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Rottnest Island Authority

Report for Rottnest Island Recycled Water Scheme

Nutrient and Irrigation Management Plan

September 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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- *that all information provided by RIA to GHD relevant to this report was accurate and complete;*
- *nutrient and water balance assumptions detailed in the limitations section 4.2.2;*
- *assumptions on scheme management detailed within this Report and based on information provided by golf course and irrigation consultants and RIA;*
- *assumptions on site conditions based on limited sampling and analysis detailed in section 3.*

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1. Introduction

The Rottnest Island Authority (RIA) proposes to use recycled wastewater from its Rottnest Island Wastewater Treatment Plant (WWTP) to irrigate the island's golf course and an adjacent sports oval. The use of recycled water for irrigation would allow the golf course and oval to be reliably maintained without increasing fresh potable water demand on Rottnest Island.

This Nutrient and Irrigation Management Plan (NIMP) has been prepared at the request of the Department of Environment and Conservation (DEC) to minimise the potential for environmental impact as a result of the application of nutrient-rich recycled water on the golf course and oval. This NIMP will be assessed by the DEC in conjunction with the works approval application for the new WWTP licence and used to determine licence conditions and reporting requirements for the operation of the WWTP.

A recycled water quality management plan (RWQMP) is also being prepared by GHD and will be used by RIA in seeking Department of Health approval of the scheme.

This NIMP should be treated as a "live" document; it will be updated from time to time. Information on environmental monitoring and decisions on management of the scheme must be incorporated into this NIMP for it to remain current.

2. Project setting

2.1 Proposed project

The RIA is advancing plans to revitalise the island's 22 hectare (ha) nine (9) hole public golf course, west of the Thomson Bay settlement. The objective is to improve the existing facilities and to ensure that fairways and greens are green year-round by installing a new irrigation scheme supplied by recycled water from the Rottnest Island WWTP. The new irrigation scheme will also connect to the existing irrigation scheme for the sports oval adjacent to the golf course, which has been irrigated with recycled water since 1996. The total area to be irrigated is 9.6 ha, comprising 8.5 hectares at the golf course and 1.1 hectares at the oval.

The upgrade of the golf course is a major project which includes reshaping the fairways and greens, installation of an irrigation system complete with weather station and automatic control system, and soil amendment and grass establishment on tees, fairways and greens. No improvements are planned for the sports oval other than connection to the new irrigation system.

The upgrade of the golf course will proceed with the following steps (Davey Shearer Golf Design, 2012). Construction documentation (including drawings) is provided in Appendix A.

- Removal of some trees and vegetation in accordance with the Staking, Clearing and Demolition plan.
- Cut and fill for golf course shaping in accordance with the Cut-fill Explanatory Plan. No water-holding pockets will be produced, and natural drainage swales will be used wherever possible.
- Grading and rough shaping of all areas where required.
- Installation of irrigation pipework.
- Excavation and subgrade fine shaping of the green cavity and surrounds.
- Application of greensmix (sand and soil amendments) to the greens.
- Installation of sprinkler heads.
- Grass planting.

This work is expected to commence at the end of 2012.

The Rottnest Island WWTP will supply recycled water to the irrigation scheme. The WWTP had an annual inflow of 163 ML in the 2010-2011 reporting year and is licenced to produce effluent with total nitrogen and total phosphorus concentrations of 10 mg/L and 1 mg/L respectively. Recycled water for irrigation is currently stored in tanks at the WWTP with a combined capacity of approximately 24 kL. Wastewater treatment is discussed further in Section 2.3.

2.2 Site location and description

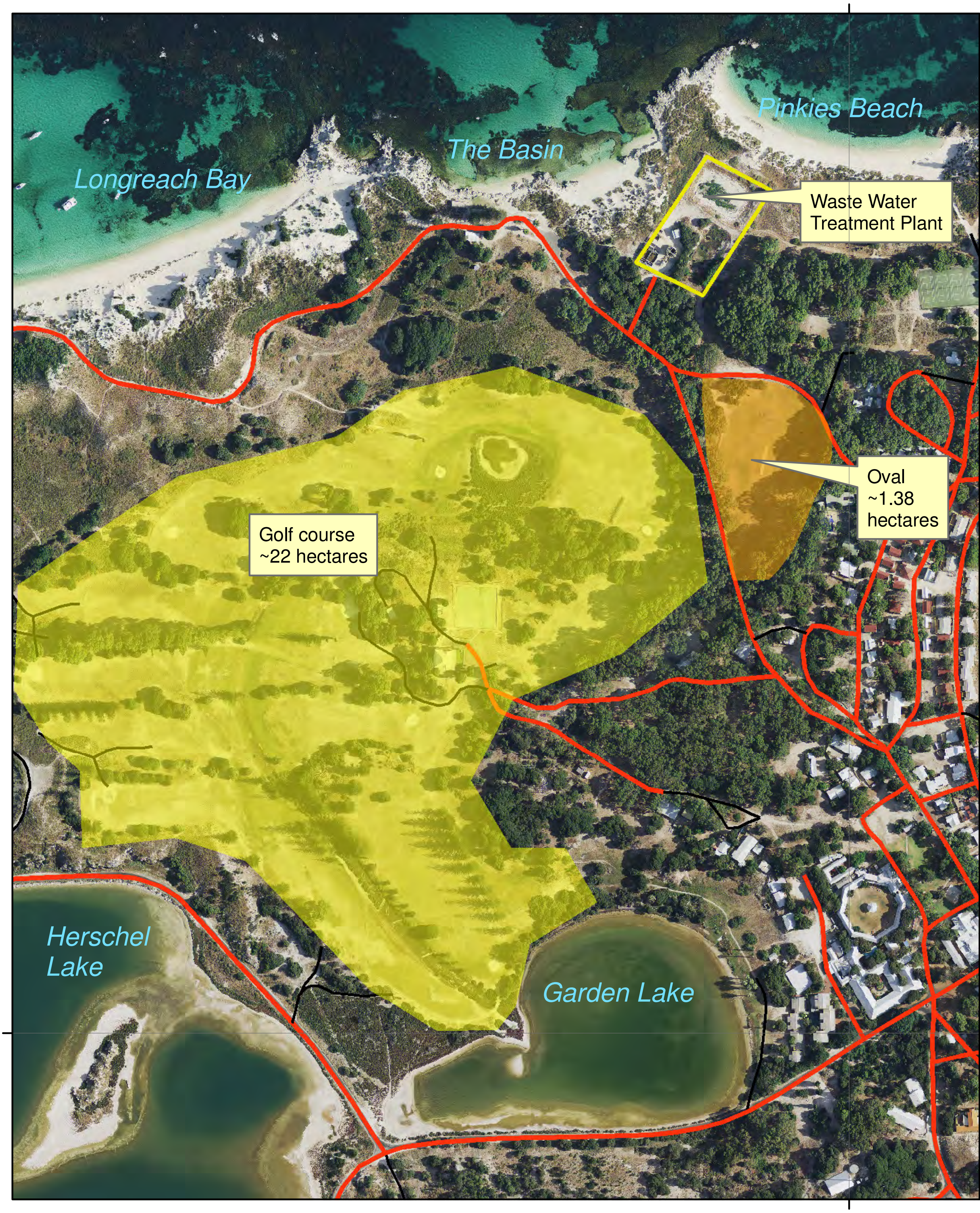
Rottnest Island is a Class A Reserve set aside for conservation and recreation, and is managed by RIA. On the land and in the surrounding waters, all flora, fauna, and landforms are protected.

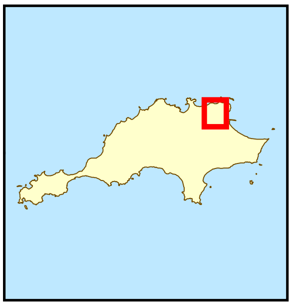
The golf course and oval are located on the northeast corner of the island, south of Longreach Bay and west of Thomson Bay (a map is provided in Figure 1). To the north of the golf course are the WWTP and approximately 200 m of native vegetation which lies between the golf course and Longreach Bay. To the west is a bitumen rainfall catchment, which was used to collect water and was decommissioned in 2010. Garden Lake is directly south of the course; the golf course design includes a tee on a sand feature in the lake. Herschel Lake is southwest of the course. To the east is the Thomson Bay settlement and Thomson Bay. The oval is adjacent to the golf course, at its north east border. The oval is proximate to a primary school to the east and camping grounds to the north.

There are no changes to land use associated with the proposed scheme. The Rottnest Island Golf Course has been operating for over 50 years. As the golf course and oval are existing facilities, the introduction of the new irrigation scheme will not change the land use. Examination of the Department of Water's Geographic Data Atlas indicated that there are no protected Public Drinking Water Source Areas (PDWSA) on the island.

European settlement led to a reduction in native forest on the island, and native vegetation on the island now consists predominantly of coastal heath and altered grass/heathland. Native and exotic vegetation exist in pockets of the golf course and at its edges. Sparse grass exists on the tees, fairways, and greens. The adjacent oval is currently used for sports activities. It is planted with grass and native and exotic tree and shrub species border its edges.

Rottnest Island visitors, residents and staff use the golf course and oval during the day. During the evening, it is understood that the premises are mostly vacant, but that visitors may walk across the golf course to take a shortcut from the main settlement to accommodation at Geordie and Longreach bays. Birds, frogs and the Rottnest native marsupial, the quokka, are known to live in the area around the golf course and lakes.





- Golf Course
- Oval
- WWTP
- Sealed Road
- Vehicle Track

Locations of WWTP, Golf Course & Oval

1:5,000

0 50 100 200 m

N

Rottnest Island Authority

Projection: GDA MGA 50

Production Date: 24 July 2012

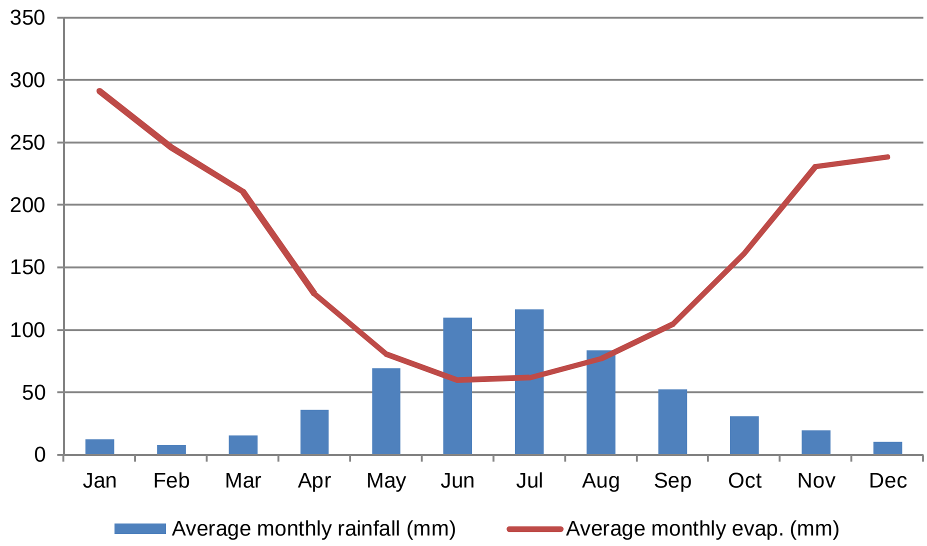
Disclaimer: The RIA accepts no responsibility for the accuracy of this image, or the results of any actions taken when using this image.

