September 2020

Development Options Puarenga & Neil Hunt Parks

Rotorua Lakes Council

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1. EXECUTIVE SUMMARY

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Puarenga Park

Site limitations to increased use

1. Regional Council nutrient cap
2. Geothermal activity
3. Grass type
4. Drainage (localised)
5. Micro -levels

Development options	Anticipated impact on hours use
1. Priority One – Optimise maintenance	Negligible increase in use (better experience for players/parents).
2. Option One – Irrigation	+ 3 – 5hrs/week (January – March) where high or impact use occurs.
3. Option Two: Slit draining/sand topdressing	Negligible – unless you are closing these fields – then by default use will increase (better experience for players/parents)

Summary

Given the nutrient cap and geothermal activity, there is limited potential to increase use on this field.

Irrigation (if it can be installed) could increase use over summer.

Increasing maintenance (aeration) would improve the playing experience during winter.

1.2. NEIL HUNT PARK

Neil Hunt Park

Site limitations to increased use

1. Micro levels
2. Maintenance
3. Drainage
4. Sub profile sawdust/trees

Development options	Anticipated impact on hours use
1. Priority one – Resurfacing to address micro levels	10hrs+/week over summer; improved playing experience over winter.
2. Priority two – Optimise maintenance	Slight increase in winter use. Improved playing experience, particularly over winter.
3. Priority three – Sand topdressing	Slight increase in winter use, improved playing experience. Reduced risk of closure.
4. Priority four – Sand carpet/irrigation	Potential for increased use over winter up to 10hrs use/week in winter. Negligible risk of winter closure.

Summary

The presence of sawdust and other mill debris means the surface levels and infrastructure on the football fields are prone to movement over time. Given the No.1 football fields has not been levelled since at least 2000 and the other fields never, movement is comparatively slow.

Resurfacing the fields would provide immediate increase in use over summer and improved satisfaction by winter users.

Increasing maintenance (fertiliser, aeration, worm control) will improve winter playing experience and if closure occurs, increased winter use. It is expected maintenance will slightly increase potential for winter use.

Installing slit drainage/sanding would improve predictability of use over winter, playing experience for users and hours use (where fields are closed over winter).

Sand carpet/irrigation are an option, but the moving profile is a risk to infrastructure (NZSTI report 2017). Irrigation would increase potential use capacity over summer, whilst sand would increase predictability of use/ level of winter use (where venue is closed over winter).

2. BACKGROUND

Rotorua Lakes Council are seeking options to increase the amount of use from their sportsfields. NZSTI was engaged to assess Puarenga Park and Neil Hunt Park and identify limitations/options impacting on use at these venues.

1.3. UNDERSTANDING USAGE

The term **hours of use** that a field can tolerate is often misleading, in that in most instances it is not linked to accurate data on field closure and playing quality.

For example:

> Where Council is forced to close the field or consciously limit play due to poor drainage (sometimes summer drought), then clearly addressing these limitations provides an immediate increase in potential use of that field/park. I'm not aware of wholesale field closure occurring on Rotorua fields.
>
> A soil/sand field can tolerate any amount of use, providing quality is not a consideration. Where a quality outcome is required use on all surfaces must be managed. Typical guidelines show that once adult use exceeds 10hrs use per week during winter/summer when growth is limited on cool season grasses, field quality will start to deteriorate (loss of cover, muddiness issues on soil etc). In saying this it is not uncommon to see natural fields tolerating 15 – 20hrs adult use/week.

	
High use soil field	Low use soil field

Consequently, when considering models for hours use, they need to be related to the desired quality of the field surface.

Recommendation:

Usage levels on a given field or standard of field (senior representative, Intermediate, Junior, Social etc) needs to be linked to a quality standard (ground cover, grass type, weed content etc) otherwise the hours of use term is relatively meaningless.

Hours of use on sportsfields can most commonly be increased where the main limitations as detailed below are addressed.

Limitation to Usage	Example
Field is closed to play/maintenance, normally due to poor drainage – this in my experience is rare on Rotorua soils. • This closure period should be quantified as it supports the case for 'upgrade options'.	
Field is unable to support a type of use, normally due to agronomic limitations – for example surface smoothness is not suitable for cricket presently at Neil Hunt.	
Lack of infrastructure preventing use – e.g. lights	
Changing or encroaching seasons - e.g. rugby now starts in January/February, but unirrigated fields aren't suitable or can't recover from drought/play that occurs at this time. Or 'New sports' – summer football/touch rugby – increase wear/reduce maintenance options.	

