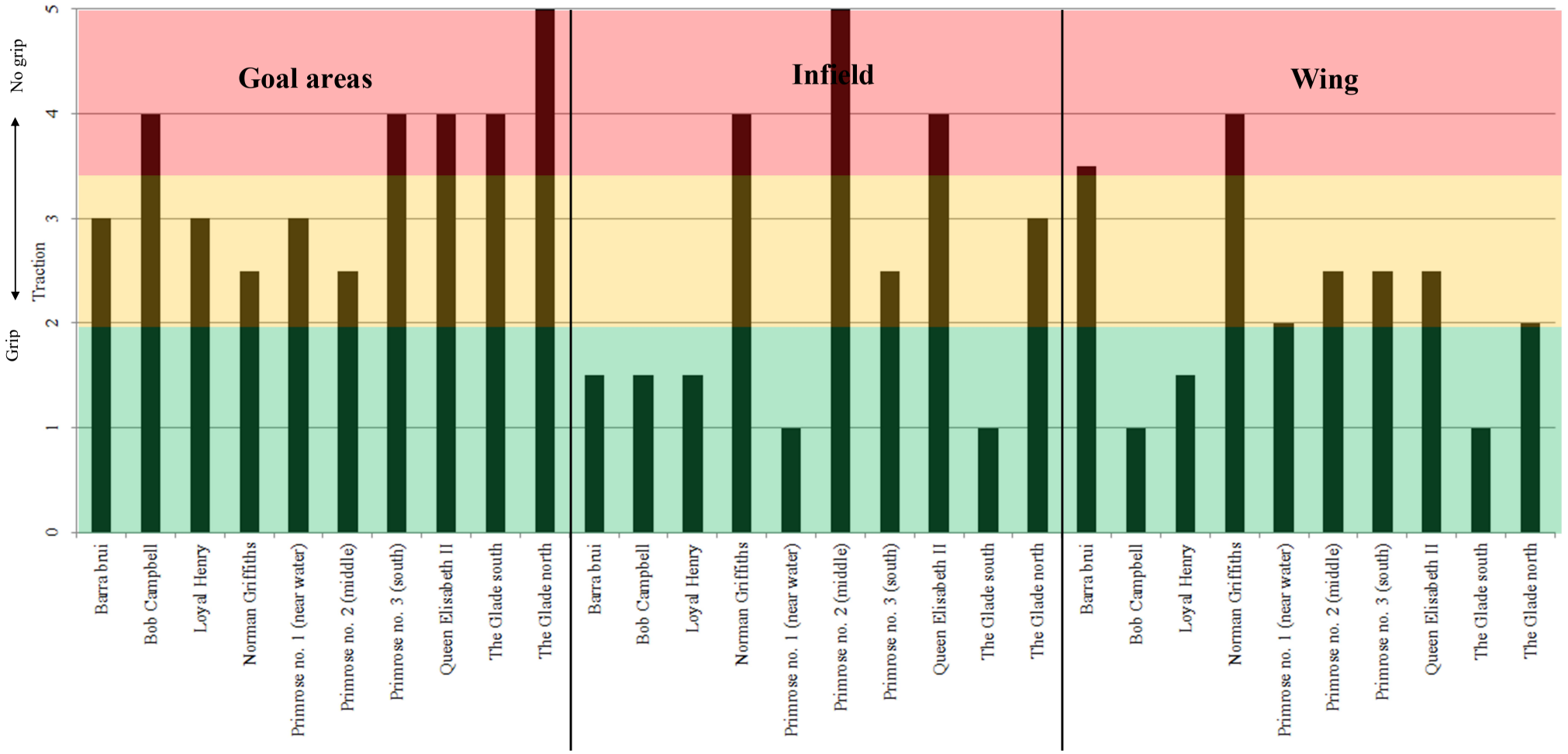


Figure 3-2 Playing surface traction on different sections of the playing fields. Colours show optimal (green), acceptable (orange) and unacceptable (red) scores for traction.

3.2 Evenness

Surface evenness refers to the degree of variation in the elevation of the playing surface measured at a scale that is relevant to the sports being played on the field. The parameter has been subjectively scored on a scale of 0 (perfectly even) to 7 (very uneven). The fields involved in this study were relatively even, being marginally uneven on sections of Loyal Henry Park (Figure 3.4).

Water lies in the numerous low spots in the surface on Primrose Park (Figure 3.3). Whilst these reflect unevenness in the cross-fall this generally occurs over a large enough scale to not adversely affect evenness from a players view point.

Topdressing will improve surface evenness and this has been recommended for several sites (Table 4.1). Depressions on most fields should be gradually filled by topdressing with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I).

Figure 3-3 Water lying in a low spot on Primrose Park.

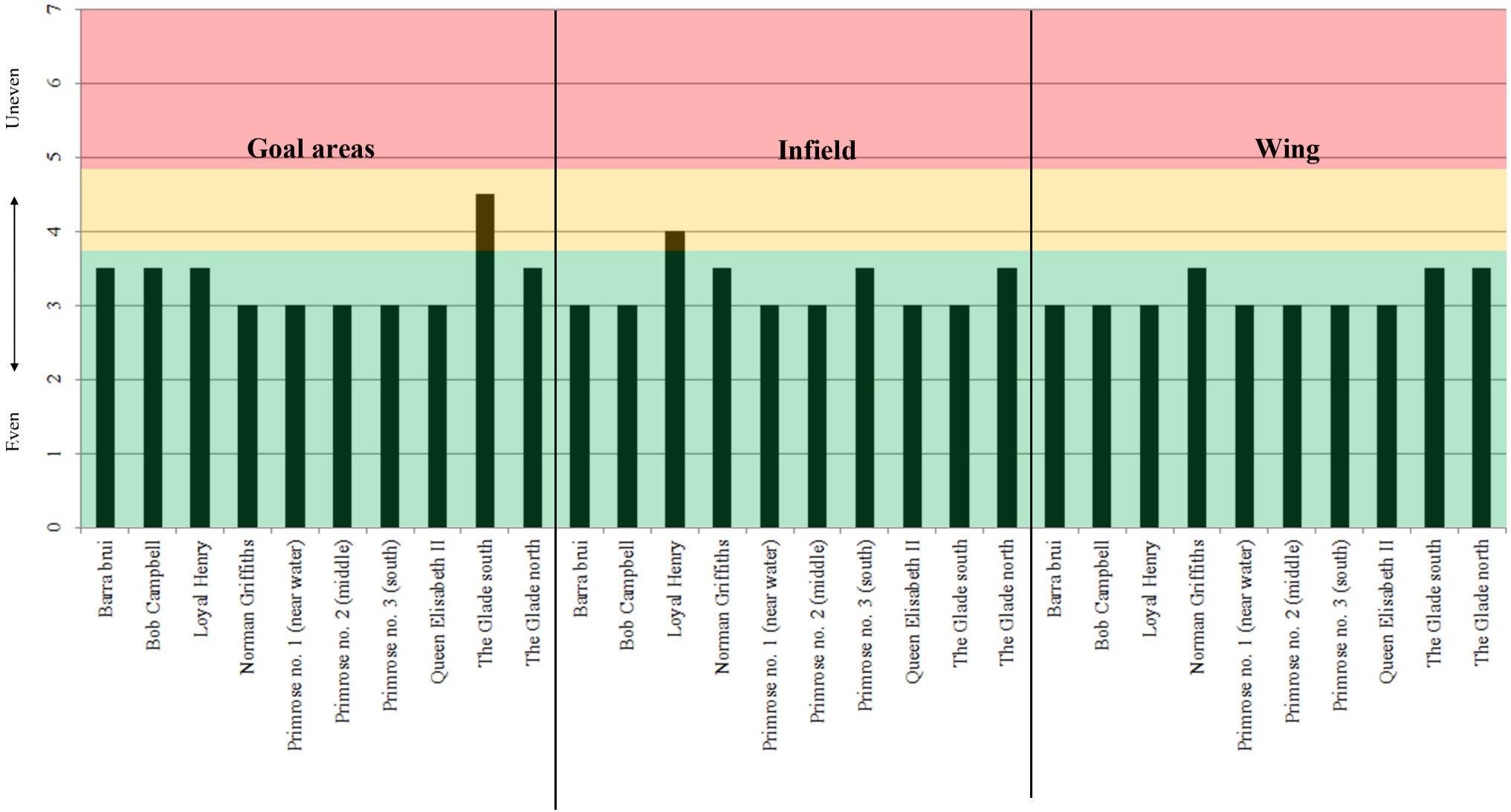


Figure 3-4 Playing surface evenness on different sections of the playing fields. Colours show optimal (green), acceptable (orange) and unacceptable (red) scores for evenness.

3.3 Hardness

Surface hardness is an important parameter that provides a measure of the impact that a player is likely to experience should they dive or fall on the playing surface. Surface hardness will change in relation to weather conditions and/or irrigation practices.

Surface hardness has been measured for the third drop of a 2.25 kg Clegg Hammer. The playing surface was (Figure 3.6):

- extremely hard on the centre of Bob Campbell Oval, Primrose Park lower and middle fields, outfield on Loyal Henry Park and the goal box areas on several other sites; and
- moderately hard on the centre of Norman Griffith Oval and Queen Elizabeth II.

Techniques for improving surface hardness and overcoming waterlogging problems have been encapsulated in the site recommendations outlined in Chapter 4.

Figure 3-5 The playing surface was hard on the centre of Primrose Park.

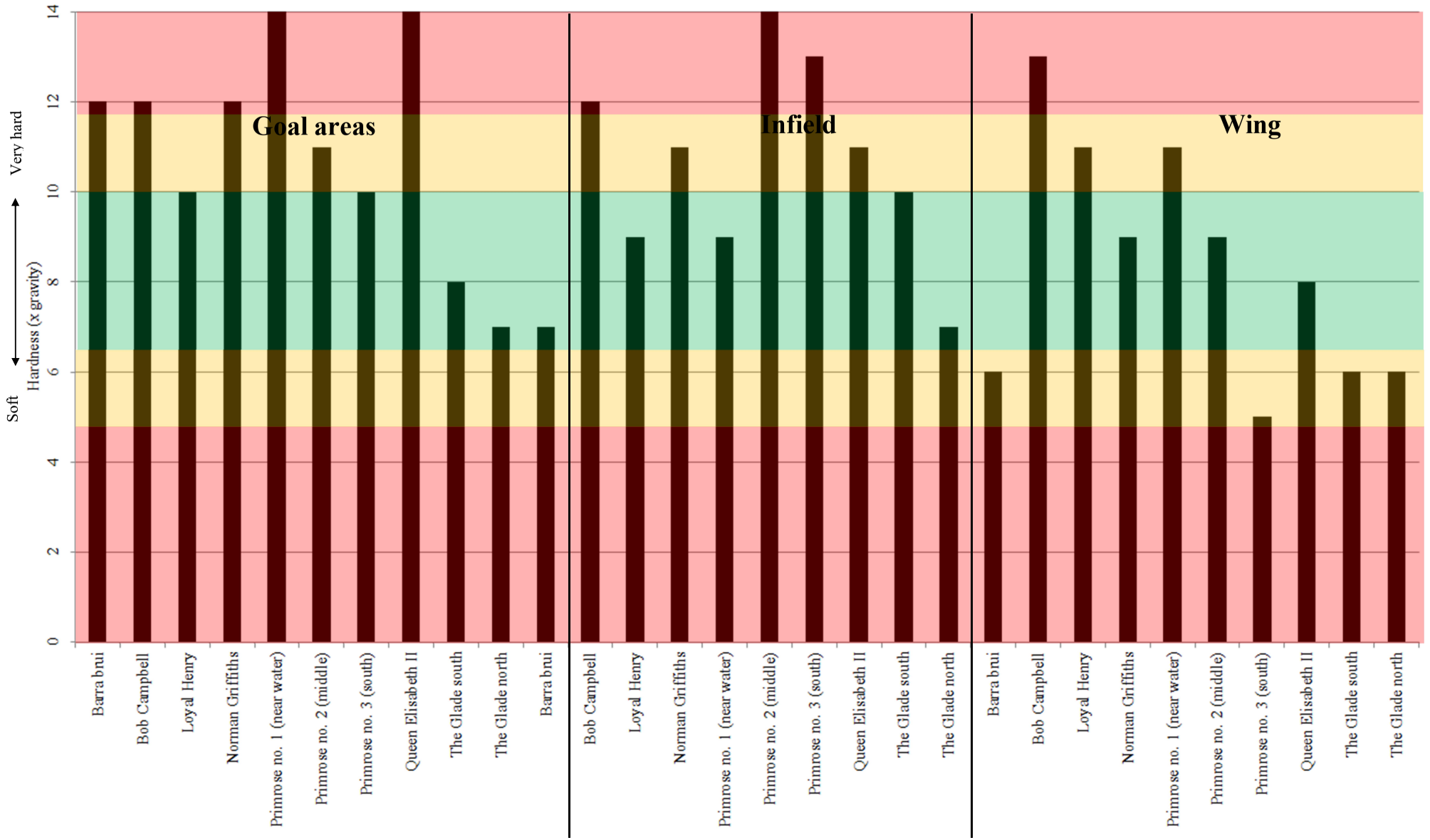


Figure 3-6 Playing surface hardness on different sections of the playing fields. Colours show optimal (green), acceptable (orange) and unacceptable (red) scores for surface hardness.

Figure 3-7: Thin turf cover at Norman Griffith Oval (left) and Loyal Henry Park (right).

3.4 Turf cover

Even though the usage levels were generally not extreme many of the fields were struggling to maintain acceptable turf cover (Figure 3.9), with very poor cover observed at:

- Loyal Henry Park;
- Primrose Park; and
- Queen Elizabeth II Reserve.

Warm season grasses represented the dominant groundcover on all fields, with (*Cynodon dactylon cvv.*) and kikuyu (*Pennisetum clandestinum*) being the most common species (Figure 3.8). Small amounts of annual ryegrass (*Lolium cvv.*) were also observed along with low levels of Queensland blue (*Digitaria didactyla*).

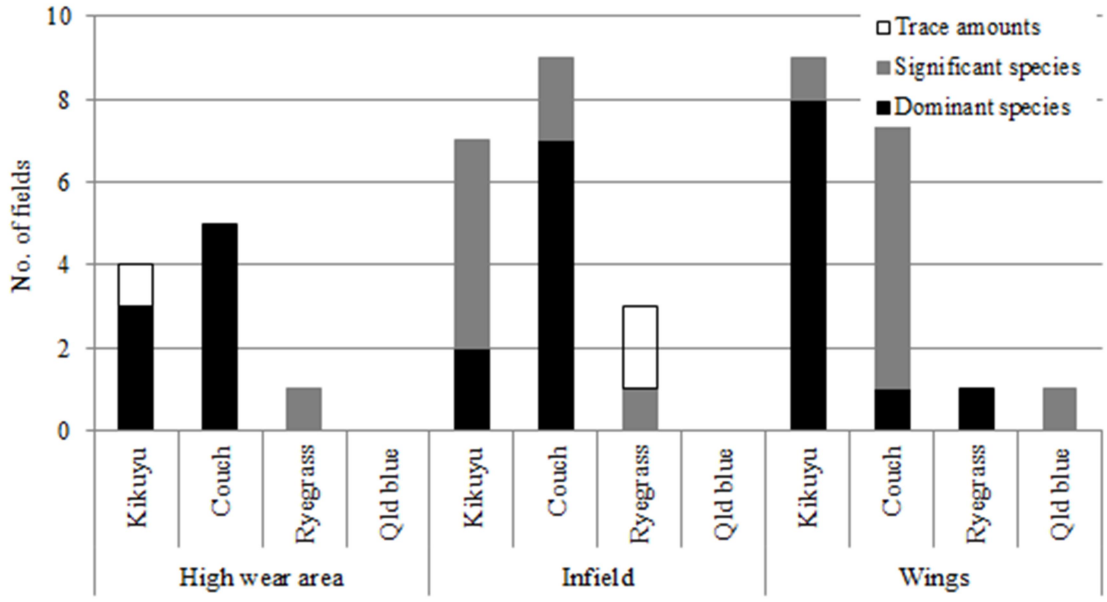


Figure 3-8 Turf species observed during the August 2016 site inspections.

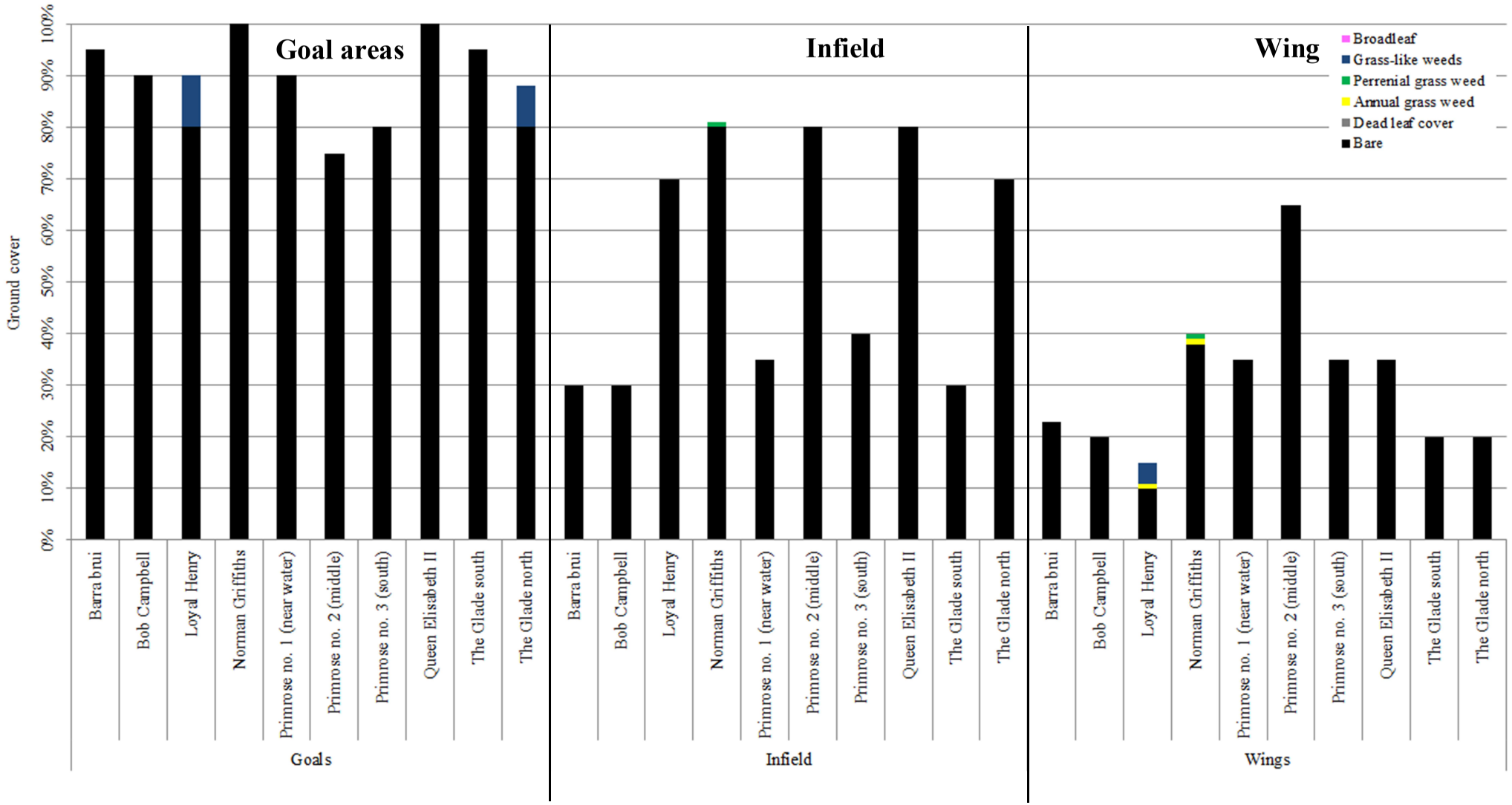


Figure 3-9 Percentage bare ground and weed cover observed on the fields during the site inspections.

4 Renovation of playing fields

Sports field renovation practices refer to those activities that are used to improve or repair playing fields. These works are often performed at the completion of the winter playing season and include activities such as:

- Aerating: which can be achieved to varying degrees with machines that turn, slice, saw, groove or punch holes into the soil profile;
- Topdressing: various topdress materials can be applied to improve surface evenness, reduce thatch and/or ameliorate soil;
- Turf patching or plugging: used to repair areas where turf has died or become worn out;
- Drainage works: such as installation of sand slit drains; and
- Other activities: pruning of trees, adjustment of surface levels around wickets, etc.

The effectiveness of these practices depends on whether they address the underlying issues that are limiting turf performance (Figure 4.1), which were identified by site inspections conducted by Dr Mick Battam. A discussion of these factors along with the associated field restoration works is provided in this chapter.

