Home Affairs Bureau
The Government of the Hong Kong Special Administrative Region

MOTT MACDONALD

Environmental Permit No. EP- 544/2017

Kai Tak Sports Park – Investigation

Environmental Team Leader Certification

Reference Document /Plan

~~Document~~/Plan to be Certified:	Grass Management Plan
Date of Report:	December 2021 (Rev.2)
Date received by ETL:	17 January 2022

Reference EP Condition

Environmental Permit Condition: 2.13, 2.14 and 2.15

The Permit Holder shall, no later than 31 December 2019 or one month before occurrence of relevant potential impacts whichever is earlier, submit five hard copies and one electronic copy of Grass Management Plan(s) (the GMP) to the Director for approval. The GMP shall include details, implementation programme, maintenance and management schedules, and drawings in an appropriate scale on grass management for the Project.

If there are any change(s) to the GMP, the Permit Holder shall, no later than one month before the implementation of such change(s), submit five hard copies and one electronic copy of an update to the GMP (the Updated GMP) to the Director for approval. The Updated GMP shall show clearly the proposed change(s). Before submission to the Director, the GMP or any Updated GMP shall be certified by the ET Leader and verified by the IEC as conforming to the requirements on grass management as set out in relevant conditions of approval of the EIA report (Register No. AEIAR-204/2017), or otherwise approved by the Director. All measures recommended in the GMP or any Updated GMP shall be fully implemented. The Permit Holder shall make available additional copies of the GMP or any Updated GMP to the Director upon his request.

The Permit Holder shall submit the GMP or any Updated GMP as certified by the ET Leader and verified by the IEC under Condition 2.14 of this Permit, to the ACE for comment prior to the submission to the Director for approval.

ETL Certification

I hereby certify that the above reference plan complies with the above referenced condition of EP-544/2017.

Mr Sunny Chan
Environmental Team Leader Date: 26 January 2022

Environmental Permit No. EP-544/2017

Kai Tak Sports Park - Investigation

Independent Environmental Checker Verification

Reference Document/Plan

~~Document~~/Plan to be ~~Certified~~/ Verified:	Grass Management Plan
Date of Report:	December 2021 (Rev. 2)
Date received by IEC:	17 January 2022

Reference EP Condition

Environmental Permit Condition: 2.13

The Permit Holder shall, no later than one month before the commencement of construction of the Project or otherwise approved by the Director, submit five hard copies and one electronic copy of Grass Management Plan(s) (the GMP) to the Director for approval. The GMP shall include details, implementation programme, maintenance and management schedules, and drawings in an appropriate scale on grass management for the Project.

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IEC Verification

I hereby verify that the above referenced ~~document~~/plan complies with the above referenced condition of EP-544/2017.

Ms Mandy To

Independent Environmental Checker

Date: 26 January 2022

Our ref: 0500384_IEC Verification Cert_KTSP_GMP_20220126.docx

Making great sport happen

Kai Tak Sports Park

Grass Management Plan Rev.2

Prepared by: Dr Christian Spring and Lee Collier

Date: 15th December 2021

Limitation: This management plan has been produced for exclusive use at Kai Tak Sports Park to help implement turfgrass management work at the Main Stadium and Public Sports Ground. STRI accept no liability or responsibility whatsoever in respect of any use of this report beyond the scope of its application by any third party. The report is the property of STRI and may not be copied nor reproduced without prior written approval of STRI except for the purposes of dealing specifically with the management and implementation of this project.

Technical note: This management plan is an evolving document. Certain strategies and technical information are likely to be modified based on the design development and as a result of the turf trial and validation, the carrying out of which is specified in the Employer's Requirements, Volume 2.1, Part XI, Playing Surface Requirements.

Job Title	Kai Tak Sports Park
Job Number	STRI REF. J002667
Document Title	Grass Management Plan Rev. 2
Document Reference	H:\Clients\K\Kai Tak\J002667 - KTSP\03. STRI Reports\Grass Management Plan\Report\Issued

Prepared by:	Dr Christian Spring	Lee Collier
Signed:	Head of Researc	Principal Technical Consultant
	Christian Spring	
Date:	15/12/21	15/12/21

Revision	**Date**	**Description of Principal Revisions**	**Checked**	**Approved**
Rev. 0	25-11-2019	Issued draft for review	RG	RG
Rev. 1	01/02/21	Project alignment update	LC	LC
Rev. 2	15/12/21	Updated project executive	LC	LC

1.0 Background

The Environmental Permit No. EP-544/2017 (EP) for the approved Environmental Impact Assessment Report (EIA) for Kai Tak Multi-purpose Sports Complex (former name of the Kai Tak Sports Park) was issued on 8 September 2017. The location of the Project is given in Fig. 1 (extracted from EP-544/2017).

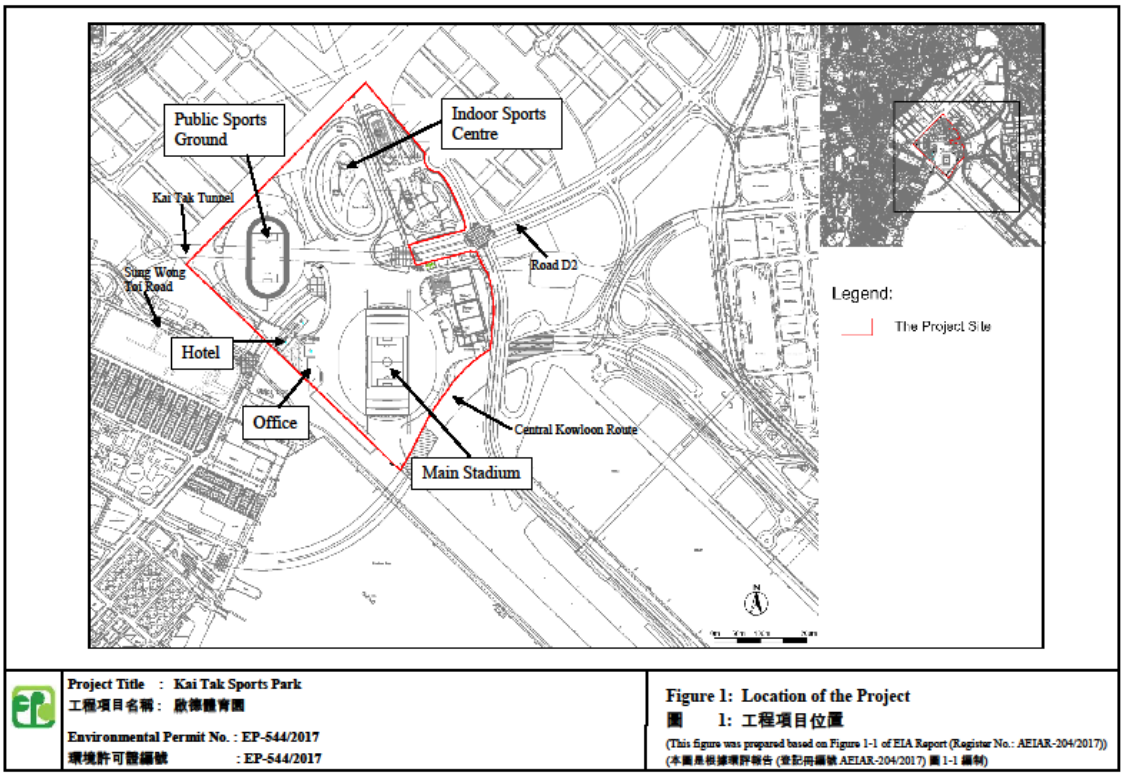


Fig. 1. Location of the Project

As stipulated in the Conditions 2.13 and 2.15 of the EP, the Permit Holder shall, no later than one month before the commencement of the construction of the Project or otherwise approved by the Director, submit a Grass Management Plan (the GMP) to the Director for approval. The GMP shall include details, implementation programme, maintenance and management schedules, and drawings in an appropriate scale on grass management for the Project. The Permit Holder shall submit the GMP as certified by the Environmental Team (ET) Leader and verified by the Independent Environmental Checker (IEC) to the Advisory Council on Environment (ACE) for comment prior to the submission to the Director for approval.

The Grass Management Plan (Rev.0) was submitted to Advisory Council on Environment (ACE) on 6 December 2019 and that the Secretariat of ACE advised on 30 December 2019 that no comment have been received from the ACE.

The purpose of the GMP is to comply with Conditions 2.13 to 2.15 of the EP. Because of the large differences in management between grass used for sports and grass used for non-sports activities, the GMP is divided into two components:

- Sports turf
- Public open space (POS) turf

1.1 Sports turf component

The purpose of the sports turf component of the GMP is to enable the implementation and refinement of Volume 2.3 of the Employer's Requirements (Section 5.3 Pitch Management Services) and general turf maintenance programmes and strategies that allow the Main Stadium and Public Sports Ground pitches to be presented on a daily basis (when installed) to the client and end users/hirers in a state suitable for use up to and including international playing quality standard, within the boundaries specified in this document, the local site conditions, and usage and event management programming. The GMP takes into account details, implementation programmes, maintenance and management schedules, and drawings in an appropriate scale on grass management for the Project as well as turfgrass species selection, growing media selection, efficient use of water resources and minimising escape of residual fertilisers and pesticides in surface run-off. The GMP should be read in conjunction with the Stormwater Reuse Management Plan (SRMP), which addresses relevant subjects in more detail (in particular pesticide and fertiliser management).

As part of the contract requirements, a turf trial and full-scale validation trial is required in order to demonstrate that the natural turf to be used within the pitch surface system is suitable for application in the Main Stadium and the Public Sports Ground. Information provided within the GMP may be refined based on the findings of the trial.

The GMP has been designed to provide a world class venue that can successfully host the widest possible range of sporting and non-sporting uses in the Main Stadium (MS) and Public Sports Ground (PSG). Key objectives will be to ensure that events are not unreasonably rejected or cancelled due to the condition of the pitches, and to foster a positive image of the Precinct to hirers, players and audience (including any TV audience). The range of sporting and non-sport uses includes:

- A concrete base mode that allows non-sports events at the Main Stadium such as concerts, other entertainment/corporate events and exhibitions.
- An compliant artificial pitch surface that allows sporting events including regular community sports use
- An overlay function (above artificial) that allows non-sports events at the Main Stadium such as concerts
- An overlay natural turf pitch surface that allows the highest international standard for Association Football and Rugby Union – required in the Main Stadium
- A permanent natural turf pitch surface that allows the highest international standard for Association Football and Rugby Union – required in the Public Sports Ground

- A permanent natural pitch surface that allows regular community sports use including track and field, Association Football and Rugby Union in the Public Sports Ground

It is recognised that the challenges for producing high quality natural turf for the Kai Tak Sports Park require a level of turf management and a solution that is beyond the conventional. Hong Kong has an extremely difficult turfgrass growing climate, defined by periods of high temperature, high levels of humidity and intense rainfall events, heavy cloud cover and low light levels, heavy disease and pest pressure, and high levels of urban pollution.

It is unlikely that a single turfgrass species or cultivar will ideally suit this climate when superimposed onto the client's high usage expectations for this project. Even the conventional dual warm season/cool season approach to turfgrass management in transitional climates where cool season turf is oversown into warm season turf for the winter period is fraught with unpredictability and variable results in Hong Kong.

This growing climate makes it very hard to produce turf of a consistently high enough quality at a time when it is needed for major events such as the Hong Kong Sevens. Superimpose these conditions on a large 'European or American style' stadium with a solid retractable roof and the challenges for sustaining a natural turf sporting surface within the stadium bowl become far more complex.

The GMP therefore focusses on using existing and emerging natural, hybrid and artificial turf technology as the core of the turf management systems for the Main Stadium and the Public Sports Ground using the following baseline criteria:

<u>Turf supply</u>

- recognising that the supply of turf for the temporary overlay natural turf pitch in the Main Stadium and also potentially the Public Sports Ground and other turf areas will come from a third-party or project specific turf farm

<u>Main Stadium</u>

- recognising that the Main Stadium needs to operate as a fully functional, multi-use, indoor arena as well as a stand-alone natural turf sports pitch

- recognising that the roof of the Main Stadium is an essential management tool to make the venue weather-proof under the Hong Kong climate, particularly in the heavy rainfall season between May and October, and that with the roof closed, the growing environment will need to be artificially created to sustain natural turf within the stadium for specific events

- ensuring that the design for the sports flooring system for the Main Stadium allows ultimate flexibility for use by being modular, demountable, transportable and being able to be stored off-site and then reused

- addressing risk by basing turfgrass management on first principles, innovative technology, and a thorough a targeted turf trial research programme

For the Main Stadium, the GMP involves an overlay natural system comprising of a removable lay-and-play natural turf 50 mm thick. This turf will be installed over an semi-permanent artificial turf system that will be installed on a semi-permanent basis on the concrete floor of the Main Stadium. The maintenance of this artificial turf surface does not form part of this GMP.

The GMP works in conjunction with:

- the ability to control the environment within the stadium bowl to controlled temperature, humidity and airflow limits so that turf can be maintained for short periods for sporting events

- the availability of a turf supply that can provide the right type of turf for the event; the turf trials and full-scale validation will determine the precise nature of this supply

- selecting a 'carpet' hybrid turf reinforcement system that allows multiple transportation for the supply of turf regardless of the type of turf; the turf trials will determine the best carpet hybrid turf reinforcement system to use

- the ability to provide artificial lighting over the whole pitch within the Main Stadium – however, note that the turf trials will determine how long turf would survive without such lights

- the strategy to keep an artificial turf in place for most of the time, over the concrete floor of the stadium bowl, and which is overlain with either natural turf or turf protection as required item 3. (consider omission in the MS – it is unlikely medium or large format pitch grow lights will be used in the MS because the use of such units with an overlay roll out turf installed for a short periods has proven difficult to manage in other similar stadium situations. This is primarily due to the weight of the rigs, which cause damage to the turf surface.)

- the strategy to keep the artificial turf surface as the default surface *in situ* and which is also the default surface for community sports events

- the requirement for the natural turf surface in the Main Stadium to be kept in place for the shortest possible time

- the requirement for the natural turf surface *never* to be overlain with any other system

- a strategy to investigate whether it is feasible not to use transitioning of one type of grass into another on the Main Stadium pitch but instead carrying out transitioning, *if so required by the results of the turf trial programme*, by using pure monocultures of turfgrass (i.e. either cool season turf or warm season turf)

Public Sports Ground

For the Public Sports Ground (PSG), the strategy is to manage the turf as a conventional warm season Hong Kong turf, grown in a permanent profile of organic-amended sand-based rootzone overlying a lightweight layer of either a conventional profile and drainage system or geocellular units.

The PSG is located above a tunnel which houses a 6-lane motorway. The structural team have been advised that the levels could move by as much as 50mm over time due to subsidence. Therefore, the final decision for the selection of drainage PSG infrastructure will be based on sub base requirements including requirements for trenching, sub grade reinforcement and potential to bridge minor imperfections.

The turf is reinforced with the same carpet hybrid system as in the Main Stadium. Reinforced turf will be essential in order to address the heavy usage KPIs for this pitch. A number of options are available for its management:

- if the events schedule and/or conditions allow, the warm season turf is oversown with cool season turf in October/November and transitioned back to warm season in May; this option will require a period of pitch closure at the beginning and end of the transition to allow for recovery/establishment

- if the events schedule and/or conditions do not allow, the warm season turf is swopped with cool season turf at the appropriate time, creating an instant transition, and then swopped back to warm season turf the following May, also creating an instant transition; this option will also require a period of closure (though not as long as above), as well as careful planning of a cool season turf mature enough for transporting into the PSG

- at any time during the playing season, it is possible to replace worn sections of the turf, such as goalmouths and penalty spots etc, with replacement turf from a turf farm

1.2 Public open space (POS) component

Grasses used in the POS may include grass in multi-purpose lawn areas, ornamental grass species, and grasses used in sloping surfaces and green roofs. Since the function of these grasses is principally for amenity purposes, slope protection, and leisure seating, their management will be very different from the MS and PSG pitches, which have much more stringent performance requirements. A normal horticultural materials and methods approach will be adopted for the POS grass areas because the intensity of grass maintenance for these areas will be much lower than the turf in sports pitches.

For the above reason, the GMP for the public open space grassed areas is produced as a separate chapter in this GMP in Appendix 5, with cross referencing to relevant areas of the GMP for sports turf as required.

2.0 Grass Management Overview

2.1 Key personnel

The following key personnel are recognised:

Designation	Definition (to be confirmed)
Client	Home Affairs Bureau, The Government of Hong Kong SAR
Supervising Officer	Leigh and Orange Ltd
Contracted Party	Kai Tak Sports Park Ltd (KTSPL)
Turf Expert	STRI (Lee Collier, Dr Ruth Mann)
Turf Specialist	Cameron Hodgkins
Head of Turf Operations	To be appointed by the Contracted Party

Note that the use of the term 'approved' within this GMP is defined as 'approved by the Supervising Officer or their representative' unless otherwise stated.

2.2 Field of Play

For the Main Stadium, the total natural grass pitch area including in-goal areas and the playing enclosure is 8,510 m^2 (115 m by 74 m), with Field of Play dimensions of 100 m by 68 m and natural turf deadball areas 7.5 m deep (Rugby Union mode).

The design of the natural grass pitch area in the Main Stadium includes a playing enclosure margin down the side-lines of 3 m natural turf with a minimum further 2 m perimeter of '3G' artificial turf approved to World Rugby Regulation 22 standards (minimum of approx. 460 m^2 of artificial turf). The total distance from the edge of the natural turf on the side lines to the edge of the bowl is 6.5 m (13m from the edge of the natural turf in the in-goal area to the edge of the bowl).

The above layout will allow advertising/media boards to be placed 5 m beyond the side-lines (a World Rugby and FIFA requirement) and the two in-goal lines.

For the PSG, the standard Field of Play area for the inner athletic pitch are dimensions of 105 m by 68 m (7,140 m^2). However, it will not even be possible to install a permanent 3 m natural turf boundary around the pitch (the minimum required for football) because of the running track limitations. For the sidelines there is a 2.5 m natural turf perimeter with 2.0 m of natural turf perimeter behind the goal lines (total natural turf area of 7,923 m^2). A temporary overlay short pile artificial turf can be used strategically around the edge of the pitch at the corners should the perimeter need to be extended to allow for events specifically requiring full size pitches (Fig. 2). It is also possible to reduce the length of a pitch to generate more perimeter space (e.g. the 95 goal-to-goal length that was used at football grounds in the UK for hosting the 2015 Rugby World Cup).

Fig. 2. Extension of turf perimeter around the Field of Play using high quality artificial turf

Drawings of both turfgrass areas covered by this Grass Management Plan are shown in Appendix 1.

2.3 Grass management operations

The following management operations will be carried out on the natural turf surfaces located at the Main Stadium and PSG:

- laying out and line marking (including routine management of any logos) *
- mowing for surface presentation (including day-to-day minor repair, and management of surface moisture)*
- general maintenance mowing*
- fertilising and soil nutrient management*
- operating the irrigation systems and soil moisture management*
- profile aeration**
- profile health management*
- disease and pest management and growth regulation*
- monitoring pests*
- artificial turf maintenance*
- turf species and turf reinforcement selection*
- environmental monitoring*
- controlling weeds**
- major pitch renovation **
- drainage management*
- turf harvesting and laying*
- management of light levels (Main Stadium only)

* Main Stadium and PSG only

** PSG only

The full operations shall be determined in response to specific turfgrass condition and the schedule of events, with methodology and detailed maintenance schedules specified in the Pitch Management Manual (PMM), which will form part of the Operations Manual The PMM is specified in Volume 2.3 (Operating Requirements) of the Employer's Requirements in Section 5.5.5.

Chemicals used in this GMP include but are not necessarily limited to logo and line marking paints, fertilisers and pesticides (such as plant growth regulators, herbicides, fungicides and insecticides). Application of chemicals, if necessary, shall be confined to the approved list and specified dosage. The frequency and intensity of application shall be well justified according to genuine operational needs. Any chemicals that may be carried away by water shall be contained in specific containers and cabinets under shelter and protected from weather. Any liquid chemical or fuel shall be contained in hard standing bounded area. The future operation shall ensure that only staff that trained in the use and handling the specific chemicals for specific task are allowed to handle the relevant chemicals.

2.4 Pitch performance

A full set of performance standards and test methodology shall be customised for the natural turf playing surfaces for Association Football and Rugby Union once the research and trials programme has been completed[1]. The performance standards will be reviewed once the pitch surface system is confirmed and revised according to the findings of the turf validation trial.

The bespoke STRI 'TurfSync™ Pro' system or an approved equivalent shall be used to capture and process all relevant pitch performance data into a comprehensive 'Pitch Quality Index' as currently used by UEFA in preparation of the EURO2020 competition (see Section 2.5). As a guideline, the following performance standards for Association Football shall be used:

Parameter	Preferred range	Acceptable range	Source
Deviation from 3 m straight edge (mm)	<10	<15	STRI Recommendations
Volumetric water content in upper 60 mm (%)	20-30	18-32	STRI Recommendations
Water infiltration rate (mm/h)*	≥150	≥100	Local recommendations (unpublished)
Total grass cover (%)	See below	See below	STRI/UEFA Recommendations

[1] Note: there are no standards published by FIFA or World Rugby for natural turf. Standards for natural turf have been published by STRI which can be developed specifically for this project.

Parameter	Preferred range	Acceptable range	Source
Height of cut (mm)	See below	See below	STRI/UEFA Recommendations
Maximum rooting depth (mm)*	>150	>100	STRI/UEFA Recommendations
Depth of main root mass (mm)*	≥60	≥45	STRI/UEFA Recommendations
Surface hardness (gravities)	70-90	60-100	STRI/UEFA Recommendations
Shock absorption/force reduction (%)**	55-65	45-70	FIFA/World Rugby
Vertical deformation (mm)**	4-10	6-10	FIFA/World Rugby
Ball rebound (cm)	60-85	60-100	FIFA/World Rugby
Ball roll (m)	4-8	4-10	FIFA
Surface traction (N m)	30-45	25-50	FIFA/World Rugby
Head impact criteria (m)	≥1.3	≥1.3	World Rugby

* May not be applicable to a temporary natural turf pitch with a shallow rootzone
** More applicable to 3G artificial turf surrounds on the Main Stadium pitch than the Field of Play

Most of the performance criteria above will apply for Rugby Union as for Association Football, with some minor changes to some of the limits.