Type of usage needs to be understood, as different types of use will impact on the hours a field can tolerate, specifically:

- Junior vs Adult – 1hrs adult play is considered equivalent in terms of wear as 2 – 3 hours junior play (<15 years old)

- Practise vs play – practise by default of its repetitive nature in localised areas is more damaging than general play. For this reason, practise should be located off main playing fields, i.e. 1 hours practise may cause as much damage as 5 – 10hrs competition play

Figure 1. Wear caused by 1 hrs practise doing shuttle runs.

- Impact vs soft use – rugby, football, league, touch rugby are more damaging to a field than for example athletics or cricket outfield.

3. PUARENGA PARK

1.4. SITE ASSESSMENT (APPENDIX TWO)

Turf cover

Excluding the geothermal areas and No.9 field, fields have a complete and dense browntop turf cover.

No.9 field has given its adult use, a sparse, mixed ryegrass/browntop turf cover.

Soils

In general, the soil profile consists of:

- Extensive thatch development (20 – 30mm deep) which holds moisture, particularly over winter
- East and south, 125 - 150mm (approx.) poorly structured silt loam textured topsoil – poorer drainage
- North/central area 125 – 150 sandy loam – above average drainage
- Topsoil overlies various grades of pumice which offers reasonable drainage.

Drainage potential

Average

Other

Geothermal activity

1.5. LIMITATIONS/RECOMMENDATIONS TO INCREASING USAGE

1.1.1 REGIONAL COUNCIL NUTRIENT CAP

Recommendation:

1. In the absence of increasing your nitrogen cap, additional growth or more wear tolerant grasses (ryegrass) are not possible.
2. Determine whether you want to consent an increased nitrogen programme on this Park.

Puarenga Park has a nutrient cap imposed on it as part of the strategy of improving water quality in the lakes. The Nutrient cap (NZSTI report; *Puarenga Park Fertiliser Programme, September 2013*) consists of:

- Nitrogen 6.9kg actual nitrogen/ha/yr
- Phosphorus 0.1kg actual phosphorus/ha/year.

Where senior use increases on this Park, the council will need to increase nitrogen inputs (up to 200kg actual nitrogen/ha/yr) to encourage additional growth for recovery and to support more wear tolerant and faster recovering ryegrass.

Note: The acidity posed by it being a geothermal site is an issue when growing ryegrass.

In the absence of increasing nitrogen applications/addressing the acidity, the ability to increase use above its present level is limited.

Heavily worn and unthrifty ryegrass at Puarenga Park – No.1 rugby, requiring additional nitrogen fertiliser.

This is best illustrated on Field 9 (No.1 rugby) where despite fertiliser inputs greater than the 'cap' the ryegrass is struggling and as a result provides a poor surface.

If council wants to increase their nutrient applications, they will need to seek a consent.

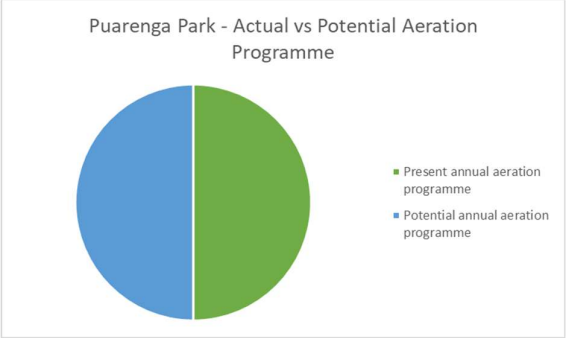
1.1.2 PRESENT MAINTENANCE PRACTISES

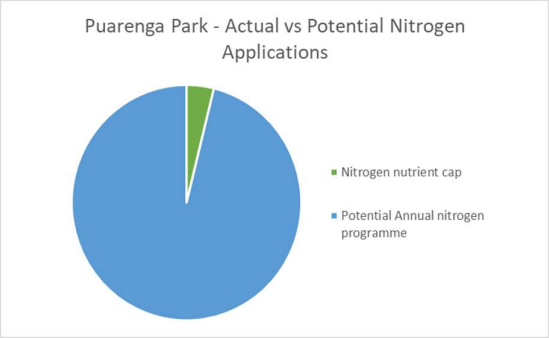
Recommendation:

1. The first priority before committing to any capital works is implementing an optimal maintenance plan.
2. This will require increasing aeration (coring, verti-draining, spiking) programmes from 3 to 6 treatments/year.
3. Continue managing thatch
4. Nitrogen can't be increased, without a consent.

Although presently limited by budget and the nutrient cap an optimum maintenance programme (Appendix One) is not presently being practised on the fields. The first priority should be to get the best out of the existing fields with appropriate maintenance before capital works are considered.

Note: Where Council commits to sand carpet fields, then you will need to raise your maintenance inputs to at least these levels.





