Department of Climate Change,
Energy, the Environment and Water

Best-practice guidelines for sporting fields

A guide for climate-resilient playing surfaces in New South Wales

January 2025

Acknowledgement of Country

The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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This document was prepared by AgEnviro Solutions and Peak Water Consulting on behalf of the Department of Climate Change, Energy, the Environment and Water.

A wide range of sites have been included in this document. Where the image is of a best-practice field, it is noted in the figure caption.

Acknowledgements
Graeme Logan, Peter McMaugh AM and Dr Peter Martin also contributed to the development of the document.

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1 Introduction

Sport is part of our culture. Sport and physical activity contribute to our health and wellbeing and provide broader benefits to the economy and productivity. NSW is home to about 4,850 sporting fields that occupy about 5,960 hectares.[1] Our desire for public green spaces is growing. At the same time, land supply is constrained in many cities, making it unaffordable to construct new sports fields. Our sporting fields are increasingly multipurpose community assets and host formal and informal sport alongside passive recreation. There has never been a better time to make the best use of these assets and invest in our existing natural turf fields. With care, we can ensure our fields continue to accommodate more sport and recreation and deliver better quality playing surfaces that are more resilient to climate extremes including floods and drought. There are also opportunities to be more efficient with irrigation and increase the use of suitable alternative water sources to reduce potable water use.

There is much room for improvement in NSW. An assessment of more than 1,000 sporting fields revealed that 76% were in poor or marginal condition and failed to meet this best-practice guidance. These fields typically require significantly more resources and water to recover, or they may deteriorate further.

The best-practice guidelines for NSW sporting fields provides help with:

- understanding the science and evidence to improve the planning, design, construction, and management of community sporting fields, and common limitations
- flexible, outcomes-focused principles to develop solutions tailored to local conditions while achieving best practice
- understanding sporting field performance benchmarks, including water use, playability, and carrying capacity
- optimising the performance, resilience, and sustainability of sporting fields to meet our social, recreational, environmental, and economic outcomes
- making more effective use of financial resources
- comparing different sports field construction types, such as perched water table, best practice, and hybrids.

We base the guidelines on data from detailed assessments of fields across NSW, including:

- irrigation systems from about 100 sporting fields
- soil, playing surface condition, microclimate, and sport wear levels from about 2,000 sporting fields.

The guidelines do not specifically apply to elite stadium fields, cricket wickets, golf greens, lawn tennis courts, bowling greens, or turf used for dog or horse sports. Many of the principles will apply, but these turf surfaces will also need other specialised treatments.

1 Office of the NSW Chief Scientist & Engineer (2022), Independent review into the design, use and impacts of synthetic turf in public open spaces, Final Report.

2 Elements of a sports field that influence quality

A few foundational elements drive the watering requirements, resilience, and amenity of outcomes for natural turf sporting fields. This includes:

- use, wear, and carrying capacity
- turf grasses
- growing medium
- waterlogging and drainage
- irrigation system design and operation.

Many individual parameters, processes and decisions within these elements can influence the outcomes.

2.1 Use, wear, and carrying capacity

2.1.1 Use

A study of about 1,150 fields in greater Sydney found 99% receive less than 46 hours per week of formal sport and school use.[2] The hours of actual use are frequently much lower than those reported in a council booking schedule.[3]

Booked hours don't reflect actual use

Never use booked hours to estimate wear levels on sports fields. The number of players using the field at a particular time, age of players, sporting code, and site conditions also affect wear. For example, a 1.5-hour school PE class causes minor wear relative to an adult soccer game. A study of about 1,150 fields in the Sydney Basin found a 5-fold variation in wear levels for fields with similar booked hours.[4]

2 Battam, M (2022) Winter usage, wear and carrying capacity of sporting fields in the Sydney Basin, Turf NSW.

3 Battam, 2022

4 Battam, 2022

2.1.2 Wear

Foot traffic damages turf when it tears leaves, stems, stolons, rhizomes, and roots. Player age, sporting code, and soil type influence are factors that influence the amount of wear on a field. We can calculate and express the amount of wear as equivalent games of adult soccer (EGAS).

Registered player numbers per field can generally indicate sport wear levels but is less accurate than other assessment methods. With about 18 hours of timeslots available for games on the weekend, many clubs find it difficult to schedule games for more than about 550 players on a full-sized football field. As such, 550 players per field is a practical logistical limit that applies to natural and synthetic fields. Other factors such as lighting, amenities, car parking, turf carrying capacity, and council-imposed booking limitations can also restrict wear levels.

Wear levels from winter sport can be assigned to sporting fields using registered players per full sized field.

- Low wear < 175 players
- Moderate wear 175- 350 players
- High wear 350-520 players
- Extreme wear >520 players.

Current wear levels on sporting fields

The survey obtained sport participation data for more than 1,500 playing fields from sporting bodies such as Football NSW, Northern NSW Football, sporting clubs, and council sport booking officers. Based on this data, winter sport on NSW sporting fields results in the following:

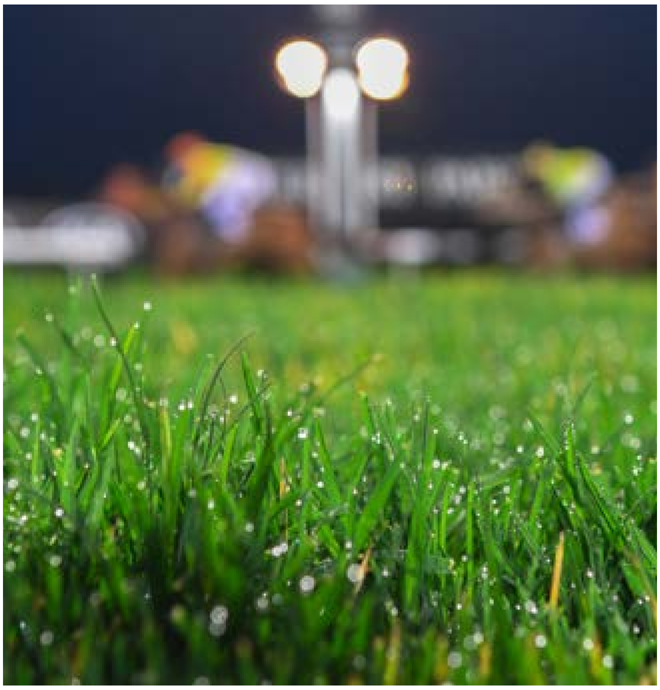
- **Extreme-wear levels** on 2% of fields and **high-wear levels** on 11% of fields. These fields are mostly in eastern Sydney, with a small number in western Sydney, Newcastle, Lake Macquarie, and Wollongong.
- **Moderate-wear levels** on 22% of fields, but the number of fields in this category can be significantly reduced by ensuring more fields have adequate lighting installed.
- **Low-wear levels** on 51% of fields.
- **No formal winter sport** on a further 14% of fields.

Almost all the fields experiencing extreme wear were within 4km of fields receiving low levels of wear, with several located close to fields that were not used for formal sport during the winter sport season.

2.1.3 Carrying capacity

The carrying capacity of a sports field is the amount of wear it can sustain before substantial reductions occur in either the playing surface useability or lifespan. Climate, growing media, turf cultivar (see Table 1), waterlogging, and maintenance practices all influence the carrying capacity of natural turf fields.

Sites where the wear levels exceed the carrying capacity will require additional water and possibly turf patching to assist in turf recovery. Additional water is not required on sites that can cope with their current wear levels.



2.2 Turf grasses

Consider the site wear levels, growing media, climate, microclimate, and water availability when choosing a turf cultivar for a sporting field. In general, we divide sports field turf grasses into 2 types:

1. Warm-season grasses (C4 grasses)

These grasses often go dormant in winter, and many couch cultivars turn dull coloured. Most NSW sporting fields use either couch or kikuyu, both of which are drought resilient. Kikuyu can only manage low levels of wear, while couch cultivars vary enormously in their carrying capacity.[5] Table 1 provides indicative carrying capacity values.

2. Cool-season grasses (C3 grasses)

These types continue to grow and retain colour in the cooler months. They require more water and cannot handle moderate or high levels of wear. They are best suited to sites in colder climates, for example, the tablelands, with low wear levels and adequate water supply. Ryegrass, tall fescue and Kentucky bluegrass are the main cool-season grasses used on sports fields in NSW.

Some councils over sow their couch and kikuyu sporting fields with ryegrass. They usually sow the ryegrass seed in autumn, and then use herbicide to kill the ryegrass in spring. These fields look greener during winter, but they require additional water, fertiliser, labour, and financial resources to maintain an acceptable playing surface. This typically has minimal impact on carrying capacity. Ryegrass-over sown fields generally are not able to handle moderate or high levels of wear (Table 1).

Table 1. Approximate number of players, per full-sized football field, that different turf cultivars can handle under optimal growing conditions. These indicative carrying capacities would decrease if soil, waterlogging, or other factors limited turf growth.

Full-sized football field indicative carrying capacity (players per week)			
Turf cultivar	**Eastern Sydney, mid and north coast**	**Tablelands (elevation above 500m)**	**Other areas of NSW**
Cool-season grasses (tablelands only)	N/A	175	N/A
Kikuyu	160 to 200	150 to 175	150 to 175
Warm-season turf oversown in winter[6]	160 to 200	150 to 175	150 to 175
Slow-growing or thinner canopy couch	160 to 200	150 to 175	150 to 175
Couch cultivar with dense canopy and rapid growth	550+	300 to 350+	400-500+

5 Hunter Water, 2022, Best Practice Sporting Fields maintenance book 2, p20.

6 Typical couch or kikuyu field oversown with ryegrass for the winter sports season. Ryegrass is sprayed out in spring and the underlying turf is allowed to recover. Additional water and fertiliser are required for recovery.

2.3 Growing medium

Growing medium refers to the material into which turf roots grow. An assessment of more than 1,000 NSW sporting fields found about 98% have a soil-based growing media. About 2% have a sand profile. Very few of these sand profiles have an underlying gravel layer. See Figure 1.

Figure 1: Texture of the topsoil used to construct more than 1,000 sporting fields across NSW.

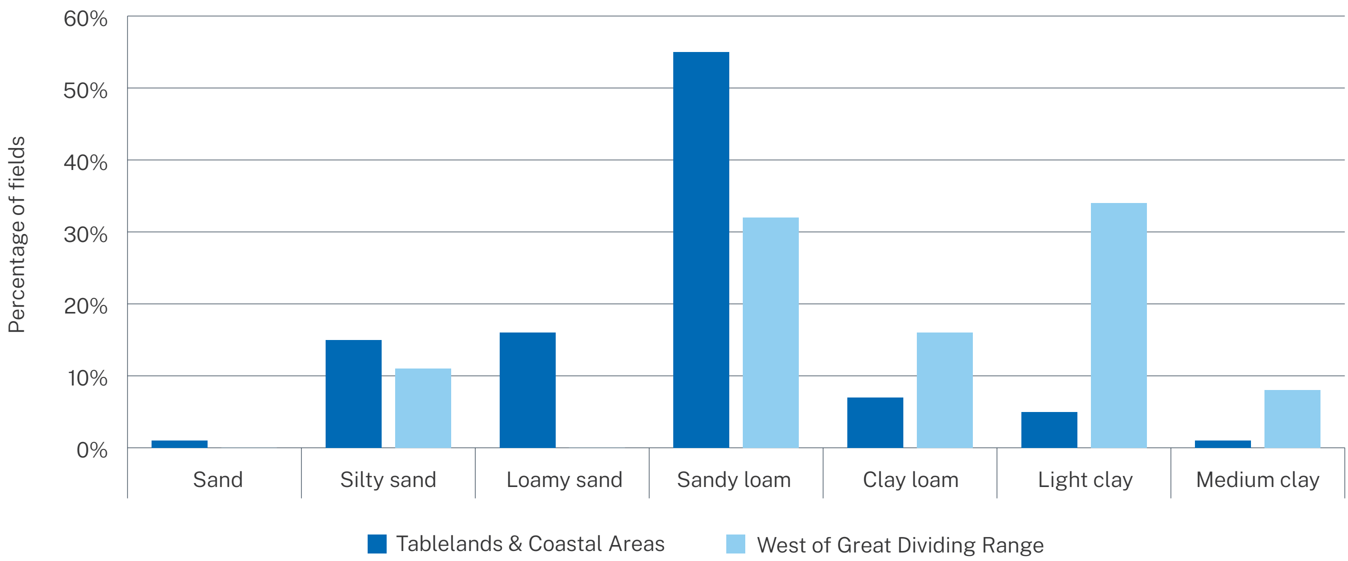


Diagram: Lamble & Battam (2024)

Major stadiums typically have a gravel base beneath the amended sand growing medium. This is the perched water table design. The sand in stadium fields is often amended with 10% to 20% organic material by volume to increase the availability of water and nutrients. Examples of amenders include coir or mature compost.[7]

To sustain healthy turf, the growing medium must ensure:

- sufficient water and nutrients can be supplied to the turf to avoid shortfalls in supply
- sufficient anchorage is provided to the turf, so it does not dislodge during play
- sufficient oxygen supply for the roots, with excess water removed in an acceptable timeframe
- the playing surface provides adequate cushioning to players.

Without meeting all these criteria, it is more difficult to maintain an acceptable playing surface, even if a wear-tolerant turf cultivar is used. Figure 2 shows 6 kikuyu fields that all receive low levels of wear, similar applications of fertilisers, and with no automatic irrigation system. The growing media has a clear impact on the performance of the fields.

7 United States Golf Association (USGA), 2018 Edition. Recommendations for a method of putting green construction.

Figure 2. The impact of growing media on the performance of 6 kikuyu fields. All fields receive low levels of wear, similar applications of fertilisers, and none of the sites have an automatic irrigation system.

Photos by Dr Mick Battam

2.3.1 Soil texture

Turf can grow well in many different soil types. It's important to understand the soil texture to tailor the management approach and use soil amendments appropriately.

Soil consists of minerals, organic matter, water, microbes, and gases. The mineral component consists of:

- sand grains
- silt-sized particles – 10 to 100-times smaller than sand grains
- clay particles – more than 100 times smaller than sand particles.

Soil texture refers to the proportion of sand, silt, and clay-sized particles that make up the mineral fraction of the soil. Common soil textures observed on community sporting fields in NSW, listed from most to least sandy, include loamy sands, sandy loams, clay loams, and clays.

Individually assess 80:20 mixes

80:20 mix is a blend of 80% sand and 20% soil. The soil texture of 80:20 mix varies between suppliers and batches depending on the soil and sand used. Hence, 80:20 is not assigned to a soil texture class. Instead, users must individually assess the properties – texture and permeability – of each 80:20 batch.

2.3.2 Soil structure

Soil structure describes the way soil components – sand, silt, clay, and organic matter – are arranged.

Well-structured soils

These consist of aggregates, also known as peds, made up of microaggregates stuck together with organic matter. The microaggregates consist of clay particles stuck together by cations such as calcium and iron (Figure 3). Stable peds can be larger than sand grains and allow fast air and water movement.

Poorly structured soils

These consist of individual sand, silt, and clay particles that pack tightly together and set hard. The tightly packed particles limit root growth, air and water movement, and available plant water storage.

Figure 3. Calcium and organic matter can bind fine soil particles together into sand-sized aggregates, enabling these soils to drain more rapidly and resist compaction.

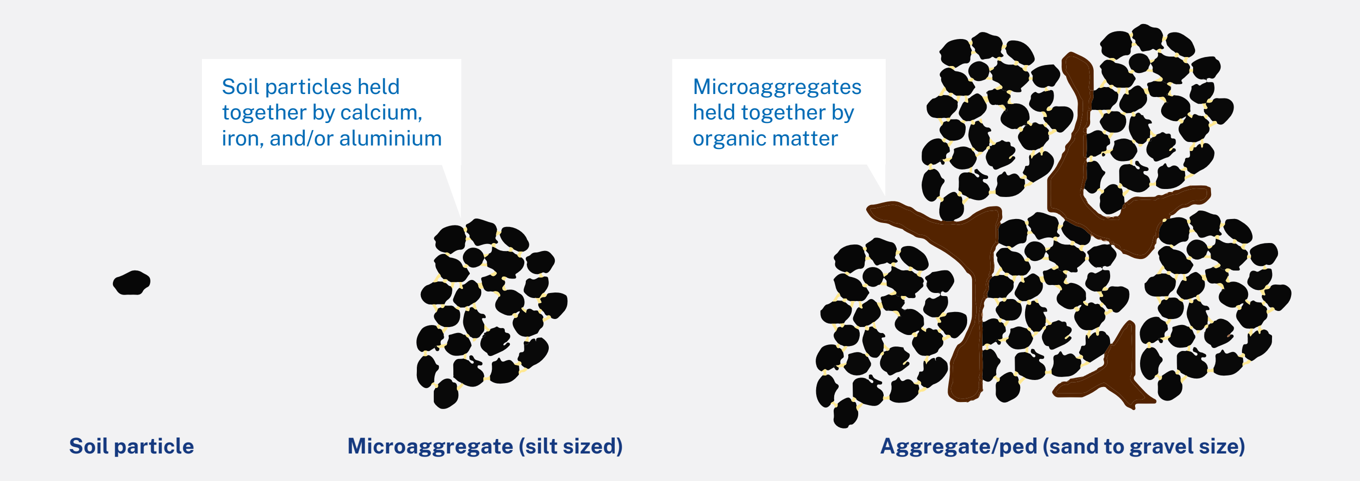


Diagram: Lamble & Battam (2024)

Many community sporting fields show signs of soil compaction. Aeration machines can reduce the packing density of these soils but the results often do not last long, and many soils will rapidly set hard again. Instead, they need stable forms of organic matter, and sometimes calcium, to improve the soil structure and form stable peds. This ensures the particles are less prone to packing tightly.