Grass cover and mowing height guidelines will depend on the time of year, type of grass present, intensity of use and the sport being played:

	Grass cover guidelines (transitional pitch with oversown cool season turf in situ, %)*		
	Oct-Dec	**Jan-Mar**	**Apr-May**
Overall mean	≥ 90	≥ 80	≥ 70
Individual pitch positions	≥ 80	≥ 70	≥ 50

* Note: the transitional period in Hong Kong is usually from October (time of oversowing) to May.

	Grass cover guidelines (warm season turf in situ with no cool season oversowing, %)				
	Jul/Aug	**Sep/Oct**	**Nov/Feb**	**Mar/Apr**	**May/Jun**
Overall mean	≥ 90	≥ 80	≥ 70	≥ 60	≥ 70
Individual pitch positions	≥ 80	≥ 70	≥ 50	≥ 50	≥ 60

Height of cut will be maintained at between 15 and 25 mm (warm season turf) and 20-30 mm (cool season turf) depending on the type of sport / event taking place, as follows:

Sporting discipline	**Optimum cutting height range**
Football	15-28 mm*
Rugby	25 mm
Athletics	20-25 mm

* dependent on type of grass present

Note, given the multi-sport usage of the Main Stadium and the indication that multiple events will overlap, a general mowing height of 20 mm may be required through large parts of the year to cater for all activities.

Performance assessment measurements will be made on the playing surfaces in accordance with STRI Standard Operating Procedures, as follows:

1. Surface evenness shall be determined using a 3 m straight edge and a wedge to determine the maximum deviation. In each area the straight edge shall be put down in four positions aiming to identify the maximum deviation in each area.
2. Volumetric water content shall be determined with Delta-T Theta probe inserted to 60 mm depth, using the mean of four readings for each test position.
3. Infiltration rate shall be determined with a double ring infiltrometer using rings of approximately 150 and 300 mm in diameter, with results standardised to a water temperature of 20^{o}C.
4. Grass cover and botanical composition shall be determined with a frame quadrat, using the mean of four readings for each test position.
5. Height of cut shall be determined using a prism gauge after completion of mowing of the pitch in preparation for testing using the mean of four readings for each test position.
6. Maximum rooting depth and depth of main rooting mass shall be recorded on samples taken using a split golf hole type cutter, with a single measurement made in each test area.
7. Surface hardness shall be determined using a 2.25 kg Clegg hammer dropped from 0.45 m using the mean of six readings for each test position.

8. Shock absorption/force reduction and vertical deformation shall be determined with a Deltec Field Tester using the mean of six readings for each test position.
9. Ball rebound shall be determined as the height of rebound when released from a 2 m drop height, using the mean of four readings for each test position.
10. Ball roll shall be determined by the release of a ball from a height of 1.0 m from an inclined ramp, using four measurements in each test area consisting of duplicate readings in each of two opposing directions
11. Surface traction shall be determined as the rotational force to cause slippage with a standard STRI traction apparatus with six 15 mm football studs (Canaway & Bell, 1986), using the mean of four readings for each test position.
12. Disease and pest assessment shall be made using visual assessment only in each test area.
13. HIC shall be determined using a head injury criterion meter to World Rugby and EN1177:2018 test method.

2.5 Pitch data reporting and monitoring

All pitch management data (e.g. selected pitch properties, turf condition, usage, maintenance activities, consumables applied) shall be recorded using STRI's bespoke TurfSync™ system or an approved equivalent system with the same functionality. This system collates and processes surface performance and pitch management data. The TurfSync™ portal allows users to access historic and real-time sport surface performance data from any device anywhere in the world. The software allows users to monitor multiple pitches simultaneously to view agronomic trends, identify risks and solve problems before they arise. In addition, data can be inputted from multiple different sources.

The TurfSync™ portals design is functional and easy to navigate, allowing for easy data entry and view. As the site is completely mobile friendly users can log in and input data directly from their mobile device. The portal will be customised to suit the requirements of the KTSP site.
TurfSync™ creates several advantages for this project, which include:

- remote monitoring of the Main Stadium pitch and PSG pitch to ensure they are performing within guideline values; typical output is graphical for a simple visual review
- incorporation of the index of pitch quality captured using the 'TurfSync™ Pro' system
- rapid identification of any pitch that is showing signs of drifting towards an unacceptable performance limit
- inputting of data by turf managers directly into TurfSync™ via the web portal on phones, tablets or laptops
- sharing of venue data with stakeholders (e.g. HAB, SMG)
- adding and manually monitoring any number of pitches

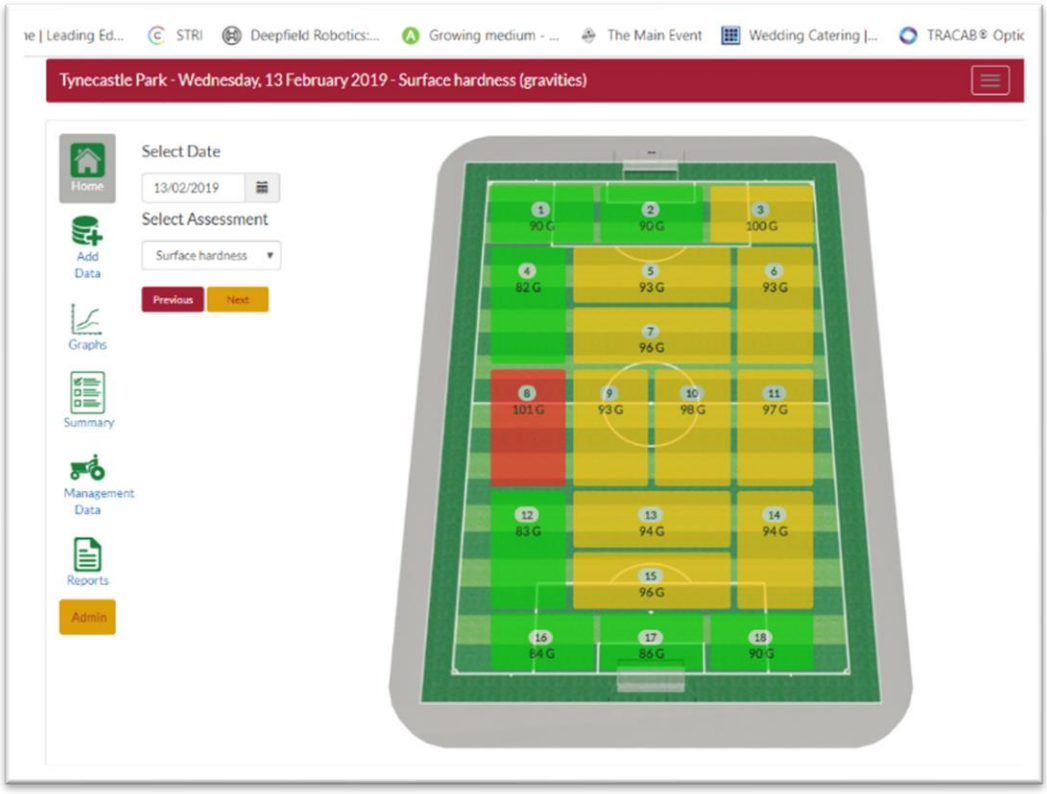


Fig. 3. TurfSync screen shot showing measurements of surface hardness over a pitch

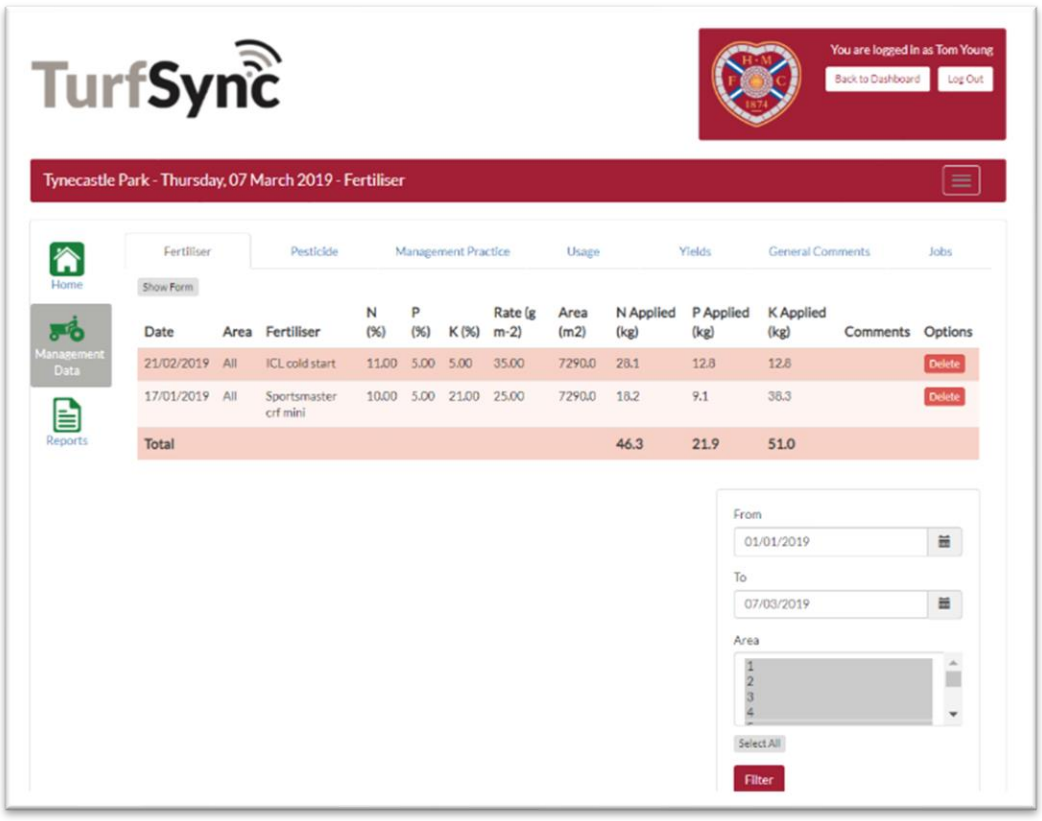


Fig. 4. TurfSync screen shot showing log of fertiliser applications made to a pitch

Date of visit:	23 May 2019	**Consultant:** Neil Rodger	**Match Status:** N/A
Competition:		**Teams playing/training:** N/A	**Maintenance operator:** In-house
Weather conditions:	Dry and sunny. Approx. 15 degrees C.		

Overall Pitch Quality Index **62%**

The pitch condition was good at the time of the site visit however the appearance was slightly patchy due to the presence of Poa annua. The most recent re-turf was carried out at the beginning of March 2019. It should be noted that the pitch was not set up for a match at the time of the visit which will have resulted in a lower overall pitch quality index (e.g. grass height).

Summary of Results	Grading
Profile and construction assessment	3
Uniformity of grass colour	3
Extent of grass cover (overall mean)	5
Extent of grass cover (individual positions)	5
Turf health and condition	3
Line marking quality	5
Presence of divots and footmarks	2
Mowing pattern quality	3
Surface levels	5
Surface traction (Nm)	1
Surface hardness (g)	4
Volumetric soil moisture content (%)	1
Grass height (mm)	1
Maximum root depth (mm)	1
Depth of main root mass (mm)	1
Grass cover consistency	4
Volumetric moisture content consistency	3
Surface hardness consistency	4
Surface traction consistency	5

< 35%	35-54.9%	55-69.9%	70-84.9%	≥ 85.0%
Unacceptable quality = fail, pitch is unsafe and requires significant work	Poor quality = pitch is below standard but playable; work required	Satisfactory quality = pitch is just at an acceptable standard; some improvements required	Acceptable quality = pitch is good with minor concerns	Good quality = pitch is excellent with no limitations

Fig. 5. TurfSync Pro screen shot showing dashboard of Pitch Quality Index

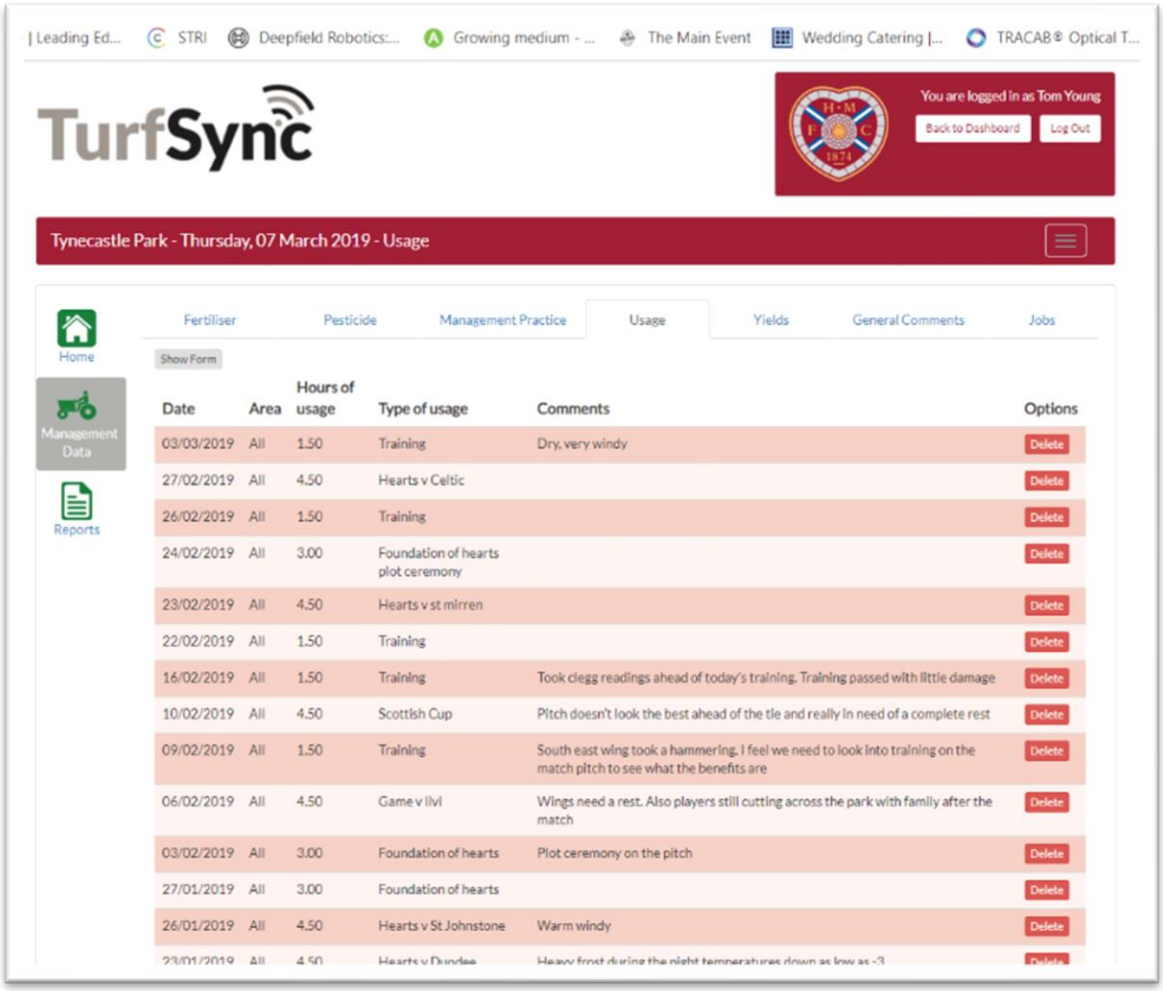


Fig. 6. TurfSync screen shot showing log of usage and events on a pitch

2.6 Codes of Practice and Regulations

The GMP shall recognise and implement where required the following non-exclusive list of codes of practice and compliance regulations:

- Code of Practice for the safe and efficient use of pesticides on sports turf (South China Turf Managers Association, May 2011) https://www.afcd.gov.hk/english/publications/publications_qua/files/leaflet_turf_e.pdf
- Code of Practice for the safe and proper use of pesticides in public areas (compiled by the Agriculture, Fisheries & Conservation Department, the Food and Environmental Hygiene Department and the Leisure and Cultural Services Department, Sep 2014) https://www.afcd.gov.hk/english/quarantine/qua_pesticide/qua_pes_safe/files/COP_public_area_ENG.pdf
- A guide to labelling of pesticides (Agriculture, Fisheries & Conservation Department, Aug 2017) https://www.afcd.gov.hk/english/publications/publications_qua/pub_qua_pes/files/2017_labelling_guide_15G07E.pdf

- Summary of the Pesticides Ordinance (Cap. 133) (Agriculture, Fisheries & Conservation Department, Jan 2014

  https://www.afcd.gov.hk/english/publications/publications_qua/pub_qua_pes/files/PPRD12G01E_27012014.pdf

- A guide to the definition of pesticide under the Pesticides Ordinance (Cap. 133) (Agriculture, Fisheries & Conservation Department, August 2020)

  https://www.afcd.gov.hk/english/quarantine/qua_pesticide/qua_pes_pes/files/Pesticides_definition_12G03E.pdf

- Safety guidelines for storage of pesticides (Agriculture, Fisheries & Conservation Department, March 2000)

  https://www.afcd.gov.hk/english/publications/publications_qua/pub_qua_pes/files/common/storageguide.pdf

- Registered pesticides list Part ll, Pesticides Ordinance (Cap. 133]

  https://www.afcd.gov.hk/english/quarantine/qua_pesticide/qua_pes_pes/qua_pes_part2.html

3.0 Grass Management Plan Operational Objectives

3.1 Lay out, line marking and management of logos

Pitches shall be set out and marked according to the Schedule of Events and bookings for the Main Stadium and PSG.

Following initial line marking, the markings shall be maintained in a clearly visible, accurate manner to sporting code requirements for the duration of that event.

Marking shall be undertaken using only proprietary marking material of a type approved by the Turf Specialist.

Routine management of logos includes ensuring that the turfgrass surface is adequately prepared for logo application (e.g. raising the height of cut, ensuring the area is dry) and that the timing and method of logo application is agreed in advance with the relevant event organiser. Note that particular care shall be exercised to ensure that the method of logo application limits the amount of paint that may end up being applied to the playing surface to ensure easier removal of logos.

3.2 Mowing

3.2.1 Machinery

Mowing machinery used on the PSG pitch shall be no larger than a Triplex unit and shall be used only during periods of active growth when the surface can be adequately dried prior to mowing. Pedestrian units shall be used for all other periods.

Mowing machinery used on the Main Stadium pitch shall be exclusively by pedestrian mowers with a minimum cutting width of 700 mm for cylinder mowers. The cylinder mowers shall be capable of receiving brush, spiking and verti-cutting attachments.

If the Triplex unit at any time is considered by the Supervising Officer to be causing unacceptable damage to the grass surface of the PSG, then pedestrian units shall be used until such a time as ground and turfgrass conditions improve.

All machinery used must be approved in advance by the Turf Expert and Turf Specialist, and an up-to-date list of machinery shall be kept by the Head of Turf Operations for inspection by the Supervising Officer. Machinery shall be maintained and operated so that it does not represent a danger to the operator, public or property.

3.2.2 Operational objectives

Cutting units on all mowing machinery shall be sharp and properly set so that they cut the sward cleanly and evenly without tearing or causing damage to the leaf blade. This may necessitate a cutting speed at the slower end of the manufacturer's recommendations, in order to achieve the desired presentation (e.g. 5-6 km/h), depending on the number of blades per reel. As a general guideline, it is expected that all cylinder cutting units will be no less than 6-bladed reels.

All movements of machinery, whether mowing, turning or in transit, shall not damage the turf or its appearance (i.e. scalping, skidding, wheel ruts, lifting turf etc.).

It shall be the Head of Turf Operations responsibility to mow as required to meet the specified cutting height range and presentational quality required for the pitches. No more than one third of the upright grass foliage should be removed at one time and allowance shall be made for cutting as frequently as grass growth demands. Care shall be required to avoid scalping the grass in particular during early establishment.

The frequency and type (rotary, cylinder, vertical) of mowing will depend ultimately on the performance standard required for each event/activity, the type of grass present and on the prevailing ground and environmental conditions. Mowing shall be carried out at a frequency to avoid excessive accumulation of grass clippings and shall be expected to include the use of double cutting where required for match presentation.

The Head of Turf Operations shall determine a programme for verti-cutting the PSG pitch to remove decaying plant material, improving circulation around the crown of the turf plant and ensuring that surface greasiness is adequately dealt with. More aggressive scarifying shall be carried out only when the grass is actively growing and there is sufficient time for recovery.

The intensity and frequency of verti-cutting and scarifying will be very dependent on the amount of thatch accumulation, schedule of events, turfgrass condition and specific recommendations from the turf reinforcement installer.

No verti-cutting or scarifying shall be carried out under periods of turfgrass stress (e.g. peak summer temperatures) or when the surface conditions are too damp. All material removed through the verti-cutting process shall be removed.

The majority of turning of machinery shall be expected to take place off natural turf surfaces (for example on the artificial turf boundary of the Main Stadium pitch) in order to minimise damage to the natural turf surface. The Head of Turf Operations shall take particular care to ensure that the artificial turf perimeter area and any hard surfaces on the Main Stadium and PSG are left clear of clippings at all times.

Mowing activities on the Main Stadium and PSG pitches shall involve the collection of clippings at all times, which shall be removed from the site for proper disposal.

The Head of Turf Operations shall ensure that the perimeter artificial turf boundary on the Main Stadium pitch is not damaged by natural turf mowing activities. In this respect, it may be necessary from time-to-time to cut the turf right on the boundary between the two surfaces using an approved weed eater or pedestrian rotary mower as appropriate.

The Main Stadium and PSG pitches may require flat rolling from time-to-time beyond that which can be provided by regular mowing. Allowance shall be made for the pitches to be flat rolled using a lightweight roller of no more than 350 kg weight, or in the case of the Main Stadium pitch, additional contingency availability of a twin-drum 2-t roller for use immediately after turfing, the precise times of which shall be determined by the Head of Turf Operations. In general, lightweight flat rolling shall be used as required for surface preparation and repair. Some pedestrian mowing units may be able to carry out this function without requiring additional machinery.

3.3 Fertilising and soil nutrient management

3.3.1 Operational objectives

The principal operational objective shall be to maintain or improve the agronomic, presentational and playing quality characteristics of the sports surfaces by using fertiliser selection and application practices that are customised for local site conditions, growing media available and turfgrass species being managed.