Monthly averages for rainfall and evaporation for Rottnest Island are shown in Table 1 below and graphically in Figure 2. Monthly evaporation is significantly higher than the rainfall, except for the winter months which have the highest rainfall. These figures have been incorporated into the site water balance prepared by Kingston Water Engineering for RIA.

Table 1 Rottnest Island average monthly rainfall and evaporation (mm) (RIA and BoM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Rainfall (Bureau of Meteorology site 009193)	13	8	16	37	70	110	117	84	53	31	20	11	573
Evaporation (RIA)	291	246	211	129	81	60	62	78	105	161	231	239	1894

Figure 2 Rottnest Island rainfall and evaporation (RIA and BoM)



2.3 Rottnest Island WWTP

Peak inflow to the WWTP occurs during holiday periods, during the December/January period, April and October school holidays, and specific events such as New Year's Eve, Australia Day, and the Rottnest Channel Swim. Daily peak period (November 2011 to February 2012) inflow ranged from 175 kL/day to 364 kL/day, with an average of 244 kL/day.

A RWQMP is being prepared, which describes the operation of the WWTP to produce the required water quality. The WWTP uses the patented cyclic activated sludge system (CASS) (Transenviro Inc). Influent currently passes through a macerator before entering the CASS tanks, where biological treatment occurs in the form of nitrification and denitrification. Screen and grit removal inlet works will be installed to replace the macerator in October 2012. Alum is added to the CASS basins to assist with phosphorus removal. Decanted effluent that is to be reused is passed through a coarse screen and sand filters followed by disinfection with chlorine gas. Effluent for disposal is decanted to one of two unlined evaporation basins within the WWTP site.

Treated wastewater quality is monitored several times a week at the onsite laboratory and once a month at a NATA accredited laboratory, in compliance with the existing DEC operating licence conditions (licence number L8189/2007/1). The facility's operating licence is due for renewal in November 2012 and this NIMP and the RWQMP are being prepared to support the approval of the new reuse scheme. The new licence will specify monitoring requirements for recycled water quality based on information and recommendations provided in this NIMP and the RWQMP.

The current WWTP licence stipulates that the treated wastewater must meet the requirements set out in Table 2 for at least 3 out of 4 consecutive samples. Water quality samples are taken at the outlet of each of the CASS basins.

Table 2 WWTP treated water quality DEC licence requirements

Treated water quality parameter	Limit
Total suspended solids (TSS)	<30 mg/L
5-day biochemical oxygen demand (BOD)	<20 mg/L
Total nitrogen (TN)	<10 mg/L
Total phosphorus (TP)	<1 mg/L

A number of improvements and major maintenance works have been made to the WWTP over the last year, including cleaning out basins and tanks, replacement of filter media, installation of dissolved oxygen probes, new inlet works, improvements to the control system and replacement of pumps. The water quality has improved with these upgrades and TSS and BOD levels were consistently below the licence limits in the July 2011 to June 2012 reporting period. TP levels were above the licence limit for two consecutive months in October and November 2011 but were otherwise below the limit. TN levels were less reliable, with concentrations greater than the licence limit for one basin 4 out of the 6 months that the other basin was offline (for maintenance or due to low flows) and above licence limits in both basins for October 2011 and March 2012. From 18 samples, the average TN concentration was 13.7 mg/L. The maximum recorded TN concentration was 37 mg/L. The Annual Environment Report for the WWTP is currently being prepared for submission to DEC.

3. Environment

3.1 Landforms

The golf course is generally flat, surrounded by hilly areas, particularly to the north and west. Refer to Figure 3 which shows the soils and landforms of the local area. The oval is located on quite flat ground; elevations range from 1 to 2 m AHD between the west and east. A minor drainage line runs from a small lake in the centre of the golf course to the salt lakes in the middle of the island.

3.2 Soils description

3.2.1 Soils mapping

Both the golf course and oval are located upon the Quaternary limestones which have been locally differentiated as the Tamala and Herschell Limestones. The Tamala limestone is an eolian calcarenite whereas the Herschell Limestone comprises marine shell beds with a weakly to strongly cemented lime sand (Playford, 1988). Figure 3 is a map of the soil types in the area. The majority of the area to be irrigated is underlain by coquina, a sedimentary rock composed of shells and shell fragments. Field investigations (GHD, 2012)) showed that the surface soils are relatively consistent across the golf course and oval, and contain shells and shell fragments as expected from the soil map. The sand and shells was only found to have cemented to form rock in two locations, and the cemented layer was thin in both.

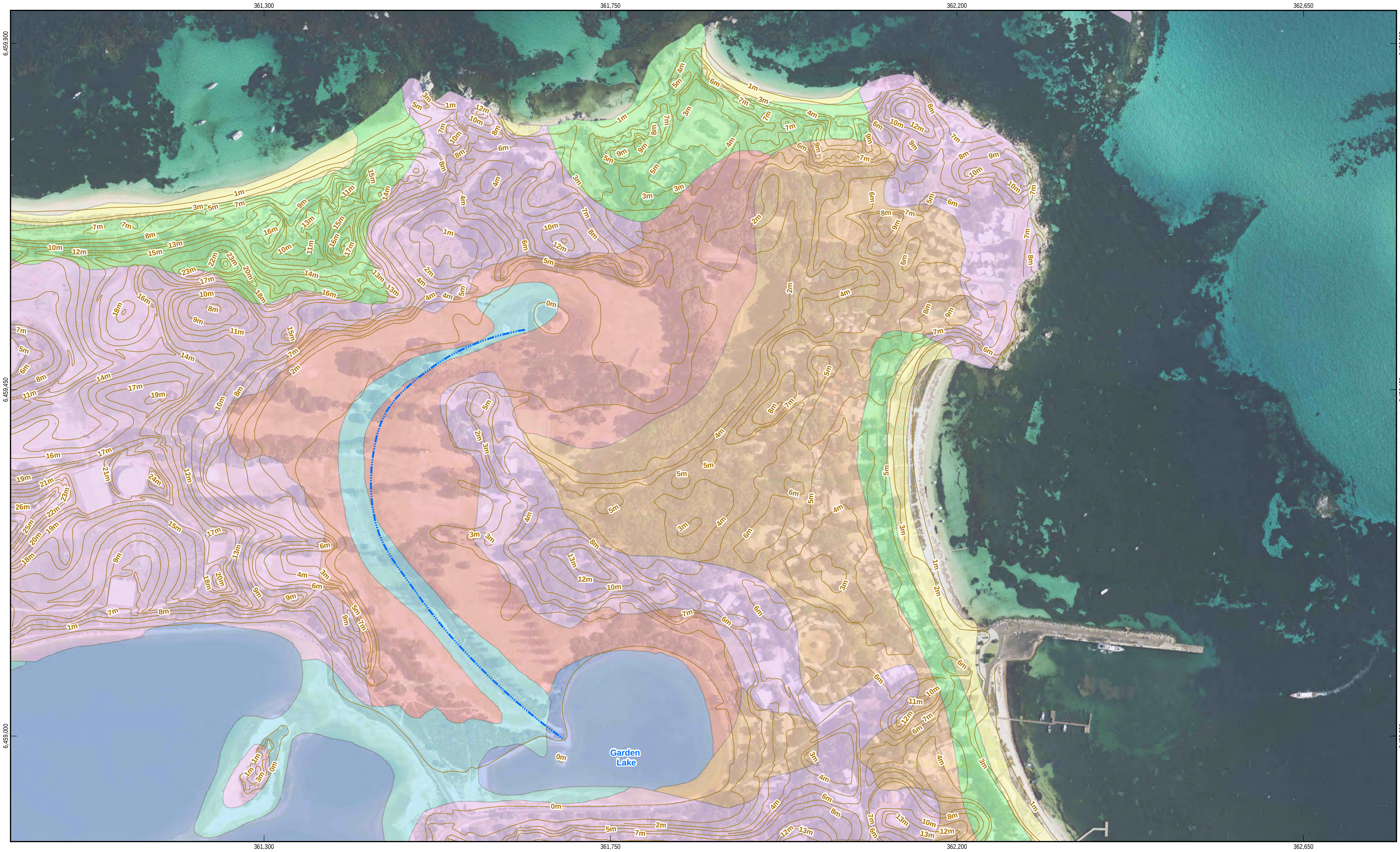
3.2.2 Field investigation of soils

GHD performed field investigations from 29-31 May 2012 at the Rottnest golf course and sports oval. Sampling locations for soil bores, groundwater monitoring wells and Acid Sulphate Soil (ASS) sampling are shown in Figure 4. Refer to Section 3.2.5 for more information about preliminary groundwater monitoring. The RIA has renamed the monitoring bores in line with their standard naming conventions and Table 3 provides a reference to the GHD naming convention adopted during field investigations and the RIA names which will be used for ongoing monitoring.

Table 3 GHD and RIA names for groundwater monitoring wells at the Rottnest oval and golf course

GHD	GCW01	GCW02	GCW03	GCW04	GCW05
RIA	OV1	GC1	GC2	GC3	GC4

Four soil bores were drilled on the golf course fairways and one on the oval to record a log of the soil profile and understand soil properties such as type, grain size and origin. Soil samples were collected for laboratory analysis of soil nutrients and nutrient and water holding capacity to enable water and nutrient balance modelling of the water recycling scheme. At each of the soil bore locations, field measurements of the saturated hydraulic conductivity of the soil were performed with a permeameter.



1:4,500 (at A3)

0 22.5 45 90 135 180 225

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

1m Contours

Intermittent Stream

Material

Beach sand	Limesand
Clay, sand and silt	Limestone
Coquina	Sand
	Water

GHD

ROTTNEST ISLAND WESTERN AUSTRALIA

Rottnest Island Authority
Rottnest Recycled Water Scheme
Field Investigations : Golf Course & Oval

Job Number 31-28991
Revision 0
Date 17 Sep 2012

Soils and Landforms

Figure 3

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Data source: GHD: Intermittant Stream - 20120725; RIA: Rottnest_Island_Aerial - 20020902, 1m contours - 20030408, Material - 20120725. Created by: erice, jrutherford

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1:2,500 (at A3)

0 12.5 25 50 75 100 125

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

Sampling Location

- Acid Sulfate Soil Sampling Location
- Monitoring Well Location
- Soil Bore Location

Road Type

- Sealed Road
- Vehicle Track
- Formal Pedestrian Track
- Boardwalk
- Stairs
- Informal Pedestrian Track

GHD

ROTTNEST ISLAND

Rottnest Isalnd Authority
Rottnest Recycled Water Scheme
Field Investigations : Golf Course & Oval

Job Number	31-28991
Revision	0
Date	17 Sep 2012

Sampling Locations

Figure 4

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Data source: Rottnest Island Authority: Roads and Tracks - 20120510, Rottnest Island Mosiac - 20120214; GHD: Sampling Locations - 20120628; GA: NATMAP 250k Series 3 - 20100418. Created by: radeleon, jrutherford

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Soils encountered during drilling at the golf course and oval were generally sandy, with a thin topsoil layer of approximately 15-30 cm. Sands were fine to coarse grained, and gravel was present at most locations in the form of limestone or shells (or fragments thereof), particularly bivalves and some gastropods. Examples of typical soils encountered in the field are shown in Figure 5 and Figure 6. Lithified soil layers (cemented sand) were encountered at two locations (GCW02 and GCS04). Further detail is provided in Appendix B which includes a summary of the soil profiles and complete borehole logs.

Figure 5 Soil from the profile at GCS01, showing topsoil at left and sand with shells and gravel

Figure 6 Shells encountered in the soil profile at GCS01

Soil samples were analysed for their physical and chemical properties to determine the site's suitability for irrigation with recycled water. The water and nutrient holding capacity of the soil samples was assessed. Key laboratory results are presented in Table 4 and the complete analysis report is provided in Appendix C.