Figure 4. Two sandy loam soils – one is poorly structured and heavily compacted (left), the other is well structured (right).

Photos: Dr Mick Battam and Dr Paul Lamble.

2.3.3 Soil layering

Major differences in the characteristics of layers in the soil profile can result in waterlogging, stunted root growth, and lack of grip to players.

Clay overlying sand

When clay from turf farm sod is laid over a sandy profile, the clay layer will remain wet and soft for long periods of time. The underlying sand layer cannot remove the excess water out of the overlying clay layer. Water is more tightly held or “perched” in the clay layer above the sand.

Sand overlying clay

The clay will remove most of the plant-available moisture out of the sand above, leaving it droughty. The dry sand surface is then also prone to rutting due to lack of surface stability for players.

Optimum results for turf performance, including field drainage, turf growth, and moisture availability, are generally achieved with a uniform profile or a gradual change in texture with depth.

2.3.4 Soil nutrition

Essential plant nutrients, in typical order of concentration within turf tissue, include nitrogen, potassium, calcium, magnesium, phosphorus, sulphur, iron, manganese, zinc, copper, and boron. Chemical analysis of about 200 NSW sporting fields found the most common nutrient deficiencies were:

- calcium – 37% of fields
- micronutrients – 36% of fields – with the most common deficiency being boron
- phosphorus – 31% of fields
- sulphur – 27% of fields
- potassium – 14% of fields.

Soils with poor fertility, for example, low cation exchange capacity (CEC), have limited ability to store nutrients. As a result, the turf is more vulnerable to shortfalls in supply. About 38% of NSW sporting fields have low CEC levels (Appendix A). Adding appropriate forms of organic soil amenders can increase soil fertility and improve soil structure. For sand profiles, organic amenders are routinely used to increase moisture storage. Suitable organic amenders can have a major impact on turf health and sports field carrying capacity – see Figure 5 for an example. Nutrient deficiencies and/or toxicities can also occur if the soil $pH_{(w)}$ is outside the range of 5.5 to 8.0.

Laboratory chemical analyses of the soil and turf tissue assess nutrient deficiencies and identify soil amenders. Most soils may require fertilisers to optimise turf performance.

Figure 5. Despite having the same soil texture, turf cultivar, and wear levels, the December condition of these 2 fields is very different. The field on the right has been amended with AS 4454 compost. It has a better soil structure and a higher level of fertility, with its carrying capacity being about 3-4 times higher than the field on the left.

Same soil type and turf cultivar

Photos: Dr Mick Battam

2.4 Drainage

Waterlogging or poor drainage is responsible for many wet-weather cancellations on sporting fields. However, it can also affect the wear levels, carrying capacity, and irrigation demand of sporting fields. Sites that “drain well” typically prevent water running onto the field from surrounding areas and use gravity to rapidly remove excess surface water from the field itself. Common techniques used on well-drained sports fields include:

- capturing runoff from roads, paths, embankments, and buildings in stormwater drains or directing this surface water around the field using swales or mounds
- having suitable crossfall, for example, 1 in 70 to 1 in 100 fall at an angle to the direction of play, and slope length to shed excess surface water rapidly off the field
- infiltrating water out of the soil profile into the underlying subsoil or sports field drainage system.

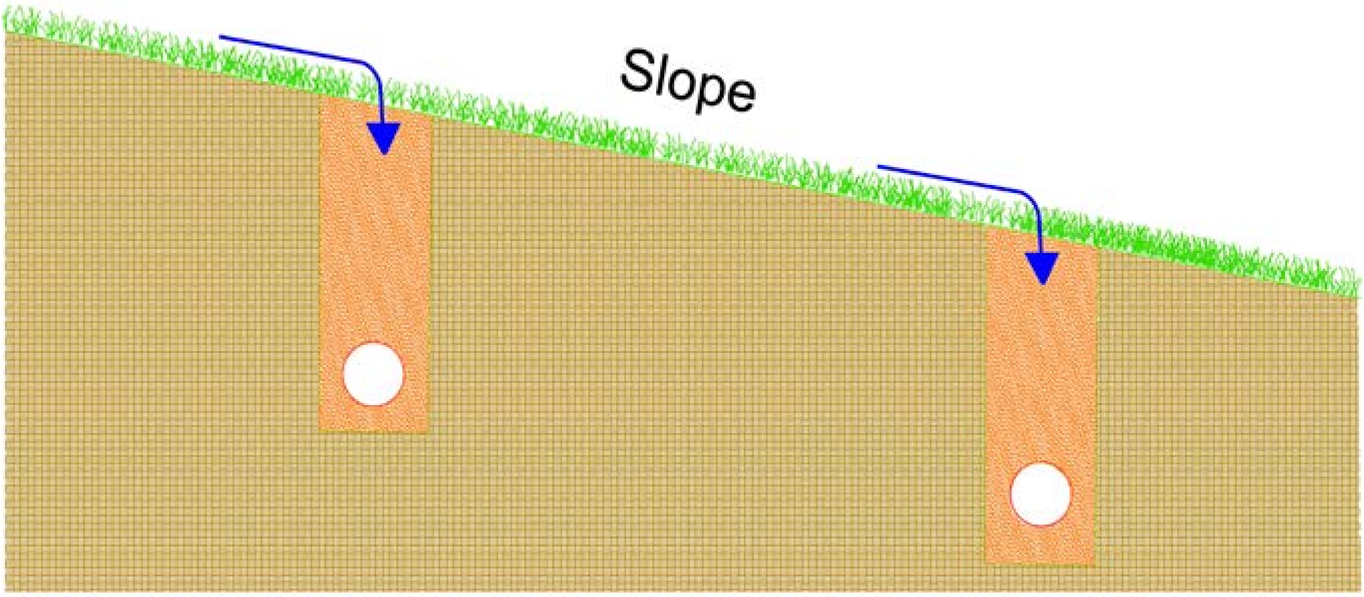
A survey of more than 1,000 NSW sporting fields found a combination of factors typically caused waterlogging problems, with water running onto the field the most common cause.

2.4.1 Sports field drainage systems

Sports field drainage, or slit drainage, consists of a series of trenches that typically install ag pipe over a bedding layer in the bottom of the trench. The trenches are backfilled to the surface with sand (Figure 6). Water is captured in the trenches and flows on to collector pipes or a mainline that discharges to the stormwater system.

Sports field drainage systems are primarily used to remove surface water as it flows across the slope. However, if the drains are installed close enough together, they can also function effectively to remove excess water pooling on top of the subsoil, which is impermeable at many sites. While a well-designed and installed sports field drainage system can overcome most waterlogging problems, it has minimal effect on addressing the waterlogging associated with soil layering (Section 2.3.3). Section 6.2 provides more information on drainage and waterlogging.

Figure 6. Cross-section of slit drains.[8] The steepness of the slope is exaggerated for visual clarity.



8 McIntyre K (2004) Problem Solving for Golf Courses, the Landscape, Sports Grounds and Race Courses. Horticultural Engineering Consultancy, Kambah, ACT.

Common causes of waterlogging and drainage issues on NSW fields

A wide range of factors can cause waterlogging, with the most common being:

- surface water running onto the field from surrounding areas
- surface unevenness that prevents excess water being able to run-off the field
- layering, particularly impermeable layers, within the soil profile.

A study of poorly draining fields in the Lower Hunter found 2 or 3 factors typically caused waterlogging (Figure 7).

Figure 7: Causes of waterlogging on fields that remain wet in the Lower Hunter. Most of the sites have multiple issues. As turf wicket tables are constructed from clay, the run-off from these areas can cause waterlogging in the nearby areas. [9]

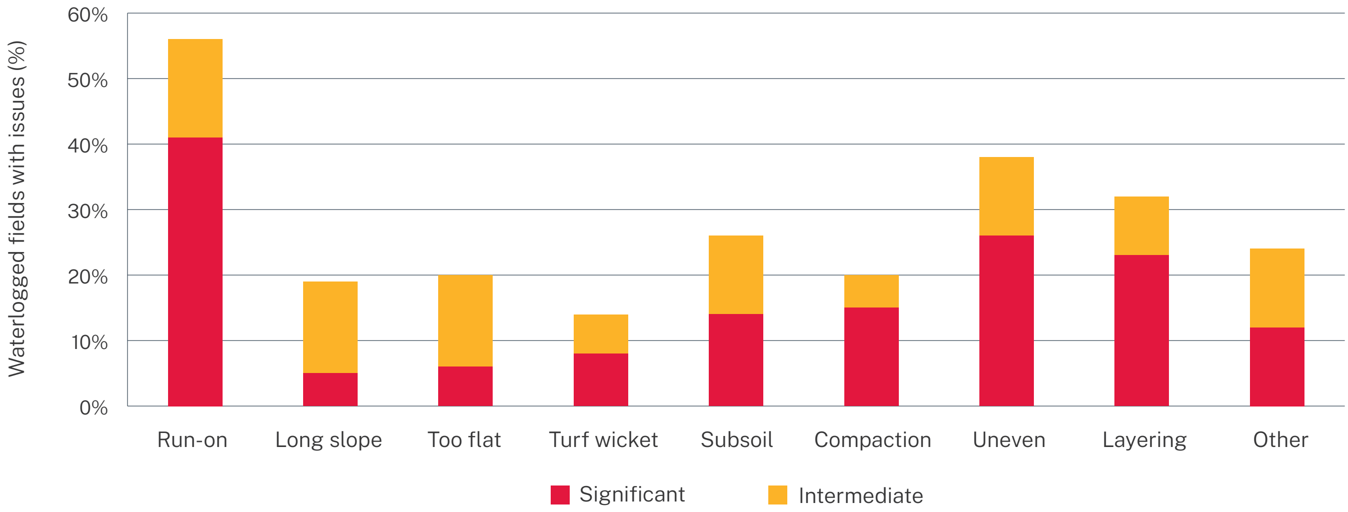


Diagram: Lamble & Battam (2022)

2.5 Irrigation systems

Performance of irrigation systems in NSW

An assessment of the performance of 100 existing sports field irrigation systems showed these systems often failed to comply with best practice, with 65% of the systems applying water unevenly (Table 2). In addition, more than half of the system displayed the following problems (Table 3):

- excessive variation in sprinkler spacing and operating pressures
- inappropriate coverage of the target area
- inadequate maintenance
- a lack of rain or soil moisture sensors.

In contrast, the assessment of 40 fields with newly installed irrigation, many of which were designed by a certified irrigation designer, found most met best-practice benchmarks.

9 Hunter Water 2022

Table 2. Performance of pre-existing irrigation systems. Percentages indicate the proportion of systems in each category.

Irrigation system performance measure	Best practice	Average	Poor	Very poor
Evenness of water distribution (scheduling coefficient)	9%	26%	20%	45%
System application rate	48%	34%	12%	5%
Pressure variation	10%	14%	22%	53%

Table 3. Synopsis of the adequacy of existing irrigation system infrastructure, installation, and maintenance.

Item	Appropriate / Adequate	Inappropriate / Inadequate
Irrigation tank sizing	72%	28%
Irrigation pump selection	57%	43%
System base operating pressure	72%	28%
Variation in sprinkler spacing	42%	58%
Coverage of irrigated area	32%	68%
Irrigation system sensors	28%	72%
Irrigation system maintenance	41%	59%

2.5.1 Indications for using an automatic irrigation system

An automatic irrigation system is not always essential for sporting fields, because couch and kikuyu are drought-hardy species. Fields on or east of the Great Dividing Range that receive low levels of wear often only need minimal irrigation. However, an automated irrigation system is often required for fields that:

- receive limited summer rainfall, for example, west of the Great Dividing Range
- host more than 250 players per week, that is, have elevated to high wear levels
- require a higher-standard playing surface, such as district or regional playing fields.

We discuss Irrigation system performance in Section 3.

2.5.2 Irrigation water sources

Irrigating with suitable non-potable water sources can reduce potable water use. Considerations include:

- regulatory requirements, licensing, and approvals, for example, for stormwater harvesting, recycled water systems, groundwater and surface water extraction, and potable water connections
- reliability or security of the supply and any restrictions/reductions or reduced water quality in dry periods
- water storage requirements, such as balance of inflows from the supply and outflows to the irrigation system
- water quality parameters – biological, chemical, and physical – that can affect
  - public and environmental health
  - soil health and turf health
  - field infrastructure
  - material selection and longevity for irrigation infrastructure.

Soil health includes chemistry, soil structure, and infiltration rate. Turf health includes nutrient availability and salt. An example of field infrastructure is clay soils in turf cricket wicket tables. Irrigation infrastructure includes pumps, pipes, and filters.

Appendix C: Irrigation technical information and tips contains additional information on water quality considerations for turf irrigation.

2.6 Acceptable playing surface

Administrators should maintain sporting fields in a condition that allows year-round safe play to occur, supporting sport participation and skill development. Table 4 provides acceptable standards for different grades of sporting fields. Sites hosting representative sport may adopt additional sport-specific parameters, for example, ball bounce and roll.

It is important to carefully interpret field condition as it will vary with position on the field, weather conditions, time of the year, and sport played on the site. These guidelines base their water-use benchmarks, principles, and other parameters on sporting fields achieving the playing surface conditions described in Table 4.

Table 4. Acceptable playing surface conditions.[10]

Category	Turf cover[1]	Evenness[2]	Hardness[3]	Traction	Time play can resume after significant rain[4, 5]	Examples
Major stadiums	Beyond the scope of this document	Beyond the scope of this document	Beyond the scope of this document	Beyond the scope of this document	Beyond the scope of this document	Parramatta Stadium
Regional (elite)	95%	8mm	80 to 100	>25 Nm	10-20 minutes	North Sydney Oval
Regional fields	95%	10mm	80 to 100	>25 Nm	2-4 hours	Allan Border Oval
District fields	90%	12mm	60 to 110	>20 Nm	4-8 hours	First grade home grounds
Local	85%	12mm	60 to 120	>20 Nm	8-16 hours	Most fields

Table notes:

1 Turf cover assumes no bare areas exceeding 300mm in diameter and excludes intensely worn areas, such as a goalkeeping box.

2 Evenness defined as the standard deviation from the mean, but single deviations not to exceed twice this figure.

3 Hardness defined as gravities as measured with Clegg Impact Soil Tester when used according to the manufacturer's instructions. Hardness values are for the third drop, with the first drop limits being at least 20% lower.

4 Significant rain defined as 25mm. Smaller rainfall events should have trivial impact on play. The impact and likely recurrence of any individual rainfall event on return to play will depend on prevailing conditions. Examples include a prolonged period of consistent rainfall in winter and the timeframe over which rainfall occurs – 15 minutes versus 2 days.

5 Fields located east of the Great Dividing Range where rainfall is higher may require a higher standard of performance. An example includes the same return-to-play time but for a larger rainfall event, say 40mm.

10 Adams W A and Gibbs R J (1994) Natural Turf for Sport and Amenity. CAB International, Wallingford.

Canaway P M, Bell M J, Holmes G and Baker S W (1990) Standards for the playing quality of natural turf for Association Football. In: "Natural and Artificial Playing Fields" (Ed. R Schmidt). American Society for Testing Materials (ASTM International).

Neylan, J and Nickson, D (2019) Compare possible hours of use for different sports field construction types and maintenance inputs. Research Report for Sports Turf Association of Victoria.

Peter Martin pers com.

3 Best-practice sporting fields

With careful consideration and thorough planning, a best-practice field can deliver a valued and sustainable community asset that will stand the test of time. Best-practice fields meet several key principles and share key characteristics.

3.1 What best-practice fields deliver to the community

These community assets:

- drain rapidly and meet or exceed the return-to-play benchmarks in Table 4.
- maintain acceptable turf cover year-round – this includes the 10% of fields across NSW that receive high wear levels (>350 players per week training and playing on a single football field)
- provide an acceptable playing surface for hosting sport, that is, meet the criteria in Table 4, and other site users
- adhere to the best-practice water-use benchmarks (Section 3.4)
- are resilient to extreme climate events such as floods, storms, high temperatures, and drought
- offer year-round play for various football codes and daytime summer sports such as cricket
- deliver a multipurpose surface the wider community can use for informal and passive recreation.

Figure 8. A rugby league field in the Lower Hunter that complies with best practice and is maintained within a typical council budget.

Photo by Dr Paul Lamble

3.2 Principles and characteristics for best-practice fields

Table 5 describes the principles and characteristics of a best-practice sporting field.

Table 5. Description of the principles and characteristics that underpin best-practice sporting fields.