It is important to understand the rationale and good sustainable practice approach when considering the impacts of fertilisers in the wider environment. The aim of fertiliser application on sports turf is quite different to that used when growing agricultural crops or grazing grassland. For the latter, biomass production is paramount and fertiliser inputs are selected to give optimum biomass production per kg of fertiliser applied. However, for turf on sports fields this is not necessarily the case. Indeed, excessive biomass production often has highly detrimental agronomic and playing quality effects. When managing turf, fertiliser inputs are optimised to produce healthy turf for the minimum possible input of nutrient.

Fertiliser selection will therefore be based on need, turfgrass nutrient demands, and product efficacy and in accordance with guidelines such as those set out in Lawson (2002), Duncan and Carrow (1999), McCarty and Miller (2002) and Carrow et al. (2001). This project demands sports surfaces with a guaranteed performance from a contractual perspective. Turf products selected (including fertilisers) will therefore also need to have a guaranteed performance. Whether such products are organic or not is immaterial. The best turf products on the market shall be selected and used responsibly within an integrated pest management programme (IPM). Such an approach automatically implies minimising the demand for chemical application, use of non-chemical means where possible and applying

products at manufacturer's recommended rates. The proposed turf trials will provide an opportunity to evaluate a range of turf products suited to the Hong Kong climate and turfgrass growing challenges.

The central tenets of fertiliser application guidance for this GMP shall be to establish what levels of nutrients are available to the grass in the rootzone, plan nutrient inputs based on supplementing this existing reserve and on the growth and plant health objectives needed to sustain the playing surfaces. The requirements for nutrient inputs will vary according to:

- species of turf
- the current condition and health of the turf
- the prevailing growing environment
- time of year
- age of the turf and level of root development
- specific objectives of nutrient input

The nature of fertilisers used in this project will be very different to those used in agricultural or horticultural situations. Firstly, the level of nutrients contained in turf fertilisers have lower nitrogen and phosphate contents than in agricultural fertilisers. This is to prevent excessive growth and to allow for more targeted and frequent fertiliser applications, thereby better meeting plant demands as they change dynamically during the season. On intensively managed turf, fertilisers tend to be applied in small quantities frequently during the growing season. This not only prevents flushes of growth, but also significantly reduces leaching or run-off risk, as there is a greater chance that turf, or the soil ecosystem, will utilise the nutrient before it is flushed from the rootzone.

Leaching and wastage of soil nutrients shall be minimised by adopting a 'good sustainable practice' nutrient management programme, coupled with judicious use of the irrigation systems.

When considering the risk of nutrient leaching, the solubility and form of fertiliser is important. Conventional/quick release fertilisers tend to be readily soluble to allow quick plant response, but if over-applied or over-irrigated could be at greater risk of leaching. Therefore, lighter but more frequent applications shall be made, in comparison to applying the same level of nutrition in one or two applications per year. Slow release or controlled release formulations shall be used to restrict the solubility/accessibility of nutrients to plants and the soil ecosystem. Both formulations will produce a slower and more measured release of nutrients over a longer time-period, thereby reducing leaching risk. Finally, liquid products shall be used to apply frequent and very small doses of nutrient that are quickly taken up by the grass plant and utilised, thereby preventing excessive growth and minimising leaching losses, as most of the nutrient is quickly assimilated in the plant.

In summary, the fertiliser programme for the Main Stadium and PSG pitches shall therefore be based on a combination of applications of granular, controlled or slow release fertilisers supplemented by foliar feeding for presentational management and disease control. Additional small applications of conventional-release granular fertiliser may also be required as 'back-up' for rapid promotion of growth at key times.

The precise programme of routine maintenance fertiliser applications shall be specified by the Head of Turf Operations from the supplied list of products selected by the Turf Expert and approved by the Turf Specialist in the Pitch Management Manual. It is expected that the maintenance fertiliser programme will be under constant review and adjustment as experience is gained with the management of the turf surfaces.

The types of fertiliser registered for use on turf in Hong Kong and likely to be used for the Project are listed in Appendix 2.

3.3.2 Programming and application

The application of fertiliser in general shall be timed so that it brings a pitch to a peak condition for any major competition or event which may be notified to the Head of Turf Operations. In this respect, it is expected that the supplier's turf farm shall be brought to peak condition before being harvested and laid in the Main Stadium. Fertiliser applications on turf laid within the Main Stadium shall be kept as minimal as possible.

Nutrient inputs shall be modified from month-to-month depending on soil test analysis and seasonal differences. Based on existing research carried out by STRI in the UK, Brisbane and Qatar and on the publications listed in this document, the following annual nitrogen applications shall be used as a guideline for the different turfgrass species that may be used for this Project:

Perennial ryegrass (*Lolium perenne*):	≤ 250 kg/N/ha
Kentucky bluegrass (*Poa pratensis*):	≤ 250 kg/N/ha
Zoysia (*Zoysia* spp.):	≤ 250 kg/N/ha
Paspalum (*Paspalum* spp.):	≤ 250 kg/N/ha
Bermudagrass (*Cynodon dactylon*):	≤ 600 kg/N/ha

The fertiliser programme shall be devised to ensure a 'little and often' approach providing a balance of NPK nutrients approximately in the ratio of 4N:1P_2O_5:3K_20 or 9N:1P:6K and shall be dependent upon environmental conditions and the rate of turfgrass growth. For the first 12 months following initial turf establishment on the PSG pitch, fertiliser inputs can be anticipated to be significantly higher than for a surface with an established mature turfgrass sward.

The above practice will ensure that there will be efficient turf nutrient uptake as well as no nutrient loading within the rootzone, thus minimising the potential for nutrient loss from the profile.

Applications of soil conditioners, wetting agents and fertilisers containing iron shall also be used as part of the routine maintenance applications as considered necessary by the Head of Turf Operations in order to maintain profile condition and health, and to present the pitches in optimal visual condition for matches and events.

Granular fertiliser shall be applied evenly using a rotary spreader and shall be washed in using a light irrigation application immediately after application. Furthermore, fertiliser shall not be applied when conditions are hot and sunny, but preferably early morning or late afternoon (ideally under overcast conditions). The main risk of these products is runoff of granules into surface water, which can easily be mitigated by ensuring they are integrated into the turf canopy base, thereby rendering the granules immobile. As a further mitigation action, mowing shall be postponed by a minimum of two days from the date of fertilising to the date of mowing so that there is minimal pick up of fertiliser granules.

Foliar fertilisers shall be applied evenly using a motorised calibrated pedestrian sprayer with a 5 m wide boom.

Applications of fertiliser will be planned on a month-by-month basis, typically consisting of one application of controlled release granular fertiliser in one week and three weeks of foliar application in the intervening weeks. A nutrient budgeting spreadsheet shall be used for all calculations (Fig. 7).

Example fertiliser plan

Month	App. Code.	Fertiliser	App. Rate	Unit	Density (kg/L)	Nutrient											
						N	P_2O_5	K_2O	S	Ca	Mg	Fe	Mn	Zn	Cu	B	Si
Annual Nutrients (kg/ha)						**347**	**59**	**195**	**85**	**14**	**10**	**30**	**10**	**2**	**1**	**0**	**1**
Achieved ratio to N						1.0	0.1	0.6	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Target ratio to N						1.0	0.1	0.8	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	-
Jan	FL1	Foltech Cytozorb-S	20	L/ha	1.27	4		1			1	2	0	0			
	FL1	Foltec Nitroplast-S	20	L/ha	1.25	19	1	4				1	0	0	0		
	FL1	Foltech Fortify	10	L/ha	1.30	6				6		1	1				0
	FL2	Foltech Cytozorb-S	20	L/ha	1.27	4		1			1	2	0	0			
	FL2	Foltec Nitroplast-S	20	L/ha	1.25	19	1	4				1	0	0	0		
	FL2	Foltech Fortify	10	L/ha	1.30	6				6		1	1				0
	FG1	Andersons 20-2-16	200	kg/ha	1.00	18	18	5	7			2	0	0	0		
						49	16	10	14	2	0	5	1	0	0	0	0

Fig. 7. Example monthly fertiliser plan

During the grow-in period of each new turf surface, the fertiliser requirements are likely to be higher than those used on mature turf, for example 250-300 kg/N/ha/yr for the first year compared with 160-250 kg/N/ha/yr for subsequent years. On newly established areas, it shall be standard practice to use only controlled-release fertilisers as these products reduce leaching risk under potentially high leaching conditions by only drip feeding the young grass plants over an extended period (typically 6-8 weeks).

All fertilisers applied shall be uniform in composition, free flowing where relevant and suitable for application with approved equipment. Fertilisers shall be delivered to the site in their original packaging with legible intact labels showing guaranteed nutrient analysis. Only mini-prill fertilisers shall be used in order to minimise granule pickup by mowers and potential run-off.

Fertilisers applied shall be specifically registered for use on turf surfaces.

Soil nutrient testing to 75 mm depth shall be carried out six months from establishment by a recognised soil testing service provider using one bulk sample per pitch area. The Head of Turf

Operations shall modify the nutrient programme of maintenance fertilising based on the results of the soil tests and from specialist advice given by the Turf Expert and reviewed by the Turf Specialist. Results of each soil test shall be recorded and stored for future reference.

Fertiliser requirements shall be planned and agreed with a 'FACTS qualified' adviser who has completed training on turf nutrient planning. As a guideline for interpretation of soil test results using the base cation saturation ratio method (Carrow et al. 2001), the following nutrient and pH levels are recommended in order to enable planning of appropriate quantities of fertiliser application (excluding nitrogen for which there is no appropriate soil test):

Characteristic	Target level
pH	5.8-7.2
% K (base saturation)	3-6
% Ca (base saturation)	35-75
% Mg (base saturation)	5-15
% Na (base saturation)	0-5
P (µg/ml)	20-30
CEC (meq/100 g)	≥ 4
%Mg:%K	1-3 to 1
%Ca:%Mg	3-10 to 1

Note that other methods of soil test interpretation may also be used, for example the SLAN approach (sufficiency level of available nutrients).

All fertiliser applications shall be documented to record the following:

- location of applications
- type of fertiliser applied
- amount applied in kg per hectare
- date of applications
- product applied

All fertiliser applications made shall be recorded using STRI's bespoke TurfSync™ system (Fig. 4) or an approved equivalent system with the same functionality.

3.4 Irrigation

3.4.1 Operational objectives

Wastage of irrigation water shall be minimised by adopting an irrigation water budgeting approach for irrigation management:

Kai Tak Sports Park Public Sports Ground

Turf type:	Transitional
Rooting depth(mm)	150
Sports field area (m2)	7923

Month	*Average ETo (mm)*	*Estimated Kcrop*	*Kturf (mm)*	*Daily ETturf (mm)*	*Average rainfall (mm)*	*Effective rainfall (mm)*	*Irrigation requirement (mm)*	*Irrigation requirement (m3/0.8ha)*	
Jan	80.8	0.68	54.9	1.8	23.4	16.4	52.1	412	Cool
Feb	72.4	0.70	50.7	1.8	48.0	33.6	23.1	183	Cool
Mar	84.6	0.75	63.5	2.0	66.9	46.8	22.4	178	Cool
Apr	99.3	0.60	59.6	2.0	161.5	113.1	0.0	0	Transition
May	126.5	0.76	96.1	3.1	316.7	221.7	0.0	0	Warm
Jun	132.3	0.72	95.3	3.2	376.0	263.2	0.0	0	Warm
Jul	155.2	0.78	121.1	3.9	323.5	226.5	0.0	0	Warm
Aug	144.5	0.80	115.6	3.7	391.4	274.0	0.0	0	Warm
Sep	130.1	0.77	100.2	3.3	299.7	209.8	0.0	0	Warm
Oct	124.3	0.60	74.6	2.4	144.8	101.4	0.0	0	Transition
Nov	99.3	0.75	74.5	2.5	35.1	24.6	67.4	534	Cool
Dec	84.5	0.70	59.2	1.9	27.3	19.1	54.1	428	Cool
TOTALS	**1333.8**		**965.1**		**2214.3**	**1550.0**	**219.0**	**1735.0**	

Use of harvested rainwater for irrigation purposes is being investigated and shall be implemented where practical in order to minimise the need to use the town water supply. At present, only rainwater collected by the pitches will be harvested for re-use on the pitches. This aspect is covered in the Kai Tak Sports Park Stormwater Re-use Management Plan produced by Arup.

Irrigation water shall be applied to ensure satisfactory maintenance of the turf surfaces. Run-off, puddling, and wilting shall be prevented. As the new grass surface becomes established the frequency of irrigation shall be adjusted, according to the weather conditions, to encourage the development of a dense vigorous rooting system.

3.4.2 Application

Irrigation water shall be applied:

- to maintain a dense and actively growing turfgrass sward in a well-aerated rootzone
- to provide optimum moisture for the germination and establishment of newly sown grass
- to provide optimum playing conditions
- to periodically ‘wash’ the turf, flush the rootzone and remove excess salts
- to ‘syringe’ the surface during peak summer temperatures to minimise the risk of heat stress

Irrigation water on the PSG pitch shall be applied predominantly by automatic pop-up sprinklers.

Irrigation water on the Main Stadium pitch shall be applied predominantly by large format perimeter sprinklers and mobile (portable) rotors house on bespoke mounts.

The frequency and amount of irrigation water required shall be adjusted by the Head of Turf Operations in accordance with soil moisture monitoring and the schedule of events. Over irrigation and the subsequent production of an anaerobic rootzone shall be avoided. Weather forecasts and predictions shall also be part of the decision-making process on whether to irrigate or not.

Irrigation will generally be programmed to take place as close to the early morning as practicable. This practice minimises evaporation loss and allows the leaf surface to dry during the day.

Deeply penetrating infrequent watering cycles are the key to strong turfgrass development on a sand-based turf.

Major repair and routine servicing of the irrigation system shall be carried out by a specialist irrigation company if the maintenance contractor does not have the necessary in-house skills for this work.

The Head of Turf Operations shall be responsible for the day-to-day maintenance of the irrigation system. However, regular inspections, servicing and testing of all irrigation components shall be undertaken by a specialist irrigation company if the maintenance contractor does not have the necessary in-house skills for this work.

The Head of Turf Operations shall ensure that at least one member on each site has a sound knowledge of the type of irrigation system operated and is skilled in the basic servicing of minor components and connections. This shall include the servicing and installation of large format sprinkler boxes, travelling irrigators, pop-up sprinklers, valves and changing of sprinkler heads and nozzles.

The Head of Turf Operations shall ensure that the irrigation systems are operating correctly at all times. In order to achieve this, the maintenance contractor shall run the various irrigation systems every month on a test cycle. Any defects or problems including sprinkler replacement, major leak repairs, controller system malfunction or potential damage to turf surfaces through the operation of the irrigation systems shall be reported to the Supervising Officer.

3.5 Profile aeration/health management

3.5.1 Operational objectives

The profile of the PSG pitch shall be maintained in an aerobic state by using regular aeration that is customised for local site conditions, growing media available, sport being played, turfgrass species being managed and type of turf reinforcing system installed. Profile aeration will not be carried out on the Main Stadium pitch due to the temporary nature of the surface.

The micro-biological activity of the profiles shall be maximised through regular application of biologically-active soil conditioners and soil wetting agents.

Damage to the irrigation and turf reinforcing systems shall be avoided when carrying out profile aeration.

3.5.2 Profile aeration

A programme of regular aeration shall be determined by the Head of Turf Operations using machinery selected by the Turf Expert and approved by the Turf Specialist. The aeration programme shall be a reactive one, which means that it should be used in response to certain surface conditions and events scheduling (e.g. aeration should be carried out as soon as the majority of the surface of the PSG pitch has dried out after an event and leading into the next event).

Deep aeration shall include Verti-draining to 175 mm depth using 18 mm solid tines to relieve compaction. The number of operations should be limited given the hybrid carpet installations with shallow aeration being preferred.

Shallow-aeration shall include using a Toro Procore 840 or approved equivalent.

Routine aeration operations will be undertaken as required depending on usage schedules and pitch conditions.

All irrigation infrastructure within the Field of Play for the PSG pitch (sprinkler heads, valve boxes etc) shall be marked out on the surface prior to aeration, to avoid accidental damage.

3.5.3 Profile health management

A programme of regular application of organic soil conditioners and wetting agents shall be specified by the Head of Turf Operations from the supplied list of products selected by the Turf Expert and approved by the Turf Specialist in the Pitch Management Manual.

As a guideline, soil conditioners are expected to be applied to the PSG pitch a minimum of twice per year. Wetting agents are expected to be applied up to six times per year.

3.6 Disease and pest management and growth regulation

3.6.1 Operational objectives

The natural turf surfaces shall be maintained using an integrated turfgrass management approach (i.e. routine dew removal, mowing when the surface is dry, avoidance of long periods of leaf wetness, avoidance of excessive nitrogen application), in conjunction with a preventative fungicide programme,

customised for local site and environmental conditions, growing media available, sport being played and turfgrass species being managed.

The Head of Turf Operations shall be able to readily identify and treat with appropriate fungicides the principal turfgrass diseases likely to affect the playing surfaces, including, but not necessarily limited to: pythium (damping off), grey leaf spot (*Pyricularia grisea*), dreschlera leaf spot (melting out), microdochium patch (fusarium) and rust (*Puccinia* spp.), brown patch (*Rhizoctonia* spp.), dollar spot (*Sclerotina homoeocarpa*), and spring dead spot.

The Head of Turf Operations, Turf Expert and Turf Specialist shall continually assess the requirement for applying fungicides with the overall goal of reducing dependency on fungicide application and minimising the risk of resistance to fungicide application.

The types of pesticides registered for use on turf in Hong Kong and likely to be used for the Project are listed in Appendix 3.

3.6.2 Disease and pest management

A full Integrated Pest Management (IPM) programme shall be implemented to limit the quantities of pesticides used in the management of the turf surfaces. IPM encourages the use of all available prevention and control methods to keep pests and diseases from reaching damaging levels. The goal is to produce a good turf and minimise the influence of pesticides on humans, the environment and the turf. IPM methods include:

- use of well adapted grasses
- proper use of cultural practices such as watering, mowing, and fertilisation
- proper selection and use of pesticides when necessary

When any turfgrass problem occurs, the cause must first be correctly identified. Early detection and prevention, or both, will minimise pest damage and disease incidence, saving time, effort and money. If the cause is found to be a weed, disease or pest, non-chemical control methods should initially be considered (e.g. hand weeding). If these are not applicable, the safest (in terms of human exposure and effects on the environment) effective chemicals should be considered. When making such decisions, it is recognised that not all chemicals registered in Hong Kong are necessarily recommended for use in turfgrass management. At all times, long term effects, as well as short term controls, shall be considered when selecting pesticides and chemicals should be chosen which best fit into an IPM programme.

When chemical control is necessary, the proper pesticide shall be selected and applied when the disease or pest is most susceptible. Once a chemical has been identified, formulation and concentration shall be selected to maximise effect against the target while minimising risk of affecting non-target organisms and the environment. Before any control programme is initiated, the safety rules as advocated by the AFCD, FEHD and LCSD in their Code of Practice for the Safe and Proper Use

of Pesticides in Public Areas shall be considered. Only pesticides registered in Hong Kong shall be used. The Director of Agriculture, Fisheries and Conservation (DAFC) maintains a register of pesticides which includes a list of the active ingredient(s), maximum concentration limit and permitted formulations of all registered pesticides (see Section 2.6).

Where possible cultural controls and good turf husbandry shall be used to minimise fungicide use, including the use of pitch-side mobile fans. Note that IPM is a systems approach that should form the foundation of any type of sound turf management plan. This holds true whether the materials being used are organic or not.

The design of the Main Stadium means that there will be reduced light conditions in winter, coupled with reduced airflow across the pitch. Both situations will increase the risk of disease incidence on the pitch when a temporary natural turf surface is in place for events. As a consequence, the Main Stadium pitch will require artificial movement of air across its surface for strengthening of the grass blades, drying of the surface and for gaseous exchange around the growing point of the plant using a combination of the HVAC system in the stadium and proprietary pitch-side fans, the latter of which provide airflow over typical throw of 1.3-1.7 m/s up to a distance of 46 m (Fig. 8).

Average humidity levels in Hong Kong are high and frequently above 80% and will be higher in an enclosed stadium bowl. The ideal humidity for turfgrass growth is less than 60% at 25°C. High humidity levels and inability to dry the leaf surface is a recipe for turfgrass disease. Control of humidity is essential for this project and will be achieved using the Main Stadium HVAC system when the turf is *in situ*.

In order to allow optimum cool season turfgrass survival in the Main Stadium, air temperature will be maintained in the range of 20-25°C during the day and 15-20°C during the night. The diurnal variation in temperature is very important to minimise the risk of turfgrass disease and to allow optimum root and shoot growth.

Fig. 8. Proprietary pitch-side turf fans used to enhance air flow across a pitch.
A full-size rugby pitch will require a minimum of 10 units.

3.6.3 Growth regulation

The Head of Turf Operations shall manipulate the growth rate of the turf surfaces using plant growth regulators from the supplied list of products selected by the Turf Expert and approved by the Turf Specialist in the Pitch Management Manual in order to maximise the plant's photosynthetic capability and increase root growth. Growth regulation shall be carried out using plant growth regulators as registered by the Pesticides Ordinance (Cap. 133)[2].

Growth regulation shall be used as a means of enhancing the quality of turf by:

- increasing the chlorophyll content of the leaves
- reducing the evapotranspiration rate (and thus water demand) of the turf
- stimulating root growth
- reducing the frequency of mowing required (and thus the carbon footprint of the turf)

3.7 Controlling weeds

3.7.1 Operational objectives

The principal objective shall be to maintain or improve the agronomic, presentational and playing quality characteristics of the PSG pitch by using weed control practices that are customised for the

[2] https://www.afcd.gov.hk/english/quarantine/qua_pesticide/qua_pes_pes/qua_pes_pes_prc.html

local site conditions and turfgrass species being managed. Weed control shall not be practiced in the Main Stadium because turf will be expected to have been treated for weeds at source at the supplier's turf farm and be delivered to the Main Stadium in a weed-free condition.

The Head of Turf Operations shall manage the weed infestation of the turf surfaces using mechanical methods (hand pulling) in order to maintain weed infestation below threshold limits. Herbicides shall also be available as a last resort, chosen from the supplied list of registered products selected by the Turf Expert and approved by the Turf Specialist in the Pitch Management Manual.

3.7.2 Weed control management

The exact timing of all herbicide applications shall be determined by the Head of Turf Operations and shall be dependent upon weather conditions, time of year and condition of the grass.