Table 4 Key results from soil testing [a]

Site [sample from depth range]	pH (in water)	PBI	Phosphorus – Colwell extraction (mg/kg)	AWC (mm/m)
GCS01 [0.15-0.5 m]	8.69	92.7	19	94
GCS02 [0.25-3.0 m]	9.40	615.0	8	91
GCS03 [0.25-3.0 m]	9.27	87.6	6	128
GCS04 [0-0.3 m]	8.57	210.4	33	65

Site [sample from depth range]	pH (in water)	PBI	Phosphorus – Colwell extraction (mg/kg)	AWC (mm/m)
GCS05 [0.2-0.6 m]	9.18	114.1	9	69
(QA sample result)	(9.20)	(112.0)	(7)	(53)

[a] EC = electrical conductivity, PBI = phosphorus buffer index, AWC = available water capacity, estimated as field capacity – wilting point

Data collected in the field using the permeameter were used to estimate saturated hydraulic conductivity of soil ~0.5 m below ground at the 5 soil bore locations. The results are displayed in Table 5 to one significant figure, to account for the uncertainties in this field measurement, and range from 50-500 mm/h.

Table 5 Saturated hydraulic conductivity of soils

Site	Measured at depth (m bgl)	Average Ksat (mm/h to 1 significant figure)
GCS01	0.3	90
GCS02	0.5	300
GCS03	0.5	200
GCS04	0.45	500
GCS05	0.5	50

Five groundwater monitoring wells were installed at the edges of the golf course and oval adjacent to the soil bore locations to allow baseline and ongoing monitoring of groundwater quality at the irrigation site. Qualitative soil observations were recorded for these five locations to ensure that the groundwater monitoring wells were suitably representative of the fairway and oval conditions (borehole logs are provided in Appendix B). No laboratory analysis was conducted on soils from the well sites.

3.2.3 Potential acid sulphate soils investigation

Risk maps indicated the golf course was within a potential ASS risk area. As part of the field soils investigation, four additional bores were drilled in high risk areas for ASS assessment. Soil bores RASS01 through RASS04 were located close to natural drainage features (lakes and swales) on the course which were expected to have the greatest potential ASS risk. Samples were taken above and below the water table.

A pH screen was carried out in the contracted laboratory as a preliminary indication of ASS. The test involved an initial measure of soil pH (pH_f) and the change in pH measured following rapid oxidation with hydrogen peroxide (pH_{FOX}). A $\Delta pH>2$ units is a general indication of potential

ASS. Table 6 provides a summary of the reaction results and the complete laboratory analysis report is provided in Appendix C.

Table 6 ASS pH test results

Sample ID (and depth of sample, in metres)	pH (F)	pH (Fox)	∆pH
RASS1-0.3-0.6	9.8	8	1.8
RASS1-0.9-1.2	9.8	8.3	1.5
RASS2-0.2-0.5	9.8	8.3	1.5
RASS2-1.2-1.5	9.9	8.3	1.6
RASS3-0.2-0.7	9.9	8.3	1.6
RASS3-1.0_1.5	9.9	8.3	1.6
RASS4-0.4_0.6	9.8	8.2	1.6
RASS4-1.0_1.2	9.9	8.2	1.7
GCS04-0.7_2.2	9.8	8.2	1.6

The preliminary ASS screen did not report any reactions >2 pH units. Therefore it was considered that the probability of ASS was low.

3.2.4 Soil amendments

Some cut and fill will be performed on the golf course during construction. All cut and fill shapes will taper to the natural terrain. Where there is not enough fill material from the existing golf course, sand will be imported from another area on the island, in accordance with the cut-fill explanatory plan (Davey Shearer Golf Design, 2012).

The sand for greens will be combined with fertilisers and soil amendments to prepare the greensmix. Fine organic material will be incorporated into the soil on fairways and tees. Amendment of sandy soils with organic carbon rich matter can increase the moisture holding capacity of the soil and minimise loss of nutrients, metals and pesticides (Department of Water WA, 2010). Soil amendments and application rates that will be used during the construction of the golf course redevelopment are listed in Table 7.

Sanoplant is a granulated soil amendment which improves the storage of water and nutrients in the soil, slowing the drainage rate. It was originally developed to prevent leaching of chemical fertilisers and herbicides, used on golf course greens, into the groundwater. It is a blend of silicate based natural stone powders which have undergone a physical treatment in which carbon compounds and cellulose are added to the product (Sanoway Australia, 2006).

Table 7 Golf course redevelopment - soil amendments [a]

Amendment	N% [b]	P% [b]	Fairways	Tees	Greens
Fine organic material (chicken manure)	5-15	1	10% incorporation per volume of	10% incorporation per volume of	10% incorporation per volume of

Amendment	N% [b]	P% [b]	Fairways	Tees	Greens
			sand	sand	sand
Super-phosphate	-	9			8 kg per 100 m^2
Potassium sulphate	-	-			5 kg per 100 m^2
Granular trace element mix	-	-			2 kg per 100 m^2
Sanoplant soil amendment	-	-			2 kg/m^3 or 400 g/m^2 worked into the top 200 mm

a Soil amendments subject to further soils testing by golf course consultant

b Information on N and P content of fertilisers sourced from Environmental Guidelines for the Establishment and Maintenance of Turf and Grassed Areas (Department of Environment Protection, Water and Rivers Commission, 2001)

3.2.5 Summary and implications for nutrient and irrigation management

The physical properties of the soils collected at Rottnest Island can be used to assess the site suitability for effluent irrigation. Bond (2002) describes the soil properties that limit the potential for effluent irrigation. The results of soil testing undertaken by GHD at the golf course and sports oval (Table 4) have been compared to the limitations described by Bond (2002) and an assessment of potential limitations for the proposed Rottnest golf course and oval water recycling scheme is presented below.

- The soils have a low available water capacity: this is defined as a moderate limitation if <200 mm/m (Bond, 2002). The soils may have limited ability to retain water between irrigations and therefore require irrigating more frequently: this may restrict plant growth and increase the risk of nitrate and salt leaching to groundwater.
- The soils have high pH (>8.5) indicating a high alkalinity which may restrict plant growth. Bond (2002) defines this as a moderate limitation if pH measured in $CaCl_2$ is between 6 - 8.5, which is equivalent to a pH measured in water of ~6.5-9 (Myers, et al., 1999).

The ability of the soils to adsorb phosphate is an important factor of consideration for effluent irrigation schemes. PBI is a measure of the adsorption potential of a particular soil, and can be interpreted along with the Colwell P result, which indicates extractable P in the soil (existing P in the soil). Soils with PBI in the range 71-140 are considered to have a low adsorption capacity and a critical Colwell P of 34 mg/kg (Gourley, et al., 2007). Effluent irrigated soils with low PBI need to be managed to avoid runoff or leaching of phosphate. GCS01 at the oval has a low PBI but the Colwell P is lower than the critical value which suggests that previously applied P was not excessive. The GCS03 and GCS05 samples also had low PBI and low Colwell P. GCS04 had a moderate PBI and the highest Colwell P of all soils sampled, but still below the critical value given by Gourley et al. (2007). The GCS02 soil sample had a high PBI and very low Colwell P. It is not known why the PBI varied between sites so greatly, but the network of monitoring bores over the different parts of the site can be used in the future to assess the heterogeneity of impacts which may be an effect of the differences in soil conditions such as

PBI. The potential for P leaching to groundwater below the irrigation site has been assessed using nutrient and water balance modelling software and is discussed in Section 4.2.

With regard to the exchangeable cation results in the complete analysis report (Appendix C), it should be noted that although the cation exchange of all samples was high (in the range normally expected of clay soils), this result is likely to be linked to the high calcium content of the soil rather than indicating the presence of clay. Field observations indicated sandy soils with limestone gravels and shells; no clay was identified.

Bond (2002) identifies the ranges of hydraulic conductivities that may be limitations for effluent irrigation schemes: conductivities in the range 20-80 mm/h are considered a slight limitation due to the risk of soil waterlogging, and conductivities >80 mm/h are a moderate limitation because the soil will act as a poor filter for contaminant and nutrient removal. The hydraulic conductivities at GCS02-GCS04 are high (Table 5), as expected for sandy/gravelly soils.

Soil sodicity is not anticipated to be an issue with the sandy soils of the golf course and oval. Irrigation will be minimal in winter which will allow fresh rainfall to percolate through the soils and flush out any salts that have accumulated over the summer period. The laboratory analysis report of soils analysis is provided in Appendix C, and shows the exchangeable sodium result for sample GCS03_0.25-3.0 was very high (18.9%) which would normally indicate sodic soil. Generally, an ESP value less than six percent indicates non-sodic soil. Although this would be an issue for a clay soil irrigation site, it is thought that this result is probably linked with the high salt content of this particular sample. The chloride content of this sample was very high, at 3,000 mg/kg. The source of this salt is likely to be the hypersaline lakes (GCS03 is close to Herschel Lake).

3.3 Water resources description

3.3.1 Groundwater and lakes

Fresh and shallow groundwater exists on the island as a thin lens overlying salt water (Playford, 1988). The groundwater environment is considered to be very sensitive, as the fresh groundwater resource on the island is limited. The main fresh water reserves are located in groundwater lenses associated with the highest ground on the island around the Wadgemup and Oliver hills (Playford, 1988). The golf course is not located in an area for favourable groundwater development as parts are located within low lying areas wedged between the sea and salt lakes, e.g. Baghdad, Garden and Herschell Lakes. Historical groundwater monitoring associated with the Rottnest Island landfill and WWTP suggests the presence of elevated nutrient concentrations in groundwater in those areas. Infiltration of effluent in unlined ponds at the WWTP has also been found to cause groundwater mounding (GHD, 2011).

At the centre of Rottnest Island is a series of hypersaline lakes which make up approximately 10% of the island area (Playford, 1988). Water level and quality in the lakes fluctuate seasonally as a result of rainfall and evaporation with minimum water level and maximum salinities usually recorded in late summer (Playford, 1988).

There is a small lake in the golf course called Lockey's Lake, at the origin of an intermittent creek which runs south through the course to Garden Lake (a hypersaline lake). One of the tees in the redeveloped golf course will be located within Garden Lake. There are several other lakes to the south-west of the golf course, including Herschel Lake on the south-west border. Maps of the golf course and the surrounding lakes are provided in Figure 1 and Figure 7.

The intermittent creek running through the golf course experiences seasonal inundation during winter, and water also pools in areas around Lockey's Lake at the north end of the creek and on the second fairway near the creek.

As part of GHD's field investigations at the golf course and oval, five groundwater monitoring wells were installed around the proposed irrigation areas (the locations of which are displayed in Figure 4) to enable a baseline assessment of groundwater conditions and a means of ongoing monitoring following implementation of the irrigation scheme.

Groundwater levels of these five bores were measured on 28 June 2012 and are displayed in Table 8. The depth to groundwater at the irrigation site ranged from 0.4-2.6 metres below ground level (m bgl). Groundwater was shallowest at the southern sites, closest to the hypersaline lakes. The seasonality of the water table depth needs to be established; the groundwater depths presented here are relevant to winter 2012 only. Previous groundwater monitoring from the WWTP bores indicates that groundwater levels are generally highest in the winter and lowest in the summer.