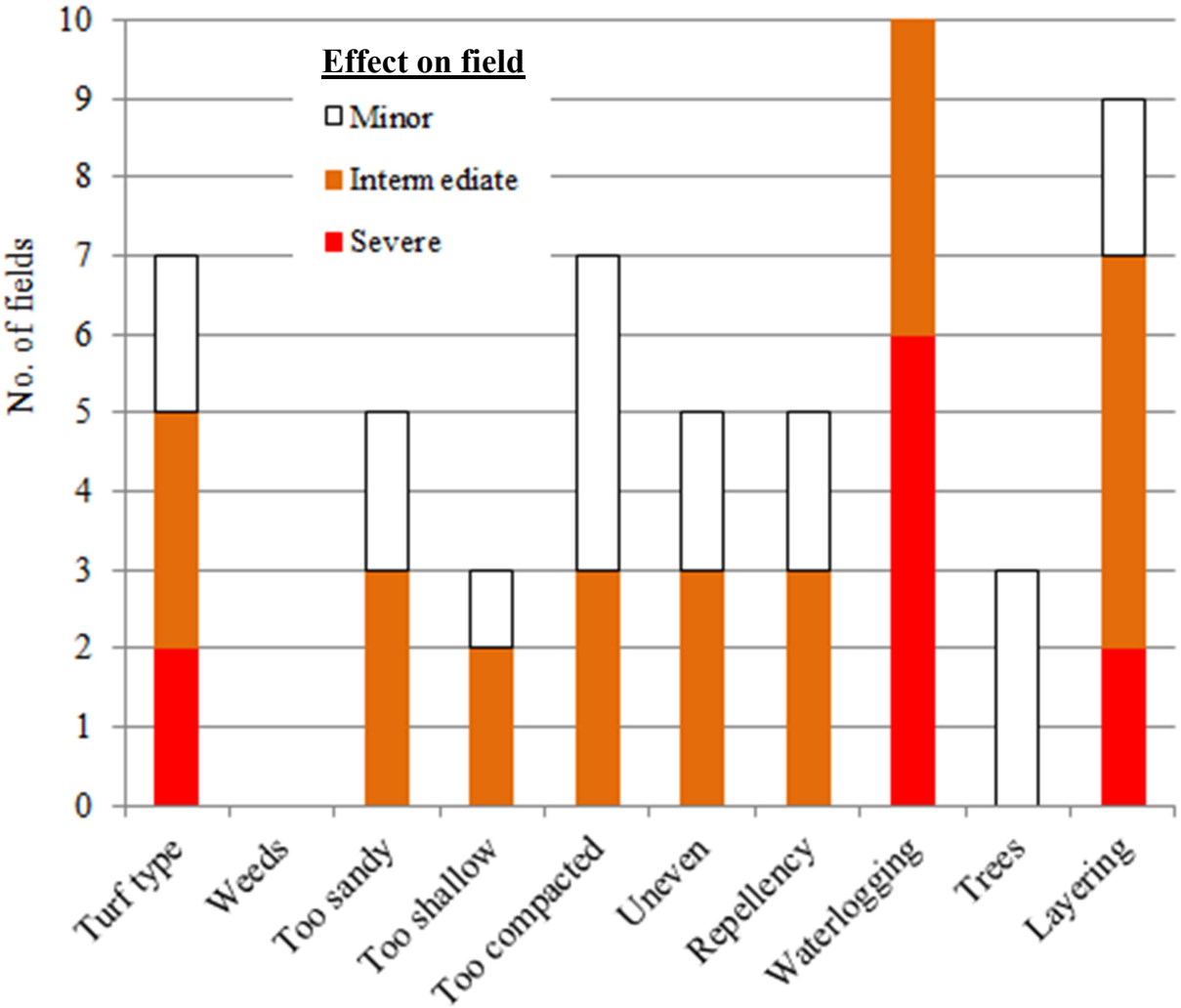


Figure 4-1 Factors limiting turf growth on the 10 winter playing fields (7 sites), many of which had multiple problems.

4.1 Turf type

The existing turf cultivars:

- are incapable of handling current sport usage levels at Bob Campbell Oval and Norman Griffith Oval; and
- could handle the wear in most areas but struggle to maintain cover due to major soil issues at Barra Brui Oval, Primrose Park and Queen Elizabeth II Reserve.

These fields should be reconstructed and converted to Santa Anna couch (most other varieties are unsuitable, regardless of claims made by suppliers). These changes to turf type will only be effective if implemented with the site specific soil amendment works outlined in this report. Those fields converted to couch will become dull coloured in winter, but will maintain cover and recover without turf patching in spring if correctly managed (Figure 4.2). The dull colour could be addressed by either oversowing with ryegrass or spraying with a leaf dye (as is common practice on couch golf courses in colder areas).

To avoid problems associated with layering it is recommended that turf be established from washed turf (very expensive) or sprigs (requires an irrigation system and takes the field out of play for an entire summer sport season). Traditional sod should only be used if it contains less than 20% fines (silt and clay) in the attached soil and it is not recommended for use at Bob Campbell Oval.

Figure 4-2: Heavily used couch sporting field at Greys Point that becomes dull coloured at the end of the winter sport season (upper), but maintains acceptable cover even in goal boxes (lower left) and rapidly recovers to be in excellent condition by October (lower right).

4.2 Compaction

The weight exerted by vehicle and foot traffic can press soil particles together, causing the soil to become compacted. Compaction restricts root development and can have an adverse effect on drainage, even in sandy soils. Compaction can also reduce the amount of water that can be stored in the soil, making turf more vulnerable to injury during hot weather. During the inspections, the surface was moderately hard at Bob Campbell Oval, Norman Griffith Oval and sections of the other sites. The soil was layered at many of the sites, with:

- major issues observed at Barra Brui and Queen Elizabeth II Reserve; and
- significant issues observed at most other sites.

Aeration machines vary with regards to their depth of penetration, effectiveness in different soil types and capacity to break up soil layers. Based on the soil, layering and drainage characteristics of the sites inspected the following recommendations are made regarding aeration equipment. Aeration should not occur in the 5 month period after applying a pre-emergent herbicide.

	Aggravator • Recommended for ongoing use at Loyal Henry Park, Norman Griffith Oval and The Glade
	Earthquake (off set deep slicer) • recommended for The Glade • should occur about every 3 years at Bob Campbell Oval, Loyal Henry Park, Queen Elizabeth II Reserve and The Glade • slicing should extend up to the edge of the site, using multiple passes on outer perimeter and high traffic areas
	Deep solid tine aerator with “kick” (vertidrain) • most site need intense aeration (4 slow passes in a row that is repeated on several occasions), especially Barra Brui Oval, Primrose Park and Queen Elizabeth II Reserve • if council does not own a vertidrain then these passes could be performed with the aerovator will, but ideally deep aeration should occur on these sites at least once a year
	Recycling topdressing machine (aerates to a depth of up to 180 mm and generates topdress in the process). Could be used to: • aerate and improve traction at Barra Brui Oval

4.3 Soil too sandy

The soil varied considerably between the sites, with:

- **Silty sand:** Barra Brui Oval and Queen Elizabeth II Reserve;
- **loamy sand:** Bob Campbell Oval,
- **loamy sand to sandy loam:** Loyal Henry Park and The Glade; and
- **sandy loam:** Norman Griffith Oval and Primrose Park.

Thin turf cover was observed on the sandiest fields, but many of the others will struggle if topdressed too heavily with sand based material such as 80:20. Instead the depressions and thin turf areas on many of these fields should be topdressed with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I).

4.4 Lack of topsoil depth

Adequate topsoil depth was observed across most sites, being shallow on the northern and western side of The Glade. The turf was thinner in these shallow areas which were often prone to waterlogging (Figure 4.3). Shallow areas could be addressed by topdressing with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I).

Figure 4-3 The turf struggling on a shallow section of The Glade. As the subsoil has a heavy clay texture (insert) this shallow area is also prone to waterlogging.

4.5 Waterlogging

Waterlogging not only limits turf growth and reduces its resistance to wear, but it increases the soils susceptibility to compaction. Waterlogging is a significant problem on all of the sites and typically occurred as a result of several interacting factors. To overcome these problems, the following recommendations are made.

Turf clay

A thin layer of clay overlays the soil profile at some sites and has been imported to the site attached to turf rolls. Once this clay becomes compacted it can prevent water from entering the soil profile, even if the underlying topsoil is very sandy (Figure 4.4). Techniques for overcoming layering problems will vary between the sites and have been encapsulated in the works outlined in Table 4.1. Ensuring these layers do not develop into the future it is recommended turf be established from sprigs or washed turf. If traditionally sod is used (not recommended for some sites) it is crucial to ensure the soil has less than 20% fines (silt and clay) in the attached soil layer.

Under no circumstances are the fields to be rolled or waterlogging problems will persist or even become worse. Instead, topdressing should be used to improve surface evenness.

Figure 4-4: The surface is soft following rain on Barra Brui Oval (lower) due to slow infiltration through the thin layer of soil imported to the site attached to turf rolls (upper left), with the underlying sand remaining relatively dry even when there is water sitting on the surface (upper right).

Managing surface water movement

Surface water moving onto fields from adjacent areas is contributing to waterlogging problems on 3 sites. To divert this water away from the field surface drainage structure have been recommend for:

- Loyal Henry Park: small contour mound to divert water flow;
- Primrose Park: additional drainage pits and a dish drain (or gutter); and
- The Glade: small contour mound (or swale) and an additional drainage pit.

A curtain drain has also been recommended for installation in the swale along the southern edge of Loyal Henry Park to prevent seepage water from flowing onto the field.

Figure 4-5: Water running onto Primrose Park (dashed arrow) that should be intercepted using surface pits, with a gutter (or dish drain) needed to divert water into the pits at the end of Denos Lane. It may also be necessary to install a dish drain or speed hump to prevent water running through the vehicle entry gate and onto the fields.

Use topdress to fill depressions

Water lying in a depression because the underlying soil is compacted will not be overcome by the addition of sand, but will remain a wet area. Instead, the soil needs to be aerated so that the water can soak away. Those depressions that remain following aeration should be gradually filled by topdressing with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded on sites where topdress is being applied to the entire field so that more material is swept into depressions.

Figure 4.6: Waterlogging caused by unevenness in the surface (upper) should not be addressed by filling these areas with sand as the turf will remain thin and these areas which will erode (lower left). Instead these depressions should be gradually filled by topdressing with a mixture of 50% loamy sand and 50% AS 4454 compost so the surface remains stable as the turf grows into these areas (lower right). Note the green tinge where compost/loamy sand topress has been spread.

Slit drainage

Slit drainage is often viewed as the ultimate solution to waterlogging problems. If designed, installed and maintained correctly, slit drainage can be a very effective means of overcoming waterlogging problems. However, many sites will not require a slit drainage system and/or the system should not be installed until the soil has been amended and the field converted to a more appropriate turf cultivar.

Just because a site has a slit drainage system does not mean it will drain well, which is clearly demonstrated by the softness in the soil surface (even though there is minimal ponding) for days following rain at Barra Brui Oval and Queen Elizabeth II Reserve (Figure 4.7).

Based on the site inspections those sites that should be considered for slit drainage installation are Primrose Park, The Glade and possibly Norman Griffiths Oval. These installations must NOT occur until the surface is even, soil is amended and the site has been converted to a suitable turf cultivar or major problems will persist (Figure 4.7).

Figure 4-7: Slit drainage systems have been recommended for installation on a few sites, but must NOT be installed until the surface is even, soil has been amended and the site converted to an appropriate turf cultivar. Failure to ensure these criteria are met can make it difficult to address uneveness (upper) or lead to major damage to the slit drainage system just months after installation (lower).

4.6 Trees

Trees that have invasive root systems (e.g. Chinese elms, honey locusts, oaks and peppermint gums) should not be planted adjacent to playing fields. However, competition for water and nutrients can occur from most tree species. Tree roots were having an adverse effect on turf performance on the outer areas of Bob Campbell Oval, Loyal Henry Park and Queen Elizabeth II Reserve. These problems are relatively minor, but will become more significant over time and should be addressed by aerating up to the edge of the field using the earthquake.

Shade can also have an adverse effect on turf performance as was occurring on sections of the Bob Campbell Oval, Loyal Henry Park, The Glade and to a lesser degree at Queen Elizabeth II Reserve.

4.7 Summary

Based on the factors limiting turf performance the following renovation practices are recommended for the playing fields involved in this study (site details in Table 4.1):

- Reconstruction of fields: involving soil amendment and conversion to Santa Anna couch is recommended for Barra Brui, Bob Campbell, Loyal Henry, Norman Griffith, Primrose and Queen Elizabeth II. If these fields are amended and maintained in accordance with the works in this report they should be able to handle current usage;
- Aeration: intense aeration (4 slow passes in a row that is repeated on several occasions) with the vertidrain has been recommended for most sites, especially Barra Brui Oval, Primrose Park and Queen Elizabeth II Reserve. If council does not own a vertidrain then these passes could be performed with the aerovator, but deep aeration should occur at least annually;
- Slicing: has been recommended for The Glade and for ongoing use every 3 years at Bob Campbell Oval, Loyal Henry Park, Queen Elizabeth II Reserve and The Glade. Slicing should extend to the edge of the field, using multiple passes on the edge and in the high traffic areas;
- Drainage structures: to prevent surface water from adjacent areas from running onto the field should be installed at Loyal Henry Park, Primrose Park and The Glade;
- Slit drains: should be considered for installation at Primrose Park, The Glade and possibly Norman Griffiths Oval. These installations must NOT occur (regardless of the claims made by installers) until the surface is even, soil is amended and the site has been converted to a suitable turf cultivar or major problems will persist;
- Turf establishment: should be achieved through sprigging, plugging or the use of washed turf, with traditional sod only to be used if it contains less than 20% fines (silt and clay) in the attached soil layer. This is crucial;
- Topdressing: with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I) is recommended for Primrose Park and The Glade. This topdress should be used to repair holes on other sites. Sand based topdress such as 80:20 must NOT be applied to the fields or ongoing turf patching will be required, with many of the fields marginally too sandy; and
- Trees: were impacting turf performance on 3 sites, but these were generally limited to perimeter areas.

It is usual to recommend the reconstruction of so many fields, but most sites have either been constructed with poor soil that have not been amended and/or using a turf cultivar that is unable to handle the site usage levels.

Table 4-1 Summary of site characteristics and recommendations. Colours refer to limitation to turf performance as severe (red), intermediate (orange) and minor (cream).

	Site issues							Recommendations						
Site	**Shallow**	**Sandy**	**Wet**	**Uneven**	**Shade**	**Trees**	**Repel.**	**Stop run-on**	**Topdress[1]**	**Slice[2]**	**Vertid.[3]**	**Patching[4]**	**Other[4]**	**Reconstruct**
Barra Brui									Local		x20	(900 m^2)		Yes
Bob Campbell									Local			(50 m^2)	(spot spray)	Yes
Loyal Henry									Local				(oversow couch)	Yes
Norman Griffith								Diversion mound	Local					Yes
Primrose no. 1 (near water)									RO/LS x2		x20	(1,500 m^2)		Ideally
Primrose no. 2 (middle field)								Pits & dish drain	RO/LS x2		x20	(1,000 m^2)		Yes
Primrose no. 3 (southern field)									RO/LS x2		x20	(800 m^2)		Yes
Queen Elizabeth II									Local		x20	(1,600 m^2)		Yes
The Glade south								Mound & pit	RO/LS x2	x2	x4	(150 m^2)	Calcium chloride	
The Glade mini									RO/LS x2	x2	x4		Calcium chloride	

1 A mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I) has been recommended for topdressing on most sites
2 Slice to the edge of the site
3 Intense aeration is recommended on sites where x20 has been noted. This can be performed by using 4 soil passes in a row with a vertidrain or aerovator, with this process repeated (once turf has recovered) on at least 5 occasions. If performed early in a week these fields should be playable by the weekend, but the machine operator should use their discretion to determine how many passes in a row the site can handle. Aeration must not be performed in the 5 month period after applying a pre-emergent herbicide
4 works in brackets only need to be implemented if field is not reconstructed

5 Maintenance of playing fields

Sports field maintenance practices refer to those activities that are used to routinely maintain and/or improve turf performance. In addition to mowing these practices include:

- fertiliser application;
- weed, pest and disease control;
- water repellency control;
- irrigation; and
- oversowing with ryegrass.

The following discussion outlines the maintenance practices recommended for NSFA playing fields.

5.1 Fertiliser

Nutrient status of playing fields

Best practice is to ensure that adequate but not excessive levels of nutrients are available in the soil so that turf is not heavily reliant on fertiliser addition. Unfortunately soil chemical analysis information was not available at the time of writing this report. However, the following comments are made based on visual inspection of the sites and the authors' knowledge of the soils used to construct these fields. Generally, the soils:

- have a low nutrient holding capacity and low fertility such as Barra Brui Oval, Loyal Henry Park and Queen Elizabeth II Reserve;
- some are more prone to hardsetting such as Primrose Park;
- calcium/magnesium imbalances are likely occurring on most sites; and
- nitrogen is likely the nutrient most limiting turf growth, but potassium and micronutrients area likely to be limiting also on Barra Brui Oval, Loyal Henry Park and Queen Elizabeth II Reserve.

However, soil testing is needed to confirm these statements and should examine parameters including:

- pH and salinity;
- total organic carbon;
- total nitrogen, nitrate, nitrite and ammonium;
- exchangeable cation (calcium, magnesium, potassium, sodium, aluminium and CEC);
- available phosphorus and sulphur; and
- micronutrients (iron, zinc, copper, manganese and boron).

It is crucial that soil tests measure total nitrogen (often ignored) and carbon levels so accurate fertiliser rates can be provided.

Improving soil fertility

The addition of compost (Appendix I) as a component of the topdress could increase the nutrient holding capacity of the soils, with as little as 10 mm likely to raise CEC levels by about 40%. Composted garden organics will also provide a good source of nutrients such as nitrogen and sulphur.

Synthetic fertilisers should be applied to these fields (N:P:K of about 9:1:9) so the equivalent of about 150 kg/ha of nitrogen is applied:

- in October at Loyal Henry Park; and
- twice during the growing season (October and early February) on the remaining sites.

Less frequent application could be achieved through the use of slow release fertilisers and/or those fields that are topdressed with a mixture of 50% loamy sand and 50% composted garden organics (Figure 5.1).

Figure 5.1: The effect of topdressing with AS 4454 composted garden organics on a sporting field in Lake Macquarie (photo courtesy of Dr Paul Lamble).

5.2 Weeds, pests and diseases

Weed species

Weeds were in very low numbers during the site inspections (Figure 3.8). Whilst this could be due to excellent weed control it is likely also related to the assessments being performed in winter. The most common weeds observed on or around the perimeter of the fields included:

- Guildford grass (*Romulea rosea*);
- White clover (*Trifolium repens*);
- Winter grass (*Poa annua*); and
- Parramatta grass (*Sporobolus sp.*).

Weed control

Spot spraying is recommended for the control of the broadleaf weeds on the outer areas of Bob Campbell Oval. Attention should be given to eradicating weeds, particularly those that:

- represent trip hazards such as Parramatta grass, paspalum and goose grass;
- do not have a selective herbicide such as paspalum (in kikuyu fields) and Parramatta grass. In small numbers these can be eradicated by hand chipping which is recommended for all sites.

The importance of controlling Parramatta grass cannot be emphasised strongly enough as it is a major weed for several nearby councils and there is no selective herbicide. At the time of the inspection Parramatta grass was only observed in small numbers on Norman Griffith Oval.

It is important to control weeds on the areas surrounding the fields which represent a source of seed.

A dense turf cover is the most effective means for weed control as it will complete strongly for light, nutrients, water and physical space in the canopy. As such, implementing the renovation recommendations outlined in this report will discourage the establishment of weeds. Once removed, the pre-emergent herbicides would provide an effective means for preventing re-establishment on sites where turf cover becomes thin over the winter period, with these sites ideally aerated later in the growing season (e.g. December) once reasonable turf cover has been achieved.

To minimise the spread of weeds it is recommended that machinery (e.g. mowers) be cleaned following use on sites that have a high weed infestation.

Pest and disease control

Relatively few disease and insect problems are likely to occur on the playing fields. During the site inspection signs of mite damage were observed on a number of fields, but the impact was relatively minor. Chemical control will occasionally be required for the control of pests and diseases, being more crucial on heavily used fields.

5.3 Water repellency control

Water repellency or hydrophobicity (frightened of water) can prevent water from entering a soil (Figure 5.2). It is caused by waxes or fats in the soil that can accumulate as a result of the breakdown of organic matter (e.g. grass clippings). Water repellency can occur in any soil, but is more common on sandy soils (e.g. Barra Brui and Queen Elizabeth II) and unirrigated fields. The outer sections of Queen Elizabeth II Reserve were water repellent at the time of the site inspection.