Wherever possible the application of herbicide shall be timed so that it maintains a pitch in peak condition for any major competition or event which may be notified to the Head of Turf Operations.

The standard shall be to keep weed infestation of the playing surfaces and surrounds to less than 1% of total ground cover and to less than 5% of ground cover for grass weeds such as poa *(Poa annua*) and nut sedge (*Cyperus rotundus*).

Broadleaf weed control shall generally be expected to be carried out up to twice per year during periods of maximum grass growth and fertiliser applications to maximise effectiveness.

3.8 Pesticide storage and preparation

3.8.1 Pesticide storage

Pesticides shall be stored in compliance with relevant Ordinances and Regulations. In particular, requirements under the Pesticides Ordinance, Cap. 133, must be met. Chemicals should be kept in secure, well ventilated storage areas with adequate fire control and spillage containment facilities. Minimum requirements for the labelling and bottling of pesticides are stipulated in the Pesticides Regulations (Cap. 133A). These requirements are set out to safeguard the pesticide users, the general public and the environment.

The Head of Turf Operations shall provide staff with adequate training, through either on-the-job training or safety training courses organised by appropriate educational institutes, to ensure that all pesticide users are equipped with relevant technical knowledge of pesticide application with a view to maintaining a quality standard of service. The training standard should meet the need of different job nature, so that pesticide users can understand the information and instructions and acquire sufficient technical knowledge to discharge their duties in a safe and proper manner. The training of pesticide users should focus on the properties of pesticides in their routine use and the potential hazards that the pesticides may pose.

The Head of Turf Operations shall develop emergency procedures (e.g. action plans) for dealing with pesticide personal contamination, spillage, poisoning and fire.

A responsible person at the appropriate level shall be appointed to receive pesticide deliveries and to ensure prompt transport to the established storage facility. This person will also ensure all deliveries are in original, undamaged containers.

Any waste chemicals and/or containers shall be disposed of through a licensed waste collector in accordance with the Waste Disposal (Chemical Waste) (General) Regulations and the LCSD horticultural guidelines on use of turf management.

3.8.2 Pesticide application

The Head of Turf Operations shall control disease attacks on the turf surfaces using registered contact and systemic fungicides from the supplied list of products selected by the Turf Expert and approved by the Turf Specialist in the Pitch Management Manual.

All chemical treatments to control diseases, weeds and pests shall be applied using products that are suitable for use on bermudagrass and perennial ryegrass or any such grass type that is selected by the Turf Expert as appropriate. Where possible, pest control will only be carried out on the PSG pitch. This is because the turf will only be located in the Main Stadium for relatively short periods of time and often with the roof closed, thus reducing the likelihood of pest infection. Disease control may be carried out on the MS pitch as well as the PSG pitch.

It is envisaged that a preventative fungicide programme shall be implemented to ensure turf health.

All pesticide treatments shall be undertaken strictly in accordance with manufacturer's recommendations as listed on the pesticides label and relevant health and safety legislation (see Section 2.6).

Prior to application, the responsible parties shall check the application area and its periphery to assess the potential hazards, which may affect humans and the environment, in particular adjacent leisure facilities or residential areas.

The Head of Turf Operations shall ensure that the application operations are well-planned and arranged at times of low pedestrian flow, or if necessary, the application area may be temporarily closed for treatment purpose.

If it is necessary to carry out treatments when the application area is with a high pedestrian flow (e.g. during weekends or public holidays), the affected parties or on-site working staff should be informed in advance and provided with details of the operations for arrangement of appropriate precautionary measures. Chinese-English bilingual warning notices (e.g. poison, no-entry, the name of active ingredients of the pesticide, pesticide registration number, date and time of application etc.) should

be posted at conspicuous places before and after spraying. The application area shall also be clearly defined and isolated prior to operations to prevent public access.

Relevant Material Safety Data Sheets of the pesticides concerned shall be made available in case of emergencies.

Records shall be kept on pesticide stocks, analytical data and pesticide use. The Head of Turf Operations shall also keep reference material such as copies of relevant Ordinances, Material Safety Data Sheets and label information. The TurfSync™ system (or an approved equivalent system with the same functionality) shall be used to log all relevant procurement information, including, but not necessarily limited to:

- type of pesticide
- amount purchased
- date purchased
- name of supplier
- date of arrival
- received by

The TurfSync™ system (or an approved equivalent system with the same functionality) shall be used to log all relevant application information, including, but not necessarily limited to:

- suitability and nature of product
- method of application
- timing of application
- application rate
- soil/climatic conditions before application
- weather conditions following application
- management prior to application
- management following application

Spray equipment used shall be fitted with shrouds to prevent drift beyond the pitch or turf areas (for example, into the stadium bowl).

3.9 Monitoring pests

3.9.1 Operational objectives

The Head of Turf Operations shall monitor and assess for the likelihood of pest outbreaks on the turf surfaces by using insect traps and carrying out regular inspection of the MS and PSG pitches and looking for signs of surface disturbance.

The Head of Turf Operations shall be capable of readily identifying the principal turfgrass pests and the stage(s) in their life cycle when the pest is likely to affect the turf surfaces, including, but not necessarily limited to: mole crickets, armyworms, white grubs, greasy cutworms and sod webworms.

The Head of Turf Operations shall develop a programme of periodic sampling of stormwater to check for pesticide and nutrient residues. To this end, the 'EnviroSync' system currently being developed by STRI, EPG and Kisters is expected to be available for this project. This system is an intelligent sustainable water management system that provides reliable meteorological data and predictive weather data processing to help manage the use and release of stormwater. The EnviroSync system measures and monitors various parameters including but not necessarily limited to:

- water level
- rainfall actual and predicted
- water outflow rate
- water chemistry
- soil electrical conductivity

By using the above system, it is expected that it will be possible to confirm compliance with the requirement for 'dosage of pesticides and fertilisers to be controlled to limit any residual dosage to less than 10%'.

3.9.2 Pest monitoring management

A pest monitoring programme shall be developed by the Head of Turf Operations upon their appointment. Monitoring can be expected to include both airborne pests (e.g. moths) and soil-born pests (e.g. grass grubs in the larval stage) and shall include the use of sticky traps, flushing the rootzone in various test positions with an irritant solution of liquid soap (1-2 tablespoons of liquid soap in 5 L of water), and using insect emergent traps.

Frequency and location of sampling shall be based on the recommendations provided by Audubon International[3]. As a guideline, 'scouting' shall take place once a week using intervals of 20-30 m between sampling areas.

The threshold level of the number of insect pests above which control measures would be considered will generally be between 10 and 40 insect pests/m^2. For example, when flushing with the irritant solution, the number of caterpillars per m^2 brought to the surface can be counted. The threshold limit of 15 caterpillars per m^2 can be used for webworms before chemical treatment should be considered.

[3] Pest Monitoring: A Key to IPM for Turfgrass, Audubon International Fact Sheet on Chemical Use Reduction and Safety, 2006.

3.10 Perimeter overlay artificial turf maintenance

3.10.1 Operational objectives

The perimeter overlay runoff artificial turf surface in the Main Stadium shall meet the performance requirements of the latest edition of World Rugby Regulation 22 (current at the time of installation) at all times.

All maintenance and repair activities for the artificial turf shall comply with recommendations and approval of the artificial turf supplier and World Rugby guidelines.

The boundary of the artificial turf overlay system shall at all times marry seamlessly with the natural turf boundary. Surface regularity or evenness testing as per EN13036 (or ISO equivalent); no undulation greater than or equal to 10 mm under a 3 m straight edge.

3.10.2 Monitoring and inspection

The Head of Turf Operations shall develop a programme for regular monitoring and inspection of the artificial turf boundary in the Main Stadium. The programme shall provide a means by which any current and potential problems that the artificial surface could face are identified and registered.

Note that because the artificial turf perimeter will abut the natural turf playing surface, there will be a significant potential for natural turf products (e.g. grass clippings) to fall on the artificial turf surface. Hence the requirement to keep the artificial turf clean will be far greater than on a dedicated artificial turf pitch.

The artificial turf perimeter shall remain clear of debris, chemicals, stains, grass clippings, moss, weeds and any other forms of foreign matter which could degrade the condition and appearance of the surface.

Traffic on the artificial turf not associated with routine turf maintenance activities being carried out under the direct control of the Head of Turf Operations shall be managed using an agreed traffic management plan between the Head of Turf Operations, the Supervising Officer and the artificial turf supplier.

The Head of Turf Operations shall be aware of the load bearing capacity of the artificial turf overlay, and shall make an assessment, in conjunction with the supplier, as to when additional turf protection is required for non-conventional vehicles and static loads wishing to access the pitch area (e.g. stage structures etc).

3.11 Turf validation trial

3.11.1 Lay-and-play system

The final methodology for the turf trials are included within "200717 STRI - KTSP trial protocol Final (Rev 8)" which has been approved by TSC on the 18th of August 2020.

3.11.2 Background

Kai Tak Sports Park has been designed to provide a world class venue that can successfully host the widest possible range of sporting and non-sporting uses in the Main Stadium and Public Sports Ground. The range of sporting and non-sport uses includes:

- a natural turf pitch surface that allows the highest international standard for Association Football and Rugby Union – required in both Main Stadium and the Public Sports Ground
- a pitch surface that allows non-sports events at the Main Stadium such as concerts, other entertainment/corporate events and exhibitions
- a pitch surface that allows regular community sports use in both the Main Stadium and the Public Sports Ground

It is recognised that the challenges for producing high quality natural turf for the Main Stadium at the Kai Tak Sports Park require a level of turf management and a solution that is beyond the conventional. Hong Kong has an extremely difficult turfgrass growing climate, defined by periods of high temperature, high levels of humidity and intense rainfall events, heavy cloud cover and low light levels, heavy disease and pest pressure, and high levels of urban pollution.

This turf trial focusses on addressing five key design and performance criteria for the pitch strategy:

- recognising that the roof of the Main Stadium is an essential management tool to make the venue weather-proof under the Hong Kong climate
- designing a multi-purpose sports flooring system for the Main Stadium that allows ultimate flexibility for use
- accepting that the predominant mode of the Main Stadium is of an indoor arena, not a natural turf sports pitch in a stadium within which other events need to be tolerated
- using existing and developing natural turf technology as the core of the sports surface design for both the Main Stadium and Public Sports Ground
- addressing design risk by basing the natural turf component of the pitch strategy on first principles, that is:
    - what are the natural growing conditions for turf?
    - are they suitable for delivering this project?
    - if not, what realistically needs to be controlled to make the conditions suitable?

Based on the above considerations, the pitch strategy for the Stadium solution at Kai Tak Sports Park has to involve a removable 'lay-and-play' natural turf. This solution requires the availability of a turf supply that can provide the right type of turf for each event. Some of this turf may need to be based on a 'carpet type' hybrid turf reinforcement system in order to provide sufficient strength and rigidity for the intended movement and use of the turf. However, unreinforced turf may also be suitable for some natural turf events.

A preliminary trial investigating the suitability of a lay-and-play system was carried out by the Home Affairs Bureau (HAB) in conjunction with Asian Sportsturf Limited in 2017/18.[4] In this trial, four species of warm season turfgrass (bermudagrass, carpet grass, paspalum and zoysia) were evaluated on a range of different bases (on a sand base, on concrete with Terraplas turf protection panels and on concrete overlain with drainage cells). Apart from the cultivar of bermudagrass being used in the trial (local adaptation of Bermuda 419), it is not reported as to what cultivars of the other three species were used.

The preliminary trial concluded that:

- bermudagrass 419 is shortlisted as the preferred species for the turf solution
- testing in full sun and partial shade should be carried out in future trials
- testing with full automatic irrigation will provide a more controlled environment to allow for better testing of drought conditions
- testing of turf removal and reinstallation using commercial turf harvesting and laying machinery should be carried out in future trials

3.11.3 Approach

The objective of this turf trial is to validate the transportable natural turf lay-and-play system(s) proposed for use at the Kai Tak Sports Park. To meet this objective will involve the following steps:

1. Completing a desktop exercise using STRI's knowledge and previous experience combined with local knowledge and expertise for first selecting the most appropriate carpet hybrid turf reinforcement system(s) for evaluation in the trial
2. Completing a consultation exercise with local expertise for selecting and sourcing the most appropriate turf species and varieties for evaluation
3. Establishing a large scale, plot-based trial with several rounds of turf harvest and movement testing over a period of 12 months from sprigging of warm season grasses and over a period of 6 months from sowing of cool season grasses, before confirming the process for the full-scale validation.

[4] Turf Trial Report. Consultancy Services for Providing Expert Advice on the Operations of the Kai Tak Sports Park. Advisian Limited and KPMG Transaction Advisory Services Limited, February 2019, 46 pp.

4. Allowing for several periods of 'trial optimisation' during the entire period of the trial so that there is sufficient flexibility to improve or change treatments as the trial progresses – such optimisation will include:

    - evaluating the effect of a 'Permavoid' geocellular layer on the performance of the turf
    - testing for the effect of artificial wear on turf performance
    - testing for the effect of shade on turf performance
    - testing for the practicality of having a permanent artificial turf surface under the natural turf overlays
    - testing for the practicality of not using any turf reinforcement at all
    - investigating the option and viability of using a pure cool season turfgrass for the cooler part of the year

5. Allowing for pure warm season turf and pure cool season turf (winter period only) to be evaluated properly
6. Allowing for a parallel carpet hybrid trial to determine whether a hybrid provides benefits in terms of turf longevity when moved and whether there are any significant differences between two of the major hybrid products in terms of suitability for this project

In terms of the desktop exercise in Point 1 above, there are only three types of manufacture of carpet hybrid turf reinforcement systems available but even within each type of manufacture, there can be significant differences in carpet integrity, agronomic compatibility and likely carpet longevity. STRI has been researching hybrid turf reinforcement systems intensively over the last seven years and has established sound working relationships with many national and international turf suppliers of both cool season and warm season turf through multiple stadium projects.

STRI has increased this knowledge base by: reviewing the international academic research literature, conducting interviews with local and international turf managers managing different types of carpet hybrid reinforcement systems, carrying out physical visits to selected stadiums and turf producers – all with the aim of gathering as much site specific or near site specific information relevant to Hong Kong.

In terms of the consultation exercise in Point 2 above, during 2019 STRI liaised with and/or visited the following individuals or organisations to discuss the early stages of implementation of this trial:

- Cameron Hodgkins, Head (Sports Turf Management Section), Leisure and Cultural Services Department (main discussion points: ability to grow bermudagrass 419 all year round, recovery potential of 419 under conventional HPS lighting rigs; turf importation into Hong Kong, sand and gravel importation in to Hong Kong, minimising use of cool season oversowing, local contact information for turf contractors, weather and climate discussion)
- Darren Moseley, Director, Birkdale International Limited, Asian Sportsturf Ltd (main discussion points: turf trial construction capability, specialist equipment provider, possible trial location sites at existing sports facilities, turf maintenance contractor)

- Danny Potter, General Manager, Centaur Asia Pacific (main discussion points: supply of specialist turf equipment and consumables, including pitch ventilation systems and fans)
- Steve Wilson, Business Development Manager, Bernhard Asia (main discussion points: supply of specialist turf equipment and consumables, including grow lights, pitch fans and reel grinders)
- Sean Goodwin, Talbot Turf Supplies Ltd (main discussion points: machinery requirements for setting up a turf farm)
- Mark Shaw, Turf Business Manager, PGG Wrightson Turf (main discussion points: supply of turf seed and consumables)
- Pako Ip, Executive Manager, Tracks, The Hong Kong Jockey Club (main discussion points: performance of bermudagrass 419, track management, turfgrass growing conditions)
- Professor KC Chau (retired), Chinese University of Hong Kong (main discussion points: athletic field management)
- Jonathan Teo, Pitch Architect, Singapore Sports Hub (main discussion points: turf harvesting and laying for the Singapore Sports Hub stadium pitch, experience with hybrid reinforced vs. non-reinforced turf, experience with a dedicated turf farm, match preparation and play, turf species selection, use of artificial lights)

In terms of Point 4 above, it should be noted that Permavoid is an integral part of the proposed pitch strategy. This product has been researched by STRI since 2014 at its Bingley and Brisbane bases for use as the supporting layer for a temporary pitch (natural and artificial), as an environmentally sustainable drainage and water attenuation medium, as a means of supporting natural turf with a reduced rootzone depth, and for use in modular turf systems.

In terms of Point 5 above, cool season turf is currently included in this trial, even if only to demonstrate that use of this type of turf is not viable. There are two principal reasons behind this decision:

- First, the effect of placing a retractable roof on the reference design of the Main Stadium has been quantified using a 'Hemiview' light/shade analysis. The roof essentially creates a 'cool season growing environment' with respect to light levels (with the roof in open position). Furthermore, the roof structure Is likely to prevent a conventional transitional warm season/cool season turf management strategy from being viable inside the stadium due to the high levels of artificial lighting that would be required.
- Second, there are at least four, but potentially up to six, months of the year when cool season turf is viable in Hong Kong. A cool season turf can be established from scratch in as little as six weeks, which makes this turf option a realistic proposal for use in the Main Stadium at certain times of the year.

The cool season component of the trial includes a blend of cool season cultivars as recommended by one of the largest global seed producing companies DLF.

In terms of Point 6 above, it quickly became apparent in 2019 that to rely on testing only one hybrid product constituted a risk to the project, with so many different hybrid products now on the market. Furthermore, it was clear from the product reviews and visits carried out in 2019 that:

- some products were tied into a method management that would have been too expensive and/or unsustainable in Hong Kong
- the Singapore Sports Hub already had significant valuable experience using the 'XtraGrass' hybrid product in a genuine multiple lay-and-play operational strategy
- 'Playmaster' hybrid is a market leader and currently used at many top European football clubs, such as Juventus, Inter Milan and Athletico Madrid

Fig. 9. Grass species and variety trials being conducted in Doha by Aspire Sports Turf in preparation for the 2022 Football World Cup.

3.11.4 Growing media selection

Sports turf profiles require highly engineered and specified materials. This subject has been well researched and documented over the last 50 years (e.g. Adams and Gibbs, 1994; Baker, 2006; Gibbs, 2014; McIntyre and Jakobsen, 1998; Stewart, 1994).

The profile for the PSG pitch design will be based on a suspended water table profile, the basis of the widely-used USGA Green Section specification (Fig. 10)[5], but with two options. Option A, where the gravel drainage layer will be replaced by the Permavoid geocellular units (Fig. 11) to mitigate risks

[5] https://www.usga.org/course-care/digitalcollections/creating-usga-putting-green.html

from subsidence and to reduce excavation into the subbase, whilst retaining a drainage function. Option B will include a more conventional profile including a gravel drainage layer to provide lateral movement of water and attenuation with panel drains to channel water to the outlet. The inclusion of panel drains is to limit the amount of excavation and trenching required into the subbase.

For the MS pitch, the turf will be grown in the same sand-based growing medium as used for the PSG pitch.

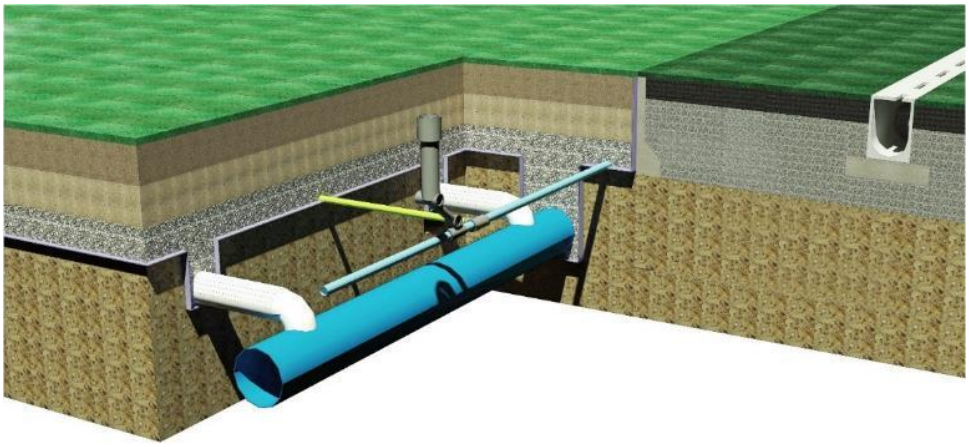


Fig. 10. 3-D visualisation of a conventional sand-over-gravel profile

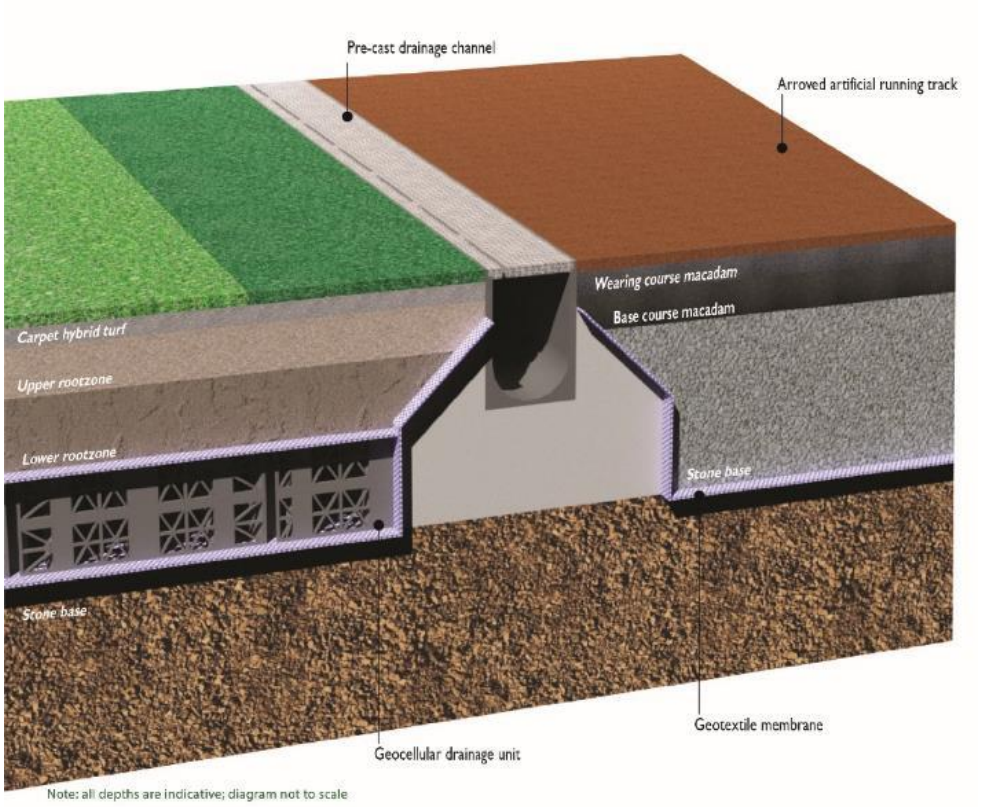


Fig. 11. 3-D visualisation of the Public Sports Ground pitch profile (option A)

The upper rootzone material (0-150 mm for the PSG pitch and 0-50 mm for the MS pitch) shall comprise an approved homogeneous mixture of fine-medium sand and approved organic amendment. The material is likely comply with the particle size range and physical characteristics specified below:

Sieve size (mm)	Acceptable Range (% passing)
8	100
4	100
2	98-100
1	95-100
0.5	65-95
0.25	20-45
0.125	5-10
0.063	0-5
0.002	0-2

i) Saturated hydraulic conductivity: ≥ 150 mm/h
ii) Total porosity: ≥35%
iii) Air-filled porosity at 30 cm tension: ≥15%
iv) Capillary porosity at 30 cm tension: ≥15%
v) pH: 5.5 to 7.0
vi) Organic matter content (by weight): 1.0 to 3.0 %

The above material specifications will be confirmed during set-up of the turf validation trial.