RIA maintains five groundwater monitoring bores at the WWTP site to the north of the golf course, and measured the groundwater levels of four of these bores on 5 June 2012. The groundwater levels from the WWTP bores (05/06/2012) and the golf course and oval bores (28/06/2012) are shown together in Figure 7 and suggest a groundwater flow direction toward the salt lakes.

Table 8 Depth to groundwater at golf course and oval bores 28/06/2012

Soil bore site ID (GHD)	Depth to groundwater (m bgl)	Groundwater level (m AHD)
GCW01	1.5	0.3
GCW02	0.4	0.1
GCW03	0.6	-0.1
GCW04	1.6	0.1
GCW05	2.6	0.3

The groundwater quality at the golf course and oval bores was assessed in the field on 28 June 2012 and samples taken were sent for laboratory analysis (complete results provided in Appendix C). The physical parameters measured in the field indicated that bores GCW02 and GCW03 had higher salinity than the other bores (Table 9). These bores are located close to Garden and Herschel lakes respectively. Chemical analysis in the laboratory showed that the chloride concentration in these bores (~10,000 mg/L) was also far greater than at the other monitoring locations (~1,000 mg/L). Historical monitoring of the hypersaline lakes has given electrical conductivity (EC) results of the order of 100,000 µS/cm and the groundwater quality variability between the near-lake bores (GCW02 and GCW03) and the others suggests groundwater-surface (lake) water connectivity. The Rottnest Island fresh groundwater lens probably meets the hypersaline lake water somewhere in the vicinity of the lake shore, but the exact location may be seasonally variable. It is likely that the direction of groundwater flow and the location of the freshwater-hypersaline water divide change with the seasons as the lake and groundwater levels rise and fall due to the impacts of rainfall and evaporation. This will be better understood after the baseline water monitoring program (discussed in Section 7) has been completed.

Table 9 Electrical conductivity measured in the field at the golf course and oval bores (GHD, June 2012)

	GCW01	GCW02	GCW03	GCW04	GCW05
EC (µS/cm)	2,941	22,491	25,708	7,573	3,162

The results of laboratory nutrient analyses of lake and groundwater samples taken in June and July 2012 are summarised in Table 10. The results indicate that the total nitrogen levels in the lake water are fairly high (8-14 mg/L) compared to a licenced discharge water quality of TN < 10 mg/L for the WWTP. The nitrogen speciation, however, is different to the WWTP outflow, which is primarily ammonia and nitrate (with some organic nitrogen). The lakes nitrogen appears to be predominantly organic. The total phosphorus levels are much lower than the treated wastewater from the WWTP, which has a TP < 1 mg/L licenced discharge concentration. The water quality of the groundwater appears to be highly variable across the site, with samples from GCW04 and GCW05 in the north and west of the course having higher nitrate levels than elsewhere. It is not possible to identify the reason for the higher nitrate levels at these sites. Although infiltration from the WWTP ponds may be affecting groundwater quality in the bores within the treatment plant boundary, there is not enough data at this stage to determine the lateral extent of the contamination. The oval site, GCW01, has higher than average ammonia concentrations, which may be linked to current irrigation and fertilisation practices there. Total phosphorus at all groundwater monitoring sites is higher than lake samples.

Monthly monitoring of the lakes and groundwater is being conducted by RIA prior to construction of the golf course in order to establish baseline water quality conditions. This monitoring is vital to establish the pre-irrigation water quality so that once irrigation begins any impacts on groundwater and lakes can be identified.

Previous monitoring data of the south-west side of Herschel Lake (associated with environmental monitoring of the impacts of the landfill) are not consistent with a recent sample taken from the north-east side of Herschel Lake. This indicates that water quality within the lake is heterogeneous, and that the previous data from water quality monitoring for the landfill are not suitable to determine site-specific trigger values for the golf course irrigation monitoring. Site-specific trigger values will be calculated once there is sufficient baseline data from the lake sites adjacent to the golf course.

Section 7 proposes a monitoring plan that will be used to track water quality of the groundwater and lakes in the vicinity of the golf course and oval order to identify any environmental impacts caused by the irrigation scheme.

Table 10 Preliminary water quality results [a]

Location	Sample ID	Date	Total nitrogen	Nitrate as N	Nitrite as N	Ammonia as N	Total phosphorus
			mg/L	mg/L	mg/L	mg/L	mg/L
Garden Lake	GL1	28/06/2012	9.7	<0.005	<0.005	0.78	<0.01
Herschel Lake	H1	28/06/2012	14.0	<0.005	<0.005	0.96	0.02
Lockey's Lake	LL1	28/06/2012	7.6	<0.005	<0.005	0.18	0.11
Oval	GCW01	28/06/2012	-	0.01	<0.01	3.48	0.49
		30/07/2012	20.0	<0.005	<0.005	6.2	1.9
Golf course	GCW02	28/06/2012	-	<0.01	<0.01	0.87	0.23
		30/07/2012	8.0	<0.005	<0.005	0.81	1.0
Golf course	GCW03	28/06/2012	-	<0.01	<0.01	0.38	0.60
		30/07/2012	8.4	<0.005	<0.005	0.91	1.1
Golf course	GCW04	28/06/2012	-	2.78	0.05	0.17	0.82
		30/07/2012	7.8	2.9	0.017	0.03	1.4
Golf course	GCW05	28/06/2012	-	0.47	0.05	2.81	0.82
		30/07/2012	7.5	0.82	0.01	2.3	1.5

a Lakes sampled by RIA, groundwater sampled by GHD 28/06/2012, groundwater sampled by RIA 30/07/2012

1:7,500 (at A3)

0 37.5 75 150 225 300 375

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

- WWTP Bores - Sampled 05/06/12 by RIA
- Golf Course Bores - Sampled 28/06/12 by GHD
- Intermittent Stream

Rottnest Island Authority
Rottnest Recycled Water Scheme
Field Investigations : Golf Course & Oval

Job Number	31-28991
Revision	0
Date	17 Sep 2012

Groundwater Levels Winter 2012

Figure 7

G:\31\28991\GIS\Maps\MXD\3128991_G003_Fig07_Rev0.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com W www.ghd.com

Data source: GHD: WWTP Bores - 20120725, Golf Course Bores - 20120725, Intermittant Stream - 20120725; Rottnest Island Authority: Rottnest Island Mosiac - 20120214. Created by: radeleon, jrutherford

3.3.2 Drinking water supply

The primary source of water for Rottnest Island is a desalination plant which is supplied by five saltwater beach bores located in the sand dunes of Longreach Bay (Programmed Facility Management, 2011). Twenty-nine fresh groundwater bores in the Wadgemup borefield (Figure 8) supply the remainder of the island's drinking water supply, but are shut down during the winter months when water demand is lower. The desalination plant supplies approximately 75% of the island's water and the freshwater borefield produces approximately 25%.

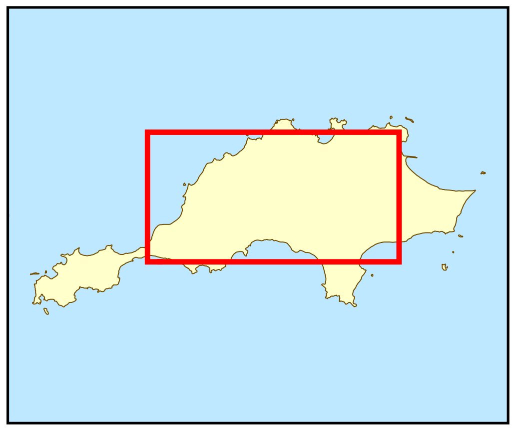
The drinking water quality management plan for Rottnest Island was prepared by Aquaterra Water & Environment Consultants (April 2009) and the RIA report annually to the Department of Health on the drinking water scheme.

Longreach Bay is located to the north of the golf course. The fresh groundwater borefield is located in the north-west portion of the island approximately 4 km from the golf course. There are no drinking water bores within the WWTP site, golf course or oval.

There is a risk that the groundwater extracted for drinking water could be contaminated as a result of the proposed irrigation of recycled water on the golf course and oval. Extracted water from the Wadgemup borefield is disinfected with chlorine prior to distribution, but no other treatment processes are used.

The topography of the island suggests that the irrigation area is well isolated from the Wadgemup drinking water borefield; the irrigation area is separated from the borefield by the island's hypersaline lakes. However, little is known about fresh groundwater connectivity and groundwater flow regimes at Rottnest and this risk is currently unquantifiable. This has been addressed in the RWQMP and it has been recommended that further investigative work is undertaken to assess this risk.

The risk of contamination of drinking water sourced from beach bores at Longreach Bay is lower, as this water is treated using reverse osmosis for desalination, which would remove most contaminants. Chlorine gas is also used for disinfection.



Legend

- Production_Bores_Min324
- Monitoring_Bores_Min324

0 50 100 200 300 400 500 600 700 800 900 1,000 1,100 1,200 1,300 1,400 1,500 m

N

1:15,000

Wadgemup Borefield Yarragadee Abstraction

Projection: GDA MGA 50

Production Date: 3 May 2011

Rottnest Island Authority

Disclaimer: The RIA accepts no responsibility for the accuracy of this image, or the results of any actions taken when using this image.

4. Nutrient and irrigation management

4.1 Irrigation management

4.1.1 Irrigation system components

A new irrigation system is planned to cover the fairways, tees, and greens on the golf course, designed by Paul F. Jones & Associates. This includes a connection to the existing irrigation system of the sports oval. The areas of land between and surrounding the nine holes will be left unirrigated with the existing vegetation. Drawings of the irrigation layout and control system can be found in Appendix D. The proposed irrigation scheme consists of fairways, tees, greens and the sports oval, the areas of which are displayed in Table 11.

Table 11 Areas to be irrigated

Irrigation scheme component	Land area (ha)
Golf greens	0.25
Golf tees	0.25
Golf fairways	8.00
Sports oval	1.10

The golf course design recommends that three different types of grass should be used for the golf course: Pencross Bent on the greens, Santa Ana Couch Sods on the tees and Wintergreen Couch on the fairways (Davey Shearer Golf Design, 2012). The grass or grasses that will be planted is yet to be confirmed, so the design was used as the assumption for the investigations undertaken for this NIMP.

In some areas surrounding the irrigated playing surfaces, the native and/or existing vegetation will be retained. Some clearing will occur and details are provided in the golf course design drawings provided in Appendix A.

The arrangement of sprinkler heads is designed to distribute the irrigation water to only the areas which require it. For example, part circle sprinkler heads will be installed around the edges of the fairways to restrict the range to the intended irrigated vegetation, and avoid spraying onto sensitive areas. There will also be measures in place to monitor conditions to ensure that irrigation of recycled water only occurs when there is a need for it and the environment can accommodate it. There will be three moisture sensors: on hole 2, on hole 4, and between holes 7 and 8. A weather station, the moisture system base station, and a central computer will be located near the clubhouse (Paul F. Jones & Associates Pty Ltd, 2012). The irrigation construction specification provides more details and is provided in Appendix D.

Each green has a minimum of four full circle sprinklers placed to ensure uniform coverage of the playing surface and green surrounds (Paul F. Jones & Associates Pty Ltd, 2012). Part circle sprinklers will be placed on the green perimeter and faced onto the green surface. The sprinklers will come complete with an electric valve-in-head and be able to be operated individually or the system will be able to simultaneously activate all full circle sprinklers or all part circle sprinklers, required for such tasks as fertiliser wash in or syringing (Paul F. Jones & Associates Pty Ltd, 2012). Full circle and part circle sprinklers will be similarly configured on the fairways. Tees will have part circle sprinklers with check valves. The area around the clubhouse has not yet been designed. Quick coupling valves will be installed in the landscaped surrounds to facilitate the connection of hoses, sprinklers on stands, drip or micro irrigation, or other suitable irrigation devices (Paul F. Jones & Associates Pty Ltd, 2012).