The effects of water repellency can be minimised by preventing the soil from drying out. The likelihood of this occurring can be reduced by amending the soil (increasing the water holding capacity) and ensuring the irrigation system applies water evenly. It is recommended that the fields be regularly inspected for signs of "dry patch" using the water droplet test (Figure 5-2). Water repellency is likely to develop on many of the other sites during extended dry periods. Sites that become water repellent should be treated with a wetting agent.

Figure 5-2 Water sitting like a "ball" on top of the soil as a result of waxes/fats in the soil that cause it to repel water.

5.4 Irrigation

To prevent deterioration in the condition of the turf, irrigation should be routinely applied during periods of inadequate rain. Of the 7 sites involved in this study, 4 have a pop-up irrigation system, with none present at:

- Loyal Henry Park;
- Norman Griffith Oval; and
- The Glade.

An irrigation system is most needed at Norman Griffith Oval and this site should be manually irrigated two to three times a week at the end of the winter sport season until full cover is achieved.

How often to water

Irrigation should occur before the soil moisture reserves become depleted to a point at which turf health is adversely affected. The optimum irrigation frequency will vary with site characteristics such as geographic location, microclimate, turf species/variety, soil and site usage patterns. Ideally irrigation scheduling would be performed in relation to evapotranspiration rates. As a guide, watering (rain or irrigation) events during the warmer months (September to March) would ideally occur on the irrigated sites about:

- **September to March:** three times a week; and
- **April to August:** fortnightly in early autumn (most of which would be satisfied by rain), with no irrigation required during winter. More frequent watering would be required if the site is oversown.

If the amendment strategies outlined in this report are implemented, then improvements to turf cover could be achieved using less water on many of these sites.

Length of watering events

The length of the irrigation event needed to replenish soil moisture reserves will vary with site characteristics, irrigation system performance, irrigation frequency and recent weather conditions. For the sites with pop-up irrigation systems an irrigation event will likely be about 25 to 35 minutes per station. To prevent run-off irrigation events should be split into several sub events using a cycle/soak watering regime (most modern controllers have this as an option).

Watering events should be reduced by 50% for stations operating only half circle heads. The run times above are only a rough guide, with more detailed information on irrigation performance needed to determine the exact watering time.

Allowing for weather conditions

Irrigation events should only occur during periods of inadequate rainfall. As such, a rain sensor should be set up and the controller appropriately programmed so irrigation events are skipped following significant rain, defined as 6 mm for the sites involved in this study.

To minimise evaporative losses, it is recommended irrigation events occur at night (as generally occurs), which will also minimise energy costs.

Irrigation maintenance

Irrigation maintenance refers to activities such as cleaning filters, repairs and adjustments to components such as sprinklers. If the irrigation systems are not appropriately maintained, then problems can occur as a result of:

- uneven watering and dry spots;
- leakage and waterlogging; and
- non-target watering.

Irrigation maintenance should be performed at least once a year (preferably twice), with the systems visually inspected regularly throughout the year. Ideally a Certified irrigation professional (installer, contractor or designer) would perform the annual irrigation maintenance. If cost is limiting it may be more effective to train a council employee so they are appropriately skilled (and ideally certified) to perform the irrigation assessment.

Based on variations in cover observed on the irrigated fields it is estimated about 25% water savings could be achieved through improvements to the irrigation system design and/or operating pressures. To achieve this will require a hydraulic audit and accurate location of the individual sprinklers.

Figure 5.4: Sprinklers were buried too deeply on some fields so the stream strikes the grass and most of the water lands near the head.

5.5 Growth regulators

Growth regulators such as primo could be used to increase the sward density, wear resistance and reduce the mowing requirement some playing fields. As many of the sites struggle to maintain ground cover these are not required until the sites have been reconstructed and converted to a more appropriate turf cultivar.

Once reconstructed according to the works outlined in this report growth regulators should be considered for use at Norman Griffith Oval (assuming an irrigation system is installed), Primrose Park, Queen Elizabeth II Reserve and to a lesser degree at Barra Brui Oval.

5.6 Repairing small bare areas

Once the fields have been reconstructed it is crucial to repair small bare areas (e.g. goal keepers' box) at the end of the winter sport season by:

- aerating thin turf areas with a garden fork and topdressing depressions; and/or
- plugging bare areas that will struggle to recover with turf harvested from low wear areas.

These areas should be fertilised and watered. If these repairs are not performed, then more significant works may be required the next year. Bowlers' run up areas may also need repairing annually.

Figure 5-5: Example of a heavily used field (similar usage to Norman Griffith Oval) that has been amended so acceptable turf cover is maintained up to the end of the soccer season. However, the small bare area wear the goal keeper stands should be repaired at the start of spring so it fully recovers prior to the commencement of the next winter sport season.

The dull colour is due to the couch which goes dormant in winter but recovers rapidly so full cover is achieved without patching by October (insert).

5.7 Oversowing with ryegrass

Some improvements in wear can be achieved by oversowing with ryegrass, particularly during late autumn. However, ryegrass grows slowly in mid-winter, resulting in a relatively modest increase in carrying capacity. Oversowing ryegrass can be used to improve the colour of couch playing fields in winter but this can also be achieved using a turf colourant (leaf dye) as occurs on some golf courses.

Oversowing is relatively costly ($0.20/m^2) and will generally require the ryegrass be sprayed out in spring. Due to its labour intensity, oversowing is more commonly used on high profile fields and/or high wear areas (e.g. goal boxes) on local fields. Before oversowing is used it is first recommended that the works outlined in this report are implemented.

Based on the current usage levels and characteristics of these playing fields, oversowing is likely to be beneficial at Barra Brui Oval (goal boxes only), Bob Campbell Oval, Primrose Park and Queen Elizabeth II (goal boxes only). Oversowing can assist in improving wear levels, but is far less important than amending the soil and converting the fields to more appropriate turf cultivars.

5.8 Summary

Based on the factors limiting turf performance the following management practices are recommended for the playing fields involved in this study:

- Fertilising: the addition of composted garden organics will improve the nutrient holding capacity of the soil. The fields will also require the addition of nitrogen and potassium, with calcium possibly required (confirm via testing) on many sites including The Glade;
- Weed control: weeds were in low numbers during the site inspections, but pre-emergent herbicides may be required at some sites. Hand chipping of Parramatta grass is recommended for Norman Griffith Oval and is crucial given this weed is a trip hazard and currently has no selective herbicide. Weed control should occur on the field surrounds (source of seed);
- Wetting agents: sites should be inspected for the occurrence of water repellency, with routine application recommended for Barra Brui Oval, Loyal Henry Park and Queen Elizabeth II Reserve;
- Irrigation: controllers would ideally operate based on ET monitoring (alternatively use the schedules outlined in this report). Maintenance should occur at least annually (visual inspections performed routinely), with water savings of about 25% likely to be achieved if an irrigation design audit was performed;
- Ryegrass oversowing: may be beneficial at Barra Brui Oval (goal boxes only), Bob Campbell Oval, Primrose Park and Queen Elizabeth II (goal boxes only). Oversowing can assist in improving wear levels, but is far less important than amending the soil and converting the fields to more appropriate turf cultivars;
- Growth regulators (e.g. primo): Barra Brui Oval (goal boxes only), Bob Campbell Oval and Primrose Park; and
- Aeration: should occur routinely using the vertidrain or aerovator, with the earthquake required every 3 years at Loyal Henry Park, Queen Elizabeth II Reserve and The Glade. Aeration must not occur in the 5 month period after applying a pre-emergent herbicide.

6 Conclusions

The sports field management review has provided answers to the following key questions:

Are the fields overused?

During winter it is estimated these playing fields receive the equivalent of wear of caused by 188 hours per week of adult soccer. Most of the fields are in very poor condition and based on their carrying capacity (100 hours per week) cannot collectively handle the winter usage. Winter use is not distributed evenly, with:

- elevated to high wear occurring at Bob Campbell Oval and Norman Griffith Oval; and
- elevated wear observed at Primrose Park and Queen Elizabeth II Reserve.

These wear levels are less intense then those observed in many of the nearby councils and if amended according to the works outlined in this report the collective carrying capacity could be increased to about 250 hours per week. As such, the fields could handle the current usage levels if amended according to the works outlined in this report.

Are the playing fields in acceptable conditions?

Most sites of the sites displayed low levels of traction and were struggling to maintain grass cover across large sections of the field, with major problems at:

- Barra Brui Oval (waterlogging, layered soil that is too sandy);
- Loyal Henry Park (uneven, layered soil and run-on);
- Norman Griffith Oval (wrong turf type, waterlogging and layered soil);
- Primrose Park (run-on, uneven cross-fall and layered soil); and
- Queen Elizabeth II Reserve (waterlogging, layered soil that is too sandy).

Less extensive problems were also observed at Bob Campbell (wrong turf cultivar and layered soil) and The Glade (shallow and receives run-on).

What are the most common problems on the playing fields?

Ignoring small localised issues, the most common problems on the 10 fields were waterlogging (all 10 fields), soil layering (7 fields), inappropriate turf cultivar (5 fields) and soil too sandy (3 fields).

Do the fields have appropriate turf cultivars?

Inappropriate turf cultivars that could never handle the current sport usage levels should be replaced with Santa Anna couch (no other turf cultivar is to be used, regardless of the claims made by turf suppliers) at Bob Campbell Oval and Norman Griffith Oval. Due to other major problems with the soil these conversions should also occur during reconstruction at Barra Brui Oval, Loyal Henry Park, Primrose Park and Queen Elizabeth II Reserve.

Turf should be established from sprigs (cheaper) or washed turf, with traditional sod not to be used unless it contains less than 20% fines (silt and clay) in the attached soil layer. Only washed turf is recommended for use at Bob Campbell Oval.

How can the waterlogging problems be overcome?

In addition to implementing the topdressing and aeration works outlined in this report, reductions in waterlogging could occur if:

- surface drainage structures were constructed to prevent run-on at Loyal Henry Park, Primrose Park and The Glade;
- surface is laser levelled during reconstructed so an even cross-fall is achieved at Norman Griffith Oval and Primrose Park; and
- depressions on the fields are gradually filled with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). Sand based topdress such as 80:20 must NOT be used to fill depressions or problems will persist.

Slit drains should be considered for installation at Primrose Park, The Glade and possibly Norman Griffiths Oval. These installations must NOT occur (regardless of the claims made by installers) until the surface is even, soil is amended and the site has been converted to a suitable turf cultivar or major problems will persist (Figure 4.7).

How much will it cost to amend the playing fields?

Techniques for improving the condition and carrying capacity of the playing have been provided, which include specific instructions for the reconstruction of:

- Barra Brui Oval: will cost ~$170,00+GST;
- Bob Cambell Oval: will cost ~$130,00+GST (this year the field will survive with minor patching);
- Loyal Henry Park: will cost ~$130,00+GST;
- Norman Griffith Oval: including an irrigation system will cost ~$310,000+GST;
- Primrose Park 1&2: will cost ~$250,00+GST;
- Queen Elizabeth II: will cost ~$130,000+GST

Funds are also needed for works on Primrose Park no. 3 (~$24,400+GST) and The Glade (~$43,400+GST).

Once amended according to the works in this report these fields should be able to handle the current usage and will require minimal patching (Figure 6.1) provided they are not trafficked when wet or topdressed with sand based material.

Short term options for repairing fields (except Norman Griffith Oval) prior to reconstruction have been provided and priority should be given to those fields that require the most patching.

It is important to note that some sites have turf cultivars incapable of handling the current sport usage levels and will continue to deteriorate.

Figure 6.1: Effect of soil amendment works on Grays Point upper playing field which receives similar levels of use to Norman Griffith Oval.

What improvements can be expected by implementing the works outlined in this report?

The works outlined in this report will result in:

- major improvements in the performance of all fields that are reconstructed; and
- significant improvements in the performance of the remaining 3 fields.

What maintenance procedures are recommended for the playing fields?

In addition to regular mowing the following maintenance practices have been recommended:

- Fertilising: the addition of composted garden organics will improve the nutrient holding capacity of the soil. The fields will also require the addition of nitrogen and potassium, with calcium possibly required (confirm via testing) on many sites including The Glade;
- Weed control: weeds were in low numbers during the site inspections, but pre-emergent herbicides may be required at some sites. Hand chipping of Parramatta grass is recommended for Norman Griffith Oval and is crucial given this weed is a trip hazard and currently has no selective herbicide. Weed control should occur on the field surrounds (source of seed);
- Wetting agents: sites should be inspected for the occurrence of water repellency, with routine application recommended for Barra Brui Oval, Loyal Henry Park and Queen Elizabeth II Reserve;
- Irrigation: controllers would ideally operate based on ET monitoring (alternatively use the schedules outlined in this report). Maintenance should occur at least annually (visual inspections performed routinely), with water savings of about 25% likely to be achieved if an irrigation design audit was performed;
- Ryegrass oversowing: may be beneficial at Barra Brui Oval (goal boxes only), Bob Campbell Oval, Primrose Park and Queen Elizabeth II (goal boxes only). Oversowing can assist in improving wear levels, but is far less important than amending the soil and converting the fields to more appropriate turf cultivars;
- Growth regulators (e.g. primo): Barra Brui Oval (goal boxes only), Bob Campbell Oval and Primrose Park; and
- Aeration: should occur routinely using the vertidrain or aerovator, with the earthquake required every 3 years at Loyal Henry Park, Queen Elizabeth II Reserve and The Glade.

Aeration must not occur in the 5 month period after applying a pre-emergent herbicide.

Appendix A: Barra Brui Oval

Barra Brui Oval is located at Burraneer Avenue St Ives. The field occupies an area of about 0.95 ha and has a centrally located synthetic wicket. The field receives afternoon shade and has good wind protection. The site has floodlighting and irrigation, but no slit drainage. A survey was conducted in April 2016 by Dr Mick Battam that involved the construction of about 40 test holes.

A.1 Soil

The soil consists of silty sand overlying compacted crushed sandstone. The topsoil is regarded as too sandy for use on a local playing field and is prone to becoming water repellent. The topsoil is at least 200 mm deep across most of the site, being shallower in some of the off-field areas and marginally shallow near the wicket (Figure A.2). A thin layer of loam overlies the soil profile in most areas and has been imported to the site attached to turf rolls (Figure A.1).

A.2 Drainage

Waterlogging is a major issue on the field, being worst on the northern and eastern side (Figure A.2). These problems arise due to a combination of slow infiltration through the turf clay layer and lack of suction in the underlying soil which is regarded as too sandy for a local sporting field. As such, the field should be reconstructed.

Figure A-1: The surface is soft following rain (lower) due to slow infiltration through the thin layer of soil imported to the site attached to turf rolls (upper left), with the underlying sand remaining relatively dry (upper right).

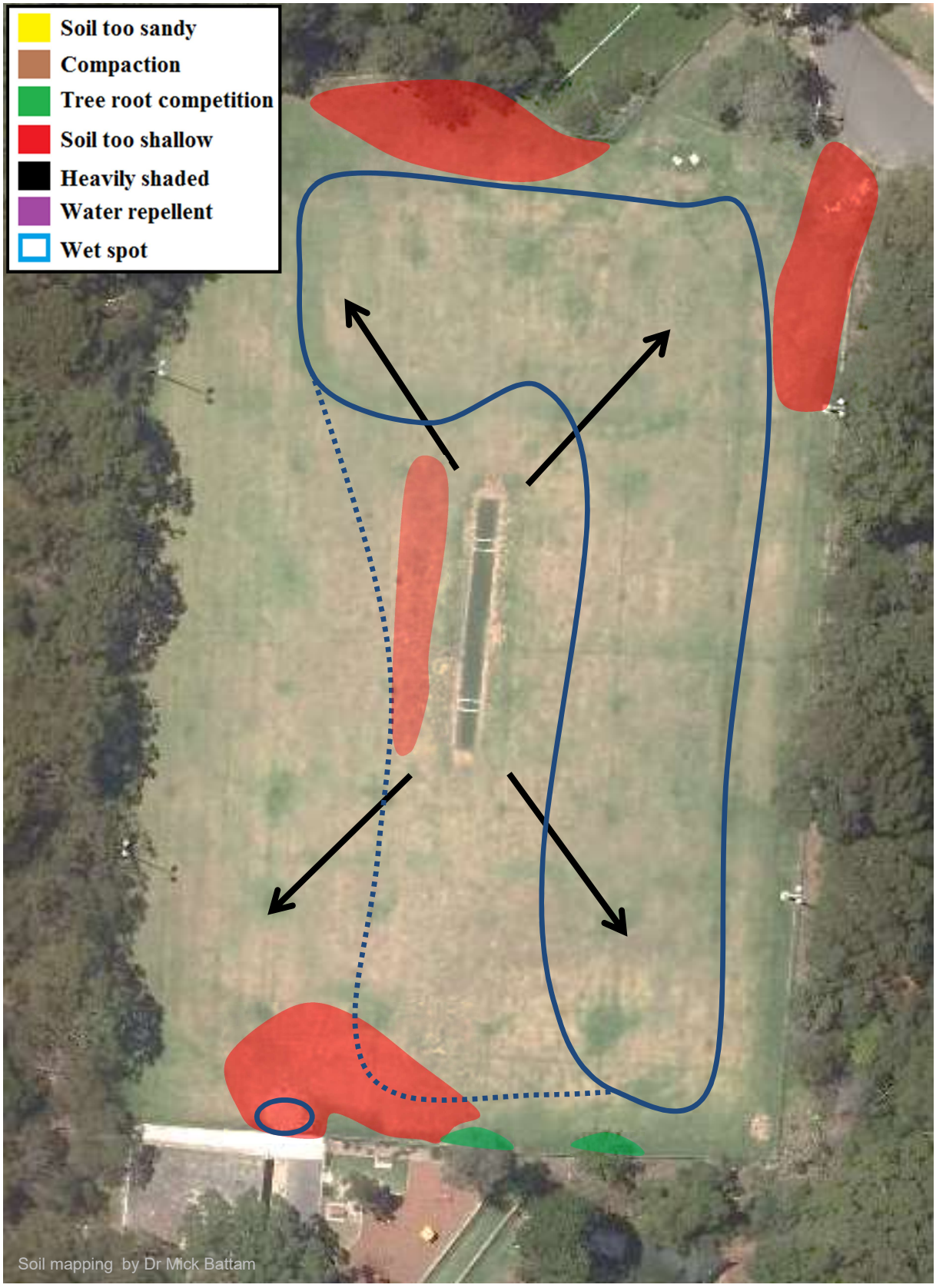


Figure A-2: Barra Brui Oval showing factors limiting turf growth. Google Earth image.

A.3 Field use and carrying capacity

Over summer the field is used for cricket, with soccer (including training) and rugby league training occurring during the winter sport season. The site is also used for school sport. In its current condition the field cannot handle the current usage levels (Figure A.3), but it could easily do so if it were reconstructed using the procedure outlined in this report.

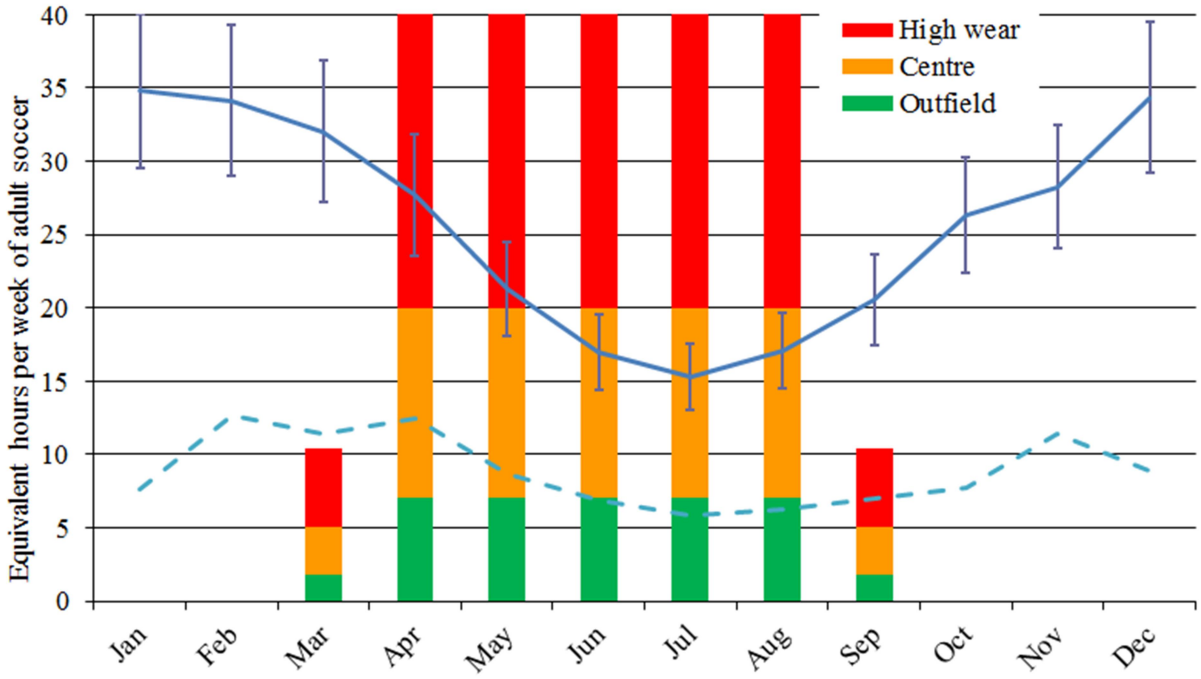


Figure A-3: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

A.4 Field condition

The field was in poor condition at the time of the inspection, with large bare areas near the goal boxes (Figure A.1). Low levels of traction were observed on the field, which displayed acceptable levels of evenness in most areas but was hard in the goal boxes (Table A.1).