3.12 Environmental monitoring

3.12.1 Operational objectives

Environmental monitoring systems will be used to fine tune turf maintenance practices in order to manage the agronomic, presentational and playing quality characteristics of the pitches using the TurfSync pro system or an approved equivalent system with the same functionality.

The environmental monitoring systems will be used to help predict and manage the incidence of turfgrass diseases.

The environmental monitoring systems will be used to compile accurate and on-going reports of environmental data that can be used to benchmark stadium performance and turfgrass condition.

3.12.2 Monitoring equipment

The environmental equipment shall be capable of measuring the following characteristics:

- wind speed/direction
- vapour pressure deficit
- dew point
- relative humidity
- air temperature
- turf canopy temperature
- photosynthetically active radiation
- rainfall
- electrical conductivity/soil temperature/soil moisture

3.13 Major pitch renovation

3.13.1 Operational objectives

A major turf renovation operation will be required from time-to-time on the PSG pitch (e.g. every two to three seasons), depending on the schedule of events and turfgrass condition. Such an operation will involve stripping off the top of the turf surface with a Koro Field Topmaker (or similar approved implement), followed by intensive raking and complete re-establishment of the turf surface.

The objective will be to maintain or improve the physical properties of the profile by using only materials that are compatible with design specifications and existing sand profile features, ensuring that all renovation activities for any hybrid carpet reinforcement system comply with recommendations and approval of the supplier.

3.13.2 Procedure

Major turf renovation shall be required under one or more of the following typical scenarios:

- the hybrid carpet reinforcement system has become completely buried
- there is a requirement to reinstate the turf surface from scratch as a result of a specific event
- there is an unacceptable build-up of thatch and greasiness on the playing surface
- there is a requirement to transition the turf surface from a warm season turf to a cool season turf or vice versa

The timing of any major renovation shall be determined by the Head of Turf Operations in conjunction with the Turf Expert and Turf Specialist and agreement from the Supervising Officer.

Major pitch renovation shall involve the following activities:

- mowing the grass as short as possible but without damaging the hybrid carpet reinforcement system, and removing clippings
- loosening of the turf surface by working the pitch crosswise in multiple passes with a scarifying rake
- removing the top 10-20 mm of the pitch profile using a Koro Field Topmaker (or similar approved implement), being careful not to damage the hybrid carpet reinforcement system
- raking or brushing the surface
- mini-tine Verti-draining the surface
- supplying and applying renovation fertilisers
- dimple seeding or re-stolonising the surface using the approved turf variety
- supplying and applying 50 m^3 topdressing sand per ha (typical amount, may vary)
- brushing and dragmatting the surface
- managing turfgrass re-establishment

The precise extent and methodology of renovation repair may vary according to surface conditions and an analysis of the profile. Where appropriate, the proposed programme shall include consideration of any relevant soil test results.

3.14 Drainage management

The mean annual rainfall from 1981 to 2010 in Hong Kong is about 2400 mm. May to August are hot and humid with occasional showers and thunderstorms, particularly during the mornings. July and September are the months during which Hong Kong is most likely to be affected by tropical cyclones, although gales are not unusual at any time between May and November. On average, about 30 tropical cyclones form in the western North Pacific or China Seas every year, and about half of them reach typhoon strength. Heavy rain from tropical cyclones may last for a few days and subsequent landslips and flooding sometimes cause considerably more damage than the winds.

All of the above present risk for managing turf. For this reason, the GMP requires the Main Stadium roof to be closed to prevent the above rainfall from landing on the pitch. The effect of such high rainfall was experienced in the 2016 international derby match between Manchester United and Manchester City on the GreenTech ITM modular pitch at the Birds Nest Stadium in Beijing where the match was cancelled due to safety concerns following a heavy rainfall event[6].

Management of drainage water is dealt with separately in the Stormwater Re-Use Management Plan, produced by Arup.

3.15 Management of light levels (Main Stadium)

A 'Hemiview' light/shade analysis report was issued in March 2020 using a 3D architectural model of the design for the Main Stadium. The analysis provides an understanding of the architectural impact

[6] Manchester derby in China off after heavy rain leaves pitch unplayable http://www.bbc.com/sport/football/36881494

of the stadium roof on the GMP (a report summary is attached in Appendix 4). It should be noted that the original report discussed all potential operational modes including permanent and overlay pitch solutions and related turf management strategies.

In summary, the report states that the effect of placing a retractable roof on the Main Stadium would mean that the level of light (photosynthetically active radiation or PAR) reaching the pitch surface with the roof permanently in an open position create a 'cool season turf growing environment'.

Therefore, because the daily light integral (DLI) is below the required threshold a transitional turf management strategy within the stadium would simply not viable. However, temperature, humidity and ventilation levels will need to be controlled to offer any possibility of sustaining cool season turfgrass in the stadium bowl, particularly between April and August when natural turf events are likely to be held.

At this time too, the roof will need to be closed for spectator comfort and to avoid the risk of high rainfall intensities, so artificial turf lighting rigs would be required over the whole pitch if the turf is to be sustained for any length of time (e.g. more than two weeks). Such a scenario is totally impractical.

The alternative is to use pure warm season turfgrass in the stadium bowl between April and October. However, the 'Hemiview' analysis has shown that whilst warm season turfgrass would grow under the higher temperature and humidity levels, the level of shade is so high (even with the roof open) that the light required from lighting rigs for long term sustainable growth would exceed those that can be delivered by current lighting technology.

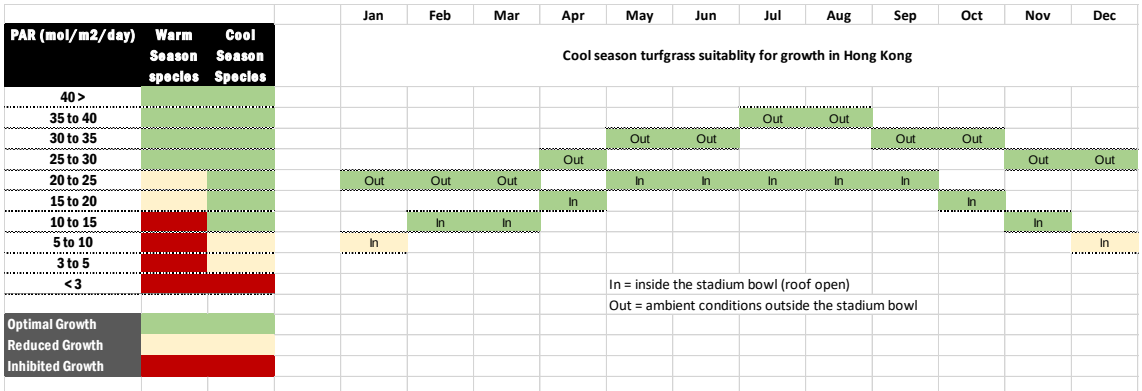


Fig. 12a. Estimates of photosynthetically active radiation (PAR) light levels inside and outside the Main Stadium bowl and suitability for growth for cool (C3) and warm season (C4) turfgrasses.

PAR (mol/m2/day)	Warm Season species	Cool Season Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Warm season turfgrass suitablity for growth in Hong Kong											
40 >														
35 to 40									Out	Out				
30 to 35							Out	Out			Out	Out		
25 to 30						Out							Out	Out
20 to 25			Out	Out	Out		In	In	In	In	In			
15 to 20						In						In		
10 to 15				In	In								In	
5 to 10			In											In
3 to 5														
< 3							In = inside the stadium bowl (roof open)							
							Out = ambient conditions outside the stadium bowl							
Optimal Growth														
Reduced Growth														
Inhibited Growth														

Fig. 12b. Estimates of photosynthetically active radiation (PAR) light levels inside and outside the Main Stadium bowl and suitability for growth for cool (C3) and warm season (C4) turfgrasses.

The key implication for pitch design and management is that a long-term permanent pitch design with a transitional turf management strategy would not be feasible with the current stadium architectural model, for the following reasons:

- The lighting rig deployment calculations indicate that the required DLI for sustainable growth would not be achievable even with the maximum application of conventional supplementary lighting rigs for eight months of the year.

- Maximum daily deployment required in any one month would be 28 days per month (in May), which is wholly impractical.

- A full 12-month growing period would require a maximum of 31 rigs assuming the roof was permanently open[7]. Additional equipment and infrastructure would also be required to manage the pitch.

- The deployment calculations represent a best case scenario; if turfgrass transition is not possible, the implications are that pitch management would be restricted all year round.

- Stadium orientation means that the southern end has low light levels imposed by stadium architecture.

Therefore, the pitch design has to include a transportable or overlay turf system.

[7] Running costs would be approximately £830,000 based on UK electricity prices (approx. HK$8.3M). The estimation is for reference only.

3.16 Turf laying

3.16.1 Operational objectives

Turf supplied from the supplier's turf farm to establish the Main Stadium natural turf playing surface shall be grown in an identical rootzone to the organic amended rootzone layer of the PSG pitch and be established and maintained with the same turfgrass as the PSG pitch.

Due to the nature of the Main Stadium and its heavy use, the turf farm shall be required to provide a large amount of turf at short notice to service the playing surface. Having access to the turf farm will also allow for sufficient renewal and establishment of new turf. The turf farm for the Main Stadium will have the capacity for two whole rugby pitch replacements plus 10 to 20%.

3.16.2 Turf harvesting quality monitoring

The sequence of events for monitoring the quality of turf for delivery to the Main Stadium is shown in Fig. 11.

1. The supply of turf is identified

2. Site visit to select turf harvest location and capture turf performance characteristics

3. Checking colour match of new turf

6. Assembling turf rolls for transport

7. Monitoring depth and evenness of surface removal

8. Delivery of turf rolls and storage at stadium

4. Approval for turf harvest

5. Turf farm harvest – checking depth of roll

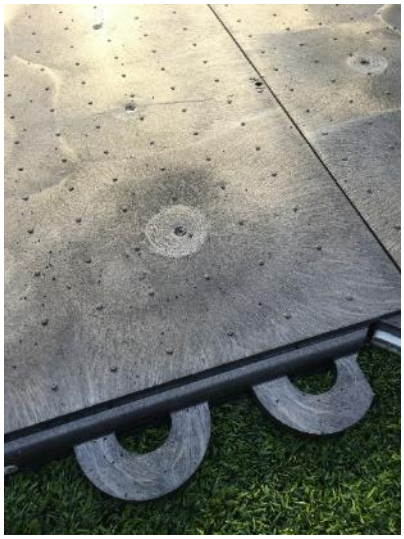
9. Turf installation monitoring

10. Turf installation monitoring

Fig. 11. Sequence of events for turf harvesting

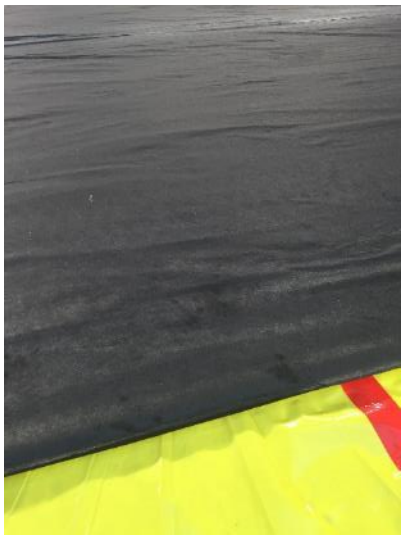
3.16.3 Turf laying

The provisional sequence of events for turf installation at the Main Stadium is shown in Fig. 12.

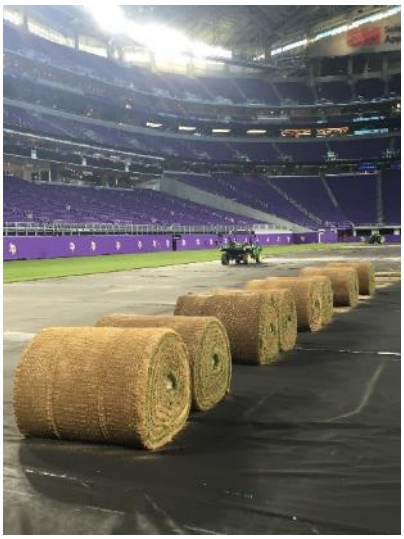


1. Proprietary turf protection system is placed over artificial turf

2. Impermeable sheeting prevents contamination of underlying artificial turf



3. Surface is then covered with shockpad



4. Big roll natural turf is delivered

5. Installation of big roll turf

6. Completed section of 50 mm thick big roll turf

Fig. 12. Sequence of events for establishing a natural turf mode in the Main Stadium

3.17 Reporting

The Head of Turf Operations shall provide a Quality Assurance Plan, demonstrating what formal monitoring will be carried out and a copy of all documentation that the Head of Turf Operations proposes to use in these monitoring procedures. This documentation will cover monthly inspection and report results on the following items:

- drainage/irrigation/usage issues
- renovation/repair work
- turfgrass health/condition
- condition of/issues with turf reinforcement and artificial turf perimeter
- traffic management and turf protection issues
- soil health/condition
- environmental and soil moisture monitoring

- details of improvements in or changes to the turfgrass maintenance programme
- details of approved variations
- formal inspections undertaken by the Head of Turf Operations
- progress and resolution of any issues and problem areas (e.g. staffing matters)
- overall performance and compliance with the contract documents
- summary of previous month's work
- overview of next month's work

The Head of Turf Operations shall maintain and provide to the Supervising Officer on request:

- an accurate schedule of work which has been carried out
- an accurate schedule of work presently being undertaken
- a detailed programme of work to be undertaken during the whole of the contract period
- records of any changes made to the specified maintenance programme

The detailed programme shall indicate what work will be undertaken at any point within the maintenance cycle and should be sufficiently detailed to enable the Supervising Officer to assess the implication of maintenance activities on planned sporting and non-sporting events.

The Head of Turf Operations shall draw to the attention of the Supervising Officer any inconsistencies which have been identified within the contract or specification.

The Head of Turf Operations shall maintain records of all fertiliser, soil amendment, wetting agent, and pesticide used including details of time, date, location, product, supervisor, applicator and environmental conditions at the time of application. and hard copy logs of all environmental and soil moisture monitoring. The Head of Turf Operations shall provide copies of all such records to the Supervising Officer as requested, and a summary of all such records in the monthly report.

The Head of Turf Operations shall keep a record of all inquiries/complaints plus follow up actions, if any. This should be made available to the Supervising Officer, upon request.

The Head of Turf Operations shall identify their monitoring processes and regimes within the Quality Assurance Plan.

The Head of Turf Operations shall submit their monthly report regularly as agreed with the Supervising Officer.

3.18 Reference material

Adams, W.A. and Gibbs, R.J. (1994). Natural Turf for Sports and Amenity: Science and Practice. CAB International, Cambridge, 404 pp.

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McCarty, L.B. and Miller, G. 2002. Managing Bermudagrass Turf: Selection, Construction, Cultural Practices, and Pest Management Strategies. Ann Arbor Press, Michigan, USA, 221 pp.

McIntyre, K. and Jakobsen, B. (1998). Drainage for Sports Turf and Horticulture, Horticultural Engineering Consultancy, Kambah, Australia, 162 pp.

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4.0 Summary of Mitigation Measures

Mitigation measures/ Good site practice		Implementation agents	Implementation Stage (Construction: C; Design: D; Operation: O)	Maintenance and management parties	Likely frequency
Disposal of organic waste (including but not limited to grass clippings and dead plant material/thatch)	Natural turf sports surfaces produce organic waste in the form of grass clippings and dead plant material/thatch. It is also common in hybrid or reinforced natural turf pitches to remove the upper part of the profile to reduce the build-up of organic material which may inhibit performance of the pitch. All of these materials will require proper disposal. The maintenance contractor shall comply with good practice and ensure that all these materials are disposed of in an environmentally friendly way. All the above materials are suitable for composting which should allow them to be re-used for general landscaping. Where possible it is recommended to compost this material for re-use in the landscaping industry.	Head of Turf Operations	O	Head of Turf Operations	Fortnightly
Pesticide use	Implement full Integrated Pest Management (IPM) programme to reduce the quantities of pesticides and chemicals used in the management of the pitch. Use of pesticides forms an integral part of turf maintenance; however, pesticides are not commonly applied on a regular basis but normally in reaction to certain climatic and ground conditions or as a result of a pest, disease, or weed being identified. The pitch maintenance contractor/groundstaff shall be properly trained in the use and application of pesticides and be ably trained in the identification of symptoms of turf disease, pest and weeds. Maintenance contractor/groundstaff shall follow pesticide label instructions and make reference to the local industry guidelines in	Head of Turf Operations	O	Head of Turf Operations	Fungicides – up to fortnightly (all venues) Insecticides and herbicides – six monthly (PSG only) Plant growth regulators – every four to six

Mitigation measures/ Good site practice		Implementation agents	Implementation Stage (Construction: C; Design: D; Operation: O)	Maintenance and management parties	Likely frequency
	relation to the application of pesticides on turf. Application of chemicals including pesticides shall only be undertaken when absolutely necessary ensuring only registered chemicals are used and applied at the manufacturer's approved dosage rate.				weeks (site specific)
Pesticide handling	The storage, use and handling of pesticides shall follow relevant laws and regulations, local industry standards and guidelines.	Head of Turf Operations	O	Head of Turf Operations	As required
Pesticide storage	Construct a suitable approved and certified chemical store capable of storing all required quantities of chemicals in a safe way. The store shall be constructed to local industry guidelines, in a suitable location, with the relevant local authorities including the fire services approval. The store as a minimum shall be bunded to allow containment of at least 110% of the overall capacity of the store (or in line with local industry guidelines), shall be sufficiently fire proofed, not be located close to any water course including drainage inlets/outlets, and not be located in any environmentally sensitive area. In order to reduce the quantities of chemicals stored, minimum stocking levels shall be maintained, carrying out regular stock checks, while maintaining adequate stock levels to allow for immediate applications of certain chemicals if required. Detailed records of all chemicals stored shall be kept and updated on a continual basis. It is recommended that a minimum of two copies of records are kept and updated with one located close to the store.	KTSP/ Head of Turf Operations	D, C and O	Head of Turf Operations	Six monthly inspection of shelving, drainage outlets, security etc Checking of stock levels – monthly Record keeping – updated with every application
Disposal of pesticide containers	All pesticide containers and packaging shall be disposed of in an environmentally friendly way in line with local industry standards. Containers shall be triple rinsed with rinsings sprayed back onto the	Head of Turf Operations	O	Head of Turf Operations	As required once a

Mitigation measures/ Good site practice		Implementation agents	Implementation Stage (Construction: C; Design: D; Operation: O)	Maintenance and management parties	Likely frequency
	target area ensuring not to exceed the product dose rate prior to recycling or disposal by a certified and licensed waste disposal contractor. Where this is not possible rinsings shall be sprayed out onto an approved bio-bed or placed back into a suitable sealable container properly labelled and disposed of by an approved licensed waste disposal contractor.				container is empty
Wash down area	A designated wash down area for all turf equipment shall be constructed. This shall be constructed with a suitable fully enclosed waste to water system. The pad shall be an area of hard standing with bunded edges and shall drain to a single discharge point which shall then connect to the waste to water unit so it can be treated. In addition, the wash down area and waste to water system shall be designed to allow for washing down of chemical/pesticide application equipment. It is critical that the waste to water system is designed to treat these types of materials.	Head of Turf Operations	C and O	KTSP/ Head of Turf Operations	Monthly inspection
Pitch maintenance equipment storage	Recommended to ensure suitably located, sized and secure maintenance facilities for storing all pitch maintenance equipment.	KTSP	D and C	KTSP	Six monthly inspection of security, shelving etc.
Fertiliser use	Use of fertilisers and plant nutrients forms an integral part of pitch maintenance. Fertilisers are normally applied to encourage growth and recovery of the grass plants and ultimately produce a healthy grass sward. The pitch maintenance contractor/groundstaff shall be ably trained in the use of fertilisers to help reduce over or under applications of fertilisers. The pitch maintenance	Head of Turf Operations	O	Head of Turf Operations	Granular applications – monthly (PSG only)