Recycled water is currently stored in tanks at the WWTP site. Additional storage is required to ensure irrigation water is available year-round. Storage options currently being investigated by RIA include the existing effluent disposal ponds and existing unused tanks near the golf course associated with the old bitumen catchment area.

RIA to update the storage description when a decision has been made.

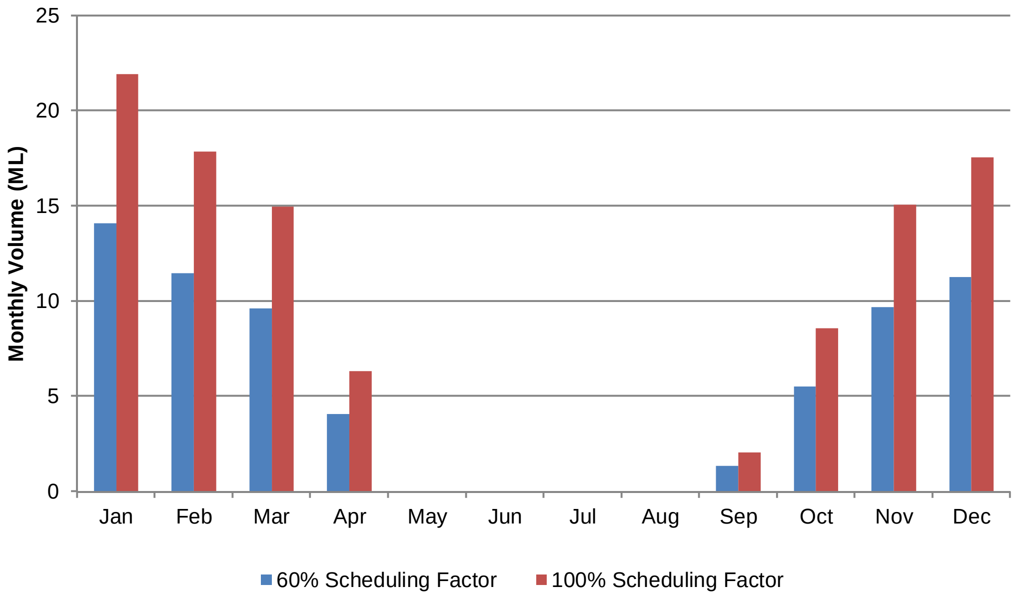
4.1.2 Irrigation system operation

Detailed plans of the irrigation control system are provided in Appendix D. The following information provides a summary of the irrigation system, detailed in the construction specification prepared by Paul F Jones & Associates (2012).

- The irrigation system will provide fully automatic control of all sprinklers on the greens, greens surrounds, tees and fairways. Quick coupling valves will be placed at each green and tee, and strategically along both sides of each fairway, to enable supplemental watering, fertilising, and other intermittent tasks.
- The control system will consist of a central or master computer located in the golf course superintendent's office, which will work in conjunction with field decoders located in close proximity to the sprinklers or control valves which they control. It will be equipped with an uninterruptable power supply. The entire watering program will be governed by the integrated weather station.
- The sprinkler systems for greens will be able to be operated separately from the surrounds. All green sprinklers will be able to be operated individually. Each valve in head sprinkler will be individually controlled, which includes all of the sprinklers with electric valves. The sprinklers with check valves can be controlled by control valves upstream.
- The moisture sensors and the weather station will interface with the control system, so that irrigation can be adjusted in accordance with site conditions. The moisture sensors will measure soil moisture content, electrical conductivity, and soil temperature. The weather station will have a wind sensor, rainfall collection, and a solar radiation sensor and be capable of calculating daily evapotranspiration rates. Reactive programs can be set for wind direction and/or speed, evapotranspiration rates, and rainfall conditions. This system will provide tools and the ability for efficient irrigation scheduling by the operator, but has been designed such that the entire watering requirement can be applied at night, with a watering window between 11:00 pm and 7:00 am.
- Scour valves will be located at suitable low points of the irrigation main lines and sub-mains to enable draining of the irrigation system should servicing be required.
- The irrigation water will be provided by a pump station located adjacent to the wastewater treatment plant. The pumps will be demand driven, and will have a flow range of 0 to 32 L/s.

The monthly irrigation design water balance (Appendix D), which is based on historical climate data, predicts that no irrigation will be required during the months May to August as there is sufficient rainfall to meet turf needs (Paul F. Jones & Associates Pty Ltd, 2012). The turf is likely to become dormant in the cooler weather. The winter period also allows fresh rain water to percolate through the soils and flush out any salts that have accumulated over the summer irrigation period. Irrigation with reuse water is highest during December, January, and February, when there is little rainfall and high temperatures. It is anticipated that there will not be enough recycled water from the WWTP to water all irrigation areas to 100% of demand (Kingston Water Engineering, 2012). As a result, a scheduling factor of 60% has been applied to the fairways and the sports oval in the design water balance (Paul F. Jones & Associates Pty Ltd, 2012). Below in Figure 9 are the anticipated monthly irrigation volumes both with and without the 60% scheduling factor on the fairways and sports oval.

Figure 9 Monthly irrigation volumes by scheduling factor (Paul F. Jones & Associates Pty Ltd, 2012)



4.2 Nutrient management

4.2.1 Water and nutrient balance modelling using MEDLI

The Model for Effluent Disposal using Land Irrigation (MEDLI) was used to assess the water and nutrient balance of irrigation at the Rottnest golf course and sports oval using recycled water. The results are summarised here and the modelling exercise is described in detail in Appendix E.

Irrigation with nutrient rich water has the potential to impact on the environment, through for example contamination of groundwater, surface waters and/or soil. For this project, the water quality, irrigation area and plant type are fixed, and information on these was combined with site specific (environmental and climatic) data gathered for the MEDLI modelling exercise to assess the likely impact on the local environment. The results of the water and nutrient balance modelling are presented here.

The MEDLI model was used to simulate a daily water and nutrient balance at the irrigation site based on the following:

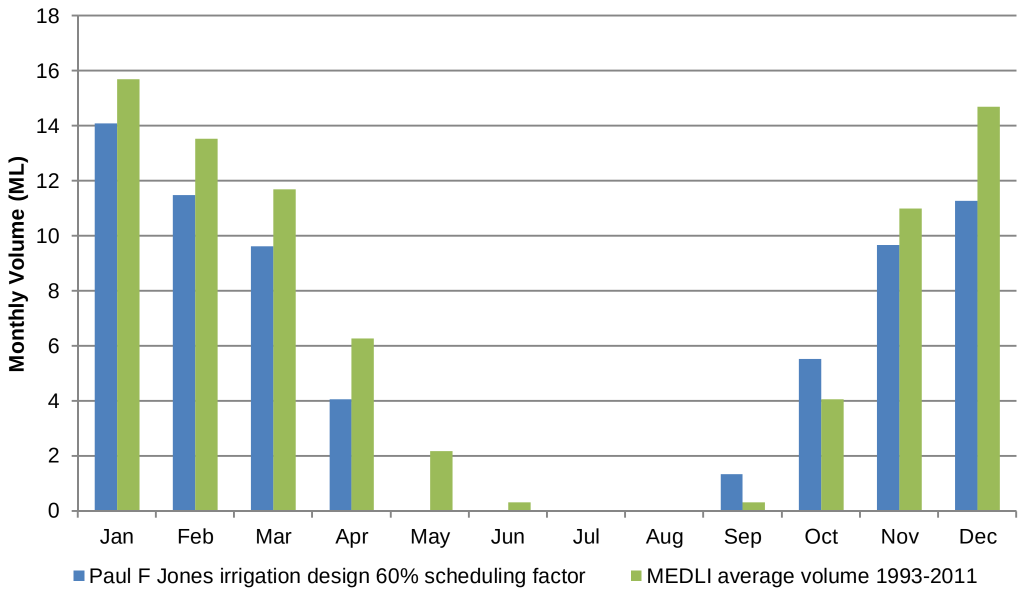
- The local climatic conditions;

- The crop type to be irrigated;
- The area available for irrigation; and
- The site-specific soil conditions and properties.

The model simulated irrigation of 9.6 hectares of couch turf with treated wastewater over a 20 year period (using climate data from 1992-2011). For the purpose of assessing the nutrient cycling at the irrigation site, it was assumed that the irrigation water storage requirements had been met with the installation of a basin with capacity 8,112 kL, equal to the current storage available at the WWTP including the evaporation basins currently used for wastewater disposal (Kingston Water Engineering 2011). This assumption had the effect in the model of irrigation not being limited by seasonal recycled water storage capacity. Instead, irrigation was controlled by supply (WWTP outflow) and demand (of the turf).

The average annual irrigation was predicted to be 79.8 ML, which is almost 20% higher than the 67.1 ML proposed in the 60% scheduling factor (for fairways and oval) water balance by Paul F Jones (irrigation designer). There are a number of differences between the calculation methods of the irrigation design water balance and MEDLI which can account for the difference in volumes. The monthly average irrigation volumes as calculated in MEDLI are compared in Figure 10 with the monthly irrigation volumes proposed in the irrigation design water balance. The seasonality of irrigation demand is comparable, and in reality, the application of irrigation will be managed according to turf performance and prevailing climatic conditions; the integration of the site weather station with the irrigation control system is discussed in Section 4.1.2.

Figure 10 Monthly irrigation volumes predicted by irrigation design and MEDLI modelling



The fate of nitrogen and phosphorus applied to the site via irrigation of recycled water is determined by MEDLI. Nutrients are taken up by plants, which can be harvested (i.e. via turf mowing) and the nutrients within can be effectively exported off-site. A portion of the nutrients applied may also enter the local environment by partitioning to the soil, leaching to groundwater or volatilising to the atmosphere. The key nutrient balance results are displayed in Table 12.

Table 12 MEDLI nutrient balance results – major sources and environmental receptors (average 1993-2011)

MEDLI nutrient balance parameter	Nitrogen	Phosphorus
Applied via irrigation (kg/ha/y)	70	9
Volatilised (to atmosphere, kg/ha/y)	7	n/a
Denitrified (to atmosphere, kg/ha/y)	<1	n/a
Uptake by turf (kg/ha/y)	136	7
Adsorbed to soil (kg/ha/y)	0	2
Leached below profile (to groundwater, kg/ha/y)	<1	0
Concentration of nutrient leached below profile (to groundwater, average mg/L)	$[NO_3^-] < 0.1$	n/a

The nutrient balance results indicate that minimal leaching of nutrients to groundwater will occur if irrigation of recycled water occurs to meet demand only, as was simulated in MEDLI. The results of the simulation show the following:

- Nitrogen uptake by turf is significantly higher than that which is applied via irrigation: the remainder of the consumed nitrogen is taken from the soil, causing the organic nitrogen in the soil to be depleted over time. Fertilisation of the irrigation area with nitrogen will be required.
- A very small amount of nitrogen is leached below the modelled soil profile and it can be assumed that this enters the groundwater as nitrate. The amount of nitrogen leached accounts for a very small proportion of the nitrogen applied, and analysis of the temporal data shows that leaching occurs during winter, when typically no irrigation is being applied and is triggered instead by rainfall.
- The majority of phosphorus applied in irrigation water is taken up by the turf and the remainder is adsorbed to the soil. The soils at Rottnest golf course and oval were found to have variable capacity for adsorbing phosphorus (see Section 3.2). The modelling results show that no phosphorus was predicted to be leached below the modelled soil profile over the 20 year simulation period, with the unused phosphorus adsorbing to the soil.