Present drainage issues could be improved with additional aeration treatments.

1.1.3 GRASS SELECTION

Recommendation:

Given your nitrogen cap and acidity due to geothermal activity, ryegrass is not recommended, and use is therefore based on browntop's wear tolerance.

With the exception of No. 9 (No.1 Rugby) all the fields have a browntop dominant grass cover. Browntop is ideally suited to the climate, acidic soils and geothermal activity present at Puarenga Park. Additionally, in the absence of irrigation, browntop offers superior drought tolerance and recovery than ryegrass.

The main disadvantage of browntop, is both its wear tolerance and most importantly recovery from wear, particularly during winter.

Where Council wants to increase use, particularly during winter a blend of ryegrass/browntop as observed at Neil Hunt Park is desirable. Unfortunately, ryegrass is a high fertility demanding grass and when subjected to wear, nitrogen programmes need to be increased closer to the optimum 200kg actual nitrogen/ha for this region.

1.1.4 GEOTHERMAL ACTIVITY

Recommendation:

Puarenga Park is a geothermal location (Appendix Two).

1. Geothermal heat can be damaging to infrastructure (pipes, sprinklers etc). Someone with more suitable qualifications needs to determine the potential for geothermal to damage this infrastructure.

Puarenga Park is a geothermal location and the worst areas of activity are shown in Appendix Two. The geothermal area on the southern side of the Park is gradually encroaching into the Park.

Most of the soil logs completed showed the profile was noticeably warmer than the surface at depth.

The challenges associated with geothermal activity are:

1. Heat 'kills' much of the soil biology, so the profile thatches up quickly and soil structural development, required for drainage is consequently poor. This is worst with the fine textured silt loam textures found to the east and southern portions of the park.
2. Where heat gets too high, grass will die. Other effects of heat are:
    - It can be damaging to plastic pipes – further advice should be sought on this if irrigation is considered
    - It can result in super-heated water being used for irrigation, which is damaging to grass.
3. Geothermal results in very acidic soils. Given the amount of sulphur generated by geothermal activity, it's unlikely we will be able to raise the pH significantly with lime. Note: Present liming is based on raising surface pH rather than the profile and thereby assisting to help with breaking down the thatch.
   This acidity means acid loving grasses, specifically browntop and carpet grass do best in these areas. Ryegrass with its higher fertility requirements will struggle in these soils.
   This acidity is very damaging to any metal fittings (associated with irrigation).
4. Geothermal activity increases issues associated with the changing surface levels. These fields were laser graded in 1996 and now show lots of micro undulations – typical of both pumice and volcanic activity.

1.1.5 DRAINAGE

Recommendation:

1. Poor drainage doesn't in my experience limit the fields availability for use. The main concern over the years has been surface wetness due to water being held in the surface thatch.
2. The main focus should be on managing thatch and maintaining infiltration with physical (aeration) treatments.
3. In terms of capital improvements, slit draining/sand topdressing could be considered.
4. A sand carpet concept is not recommended on this site – given the sites other inherent limitations.

Since the field was reconstructed in 1996, it has functioned well as a junior/intermediate sportsfield complex. To my knowledge drainage limitations haven't required the fields to be closed regularly or for significant periods over winter. Surface water has been raised as a concern. These reflect:

- Variable topsoil quality over the site
- Poor soil structural development due to geothermal activity
- Extensive thatch layer that has developed
- Increasingly, the developing micro-hollows within the Park

Soils (Appendix Two)

'Wetness concerns' are worst adjacent to the geothermal areas and eastern part of the Park where the topsoils are a structureless silty loam texture.

The best areas of the park (western half of the Park) have a sandy loam soil texture which offers better inherent drainage.

Throughout the Park topsoils (ave 125mm depth) overly varying grades of pumice which all offer a reasonable degree of drainage.

Perched water tables were found particularly in the East and Northern parts of the Park at depths of at least 0.5m and are not considered to adversely affect the fields performance.

Excluding No.9 field, all fields have a substantial thatch (20 – 30mm deep) layer which holds water in the surface.

Drainage improvement

1. Priority one: Maintenance
   First emphasis should be on managing thatch and maintaining water movement through the topsoil to the underlying free draining pumice subgrade. Ideally this would involve increasing your present aeration programme, notably:
   - Solid tyne verti-draining: April, May, June
   - Spiking (groundhog): July, August

- Hollow tyne coring and liming: September

2. Priority two: slit draining/sand topdressing
   Where drainage is limiting use of the Park, then secondary drainage (slit drain, gravel banding) coupled with a sand topdressing programme is recommended to provide a link with the surface and freer draining subgrade.
   Note Slit draining was installed in southern area around the geothermal zone in 2012. I suspect this has been compromised with the new service road.
3. Sand carpet
   Given constraints around fertiliser use, geothermal activity the sand carpet concept is not recommended. The basis for this is that given these constraints I do not believe you will achieve additional use over what is presently occurring.