Table A-1: Field condition in July 2016. Shading indicates non-optimal observations.

Parameter	Goals	Near wicket	Wing
Grip (1) to no grip (5)	3	1.5	3.5
Soft (<6) to hard (>10)[1]	12	7	6
Even (1) to uneven (8)	3.5	3	3
Turf cover	5% Couch[2]	30% Kikuyu 40% Couch[2]	70% Kikuyu 7% Couch[2]
Weed cover			
Bare[3]	95%	30%	23%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Turf cultivar could not be identified but has a growth habit similar to Wintergreen
3 despite being very bare the turf is likely to recover

A.5 Current irrigation requirements

In its current condition the field would ideally receive 4 mm of water (irrigation or rain):

- three times a week in the warmer months (September to March); and
- fortnightly in early autumn (most of which would be satisfied by rain), with no irrigation required during winter. More frequent watering would be required if the site is oversown.

Irrigation events should be delayed according to the above schedule if significant rain occurs (>6 mm). The run time cannot be determined without more information on system performance, but is likely about 25 to 35 minutes per station. To minimise run-off losses, the irrigation events should be divided into several sub-events by programming a cycle/soak regime into the controller.

A.6 Water saving options

The watering requirements of the field could be reduced by about 35% if improvements were made to the irrigation system and the amendment works outlined in this report were implemented. An irrigation audit should be performed to determine how these improvements could be achieved and should examine:

- system headworks (pump, tank, filter and controller);
- system hydraulics (pipe sizing and operating pressures);
- sprinkler layout (each head should be accurately located to within 0.2 m), operating pressure and evaluation of design (type of head and/or nozzle).

The audit should be performed by a Certified Irrigation Designer, with a list of persons holding this certification provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers. If cost is limiting, then Council could train staff so they are qualified/certified to perform these works.

A.7 Recommendations

Reconstruction

Ideally the field would be reconstructed by:

- spraying the existing turf until it is dead (4 applications of round up containing fusillade);
- incorporating the dead turf, 20 mm of loam (Appendix J) and 35 mm of AS 4454 composted garden organics (Appendix I) to a depth of 180 mm using two passes with a blechivator (inspect site to ensure adequate mixing has occurred);
- screed the surface so it is firm but even and has similar cross-fall to that currently present at the site that is smooth, ensuring levels marry into the wicket;
- establishing Santa Anna couch (no other cultivar is to be used) from washed turf; and
- topdressing until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand based material such as 80:20 NOT to be used).

These works will about $170,000+GST. Once amended these fields will be able to handle the current usage levels and will likely drainage rapidly without a slit drainage system (Figure A.4).

These amendment costs could be reduced by using traditional sod, but it is crucial to ensure the turf has less than 20% fines (silt and clay) in the attached soil layer or drainage problems will persists (Figure A.1).

Before amendment	After amendment

Figure A-4: The impact of amendment works on the October condition of Kareela no. 4 sporting field which receives about 50% more wear then Barra Brui Oval.

Short term amendment

If cost is limiting then improvements could be achieved by patching areas unlikely to recover by:

- shaving out the existing turf to about 50 mm depth;
- incorporating 30 mm of a mixture of 50% loamy sand (Appendix H) and 50% AS 4454 composted garden organics (Appendix I) to a depth to about 150 mm depth using a blechivator;
- screeding the surface multiple times until the area is firm, level and will match into the adjacent areas once the turf has been laid;
- laying washed Santa Anna couch (no other cultivar is to used, regardless of the claims made by turf suppliers);
- watering the turf until established;
- topdressing depressions with a mixture of 50% loamy sand (Appendix H) and 50% AS 4454 compost (Appendix I) until an even playing surface is achieved; and
- aerating using four slow passes (these can occur in a row) with Council's aerovator on at least five occasions.

Based on the August 2016 site inspections the site requires as little as 900 m^2 of turf patching, but ideally at least 1,800 m^2 would be used. Under no circumstances is the new turf to be laid on the soil without first amending the soil.

Table A-2: Cost (excluding GST) to implement the short term amendment options at Barra Brui Oval.

Activity	Cost	Notes
About 900 m^2 should be patched by shaving out about 40 mm of material, incorporating 40 tonne of 50% loamy sand[1] and 50% compost[1], screed the surface and patch with Santa Anna couch	$11,500	**B. Important:** crucial if the soil is not reconstructed in the near future
After patching topdress depressions with 8 tonne of 50% loamy sand[1] and 50% compost[1]	$600	**B. Important**
Aerate using 4 slow passes in a row (perform early in a week so field can still be used for weekend cricket) with Councils aerovator, with this to be repeated on at least 5 occasions	NA	**A. Crucial**

1 characteristics of loamy sand and compost described in Appendices H and I respectively

A.8 Ongoing requirements

If the site is amended in accordance with the recommendations outlined Section A.7 it will require (most important activities are underlined):

- **Pre-emergent herbicide:** may periodically need to be applied to control annual weeds;
- **Selective herbicide:** will periodically be required to control broadleaf weeds such as clover;
- **Hand chip Parramatta grass:** which was not observed on the field at the time of the inspection but is a major weed on nearby sites and has no selective herbicide;
- **Localised topdressing:** of depressions and thin turf areas with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I). Under no circumstances is sand based topdress to be used to fill holes, with 80:20 regarded as far too sandy;
- **Topdressing:** of the fields is likely to be required about every 3 to 5 years with 8 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions;
- **Aeration:** should occur as frequently as possible using a Councils' aerovator. Depending on the condition of the field up to four passes can be performed in a row. Periodically the site should be aerated with a solid tine aerator that can penetrate to a depth of 180 mm such as the vertidrain. Aeration must NOT occur in the 5 months after applying a pre-emergent;
- **Repairing small bare areas:** that struggle to recover (e.g. goal boxes) using turf plugs from low wear areas. Small heavily trafficked areas where the turf has become thin (but will recover) should be manually aerated with a garden fork and fertilised/watered at the end of the soccer. Similar works should be used to repair run-up areas at the end of the cricket season and athletics start areas;
- **Wetting agent:** should be applied to site annually in October;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of 150 kg/ha of nitrogen is applied in October, with a second application in early February; and
- **Irrigation:** should occur according to the schedule outlined in Section A.5. The system performance should be assessed at least annually, with more frequent visual inspections;
- **Oversowing:** with ryegrass should be considered in the goal box areas. This will not be required if the site is reconstructed using the works outlined in this report and growth regulator (primo) is applied at appropriate intervals over summer to improve sward density.

Sand based topdress is not to be applied (soil is already marginally too sandy), with 80:20 regarded as far too sandy for this site.

Appendix B: Bob Campbell Oval

Bob Campbell Oval is located at located at Lot 2 Cliff Rd at Northwood. The playing area occupies about 0.75 ha and has a centrally located synthetic wicket. The field receives late afternoon shade and good wind protection. The site has floodlighting and irrigation, but no slit drainage. A survey was conducted in July 2016 by Dr Mick Battam that involved the construction of about 40 test holes.

B.1 Soil

The soil consists of loamy sand that was at least 200 mm deep across most of the site. The soil is relatively friable in most locations, but was compacted near the vehicle entry point.

A thin layer of loam or light clay overlies the soil profile in most areas and has been imported to the site attached to turf rolls (Figure B.1). In some locations the thin layer of soil from the turf sandwiched between two sand layers which were applied as a turf underlay and as a result of topdressing after laying the turf.

B.2 Drainage

Limited contour information was available at the time of writing this report, but based on visual inspection the field generally slopes from a central crown. Surface water gets away relatively rapidly, but the ground remains soft following rain especially in the areas the turf soil layer was heavier textured (Figure B.2).

Figure B-1: The soil is highly layered in some locations (left), with the surface remaining soft after rain due despite the underlying soil being relatively dry (right).

Figure B-2: Bob Campbell Oval showing factors limiting turf growth. Six Maps image.

B.3 Field use and carrying capacity

The site is used for cricket over summer, with soccer (including training) occurring during the winter sport season. The existing turf cultivar cannot handle the current usage levels (Figure B.3) and will likely continue to deteriorate, especially in high traffic areas where the soil is layered. However, the field could handle the current usage levels if it were amended according to the works in Section B.7.

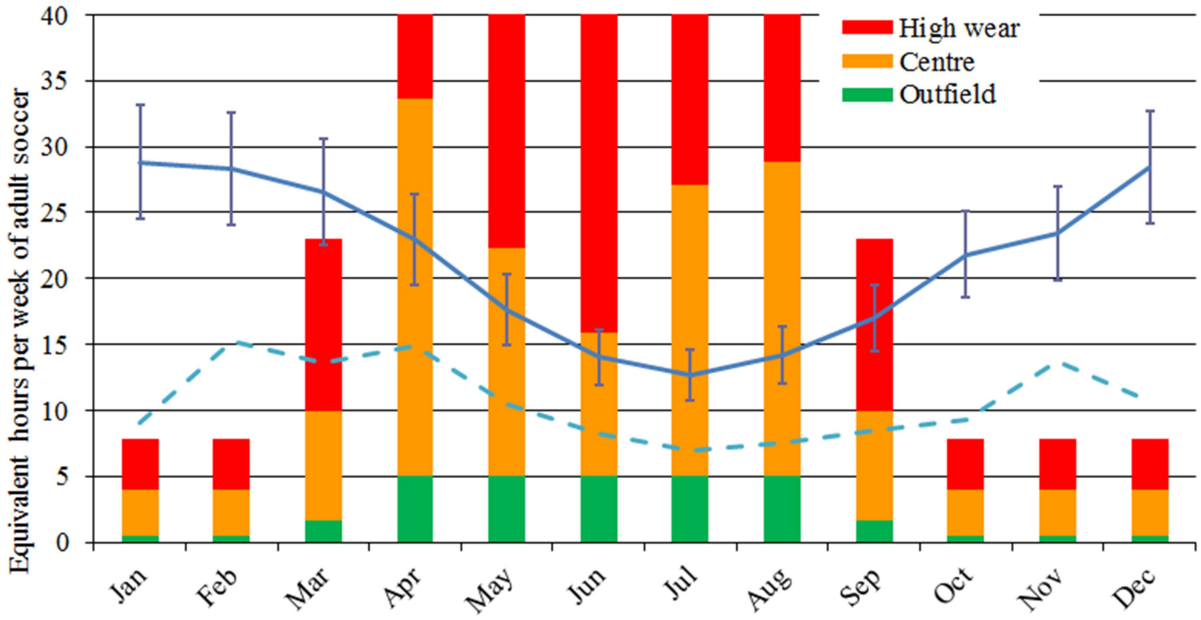


Figure B-3: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

B.4 Field condition

The field was in reasonable condition at the time of the inspection, but turf cover was quite thin in the goal box areas and wet areas. Despite recent rain the playing surface is very hard, with low levels of traction observed in the northern goal box (Table B.1).

Table B-1: Field condition in July 2016. Shading indicates non-optimal observations.

Parameter	North goal	Infield	Wing	East off field
Grip (1) to no grip (5)	4	1.5	1	2
Soft (<6) to hard (>10)[1]	12	12	13	10
Even (1) to uneven (8)	3.5	3	3	3
Turf cover	10% Couch[2]	50% Couch[2] 20% Rye	20% Couch[2] 60% Rye	30% Kikuyu
Weed cover				25% Chickweed 25% Bindii 3% Clover 7% Winter
Bare	90%	30%	20%	10%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Cultivar could not be identified, but has a growth habit similar to Greenleas Park

B.5 Current irrigation requirements

In its current condition the field would ideally receive 3.5 mm of water (irrigation or rain):

- three times a week in the warmer months (September to March); and
- weekly in early autumn (more frequently following oversowing), with no irrigation required during winter.

Irrigation events should be delayed according to the above schedule if significant rain occurs (>8 mm). The run time cannot be determined without more information on system performance, but is likely about 30 to 45 minutes per station. To minimise run-off losses, the irrigation events should be divided into several sub-events by programming a cycle/soak regime into the controller.

B.6 Water saving options

The watering requirements of the field could be reduced by about 10 to 25% if improvements were made to the irrigation system. An irrigation audit should be performed to determine how these improvements could be achieved and should examine:

- system headworks (pump, tank, filter and controller);
- system hydraulics (pipe sizing and operating pressures);
- sprinkler layout (each head should be accurately located to within 0.2 m), operating pressure and evaluation of design (type of head and/or nozzle).

The audit should be performed by a Certified Irrigation Designer, with a list of persons holding this certification provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers. If cost is limiting, then Council could train staff so they are qualified/certified to perform these works

B.7 Recommendations

Reconstruction

The field will survive another season, but is likely to continue to deteriorate until the soil is amended and the turf converted to a more appropriate cultivar. Ideally the field would be reconstructed by:

- spraying the existing turf until it is dead (4 applications of round up containing fusillade);
- incorporating the dead turf and 35 mm of AS 4454 composted garden organics (Appendix I) to a depth of 180 mm using two passes with a blechivator (inspect site to ensure adequate mixing has occurred);
- screed the surface on multiple occasions so it is firm but even and has similar cross-fall to that currently present at the site that is smooth, ensuring levels marry into the wicket;
- establishing Santa Anna couch (no other cultivar is to be used, regardless of the claims made by turf suppliers) from washed turf; and
- topdressing until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand based material such as 80:20 NOT to be used).

These works will about $105,000+GST to perform on the formal marked field area only or $130,000+GST to implement over 0.75 hectares. Traditional sod not recommended for use on this shaded site or problems will likely occur (Figure B.1).

Once amended these fields will be able to handle the current usage levels and will likely drain rapidly without a slit drainage system (Figure B.4).

Figure B-4: The impact of amendment works on the northern end of Waterloo Oval which is in shade much of the winter sport season. This areas recieves about 20% more wear than occurs at Bob Campbell Oval.

Short term amendment

If cost is limiting then improvements could be achieved by patching areas unlikely to recover by:

- **Aerate:** using four slow passes (these can occur in a row) with Council's aerovator on at least five occasions;
- **Repair small bare areas:** in goals using couch turf plugs (from off field areas) to patch bare areas. Small areas where the turf has become thin should be manually aerated with a garden fork and fertilised/watered at the end of the soccer; OR patch southern goal boxes with about 50 m^2 of washed Santa Anna couch;
- **Localised topdressing:** of depressions with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I); and
- **Apply a selective herbicide:** to control clover, chickweed and bindii which are in very high numbers on the far eastern side of the site. If cost is limiting, then spot spray these areas.

Ideally a synthetic cover (with padding beneath) would be installed over the wicket during the winter sport season.

Table B-2: Cost (excluding GST) to implement the short term amendment options at Bob Campbell Oval which should be reconstructed.

Activity	Cost	Notes
Aerate using 4 slow passes in a row (perform early in a week so field can still be used for weekend cricket) with Councils aerovator, with this to be repeated on at least 5 occasions	NA	**A. Crucial**
Repair small bare areas using turf plugs harvested off the side of the field. Minor topdressing is needed with a mixture of 50% loamy sand[1] and 50% AS 4454 compost[1]	$100	**A. Crucial:** or these areas will deteriorate over time
Apply a selective herbicide to control broadleaf weeds such as clover on field and surrounds	$700	**B. Important:** large numbers of weeds on perimeter (source of seed)

1 characteristics of loamy sand and compost described in Appendices H and I respectively

B.8 Ongoing requirements

If the site is amended in accordance with the recommendations outlined Section B.7 it will require (most important activities are underlined):

- **Growth regulator (primo):** should be applied at appropriate intervals to improve turf quality and sward density during the summer period;
- **Pre-emergent herbicide:** apply periodically to control annual weeds such as bindii;
- **Selective herbicide:** will periodically need to be applied to control broadleaf weeds;
- **Localised topdressing:** of depressions with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I);
- **Topdress:** about every 3 years with 8 mm a mixture of 50% loamy (Appendix H) and 50% compost (Appendix I) that is incorporated using multiple passes with a solid tine aerator. The surface should be screeded following topdressing so more material is swept into depressions;
- **Slice:** up to the edge of the site every 3 years using the earthquake;
- **Aeration:** to at least 180 mm depth using 4 to 12 slow passes annually with a solid tine aerator such as the vertidrain. Ideally this intense aeration would be performed more frequently;
- **Repairing small bare areas:** that will struggle to recover (e.g. near goal posts) using turf plugs harvested from low wear areas. Small, heavily trafficked areas where the turf has become thin (but will recover without plugging) should be manually aerated with a garden fork and fertilised/watered at the end of the winter sport season. Similar works should be used to repair the wicket at the end of the cricket season;
- **Turf patching:** if the goal box areas require patching then only Santa Anna couch is to be used (regardless of claims made by turf suppliers). Only turf containing less than 20% fines (silt and clay) in the attached soil layer is to be used or preferably washed turf;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of about 150 kg/ha of nitrogen is applied in October, with a second application in February;
- **Irrigation:** should occur according to the schedule outlined in Section B.5. The system performance should be assessed at least annually, with more frequent visual inspections; and
- **Wicket covering:** would ideally be performed using synthetic turf with underlying padding. If traditional sod continues to be used, then use Santa Anna couch and ensure soil consists of a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I). This turf and soil can then be used to repair the field at the end of the winter sport season. Soil must NOT be spread next to the wicket to create a mound.
- **Oversowing:** with ryegrass should be considered and will be required to maintain winter cover until the site is reconstructed, but it is crucial the ryegrass is sprayed out in early spring.

Appendix C: Loyal Henry Park

Loyal Henry Park is located at Thomas Avenue Roseville. The field occupies an area of about 0.35 ha and has a centrally located synthetic wicket. The field is well wind protected and receives shade, especially along the northern edge. The site has no floodlighting, pop-up irrigation or slit drainage. A survey was conducted in August 2016 by Dr Mick Battam that involved the construction of about 30 test holes.

C.1 Soil

The soil generally consisted of coarse sandy loam topsoil overlying sandy clay, typically of material derived from sandstone. However, the soil was sandier along the northern edge of the field where the turf was thinner. The topsoil was generally more than 200 mm deep, but was only 100 mm thick along the southern edge of the field next to the swale. Visual inspection of the soil suggests it has a very low nutrient holding capacity and is prone to becoming water repellent.

C.2 Drainage

Contour information was not available at the time of writing this report, but based on visual inspection the field generally falls towards the northwest. Waterlogging occurs on the southern edge of the field due to water seeping from the base of the embankment (downslope of the swale) (Figure C-3). This could be overcome by installing a curtain drain in accordance with the design provided in Appendix K. If cost is limiting then partial improvements (some seepage will still occur) could be achieved by:

- using a shovel to dig out high spots and topdress low areas (use spoil from high areas) to ensure water does not pool in any area; and
- spreading bentonite clay on the base of the swale (do not apply to upslope areas).

Ideally the gutter near the end of Thomas Avenue would be kept clean so this is less likely to overflow onto the field (Figure C.1).

Figure C-1: Waterlogging at the eastern end of the field due to the gutter in street overflowing (insert) so water runs onto the field.