Analysis of daily data from an average rainfall year showed that irrigation occurs predominantly in the summer months, and that deep drainage (water that infiltrates below the modelled soil profile – presumably reaching groundwater) follows rain events rather than irrigation. The turf can survive on rain water alone for the winter, and this annual break in irrigation will help to prevent salt building up in the soil. The soil is effectively “flushed” of salts in the winter by the rain that infiltrates through the profile.

The nitrogen results indicate that leaching (which accounts for only a small proportion of applied nitrogen) occurs at the same time as deep drainage, following rain events. Leaching of nitrogen is not associated with excess irrigation in this simulation. Nitrogen uptake by turf appears to be responsive to application via irrigation, although a low rate of uptake occurs constantly. The phosphorus uptake is less responsive to application, and the excess is adsorbed to the soil over peak irrigation periods (summer) and then desorbed over winter when no irrigation is occurring. Analysis of results from the entire simulation period showed that there was a net increase in the adsorbed phosphorus in the soils below the golf course and oval irrigation sites.

The EC in the soil profile was found to fluctuate throughout the simulation period due to application of effluent and the influence of climate. Over the 20 years simulated, MEDLI predicted an increase in EC at the base of the modelled soil profile to 3.9 dS/m. This salinity is within the range of EC values measured in groundwater in the first rounds of monitoring the golf course and oval bores (see Section 3.3.1) and no decrease in turf yield was predicted.

MEDLI predicted vegetation growth stress, particularly due to insufficient nitrogen application. Fertilisation is recommended and management of nutrient application is discussed further in Section 4.2.3. Temperature stress was recorded over winter, as expected, which causes the turf growth to slow in cooler temperatures. Irrigation demand is significantly decreased and the need for turf mowing over the winter period is minimal. Water stress is predicted only in very dry years in MEDLI, which demonstrates that if the appropriate storage is created, this scheme can be effectively managed.

A number of simulations were run to determine the sensitivity of model results to parameter values and increase the confidence with which MEDLI modelling results are converted into nutrient management strategies for this irrigation system (more details are provided in Appendix E). The results showed that the minimal leaching outcome achieved in the design model was robust. The system was not sensitive to increased salt application in irrigation water. As expected, turf growth improved with additional (doubled) nitrogen application but no significant leaching was predicted as a result.

4.2.2 Limitations of MEDLI modelling

The results of the MEDLI modelling should be interpreted together with the following limitations:

- The model simulated irrigation over the entire 9.6 ha area at the same rate. Fairways, tees, greens and the oval were modelled with couch turf irrigated with equal water and nutrient application. The actual management of the golf course and oval will be more complicated with vegetation type and water requirements varying across the irrigated area. Greens may be subject to more frequent watering which could cause local impacts that vary from the average situation modelled.
- The model simulated irrigation with recycled water that had a constant water quality. In reality, effluent characteristics will be variable as inflows and management of the WWTP change.
- The model is unable to simulate fertiliser application in addition to irrigation with nutrient-rich water. The results presented for the proposed scheme show that a nitrogen deficit exists (which caused plant stress) which should be managed by application of nitrogen fertiliser when required. As the sensitivity analysis showed, increasing nutrient application when plant demand exists causes increased plant growth. The MEDLI results presented here show the potential for impacts with irrigation using recycled water as the only nutrient input to the system.
- MEDLI modelling is based on the assumption that some site conditions are constant in time and space. In reality there are conditions that vary across the site: such as soil type and depth to groundwater, and with time: such as irrigation water quality. The potential exists for impacts to also vary across the site, and this risk needs to be managed through ongoing environmental monitoring. A network of groundwater bores has been established and will be used to determine the variability in groundwater levels and water quality over time. The results of the monitoring can be used by

managers of the scheme to assess the impact of the scheme on groundwater over time, and to adjust the management as required. Refer to Section 7.

4.2.3 Management of nutrient application

RIA to update this section when the golf course manager is appointed and a golf course maintenance program is established.

The water and nutrient balance modelling has shown that irrigation of the Rottnest golf course and sports oval with recycled water will have minimal impact on the shallow groundwater if managed appropriately.

Modelling showed that nitrogen uptake by couch turf is predicted to exceed the application rate, and additional fertiliser will be required. Phosphorus uptake by couch turf combined with adsorption to soil accounted for the entire amount applied. The Environmental Guidelines for the Establishment and Maintenance of Turf and Grassed Areas (Department of Environment Protection, Water and Rivers Commission, 2001), "the turf guidelines" provides recommended nutrient application rates for nitrogen and phosphorus for different turf types. The relevant application rates are displayed in Table 13. The MEDLI modelling results (Table 12) showed that with effluent irrigation alone, nutrient application rates were approximately 70 and 9 kg/ha/year for nitrogen and phosphorus respectively. While this is within the range of recommended application rates for low maintenance active turf (such as the fairways modelled in MEDLI), the modelling results showed that nutrient uptake rates were on average 136 and 7 kg/ha/year for nitrogen and phosphorus respectively. It is recommended that nitrogen fertilisation will be required to supplement the nutrient application in irrigation water. This should be applied at rates applicable to the turf category. Recommended supplementary nutrient application rates are displayed in Table 13 and are based on a combination of modelling results and the turf guidelines application rates.

Fertiliser application should be concentrated during times of strong plant growth such as summer, and not during winter when the turf has become dormant and applied nutrients may be flushed to groundwater with infiltrating rain. The turf guidelines (Department of Environment Protection, Water and Rivers Commission, 2001) recommend nitrogen application in early autumn (when the soil is still warm) can be combined with increased mowing height during autumn and winter to improve turf durability and reduce weed seed germination.

Table 13 Guideline, modelled and recommended supplementary nutrient application rates by turf category

Turf category	Applicable area at Rottnest	Guideline recommended nutrient application rates (kg/ha/year) [a]		Modelled nutrient application rates through effluent irrigation alone (kg/ha/year)		Recommended supplementary nutrient requirements (kg/ha/year)	
		N	P	N	P	N	P
Passive turf	Golf course rough	0-50	0-5	0 [b]	0 [b]	0-50	0-5
Low maintenance active turf	Golf course fairways, tees and sports oval	50-100	0-15	70	9	30-60	0-5
High maintenance active turf	Golf course greens	100-200	0-50	70	9	30-130	0-40

a Environmental Guidelines for the Establishment and Maintenance of Turf and Grassed Areas (Department of Environment Protection, Water and Rivers Commission, 2001)
b No irrigation proposed or simulated on rough areas

The capacity of the soil to adsorb phosphorus should be monitored on an ongoing basis, as this capacity will be diminished over time. Monitoring requirements are discussed in Section 7.

There may also be a need for trace element fertilisation. Trace element deficiencies are common in alkaline sandy soils close to the coast (Department of Environment Protection, Water and Rivers Commission, 2001). Iron and manganese deficiencies are particularly common and can cause pale coloured and poor quality turf. It is important for the golf course and oval at Rottnest to be managed to maximise plant health so that nutrients applied through effluent irrigation will be taken up. Ongoing monitoring of soil and leaf tissue can be used to confirm the need for any additional fertiliser and to predict the potential for environmental contamination over time. Refer to Section 7 for the site monitoring plan. The solubility of trace elements is low at high pH which can be an issue when applied to alkaline soils such as those at Rottnest. The turf guidelines recommend that trace element deficiencies are corrected with the application of foliar sprays (Department of Environment Protection, Water and Rivers Commission, 2001).

The MEDLI modelling results reported in Section 4.2.1 omitted the plant establishment period (assumed to be one year). While nutrient requirements during turf establishment are high, the potential for losses (leaching) are also high because the root system of young plants has limited ability to collect nutrients. As per the turf guidelines (Department of Environment Protection, Water and Rivers Commission, 2001) frequent application of low concentration organic fertilisers is recommended during the establishment phase.

5. Drainage and water resources protection

5.1 Drainage system design

There is an existing natural drainage line which runs through the golf course from Lockey's Lake to Garden Lake (discussed in Section 3.2.5 and mapped in Figure 7). Flow is intermittent and associated with periods of heavy rain. The golf course design (Davey Shearer Golf Design, 2012) includes realignment of the drainage line, and at this stage it is unconfirmed whether it will be connected to Garden Lake, although some runoff is likely to flow to the lake following heavy rain.

Grading will be performed so that no water-holding pockets are produced on the course (Davey Shearer Golf Design, 2012). Natural drainage swales will be used wherever possible.

Soil amendments for the greens are designed to improve retention of water and nutrients and slow the rate of drainage. Data from the moisture sensors and weather station will be used to prevent irrigation during wet weather when soils are saturated and runoff is likely.

Any runoff which does occur is likely to occur as sheet flow to the intermittent drainage line in the golf course, and infiltrate to groundwater or eventually flow to Garden Lake.

5.2 Surface water protection

The irrigation system has been designed with the following measures which protect surface water:

- The sprinklers are designed only to cover ground which is intended to be irrigated, thus avoiding aerial spray into nearby lakes.
- Inputs from the weather station will be used to ensure irrigation does not occur when it is raining, and soil moisture sensors will prevent irrigation of waterlogged soils. These measures have been proposed to prevent runoff of irrigation water to the nearby lakes.
- The irrigation control system is linked to the weather station, which is equipped with a wind sensor, rainfall collection, and a solar radiation sensor, and is capable of calculating daily evapotranspiration rates. Soil moisture sensors are also integrated. Irrigation rates will be adjusted to meet the vegetation demand to prevent over-irrigation. Soil amendments will be incorporated into the greens to improve the nutrient and water retention of the soil (Davey Shearer Golf Design, 2012).

Surface water monitoring will be integrated with the monitoring plan. Refer to Section 7.

5.3 Groundwater protection

Modelling results (Section 4.2.1) suggest that if water and nutrient application rates are matched to plant requirements, only minimal nutrient leaching associated with percolation of rain will occur. This is important due to the shallow groundwater at this site. The modelled irrigation volume (result from running the model to irrigate on demand only) was similar to the irrigation design volume, and water quality matched recycled water quality being achieved at the WWTP.

Preliminary groundwater quality monitoring results (presented in Section 3.3.1) recorded background concentrations of TN of 7-8 mg/L and TP of 0.2-1.5 mg/L. The predicted leaching of nitrogen to groundwater (presented in Section 4.2.1) occurred in the simulation at low concentrations (< 0.1 mg/L). No phosphorus was predicted to be leached. Groundwater monitoring will be integrated with the monitoring plan, outlined in Section 7. If preliminary monitoring results are representative of the existing environmental condition of the groundwater beneath the golf course and oval, the application of nutrients in irrigation water is not expected to result in any nutrient contamination.

Although the groundwater levels are relatively shallow, the modelling results have shown that the scheme should have minimal impact on groundwater quality if irrigation is applied to meet turf demand only. The monitoring plan will be used to validate these predictions and protection measures and detect any water quality impacts associated with the irrigation scheme.

No groundwater below the golf course or oval will be extracted for any use other than monitoring. The drinking water scheme was discussed in Section 3.3.2.

5.4 Soils protection

The nutrient balance modelling (refer to Section 4.2.1) showed that over time, the irrigation of the golf course and oval with recycled water could result in:

- A small increase in the electrical conductivity (EC) of the soil;
- A build-up of phosphorus that has been adsorbed to the soil; and
- Stripping the native soils of organic nitrogen.