1.1.6 MICRO LEVELS

Although laser levelled in 1996, the fields micro levels are gradually deteriorating and will get worst with time. Although not presently effecting use of the Park, as they get worst, usage of the Park will decline.

Recommendation:

Volcanic soils are very mobile, and this is worst with geothermal activity. Present micro-hollows will get progressively worst with time.

1. Recommend including in the Asset Management Plan, provisions for resurfacing the fields to re-establish a smooth surface (2030 – approx.)

1.1.7 IRRIGATION

Recommendation:

1. Where the intention is to use the fields for 'impact type use' over summer/early autumn then irrigation would increase the hours that the fields could be used.
2. Further investigation is required on how geothermal would impact on an irrigation system

Whilst the fields are primarily used for junior/intermediate use (football and cricket), irrigation is not expected to increase the hours of use.

Where an alternative use/different level of play for the Park is considered; such as representative play (unlikely given present standard), senior summer play (e.g. touch rugby, nine aside football), change of winter use (e.g. rugby with its early season) then **well managed** irrigation (subject to site constraints) would offer the potential for increased use. This additional use is estimated around 3 – 5hrs/week during January – early March period, i.e. it would allow grass to continue growing and recover from the wear; and provide better playing conditions.

Notes:

1. Normally irrigation would offer more use on cool season grasses – up to 10 – 15hours use over summer on cool season grasses. However, this won't be possible due to grass type and inability to fertilise.

2. Unless well managed, irrigation can cause many problems that can actually limit hours use. Commonly the main issue is over-watering which contributes to:
   - Change in grass species to the weed Poa annua – poor traction, drainage, cover loss
   - Increased disease – cover loss
   - Poorer drainage over winter

4. NEIL HUNT PARK

1.6. SITE ASSESSMENT (APPENDIX THREE)

Turf cover

All fields have a complete mixed turf ryegrass/browntop turf cover.

Soils

In essence, soils consist of:

- 150 – 200mm sandy loam topsoil with significant sealing (poor drainage) in the surface 25mm
- Various grades of pumice to 800mm+
- In several soil logs trees stumps and/or sawdust was located at approximately 800mm

Drainage potential

Average to slightly above average

Other

- Substantial earthworm casting is present. Numbers of earthworms ranged from 15 – 30/m^2
- The site is an old timber mill site which over its history has experienced continual movement and loss of surface smoothness. In essence approximately 600mm of different grades of pumice have been spread over the site (incl old mill debris) and then 200mm (approx.) of volcanic topsoil spread over the site to form the fields.
- Football fields have poor micro surface levels.

1.7. LIMITATIONS/RECOMMENDATIONS TO INCREASING USAGE

1.1.8 PRESENT MAINTENANCE PRACTISES

Recommendation:

1. The first priority before committing to capital works is implementing an optimal maintenance plan, ie getting the best from the current facility, specifically:
   a. This will require increasing aeration (verti-draining, spiking) programmes from 3 to 6 treatments/year.
   b. Increase nitrogen applications up to 190Kg actual nitrogen/ha/yr, i.e. from 2 up to 7 applications a year. This increase should be introduced gradually based on turf density/wear.
   c. Implement an earthworm control programme, i.e. 2 – 3 applications/year

Although presently limited by budget, the first priority is to increase the present maintenance inputs, in order to get the best from your existing facility. This would be required with a sand carpet construction and in part explains why these types of fields perform better. An optimum maintenance programme (Appendix One) on this park, specifically the football fields is:

- Increasing aeration from 3 to 6 times a year – maintain a drainage link from the surface to the underlying pumice subgrade.

- Increasing nitrogen inputs, based on maintaining turf density, from the present to up to 7 applications/year.
- Implementing an earthworm suppression programme.

Earthworms

Earthworm casting (a major problem at Neil Hunt Park smearing, resulting in reduced winter turf density and drainage.