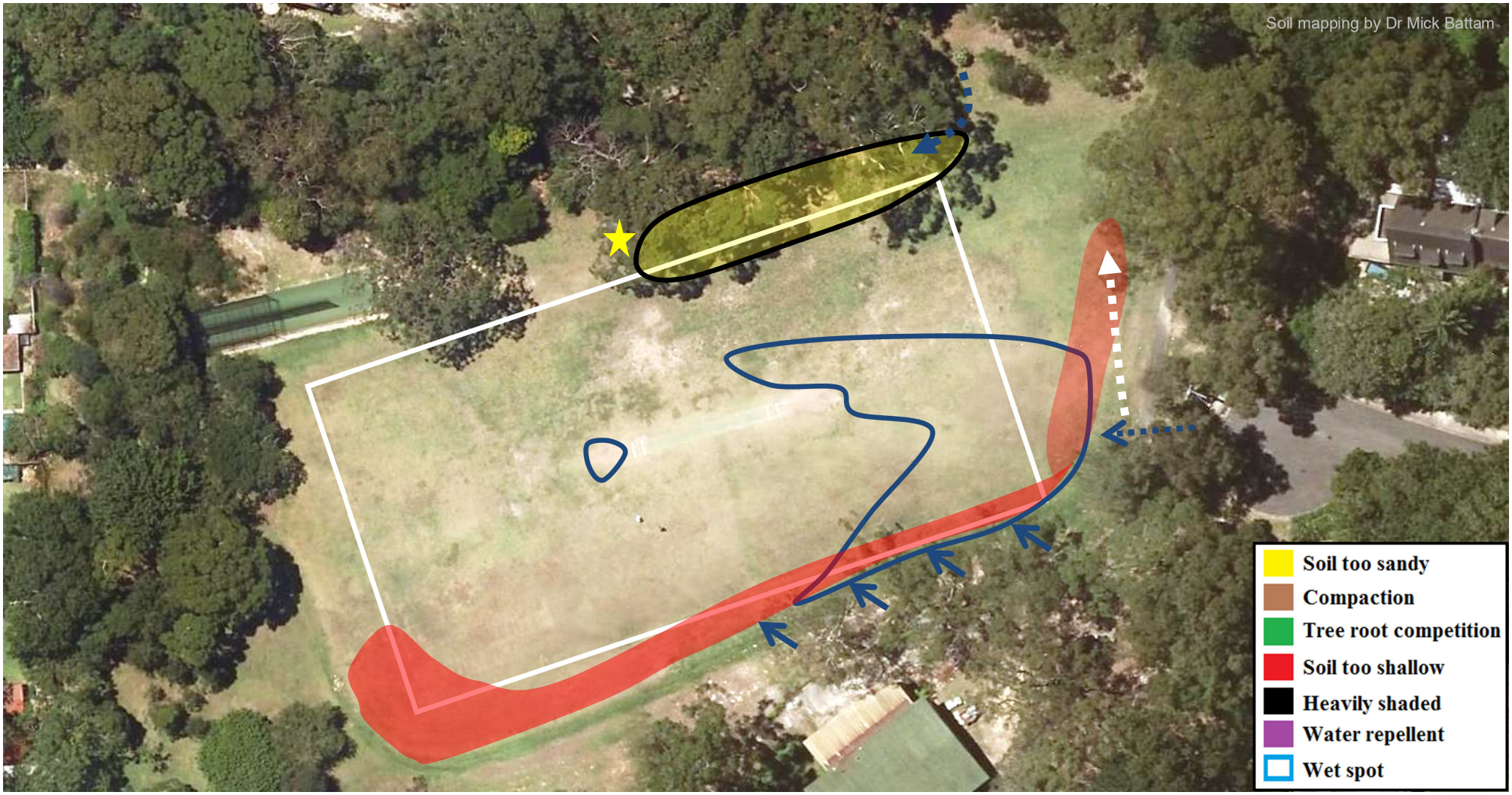


Figure C-2: Loyal Henry Park showing factors limiting turf growth. Arrows show surface water flowing onto the site from the surrounding areas (southern edge is seepage water), with white arrow showing where a small mound could be constructed to divert surface water around the field. Star shows stormwater pit location. Six Maps image.

Figure C-3: Some of the water intercepted by the southern swale soaks into the soil until it reaches the subsoil (insert) and then moves downslope and seeps out of the embankment and onto the field. This could be overcome by installing a curtain drain within the swale in accordance with the design provided in Appendix K..

C.3 Field condition

The site was in very poor condition at the time of the inspection, with very thin cover across much of the site (Figure C.4). Onion weed was the only ground cover in some areas, with the ground relatively uneven near the wicket (Table C.1).

Table C-1: Field condition in July 2016. Shading indicates non-optimal observations.

Parameter	Goals	Near wicket	Wings
Grip (1) to no grip (5)	3	1.5	1.5
Soft (<6) to hard (>10)[1]	10	9	11
Even (1) to uneven (8)	3.5	4	3
Turf cover	10% Couch[2]	30% Couch[2]	70% Couch[2] 15% Qld blue
Weed cover	10% Onion		4% Onion 1% Winter
Bare	80%	70%[3]	10%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Turf cultivar could not be identified but has a growth habit similar to Wintergreen
3 will likely recover

Figure C-4: Very thin cover was observed across large sections of the site.

C.4 Field use and carrying capacity

Over summer the site is used for cricket, with soccer gameplay (and small amounts of training) occurring during the winter sport season. Although the field receives relatively low levels of use it struggles due to its very poor condition (Figure C.5). Once reconstructed the field could easily handle the current usage levels.

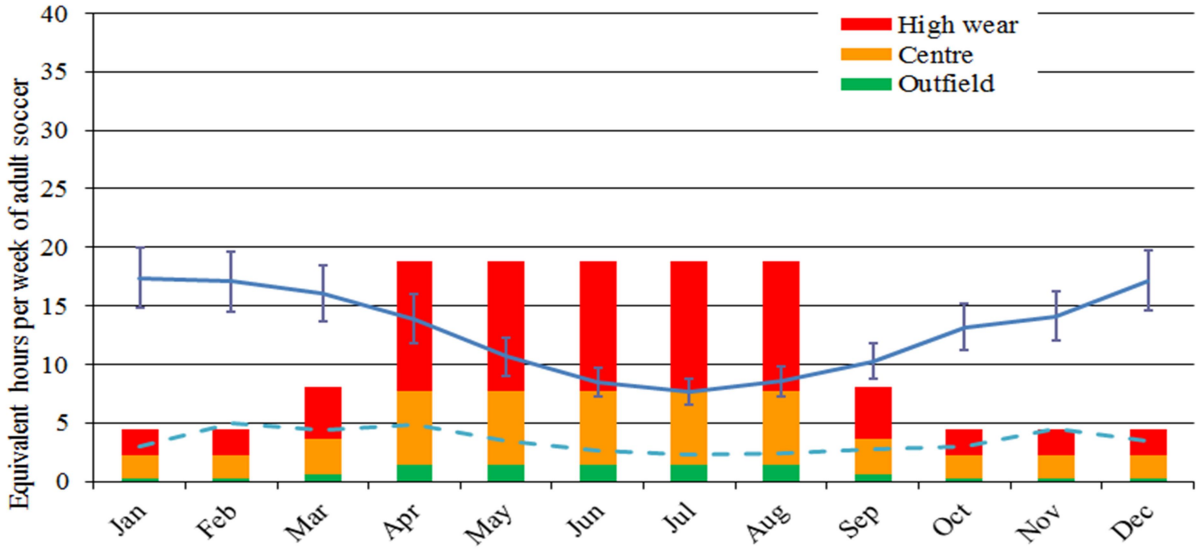


Figure C-5: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

C.5 Without irrigation

Once the soil is amended the field it should be possible to maintain acceptable turf cover using occasional watering events provided:

- minor repairs to worn areas are performed at the end of each sport season;
- the field is not trafficked when wet; and
- weeds are not permitted to take over.

However, thin turf is likely to persist in the most shaded areas.

C.6 Recommendations

Consideration should be given to installing a multi-purpose wicket at the site so that it does not need to be covered during the winter sport season.

Reconstruction

Ideally the field would be reconstructed by:

- installing a curtain drain in the southern swale (Appendix K);
- spraying the existing turf until it is dead (4 applications of round up containing fusillade);
- incorporating the dead turf, 20 mm of loam (Appendix J) and 35 mm of AS 4454 composted garden organics (Appendix I) to a depth of 180 mm using two passes with a blechivator (inspect site to ensure adequate mixing has occurred);
- install a small mound and/or shape the surface so any water overflowing out of the Bromborough Road drain is diverted around the field;
- screed the surface it is firm but even and has similar cross-fall to that currently present at the site that is smooth, ensuring levels marry into the wicket;
- establishing Santa Anna couch (no other cultivar is to be used) from sod that contains less than 25% fines (silt and clay) in the attached soil layer; and
- topdressing until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand based material such as 80:20 NOT to be used).

These works will about $80,000+GST and will allow the field to easily handle the current usage levels.

Short term amendment

If cost is limiting then minor improvements could be achieved by:

- installing a curtain drain in the southern swale (Appendix K);
- localised topdressing of depressions with a mixture of 50% loamy sand (Appendix H) and 50% AS 4454 composted garden organics (Appendix I); and
- oversowing field with couch seed (e.g. Transcontinental) that is sown at 3 to 5 mm depth; and
- install a small mound so any water overflowing out of the Bromborough Road drain is diverted around the field. This could be achieved using about 3 tonnes of 50% loamy sand (Appendix H) and 50% AS 4454 composted garden organics (Appendix I), with this topdress fertile enough that the turf in the adjacent areas will grow over the mound.

Oversowing should occur prior to rain and will likely need to be repeated.

Table C-2: Cost (excluding GST) to implement the short term amendment options at Loyal Henry Park.

Activity	Cost	Notes
Install curtain drain in southern swale to prevent seepage	$3,500	**B. Important**
Topdress depressions with 8 tonne of 50% loamy sand[1] and 50% compost[1]	$600	**B. Important**
Oversow field with Transcontinental couch	$1,500	**B. Important:** especially if the field is not reconstructed in the near future
Install a mound to divert any water overflowing from the Bromborough Road drain around the field. This could be performed using 3 tonne of 50% loamy sand[1] and 50% compost[1]	$300	**B. Important**

1 characteristics of loamy sand and compost described in Appendices H and I respectively

C.7 Ongoing requirements

If the site is reconstructed in accordance with the recommendations outlined Section C.6 it will require (most important activities are underlined):

- **Clean the street drains:** regularly so these do not overflow onto the field;
- **Selective herbicide:** will periodically be required to control weeds such as onion weed;
- **Hand chip Parramatta grass:** which was not observed on the field at the time of the inspection but is a major weed on nearby sites and has no selective herbicide;
- **Localised topdressing:** of depressions and thin turf areas with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I). Under no circumstances is sand based topdress to be used to fill holes, with 80:20 regarded as far too sandy;
- **Slice:** at least every 3 years to the edge of the site using the earthquake;
- **Aeration:** would ideally occur at least annually using a solid tine aerator capable of penetrating to a depth of 180 mm such as the aggravator. If cost is limiting the site could be aerated using at least four passes annually with Councils' aerovator;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of 150 kg/ha of nitrogen is applied in October;
- **Wetting agent:** should be applied to site annually in October;
- **Irrigation:** as the site does not currently have a pop-up system it would ideally be manually irrigated twice a week until full cover is achieved at the end of the winter sport season;
- **Repairing small bare areas:** that struggle to recover (e.g. goal boxes) using turf plugs from low wear areas. Small heavily trafficked areas where the turf has become thin (but will recover) should be manually aerated with a garden fork and fertilised/watered at the end of the soccer. Similar works should be used to repair wicket run-up areas at the end of cricket season;
- **Wicket covering:** consideration should be given to installing a multi-purpose wicket so it does not need to be covered during the winter sport season. In the short-term sod and a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I) should be used as a winter cover. The soil can then be used to fill depressions when the wicket is uncovered (it must not simply be spread around the wicket or this structure will eventually struggle to drain).

Until the field is reconstructed the bare areas should be oversown at least twice annually with Transcontinental couch.

Appendix D: Normal Griffiths Oval

Norman Griffiths Oval is located at Prince of Wales Drive West Pymble and occupies about 0.85 ha. The field receives wind protection and late afternoon shade on the western side. The field has floodlighting, but no slit drainage or pop-up irrigation system. A soil survey was conducted in August 2016 by Dr Mick Battam that involved the construction of about 40 test holes.

D.1 Soil

The soil consists of sandy loam overlying heavy clay subsoil, with the topsoil being much sandier in in some of the high wear areas presumably due to topdressing (Figure D.2). The topsoil is generally more than 200 mm deep, but was shallower around the perimeter of the field.

A thin layer of clay or clay loam overlies the soil profile and has been imported to the site attached to turf rolls (Figure D.1). The topsoil was relatively compacted, especially along the western perimeter.

D.2 Drainage

Contour information was not available at the time of writing this report, but from visual inspection the field slopes towards to the southwest and southeast (Figure D.2). The site functions as a flood detention basin, but owing to its relatively steep cross-fall and upslope swale any flooding is likely to be limited to the off field areas at the southern edge of the field. Whilst the field rarely is subject to flooding it is very prone to waterlogging which was observed across much of the site (Figure D.1).

Figure D-1: A thin layer of clay loam or light clay overlies the sand loam soil (upper) and has likely been imported to the site attached to turf rolls. As result there is slow infiltration into the soil (lower left), leaving the surface soft after rain (lower right).

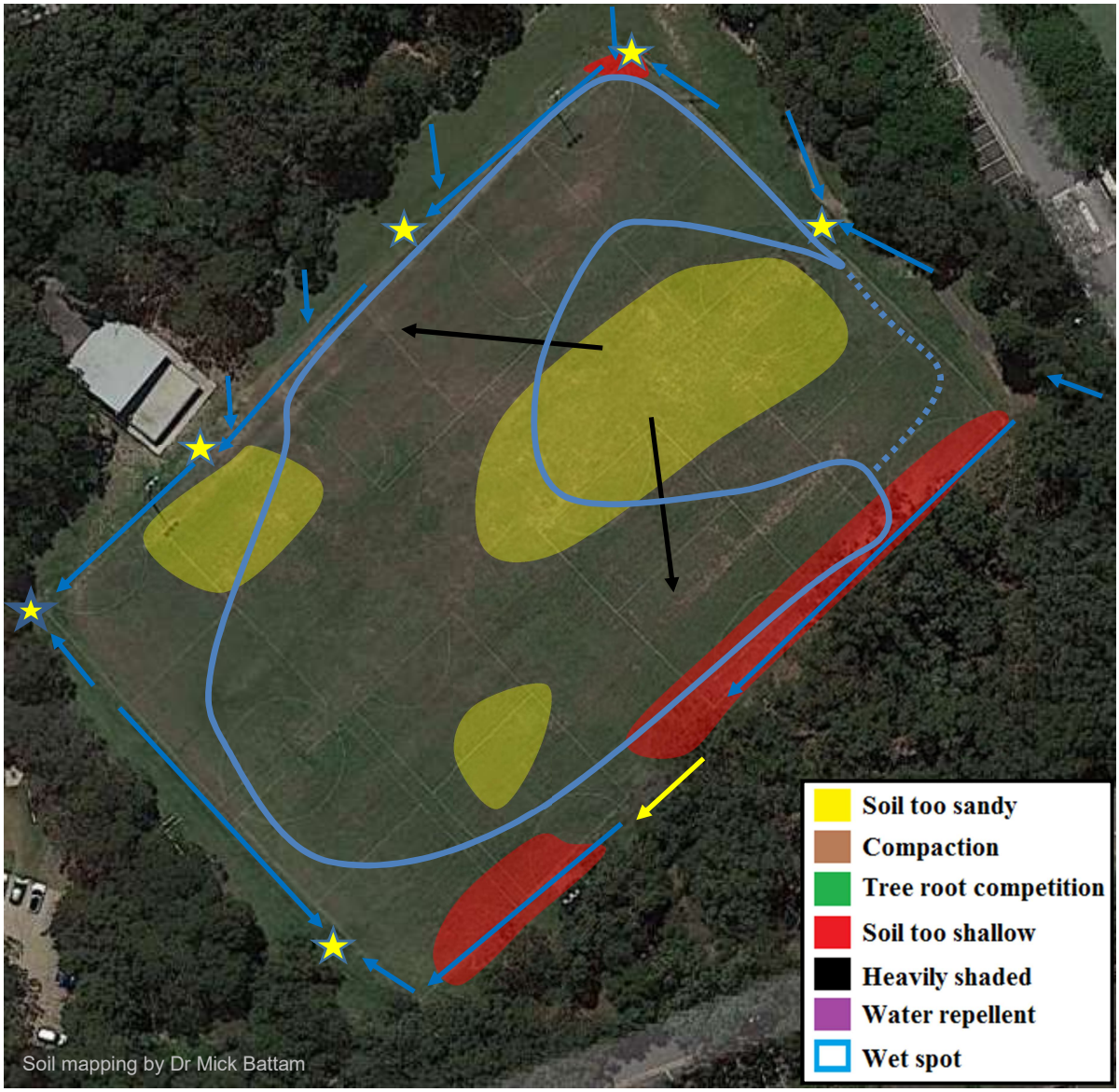


Figure D-2: Norman Griffiths Oval showing factors limiting turf performance, with arrows showing approproximate cross-fall based on visual inspection of the site. Yellow stars show stormwater pits. Six Maps image.

D.3 Field use and carrying capacity

The field is used for soccer (including training) during the winter months and cricket over summer. The site also receives significant amounts of unbooked use and is an under-size field. The field cannot handle the current usage levels (Figure D.3), but the couch in the centre of the field should recover each year even though the surface will become bare by then end of the winter sport season. The field could handle the current usage levels if the soil was amended and converted to a more appropriate turf cultivar, but thin cover is likely to occur in the goal keeping boxes each year.

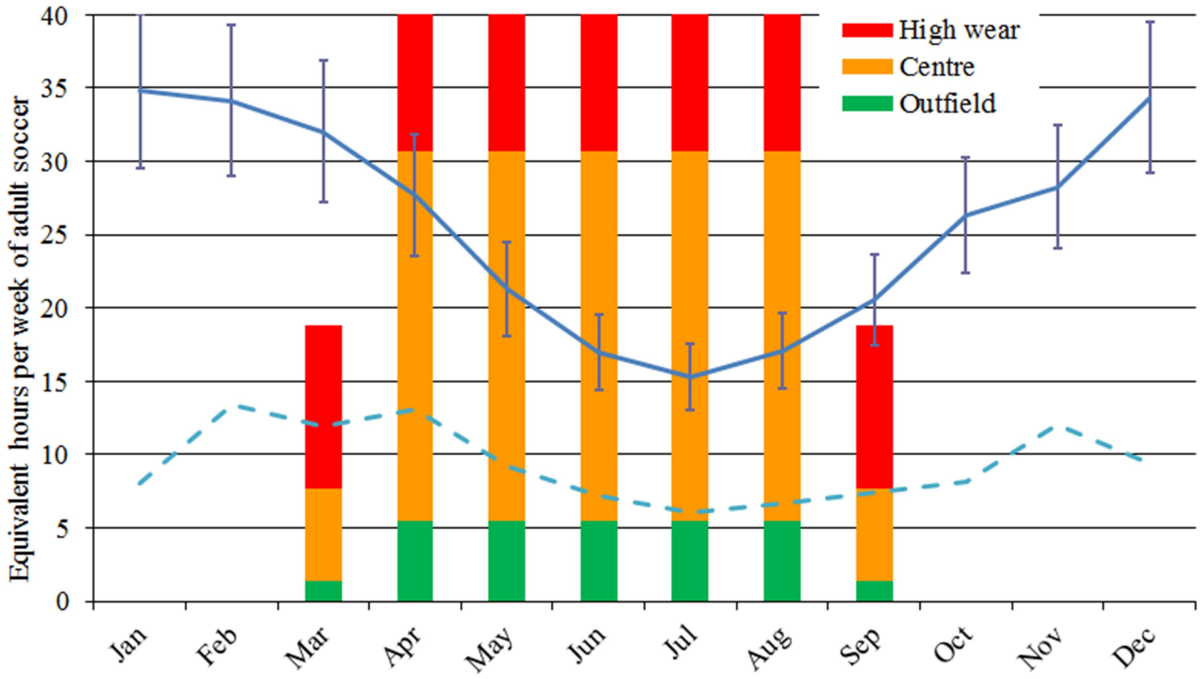


Figure D-3: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

D.4 Field condition

The field was in poor condition at the time of the inspection, with large bare areas observed across the site. The area in the centre of the field was also bare, but should recover without the need for turf patching (Figure D.4). The surface was hard in the goal box areas and generally displayed low levels of traction (Table D.1).

Table D-1: Condition of the field in July 2016. Shading indicates non-optimal observations.

Parameter	Goal	Infield	Wing
Grip (1) to no grip (5)	2.5	4	4
Soft (<6) to hard (>10)[1]	12	11	9
Even (1) to uneven (8)	3	3.5	3.5
Turf cover		19% Couch[2]	40% Kikuyu 20% Couch[2]
Weed cover		1% Parramatta	1% Parramatta 1% Winter
Bare	100%	80%[3]	38%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Turf cultivar could not be identified but has a growth habit similar to Wintergreen
3 will likely recover

Figure D-4: Thin cover was observed across the field at the time of the inspection, but much of this will recover.