The soil will be monitored to assess the rate of these changes as set out in the plan in Section 7. It is expected that the increase in EC will be small due to the break in irrigation in winter. The phosphorus adsorption capacity of the soil will be monitored over time. The management of the nitrogen levels in the soil is set out in Section 4.2.3, which recommends appropriate fertiliser application rates.

Given the sandy nature of the soils encountered at the golf course and oval, sodicity is not considered to be an issue for the irrigation of recycled water at this site.

6. Vegetation management

6.1 Turf maintenance

RIA to update this section when the golf course manager is appointed and a golf course maintenance program is established.

Turf maintenance at the golf course will be managed by a golf course manager and the sports oval will be managed by a contractor to the RIA (currently PFM). Maintenance activities will include irrigation, mowing, rolling (particularly greens) and fertiliser application.

Turf irrigation and nutrient application will be programmed to match irrigation demand. Modelling of the system has been performed to provide a water and nutrient balance on which to assess the scheme, which was discussed in Section 4.2. Irrigation rates have been determined based on plant needs and documented in the irrigation design (Paul F. Jones & Associates Pty Ltd, 2012), and will be subject to input from the onsite weather station to avoid over-irrigation. Plant health will be assessed through regular monitoring. Refer to Section 7.

The grass will require mowing dependent on the time of year, turf type and playing surface. It is expected that the couch grass (on the fairways) will be dormant during the winter months and will not require mowing. The mowing procedure including the frequency and amount of grass to be removed will be established by the golf course and oval managers in maintenance programs.

The grass clippings should be captured and removed from the site to control the nutrient balance of the irrigation sites.

6.2 Pesticide storage and use

RIA to update this section when the golf course manager is appointed and a golf course maintenance program is established.

Existing pesticide use consists of regular spraying with herbicide to remove undesired vegetation from the sand greens at the golf course. Lee Rogers of Programmed Facility Management (PFM) performs this task and has a spraying ticket. All chemicals are stored at the PFM chemical shed.

There is likely to be spot treatment with herbicides or pesticides should there be any weed or pest infestations once the new turf and plants are installed. Pesticide use should be timed to minimise the risk of chemicals entering the local environment. Weather forecasts and the onsite weather station and soil moisture probes can be used to provide information to ensure the following:

- Spraying should not occur during strong winds, to avoid spray drift of chemicals to nearby sensitive environmental receptors, such as salt lakes; and
- Pesticide application should not occur when the soil is waterlogged, before or after rain or irrigation, to avoid leaching or runoff to ground or surface water.

The golf course manager will be responsible for the golf course maintenance program, including obtaining the required approvals for any planned pesticide or herbicide use. The Environmental Guidelines for the Establishment and Maintenance of Turf and Grassed Areas (Department of Environment Protection, Water and Rivers Commission, 2001) provides guidance on appropriate use of pesticides.

The golf course maintenance program should include details of pesticide use such as

- Description of type and constituents of pesticides, including frequency and rate of application;
- Potential for residue leaching and impact on non-target species; and
- Information on the qualifications, training and experience of those applying pesticides.

7. Site monitoring and reporting

RIA maintains a monitoring schedule for all of its environmental monitoring requirements associated with the landfill, WWTP, salt lakes, seeps, Parker Point, Thomsons Bay and Wadgemup Borefield. Required monitoring to assess environmental impacts associated with recycled water irrigation of the golf course and sports oval will be added to this program. The monitoring plan recommended in this section for the golf course and sports oval is subject to review by DEC, who will prescribe required monitoring as conditions of the WWTP operating licence due for renewal in November 2012.

The recommended environmental monitoring program for groundwater, surface water, soils and vegetation associated with the proposed irrigation scheme is listed in Table 14 and a map of the RIA ground and surface water monitoring locations is provided in Figure 11. The five groundwater monitoring bores were installed throughout the golf course and sports oval in June 2012. Preliminary monitoring results were reported in Section 3.2.5, but the differences between GHD and RIA naming of bores should be noted (see Table 3). The bores are being used by RIA to establish baseline groundwater quality data and will be used to monitor ongoing groundwater quality during operation of the irrigation scheme. An additional bore (reference bore 28/90) will be monitored at the same time as the golf course and oval bores to differentiate local impacts from regional changes in water level or quality due to, for example, climate effects.

The environmental monitoring parameters were chosen to enable detection of environmental impacts of irrigation with treated sewage effluent, such as leaching of nutrients to groundwater, eutrophication of lakes or a build-up of salts in the soil. Considering the Class A reserve classification of Rottnest, seasonal variations, and the potential for impacts associated with the landfill across the lakes from the golf course, monthly monitoring of the groundwater and surface water during the first year of operation is prudent. The first set of monitoring results (see Section 3.3.1) suggests connectivity between the fresh groundwater lens and the hypersaline lakes at the edge of the golf course. Monthly monitoring for the first year will enable better understanding of seasonal variations associated with this, and allow for earlier identification of any impacts of the irrigation scheme. The results will also be used to establish site specific trigger values for monitoring parameters. After the first year, it is recommended that the frequency of groundwater and surface water monitoring be reassessed. An ongoing monitoring frequency will be proposed by RIA in the AER to be submitted to DEC at the end of the 2012-2013 reporting year for review and approval.

Soil sampling should be conducted at the same locations as were used in the field investigations reported in Section 3.2.2. A map of the locations is also provided in that section.

In addition to the recommended environmental monitoring program, monitoring of treated wastewater quality will be required as part of the WWTP operating licence. Anticipated environmental monitoring requirements for the treated wastewater to be used for irrigation are listed in Table 15 below. Additional monitoring requirements associated with health risks of irrigation using recycled water are currently being assessed and will be reported in the RWQMP.

Parameters associated with the operation of the golf course and sports oval will be monitored as listed in Table 16. These will be used to track nutrient loading and inform the programming of future watering schedules.

All sample analysis will be performed at a National Association of Testing Authorities (NATA) accredited laboratory. Records of all results and measurements are to be kept and maintained for at least five (5) years.

GHD is currently preparing the 2011-2012 Annual Environmental Report (AER) for RIA to fulfil its landfill and WWTP licence condition reporting requirements to DEC. It is recommended that results of the irrigation scheme environmental monitoring program detailed in Table 14 are analysed and reported in future Annual Environmental Reports.

Due to the unique environment at Rottnest Island (such as the hypersaline inland lakes), published guideline values for water quality (such as the ANZECC guidelines) are not applicable. Site-specific trigger values will be calculated (particularly for nutrients) once sufficient baseline data has been captured. Future monitoring results should be compared to these trigger values and exceedances treated as environmental incidents. The procedure for responding to environmental incidents at Rottnest is discussed in Section 8.

Table 14 Recommended environmental monitoring program (RIA responsibility)

Sample type	Sample locations	Frequency	Parameters
Groundwater	OV1, GC1, GC2, GC3, GC4, REF28/90	Monthly for the first year [a]	Water level, electrical conductivity, pH, temperature, redox, dissolved oxygen, total dissolved solids (TDS), total nitrogen (TN), total Kjeldalh nitrogen (TKN), ammonia, nitrate, nitrite, total phosphorus (TP), filterable reactive phosphorus, thermotolerant coliforms, E. coli, chloride
Surface water (lakes)	LL1, H1, GL1, GL2, GH1	Monthly for the first year [a]	Electrical conductivity, pH, temperature, redox, dissolved oxygen, total dissolved solids (TDS), total nitrogen (TN), total Kjeldahl nitrogen (TKN), ammonia, nitrate, nitrite, total phosphorus (TP), filterable reactive phosphorus, thermotolerant coliforms, E. coli, chlorophyll-a, chloride
Soils (0-10 cm, 30-50 cm and 90-100 cm depths)	GCS01, GCS02, GCS03, GCS04, GCS05	Annually	Phosphorus buffering index (PBI), electrical conductivity, pH
Plant tissue analysis	Golf course and oval grass	If vegetation appears to be in poor health	Nutrients (nitrogen, phosphorus and potassium) and trace elements (iron, manganese, copper, zinc and magnesium)

a Monitoring frequency to be reassessed by RIA after first year. New ongoing frequency to be proposed in AER for DEC review and approval.

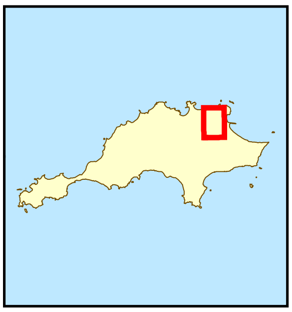
Table 15 Treated wastewater monitoring program (recycled water at WWTP outlet) (RIA responsibility)

Frequency	Parameters
Monthly	Total wastewater flow, pH, total dissolved solids (TDS), total nitrogen (TN), ammonium, nitrate, nitrite, total phosphorus (TP)

Table 16 Irrigation scheme monitoring program (RIA responsibility)

Type	Frequency	Parameters
Irrigation	Daily	Where irrigation occurred (station/s), flow volumes applied, and time and length of irrigation
Fertilisers	Whenever fertiliser is applied	Where applied, date applied, rate of application, type of fertiliser, nitrogen and phosphorus content
Weather station	Daily	Weather data (rain, wind speed and direction, solar radiation) and calculated evapotranspiration rates

Reference bore (REF28/90) must be included when sampling golf course bores



Golf Course Boundary
Oval Fence
Golf Course & Oval Bores
Golf Course Lake Locations

N

Rottnest Island Authority

Golf Course Bore & Salt Lake Monitoring Locations

0 50 100 200 300 m 1:5,500

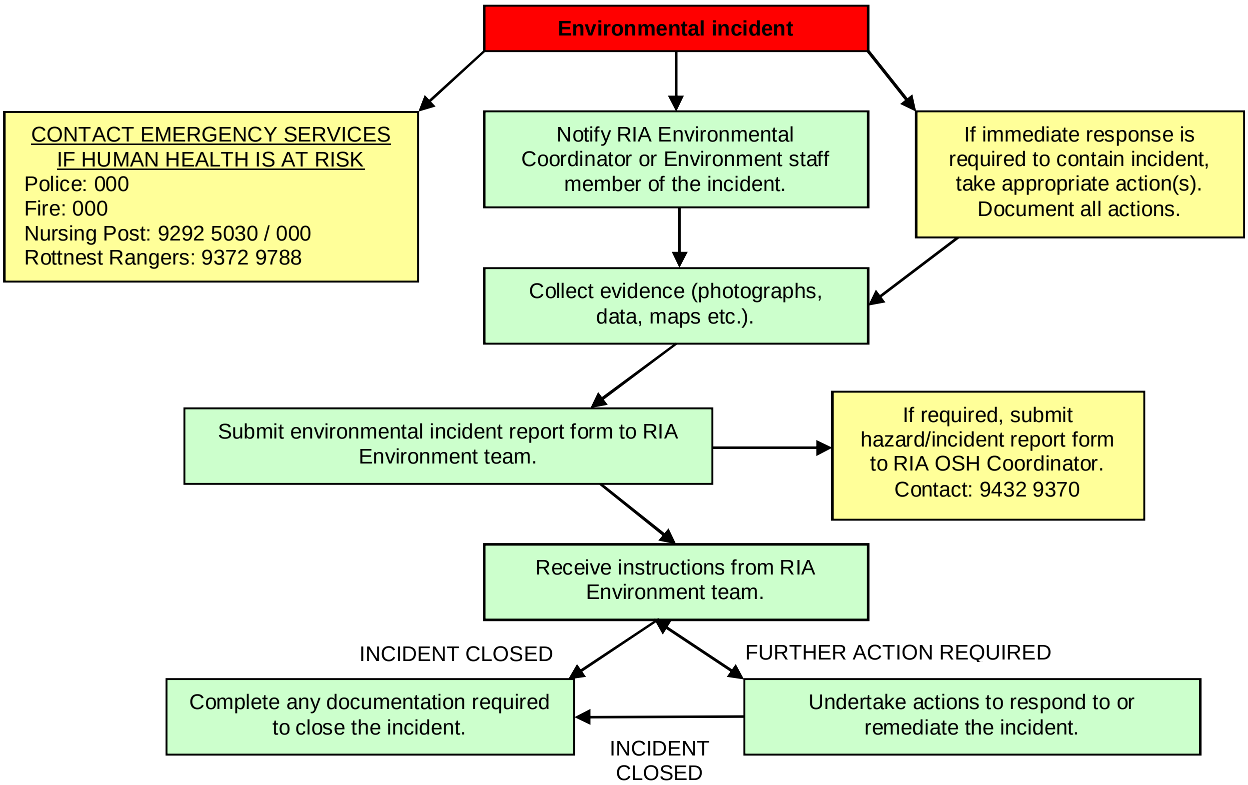
Projection: GDA MGA 50
Production Date: 6 August 2012

8. Contingency plans

In the event that the recycled water is known to be unfit for irrigation due to problems with the wastewater treatment process, the reuse system can be shut off and effluent diverted to the basins at the WWTP for disposal.