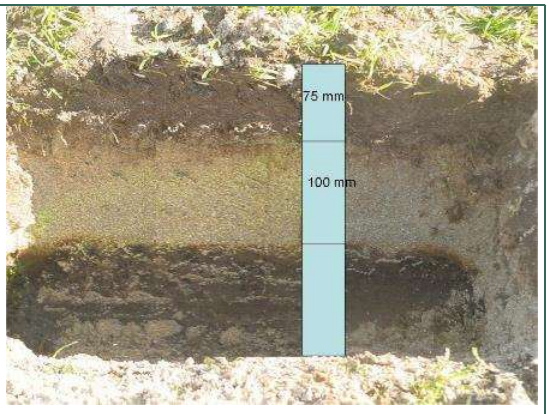


Illustration of the amount of earthworm castings that can be generated in a 3 year period – Note Boord Park already has a 25 – 30mm layer of castings over the sand layer in 1 year.

Neil Hunt Park has a substantial earthworm population present on all fields. Although earthworms (in a horticultural sense) do a good job improving soil structure, unfortunately on NZ turf our main earthworm species are surface casting. These castings are essentially mud and with play/maintenance smear over the surface, restricting drainage, thinning the grass cover and contributing to muddy surfaces.

1.1.9 MICRO LEVELS

Recommendation:

1. The second priority is to resurface the football fields and create a smooth surface.

The micro levels on the football fields are poorer than desired and already limit usage, i.e. levels are not considered safe/appropriate for cricket (summer use).

Poor micro levels contribute to ponding which has been cited as a concern in the past following significant rain.

Poor /changing micro levels is a reflection of the pumice subgrade and most importantly the buried ‘mill debris’.

There was talk of resurfacing the No.1 football field in 2000 – I’m unsure if this proceeded.

Addressing the micro levels would improve the experience for football (a common concern over the years) and most importantly would allow fields to be used over summer.

1.1.10 DRAINAGE

Recommendation:

Given the Park has reasonable drainage a staged approach to improving drainage is recommended:

1. Maintenance – which would largely improve the playing experience during winter.
2. Sand top dressing with possible slit drainage would improve the playing experience during winter and a slight increase in winter use.
3. Sand carpet provides a better playing experience and more predictable usage, ie risk of closure is minimal.

Sand topdressing

The present soil profile at Neil Hunt Park, for the main has good drainage. The main limitation is the topsoil which seals over, restricting water movement.

The first priority (discussed above) is maintenance to address the effects of play.

The next option is to adopt a sand top dressing programme and over time create a sandy loam surface that has better internal drainage than the present topsoil. Realistically you need to plan on applying 10 – 15mm of sand a year (same as occurs with a sand carpet field).

Slit drains/gravel banding could be added to sanding, offering improved drainage pathways to the freer draining subgrade and are less likely to be damaged by a moving profile.

This is expected to improve the playing experience, provide a slight increase in winter playing hours.

Sand carpet/irrigation

This offers the highest level of use throughout the year and the most predictability in terms of use, i.e. risk of closure (if this is an issue in Rotorua) due to wet weather is negligible.

The main risk is the increased movement that occurs on this park, which could damage the infrastructure (drains, irrigation).

This option was detailed in NZSTI report 14/8/2017 Development Concept for Neil Hunt Park

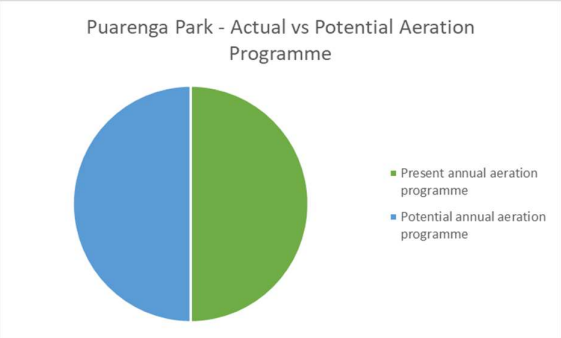
5. APPENDICES

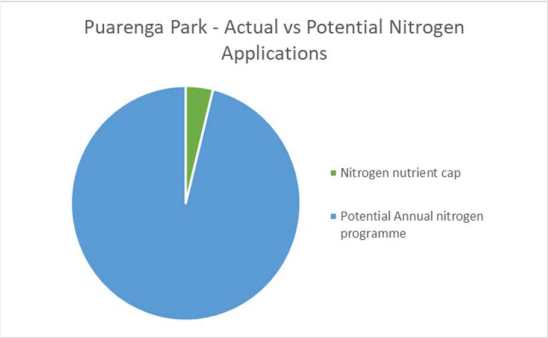
1.8. APPENDIX – ONE: MAINTENANCE

1.1.11 SUMMARY – PRESENT MAINTENANCE

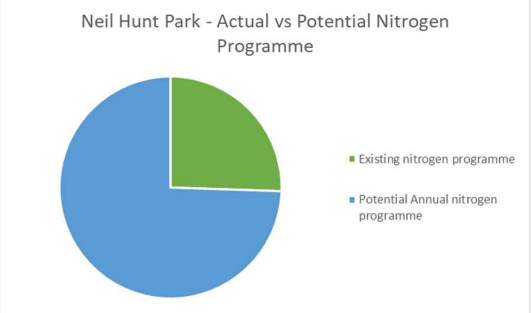
As illustrated below, there is s potential to get more use from the fields, particularly Neil Hunt and improve the playing experience, by increasing the maintenance inputs. Such inputs would be required if you went to a sand carpet approach. Unfortunately, with soil based fields, the predictability of use is an unknown and dependent on the weather – occurrence of rain.