D.5 Irrigation

A pop-up irrigation system should be considered for installation at the site. The site will struggle to maintain acceptable cover until the soil is amended and the field converted to a more appropriate cultivar. However, a reasonable result could be achieved if the amendments were made and the goal boxes are manually watered at the end of the winter sport season until full cover is achieved. If this is not performed these areas will deteriorate over time.

To ensure an irrigation system is capable of applying water evenly (so it is not wasted) it should be:

- designed so a scheduling coefficient of less than 1.15 can be demonstrated through appropriate hydraulic modelling output; and
- accurately installed so sprinklers are located within 0.2 m of their design location.

This can be achieved by having the irrigation system designed (to meet the above criteria) by a Certified Irrigation Designer who then oversees an irrigation installer (engaged independently by council) to ensure the system is accurately installed. Lists of persons holding appropriate certifications are provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers.

Design and construct installations are not recommended, with an audit of seven irrigation systems less than 5 years old finding six of these applied water very unevenly with about 25% wastage on average (Aqueduct Consulting, 2014). In some cases sprinklers had been installed several metres from their design locations, with inappropriate sprinkler spacings often nominated in the design.

D.6 Recommendations

Ideally the field would be fully amended by:

- spraying the existing turf until it is dead (4 applications of roundup containing fusillade);
- incorporating the dead turf and laser level the surface so the surface is even and has a similar cross-fall to that currently present on site;
- installing an irrigation system that is capable of applying water evenly to the site (Section D.5);
- incorporate 15 mm of loam (Appendix J) and 35 mm of AS 4454 composted garden organics (Appendix I) to a depth of 180 mm using multiple passes with a blechivator (inspect site to ensure adequate mixing has occurred, with the depth of incorporation crucial);
- trim the surface so it is firm but even prior to laying turf;
- laying washed Santa Anna couch (no other cultivar is to used, regardless of the claims made by turf suppliers);
- watering and fertilising turf until it is established (will require up to 12 watering events per day initially), ensuring appropriate weed control is implemented;
- topdressing the field until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand NOT to be used); and
- hand chipping at weekly intervals for the at least four months to control any kikuyu that attempts to re-establish (this is crucial).

The cost of performing these works is estimated to be about $190,000+GST, with an additional $120,000+GST required for the installation of an irrigation system. Problems are likely to occur if traditional sod containing soil is laid on this site.

Once amended the field will be able to handle the current usage levels provided sand based topdress is not applied to the site and it is not trafficked when wet. Ideally training goals would be used to ensure wear is spread more evenly, with the impact of implementing similar works provided in Figure D.5.

Before (~60% returfing per year)	After amendment (nil patching)

Figure D-5: Impact of similar soil amendment works on Gymea Bay Oval which recieves about 50% more wear than Norman Griffith Oval and is likely the most intensely used field in Australia. Both photos were taken in the first week of August at the end of the winter sport season.

D.7 Ongoing requirements

If the site is reconstructed and converted to Santa Anna couch (Section D.6) then it will require (most important activities are underlined):

- **Growth regulator (primo):** should be applied at appropriate intervals to improve turf quality and sward density during the summer period;
- **Spot poison kikuyu:** or this will outgrow couch in autumn only to wear out in winter;
- **Pre-emergent herbicide:** should be applied periodically (timing is crucial) to control annual weeds;
- **Selective herbicide:** will periodically need to be controlled;
- **Hand chip** Parramatta grass: this is currently a small task, but this weed is a trip hazard that will infest the field (major weed for nearby councils) and there is no selective herbicide;
- **Localised topdressing:** of depressions with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). These must NOT be filled with sand;
- **Topdress:** every 3 years using about 8 mm of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions;
- **Aerate:** at least twice a year to a depth of at least 180 mm using a solid tine aerator such as the aggravator. If cost is limiting then multiple passes (up to 4 in a row about 4 times a year) could be performed with Council's aerovator;
- **Repair small bare areas:** that will struggle to recover with turf plugs harvested from low wear areas. Small heavily trafficked areas where the turf is thin (but will recover) should be aerated with a garden fork and fertilised/watered at the end of the winter sport season;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of 150 kg/ha of nitrogen is applied in October, with a second application in early February;
- **Irrigation:** should occur according to the schedule outlined in Section D.6. The system performance should be assessed at least annually, with more frequent visual inspections; and
- **Oversowing:** is not recommended as the usage levels are so high it will become clumpy so the ryegrass becomes a trip hazard. Spray with colourguard (dye) if winter colour is an issue;

Minimal sand topdress should be applied to the field or major problems will occur, with 80:20 regarded as far too sandy.

Appendix E: Primrose Park

Primrose Park is located at Young Street Cremorne. The site occupies about 3 ha (4 synthetic wickets) and consists of:

- **Field 1:** northern field that is used for rugby and soccer (~0.7 ha), with an adjacent 0.6 ha sometimes utilised for training;
- **Field 2:** Middle field that is used for rugby and soccer (~0.6 ha);
- **Field 3:** Southern soccer field (~0.5 ha).

The field is well wind protected and receives some shade, especially along the far southwest edge. The site has floodlighting and irrigation, but no slit drainage. A soil survey was conducted in August 2016 by Dr Mick Battam that involved the construction of about 150 test holes.

E.1 Soil

The soil generally consisted of sandy loam topsoil overlying large sandstone rocks that have been used as fill. The soil was slightly heavier textured along the northwest edge of the site, but this was generally restricted to the far edge of the fields and off field areas. The topsoil was generally more than 180 mm deep, but was shallower in a few off field areas.

A thin layer of clay loam (sometimes red coloured) overlies the soil profile in many areas and has likely been imported to the site attached to turf rolls.

E.2 Drainage

The site drains very poorly, with waterlogging worst in low lying areas where turf patching has been performed historically (Figure E.2). These problems could be reduced by:

- installing drains to prevent surface water from running onto the site from the end of Denos Lane and just south of this area; and
- gradually filling depressions by topdressing with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I).

However, the playing surface is so uneven on sections of the southern and middle field that these areas should be amended and levelled (so they match into the adjacent areas) prior to turf patching.

Slit drainage should be considered for use at the site but should NOT be installed (regardless of the claims made by suppliers) until with evenness, soil amendment and turf cultivar have been addressed.

Figure E-1: Water lying in the numerous depressions in the field (left) due to slow infiltration through the surface, with the underlying soil being relatively dry (right).

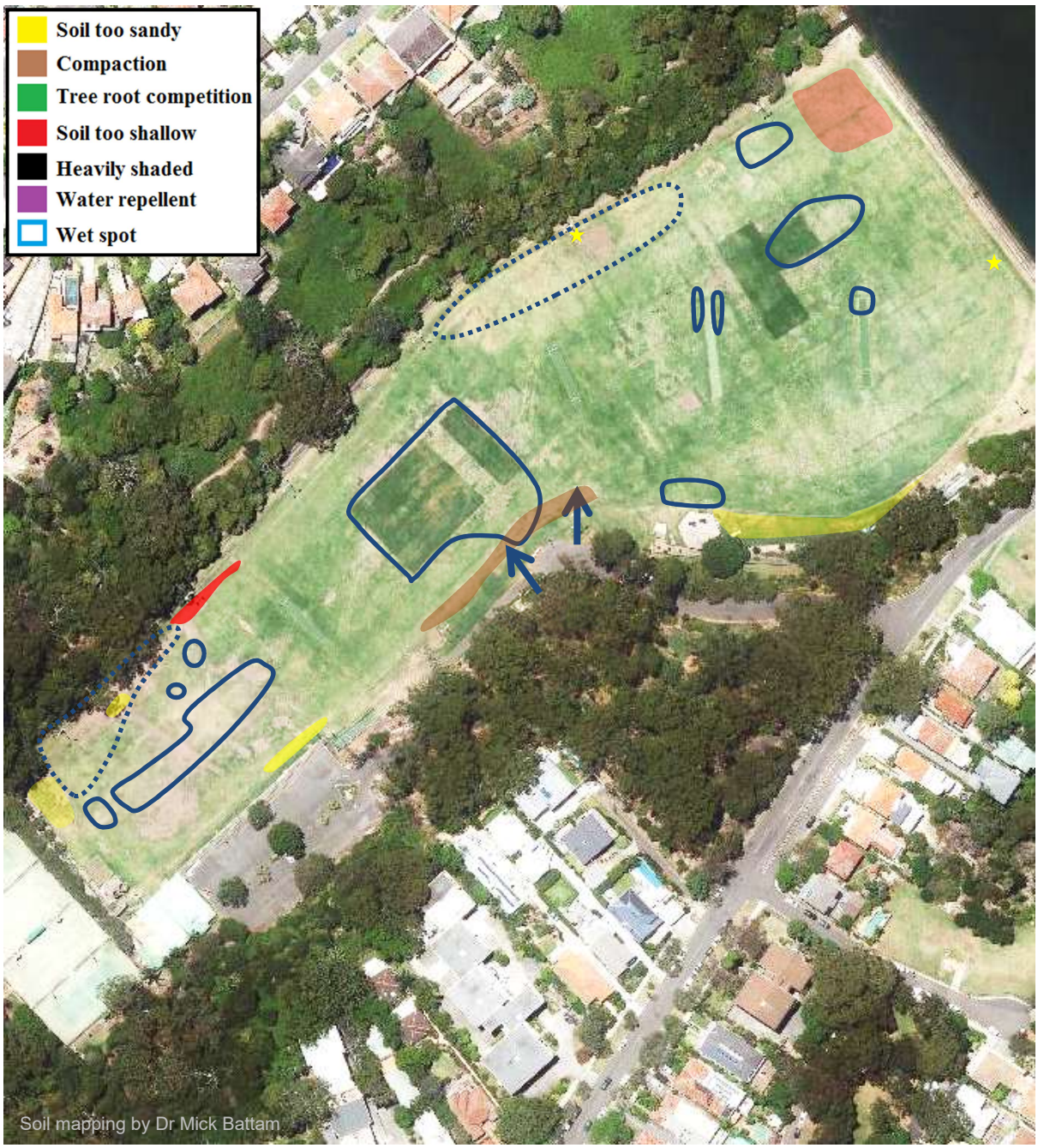


Figure E-2: Primrose Park showing factors limiting turf growth. Blue arrows show locations where surface water runs onto the site. Six Maps image.

Figure E-3: Water running onto the fields (dashed arrows) that should be intercepted using surface pits, with a gutter or dish drain needed to divert water into the pits at the end of Denos Lane. It may also be necessary to install a dish drain or speed hump to prevent water running through the vehicle entry gate and onto the fields.

E.3 Field use and carrying capacity

During the winter sport season the fields are used for soccer (including training) and rugby (including training), with cricket played over summer. The site is also used for school sport and casual use by dog owners. Whilst wear levels are not excessively high the fields cannot handle the current usage (Figure E.4) due to major problems with the soil and drainage. Once amended and converted to a suitable turf cultivar the fields should be able to handle the current usage.

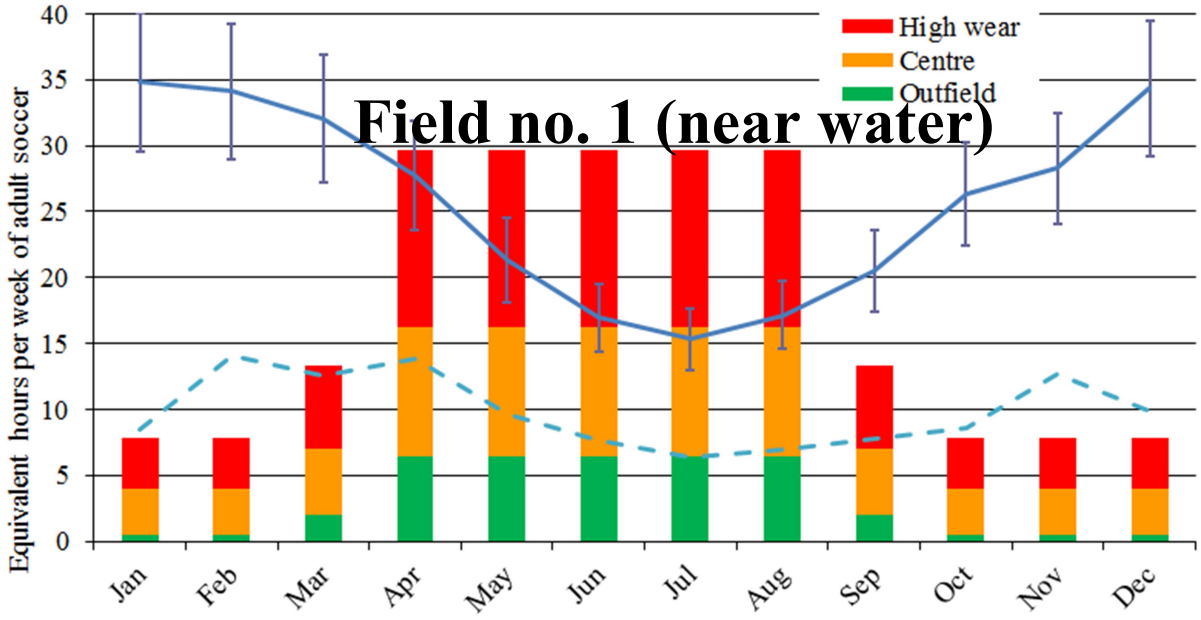
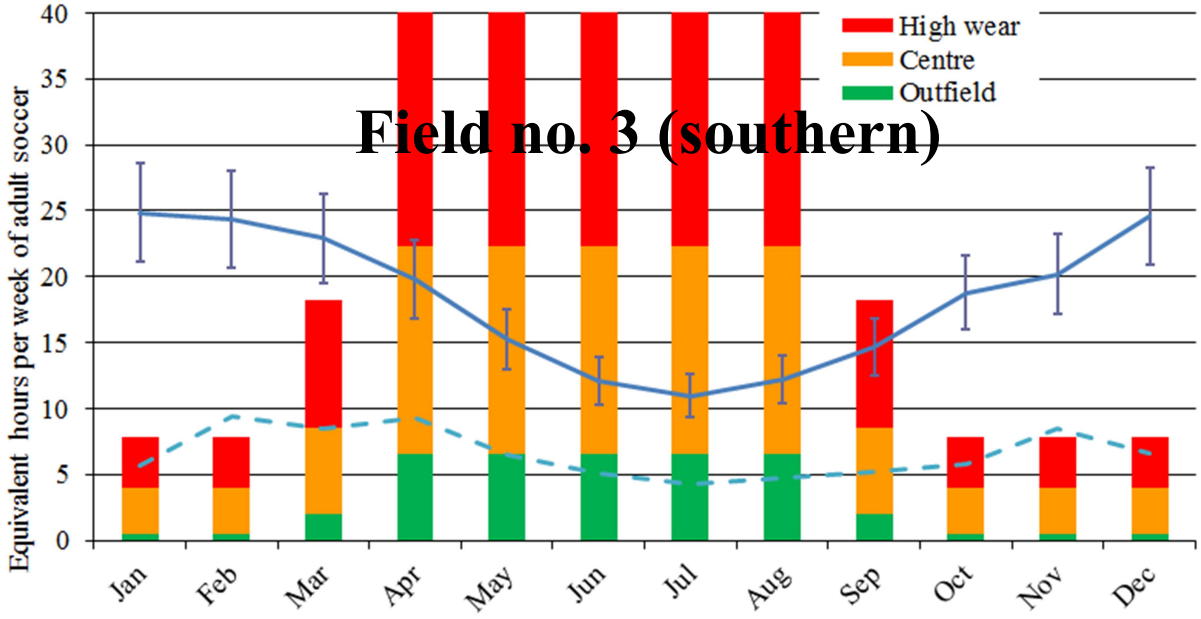


Figure E-4: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.



Field no. 2 (middle field)	Field no. 3 (southern field)

Figure E-5: Thin cover was observed across large sections of the site.

E.4 Field condition

The fields were in relatively poor condition at the time of the site inspection, with very thin cover and low levels of traction observed in many areas (Figure E.5). The surface was also relatively hard in the centre of the fields (Table E.1). Almost no weeds were observed on the site.

Table E-1: Field condition in August 2016. Shading indicates non-optimal observations.

	Parameter	Goal	Infield	Wing
Field 1 (near water)	Grip (0) to no grip (5)	3	1	2
	Soft (<6) to hard (>10)[1]	14	9	11
	Even (0) to uneven (8)	3	3	3
	Turf cover	10% Kikuyu	40% Kikuyu 25% Couch[2]	60% Kikuyu 5% Couch[2]
	Weed cover			
	Bare	90%	35%	35%
Field 2	Grip (0) to no grip (5)	2.5	5	2.5
	Soft (<6) to hard (>10)[1]	11	16	9
	Even (0) to uneven (8)	3	3	3
	Turf cover	20% Kikuyu 5% Rye	20% Kikuyu <1% Rye	35% Kikuyu
	Weed cover			
	Bare	75%	80%	65%
Field 3 (southern)	Grip (0) to no grip (5)	4	2.5	2.5
	Soft (<6) to hard (>10)[1]	10	13	5
	Even (0) to uneven (8)	3	3.5	3
	Turf cover	<1% Kikuyu 20% Couch[2]	20% Kikuyu 40% Couch[2] <1% Rye	60% Kikuyu 5% Couch[2]
	Weed cover			
	Bare	80%	40%	35%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Couch cultivar could not be identified, but growth habit similar to Wintergreen

E.5 Current irrigation requirements

In its current condition the field would ideally receive 4 mm of water (irrigation or rain):

- three time a week in the warmer months (September to March); and
- every fortnight in autumn, most of which would be satisfied by rain, with more frequent watering required if the site is oversown.

Irrigation events should be delayed according to the above schedule if significant amounts of rain occurs (>5 mm). The run time cannot be determined without more information on the performance of the irrigation system, but is likely be about 25 to 35 minutes per station.

E.6 Water saving options

An irrigation audit should be performed to determine how these improvements could be achieved and should examine:

- system headworks (pump, tank, filter and controller);
- system hydraulics (pipe sizing and operating pressures);
- sprinkler layout (each head should be accurately located to within 0.2 m), operating pressure and evaluation of design (type of head and/or nozzle).

The audit should be performed by a Certified Irrigation Designer, with a list of persons holding this certification provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers. When performed on sports fields in Lake Macquarie these audits typically reduced irrigation demand by about 25%, even for sites that had new irrigation systems installed (AgEnviro Solutions, 2014).

E.7 Recommendations

To prevent surface water from running onto the site (Figure E.3):

- a dish drain (or gutter) and at least two drainage pits should be installed at the end of Denos Lane (Figure E.3); and
- a drainage pit should be installed where surface water flows across the path near entry gate.

Southern field (no. 3 field)

The southern field would ideally be rebuilt, but significant improvements could be achieved by patching a 16 m wide strip running lengthways through the centre of the field by:

- incorporating 30 mm of composted garden organics (Appendix I) and the existing turf to a depth of at least 150 mm using the blechivator;
- screeding the surface until the ground will marry (after the turf is laid) with surrounding areas. Any excess topsoil generated by these works could be used to fill depressions;
- patching with Santa Anna couch (most other turf cultivars are unsuitable for use at this site, regardless of the claims made by suppliers). The turf must contain less than 25% fines (silt and clay) in the attached soil layer;
- once the turf is established the field should topdressed on 2 occasions with 8 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions;
- after topdressing aerate to a depth of at least 150 mm using four slow passes (these can occur in a row) with Council's vertidrain on at least five occasions. These works should be performed early in a week (during the turf growing season) so the fields are in acceptable condition for weekend sport.

Under no circumstances is then new turf to be laid on the soil without first amending the soil. Sand based topdress must NOT be applied to the field or problems will arise, with 80:20 regarded as far too sandy.

Lower (no. 1) and middle (no. 2) fields

The lower and middle fields are in such poor condition that they would ideally be reconstructed by:

- installing drains to prevent run-on from Denos Lane and the adjacent areas (Figure E.3);
- spraying the existing turf until it is dead (4 applications of round up containing fusillade);
- incorporating the dead turf and laser levelling the site so it has an appropriate even cross-fall, ensuring the topsoil is at least 200 mm deep in all areas;
- 35 mm of AS 4454 composted garden organics (Appendix I) to a depth of 180 mm using two passes with a blechivator (inspect site to ensure adequate mixing has occurred);
- trim the surface so it is firm and even prior to laying turf;
- establishing Santa Anna couch (no other cultivar is to be used, regardless of the claims made by turf suppliers) from sod that contains less than 20% fines (silt and clay content) in the attached soil layer; and
- topdressing until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand based material such as 80:20 NOT to be used).

These works will about $250,000+GST. If sod with sandy soil cannot be found then washed turf (more expensive) should be used or drainage issues will persist.