Overarching principle	Characteristics
Turf cultivar is suited to the site	• Can handle site wear levels • Suited to the microclimate and soil
The growing medium facilitates healthy turf	• Adequate moisture reserves • High fertility • Excess water can move freely through the profile and be removed • Turf growth isn't limited by the growing medium such as poor structure, low fertility, shallowness
Rapid drainage	• No water runs onto the field from upslope areas, roofs, roads, paths, or embankments • Field is shaped so excess surface water is removed, that is, there is suitable crossfall and slope length • Drainage systems, if required, are effective and tailored to site conditions
Irrigation water use is efficient and effective	• Adhere to the best-practice irrigation water use benchmarks (Section 3.4) • Have the appropriate licences and connection approvals for the irrigation water supply • Irrigation systems are designed to best-practice performance standards (Section 3.5) • Irrigation systems are installed and operated to apply water to the target area in a timely manner
Maintenance activities are conducted in a timely and effective manner	• Irrigation systems are effectively maintained • Effective weed control and adequate nutrition optimise turf growth • Additional maintenance and horticultural practices address factors limiting turf performance at the site in question • Minor repairs are performed to intensely worn areas such as goalmouths
Field condition is optimised	• Intensely worn areas are effectively managed • The field is not trafficked when wet
Climate resilient	• Field is resilient to drought (prolonged hot and dry periods) and flood (inundation, sediment and weeds).

3.3 Aligning processes to achieve best practice

A commitment to implementing best-practice principles and aligning processes are key to achieving a best-practice sports field. It is important to align processes for planning, budgets and finance, design, procurement, construction, maintenance, and training for staff and users. This means:

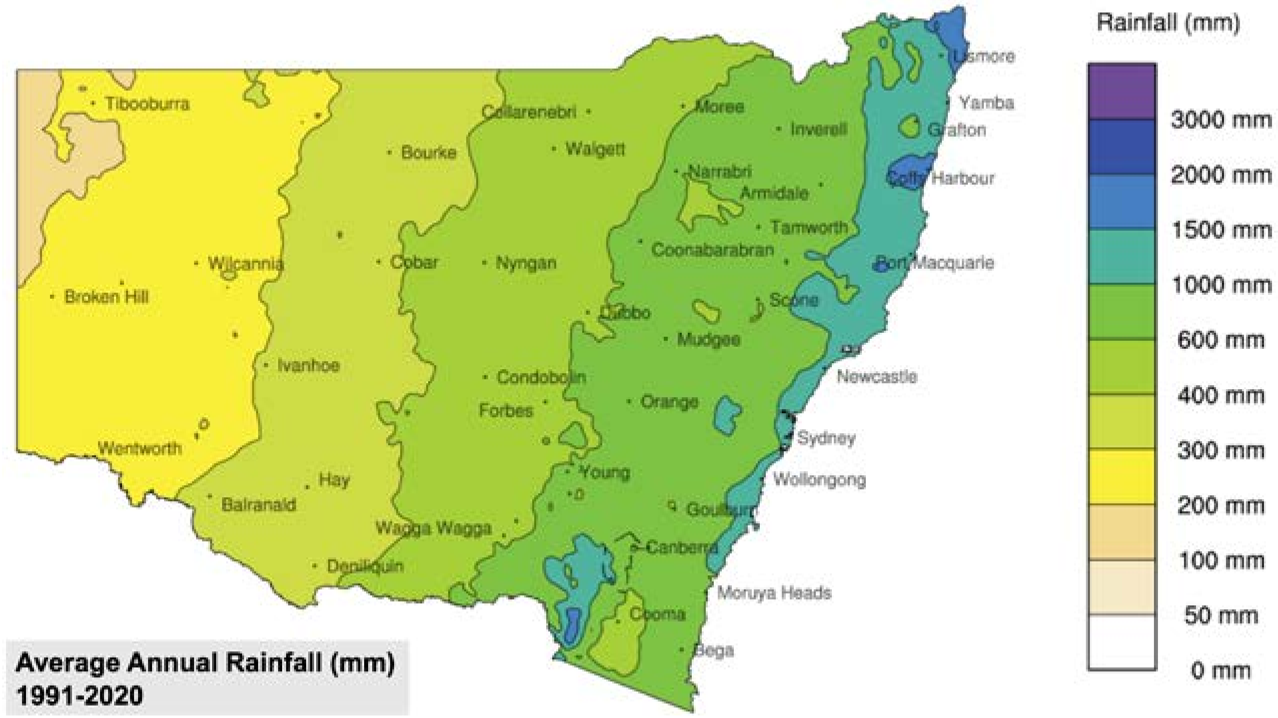
- science and evidence underpin strategies, planning, design, and decision-making processes
- investments demonstrate they are economically, environmentally, and financially sustainable
- site conditions, climate risks such as drought and floods, and available resources such as staff, skills, machinery, water, and existing site soil, informed sports field design and construction choices
- off-field and playing surface works are integrated and sequenced appropriately
- adequate budgets are provided for construction and maintenance activities
- technical aspects and decision making in planning, design, procurement, and construction are based on advice from independent technical expertise, for example, a certified professional soil scientist, certified irrigation designer
- sport users ensure the site is not trafficked when wet and do not concentrate wear in small areas.

3.4 Irrigation water-use benchmarks

Climate drives irrigation demand and sports field carrying capacity. Irrigation and sports field management should be tailored to the site conditions. This includes the climate and seasonal conditions at the location of the sports field.

In general, higher rainfall occurs in coastal areas (Figure 9). Much of this rain occurs in the warmer months in the northern parts of the state, with winter rainfall dominant in the south.

Figure 9. Map of average annual rainfall (mm) across NSW for 1991-2020.



Source: Bureau of Meteorology

A field with a reasonable soil and turf cultivar needs about 600-800 Growing Degree Days (GDD) units to recover from bare ground to full turf cover. Due to warmer summers and milder winters, turf growth potential (GDD) is higher in northern NSW and is typically lower in areas with higher elevation. Figure 10 shows the average GDD for warm season turfgrass.

Figure 10. Map of NSW showing average turf growth potential (GDD) for warm season turfgrass. Figure derived by Peak Water Consulting (2023) using daily weather data for 2000-2023 from the Bureau of Meteorology.

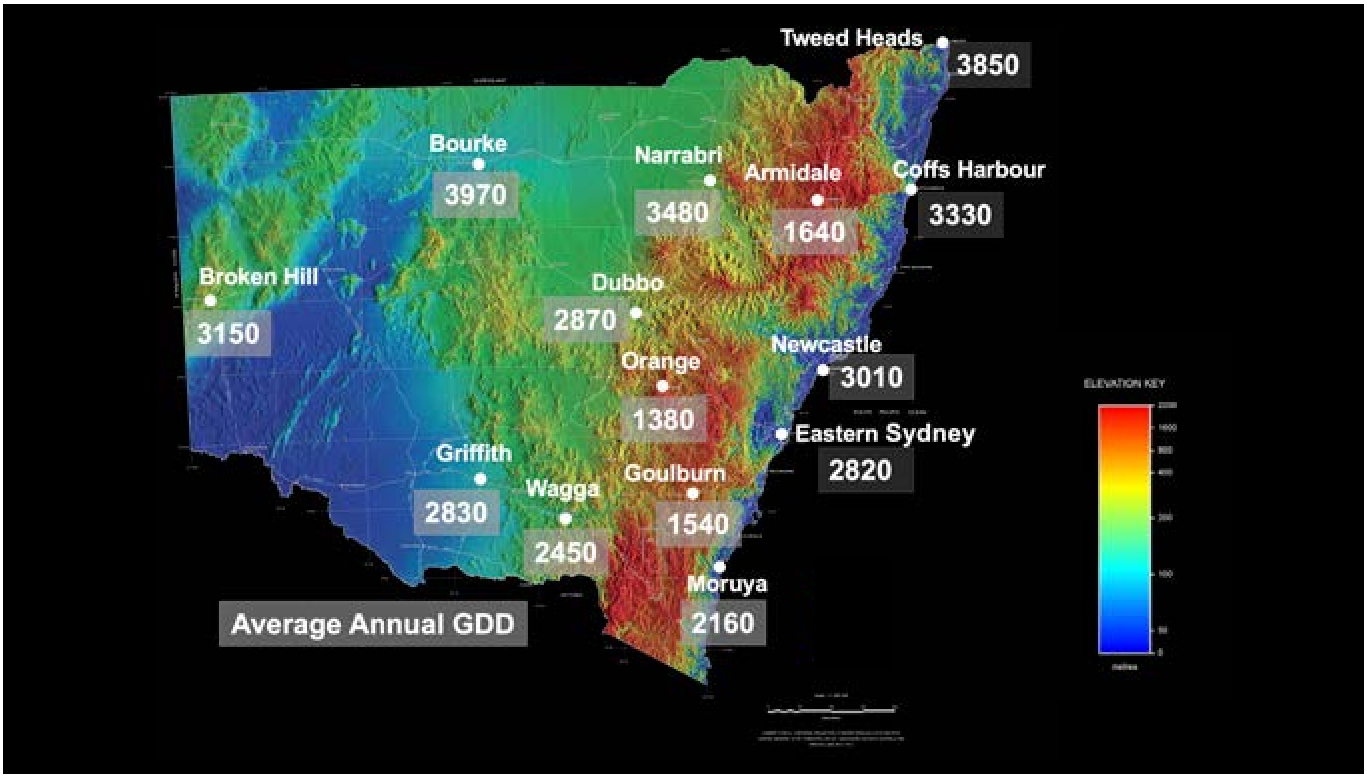


Diagram: Battam & Lamble (2023)

Table 6 provides irrigation water-use benchmarks for sporting fields across NSW. These irrigation volumes are in addition to rainfall and represent the irrigation demand for sporting fields that have:

- been constructed and maintained according to the best-practice criteria described in Section 3
- an efficient and effective irrigation system that applies water evenly and is well operated and maintained.

Sports fields will require significantly more water than these benchmarks if the site has poor soil, an inappropriate turf cultivar, high weed infestations, or a poorly performing irrigation system.

Table 6. Annual water use benchmarks for sporting fields with warm-season turf (ML/ha).

Fields east of the Great Dividing Range								
Northern areas	**Median year**	**Dry year[1]**	**Central areas**	**Median year**	**Dry year[1]**	**Southern areas**	**Median year**	**Dry year[1]**
Tweed Heads	2.1	2.4	Port Macquarie	1.3	1.5	Wollongong	1.9	2.2
Ballina	1.8	2.1	Newcastle	2.2	2.5	Moruya	1.2	1.3
Casino and Grafton	2.6	2.9	Eastern Sydney[2]	2.3	2.8			
Coffs Harbour	1.4	1.7	Western Sydney	2.6	3.0			

Fields west of the Great Dividing Range								
Northern areas	**Median Year**	**Dry year[1]**	**Central areas**	**Median year**	**Dry year[1]**	**Southern areas**	**Median year**	**Dry year[1]**
Bourke	6.4	6.7	Dubbo	4.4	4.9	Griffith	4.8	5.1
Narrabri	5.1	5.4	Broken Hill	6.5	6.8	Wagga Wagga	3.6	3.8
Tamworth	3.4	3.7						

Tablelands fields on the Great Dividing Range								
Northern areas	**Median year**	**Dry year[1]**	**Central areas**	**Median year**	**Dry year[1]**	**Southern areas**	**Median year**	**Dry year[1]**
Armidale	1.3	1.6	Orange	1.1	1.3	Goulburn	1.6	1.8
						Cooma	0.7	0.8

Table notes:

1 Dry year is the 85th percentile irrigation requirement.

2 The values for eastern Sydney should increase by 0.3 ML/ha for individual fields receiving high to extreme levels of wear (~ 35% of all fields in eastern Sydney).

3 In cold environments present in the tablelands, cool-season turf may be appropriate for regional elite facilities where a lush green colour is required all year round and foot traffic levels are lower. Approximately 3.0 ML/ha of additional water may be needed in these individual cases.

3.4.1 Example irrigation schedules to meet water-use benchmarks

Best-practice irrigation scheduling and management uses:

- science and data – irrigation frequency and run times must account for climate, microclimate, site soils, turf water requirements, irrigation system performance, water quality, and soil health
- tools such as on-site rain gauges, weather forecasts, and projected rainfall to adapt to seasonal conditions and avoid irrigation before forecast rain or after significant rain events.

Scheduling irrigation without system performance information can result in water being wasted and over or under-watering detrimentally affecting turf performance. Ideally, detailed performance assessment or catch-can tests would provide system performance data. In the absence of this or other data, baseline information for irrigation scheduling can be obtained using the method described in Appendix C: Irrigation technical information and tips.

Graeme Logan, former head curator at Parramatta Stadium, has an adaptive approach to irrigation scheduling and management. He reviews water applications weekly and relates the volume applied with soil moisture. He knows the amount of water – depth in mm and volume in kL – the irrigation system will apply for a given run time. To get the optimum moisture level in the profile for the firmness of the playing surface, he then uses soil moisture sensors as a guide rather than driving the irrigation system, (Logan, pers comm 2021).

> Be prepared to change your mindset. Don't follow a program because it has always been done that way. Look at the conditions, usage, et cetera and adjust. Be willing to constantly adjust.
>
> **– Graeme Logan (former curator Parramatta Stadium, vice-president NSW Sports Turf Association)**

Table 7 provides indicative weekly irrigation schedules for best-practice fields to meet the water-use benchmarks during an average year. These schedules are not applicable for irrigation systems that apply water unevenly. Nor for other sports field construction types where the soil moisture storage is relatively low (perched water table) or very low (sand over soil). Such fields will require a different schedule using frequency and application depth.

Table 7. Indicative weekly irrigation schedules for best-practice sporting fields during an average year. Irrigation applications include allowances for losses, for example, to the atmosphere, and rely on the even distribution of water or best-practice irrigation performance. The schedule is mm per irrigation event multiplied by frequency per week. For example, 6.0 (x2) is 6.0mm 2 times per week.

Location	Irrigation depth (mm)	Jan	Feb	Mar	Apr	May	Jun-Aug	Sept	Oct	Nov	Dec
Armidale	6.0	x2	x2	x1	Nil	Nil	Nil	Nil	Nil	x1	x2
Ballina	4.5	x3	x2	x1	Nil	Nil	Nil	Nil	x3	x3	x3
Bourke	6.0	x5	x4	x3	x2	x1	Nil	x1	x3	x4	x5
Broken Hill	6.0	x5	x5	x3	x2	Nil	Nil	Nil	x3	x4	x5
Casino	6.0	x3	x2	x2	Nil	Nil	Nil	Nil	x2	x3	x3
Coffs Harbour	5.0	x3	x1	x1	Nil	Nil	Nil	Nil	x2	x2	x2
Cooma	4.0	x3	x2	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Dubbo	6.0	x5	x4	x3	x2	Nil	Nil	Nil	Nil	x4	x4
Goulburn	6.0	x3	x2	x1	Nil	Nil	Nil	Nil	Nil	Nil	x2
Grafton	6.0	x3	x2	x2	Nil	Nil	Nil	Nil	x2	x3	x3
Griffith	6.0	x5	x4	x3	x1	Nil	Nil	Nil	Nil	x4	x4
Moruya	5.0	x2	x2	x1	Nil	Nil	Nil	Nil	Nil	x1	x2
Narrabri	6.0	x5	x4	x3	x3	Nil	Nil	Nil	x3	x4	x4
Orange	5.0	x3	x2	x1	Nil	Nil	Nil	Nil	Nil	Nil	x1
Port Macquarie	5.0	x3	x1	x1	Nil	Nil	Nil	Nil	Nil	x2	x3
Newcastle	6.0	x3	x2	x1	Nil	Nil	Nil	Nil	x1	x2	x3
Sydney – eastern	6.0	x3	x2	x1	Nil	Nil	Nil	Nil	x2	x2	x3
Sydney – western	6.0	x3	x2	x1	Nil	Nil	Nil	Nil	x2	x3	x3
Tamworth	6.0	x4	x3	x3	x1	Nil	Nil	Nil	Nil	x3	x4
Tweed Heads	4.5	x3	x2	x1	Nil	Nil	Nil	x2	x3	x3	x3
Wagga Wagga	6.0	x5	x3	x3	Nil	Nil	Nil	Nil	Nil	x1	x4
Wollongong	5.5	x2	x2	x1	Nil	Nil	Nil	x1	x2	x2	x2

Table notes:

1 Adjustment of irrigation schedules to seasonal conditions is essential, for example, wet/dry, relatively cool/hot.

2 Irrigation schedules assume a rain sensor is installed to skip irrigation events after rainfall. This will reduce actual irrigation volume in higher rainfall areas or where rainfall is summer dominant, even though the schedule is similar.

3 Fields with soils that have low soil moisture storage will require a different irrigation schedule using frequency and amounts.

3.5 Irrigation system performance

Systems that irrigate evenly have fewer dry spots. They require less water to ensure all areas are adequately watered. Even irrigation across the field ensures consistent washing-in of fertilisers and chemicals, for example, pre-emergent herbicides. It also reduces the risks of turf stress, water repellency, and waterlogging.