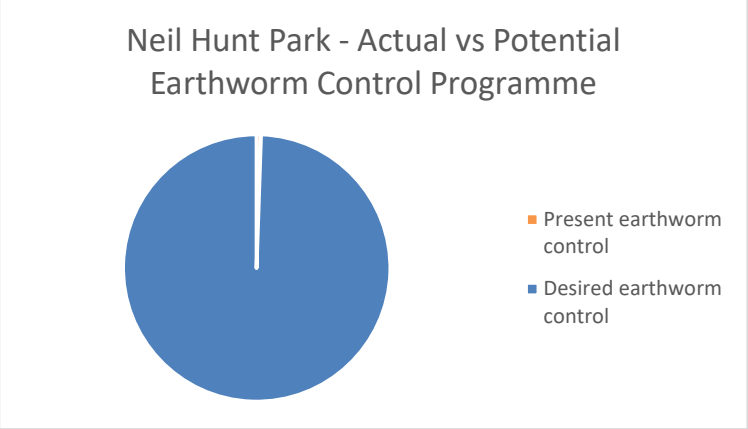
Puarenga Park





Neil Hunt Park





1.1.12 GROWTH/CLIMATE DATA

Climate data for Rotorua has been evaluated for the last 5 years, to determine when growth of the turf is naturally possible. This is summarised below.

Item	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Mean Air Temperature (°C) 2015 - 2020	18.9	19.3	17.3	13.9	11.4	8.9	8.3	9.1	10.8	12.6	15.0	17.2
Average rainfall 2015 – 2020 (mm)	103	117	142	145	108	122	146	132	110	89	105	111
Average monthly Evapotranspiration (mm)	143	111	90	49	27	17	20	33	54	87	112	129
Moisture deficit (mm)	-40	-6	52	96	81	105	126	99	56	2	-7	-18
Average soil temperature (°C at 100mm)	19.4	19.3	16.7	14.2	11.1	8.3	7.4	8.5	11.0	12.7	15.3	18.7
Likelihood of natural growth												
Key	Average to above average growth expected											
	Below average or minimal growth expected											
	Growth is unlikely											

1.1.13 RECOMMENDATION

Summarised below are potential changes to maintenance, specifically:

- Puarenga Park (aeration)
- Neil Hunt Park (aeration, Nitrogen fertiliser and earthworm control.

SPORTSFIELD MAINTENANCE PRACTISES at PUARENGA & NEIL HUNT PARKS													
Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Potential for turf growth/recovery (without irrigation)													8 months of potential turf growth
Nitrogen programme (Exg) Neil Hunt Park						30kg/ha		30kg/ha					60kg actual N/ha/yr
Nitrogen programme (Opt)				25kg/ha	25kg/ha	30kg/ha	30kg/ha	30kg/ha	25kg/ha	25kg/ha			190kg actual N/ha/yr
Aeration (Exg)				Vertidrain	Groundhog	Vertidrain		Groundhog					4 treatments
Aeration (Opt)				Vertidrain	Groundhog	Vertidrain	Groundhog	Groundhog	Vertidrain				6 treatments
Earthworm control (Exg)	None												0 treatments
Earthworm control (Opt) - Neil Hunt only				Proposed earthworm control									2 - 3 treatments
Notes	1. Purenga Park has a nitrogen/phosphorus cap and an optimum fertiliser programme cannot be run.												
	2. Only those maintenance practises which increase use have been considered, ie weed control, soiling, undersowing are about improving the playing experience.												
	3. The requirement for nitrogen during November - December assumes Neil Hunt Park fields will be actively used. Otherwise nitrogen is not required.												