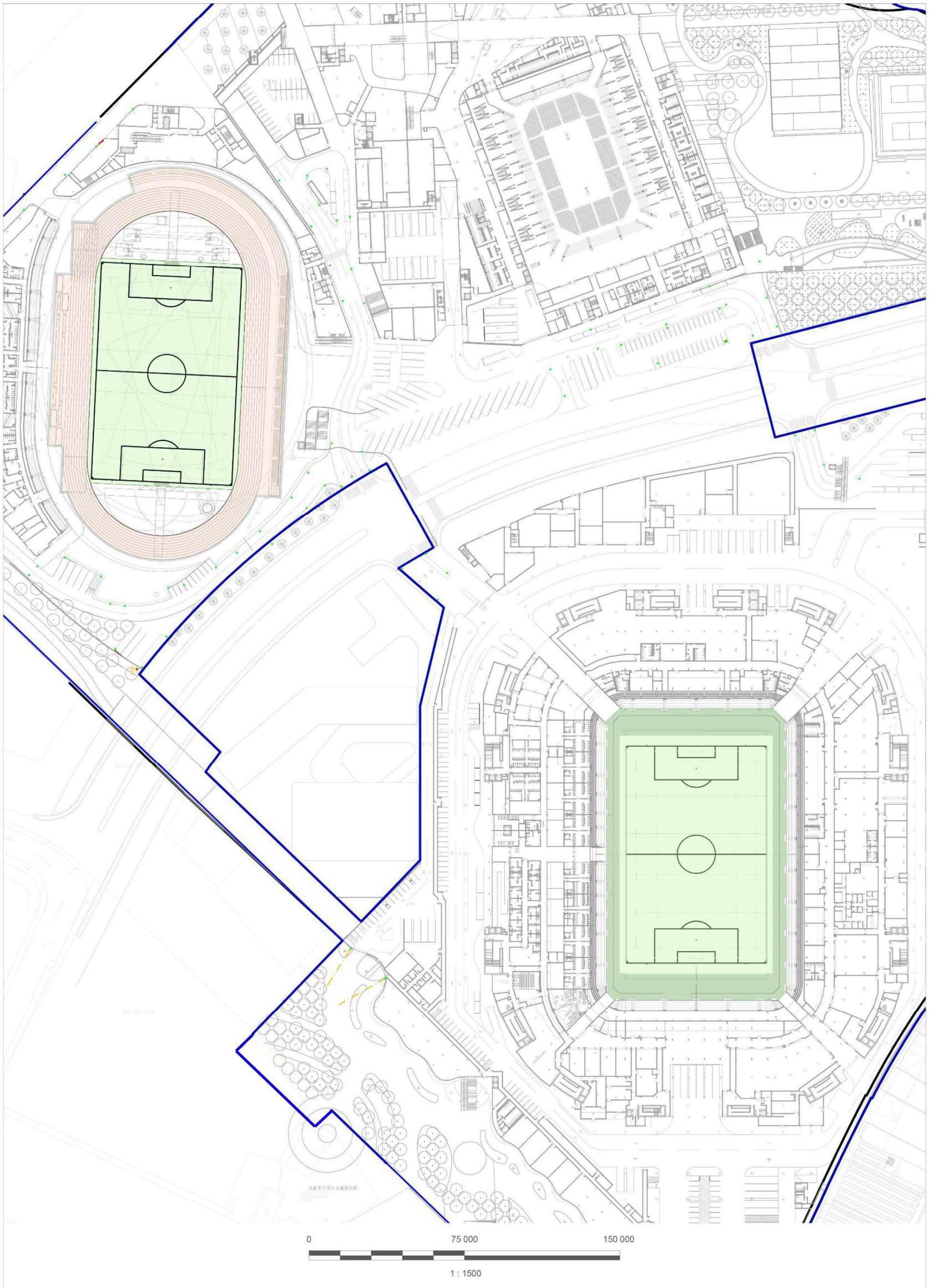
Mitigation measures/ Good site practice		Implementation agents	Implementation Stage (Construction: C; Design: D; Operation: O)	Maintenance and management parties	Likely frequency
	contractor/groundstaff shall follow industry guidelines in relation to the use and application of fertilisers on turf. It is important that the quantity of nutrient loss is minimised to prevent any impact on water quality.				Foliar applications – fortnightly (PSG only but will include MS when turf is in situ) Soil ameliorants and conditioners – monthly (PSG only but will include MS when turf is in situ)
Leaching of nutrients	In order to reduce the quantities of leachate it is recommended to: only apply fertiliser products during appropriate weather conditions, choose the correct type of product for the desired result (i.e. foliar feed or granular feed), only apply the required amount of product (don't over apply), apply products as per the product label and the manufacturer's recommendations. While the turf is installed within the stadium, both fertiliser and chemical applications shall be minimised and only applied if and when necessary. It is likely that when the turf is within the stadium, fertiliser applications will take the form of foliar feeds and with the main focus on pitch aesthetics.	Head of Turf Operations	O	Head of Turf Operations	See above

Mitigation measures/ Good site practice		Implementation agents	Implementation Stage (Construction: C; Design: D; Operation: O)	Maintenance and management parties	Likely frequency
	It is intended to intercept and store any drainage water or surface water from the pitch when it is in the stadium in order for this water to be treated.				

Note: in terms of grass management at the two sites, specialist turf sub-contractors shall be appointed by KTSP to carry out construction work of the trial site and PSG pitch. The turf trial will be managed by STRI using local turf management expertise as required. SMG are already appointed as event managers for the Project and they may appoint specialist sub-contractors and/or consultants to manage sports turf-related events. The Head of Turf Operations has yet to be appointed.

Appendix 1 – turfgrass areas covered by this Grass Management Plan

Public Sports Ground (top left) and Main Stadium (bottom right)



Appendix 2 – list of turf fertilisers

Product name	Granular/liquid	Controlled release	Readily available	Description	NPK	Rate per hectare	Typical number of applications per year	Product label	MSDS	Fact sheet	GHS signal word	Package size
General turf maintenance												
Nutri DG	Greens Grade Granular		Yes	Mag-tec™, 24% Mg	0+0+12	100-200 kg	4	Yes	Yes	Yes	Warning	25 kg
Nutri DG	Greens Grade Granular		Yes	Kal-tec®9.2% Ca, 2.0% Mg, 1.5% Mn	0+0+13	250-400 kg	4	Yes	Yes	Yes	Warning	25 kg
Nutri DG	Greens Grade Granular		Yes	3.0% Mn, 4.0% Mg, Bio-enhanced with Amvital™	0+0+25	150-300 kg	6	Yes	Yes	Yes	Warning	20 kg
Nutri DG	Greens Grade Granular	Yes		65% MUtech®, 0.3% Fe, 6.0% Mn	9+0+18	150-300 kg	2	Yes	Yes	No	Warning	20 kg
Nutri DG	Greens Grade Granular	Yes		50% MUtech®, 0.3% Fe, 0.5% Mn, 0.5% Mg	10+5+20	150-300 kg	2	Yes	Yes	Yes	Warning	20 kg
Nutri DG	Greens Grade Granular	Yes		50% MUtech®, 0.3% Fe, 0.5% Mn	12+24+8	150-300 kg	4	Yes	Yes	Yes	Warning	20 kg
Nutri DG	Greens Grade Granular	Yes		100% MUtech®	13+0+26	150-300 kg	2	Yes	Yes	Yes	Warning	20 kg
Nutri DG	Greens Grade Granular	Yes		60% MUtech®, 0.3% Fe, 0.14% Mn	18+9+18	150-300 kg	6	Yes	Yes	Yes	Warning	20 kg
Sustane	Organic Granular	Yes		Organic compost base and trace minerals	15+3+9	330 kg	4	Yes	Yes	Yes	Warning	22 kg
Sustane	Organic Granular	Yes		Organic compost base and mycorrhizal fungi	4+4+4	1250 kg	1	Yes	Yes	Yes	Warning	22 kg
Gypsum & lime												
DG Soil Enhancers	Sports Field Granular		Yes	Dispersible limestone, 30% Ca, 4% Mg, SGN 100	DG Lime	100-400 kg	4	Yes	Yes	Yes	Warning	25 kg
DG Soil Enhancers	Sports Field Granular		Yes	Dispersible gypsum, 21% Ca, SGN 100	DG Gypsum	250-500 kg	2	Yes	Yes	Yes	Warning	25 kg
Sea plant + amino acid based nutrients												
Fortify	Liquid		Yes	6% N, 6%Ca, 0.5%Fe, 0.5%Mg, 0.3%Si	6+0+0	10-20 L	8	Yes	Yes	Yes	Warning	9.45 L
Cytozorb-S	Liquid		Yes	0.53%Mg, 2.00%Fe, 0.25%Mn, 0.20%Mn	4+0+1	10-20 L	8	Yes	Yes	Yes	Warning	9.45 L
Tur-Gade	Liquid		Yes	0.50%Fe, 0.45%Mn	0+0+18	10 -22 L	12	Yes	Yes	Yes	Warning	9.45 L
Chlorofast-S	Liquid		Yes	2%Mg, 5%Mn	6+0+0	10-26 L	6	Yes	Yes	Yes	Warning	9.45 L
Nitroplast-S	Liquid		Yes	0.50%Fe, 0.18%Mn, 0.10%Zn, 0.10%Cu	19+1+4	10-38 L	12	Yes	Yes	Yes	Warning	9.45 L
NusioN	Liquid		Yes	No Trace	29+2+3	6-64 L	18	Yes	Yes	Yes	Warning	9.45 L
Minors	Liquid		Yes	1.50%Mg, 3.50%Fe, 0.75%Mn, 0.20%B	0+0+0	5-10 L	6	Yes	Yes	Yes	Warning	9.45 L
Ultramate LQ	Liquid		Yes	Humic acid 12%	0+0+0	9.4-14 L	18	Yes	Yes	Yes	Warning	9.45 L

Appendix 3 - list of registered pesticides, surfactants and wetting agents

Funigcides	Product name	Active ingredient	Type	Registration number	Company	Concentration	Recommended application rate	Typical number of applications per year	Product label available	MSDS available	Fact sheet available	GHS signal word	Application rates available	Package size
	Fore Rainshield	Mancozeb	Suspention concentrate	2P127	Amgrow	480 g/L	390 ml/100 m2	6	Yes	Yes	Yes	Caution	Yes	10 L
	Heritage Maxx	Azoxystrobin	Dispersible concentrate	2P287	Syngenta	95 g/L	60 ml/100 m2	3	Yes	Yes	Yes	Caution	Yes	1 L
	Banol	Propamocarb hydrochloride	Soluble concentrate	2P161	Bayer	600 g/L	55 ml/100 m2	3	Yes	Yes	Yes	Caution	Yes	1 L
	Captan	Captan	Wettable powder	2P37	Adama	800 g/kg	125 g/100 m2	3	Yes	Yes	no	Danger	Yes	10 kg
	Daconil WeatherStik	Chlorothalonil	Suspension concentrate	2P47	Syngenta	720 g/L	160 ml/100 m2	6	Yes	Yes	Yes	Caution	Yes	10 L
	Chipco Signature	fosetyl-aluminium	Water-dispersible granule	2P110	Bayer	800 g/kg	125 g/100 m2	3	Yes	Yes	Yes	Danger	Yes	2.25 kg
	Chipco GT	Iprodione	Suspension concentrate	2P119	Bayer	340 g/L	200 ml/100 m2	6	Yes	Yes	Yes	Caution	Yes	2.5, 5, 10 L
	Banner Maxx	Propiconazole	Emulsifiable concentrate	2P206	Syngenta	156 g/L	30 ml/100 m2	4	Yes	Yes	Yes	Caution	Yes	3 L
	Triumph	Metalaxyl-M	Soluble concentrate	2P314	Adama	240 g/L	25 ml/100 m2	3	Yes	Yes	Yes	Caution	Yes	1 L
Insecticides	**Product name**	**Active ingredient**	**Type**	**Registration number**	**Company**	**Concentration**			**Product label supplied**	**MSDS supplied**	**Fact Sheet**	**GHS signal word**	**Application rates supplied**	**Package size**
	Acelepryn	CHLORANTRANILIPROLE	Suspension concentrate	2P327	Syngenta	200 g/L	10 ml/100 m2	2	Yes	Yes	Yes	Warning	Yes	750 ml
	Agador	ABAMECTIN	Suspension concentrate	2P226	Syngenta	20 g/L	15 ml/100 m2	2	Yes	Yes	Yes	Danger	Yes	1, 5, 10 L
	Meridian	THIAMETHOXAM	Water-dispersible granule	2P313	Syngenta	250 g/kg	10 g/100 m2	2	Yes	Yes	Yes	Warning	Yes	1 kg
	Compel	BIFENTHRIN	Emulsifiable concentrate	2P240	Amgrow	100 g/L	30 ml/100 m2	2	Yes	Yes	Yes	Warning	Yes	5 L
	Pride	IMIDACLOPRID	Suspension concentrate	2P256	Amgrow	200 g/L	25 ml/100 m2	1	Yes	Yes	Yes	Warning	Yes	1 L
Herbicides	**Product name**	**Active ingredient**	**Type**	**Registration number**	**Company**	**Concentration**			**Product label supplied**	**MSDS supplied**	**Fact sheet**	**GHS signal word**	**Application rates supplied**	**Package size**
	Barricade	PRODIAMINE	Water-dispersive granule	2P312	Syngenta	65 g/kg	6.3 g/100 m2	1	Yes	Yes	Yes	Caution	Yes	8.16 kg
	Monument	Trifloxysulfuron-sodium	Water-dispersive granule	2P308	Syngenta	75 g/kg	2.5 g/100 m2	3	Yes	Yes	Yes	Caution	Yes	25 g
	Drive XL	QUINCLORAC	Wettable powder	2P173	BASF	180 g/L	46 ml/100 m2	2	Yes	Yes	Yes	Warning	Yes	5, 10, 20 L
	Monopoly	MSMA	Soluble concentrate	2P124	Amgrow	720 g/L	33 ml/100 m2	4	Yes	Yes	Yes	Danger	Yes	10 L
	Ronstar	OXADIAZON	Granular	2P141	Bayer	20 g/kg	2 kg/100 m2	1	Yes	Yes	Yes	Poison	Yes	15 kg
Plant growth regulators	**Product name**	**Active ingredient**	**Type**	**Registration number**	**Company**	**Concentration**			**Product label supplied**	**MSDS supplied**	**Fact sheet**	**GHS signal word**	**Application rates supplied**	**Package size**
	Primo Maxx	TRINEXAPAC-ETHYL	Emulsifiable concentrate	2P222	Syngenta	120 g/L	10 ml/100 m2	8	Yes	Yes	Yes	Caution	Yes	5 L

Surfactants & wetting agents	Product name	Active ingredient	Type	Registration number	Company	Concentration			Product label supplied	MSDS supplied	Fact sheet	GHS signal word	Application rates supplied	Package size
	Revolution	Modified Alkylated Polyol	Liquid form	N/A	Aquatrols	100%	185 ml/100 m2	6	Yes	Yes	Yes	Caution	Yes	208 L
	Primer	Alkoxylated polyols	Liquid form	N/A	Aquatrols	100%	125 ml/100 m2	6	Yes	Yes	Yes	Caution	Yes	208 L
	LeafSheild Anti-Transpirant	Parrafin	Liquid form	N/A	Aquatrols	14.86%	50 ml/100 m2		Yes	Yes	Yes	Danger	Yes	208 L
		Oxidized Polyethylene				7.42%								
		Ethoxylated Nonylpheno				7.42%								
		Potassium Hydroxide				0.16%								
	Capsil Nonionic Surfactant	Polyether	Liquid form	N/A	Aquatrols	100%	175 ml/400 L	45	Yes	Yes	Yes	Caution	Yes	3.8 L
	DeSaltus	Polymaleic Acid	Liquid form	N/A	Aquatrols	50%	100 ml/1 L	3	Yes	Yes	Yes	Danger	Yes	1022 L

Appendix 4 – summary hemiview report for Main Stadium reference design

A 'Hemiview' light and shade analysis was carried out using a 3D architectural model of the reference design for the Main Stadium (Fig. A1). The analysis provides an understanding of the architectural impact of the stadium on the pitch strategy.

This analysis included the following elements:

- Stadium roof information – outlining the extent of roof analysed, materials within the roof and other factors
- Light gradient mapping – calculation of modelled photosynthetically active radiation (PAR) light levels throughout the year imposed by stadium architecture
- Deployment position options – calculation of predicted levels of supplementary lighting that would be required to mitigate the effects of stadium architecture on turfgrass growth
- Summary – outlining key considerations for the Main Stadium pitch design

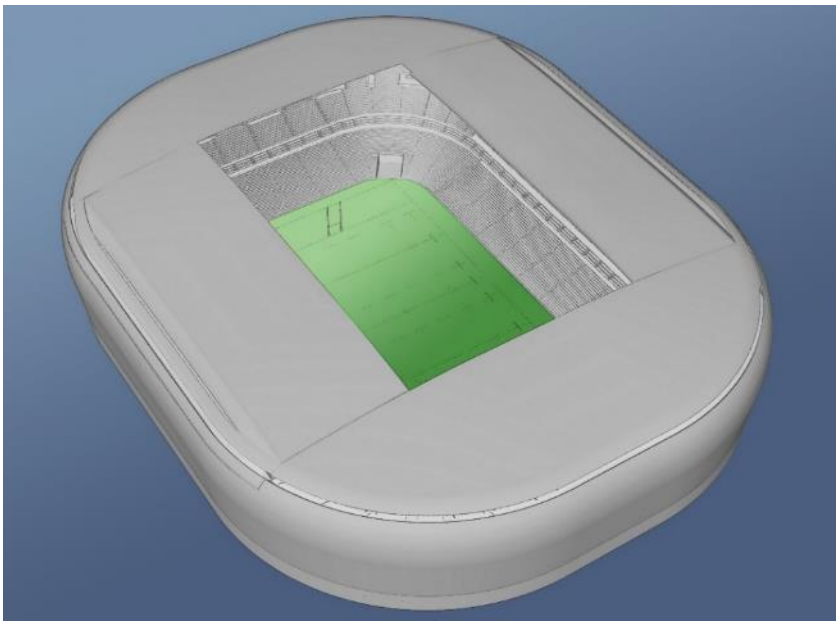


Fig. A1. Stadium render from detailed 3D model

The 3D model is of a conventional rectangular oculus with a dripline that follows the pitch edge. The stadium roof is a relatively high measuring almost 52 m at its highest point. The roof opening measures approximately 86 x 140 m, and the roof is shaped meaning that roof heights are not constant.

For the analysis, it has been assumed that the roof cladding is slightly opaque as that is how it appears both on the model and the renders provided.

Fig. A2 illustrates the solar track (in red) from the viewpoint of the pitch surface looking up.

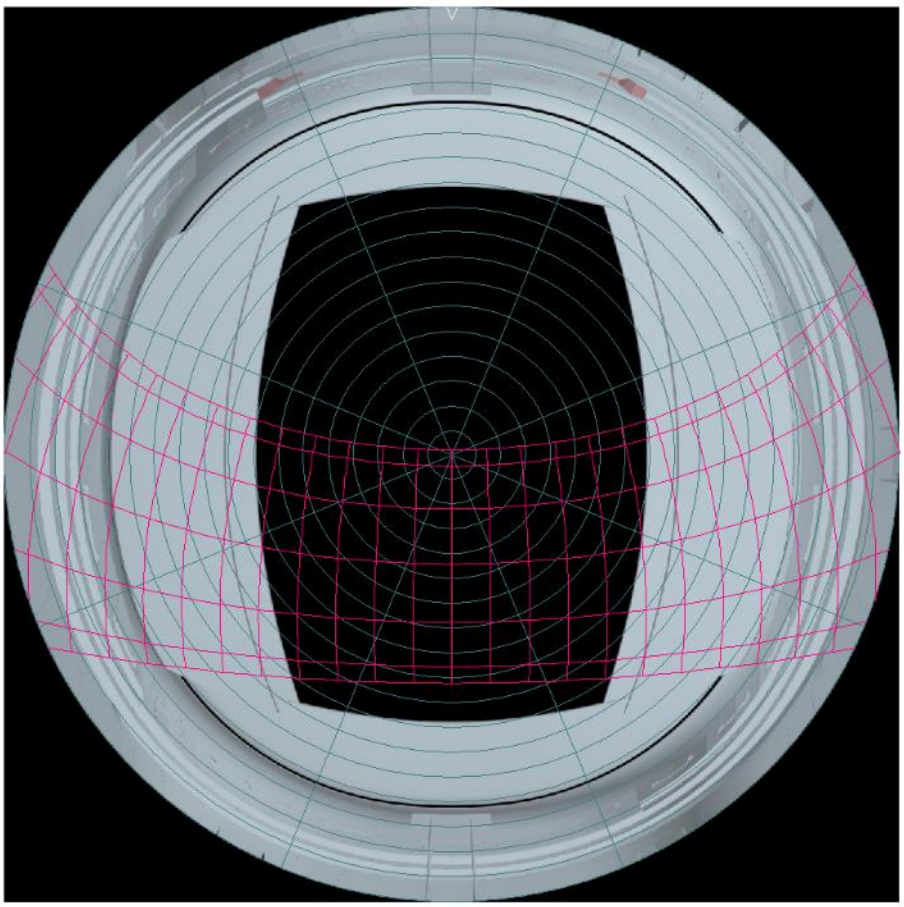


Fig. A2. Roof extent and solar track for each month of the year (image taken from pitch centre)

Results of the analysis are shown in Fig. A3. They show that the required DLI* for warm season turf of around 35 mol/day of PAR for active growth is not achievable within the stadium bowl even with the roof open permanently. Instead, the PAR light levels are more in line with the cool season turf DLI requirement of a minimum of around 10 mol/day of PAR for active growth.