If cost is limiting then some improvements could be achieved by installing drains to prevent run-on from Denos Lane and the adjacent areas (Figure E.3) and patching bare areas with of Santa Anna couch (no other turf cultivar is to be used, regardless of claims made by turf suppliers) by:

- incorporating 30 mm of composted garden organics (Appendix I) and the existing turf to a depth of at least 150 mm using the blechivator;
- screeding the surface until the ground will marry (after the turf is laid) with surrounding areas. Any excess topsoil generated by these works could be used to fill depressions, but it is likely the area will still sit low and may require the addition of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I) so levels marry;
- patching with Santa Anna couch (most other turf cultivars are unsuitable for use at this site, regardless of the claims made by suppliers). The turf must contain less than 20% fines (silt and clay) in the attached soil layer;
- once the turf is established the field should topdressed on 2 occasions with 8 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions; and
- after topdressing aerate to a depth of at least 150 mm using four slow passes (these can occur in a row) with Council's vertidrain on at least five occasions. These works should be performed early in a week (during the turf growing season) so the fields are in acceptable condition for weekend sport.

Under no circumstances is the new turf to be laid on the soil without first amending the soil. Based on the August 2016 site inspections it is estimated about 800 m^2 (lower field) and 1,000 m^2 (middle field) of turf patching is required.

Sand based topdress must NOT be applied to the field or problems will arise, with 80:20 regarded as far too sandy.

Table E-2: Cost (excluding GST) to implement the short term amendment options at Primrose Park.

	Activity	Cost	Notes
Field 1 (near water)	Repair 800 m^2 area that will struggle to recover by incorporating 25 m^3 of compost[1], screeding so the surface is even and marries with surrounds (if required raise with mixture of 50% Loamy sand[1] and 50% AS 4454 compost[1]) and patching with Santa Anna couch[3]	$10,500	**A. Crucial:** less important if field is reconstructed in the near future
	After turf is establish topdress twice with 80 tonnes of a mixture of 50% Loamy sand[1] and 50% AS 4454 compost[1]	$5,600 /event	**A. Crucial:** less important if field is reconstructed in the near future
Field 2 (middle)	Install dish drain (or gutter) and at least 3 surface pits to prevent run-on (Figure E.3)	$15,000[3]	**A. Crucial**
	Repair 1,000 m^2 area that will struggle to recover by incorporating 30 m^3 of compost[1], screeding so the surface is even and marries with surrounds (if required raise with mixture of 50% Loamy sand[1] and 50% AS 4454 compost[1]) and patching with Santa Anna couch[3]	$12,000	**A. Crucial:** less important if field is reconstructed in the near future
	After turf is establish topdress twice with 80 tonnes of a mixture of 50% Loamy sand[1] and 50% AS 4454 compost[1]	$5,600 /event	**A. Crucial:** less important if field is reconstructed in the near future
Field 3 (southern)	Repair 16 m wide strip in the middle of the field (running goal box to goal box) by incorporating 45 m^3 of compost[1], screeding so the surface is even and patching with 1,500 m^2 of Santa Anna couch[3]	$16,000	**A. Crucial:** bare area will become larger if not repaired or will develop again if soil is not amended
	After turf is establish topdress twice with 60 tonnes of a mixture of 50% Loamy sand[1] and 50% AS 4454 compost[1]	$4,200 /event	**A. Crucial:** unevenness is contributing to drainage problems
All fields	Aerate using 4 slow passes in a row (perform early in a week so field can still be used for weekend cricket) with Councils vertidrain, with this to be repeated on at least 5 occasions	NA	**A. Crucial**

1 characteristics described in Appendix H and I
2 price sensitive to the location of existing drainage infrastructure
3 no other turf cultivar is to be used and it is crucial it contains less than 20% fines (silt and clay) in the attached soil layer

E.8 Ongoing requirements

If the site is amended in accordance with the recommendations outlined Section E.8 it will require (most important activities are underlined):

- **Clean drains:** regularly so these do not overflow onto the fields;
- **Growth regulator (primo):** should be applied at appropriate intervals to improve turf quality and sward density during the summer period;
- **Pre-emergent herbicide:** apply periodically to control annual weeds such as bindii;
- **Selective herbicide:** will periodically need to be applied to control broadleaf weeds;
- **Localised topdressing:** of depressions with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I);
- **Topdress:** about every 2 years with 8 mm a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I) that is incorporated using multiple passes with a solid tine aerator. The surface should be screeded following topdressing so more material is swept into depressions;
- **Aeration:** to at least 180 mm depth using up to 16 slow passes annually (up to 4 passes can be performed in a row) with Councils' vertidrain;
- **Repairing small bare areas:** that will struggle to recover (e.g. near goal posts) using turf plugs harvested from low wear areas. Small, heavily trafficked areas where the turf has become thin (but will recover without plugging) should be manually aerated with a garden fork and fertilised/watered at the end of the winter sport season. Similar works should be used to repair the wicket at the end of the cricket season;
- **Turf patching:** only Santa Anna couch is to be used (regardless of claims made by turf suppliers). Only turf containing less than 20% fines (silt and clay) in the attached soil layer or preferably washed turf;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of about 150 kg/ha of nitrogen is applied in October, with a second application in February;
- **Irrigation:** should occur according to the schedule outlined in Section E.5. The system performance should be assessed at least annually, with more frequent visual inspections; and
- **Oversowing:** with ryegrass should be considered and will be required to maintain winter cover until the site is reconstructed, but it is crucial the ryegrass is sprayed out in early spring. Once the fields are reconstructed oversowing will only be required in the goal keeping boxes, with a dye able to improve winter colour if this is an issue.

Appendix F: Queen Elizabeth II Reserve

Queen Elizabeth II Reserve is located at Bradfield Road Lindfield and occupies an area of about 0.75 ha. The field receives some wind protection and shade, with some heavily shaded areas along the far western and northern perimeter of the site. The site has floodlighting and a pop-up irrigation system but no slit drainage. A soil survey was conducted in July 2016 by Dr Mick Battam that involved the construction of about 30 test holes.

F.1 Soil

The soil consists of silty sand that was at least 200 mm deep across most of the field, but the soil was sandier on the outer perimeter (Figure F.2). The topsoil is regarded as too sandy for use on a local playing field and is prone to becoming water repellent which was observed during the site inspection. A thin layer of loam overlies the soil profile in most areas and has been imported to the site attached to turf rolls (Figure F.1). This layer was up to 40 mm thick in some areas, presumably due to turf patching in the same location in over several years.

F.2 Drainage

Waterlogging is a major issue on the field, being worst on the south western side with most other areas remaining soft after rain (Figure F.1). These problems arise due to a combination of slow infiltration through the turf clay layer and lack of suction in the underlying soil which is regarded as too sandy for a local sporting field. As such, the field should be reconstructed.

Figure F-1: The surface is soft following rain (lower) due to slow infiltration through the topsoil, with the underlying sand remaining relatively dry (upper).

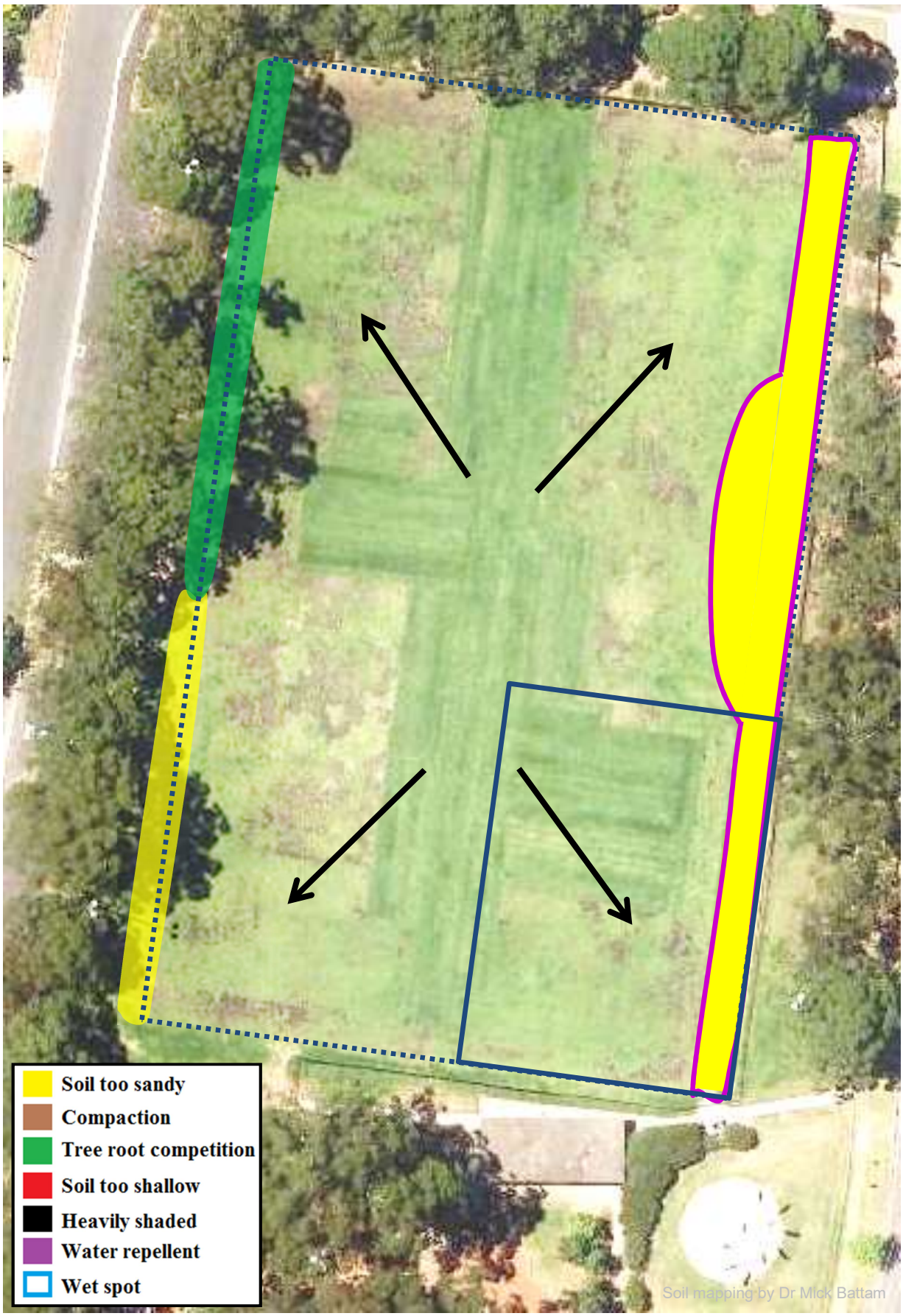


Figure F-2: Queen Elizabeth II Reserve showing factors limiting turf growth and approximate cross-fall (black arrows) based on visual inspection. Six Maps image.

F.3 Trees

The turf was struggling along the western edge of the site due to competition for water and nutrients by tree roots (Figure F.3). The soil was water repellent and/or sandier around the perimeter which was compounding the effects of the tree roots.

Some sections of the far northern end of the site are located in significant amounts of shade, but this appears to be having a relatively minor effect on turf growth at this point in time. Ideally the canopy on these trees would be thinned periodically to ensure deep shade does not occur, especially in the northern goal box.

Figure F-3: Thin turf was observed along the perimeter of the field (left) due to competition for water and nutrients by tree roots (right).

F.4 Field use and carrying capacity

The field is used for soccer (including training) during the winter sport season, with minimal formal sport occurring over the winter sport season. The site is also used as a dog of the leash area. In its current condition the field cannot handle the current usage levels (Figure F.4), but it could easily do so if it were reconstructed using the procedure outlined in this report.

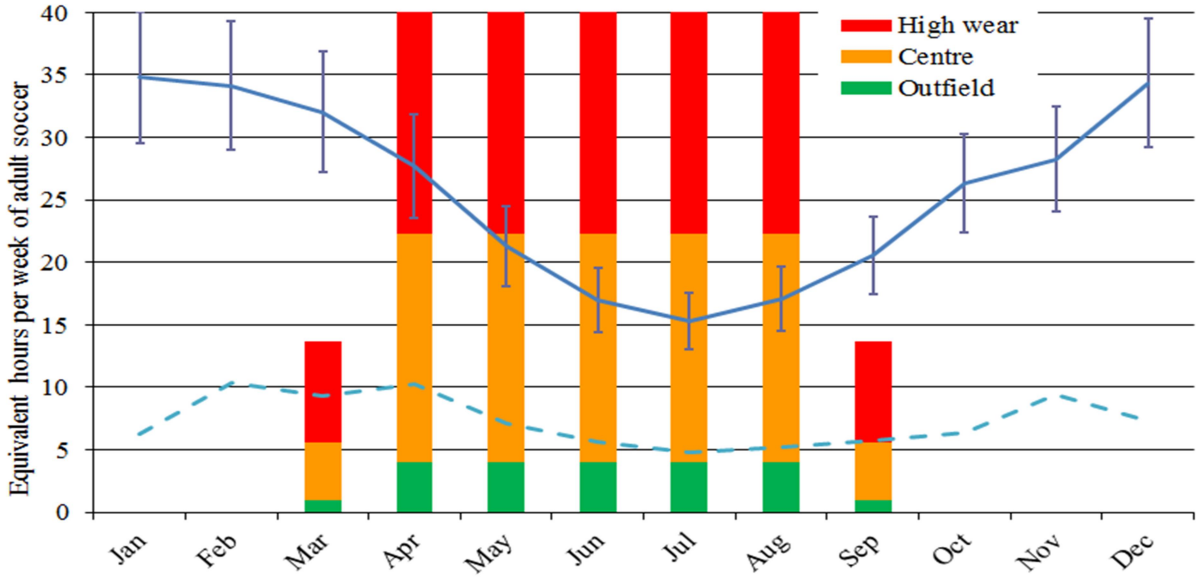


Figure F-4: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

F.5 Field condition

The field was in very poor condition at the time of the inspection, with large areas bare ground (Figure F.1). In addition the site displayed very lower levels of traction and was hard in the goal box areas (Table F.1). Minimal weeds were observed during the site inspection.

Table F-1: Field condition in July 2016. Shading indicates non-optimal observations.

Parameter	Goals	Infield	Wing
Grip (1) to no grip (5)	4	4	2.5
Soft (<6) to hard (>10)[1]	14	11	8
Even (1) to uneven (8)	3	3	3
Turf cover		10% Kikuyu 10% Couch[2]	55% Kikuyu 10% Couch[2]
Weed cover			
Bare	100%	80%	35%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Difficult to determine couch cultivar but it appears to be Wintergreen

F.6 Current irrigation requirements

In its current condition the field would ideally receive 4 mm of water (irrigation or rain):

- three times a week in the warmer months (October to March); and
- no irrigation (unless field is oversown) in the cooler months.

Irrigation events should be delayed based on the above schedule if more than 5 mm of rain occurs. The run time cannot be determined without more information on irrigation system performance, but is likely be about 25 to 35 minutes per station.

F.7 Water saving options

The watering requirements of the field could be reduced by about 35% if improvements were made to the irrigation system and the amendment works outlined in this report were implemented. An irrigation audit should be performed to determine how these improvements could be achieved and should examine:

- system headworks (pump, tank, filter and controller);
- system hydraulics (pipe sizing and operating pressures);
- sprinkler layout (each head should be accurately located to within 0.2 m), operating pressure and evaluation of design (type of head and/or nozzle).

The audit should be performed by a Certified Irrigation Designer, with a list of persons holding this certification provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers. If cost is limiting, then Council could train staff so they are qualified/certified to perform these works.

F.8 Recommendations

Reconstruction

Ideally the field would be reconstructed by:

- spraying the existing turf until it is dead (e.g. 4 applications of round up with fusillade);
- incorporate 20 mm of loam (Appendix J) and 35 mm of composted garden organics (Appendix I) to a depth of 180 mm using multiple passes with a blechivator (inspect site to ensure adequate mixing has occurred and that it has been incorporated to depth);
- screed the surface on multiple occasions so it is firm but even and has similar cross-fall to that currently present at the site that is smooth;
- establishing Santa Anna couch from washed turf ensuring it is free of weeds and kikuyu;
- watering and fertilising turf until it is established; and
- topdressing the field until an even playing surface is achieved (inspect site during construction to determine topdressing requirements with sand NOT to be used) and hand chip the field weekly until no more kikuyu attempts to establish on the field.

The cost of performing these works is estimated to be about $130,000+GST. Once amended the field will be able to handle the current usage levels and will likely drain rapidly without a slit drainage system.

The amendment costs could be reduced by using traditional sod, but it is crucial to ensure it has less than 20% fines (silt and clay) in the attached soil layer or issues will persist (Figure A.1).

A superior outcome to using traditional sod (particularly during the second season onwards) could be achieved for if Santa Anna couch is established from sprigs which will cost about $70,000+GST, but this will take the site out of play for the entire summer sport season. Sprigs should be sown densely and as early in spring as possible to ensure good turf cover is achieved by the start of the soccer season, with ongoing weed control needed until full cover is achieved. Many of the fields in Hornsby Shire Council have been successfully established from sprigs (Figure F.5).

Before (~25% returfing per year)	End of 1st winter sport season after soil amendment and establishment from sprigs (nil patching)

Figure F-5: Impact of amendment works on John Dwyer Oval (recieves slightly high wear levels to Queen Elizabeth II Reserve) which was re-established from sprigs. Both photos were taken in the first week of August, with much better cover observed at the end of the second winter sport season.

Short term amendment

If cost is limiting and/or insufficient time exists to sprig then improvements could be achieved by patching areas unlikely to recover by patching the 16 m wide strip running through the centre of the field (goal to goal) by:

- shaving out the existing turf to about 50 mm depth;
- incorporating 30 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I) to about 150 mm depth using a blechivator;
- screeding the surface multiple times until the area is firm, level and will match into the adjacent areas once the turf has been laid;
- laying Santa Anna couch (no other cultivar is to used, regardless of the claims made by turf suppliers). Ideally washed turf would be laid, but traditional sod could be used if it contains less than 20% fines (silt and clay) in the attached soil layer;
- once the turf becomes established depressions should be filled by topdressing with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I); and
- aerating using four slow passes (these can occur in a row) with Council's aerovator on at least five occasions.

Under no circumstances is then new turf to be laid on the soil without first amending the soil. Sand based topdress to be used, with 80:20 regarded as far too sandy for application to this site.

Table F-2: Cost (excluding GST) to implement the short term amendment options at Queen Elizabeth II Reserve.

Activity	Cost	Notes
About 1,600 m^2 should be patched (16 m wide middle strip running goal to goal) by shaving out about 40 mm of material, incorporating 70 tonne of 50% loamy sand[1] and 50% compost[1], screed the surface and patch with Santa Anna couch	$25,000	**A. Crucial:** but only required if the field is not reconstructed
After patching, fill depressions with 10 tonne of a mixture of 50% loamy sand[1] and 50% compost[1]	$800	**A. Crucial:** but only required if the field is not reconstructed
Aerate using 4 slow passes in a row with Councils aerovator, with this to be repeated on at least 5 occasions	NA	**A. Crucial**

1 characteristics loam and compost described in Appendices H and I respectively

F.9 Ongoing requirements

If the lower field is reconstructed according to the works outlined in Section F.8, then the field will require (most important activities are underlined):

- **Growth regulator (primo):** should be applied at appropriate intervals to improve turf quality and sward density during the summer period;
- **Pre-emergent herbicide:** may periodically need to be applied to control annual weeds;
- **Selective herbicide:** will periodically be required to control broadleaf weeds such as clover;
- **Hand chip Parramatta grass:** which was not observed on the field at the time of the inspection but is a major weed on nearby sites and has no selective herbicide;
- **Localised topdressing:** of depressions and thin turf areas with a mixture of 50% loamy sand (Appendix H) and 50% compost (Appendix I). Under no circumstances is sand based topdress to be used to fill holes, with 80:20 regarded as far too sandy;
- **Topdressing:** of the fields is likely to be required about every 3 years with 8 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions;
- **Slice:** with the earthquake every 2 to 3 years up to the fence line;
- **Aeration:** should occur as frequently as possible using a Councils' aerovator. Depending on the condition of the field up to four passes can be performed in a row. Periodically the site should be aerated with a solid tine aerator that can penetrate to a depth of 180 mm such as the vertidrain. Aeration must NOT occur in the 5 months after applying a pre-emergent;
- **Repairing small bare areas:** that struggle to recover (e.g. goal boxes) using turf plugs from low wear areas. Small heavily trafficked areas where the turf has become thin (but will recover) should be manually aerated with a garden fork and fertilised/watered at the end of the soccer;
- **Wetting agent:** should be applied to site annually in October;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of 150 kg/ha of nitrogen is applied in October, with a second application in early February; and
- **Irrigation:** should occur according to the schedule outlined in Section F.6. The system performance should be assessed at least annually, with more frequent visual inspections;
- **Oversowing:** with ryegrass should be considered in the goal box areas. This will not be required if the site is reconstructed using the works outlined in this report and growth regulator (primo) is applied at appropriate intervals over summer to improve sward density. Spray with colourguard (dye) if winter colour is an issue.