1.9. APPENDIX TWO: PUARENGA PARK

1.1.14 SITE ASSESSMENT

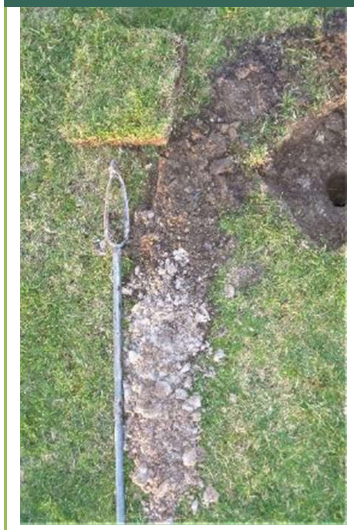
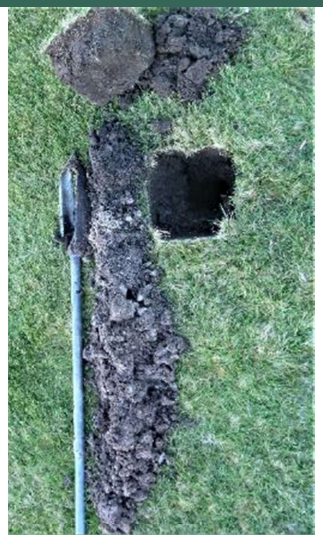
Key

Soil log

Main geothermal areas

Structureless silty loam textured soils dominate

1.10. SOIL LOGS

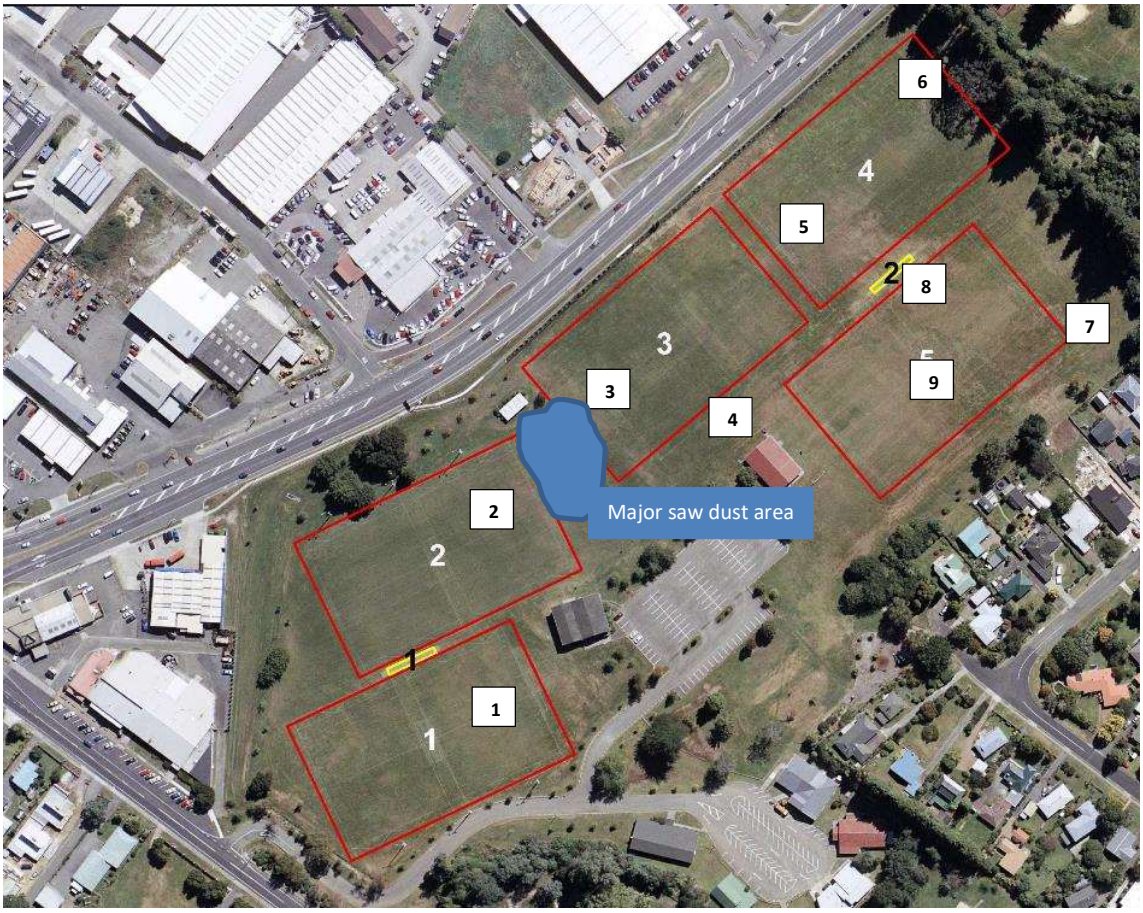
Soil log	Description	Soil Log	Description	Soil log	Description
 *Figure 2. Soil log 1*	• 0 – 25mm Thatch – drainage (average to below average) • 25 – 125 sandy loam – drainage (good) • 125 – 300 sandy loam/pumice mixture drainage =good • 300 – 700 – fine pumice drainage = good	 *Figure 3. Soil log 2*	• 0- 25mm thatch drainage = average to below average. • To 300mm - sandy loam drainage = good • 300 to 500 pumice soil mix drainage = average • 500 to 700 pumice sand drainage = excellent • Water table at 600mm	 *Figure 4. Soil log 3*	• 0 – 25mm thatch drainage = average to poor • To 250 silty loam drainage = poor • 250 to 500 pumice soil mix drainage = poor • Soil very wet at 500mm