Various parameters define evenness of watering:

- **Coefficient of uniformity (CU) or J.E. Christiansen's uniformity**
  The variation of applied water relative to average applied water as a percentage, with 100% representing perfectly even irrigation.
- **Distribution uniformity (DU) or lower quartile (DULQ)**
  The application rate from the lowest 25% of test measurements divided by the average application rate, with 100% representing perfectly even irrigation.
- **Scheduling coefficient (SC)**
  The amount of additional water to apply to ensure enough water reaches the driest location, which is typically the driest 5% contiguous area for turf. If the site receives 10mm on average, but the driest areas only receive 5mm, then the SC is 2.0 because the driest areas are getting half the water.

3.5.1 Irrigation system performance benchmarks

Best-practice irrigation systems:

- apply water evenly across the entire target area and meet the performance standards in Table 8
- have less than 2% of water overthrowing onto adjacent non-target areas
- have the hydraulic capacity to meet peak irrigation demand in the watering window, that is, times when irrigation can occur. This will vary with site characteristics, water supply, storage size, pumps, and system layout
- have sensors that shut down the system in response to adverse conditions such as rain or major leaks
- are accurately installed – sprinklers within +/- 10cm of the target position
- receive adequate maintenance to ensure they continue to function efficiently and effectively
- are actively managed so irrigation scheduling responds to prevailing conditions and risks.

Hunter Water provides a more detailed description of irrigation best practice in Book 4 of its Best Practice Sporting Field Guidelines.

Table 8. Irrigation performance rating matrix for sports field irrigation systems.

Parameter	Best practice	Average	Poor	Very poor
Scheduling coefficient (driest 5% bordering area)[1]	<1.25	1.25-1.35	1.35-1.45	>1.45
Coefficient of uniformity (%)[1]	>85	80-85	75-80	<75
Distribution uniformity (%)[1]	>80	75-80	70-75	<70
Application rate (mm/hr)[2]	>10.0	7.5-10.0	5..0-7.5	<5.0
Pressure variation between heads (%)	<5	5-12	12-20	>20

Source: Rex Sullings & Dr Paul Lamble

Table notes:

1 Parameters for irrigation evenness are described above. These parameters can be measured in the field using catch-can tests or evaluated using specialised analysis software and tools combined with laboratory test results of sprinkler nozzles. Irrigation systems that apply water evenly perform well on all three parameters, not just one or two.

2 The application rate applies to sports turf situations where slopes are relatively low and infiltration rates are relatively high.

3.6 How NSW sporting fields compare with best practice

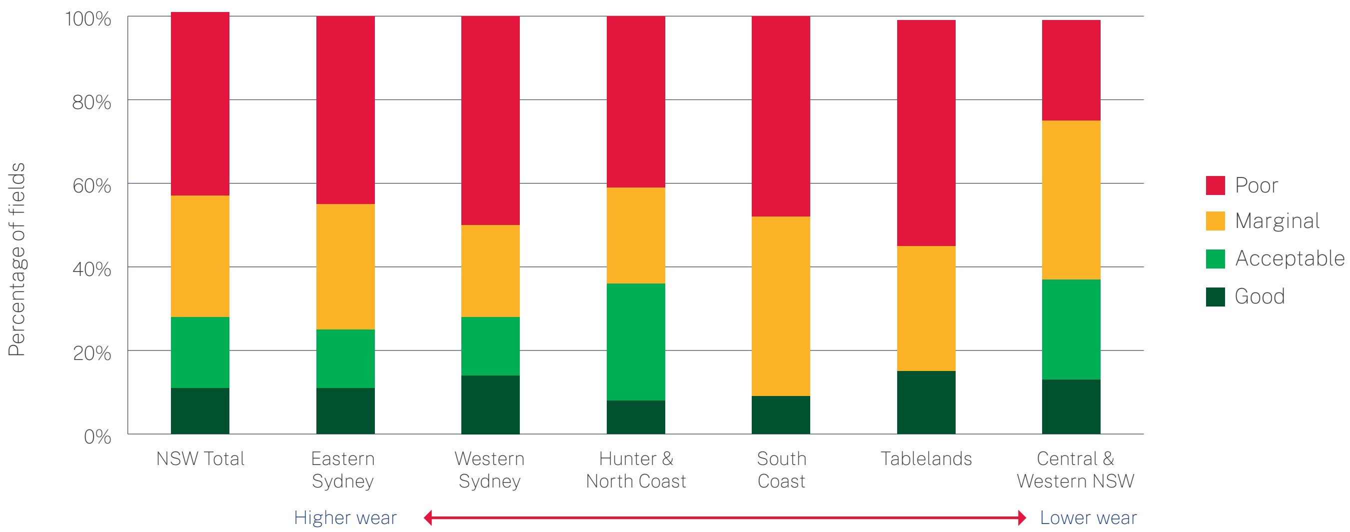
3.6.1 Condition of NSW sporting fields

An assessment of more than 1,000 sporting fields across NSW shows about 10% are in good condition and meet best-practice benchmarks, with a further 14% in reasonable condition. The remaining 76% of fields are in poor or marginal condition and fail to meet best-practice benchmarks. These fields typically require significantly more resources and water to recover or may deteriorate further. Eastern Sydney has a similar percentage of fields in poor condition to regional areas (Figure 12) suggesting wear levels are not the primary reason playing fields struggle.

Figure 11: Example of fields of poor, marginal, reasonable and good condition.

Figure 12. Despite wear levels generally being higher in eastern Sydney, there were just as many fields in poor condition as observed in most other parts of NSW.

Observed condition of sporting fields in NSW



3.6.2 Common issues affecting field condition and irrigation performance

The condition of NSW sporting fields is not related to wear levels. The percentage of fields in poor/marginal condition are similar in eastern Sydney (higher wear levels) to other NSW areas (lower wear levels). The major issues identified on NSW sporting fields include the following:

- About two-thirds of fields in Sydney do not have a wear-tolerant turf cultivar. Kikuyu can only tolerate low wear levels.
- More than 70% of fields have significant soil problems. The most common is compaction – poor soil structure – and layering within the profile. Incorporating suitable amenders into the profile can often overcome these problems.
- Many irrigation systems are inefficient and poorly maintained, with 65% applying water unevenly.
- Nearly half – 48% – of the fields have significant weed infestation and poor weed control.
- About 30% of fields have major waterlogging issues. Of these fields 40% have water running onto the playing surface from upslope areas or impermeable surfaces such as buildings and roads.
- Inadequate management of wear on the site, for example, using the same goal areas for training and games.
- Insufficient budgeting for turf maintenance and poor prioritising of activities that focus on aesthetics over activities that increase carrying capacity. For example, ryegrass oversowing for aesthetics, but not performing weed control.

Figure 13. Since best-practice reconstruction, this site now maintains acceptable turf cover year-round (right). Before the works, it struggled (left). This site receives higher wear levels than 97% of sporting fields in NSW.

Nearmaps images

4 How best-practice sporting fields perform

Best-practice fields use less water, drain rapidly, are more resilient, and have lower lifecycle costs. Understanding the benefits guides decision making when assessing options for new fields or upgrades to existing fields. To be fit for purpose, a field should:

- be suitable for the site users and location
- have minimal cancellations due to adverse weather
- have resilience to natural disasters that may affect the site such as floods and drought
- be cost-effective and within available construction, maintenance, and asset renewal budgets
- be able to handle the site wear levels
- align with strategies and goals such as sustainability, social inclusion, and water resilience.

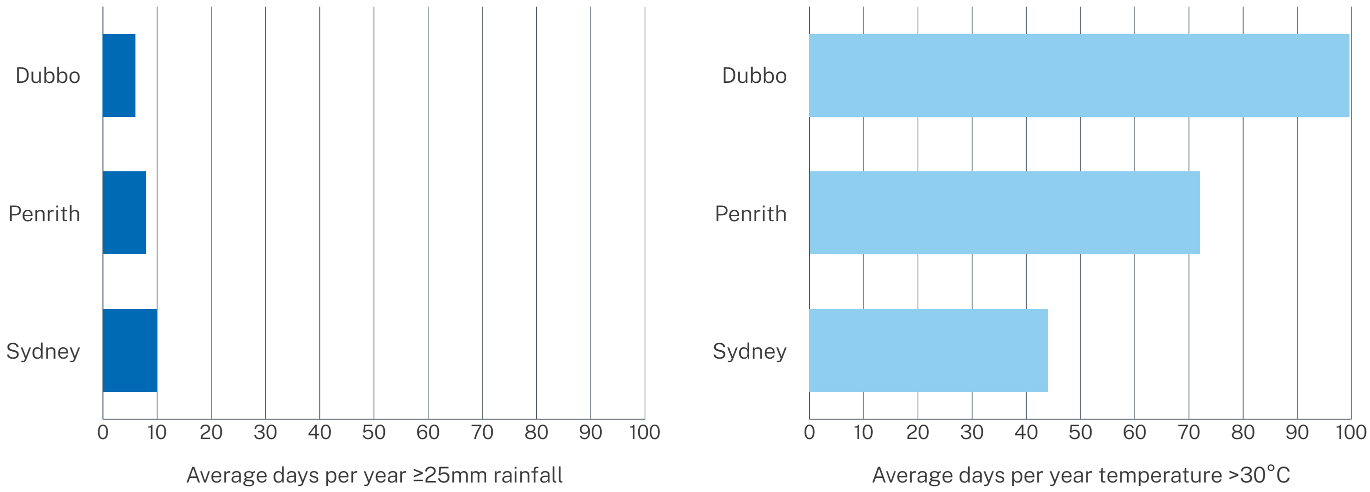
4.1 Suitable for a variety of sites

Best-practice sporting fields are suitable for most sites across the various climates in NSW and offer greater flexibility and resilience compared to other fields. They've even been successful in sites with limited water supply, on floodplains, near waterways, and in bushfire-prone areas. Best-practice fields are suitable for summer and winter sports, and informal and passive recreational users such as dog walkers. When the full lifecycle costs are considered over a 30-year period for low and high-wear fields, best-practice fields typically compare favourably to alternative options.

4.2 Weather cancellations are fewer

Best-practice sporting fields drain rapidly so there are minimal interruptions to play. Synthetic fields are typically hotter and can be more vulnerable to hot-weather cancellations. Poorly constructed natural turf and hybrid fields experience wet weather cancellations. Site climate and sports field construction type (Figure 14) shapes the number of days per year where weather causes interruptions to play.

Figure 14. Average days per year when weather is likely to impact on natural turf and hybrid fields (left) and synthetic fields (right). Rain has minimal impact on well-constructed natural turf fields, but poorly constructed fields can remain wet for days after rain.



Derived from Bureau of Meteorology data

4.3 Higher resilience to natural disasters

The resilience of a field to natural disasters is a function of:

- the damage done to the field and the cost of restoration or replacement work
- its capacity for recovery, for example, length of time needed to reinstate the field ready for use
- the loss of carrying capacity and/or field availability during and after the event.

4.3.1 Floods

Best-practice sporting fields are well suited to flood-prone sites. The construction method including amended site soil and suitable turf cultivar, enable these fields to:

- withstand significant forces from floodwaters
- tolerate sediment deposition
- allow easier eradication of weeds that result from floodwater seed deposits.

Figure 15 shows an example of a sports field that was able to return to use shortly after a flood.

Couch and kikuyu can both handle more than 10 days under floodwaters, with this occurring at least twice to dozens of sporting fields and multiple turf farms in 2022. One turf farm in the Hawkesbury harvested healthy turf 4 days after floodwaters subsided, having been covered for 10 days up to 5 metres deep.

Figure 15. In addition to enduring significant erosive forces from the 2022 Brisbane floods, the natural turf field (left) was hosting competition sport within months after flooding.

Nearmaps image

4.3.2 Drought

Drought can impact all field construction types. The following reduce water availability on fields:

- water restrictions on potable supply
- lower water allocations for those with licences and access to groundwater or surface water systems
- lower water quality, for example, higher salt levels of groundwater or recycled water supplies.

During a drought, there are more hot days that can result in cancellations to play on synthetic fields. We discuss best-practice strategies to minimise ground closures and turf losses on natural turf fields below.

Reducing irrigation demand

Sporting fields that require less irrigation to remain in acceptable condition are less likely to be impacted by water restrictions (Figure 16).

Figure 16. Condition of 2 low-wear fields in the Lower Hunter with the same turf cultivar during the 2019 drought when level 1 restrictions limited irrigation to twice per week. Apart from needing more water, the imported sand mix field (right) poses a risk to council and users as it might not survive during more severe water restrictions.

Photos by Dr Mick Battam

Two ways to reduce irrigation demand:

1. **Improve the irrigation system**

- Adjust the system so water is applied more evenly, reducing sprinkler overthrow onto adjacent areas and/or improving the accuracy of the system's response to leaks and adverse weather.

2. **Ensure fields are built to best practice**

The impact of reducing the irrigation volume on turf-carrying capacity was modelled for different sports field construction types in Sydney and Wagga Wagga during the 2019 drought, see Figure 17. The modelling showed that during 2019:

- best-practice fields required less than 2ML per hectare to sustain a high carrying capacity
- perched water table fields required 3ML/ha (Sydney) and 4.5ML/ha (Wagga Wagga)
- sand-over-soil (SoS) fields required 4.5 to 6.0+ ML/ha.

The high carrying capacity and low watering requirements of best-practice fields align with observations in Sutherland Shire that has several high-wear fields that receive minimal irrigation.

Reconstructing sporting fields during periods of low water availability is risky as the turf requires frequent irrigation until it is established. Integrate best-practice strategies into all works before drought, so fields are less susceptible to injury when drought occurs.

Figure 17. Impact of applied water on the carrying capacity of different playing field construction types for the 2019 calendar year (drought). Results based on a wear-tolerant turf cultivar. The actual irrigation volume will vary with the performance of the irrigation system and site microclimate.

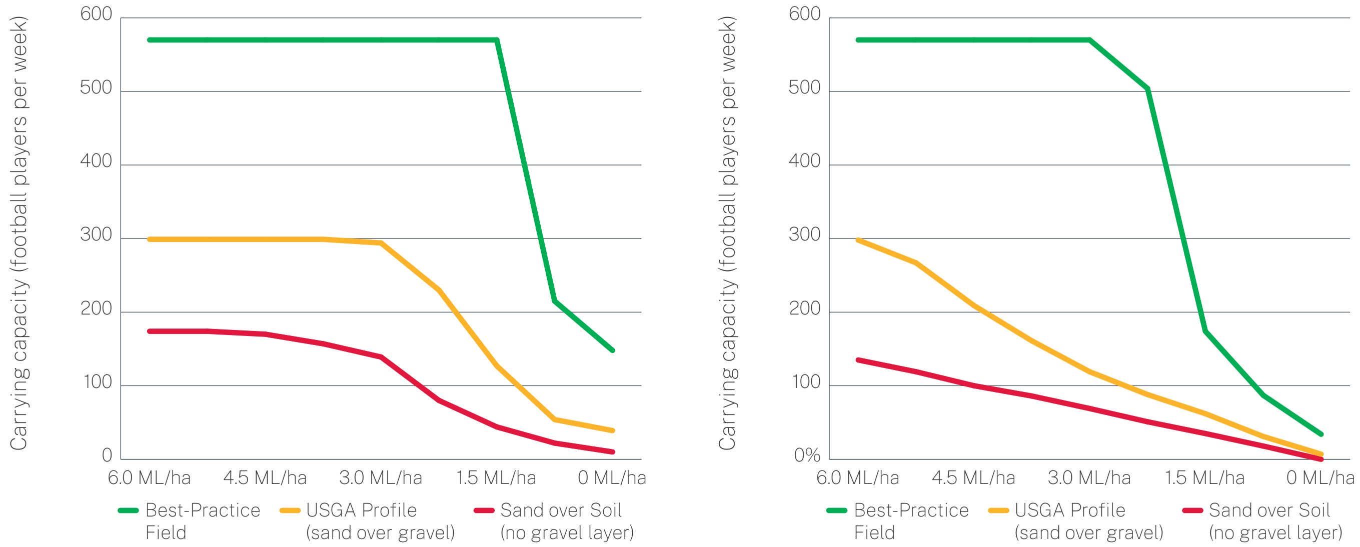


Diagram: Lamble & Battam (2024).

Minimising drought damage to fields

Councils and clubs should develop drought-management plans they can implement when water availability is limited. These should minimise the damage to fields while maximising sport use. To achieve this, councils should be aware of each field's carrying capacity for different levels of water restrictions (example in Figure 18). To protect sites that are likely to struggle:

- reconstruct the field according to best-practice and/or irrigate with non-potable water
- move some play such as training to sites nearby that can handle higher levels of wear
- prioritise water to high-wear areas on fields, subject to irrigation zoning
- transport recycled water via tanker to some sites.

Other measures include mowing turf higher, applying wetting agents to maximise rain capture, training in joggers rather than football boots, and ensuring weeds are controlled so all available water is only used by the turf.

Figure 18. Impact of water restrictions on the carrying capacity for three sporting venues in the current condition (left) versus upgrade to best practice (right).