Sand based topdress is not applied (soil is already marginally too sandy), with 80:20 regarded as far too sandy for this site.

Appendix G: The Glade

The Glade is located at Koora Avenue Wahroonga. The 1.5 ha site has a centrally located turf wicket and is divided into two soccer fields during the winter sport season. The site is well wind protected and receives late afternoon shade, with heavy shade occurring at the north end. The site has no floodlighting irrigation system or slit drainage. A soil survey was conducted in August 2016 by Dr Mick Battam that involved the construction of about 70 test holes.

G.1 Soil

The soil mostly consisted of loamy sand to sandy loam topsoil overlying compacted heavy clay subsoil (Figure G.1). The topsoil was at least 180 mm deep across most of the site, but was only 50 to 100 mm thick on the northern and eastern perimeter (Figure G.2). A thin layer of clay loam overlies the soil profile in some locations and has likely been imported to the site attached to turf rolls.

G.2 Drainage

Contour information was not available at the time of writing this report, but based on visual inspection the field generally slopes from the northern end towards the southwest and southeast. The field drains relatively poorly, with waterlogging generally being worst in the shallow areas and those sections of the site receiving run-on. These problems could be overcome by preventing run-on (Figure G.3) and performing the works outlined Section G.7.

Figure G-1: Waterlogging in the northwest goal box where the soil was very shallow (insert).

Figure G-2: The Glade Oval showing factors limiting turf growth. Google Earth image.

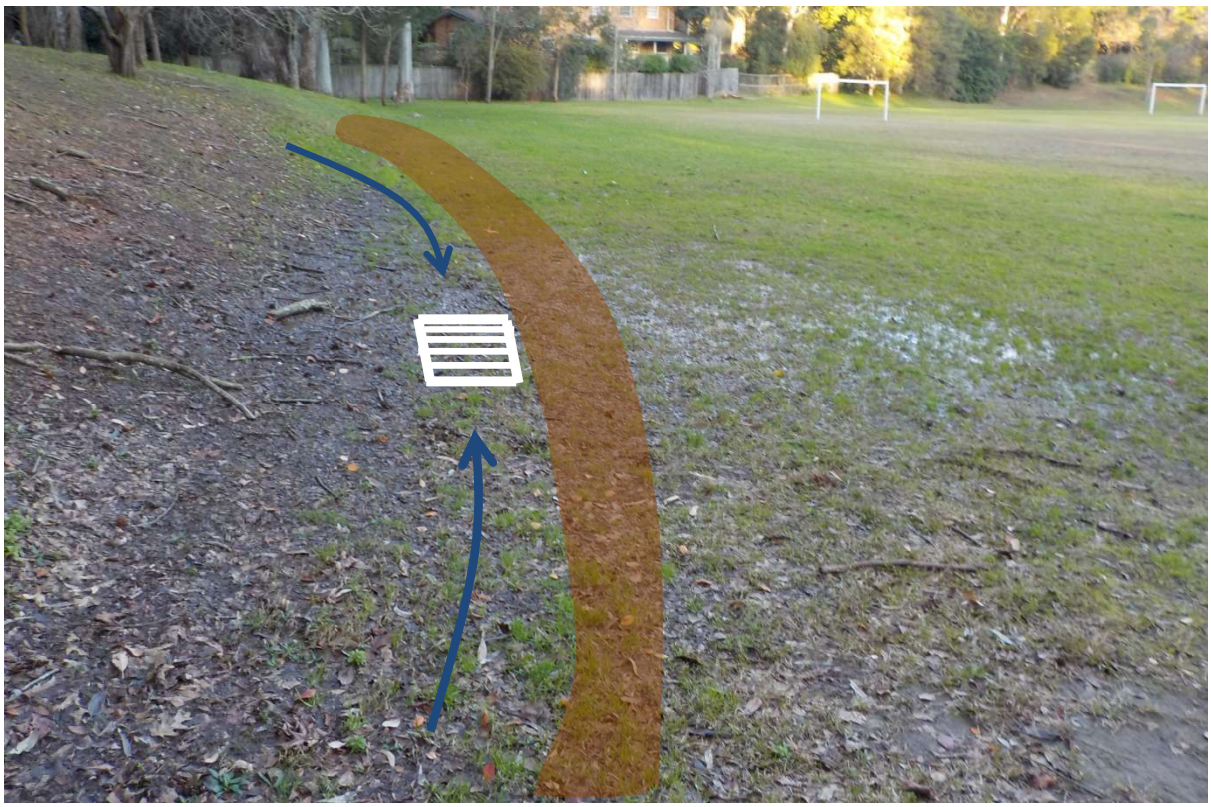


Figure G-3: Water running onto the northern edge of the field should be diverted using a small mound (or swale) into a drain.

G.3 Field use and carrying capacity

Over summer the field is used for cricket, with soccer (no training) played over the winter months. The site is also used for school sport. The field cannot handle the current used levels, but could it were amended (Figure G.4). However, some minor repairs (plugging and topdressing) will still likely be required to repair the goal box areas at the end of the winter sport season.

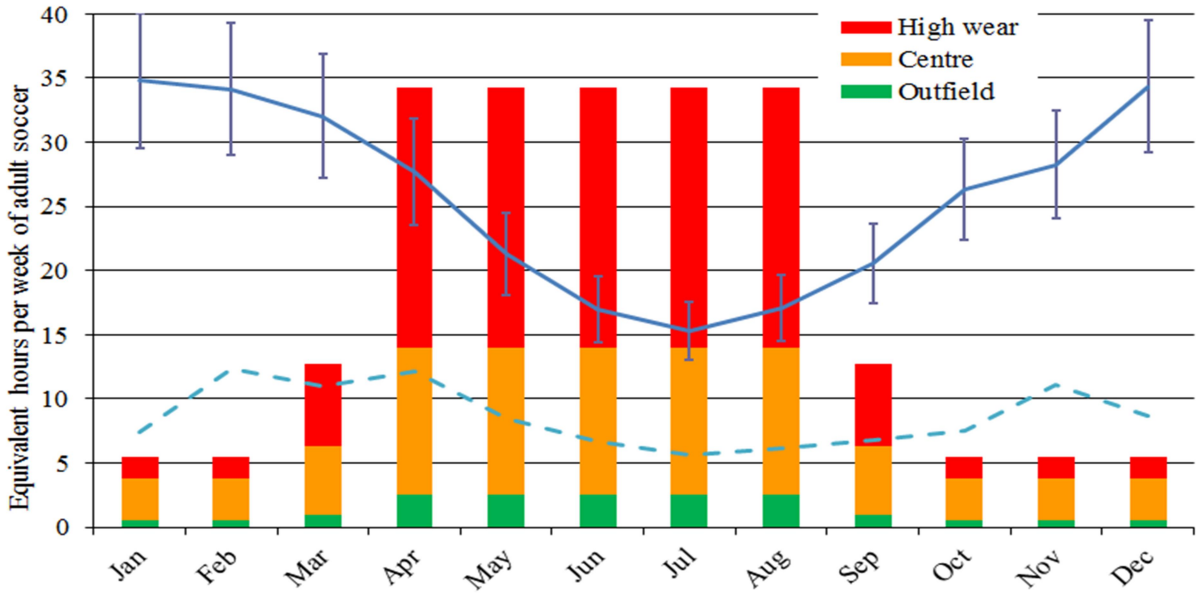


Figure G-4: Current use on the high wear (red), infield (orange) and wing areas (green) relative to the fields current (dashed line) and maximum carrying capacity of current turf type (solid line). Modelling performed with the foot traffic model developed by Dr Mick Battam.

G.4 Field condition

The field was in moderate to poor condition at the time of the inspection, with large amounts of damage observed on the northern field (Figure G.1). Low levels of traction were observed in worn areas (Table G.1), which not only occurred in goal boxes but also shallow sections of the field. Onion weed was observed in one of the goal box areas.

Table G-1: Field condition in July 2016. Shading indicates non-optimal observations.

	Parameter	Goal	Infield	Wing
Northern soccer field	Grip (0) to no grip (5)	5	3	2
	Soft (<6) to hard (>10)[1]	7	7	6
	Even (0) to uneven (8)	3.5	3.5	3.5
	Turf cover	12% Couch[2]	10% Kikuyu 20% Couch[2]	50% Kikuyu 30% Couch[2]
	Weed cover	8% Onion		
	Bare	80%	70%	20%
Southern soccer field	Grip (0) to no grip (5)	4	1	1
	Soft (<6) to hard (>10)[1]	8	10	6
	Even (0) to uneven (8)	4.5	3	3.5
	Turf cover	5% Kikuyu	20% Kikuyu 50% Couch[2]	50% Kikuyu 30% Couch[2]
	Weed cover			
	Bare	95%	30%	20%

1 Measured from the 3rd drop of a 2.25 kg Clegg hammer
2 Difficult to determine couch cultivar but it appears to be Wintergreen

G.5 Without irrigation

The site is currently irrigated manually from quick coupling valves points. Acceptable turf cover could be maintained using small amounts of supplementary irrigation provided:

- the soil is amended according to the works outlined in this report (Section G.7);
- the field is not trafficked when wet;
- compaction is effectively managed; and
- worn areas are repaired at the end of their corresponding sport season.

Ideally the field would receive some irrigation, especially the goal boxes areas until they have achieved full cover at the end of the winter sport season.

G.6 Irrigation

The field could handle higher usage if it was irrigated and converted to a more wear tolerant turf cultivar. If an irrigation system is installed it should be:

- designed so a scheduling coefficient of less than 1.15 can be demonstrated through appropriate hydraulic modelling output; and
- accurately installed so sprinklers are located within 0.2 m of their design location.

This can be achieved by having the irrigation system designed (to meet the above criteria) by a Certified Irrigation Designer who then oversees an irrigation installer (engaged independently by council) to ensure the system is accurately installed. Lists of persons holding appropriate certifications are provided at http://irrigation.org.au/certification/listing-of-certified-irrigation-designers.

G.7 Recommendations

The field condition could be improved by (cost estimates in Table G.2):

- **installing a drainage pit:** at the northern end of the field and construct a small mound (or swale) to divert water into this structure so it no longer runs onto the field;
- **Calcium chloride:** should be applied at the rate of 120 kg/ha, ensuring it is watered into the soil profile;
- **Topdress (following calcium chloride application):** the field on at least 3 occasions with 8 mm of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). The surface should be screeded following topdressing so more material is swept into depressions. No topdress should be applied in the 10 m area around the wicket, especially on the downslope side;
- **Slice:** to the edge of the site using two passes with the earthquake;
- **Aerate (after topdressing):** using multiple passes with Council's aeratovator; and
- **Repair goal box areas:** on the southern field by patching with about 150 m^2 of Santa Anna couch, ensuring the sod contains less than 25% fines (silt and clay) in the attached soil layer. Despite its very poor condition the northern soccer field should recover without needing turf patching, but plugging may be required in some areas.

Following these works the site should be inspected to determine if additional soil amendment is required prior to installing a slit drainage system.

Table G-2: Cost (excluding GST) for the amendment of The Glade.

Activity	Cost	Notes
Install drainage pit at northern end of the field and create a mound or swale to direct water to this structure so run-on is prevented	$4,500	**B. Important**
Apply calcium chloride to the main field at the rate of 120 kg/ha being sure to adequately water in	$600	**B. Important**
After applying calcium chloride, topdress the field on at least 3 occasions with 160 tonnes of 50% Loamy sand[1] and 50% AS 4454 compost[1]. Minimal topdress should be applied near the wicket	$11,200 /event	**A. Crucial**
Slice to the edge of the site using two passes with the earthquake	$2,200	**B. Important**
Aerate using 4 slow passes (can occur in a row) with Councils aerovator	NA	**B. Important**
Repair goal keeping boxes by incorporation about 5 tonne of a mixture of 50% loamy sand and 50% compost so levels marry, then patch with about 150 m^2 of washed Santa Anna couch	$2,500	**A. Crucial**

1 characteristics loam and compost described in Appendices H and I respectively

G.8 Ongoing requirements

If the site is amended in accordance with the recommendations outlined Section G.7 it will require (most important activities are underlined):

- **Pre-emergent herbicide:** may periodically need to be applied to control annual weeds;
- **Selective herbicide:** will periodically be required to control weeds such as nutgrass and clover;
- **Hand chip Parramatta grass:** which was not observed on the field at the time of the inspection but is a major weed on nearby sites and has no selective herbicide;
- **Turf patching:** of worn goal box areas should occur using Santa Anna couch (no other cultivar to be used regardless of the claims made by turf suppliers), ensuring it contains less than 25% fines (silt and clay) in the attached soil layer;
- **Repair small bare areas:** that will struggle to recover using couch turf plugs harvested from low wear areas. Small heavily trafficked areas where the turf is thin (but will recover without plugging) should be aerated with a garden fork and fertilised/watered at the end of the winter sport season. Similar works should be used at the end of summer to repair cricket run-ups;
- **Localised topdressing:** of depressions with a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I);
- **Topdress:** at least twice a year until good turf cover can be maintained in all areas. The topdress should consist of a mixture of 50% loamy sand (Appendix H) and 50% composted garden organics (Appendix I). Under no circumstances is sand based topdress to be applied to the field, with 80:20 regarded as far too sandy;
- **Slice:** at least twice a year using the earthquake, but not with the 5 month period after applying a pre-emergent herbicide;
- **Aeration:** would ideally occur at least annually using a solid tine aerator capable of penetrating to a depth of 180 mm such as the aggravator. If cost is limiting the site could be aerated using at least four passes annually with Councils' aerovator. Aeration must NOT occur in the 5 months after applying a pre-emergent;
- **Fertiliser:** should be applied (N:P:K of about 9:1:9) so the equivalent of 150 kg/ha of nitrogen is applied in October, with a second application to the goal box areas in early February;

Consideration should be given to installing a slit drainage system (at least around the wicket table), but this must not occur until the soil amendment works outlined in this report are implemented and healthy turf cover can be maintained in all areas. Once the slit drainage is installed the type of topdress will need to be altered, but the loamy sand/compost mix should still be used to fill depressions (except those directly above slit drains).

Appendix H: Loamy sand characteristics

A topdress consisting of a mixture (by volume) of 50% loamy sand and 50% composted garden organics (Appendix I) has been recommended. This loamy sand is lighter texture then the material to be used when reconstructing fields and must:

- meet the requirements of AS 4419 (2003): 'Soils for landscape and garden use' (0 to 12% organic matter levels are permissible)
- contain 10 to 15% fines (silt and clay content);
- be non-dispersive (apply gypsum if required); and
- have a minimum permeability of 50 mm/hr following 16 drops as per the McIntyre test.

Such material is readily available from several local suppliers.

Appendix I: Compost characteristics

All composted garden organics applied to the field must meet the following criteria:

1) Has passed through a 8 mm (square grid) screen;
2) Meets the requirements of AS 4454 'Composts, soil conditioners and mulches' (2012) including the toxicity growth test and is either:
    a. Certified to AS 4454 (2012); OR
    b. Supplied by a quality endorsed company.
3) Has an $EC_{1:5}$ less than 3.5 dS/m;
4) Has a pH greater than 5.0 and less than 8.2; and
5) Has a C:N ratio less than 20:1.

To demonstrate compliance with the above criteria, the compost supplier must:

6) Provide a batch test certificate from an accredited laboratory proving the compost complies with the above criteria;
7) For certified compost product, provide the certification certificate for the certified compost product; and
8) For quality endorsed companies, provide the quality certification certificate.

No delivery of compost should be accepted at the site until the above criteria have been demonstrated in writing.

Appendix J: Loam characteristics

Loam has been specified for use during the reconstruction of some sporting fields. Such material is heavier texture than the topdress (Appendix H) and must:

- meet the requirements of AS 4419 (2003): 'Soils for landscape and garden use' (0 to 12% organic matter levels are permissible)
- contain 13 to 18% fines (silt and clay content);
- be non-dispersive (apply gypsum if required); and
- have a minimum permeability of 25 mm/hr following 16 drops as per the McIntyre test.

Such material is readily available from several local suppliers.

Appendix K: Curtain drain for Loyal Henry Reserve

Seepage along the southern edge of Loyal Henry Park could be overcome by installing a curtain drains (~60 lineal metres in total) that discharges at the surface of the swale at a point beyond where seepage water can adversely affect the field. The curtain drains should be constructed in a trench about 70 mm wide that has:

- 10 to 15 mm of bentonite clay pressed against the base and downslope side of the trench (bentonite is sticky to handle when wet and can be applied by a labourer manually pressing handfuls of the material against the trench wall which will likely be moist). It must **NOT** be applied to the upslope side of the trench;
- plastic laid in the trench so it lies across the base and vertically up the downslope side of the trench almost to the surface; and
- corrugated slotted drainage pipe 65 mm diameter (**no sock**) that is laid on top of 10 to 20 mm of drainage sand (over the top of the plastic and bentonite). The trench is then backfilled to the surface with drainage sand.

The base of the trench must be sited at least 130 mm into the underlying clay and have uninterrupted fall towards the drainage outlet (ag-drain can discharge into the swale beyond the end of the field (Figure K.1).

In addition to adhering to the particle size requirements (Table K.1), the drainage sand should have a saturated hydraulic conductivity at least 600 mm/hr. The sand in the curtain drains should extend all the way to the surface (Figure K.1). Under no circumstances is any foreign soil attached to turf rolls to be laid over the top of the lateral drains. Instead, turf should be encouraged to grow over the drains from the adjacent areas.

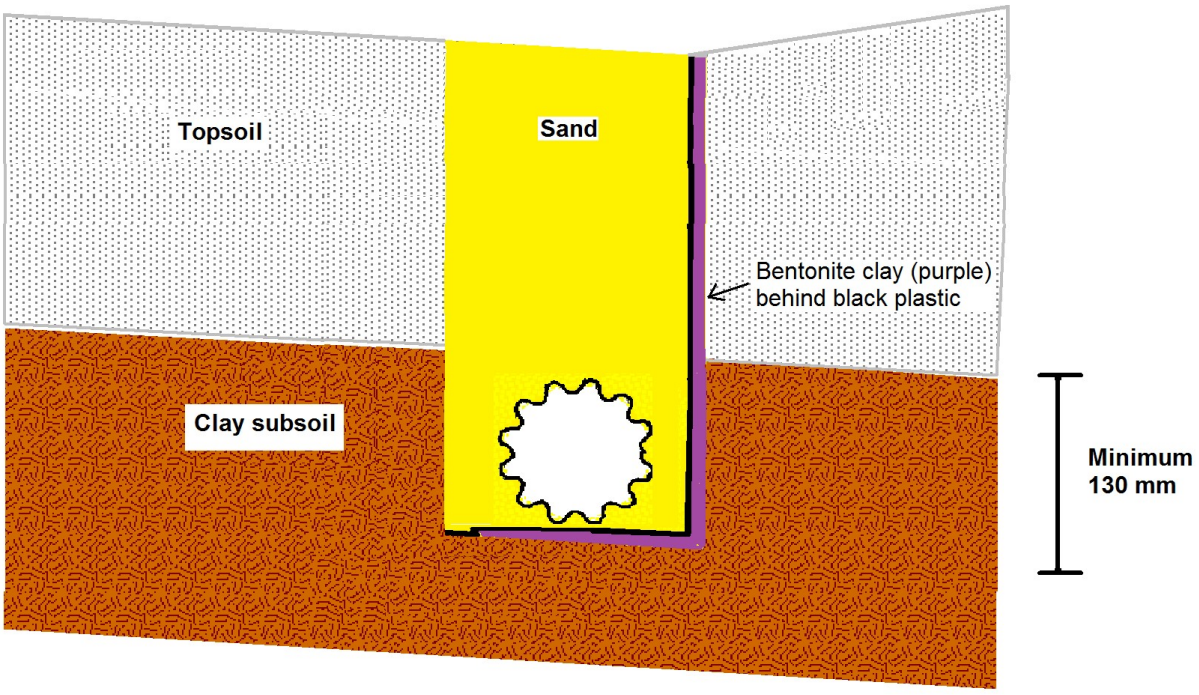


Figure K-1: Design for the lateral drains at Loyal Henry Park. Sock should NOT be installed around the ag-pipe.

Table K.1: Drainage sand particle size characteristics

Description	Size	Proportion by wieght
Fine gravel	2.0 – 3.4 mm	<3%
Very coarse sand	1.0 – 2.0 mm	<7%
Coarse sand	0.5 -1.0 mm	Minimum of 60%
Medium sand	0.25 - 0.5 mm	
Fine sand	0.15 – 0.25 mm	<20%
Very fine sand	0.05 – 0.15 mm	<5%
Silt and clay	<0.05 mm	<3%

.