Soil log	Description	Soil Log	Description	Soil log	Description
 *Figure 5. Soil log 4*	• 0 – 25mm thatch drainage = average to below average • To 250mm – sandy loam drainage = good • 250 – 600 volcanic mud/pumice drainage = poor wet at 500mm	 *Figure 6. Soil log 5*	• 0 -30mm thatch drainage = below average • To 200 silty loam (mottled) drainage = poor • 300 to 700 fine pumice drainage = average • Water table at 700mm	 *Figure 7. soil log 6*	• 0 – 30mm thatch drainage = average to below average • To 250mm silty loam drainage = poor • 250 – 700mm pumice drainage = good • Water table at 700mm

Soil log	Description	Soil Log	Description	Soil log	Description
 *Figure 8. Soil log 7*	• 0 – 25mm thatch drainage = average to below average • To 250mm silt loam drainage = poor • 250 to 500mm pumice drainage average • 500 to 650 mud drainage = poor • Pumice sand & water table	 *Figure 9. Soil log 8*	• 0 – 25mm thatch drainage = average. • To 270mm sandy loam drainage = good • 270 to 520 pumice (mottling) drainage = good • 520 to 700 silt drainage = poor	 *Figure 10. Soil log 9*	• 0 – 15 thatch • To 250 silt drainage = poor • 250 to 650mm fine pumice sand (mottled) drainage = good • Water table at 650

1.11. APPENDIX THREE: NEIL HUNT PARK

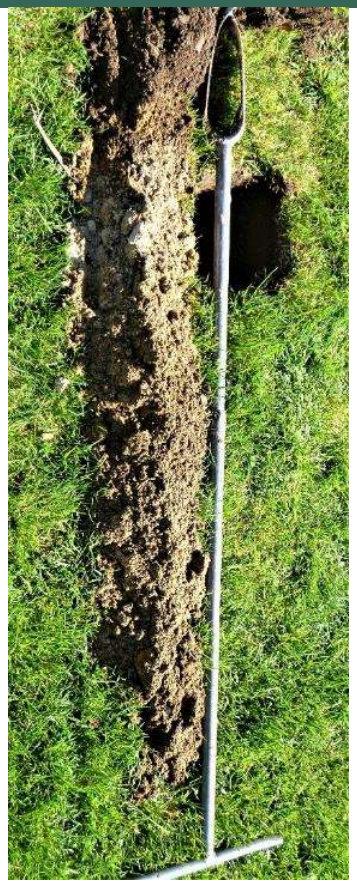
1.1.15 SITE ASSESSMENT



1.1.16 SOIL PROFILE

Soil log	Description	Soil Log	Description	Soil log	Description
	**Soil log 1** 0 – 150 Sandy loam average drainage 150 – 350 pumice – good drainage 350 – 500 – fine pumice good drainage 500+ coarse pumice excellent drainage		**Soil log 2** 0 – 150 Sandy loam average drainage 150 – 500 pumice – good drainage		**Soil log 3** 0 – 200 sandy loam average drainage 200 – 600 fine pumice good drainage 600+ sawdust

Soil log	Description	Soil Log	Description	Soil log	Description
	**Soil log 4** 0-200 sandy loam average drainage – severe surface sealing 200 – 600 pumice good drainage 650 Tree trunk		**Soil log 5** 0-150 sandy loam average drainage 150 – 750 pumice good drainage		**Soil log 6** 0 – 150 sandy loam average drainage 150 – 350 pumice & soil good drainage 350 – 500 fine pumice water table

Soil log	Description	Soil Log	Description	Soil log	Description
	**Soil log 7** 150 sandy loam average drainage 150 – 300 pumice/soil good drainage 300 – 600 pumice sand good drainage 600+ pumice is cemented and water table present poor drainage		**Soil log 8** 150 sandy loam average drainage 150 – 300 pumice/soil good drainage 300 – 600 fine pumice sand good drainage 600 – 750 cemented pumice/mud poor drainage		**Log 9 sinking hollow** 0-150 sandy loam average drainage 150 – 900 pumice good drainage Tree trunk