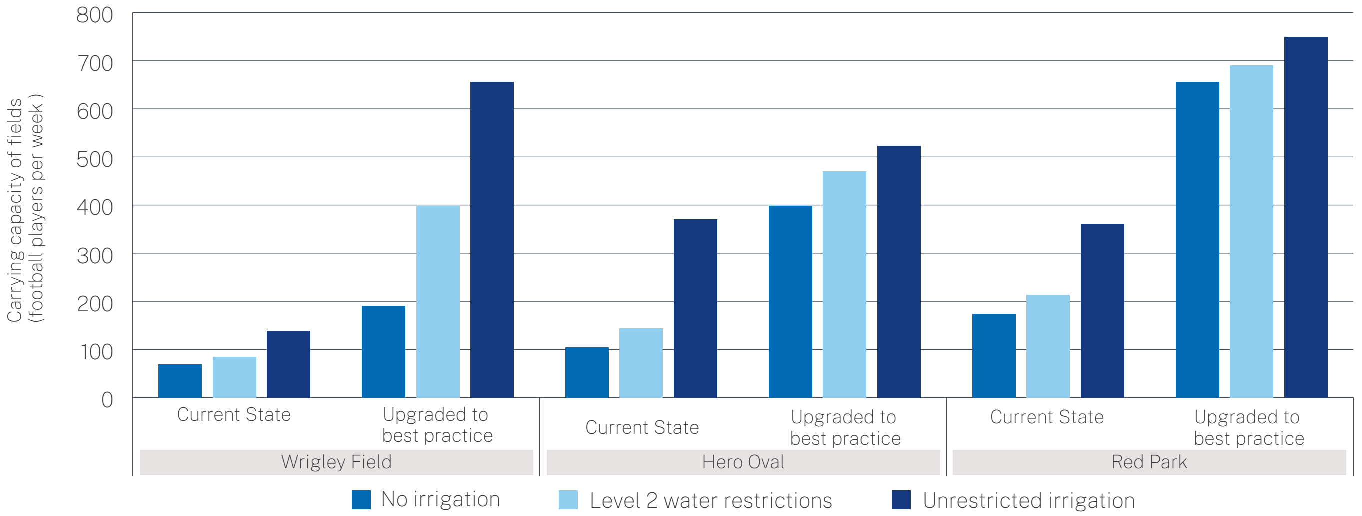


Diagram: Lamble & Battam

4.4 Typical outcomes for low, moderate, and high-wear fields

The different sports field construction types commonly used in NSW are described in Section 5.2.1 and Appendix A. We describe typical outcomes and risks for different sporting fields types in:

- Table 9 for low-wear levels – <175 registered players per full-sized football field per week
- Table 10 for moderate-wear levels – 175-350 registered players per full-sized football field per week
- Table 11 for high-wear levels – >350 registered players per full-sized football field per week.

Registered player numbers provide an indicative guide to wear, with exact wear levels requiring detailed calculations and site information (Section 2.1). Cold areas (Table 1) and district or regional fields that require the delivery of a premium playing surface should use lower-wear levels than those described above.

> Do not estimate wear levels from booked hours. Many clubs blanket-book fields (Section 2.1). If no registered player numbers are available, then it is possible to identify at least some of the low-wear fields. As a guide, kikuyu fields in good condition are likely receiving low levels of wear.

Table 9. Typical outcomes for sporting fields that receive low sport wear levels (<175 registered players per full-sized football field per week). This applies to about 66% of fields in NSW with about 51% having low-wear levels, while 15% have no formal winter sport (Appendix A).

Low wear fields	Best-practice field	Traditional field	Traditional field	Sand over soil (SoS)	Best-practice field	Traditional field	Sand over soil (SoS)
Turf	Non-wear tolerant turf cultivar	Non-wear tolerant turf cultivar	Non-wear tolerant turf cultivar	Non-wear tolerant turf cultivar	Wear tolerant turf cultivar	Wear tolerant turf cultivar	Wear tolerant turf cultivar
Growing media	Amended site soil	Site soil (decent)	Site soil (poor)	Sand	Amended site soil	Site soil (decent)	Sand
Amenders added[1]	Yes	No	No	Short-lived amender	Yes	No	Yes
Carrying capacity[2]	Low	Low	Low	Low	High	Moderate	Low to moderate
Turf quality	High	Moderate	Low	Low to Moderate	High	Moderate	Moderate
Relative irrigation demand	Low	Low to moderate	Moderate to high	High	Low	Low to moderate	High
Hot weather cancellations[3]	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Wet weather cancellations	Minimal	Variable[4]	High	Variable[4]	Minimal	Variable[4]	Variable[4]
Drought resilience	High	Moderate	Low to moderate	Low	High	Moderate	Low
Flood resilience	Moderate	Moderate	Low to moderate	Low	High	High	Low
Lifecycle costs	Low	Low	Low	Low to moderate	Low	Low	Low to moderate
Maintenance requirements	Low	Low	Moderate	Moderate	Low	Low to moderate	Moderate
Multipurpose functionality (other sports and users)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table notes:

1 Suitable soil amenders as recommended by a certified professional soil scientist specialising in turf.

2 Wear levels that the field can tolerate. Refer to Table 1 for indicative carrying capacity in different areas of NSW.

3 Potential cancellations arising due to high playing surface temperatures, low thermal comfort, and heat stress risks to players.

4 Substantial variation in outcomes depending on site topsoil and subsoil, for example, soil depth, permeability, and structure, and if adequate sports field drainage is installed.

Table 10. Typical outcomes for sporting fields that receive moderate sport wear levels (~175-350 registered players per full-sized football field per week). As noted in Appendix A, this applies to approximately 19% of fields across NSW, (32% of fields in eastern Sydney).

Moderate wear fields	Best-practice field	Traditional field	Sand over soil (SoS)	Perched water table	Reinforced turf + perched water table	Reinforced turf + best practice
Wear-tolerant turf	Yes	Yes	Yes	Yes	Yes (hybrid)	Yes (hybrid)
Growing media	Amended-site soil	Site soil (decent)[1]	Sand	Sand	Sand	Amended-site soil
Amenders added[2]	Yes	No	Short-lived amender	Yes	Yes	Yes
Carrying capacity[3]	High	Moderate	Low to moderate	Low to moderate	Moderate	High
Turf quality	High	Low to moderate	Low to moderate	High	High	High
Relative water demand	Low	Moderate	High	High	High	Low
Hot-weather cancellations[4]	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Wet-weather cancellations	Minimal	Variable[5]	Variable[5]	Minimal	Minimal	Minimal
Drought resilience	High	Moderate	Low	Low	Low	High
Flood resilience	High	Moderate to high	Low	Low	Low	High
Lifecycle costs	Low	Low to moderate	Moderate	High	High	Moderate to high
Maintenance requirements	Low to moderate	Moderate	Moderate to high	High	High	Low to moderate
Multipurpose functionality (other users)	Yes	Yes	Yes	Yes	Yes	Yes

Table notes:

1 Only applies if the site soil is reasonable quality. Turf on poor soils is unable to handle these levels of wear.

2 As recommended by a certified professional soil scientist specialising in turf.

3 Wear levels that the field can tolerate. Refer to Table 1 for indicative carrying capacity in different areas of NSW.

4 Potential cancellations arising due to high playing surface temperatures, low thermal comfort, and heat-stress risks to players.

5 Substantial variation in outcomes depending on site topsoil and subsoil, for example, soil depth, permeability and structure, and if adequate sports field drainage installed.

Table 11. Typical outcomes for sporting fields that can tolerate high or extreme sport wear levels (>350 registered players per field per week). This applies to about 32% of fields in eastern Sydney and a small number of fields in western Sydney, Newcastle, Lake Macquarie, and Wollongong.

High-wear fields	Best-practice field	Best-practice field	Reinforced + best practice	Synthetic
Wear-tolerant turf	Yes	Yes	Yes (hybrid)	N/A
Growing Media	Amended-site soil	Specialist soil mix[1]	Specialist soil mix[1]	N/A
Amenders added[2]	Yes	Yes	Yes	N/A
Carrying capacity[3]	High	High	High	High
Surface (turf) quality	Moderate to high	Moderate to high	Moderate to high	Moderate to high
Relative water demand	Low	Low	Low	Nil
Hot-weather cancellations[4]	Minimal	Minimal	Minimal	High to very high
Wet-weather cancellations	Minimal	Minimal	Minimal	Minimal
Drought resilience[5]	Moderate to high	Moderate to high	Moderate to high	N/A
Flood resilience	High	High	High	Low
Lifecycle costs	Low to moderate	Moderate	Moderate to high	Very high
Maintenance requirements	Moderate	Moderate	Moderate	Moderate
Multi-purpose functionality (other sports & users)	Yes	Yes	Yes	No
Potential stormwater impacts (quality & quantity)	Low	Low	Low	High

Table notes:

1 A free-draining, fertile and well-structured soil mix – typically loamy sand texture – specified by a certified professional soil scientist specifically for high-wear fields.

2 As recommended by a certified professional soil scientist specialising in turf.

3 Wear levels the field can tolerate. Refer to Table 1 for indicative carrying capacity in different areas of NSW.

4 Potential cancellations arising due to high playing surface temperatures, low thermal comfort, and heat-stress risks to players.[11]

5 Natural turf requires a small amount of irrigation to maintain capacity. Synthetic fields have a higher number of heat cancellations due to higher temperatures

11 Pfausch, S and Wujesak-Klause, A. (2022), Synthetic Turf in Public Spaces. Systematic Assessment of Surface Temperatures and Associated Environmental Impacts. Report prepared for Office of the NSW Chief Scientist and Engineer.

5 Designing and delivering new best-practice fields

Following the basic principles and tailoring solutions to local conditions is the best approach to planning, designing, and delivering new high-quality sports fields.

> Often the path of least resistance is to follow a program or process year after year. However, the pathway to success requires constant adaptation, questioning, and following principles, not recipes.
>
> With the right knowledge, attitude, expenditure, and skill set it is possible to successfully deliver and manage community and elite sporting fields. An open and inquiring mind is the most powerful tool available. Instead of following a recipe book, focus on outcomes, use principles, and ask questions such as the following:
>
> - What is needed to get the field to perform at its best? Is there more than one issue to address?
> - Does the solution involve addressing an issue in the soil or subsoil, the surrounds, or the infrastructure? This might include the water running onto the field, the irrigation system, or lighting. Don't forget to look beyond the turf.
>
> **Graeme Logan (former curator Parramatta Stadium, vice-president NSW Sports Turf Association)**

5.1 Planning

During planning, critical long-term decisions are made for sports field outcomes. These decisions have significant implications for site water use, functionality, liveability, and amenity outcomes. Key considerations in the planning phase include the following:

- The direction of broader organisational and regional strategic outcomes, including environmental, social, sport and recreation, climate change adaptation, natural disaster, and water resource outcomes.
- Available budgets and financial capacity for facility construction, maintenance, and asset renewal.
- Site conditions, particularly those effecting water use, useability, and field resilience (refer section 2 to section 4).
- Likely wear levels, including the amount of additional wear and carrying capacity the works will enable. Consider potential constraints, for example, logistical, car parking, lighting, and amenities.
- Value assessments that use metrics to compare the outcomes and costs across different options, for example additional player numbers per thousand dollars spent.

Best-practice planning focuses on the required outcomes to enable examination of all viable solutions. This is more successful than selecting a technology, for example, a perched water table, to solve a perceived problem such as low carrying capacity, and then refining it in the design phase.

A site masterplan process provides a rigorous planning framework to identify risks and opportunities. The masterplan investigations must be sufficiently detailed for a concept-level feasibility and option analysis for sports field works at new and existing sites. The masterplan process provides a transparent mechanism for formal community engagement and consultation before significant funding commitments including grant applications or commencing detailed design.

5.1.1. Consider the total lifecycle budget

The lifecycle costs in Section 4.4 provide a high-level indication of the funding that may be required for different construction types. Costs change over time. It is important to complete independent cost estimates during the initial masterplan process and at critical stages in the detailed design phase. All infrastructure, such as irrigation, field drainage, and field construction/reconstruction projects will require funding for design, build, and quality assurance checks during construction.

It is crucial to link construction, asset renewal, and maintenance budgets when considering sports field construction options during planning and design. The funding levels required for effective maintenance and asset management of high-cost solutions often exceed typically available budgets.

5.1.2 Plan for more space to manage wear

The most intensely worn areas on a football field are around the goalmouths. Providing a small amount of additional space significantly improves the quality of sporting fields. It creates the opportunity to:

- move the football field by a few metres each year
- provide separate training goals, or movable goals, on the side of the field for goal shooting and goalkeeping drills.

Using moveable FA and FIFA-approved soccer goals or installing additional goalpost sleeves for AFL, league, and union, allows more than 18 months for intensely worn areas to recover. About 50% of existing fields in eastern Sydney, and many fields in western Sydney, have additional space to move the field position by at least 2 metres.

There are also opportunities to move training onto underused or unused fields or those with low winter wear levels. Match-day field can remain unchanged. About 35% of fields in eastern Sydney and 71% in western Sydney are underused. Lighting installations or upgrades may be required. On some sites, additional capacity exists on adjacent fields (Figure 20).

Figure 19. Conducting more training on the field further from the amenity building would improve the condition of this site.

5.2 Design

Appoint suitably qualified and independent designers to design sporting field construction, reconstruction, drainage systems, and irrigation systems. They should:

- hold relevant professional certifications such as Certified Professional Soil Scientist and Certified Irrigation Designer
- declare any actual, potential, or perceived conflicts of interest.

Soil science, irrigation, and drainage design are specialist disciplines. Engineering, landscape architecture, and greenkeeping courses only provide cursory training in these areas.

Carefully review construction tenders to ensure design requirements are met and delivered. Common pitfalls include:

- using the cheapest turf cultivar – its low-carrying capacity can't handle the wear
- laying turf with a clay layer attached – it creates drainage problems
- using poor soil and/or not amending the soil – increases the risk of water logging, reduces carrying capacity and increases water demand
- undersizing irrigation pump/mainline, or sprinklers widely spaced or not on perimeter – results in higher water demand
- undersizing drainage infrastructure – leads to increased wet-weather cancellations and localised waterlogging. These problems are more pronounced during periods of extended wet weather.

Figure 21 provides a visual comparison of the project outcomes for 2 nearby fields – ~300m apart – 2 football seasons after reconstruction. The independently designed field has far superior outcomes.

Figure 20. Both these fields were reconstructed in 2021-22. After 2 winter seasons of use, the performance contrast is stark for playing surface quality, carrying capacity, and visual aesthetic. The field on the left was rebuilt according to best practice by a contractor complying with a specification written by an independent designer.

Nearmaps images

5.2.1 Common sport field construction types

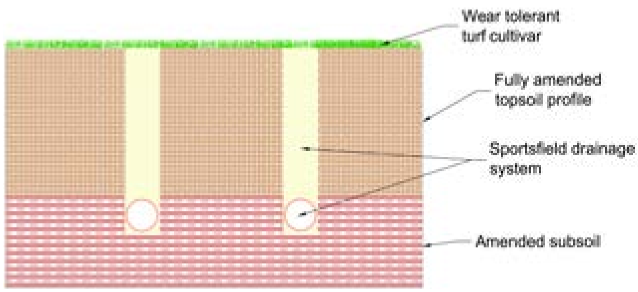
There are several sports field construction options available for use in NSW. We broadly divide them into 3 options:

- natural turf fields
- rootzone reinforced natural turf fields, also known as hybrids. Some hybrids also have 5% synthetic blades, making them 95% natural turf
- synthetic fields.

A best-practice field consists of the following:

- wear-tolerant turf cultivar
- fully amended soil profile – loamy sand to sandy loam soil texture – that is well structured and at least 200mm thick
- uniform soil profile – no layers – that drains freely
- suitably amended subsoil that is permeable and/or adequate sub-soil drainage system
- adequate crossfall and measures to prevent surface water running onto the field from upslope areas.

Figure 21. Best-practice field.



Other common construction options are described in Appendix A: Construction options to achieve playing surface standards.

5.3 Delivery

Tips for delivering a best-practice sports field, irrigation system, and drainage system:

- Manage project timelines and tasks to ensure the turf establishment or recovery period occurs during the growing season – the warmer months – and that bulk earthworks avoid wetter periods.
- Carefully evaluate tender submissions. This involves technical review and due diligence, requesting contractors to nominate subcontractors and suppliers in their tender submission, and submit samples of proposed materials.
- Incorporate quality assurance checks – hold and witness points – during construction.
- Ensure all project change requests are submitted in writing with verifiable supporting evidence. Appropriately qualified technical specialists should independently review technical aspects.
- Consider engaging independent designers to provide specialist advice and support to ensure the desired project outcomes are achieved (refer to Figure 23.). The cost depends on the scope of work but is typically a small fraction of the construction cost.

- The activities may include:
  - reviewing technical aspects of tender responses or any proposed changes to materials, work methods, or product supplier
  - developing options to adjust project scope, staging, and methods to optimise outcomes where there is a budget shortfall, or to assist in additional funding requests
  - completing quality assurance inspections during construction (hold and witness points)
  - reviewing works as executed drawings submitted by the contractor.