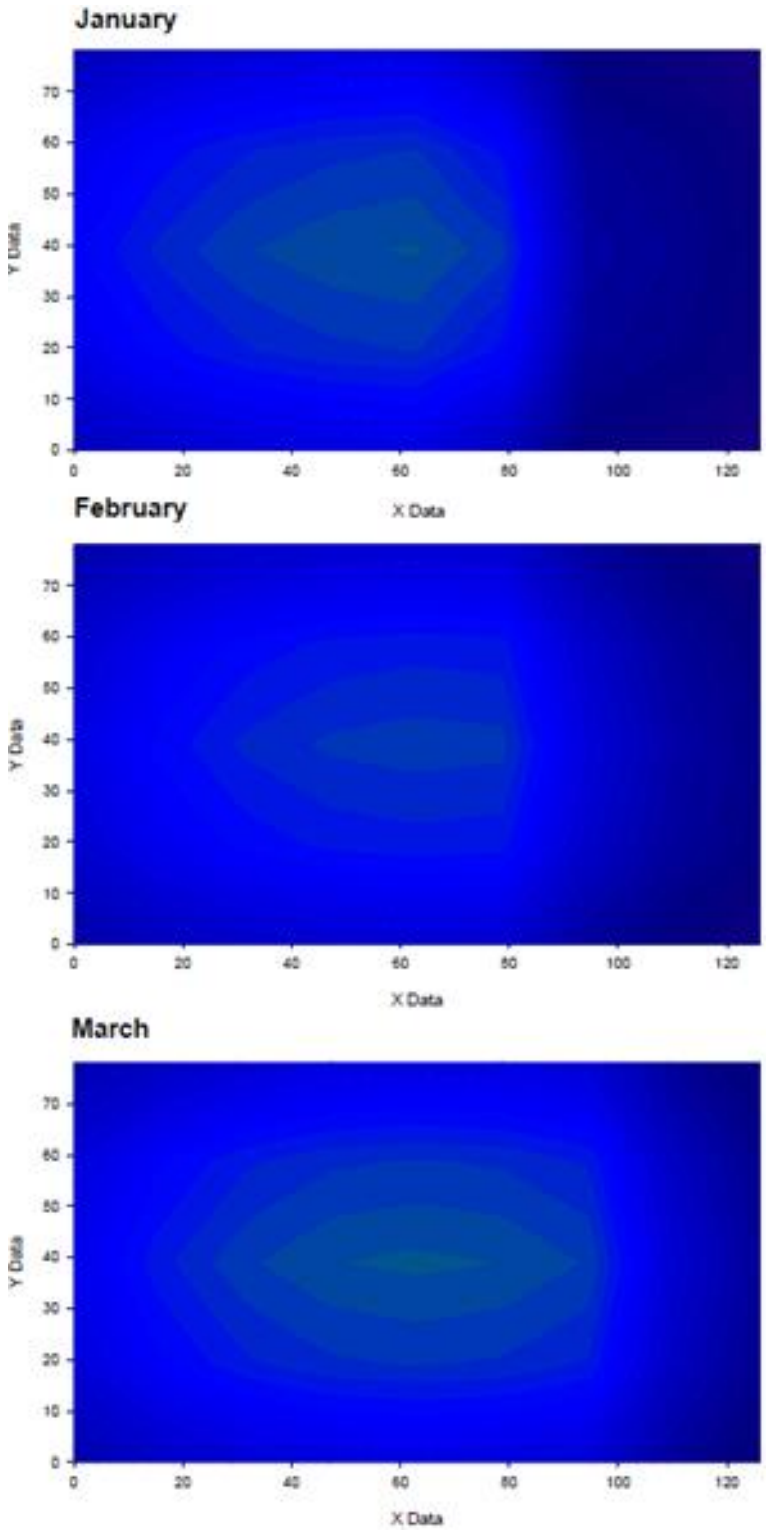
Theoretical target DLI values have been used to assess whether turfgrass could be managed in transition between warm and cool season grass types in the Main Stadium environment (warm season from May to October and cool season from November to April), by deploying supplementary pitch lighting rigs to make up the shortfall in light. The DLI target values were based on a maximum of 35 mol/day between May and August inclusive, and between 12 and 30 mol/day for the remaining months during transition.

The deployment plan calculations show that the target DLI is not achievable for long periods during the summer months even when using supplementary lighting rigs at normal operational levels (Fig.A4). Normal operational levels of supplementary lighting would be when match play, match preparation, maintenance and other operational requirements are factored into the

schedule. The maximum number of days that a lighting rig may be operational in any month is nominally set at 22 days per month.

From the deployment calculations in Fig.A4, it can be seen that all months between March and October inclusive have some areas of the pitch that exceed the maximum deployment possible with current lighting rig technology. Moreover, up to 31 lighting rigs would be required, a wholly impractical number. In contrast, if the Main Stadium pitch was managed as a pure cool season turf, then target light levels would be wholly achievable and only four lighting rigs would theoretically be required (Fig.A5).

**Daily light integral*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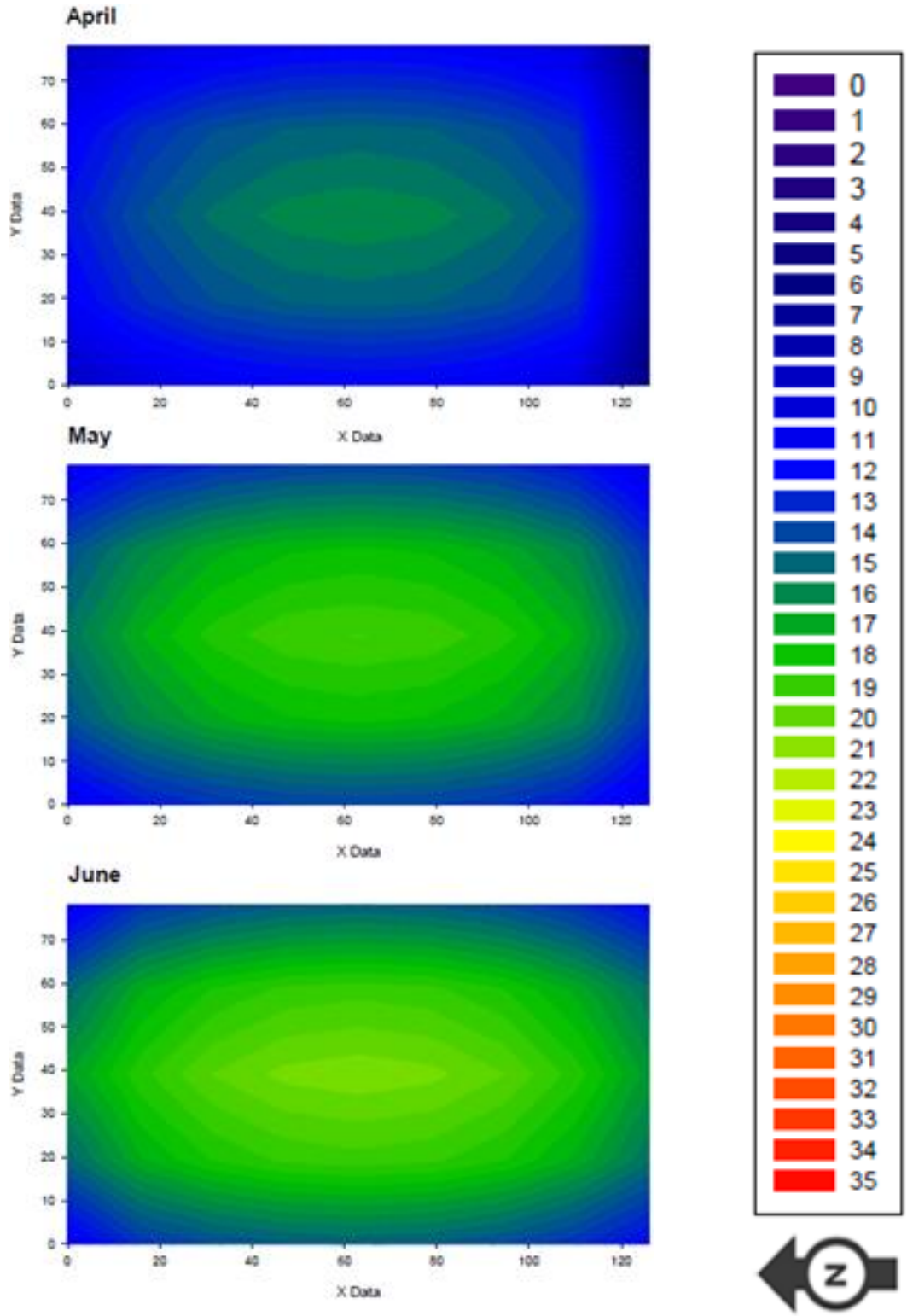
February
Y Data
X Data
March
Y Data
X Data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May
June
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X Data
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60
80
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120
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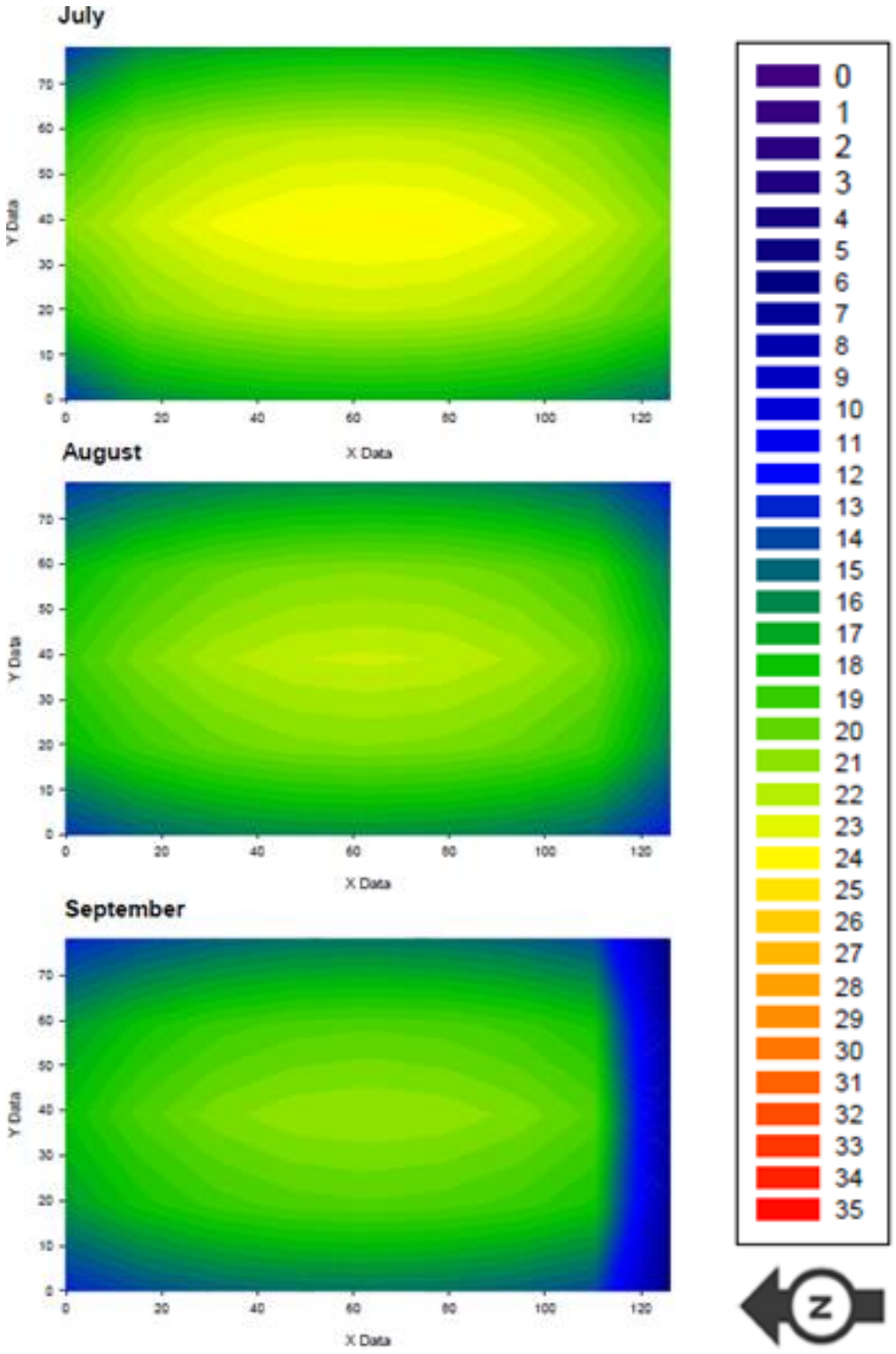
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August
September
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X Data
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40
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60
70
0
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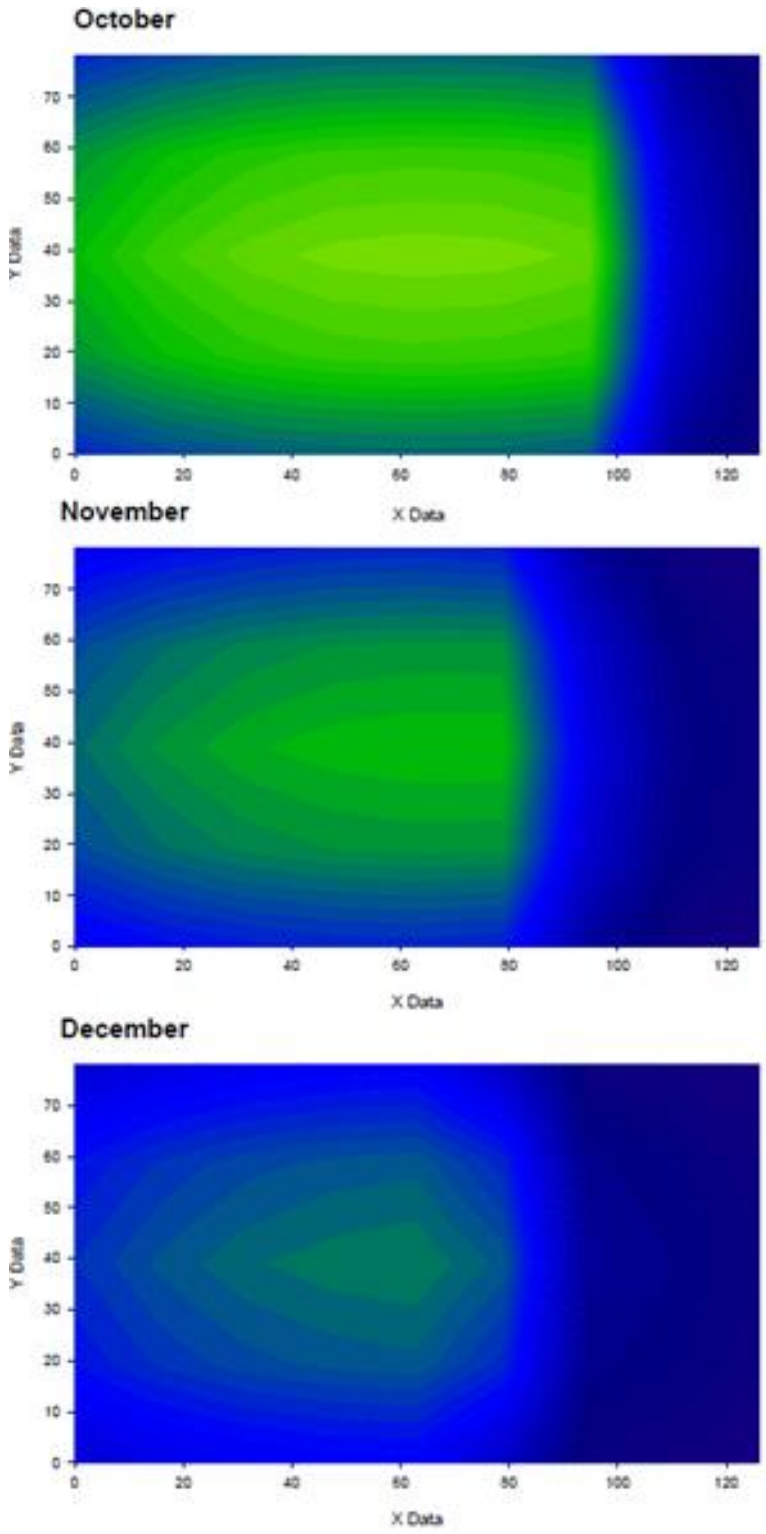

Fig. A3. PAR light contour maps for the reference design for the Main Stadium (with roof open). Units are mol/day of photosynthetically active radiation (PAR).

Kai Tak Sports Park Main Stadium C3/C4 Transition Lighting Rig Deployment

Deployment Positions

	1	2	3	4	5	6	7	8
N	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24
	25	26	27	28	28	30	31	32

S

January							
4	2	1	1	2	7	11	12
1	0	0	0	0	4	9	11
1	0	0	0	0	4	9	11
4	2	1	1	2	7	11	12

February							
17	15	15	14	14	16	20	22
15	13	12	11	11	14	18	21
15	13	12	11	11	14	18	21
17	15	15	14	14	16	20	22

March							
27	25	24	23	23	24	27	31
24	22	20	20	20	20	24	29
24	22	20	20	20	20	24	29
27	25	24	23	23	23	27	31

April							
32	30	29	28	28	29	30	35
29	26	25	24	24	25	26	33
29	26	25	24	24	25	26	33
32	30	29	28	28	29	30	35

May							
37	35	34	33	33	34	35	38
33	31	29	29	29	29	31	34
33	31	29	29	29	29	31	34
37	35	34	33	33	34	35	38

June							
35	32	31	30	30	31	32	34
30	28	26	26	26	26	28	30
30	28	26	26	26	26	28	30
35	32	31	30	30	31	32	34

July							
31	28	27	27	27	27	28	30
25	23	21	21	21	21	23	25
25	23	21	21	21	21	23	25
31	28	27	27	27	27	28	30

August							
33	31	29	29	29	29	31	34
28	26	24	24	24	24	26	29
28	26	24	24	24	24	26	29
33	31	29	29	29	29	31	34

September							
25	23	22	21	21	22	23	32
20	18	17	16	16	17	18	29
20	18	17	16	16	17	18	29
25	23	22	21	21	22	23	32

October							
17	16	15	14	14	15	22	32
13	11	10	9	9	10	19	30
13	11	10	9	9	10	19	30
17	16	15	14	14	15	22	32

November							
12	11	10	9	9	15	22	25
8	7	6	5	5	11	20	24
8	7	6	5	5	11	20	24
12	11	10	9	9	15	22	25

December							
1	0	0	0	0	6	12	13
0	0	0	0	0	3	10	11
0	0	0	0	0	3	10	11
1	0	0	0	0	6	12	13

Deployment positions where it is possible to achieve target DLI without any supplementary lighting rigs.

Deployment positions where it is possible to achieve target DLI with minimal supplementary lighting rigs.

Deployment positions where it is possible to achieve target DLI with 'normal operational levels' of supplementary lighting rigs.

Deployment positions where it is not possible to achieve target DLI with 'normal operational levels' of supplementary lighting rigs.

Fig. A4. Predicted deployment of 1000W supplementary lighting rigs in days per month for each deployment position required to meet the DLI for a cool season/warm season (C3/C4) transitional turf management strategy in the Main Stadium (with roof permanently open).

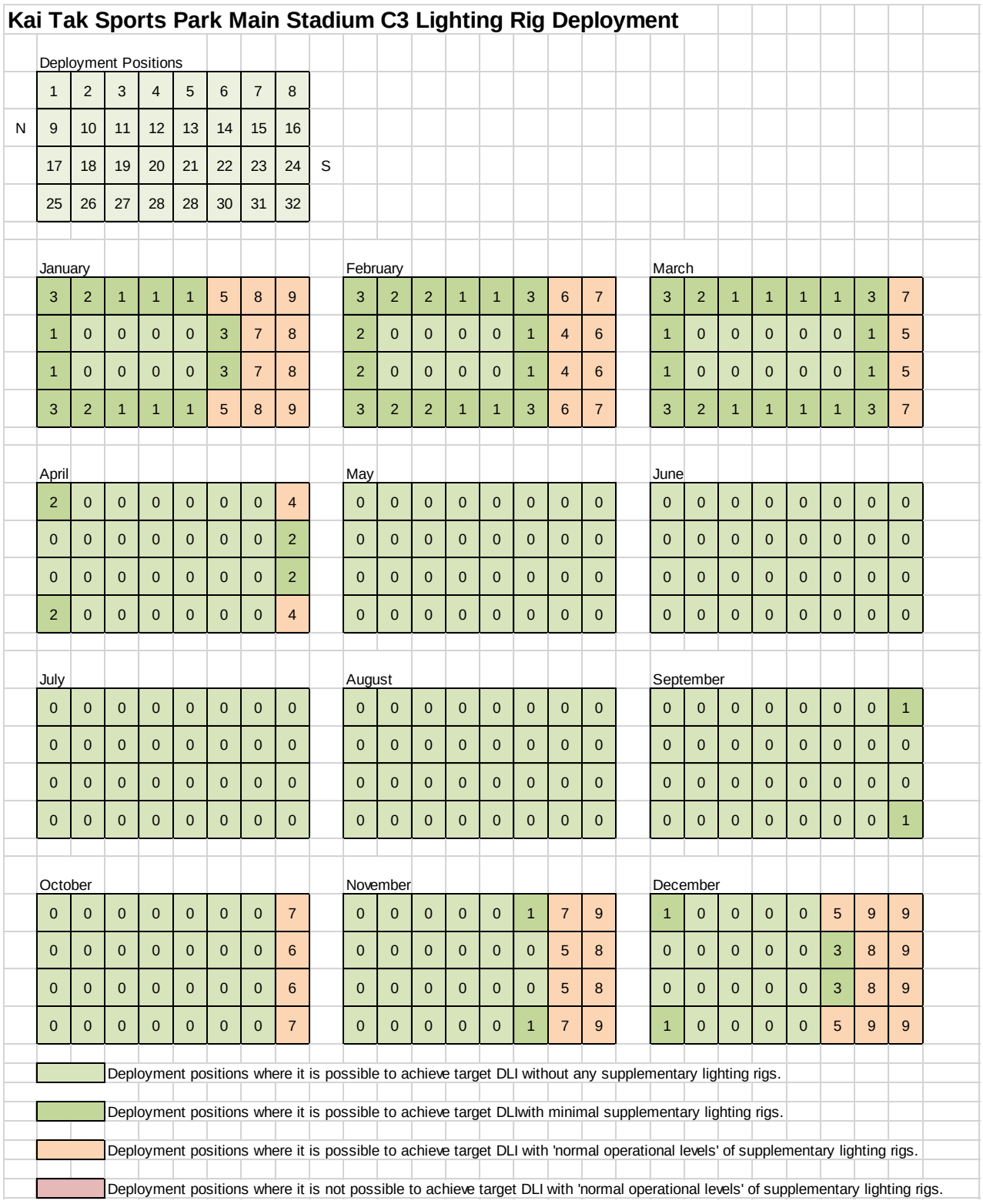

Fig. A5. Predicted deployment of 1000W supplementary lighting rigs in days per month for each deployment position required to meet the DLI for a cool season (C3) turf management strategy in the Main Stadium (with roof permanently open).

The key implication for pitch design and management is that a long term permanent pitch design with a transitional turf management strategy would not be feasible with the current stadium architectural model, for the following reasons:

- The lighting rig deployment calculations indicate that the required DLI would not be achievable even with the maximum application of conventional supplementary lighting rigs for eight months of the year.
- Maximum daily deployment required in any one month would be 28 days per month (in May), which is wholly impractical.
- A full 12-month growing period would require a maximum of 31 rigs assuming the roof was permanently open[8]. Additional equipment and infrastructure would also be required to manage the pitch.
- The deployment calculations represent a best case scenario; if turfgrass transition is not possible, the implications are that pitch management would be restricted all year round.
- Stadium orientation means that the southern end has low light levels imposed by stadium architecture.

Therefore, the pitch design has to include a form of temporary, transportable turf system.