If the budget for independent technical support during project delivery is limited, then the most cost-effective and crucial element for delivering best practice is to undertake a technical review and due diligence of tender submissions. Complete this step before a full evaluation of tenders. This process clearly identifies the tenders capable of delivering the project in accordance with best practice, the design documentation, and the provisions of the contract. The costs for technical review of tender submissions are small, but significantly reduce the risks of non-compliance and delays during construction.

5.3.1 Irrigation system installation

Best-practice irrigation systems apply water evenly and are easy to service and maintain. For new irrigation systems, requiring the design to meet the best-practice performance benchmarks and characteristics in Section 3.3 can ensure significant gains.

Critical elements include the following:

- Ensure appropriately qualified tenderers with the required licences complete the design and installation.
- Accurately set out the location of sprinkler heads using survey-standard GPS equipment. Accurately install the heads to set-out position with sprinklers within +/- 10cm.
- If minor adjustments to the sprinkler grid are required, only adjust the perimeter sprinkler spacing.
- Ensure all sprinklers are at the correct height, plumb to vertical, and have the correct arc.
- Correctly adjust the sprinkler arc to minimise overspray off the field. Don't use the interference screw.
- Adjust irrigation system settings such as pump set points, valve pressure regulators, and flow controls, to ensure the sprinkler operating pressure is within 20kPa of the design pressure.
- Ensure sufficient depth of coverage over all pipework, allowing the field to be aerated without damaging pipes. This is a minimum 450mm for main lines and 350mm for laterals.
- Ensure all trenches are backfilled so they cannot function as pseudo slit drains and cause waterlogging.

Figure 22. The field on the right demonstrates the value of independent technical support during construction after it was fully amended in 2017. Previously, incorrect construction practices meant the field was reconstructed every 3 to 7 years with poor outcomes for turf performance and water use.

End of soccer season: before amendment

End of soccer season: after amendment

Photos by Dr Mick Battam

6 Improving existing fields

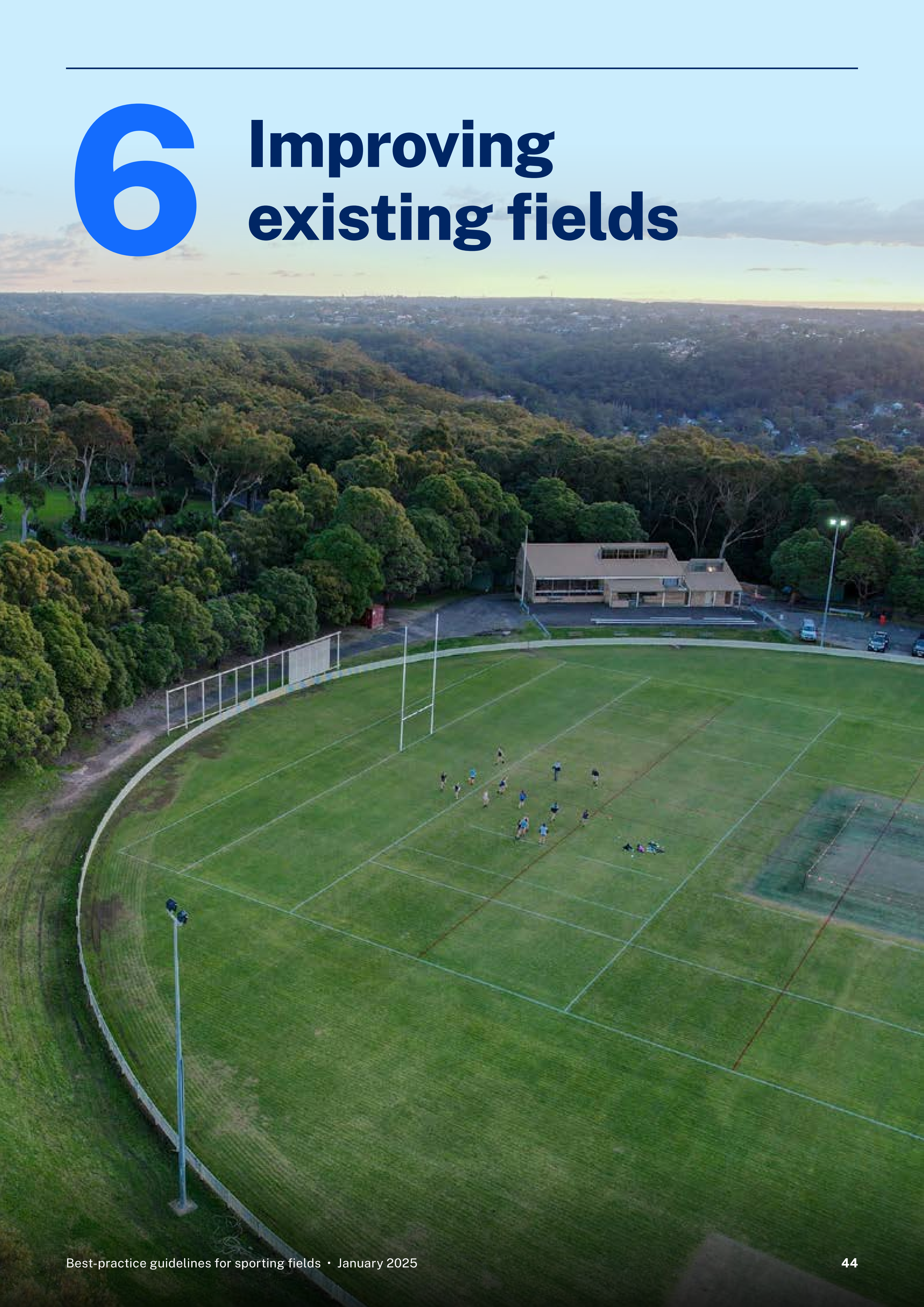


Figure 23. Clubs using this field requested its conversion to synthetic as it previously struggled. Since being reconstructed according to best practice, it has made it through 5 football seasons without turf patching. The soccer and AFL club presidents are very happy with its performance (see case study videos at: www.agenviro.com). While booked hours have fluctuated each year, the wear levels on this site during 2019 when the photo was taken were higher than about 97% of NSW sporting fields. This site would benefit from a new drainage system.

Photos: Dr Mick Battam

6.1 Improving growing medium

6.1.1 Growing medium measures for healthy turf

Table 12. Growing media requirements and measures implemented for healthy turf.

Requirement	Perched water table designs (typically stadiums)	Soil-based fields
Sufficient available water (moisture storage)	• Gravel layer underlies sand layer so the growing media can hold adequate moisture • Amenders added to sand, for example, coir, peat, zeolite, mature compost, to increase water-holding capacity • Growing media has appropriate depth, particle shape, and size distribution	• Ensure topsoil is at least 200mm deep • Amend topsoil to provide good soil structure –typically gypsum and fibrous organic matter such AS 4454 compost
Sufficient available nutrients (fertility)	• Amenders added to sand to increase cation exchange capacity • USGA-listed amenders include peat, zeolite, and mature compost[12] • ACT Guidelines recommend coir, but advise against chicken manure for amending sporting field sands[13] • Fertilisers added as required	• Add amenders such as fibrous organic matter to increase cation exchange capacity and nutrient levels in the growing media • Fertilisers added as required
Available oxygen (access to air)	• Depth of sand profile optimised based on laboratory tests • Appropriate particle size distribution and shape for sand or sand/soil mix such as 80:20	• Ensure topsoil is at least 200mm deep • Amend topsoil to provide good soil structure –typically gypsum and fibrous organic matter • Amend subsoil, where practical, to ensure it is permeable
Removing excess water (access to air for turf and field playability)	• Prevent surface water running onto the field from surrounding spectator areas and infrastructure • Allow excess surface water to flow off the surface, for example, crossfall, slope length • High infiltration rate for sand, with gravel layer placed under sand so that profile drains freely • Drainage system to remove water in below the gravel layer	• Prevent surface water running onto the field from surrounding spectator areas and infrastructure • Allow excess surface water to flow off the surface, for example, crossfall, slope length • Ensure topsoil is at least 200mm deep • Amend topsoil to provide adequate infiltration • Ensure subsoil is permeable, or install slit drainage

Soil science

Soil science is a specialised discipline. Engineering, landscape architecture, and greenkeeping courses typically provide only cursory training in soil science and not in-depth specialist knowledge. Conflicts of interest may arise if the provider of soil advice has a commercial interest in the outcome. One way to manage these issues is to obtain soil advice from an independent certified professional soil scientist specialising in turf.

12 USGA 2018 p10.

13 ACT Government (2010). Design Standards for Urban Infrastructure. 24 Sportsground Design. Edition 1. Revision 2, Department of Urban Services.

6.1.2 Avoiding growing medium problems

Table 13. Design solutions to reduce the risks of growing media problems developing.

Topic	Observation	Solution
Hydraulic conductivity	Specifying that the growing media for community field has a 70mm-300mm per hour saturated hydraulic conductivity (Ksat). This is similar to elite stadium fields, which have an underlying gravel layer. Laying such permeable material directly over soil results in the need for significant water and resources to maintain acceptable turf cover. The field is likely to deteriorate when fewer resources are used.	Hydraulic conductivity Ksat values of 20mm per hour is adequate for most community fields provided the site has a suitable crossfall – typically 1 in 70 to 1 in 100. For perspective, many slit drainage systems on community fields will remove water at less than 10mm/hr and many of these sites drain within an acceptable timeframe after rain.
Sand and soil mixes	Laying sand or a sand/soil mix such as 80:20 directly over soil without an underlying gravel layer. This results in fields that are droughty and have low levels of fertility. Many of these fields also set hard and are more prone to damage.	Either lay a USGA gravel layer under the sand or sand/soil mix and adopt a perched water table design. Or use a soil profile better suited to community fields.
Soil amendment	Not addressing soil structure or fertility issues, which then allows poor growing media. This results in reduced playing surface quality with a thinner turf and harder surface. This can severely limit the carrying capacity of the field.	Most soils used for the construction of NSW sporting fields require amendment with suitable forms of fibrous organic matter such as AS 4454 composed garden organics. Other amenders such as gypsum, lime, or mineral fertilisers may also be required. Verify using laboratory analysis interpreted by a Certified Professional Soil Scientist.
Turf rolls	Laying turf rolls with relatively impermeable soil (clay) attached that create drainage problems.	Lay turf grown on sandy paddocks or establish using sprigs, which is cheaper but slower. Or lay washed turf, which is more expensive.

6.2 Improving drainage

6.2.1 Stop surface water running onto the field

Most fields will drain rapidly if:

- all water running onto the field is diverted using contour mounds or surface drains such as pits, gutters, or swales
- the field has adequate crossfall and the soil is amended so there are no impermeable layers in the profile.

To problem-solve waterlogging issues, stop all surface water running onto the field and then investigate if waterlogging problems persist. Seek an independent certified professional soil scientist specialising in sports turf if problems persist.

6.2.2 Avoid irrigation in the cooler months

Most soil-based fields require minimal irrigation in the cooler months. This varies by region as shown in the irrigation schedules in Table 7. Field hardness is due to poor soil structure and should not be addressed with watering before play. Other interim options to address field hardness can include more intensive maintenance to achieve denser turf cover and more frequent aeration.

Fields oversown with ryegrass require irrigation in the cooler months. This makes the site more susceptible to waterlogging, compaction, and wear. The breakdown of ryegrass can also slow the infiltration of water into the soil profile as well as the sand in sports field drainage systems.

6.2.3 Beware of the soil layer attached to turf rolls

Turf is often laid with a thin layer of soil, often clay, attached. This is a common cause of waterlogging on sporting fields. To prevent this from occurring, only use turf grown on a sandy paddock, lay washed turf, or establish turf from sprigs. Washed turf is more expensive. Turf established from sprigs is cheaper and slower but often results in a premium outcome.

Sand's impact on drainage

Rapid drainage, often in minutes, is one reason elite stadium fields use sands. These fields have a gravel layer beneath the sand – perched water table design – to rapidly remove water as it percolates through the sand. However, gravel is rarely installed beneath community fields, which are often built over clay or compacted fill.

Using a very sandy growing media on these fields, or adding sand to the existing soil, can increase the risk of waterlogging because:

- more water infiltrates into the profile, meaning less run-off, but the subsoil is slow to remove the excess water
- soil, particularly clay, attached to turf rolls is more likely to cause waterlogging problems on sandy profiles.

6.2.4 Avoid earthworks and prevent traffic when the soil is wet

During construction, avoid working the subsoil or topsoil when it is wet as this can lead to compaction and smearing. This can then hinder turf roots and make the field more susceptible to waterlogging.

Sport and vehicles should never traffic a field when it is wet. This can damage:

- surface evenness by leaving footprints or ruts (Figure 34)
- soil infiltration rate by squishing fine particles into soil pores so they become blocked
- soil structure by crushing the soil pores so the soil becomes denser, or harder, and limits root growth.

Figure 24. Damage to sporting fields from being trafficked when wet.

Photo: Dr Paul Lamble

6.2.5 Ensure water does not pool on cricket wickets

Water lying on wickets is a common cause of cricket game cancellations, with these wickets often becoming slippery due to algal growth. To avoid these problems, wickets should sit at least 40mm higher than the ground 2m downslope from the wicket. In addition:

- concrete and synthetic wickets should have a fall of about 1 in 50 towards one side of the wicket
- turf (clay) wicket tables should have
  - 1 in 100 crossfall from the centre line towards both sides of the wicket table
  - slit drainage installed around the perimeter of the wicket table to capture runoff.

Ideally, wickets would not be played over in winter, but this cannot be avoided at some sites. If the wicket needs covering, ideally lay a shock pad and synthetic cover. Alternatively, cover the wicket with soil and turf for the winter months. This soil should have a similar texture and nature to the site soil so it can be used to fill depressions when the wicket is uncovered. This soil must not be mounded up beside the wicket.

Figure 25. The relative levels of the wicket and surrounds at these sites are incorrect, resulting in water ponding on the wicket and causing match cancellations. To allow wickets to drain, the surrounds 2m from the wicket should be 40mm lower than the pitch.

Photos by Dr Mick Battam, Matt Graham, Mark Garner

6.2.6 Consider sports field drainage systems or slit drainage

Sports field drainage or slit drainage consist of a series of trenches that typically have ag pipe installed over a bedding layer in the bottom of the trench. The trenches are backfilled to the surface with sand (see Section 2.4.1 and Figure 6). When considering slit drainage, there are key questions:

- Is slit drainage needed?
  - How fast does the field need to drain? Table 4 presents benchmarks for local, district, and regional fields.
  - Will slit drainage solve the problem? Investigate other causes of waterlogging.
- What site-specific conditions will affect the system design and performance?
- Are there other issues that affect the timing of slit-drainage installation such as sequencing of works?

As a rough guide, slit drainage is often needed on sites requiring very rapid return to play, such as district and regional fields, sites with a long slope length, sites with an impermeable subsoil and those with a turf cricket wicket table. The proportion of fields that require silt drainage can vary dramatically between local government areas depending on the prevalence of waterlogging issues.

Site-specific conditions will affect the design and performance of the slit drainage system

Slit drainage systems must be individually designed for the conditions at each site. They are not an "off the shelf" purchase and require the integration of multiple factors to achieve a fit-for-purpose system. Fields can take significantly longer to drain when the system design does not adequately consider site conditions (Figure 36).

To achieve optimum outcomes, the sports field drainage system should be:

- designed by a sports field drainage specialist who is independent of any installer
- installed by a specialist sports field drainage contractor
- tailored to the site conditions and constraints.
- It should encompass both the field of play and adjacent run-off and spectator areas
- meet performance standards
  - water is removed at a rate of at least 8mm per hour when functioning as a surface drainage system
  - satisfies required return to play times when functioning as a sub-surface drainage system.

Figure 26. After installing a slit drainage system (left) with an undersized mainline (100mm diameter) and inappropriate spacing, this field was often covered in worm casts (right). Worms go to the surface when there is not enough air in the soil.

Install slit drainage at the right time

Complete the works to amend the soil and change the turf to a suitable cultivar before installing slit drainage, for these reasons:

- If the field does not have healthy soil and a suitable turf cultivar then it will continue to struggle, even with slit drainage. The field may become worse because there are fewer wet-weather cancellations (Figure 37).
- Amending the soil or changing the turf cultivar is likely to compromise the previously installed slit drains and be more difficult and expensive to implement.

Works must be sequenced so any issues with the soil and turf cultivar are fully addressed before installing slit drainage. Once slit drainage has been installed, only the same sand used to construct the slit drains should be used for topdressing.

Figure 27. An example of a double soccer field in eastern Sydney that now easily handles 700 football players per week. However, before reconstruction (left), the field struggled, especially following the installation of a slit drainage system as this resulted in fewer washouts. After the field was reconstructed including soil amendment and laying of a wear-tolerant turf cultivar, the slit drains had to be reinstated after reconstruction (right), which added cost to the project.

Photos: Dr Mick Battam

6.3 Improving irrigation

6.3.1 Assessing and improving irrigation system performance

Improving existing irrigation systems requires knowledge of the system performance. This information also applies to system upgrades, maintenance, and scheduling.

The effect of uneven watering is most pronounced during dry periods (Figure 33 – left). However, uneven watering is not always visually obvious (Figure 33– middle). Instead, it requires a catch-can test or a detailed irrigation assessment (Figure 33– right). A catch-can test can assess the performance of existing systems. But comparing options for improving the system requires a detailed irrigation assessment using specialist software.

Figure 28. Both these irrigation systems apply water unevenly. While uneven watering is obvious on some sites (left), it is not always visually obvious (middle). However, a densogram (right) from a detailed irrigation assessment clearly identifies the problem. Improving the systems on these fields would achieve better turf and more than 20% water savings.

Nearmaps Image

6.3.2 Irrigation maintenance

Irrigation systems with electrical and hydraulic components require regular servicing. This should be proactive and preventive, ensuring sufficient operational budget exists to allow prompt repairs.

Irrigation systems primarily operate at night and require regular visual checks to make sure sprinklers operate correctly. Flow-monitoring systems will not detect faults such as sprinklers that don't rotate, are too low, or are not plumb to vertical or incorrect arcs (Figure 32). More regular inspections are required if the system doesn't automatically send alerts or monitor flows. Appendix C: Irrigation technical information and tips provides an example irrigation inspection checklist.

Figure 29. Common irrigation maintenance issues.

Photos: Rex Sullings

6.4 Improving maintenance

All sporting field construction types require maintenance to remain in acceptable condition. Best-practice maintenance involves performing only the activities required to address the issues limiting field performance at the site. Not all sites require all activities. It is best to target and adapt maintenance plans to the site.

Appendix D Example sports field maintenance program provides a detailed description of maintenance practices and a sample program.

6.4.1 Ensure adequate nutrition

Base the fertiliser application rates on soil test results interpreted by a certified professional soil scientist. General advice includes the following:

- **Fully amended soils**
  Fields will require about 120kg (low-wear fields) to 350kg (high-wear fields) of nitrogen per hectare each year. Many commercially available fertilisers contain between 12% and 25% nitrogen. Fields also require significant quantities of potassium and calcium, with lesser amounts of other nutrients.
- **Unamended soils**
  In addition to the above fertiliser rates, some fields require more nutrients to overcome any deficiencies. The most common on NSW fields are calcium, phosphorus, sulphur, potassium, and most of the micronutrients.

Regardless of fertiliser applications, turf will struggle if the soil is compacted, layered, or shallow.

6.4.2 Control weeds

Weeds are a major issue on almost half of NSW sporting fields. The most common weeds are annuals that die in winter and leave gaps. This leaves the turf thin before football players wear it down (Figure 25). Controlling weeds is crucial.

Maintaining dense turf all year is the best way to supress weeds. This is easier on best-practice fields as they have a healthy soil and suitable turf cultivar, especially if intensely worn areas are effectively managed. It is possible to achieve weed control with the following.

- Pre-emergent herbicides that kill seeds as they germinate. They are ideally applied 2 or 3 times a year, but this must be coordinated with aeration to ensure the herbicide barrier is not disturbed.
- Chipping or spot spraying any weeds that establish in small numbers before the weeds form a seed.
- Selective herbicides, which are sometimes required if many weeds become established.

Weed control is also needed on areas surrounding sports fields to limit the source of seed. More information on weed control is provided in Hunter Water's Best Practice Sporting Fields' maintenance book.[14]

Figure 30. For much of the year this field appears to have grass cover. The main weed, summer grass, only lives for part of the year before it dies and leaves gaps during winter. The acceptable grass cover over summer followed by the large gaps in winter often leads people to think the thin turf is due to overuse by football players, when it's actually a weed control issue.

Photos by Dr Mick Battam

6.4.3 Aerate adequately

Usually sporting fields require aeration:

- 3 to 12 times a year for poorly structured soils – most sites
- 1 to 2 times a year for fully amended soils
- rarely for sites on dune sand.

Aeration should generally occur to a depth of at least 160mm. The aeration machine should be chosen to address the underlying soil issues at that site. Seek advice from a certified professional soil scientist.

Even frequent aeration only provides short-term relief. It does not address the underlying cause of the problem, which is usually poor structure typically due to a lack of fibrous organic matter.

Figure 31. The loamy sand soil on this field was never amended and aeration needs to occur 12 times per year. Without aeration, sport is played on an extremely hard field with poor turf cover.

Photos by Dr Mick Battam

14 Hunter Water 2022.

6.4.4 Control water repellency

Water repellency or hydrophobicity can prevent infiltration (see Figure 27). It is more common on sandy and/or unirrigated areas. It is often caused by the decomposition of plant material such as clippings or dead ryegrass, or fertilisers high in fat/wax, for example, blood and bone. Treat water repellency with a wetting agent and apply 1 to 3 times per year. Do not apply wetting agents if hot weather is forecast. Ideally, it is watered-in or applied before rain. It is important to alternate wetting agents with a different mode of action.

Figure 32. Water sitting like a "ball" on top of sandy soil. Waxes/fats in the soil cause it to repel water (left and middle), with the resultant impact on turf performance (right).

Photos by Dr Mick Battam

6.4.5 Perform minor repairs

It is crucial to repair small bare areas at the end of each football season to allow them to fully recover each year. Bowlers' run-ups on cricket fields also need minor repairs at season end, usually with a garden fork to aerate sunken areas.

Thin areas

Aerate with a garden fork, and hand-spread slow-release fertiliser and water.

Small bare areas that won't recover

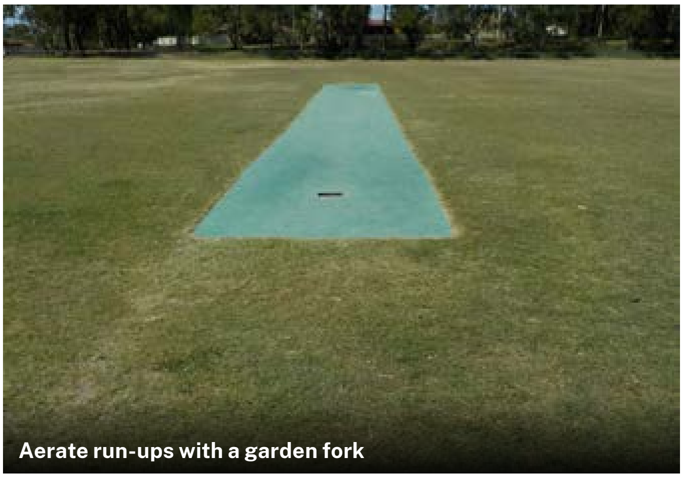
Mix compost into the soil. Harvest turf from healthy turf beside the field with a golf hole changer and plug. Ensure surface is level afterwards.

Many councils lack the labour force to complete minor repairs across their portfolio of fields. Prevention is better than cure, so using moveable goals to allow the field to be moved a few metres each year can significantly reduce the size and occurrence of bare areas from intense wear (Section 5.1.2).

Figure 33. Example of fields that require minor repairs.

Requires minor repairs

Over time if minor repairs not performed



Aerate run-ups with a garden fork

Over time if minor repairs not performed

Natural turf recovers well

Natural turf has exceptional capacity for fast recovery and regrowth if the soil has been prepared well. Turf farms can harvest turf rolls with 10mm of soil attached in September and the paddock recovers from the remaining material in the ground. Turf is then harvested again 4 months later in January.

One intensely used sports field in Sydney has about 800 soccer players per field. This high number is a result of a high proportion of junior players, small training areas on the field per team, and creative scheduling. This field is very worn at the end of the season as turf cover falls to about 50%. It regenerates to full turf cover in December each year (see Figure 29) using typical resources and maintenance practices. It would recover faster with additional fertiliser.

Figure 34. Performance of one of the most intensely used fields in NSW (~800 players per soccer field), which has had minimal patching since being reconstructed to best practice in 2013.

August (50% turf cover, dull from winter) | November (80% turf cover) | December (full cover)

Photos by Dr Mick Battam

Despite wearing to only 50% cover by the end of the winter season, this field meets best-practice benchmarks for traction, evenness, and hardness. This is due to a strong network of stolons and rhizomes in the turf, providing traction, along with a stable and an even playing surface. The important role of the turf stolons and rhizomes was also noted in a separate Victorian study.[15]

15 Neylan 2019.

6.4.6 Use turf plugging

Plugging is a superior option to turf patching. The turf in the plug is already established and uses existing material – on-site soil and turf. Harvest turf plugs from healthy turf in low-wear areas off to the sides of the field or behind the goals.

Make the process easier with a low-cost turf plugging or repair tool that comes in various sizes and shapes. The number of plugs needed depends on the size of the area to be repaired and the turf plugger used. For fast recovery, aim for about 75mm or less of bare ground around each turf plug.

6.4.7 Minimise turf patching

The need to turf patch is evidence of a major issue, usually with the soil and/or the turf cultivar. Minor patching may also be required if foot traffic is highly concentrated. Recovering turf often results in a superior outcome and it is much cheaper. Speed up the process using growth mats. If patching is needed, then fully amend the soil to allow the turf to thrive. Lay wear-tolerant turf grown on sandy soil and solid-tine aerate when turf is established. An alternative option is laying hybrid turf in goalmouth areas.

Repeatedly patching the same areas is a waste of time and money. Try amending the soil or using a wear-tolerant turf cultivar. Best practice involves doing both. Excluding rebuilds, one council in Sydney adopted best practice (see Figure 30) and reduced its annual turf patching bill from $280,000 in 2012 to $8000 in 2017.

Recovering the turf on a field that has thin grass cover after winter wear requires additional fertiliser and water. Using extensive turf patching is an expensive and ultimately futile activity as it only addresses symptoms, not the causes such as poor soil, unsuitable turf cultivar, or training in game-day goal areas.

Figure 35. Reduction in turf patching after field was reconstructed according to best practice (high-wear levels).

6.4.8 Fill holes and top-dress

To repair small, deep holes, lift back the turf with 50mm of soil attached and fill underneath with suitable soil (see below). Put the turf back and tap the surface until it is level and firm, but not compacted. Aerate shallow holes or depressions with a garden fork and gradually fill with top-dress.

Top-dress shallow or uneven sporting fields. Apply 10mm of top-dress material similar to the existing site topsoil, or slightly sandier, during the turf growing season, ideally spring. If this forms a crust, then mix compost and/or gypsum or break up the crust every few days until the turf grows through.

Only use sand to top-dress over slits, never soil. Sand should match the slit sand and be free of stones.

Laying sandy material such as 80:20 over heavier textured soil often results in thin turf (Figure 31). If unsure, test a small area and observe turf growth.

Never roll a soil field. The soil can smear and form a seal that causes waterlogging. Instead, use topdressing to address surface unevenness.

Figure 36. Effectiveness of 2 different top-dress materials used to fill depressions on a loam field. The 80:20 not only results in poor turf cover but provides minimal grip to players.

6.4.9 Consider alternatives to ryegrass oversowing

Ryegrass oversowing is often used on stadium fields to improve aesthetic appearance. Typically, oversowing:

- costs about $14,000 per hectare for seed, labour, fertiliser, spraying out, and additional water
- has limited carrying capacity and generally handles less than 175 players per week
- increases waterlogging risks due to autumn irrigation and blocking of slit drains
- increases maintenance costs, as the underlying turf needs resources for recovery.

In the colder tableland areas of NSW, ryegrass oversowing may be desirable on high-profile sites. Some fields with reliable water sources in these areas consist solely of cool-season grasses.

The breakdown of ryegrass used for oversowing and winter grass or weed can form a gelatinous surface layer that can slow the infiltration of water into slit drains and sand profiles. As a result, oversown fields may need more frequent sand grooving to re-open the slit drain connection to the surface.

To improve turf quality, cut with a cylinder mower and apply a growth regulator in the warmer months. Use a turf colourant like the stadiums do to improve winter colour. Councils using colourants report there is minimal transference onto players once the colourant dries. It is possible to apply turf colourants in early spring to increase turf growth.

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Appendices

Appendix A: Common sports field construction types in NSW

A1 Best-practice field

Best-practice fields consist of the following:

- A wear-tolerant turf cultivar.
- Fully amended soil profile – loamy sand to sandy loam texture – that is well structured and at least 200mm thick.
- A uniform soil profile with no layers that drains freely.
- A suitably amended subsoil that is permeable and/or installed adequate sub-soil sports field drainage.
- Adequate crossfall and measures to prevent surface water running onto the field from upslope areas.

Figure 37. Best-practice field.

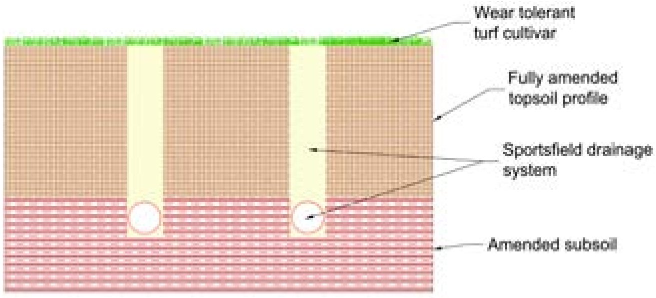


Diagram: Lamble & Battam (2024)

A2 Traditionally constructed field

Construction varies, but these fields often have the following:

- Kikuyu turf, which is low-wear tolerance, and its maximum carrying capacity is typically limited to no more than 175 players per field per week.
- A layer of different soil near the surface, for example, a thin clay layer attached to turf rolls, a sand-based turf underlay, or both.
- Existing site soil with minimal or no amendment. This is often poorly structured, sets hard, and has low fertility.
- A subsoil that is often impermeable. Some sites have drainage, but the spacing is often too wide to effectively remove subsoil water.
- Drainage problems, which are common because many sites have water running onto the field from upslope areas such as embankments, buildings, and roads.

Figure 38. Traditionally constructed field.

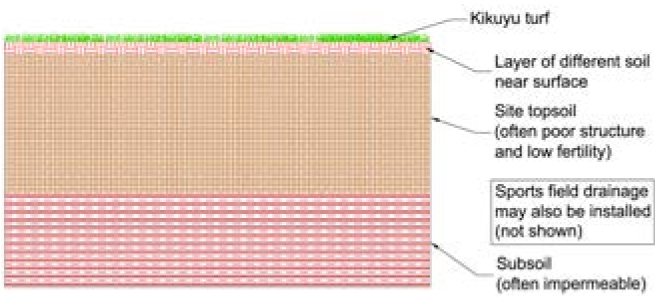


Diagram: Lamble & Battam (2024)

A3 Sand-over-soil (SoS) field

Sand-over-soil fields typically have the following:

- A wear-tolerant turf cultivar, with turf laid either as washed, that is, no soil attached, or with a 10mm layer of soil or clay attached.
- An imported sand layer that is 100mm-300mm thick. Short-lived amenders such as chicken manure are sometimes added.
- Sand laid on top of unamended site subsoil, which is often impermeable.
- Sports field drainage installed, which varies in effectiveness depending on the design and site characteristics.

These fields are sometimes called sand carpet or rootzone sand.

Figure 39.Sand-over-soil field.

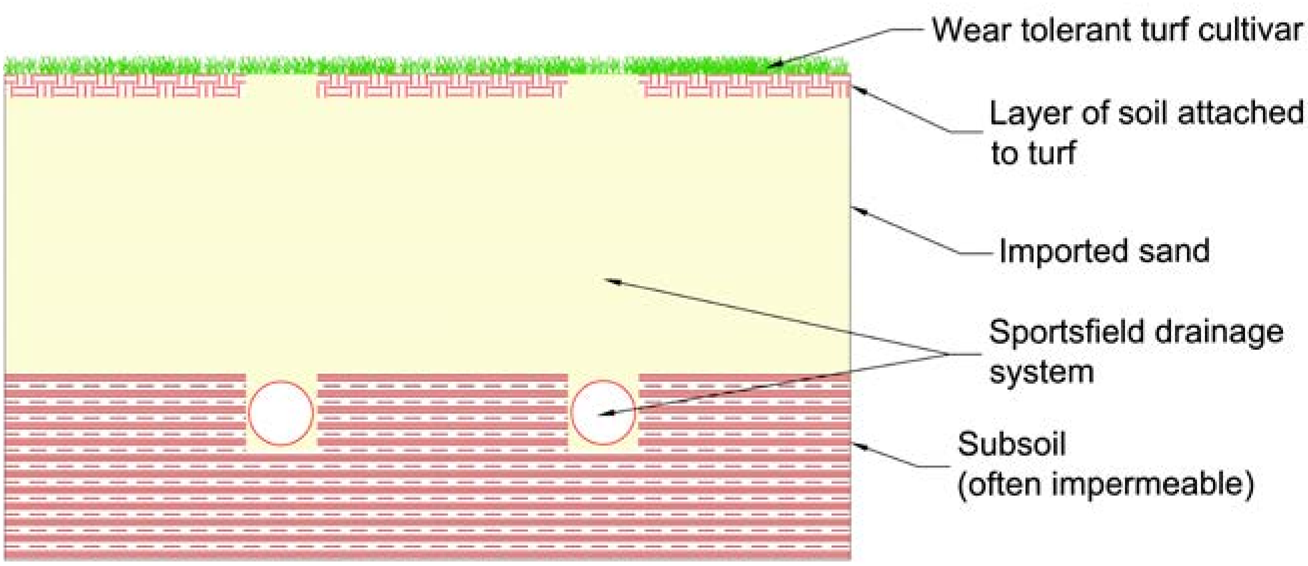


Diagram: Lamble & Battam (2024)

A4 Perched water table field

Perched water table fields often consist of the following:

- A wear-tolerant turf cultivar laid without soil attached, or washed turf.
- An angular sand that is 240mm-280mm thick and amended with 10%-20% coir so water retention complies with USGA requirements.
- An underlying gravel layer, 100mm thick, consisting of 5mm-7mm diameter gravel to ensure the sand holds enough moisture and the field can drain rapidly. This uses the perched water table principle.
- Subsurface drainage beneath the gravel layer.