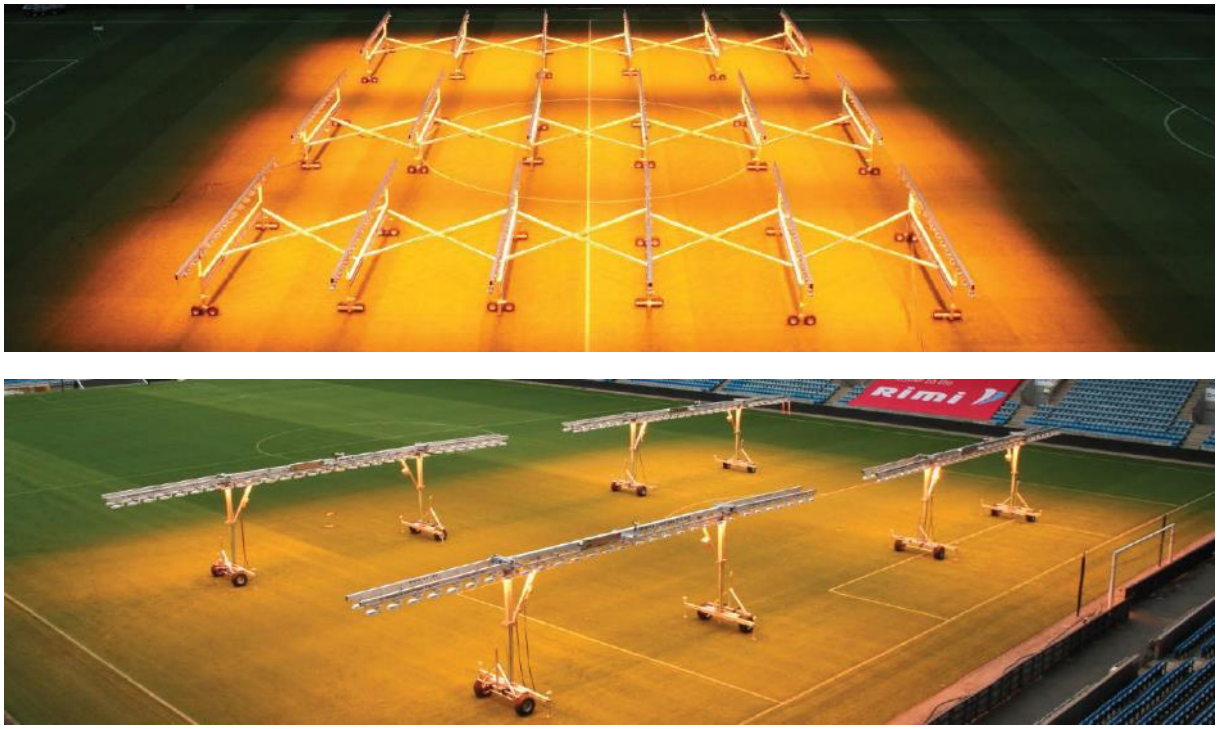

Fig. A6. Example of a lighting rig with folding arms (above) and interlocking arms (below)

[8] Running costs would be approximately £830,000 based on UK electricity prices (approx. HK$8.3M). The estimation is for reference only.

Appendix 5 – GMP for public open space

Kai Tak Sports Park

Grass Management Plan for Public Open Space

Prepared by: ADI Limited

Date: 22 June 2020

Content:

Turfing on Public Open Space

The requirement and maintenance of turfing on landscape area is highlighted in Landscape Architectural Requirements of Employer's Requirements. The turfing work shall be stated in this report for site work execution.

1.0 Turfing soil mix

1.1 Sand

Sand for turf bedding soil and top dressing of lawn areas shall be clean sharp Medium-Fine graded horticultural sand, salt and carbonate free and shall possess the following size distribution by weight:

	Particle Size (mm)	% by Weight
Fine Gravel	2.0 – 3.4	0
Very Coarse Sand	1.0 – 2.0	<0.1
Coarse Sand	0.5 – 1.0	<0.5
Medium Sand	0.25 – 0.5	73 - 78
Fine Sand	0.15 – 0.25	22 - 27
Very Fine Sand	0.05 – 0.15	<3.0
Silt and Clay	<0.05	<0.1

1.2 Test for Topsoil

Certification: prior to first use of any topsoil from each approved source and for every 300m^3 delivered to the Site, produce certificates of analysis of topsoil from an approved laboratory within 14 calendar days of taking the samples. If the total volume of topsoil is less than 300m^3, one certificate of analysis shall be provided. An approved laboratory shall mean one of the Employer's laboratories or a laboratory accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for the relevant tests in which case the laboratory shall have no affiliation as a legal entity to the Contracted Party or its Specialist Contractors. Particulars of the laboratory proposed by
the Contracted Party shall be submitted to the Supervising Officer for approval. Tests shall be carried out according to BS 3882 and BS 1377. Each certificate shall state the results of test for the properties stipulated for compliance in Clauses 25.02(a).

1.3 Test for Fabricated Soil Mix

Certification: after mixing operation but prior to first use in any planting and/or grassing works and for every 300m^3 of the mix, produce certificates of analysis of fabricated soil mix from an approved laboratory within 14 calendar days of taking the samples. If the total volume of fabricated soil mix is less than 300m^3, one certificate of analysis shall be provided. An approved laboratory shall mean one of the Employer's laboratories or a laboratory accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for
the relevant tests in which case the laboratory shall have no affiliation as a legal entity to the Contracted Party or its Specialist Contractors. Particulars of the laboratory proposed by the Contracted Party shall be submitted to the Supervising Officer for approval. Tests shall be carried out according to BS 3882 and BS 1377. Each certificate shall state the results of test for the following properties stipulated for compliance in Clause 25.02(b):

(i) pH (H_2O) value;

(ii) Organic matter content (dry weight) expressed in %;

(iii) Organic carbon content (using loss of ignition "Ashing" method of testing);

(iv) Nitrogen content: ("Kjeldahl" Method) expressed in %;

(v) Carbon: nitrogen ratio;

(vi) Extractable phosphorous (P) content per litre of the sample;

(vii) Extractable potassium (K) content per kilogram of the sample;

(viii) Extractable magnesium (Mg) content per kilogram of the sample;

(ix) Extractable magnesium (Ca) content per kilogram of the sample;

(x) Cation Exchange Capacity in m.e./100g;

(xi) Soil salinity;

(xii) Moisture content (calculated as the loss in weight between the dry weight and the overall weight as a percentage of the overall weight);

(xiii) Soil texture content expressed in percentage of the following categorisation of soil particles sizes:

a. sand (0.06 - 2.0 mm);

b. silt (0.002 - 0.06 mm) and

c. clay (less than 0.002 mm).

(xiv) Stone content % (m/m) as tested under BS 1377-2; and

(xv) Exchangeable sodium percentage (ESP) %.

1.4 **Test for Sand**

Certification: prior to first use and for every 300m^3 delivered to the Site, produce certificates of analysis of the sand from an approved laboratory within 14 calendar days of taking the samples. If the total volume of sand is less than 300m^3, one certificate of analysis shall be provided. An approved laboratory shall mean one of the Employer's laboratories or a laboratory accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for
the relevant tests in which case the laboratory shall have no affiliation as a legal entity to the Contracted Party or its Specialist Contractors. Particulars of the laboratory proposed by the Contracted Party shall be submitted to the Supervising Officer for approval. Tests shall be carried out according to BS 3882 and BS 1377. Each test certificate shall provide content of:

(i) Percentage passing 3mm sieve;

(ii) Percentage passing 2mm sieve; and

(iii) Percentage passing 1mm sieve.

1.5 **Turf Bedding Soil**

(i) Turf bedding soil shall be used for all turf lawn areas and shall comprise 2 layers according to the following specification unless instructed otherwise by the Supervising Officer:

- Upper Layer of turf bedding soil shall be 100mm thick and shall be made up of the following components by percentage volume:

Medium-Fine Graded Sand	80% Soil

Conditioner	15%
Sustane 4-6-4	5%

(i) Sustane 4-6-4 (an organic compost-based all-natural fertiliser) and Soil Conditioner shall be evenly incorporated into the upper layer of turf bedding soil.

(ii) Lower Layer of Turf Bedding Soil shall be minimum 200mm thick and shall be made up of the following components:

Medium-Fine Graded Sand	100%

(iii) The sand for the upper and lower layers shall be from the same source with exactly the same particle size distribution. The upper layer shall be mixed on-site using sand that has been imported for use for both upper and lower layers.

(iv) Upper Layer of Turf Bedding Soil shall be evenly mixed and attain a pH value between 6.5 and 7.0.

(v) Turf Bedding Soil quality shall be to the approval of the Supervising Officer and amendments/additional products may be required as necessary.

1.6 **Fertiliser for Turf Bedding Soil**

(a) Fertiliser for turf bedding soil shall be an organic compost based all- natural fertiliser such as Sustane 4-6-4 or equal approved by the Supervising Officer.

(b) Slow releasing fertilizer shall be used to minimize eutrophication to surrounding environments.

2.0 Grass Selection

2.1 (a) Vigorous grass (in turf plank) of even density with closely-knit sward, with a healthy green colour, true to the species specified and capable of healthy growth;
(b) Each piece of turf should have no more than 10mm thatch (including dead fibre) on average and be of uniform thickness, with soil thickness below the thatch of not less than 7mm and not greater 18mm. The turf shall have with a sufficiently fibrous root system to hold together during handling;
(c) In consistent size, shape and thickness, approximately 500 x 300 x 50mm thick with an even thickness of both grass sward and growing medium;
(d) Grown in well-drained growing medium suitable for horticultural purpose that shall contain not more than 40% clay sized particle (<0.002mm in accordance with BS 3882) and free from stones over 15mm in any dimension;
(e) With density of sods sufficient so that no soil is visible when mown to height of 25mm; and
(f) Free from diseases, impurities, weeds or insect pests or contamination.

2.2 Turf species shall be the following: *Axonopus compressus*
Ability to grow and recuperate from stolon that would be tolerant to wear and environmental stresses and providing the quality of surface appropriate for its functions.

2.3 Turf and sprigs shall not be lifted when waterlogged or very dry and shall be packed to avoid drying out. Turf and sprigs shall be stored by spreading out and shall not be stacked. Turf and sprigs shall be kept moist and in good condition and shall be delivered and laid within 36 hours after lifting.

3.0 WORKMANSHIP

3.1 **Discrepancies on site**

The Contracted Party shall notify the Supervising Officer of any discrepancy between the drawings and the actual ground condition prior to commencement of works in the area to which such discrepancy relates.

3.2 **Soiling of landscape areas**

All lawn areas shall consist of turf bedding soil mix. All lawn areas, whether at-grade or on structure, shall be provided with sufficient soil depths and, where on structure, associated structure loading shall be accounted for. Depending on the type of planting, the minimum soil depths excluding drainage layers shall be:

Type of Planting	**Minimum Soil Depths excluding Drainage Layers (mm)**
Turf	300mm

(a) Turf bedding soil shall be applied for the lawn areas. The Contracted Party should provide a detail turf bedding soil specification for Supervising Officer's approval.

(b) The finished level of un-compacted planting areas shall be sufficiently high as required to allow the level of the areas to achieve designed finished levels after natural settlement has taken place.

3.3 **Backfilling of closed-bottom planters**

(i) Backfilling of closed-bottom planters shall follow the following procedures regardless of the height relationship between the top of the planters and adjacent finished levels.

(ii) A drainage layer of drain cells shall be placed at the bottom and the sides of the planters. Vertical drainpipes with capping grates shall be positioned above all drain points penetrating the base of the closed-bottom planters, as shown in the drawings.

(iii) The drainage layer shall be covered with a geotextile filter membrane before the spread of topsoil. The membrane shall be laid with upturned edges at all faces of vertical walls. Overlaps shall be in accordance with the manufacturer's recommendations.

i. A layer of lightweight fill material if proposed shall be laid above the drainage layer to the depths and profiles. The lightweight fill material shall be covered by a geotextile filter membrane to prevent migration of soil.

ii. Fabricated soil mix and/or turf bedding soil mix shall be spread to achieve the requisite finished levels allowing for settlement and mulch.

iii. The backfill of subsoil in closed-bottom planters is not permitted.

3.4 **Inspections**

The Contracted Party shall notify the Supervising Officer at least 48 hours in advance when landscape areas are ready for inspection at the occasion as follows

(a) Placing drainage layer and filter membrane.

(b) Placing modular suspended pavement system.

(c) Placing topsoil or soil-mix.

(d) Placing soil conditioner.

(e) Preparing the lawn sub-grade.

(f) Placing the turf bedding soil.

(g) Setting-out irrigation pipe.

3.5 **Constructing the lawn sub-grade**

Construct the sub-grade beneath lawn areas as follows:

(i) Form the subgrade at the specified depth which shall be not less than 300mm below the finished levels of the lawn.

(ii) Grade the slopes of the subgrade to conform to the slopes of the proposed finished levels of the lawn and create free flowing contours free from humps and water collecting hollows. Ensure a gentle fall is designed into the levelling process to avoid drainage problems.

(iii) Lightly compact the subgrade to prevent further settlement.

(iv) Conduct a percolation test as per clause 25.12(1).

3.6 **Laying turf bedding soil**

Turf bedding soil shall be placed on the lightly compacted subgrade as follows:

(i) Spread approved lower layer of turf bedding soil to form a uniform and consolidated surface to form the designed contours for the finished grade. The lower layer of turf bedding soil shall be evenly consolidated such that subsequent settling of the soil is unlikely to occur.

(ii) Spread approved upper layer of turf bedding soil evenly on top of the lower layer of turf bedding soil.

(iii) Total depth of turf bedding soil (combined upper and lower layers) shall be as specified on the drawings and not less than 300mm unless otherwise specified by the Supervising Officer.

(iv) When turf areas are located in closed bottom planters the lower layer of the turf bedding soil shall extend down to the drainage layer at the bottom of the planter, unless otherwise specified by the Supervising Officer.

(v) Tolerance for levelling shall be not more than 10mm.

(vi) Turf bedding soil shall be rolled by hand roller until a smooth and uniform finish has been attained. This surface shall be free of any localised humps and hollows. Designed contours shall be created as shown on the contract drawings or as directed by the Supervising Officer.

3.7 **Regrading**

If necessary, carry out regrading of the surface to conform to the prescribed finished levels and create free flowing contours free from humps and water collecting hollows. Ensure a gentle fall is designed into the levelling process to avoid drainage problems. Lightly water the prepared area to settle the soil and provide a moist base for the turf. The prepared surface shall be firm enough to walk on without leaving deep footprints. Regrade the surface as required following irrigation settlement. The surface shall have no footprints or wheel mark depressions greater than 15mm in depth. Only when the turf bedding soil surface has been reviewed and approved by the Supervising Officer can the turf laying commence.

3.8 **Watering**

(a) Automatic Irrigation/watering with controller (timer) is required to maintain soil field capacity and prevent the soil profile from drying out to a point where the turf becomes moisture stressed. Subsequent to seeding or turfing, the area shall be irrigated on the same day to promote germination, survival

and establishment of a healthy grass sward.

(b) For the first 5 weeks after seeding or turfing, watering shall be on a daily basis during daylight hours to prevent the surface, profile and seed from drying out.

(c) After 5 weeks, the seed should have formed roots and a less frequent regime may be adopted if approved by the Supervising Officer.

(d) Watering shall use a fine mist to avoid seed displacement, erosion and nutrient run off.

(e) For watering efficiency, soil moisture monitoring sensor shall be incorporated in irrigation system and rainwater shall be harvested for irrigation to reduce potable water usage.

4.0 Workmanship – Follow up operations on grassing

4.1 Insect and disease control

(a) Take all precautions as necessary to prevent any outbreak of disease or insect attack. When such attacks occur, this shall be reported to the Supervising Officer within 48 hours of the attack, together with an action plan to eradicate any such disease or insect attacks. When the action plan includes use of chemicals this shall be approved by the Supervising Officer prior to use. Information required for approval includes the product trade name, the active ingredient of the product, the product Material Safety Data Sheet, the application method and the dilution rates.

(b) Integrated management for pest control shall be introduced in turf management operation including routine dew removal, mowing when the surface is dry, avoidance of long periods of leaf wetness, avoidance of excessive nitrogen application and growing media inspection to minimize the application of pesticide at open public space.

- Using knowledge about the pest's habits, life cycle, needs and dislikes;
- Using the least toxic methods first, up to and including pesticides;
- Monitoring the pest's activity and adjusting methods over time;
- Tolerating harmless insects or soil organisms; and
- Setting a threshold to decide when it's time to act

(c) Only pesticides registered in Hong Kong shall be applied if necessary and the application of pesticides should be approved by SOR/TS.

(d) Before any control programme is initiated, the safety rules as advocated by the AFCD, FEHD and LCSD in their Code of Practice for the Safe and Proper Use of Pesticides in Public Areas shall be considered for storage, application and disposal of pesticides.

4.2 Workmanship – Turfing

4.2.1 Laying turf

Lay turf as follows:

(a) Before delivering turf to the Site, make sure the Site is ready for turf installation without delay.

(b) The finished bedding surface shall be smooth and uniform and free of any humps or hollows.

(c) Turfing shall be carried out directly onto a levelled and contoured bedding surface.

(d) Lay turf on the prepared soil bed and firm into position in consecutive rows with 10 mm wide broken joints (as in stretcher bond brickwork) and to the correct levels. Lay turf off planks working over turf previously laid. Where necessary, lightly and evenly firm turf with wooden beaters, the bottom of the beaters being frequently scraped clean of accumulated soil or mud. Access over the turf shall be achieved through the use of track mats or plywood boards to spread load, maintain the levelled surface and avoid damage.

(e) On slopes, pin turf in place with small wooden pegs as necessary to avoid slippage.

(f) Turf edges shall be butted tightly together with no gaps and no overlapping. Lawn edges and margins shall be laid with turf and trimmed to clean straight lines or smooth regular curves.

(g) Begin watering within 1 hour of installation.

(h) During the first two weeks, avoid use of the turf.

4.2.2 **Turfing acceptance**

Turfgrass area will only be accepted when all of the following acceptance standards have been met:

(a) Turfgrass vitality shall be healthy and free from disease, uniform in density, texture, colour and appearance. Colour of turfgrass shall have consistent colour with no patchiness;

(b) The turf surface shall be smooth with no discernible junctions between turf sods. The surface texture shall be smooth without any unevenness or visible bumps;

(c) No a bare patch >75 mm diameter through random 0.5m^2 quadrat examinations;

(d) Less than 2% ground cover in weeds through random 0.5m^2 quadrat examinations; and

(e) Finished levels are achieved within 25mm of specified range.

4.2.3 **Establishment works**

General – Establishment Works

Establishment works means the maintenance works of soft landscape works which shall be carried out immediately after the completion of the Soft Landscape Works and prior to the Operational Commencement Date. During the period, the Contracted Party shall carry out the maintenance works as specified in the GS 25.94 to 25.109 and the relevant amendments as outlined below. After the Operational Commencement Date, horticultural maintenance works shall take place.

4.2.4 **Weeding**

All areas within 300mm radius of the base of each plant shall be kept in a weed/grass free and tidy condition.

(a) The Contracted Party shall weed areas as necessary and shall complete weeding within seven days of inspection.

(b) All weeds and other rubbish are to be collected and removed from the Site to a designated refuse tip.

4.2.5 **Fertilizing**

Slow release fertiliser shall be applied not less than 100 days, and not more than 300 days, after grassing or planting. The fertiliser shall be applied at a rate of:

(i) ≤5 g/m^2/year of nitrogen for grassed area formed by turfing or

sprigging, hydroseeding or broadcast seeding; and

4.2.6 **Pests and disease control**

Pesticide shall be applied in accordance with the manufacturer's recommendations to control pests and disease.

4.2.7 List of horticultural machinery, equipment and tool

The horticultural machinery, equipment and tool shall be stored at site for operation and maintenance at lawn areas including on flat and sloping surface. The workers shall operate the machinery, equipment and tool at site in accordance with manufacturer's instruction and guidelines. The horticultural machinery, equipment and tool for lawn maintenance are listed below:

(A) Public Open Space

Horticultural Machinery Equipment

Proposed Machinery List for the POS

	Type of Machinery	Description (for reference only)	Qty.
1	4 Wheel Transporter	Village Vehicle "Canycom" J71D	1
2	Tractor	4 wheels tractor "John Deere" 2520 c/w Front Loader	1
3	Rotary Mower	Riding Mower "Iseki" SXG19	1
		Walk behind rotary mower "Iseki" SW8210BAE4	3
4	Top Dresser	Top Dresser " Turfco" METE-R-MATIC IV	1
5	Tractor Mounted Sprayer	"Broyhill " Sprayer 110 Gallon	1
6	Tractor Mounted Aerator	"Redexim" Verti-Drain 7110	1
		"Sisis" Implement Frames FS1237 (Twinplay) Spiker slitter and straight brush	1
7	Brush Cutter	Brush cutter "Stihl" FS250 & Knapsack type brush cutter, "Zenoah" BK3420EZ	5
8	Cultivator	Mini Tiller "Ryobi" PCVK-4300	1
9	Water filled lawn roller		1
10	Broadcast and Fertilizer Spreader		1

Horticultural Tool

1. Garden spade
2. Grass crawler
3. Lawn fork
4. Wild weed remover
5. Hand saw
6. Wheel barrow
7. Spade digging shovel iron

(B) Sloping surface

Horticultural Machinery Equipment

1. Grass trimmer

Horticultural Tool

1. Grass crawler

2. Lawn fork
3. Wild weed remover

5.0 Maintenance Schedule

5.1 The maintenance schedule is used to advise the contractor and operator how to keep the turf during construction, maintenance and operation periods.

Item	Maintenance Operation	Frequency	J	F	M	A	M	J	J	A	S	O	N	D
1.0	Reinstatement of turf condition after activity stress.	As required												
2.0	Checking after exceptional weather	As required												
3.0	Checking the automatic irrigation	As required												
4.0	Mowing debris collection and disposal	As required												
5.0	Weed control	Once/month												
6.0	Fertilizer application (not application in winter)	Twice/ 2 months												
7.0	Mowing	Once / month in summer One / 2 months in winter												
8.0	Sand layering and soil topping	Once/ 3 months												
9.0	Pest control	As required												
10.0	Monthly report for turf condition records	Once/ month or as required												
12.0	Maintenance inspection	Four/year												