Also called “USGA” (United States Golf Association) or “USGA profile” fields.

Figure 40. Perched water table field.

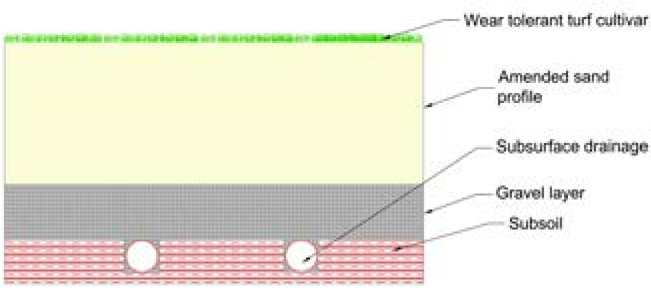


Diagram: Lamble & Battam (2024)

A5 Hybrid turf, or reinforced natural turf, fields

Hybrid turf fields often consist of the following:

- A turf surface with a wear-tolerant turf cultivar that has plastic reinforcing in the soil. The surface consists of either:
  - 100% natural turf
  - 95% natural turf and 5% synthetic blades
- A growing medium that could consist of any of the sand or soil profile construction types described above.

Hybrid turf with no synthetic blades on the surface is often laid on perched water table growing media, USGA profile, in elite stadium fields.

Figure 41. Hybrid turf.

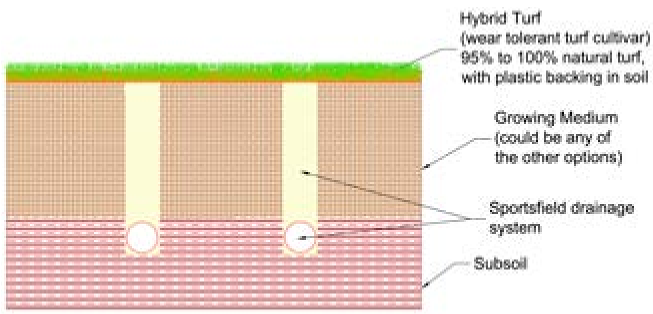


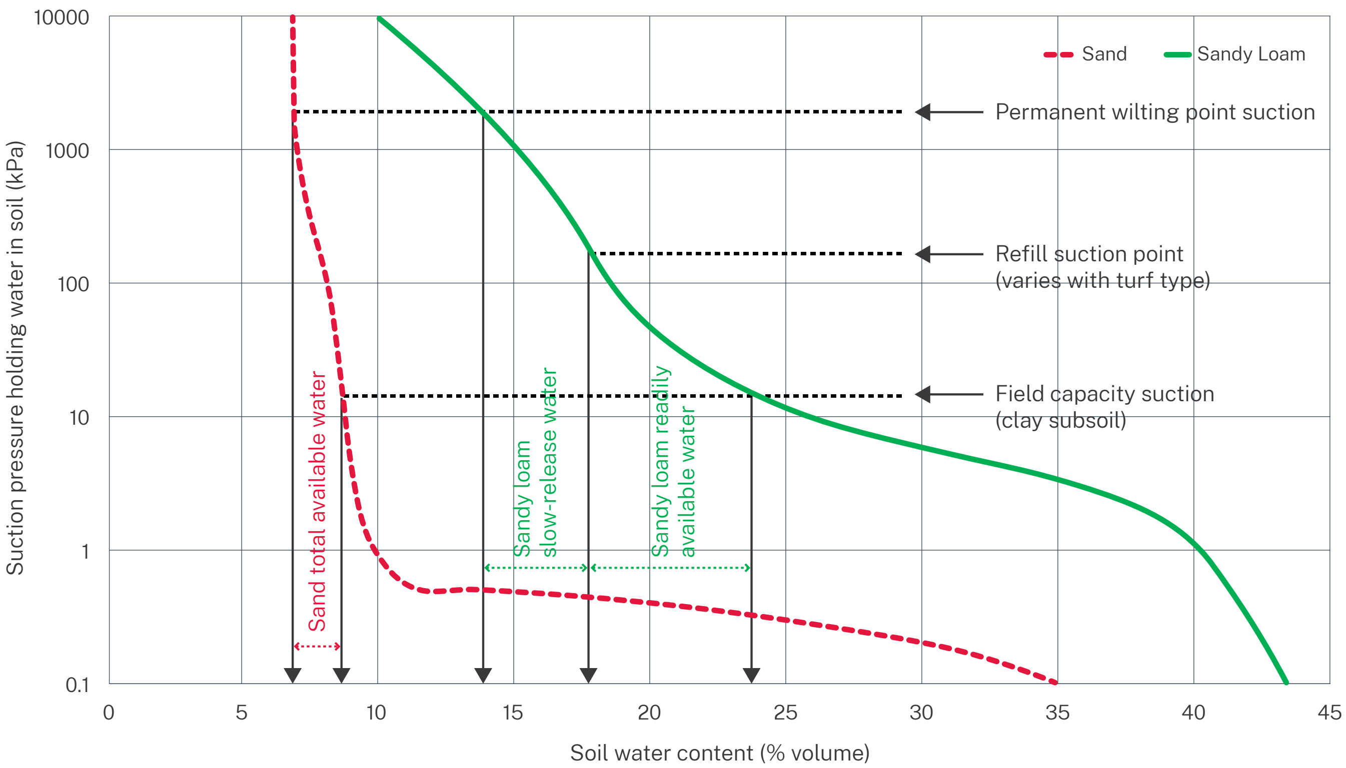
Diagram: Lamble & Battam (2024)

Appendix B: Understanding why sand-over-soil (SoS) profiles perform poorly in a drought

The soil moisture characteristic is a graph showing the relationship between the amount of waters stored in the soil and the amount of energy required for the plant roots to draw this water out of the soil. Broadly speaking, there are 3 key sections on this curve (Figure 43):

1. Water that will drain through the soil due to gravity, assuming the subsoil is free-draining.
2. Plant-available water, which is made up of:
   - readily available water that roots usually take from the soil as fast as the plant needs it
   - slow-release water that, with effort, the roots can remove from the soil. During summer, this water often does not get to the plant fast enough. As such, the turf becomes stressed but is still trickle fed with some water allowing it to survive.
3. Non-available water that the roots cannot draw out of the soil. Any hot weather is likely to injure or kill the turf if the soil is this dry.

Figure 42. Moisture characteristic for a sandy soil (red line) and a sandy loam (green line), demonstrating that sands have very small amounts of plant-available water relative to sandy loams. In this example, the available water in the sandy loam is about 4 to 5 times greater relative to the sand.



Sands generally hold small amounts of plant-available water, with the roots able to take most of this water out of the soil with relatively little effort (Figure 43.). As such, during drought, sands are prone to drying out rapidly, so the turf is vulnerable to heat damage when there is no water left for the plant.

In contrast to sands, sandy loam soils, especially those that are well structured, will have more water available for plant uptake. But almost half of this is slow-release water (Figure 43), so the turf survives even though it is stressed because this water is being trickle fed to the plant.

Appendix C: Irrigation technical information and tips

C1 Water quality considerations

The adequacy and suitability of non-potable water sources should be determined based on detailed water, salt, and nutrient balance modelling that encapsulates the conditions at each site. This includes evaluating the impact of the water chemistry on the clay used in turf cricket wickets, which is often overlooked.

When considering or using non-potable water sources it is crucial to:

- get independent professional advice from a multi-disciplinary team, including a certified professional soil scientist, turf, and water quality specialists
- adopt a regular monitoring and an adaptative management program
- allow for specific irrigation and soil chemistry management measures, for example, leaching of harmful salts and/or the addition of calcium.

Table 14. provides indicative limits for irrigation water quality parameters.

Table 14. Guidelines for water quality for irrigation use.[1]

Water quality parameter	Preferred value	Reference/sources
pH	6.0 to 8.0	Varies with water quality, soil, and site requirements
Salinity – EC	< 0.28 dS/m	ANZECC (1992)[2]
Salinity – TDS	<175 mg/L	ANZECC (1992)
Alkalinity (CaCO3 equiv.)	<100 mg/L	Handreck (2008)[3]
Bicarbonate	<90 mg/L	Handreck and Black (2001)[4]
Chloride (overhead sprinklers)	<100 mg/L	Handreck and Black (2001)
Sodium (overhead sprinklers)	<70 mg/L	Handreck and Black (2001)
Boron	<0.5 mg/L	Handreck (2008)
Sodium adsorption ratio (SAR)	<6	Neylan (2003)[5]
Total suspended solids (TSS)*	<50 ppm	Burt and Styles (1994)[6]

* For micro-irrigation and drip systems

1 Connellan, Geoff (2013), p52 Water Use Efficiency for Irrigated Turf and Landscape, CSIRO Publishing, Collingwood.

2 ANZECC (1992) Australian Water Quality Guidelines For Fresh and Marine Waters. Australian and New Zealand Environment and Conservation Council, Canberra.

3 Handreck K (2008) Good Gardens with Less Water. CSIRO Publishing, Melbourne

4 Handreck and Black (2001) Growing Media for Ornamental Plants and Turf. Third edition. University of New South Wales Press, Randwick, NSW

5 Neylan J (2003) Improving the Environmental Management of New South Wales Golf Courses, AGCSA and NSW Department of Environment, Sydney, https://www.environment.nsw.gov.au/resources/business/07588GolfCourses.pdf

6 Burt CM and Styles SW (1994) Drip and Microirrigation for Trees, Vines and Row Crops. Irrigation Training and Research Center, Cal Poly, San Louis Obispo, California.

C2 Irrigation inspection checklist

Use this checklist for irrigation inspections.

Table 15. Irrigation inspection checklist.

Inspect	Check
All sprinkler heads have been visually inspected for: • leaks • uniform sprinkler throw • upright position (plumb) • broken or sunken sprinkler heads • correct arc and trajectory.	
Valve boxes, tank surrounds, and visible pipework are leak-free.	
Pump station or mains connection are operating at pressures within the design specification.	
Pressures on sprinkler heads – at least the first and last head on each station/zone – are within design specification. Flow control or pressure regulator at solenoid valve are adjusted.	
A backflow prevention-accredited licensed plumber has tested the backflow prevention device.	
Filters and disinfection units are operating correctly and are cleaned as required.	
Testing controller is operating correctly, and that the back-up battery is working.	
Programming in central control system aligns with programming in field controllers.	
Surface grade valve boxes are flush with the surface and undamaged. Adjust valve box levels and replace lids as required. Buried valve boxes have not subsided or collapsed. Repair and/or replace boxes as required and top-dress subsided areas.	
System sensors are working properly and within their calibrated levels of accuracy.	
Broken hardware such as sprinklers and valve components, or pipe items are repaired or replaced with the same or equivalent updated models that meet original specifications, so the entire system continues to perform as designed.	

C3 Gathering baseline system information for irrigation scheduling

Sometimes there is a lack of information on the performance of an existing sports field irrigation system. In those circumstances, use the following method to gather baseline information to inform irrigation scheduling.

Set and run a test irrigation program to water all irrigation zones. Ignore zones for cricket wickets or small specialised areas:

- Zone run times are based on the sprinkler arc. For example, zones with full-circle sprinklers are run for 20 minutes, half-circles for 10 minutes, and quarter-circle 5 minutes.
- If there are sprinklers with mixed arcs, for example, half-circles on the end of zone with full-circle sprinklers, set the run time based on the arc used by most sprinklers on that zone.
- If the system does not have the hydraulic capacity to run this program, halve the run times.

Record the water meter readings immediately before and after irrigation to obtain the water volume (litres) used during the irrigation cycle.

Measure and record the area (m^2) of the field covered by the irrigation system.

Divide the water used (litres) by the watered area (m^2) to obtain the average irrigation application (mm). mm depth = volume (L) ÷ area (m^2).

The average application from the test program can then be used to convert the 20-minute run time from the test program to irrigation schedules based on a 5mm application. For example, if the system applied 4mm on average during the test program, then a 25-minute run time is needed for full-circle sprinklers to apply 5mm (5mm ÷ 4mm x 20 minutes).

If feasible, use an irrigation program that applies either 4mm or 5mm of irrigation as the base. Adjust irrigation frequency to suit weather and site conditions. This is easiest with central irrigation control systems. If manual adjustment is required at the controller, adjust schedules monthly or as weather conditions change.

As a rough guide and starting point, many sites with reasonable soil and irrigation will require watering between 1 and 3 times per week depending on weather and rainfall.

Additional irrigation is likely during hotter weather or in drier parts of NSW, for example, areas receiving less than 400mm of annual rainfall. Sites with poor soils may require more frequent irrigation and smaller irrigation amounts. Use rain sensors to skip irrigation following rain events.

Monitor turf health regularly, noting that other issues such as tree roots, shallow soils, water repellency, uneven irrigation, pests, or diseases may cause dry patches – “dry spot” or areas of turf stress. This is especially the case if the turf on the remainder of the field is healthy.

Appendix D: Example sports field maintenance program

This is an example program for maintaining a typical best-practice field in an acceptable condition. Poorly constructed fields usually require more intensive aeration, irrigation, and weed control, which seldom occurs. Players must contend with poor and sometimes dangerous playing fields. If fields are not appropriately maintained, they will require additional water to assist in turf recovery and management.

This program is a rough guide only. Its purpose is to illustrate the core elements required for optimising field performance. However, adaptive management is essential. The program must be tailored to match the climatic, seasonal, and current weather conditions, the micro-climate, resource availability, and turf performance requirements at the site.

Table 16. Example sports field maintenance program.

Month	Black text shows crucial work, green text shows highly desirable works
Year-round activities	**Clean drains**: after major storms or at least annually at the start of the football season. **Weed control**: in addition to pre-emergent herbicide applications. Hand-chip established perennial weeds in small numbers, especially those with no selective herbicide such as Parramatta grass. Kikuyu is weed in most couch fields. Use selective herbicide as required to control any established weeds in high numbers. Couch fields generally have more suitable herbicide options available. **Pest and disease control**: examine turf regularly for diagnostic signs. Consult a turf specialist as required and apply control. Ideally, use preventive controls. During the winter sports season, cover turf wicket tables that are played over prior to the forecast rainfall.
August – coastal areas only, September for cooler areas	**Weed control:** apply a short-lived pre-emergent herbicide for control of summer weeds.
September October for cooler areas	**Manually repair small worn area, for example, centre kick and near goals**: aerate with a garden fork and spread a starter fertiliser over these areas. **Manually fill depressions**: with material matching site topsoil. Do not fill depressions with sand or 80:20, unless this is the site soil. Only spread slit sand over slit drains. **General top-dress** only apply if it is needed to improve evenness or topsoil depth. **Aerate**: with a machine that best addresses site issues. Many sites need solid tine aeration to at least 180mm depth. Note: most poorly constructed fields need much aeration. **Weed control**: pre-emergent (after aeration) including surrounds to ensure 4 months of protection. Or use shorter-lived pre-emergent and reapply. **Fertiliser (after last frost)**: starter fertiliser and modify based on laboratory soil tests. **Wetting agent** **Irrigation**: only commence once turf is growing and weather conditions are dry. **Uncover synthetic/concrete wickets**: ensuring topsoil used to cover the wicket is moved away from the wicket. Use this as topdressing to fill depressions in other parts of the site. **Turf colourant (after last frost)**: to increase canopy temperature

October to March **November to March in cooler areas** **October to April in drier areas**	**Weed control**: ensure pre-emergent herbicide protection continues. Pre-emergent application in March for control of winter weeds will prevent ryegrass oversowing. **Nutrition (fertiliser)**: fields should receive 120kg per ha (low-wear field) to 350kg per ha (high-wear field) of nitrogen annually. Most sites need N:P:K:Ca ratio of about 9:1:5:5. Modify based on soil tests. Many fields would benefit from the addition of fertiliser containing micronutrients (Fe, Mn, Cu, Zn & B) at least annually. **Irrigation**: as weather conditions dictate. **Wetting agent (February)**: use wetting agent with a different mode of action to that used in September/October. Do not apply before hot weather. **Plant growth regulator**: to achieve dense turf cover and reduce mowing requirements.
April to August **May to August in drier areas**	**Turf colourant**: will increase canopy temperature, ensuring turf continues to grow into April. **Irrigation**: turn off in most areas from April to August. Or May to August in drier areas such as Bourke, Broken Hill, and Griffith, to prevent potential waterlogging of field. **Cover synthetic/concrete wickets**: ideally with a shock pad and synthetic turf cover, but topsoil is an alternative option. Use topsoil with a similar texture to the site topsoil – not 80:20 – to allow its use for topdressing low areas on site in summer.