In the event of an environmental incident, such as the detection of an environmental impact (acute such as a chemical spill or chronic such as contamination of groundwater detected in monitoring) of the irrigation scheme, the RIA standard operating procedure (SOP) for Environmental Incidents should be followed. The SOP is currently in draft form and is being finalised ready for distribution to individuals or organisations working on Rottnest, including external contractors, researchers, volunteers and Programmed Facility Management (PFM) (RIA, 2012). This procedure provides examples of environmental disturbances, which include discharge/s of harmful substances into water. The procedure for responding to an environmental incident is summarised in Figure 12 below and the draft SOP is provided in Appendix F.

Figure 12 RIA environmental incident response flowchart



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Appendix A

Golf course design (Davey Shearer Golf Design, 2012)

Construction specification

Construction drawings

ROTTNEST ISLAND GOLF COURSE, WESTERN AUSTRALIA

CONSTRUCTION SPECIFICATION

Prepared by:

davey shearer golf design

May 2012

Table of Contents:

1. Section 1 – Introduction

1.1 Design to Site Information Supplied

The design for the golf course and the drawings describing the design respect base site information supplied to the architects by the Client. Any discrepancy between the drawn design contours and what is actually on site will be resolved during the construction program, and the Architect remains the sole decision maker in any such adjustments required.

1.2 Definitions

In this Specification, the word **Principal** refers to the Client (the Rottnest Island Authority), or particularly his representative on site for the purpose of overseeing the development of the golf course.

His representative on site (Davey Shearer Golf Design) shall be called the **Architect** for purposes of this Specification. The word **Architect** also refers to Ben Davey & Bob Shearer, the Architects for the Golf Course.

The word **Contractor** describes the nominated person responsible for any actually constructing the golf course and the project manager.

The word **Sub-contractor** refers to the person responsible for the company appointed by the Principal to undertake specific construction or finishing work on the golf course, apart from the work being undertaken by the Contractor. Sub-contractors may be suppliers of materials required for construction purposes, or may undertake specialized installation and finishing works such as irrigation, or grassing of the golf course.

1.3 Instructions on Site

Instructions to the Contractor that are related to the construction of the golf course, the interpretation of design drawings and all design matters shall be given by the Architect. The Architect will be permitted to instruct the Contractor directly, in liaison with the Principal.

1.4 Engineering Works

The documentation prepared by the Architect is for the shaping and finishing of the golf course. If engineers are required for any aspect of the works, such engineers will be appointed by the Principal, and will liaise closely with the Architect in the design of all elements and systems which will impact on the quality and visual harmony of the finished golf course. The engineers will instruct the Contractor on all construction works under their control.

2. Section 2 – General

2.1 Surveys and Setting out of Work

The Contractor is responsible for the initial location and staking of the centerlines of fairways, and for providing coordinated master benchmarks (survey posts) for horizontal and vertical control. Staking by the Contractor covers only the centre points of the greens, tee positions and landing (turn) points. Maintenance of the staking and survey pillars shall be the responsibility of the Contractor. Should any of these marks or stakes be disturbed or destroyed they will be re-established immediately by, and at the cost of the Contractor. All other surveys and setting out shall be the responsibility of the Contractor.

The staked points will be confirmed on site by the architect. Any adjustments required shall be at the discretion of the architect and will be made prior to the commencement of construction on that hole.

2.2 Project Record Documents

The Contractor will be responsible for preparing detailed Project Record Documents ("as-constructed surveys and plans") for horizontal and vertical location in both CAD disk (CD) format and hard copy (three sets of prints) for each of the following categories:

a) Greens, tees and fairways
b) Drainage (if applicable)
e) Any lakes, pump stations, bridges etc
f) Water reticulation
g) Electrical reticulation and other conduit/pipe

2.3 Standards

All materials, methods of construction and testing not otherwise specified shall be in accordance with applicable Government Codes and/or manufacturers requirements and/or recommendations.

2.4 First Aid

The Contractor shall provide, equip and maintain an adequate first aid treatment centre on the site and shall have an experienced first aid person available at all times work is in progress.

2.5 Inspection of Site

The Principal, Architect and Contractor shall make a careful inspection of the site before works commence, to ascertain the exact extent, difficulty and nature of work, and the location of all existing services which are to remain. This joint inspection will form part of the agreement process. The Contractor shall be responsible for the cost of making good any damage to existing services, whether or not they are shown on drawings.

2.6 Site Maintenance

For the full extent of this Contract the Contractor shall maintain the site in a tidy and safe manner. In particular the Contractor shall observe the principles of any Environmental Management Plans (EMP) prepared to respect government requirements and shall control water erosion and wind erosion (dust) and provide all labour and materials for the effective control of such. For the control of dust, the Contractor shall provide and operate a water cart(s) of 30,000 litre minimum capacity with side throw ability (batter spray) on site and on access roads to the site.

2.7 Signs and Advertising

The Contractor, his subcontractors and suppliers shall not erect or cause to be erected, any signs, notices, sign posts or advertisements on or near the site without the prior approval of the Principal.

2.8 Site and Local Environment

The Contractor shall take all precautions to protect the site and local environment. This includes the protection of:

- all trees that are marked (on site or on plans) for retention and protection.
- any known native wildlife (not deemed a pest)
- current water moving through the site
- any human remains found on site
- neighbouring properties, stock, fauna or wildlife
- the general amenity of the area.

2.9 Scheduling of Works

The Contractor will provide the Principal and the Architect a Construction Schedule showing the order of works to be undertaken. The Schedule will show the haul roads and construction roads to be developed through the site to serve the construction programme. The provision, removal and reinstatement of all haul roads required by the Contractor shall be the Contractor's responsibility and cost. Reinstatement shall include:

- removal and disposal of any rock (if applicable) elsewhere on site and incorporation of same into the bulk earthworks 1 m minimum below subgrade level,
- ripping compacted ground to a depth of 450 mm below subgrade.

Work shall be scheduled in such a manner as to allow for the progressive handover, on a hole by hole basis, of completed work to the grassing contractor or subcontractor, including coordinating work with the irrigation contractor to provide an operational irrigation system at handover.
with the Project Control Programme).

Where pipework intersects (eg fairways) scheduling shall take into consideration the following sequencing:

Order of Work	**Item**	**Minimum cover to Finished Surface Level**
1	Major stormwater drainage	800 m
2	Minor solid stormwater drainage	400 mm
3	Irrigation lines	450mm
4	Minor ‘Agflow’ or similar stormwater drainage	300 mm

2.10 Use of Private and Public Roads

Where private and public roads are used outside the Site, the Contractor shall maintain them free of earth, rock or other materials. All plant and equipment shall be cleaned of such material prior to leaving site. Any material dropped onto private and public roads shall be promptly and properly removed and the roads cleared by, and at the cost of, the Contractor, to the satisfaction of the Principal and the relevant Local Authority.

2.11 Site Drainage

The Contractor shall ensure that the entire site remains free draining throughout the contract period and shall provide temporary drainage facilities and procedures as required. No water shall be discharged into any drain, trench, water body or channel etc without the approval of the Principal and Architect. The cost for any repairs by the Contractor of damage caused by flooding, or stormwater shall **not** be grounds for a variation to the contract price. The Contractor shall allow for the works necessary to effectively control erosion and siltation on the site for the duration of the contract period. Any soil subsidence or erosion which may occur after finishing and prior to grassing shall be made good by, and at the cost of, the Contractor. Any rectification and/or repair work shall match previously completed or existing finished profiles.

2.12 Access by Others

The Contractor shall take into account in planning, and undertaking the Contract, the need to maintain at all times adequate all weather access to all adjoining areas of the works. The Contractor shall also provide reasonable access by others to areas of the work of this contract as required by the Architect.

The Principal, Architect and their employees shall at all times have the right to enter and inspect any area of the site. The Contractor will post a notice at the entry to the site should any area deemed to be unsafe to enter (eg explosives, deep water etc).

2.13 Site Soil and Water Testing

Results of any soil, sand and water tests undertaken on or off site will be made available to the Architect on a weekly basis or in accordance with the sampling interval.

2.14 Separate Contractors

The Principal retains the right to employ separate contractors to undertake many aspects of the golf course construction, and the Contractor will agree to, and facilitate the work on site by all such separate contractors. All separate contractors must be approved by the Architects.

Separate contractors *may* be employed for:

a) Landscaping

b) Irrigation work

c) Electrical work

d) Grassing

e) Building (timber or stone work as required)

2.15 Nominated Subcontractors

The Principal retains the right to nominate specific sub contractors for achieving specific parts of the construction and finishing of the golf course.

2.16 Separate Supply Contractors

The following materials may be supplied by Separate Supply Contractors; who will be nominated by the Principal:

Material

a) Greens, tees and general construction sand (to be locally sourced on the island)

2.17 Access to the Site

Vehicular and machinery access to the site shall be via the sealed access road, or as directed by the Principal.

2.18 Internal Site Access

The following procedure is to be adopted for access around the golf course construction site following commencement of shaping activities:

- Access around the site shall be strictly by way of the defined corridors or Contractor’s haul roads. No "cross country" access will be permitted.
- If construction work is required to be carried out on a specific fairway, access for the contractor's plant and equipment shall be initially via the haul road network to

a point at right angles to the work site, then directly from this point to the work site.

- Only plant and equipment directly involved in construction work activities are permitted to leave the haul road.
- All other vehicular transport shall remain on the haul road. Occupants will walk from the vehicle to any other part of the hole for inspection purposes or otherwise.
- Compliance by all parties with the above procedure is essential to preserve the integrity of shaping work during the course of the Contract and to avoid unnecessary compaction. Any damage caused by noncompliance with the above procedure shall be immediately rectified by and at the cost of the Contractor.

3. Section 3 – Vegetation Removal and demolition

3.1 General

Procedure for vegetation removal shall be as follows unless otherwise directed by the Architect:

The first phase shall consist of the architect clearly marking with paint all trees and vegetation requiring removal. This will be done in accordance with the approved **Staking and Clearing Plan**. Trees to be removed shall be clearly marked with a cross with coloured paint. The extent of removal of vegetation such as native ground-covering shrubs will be marked with coloured tape (or similar) to the approval of the Principal. All stumps and roots shall be removed and all removed trees, branches, stumps and other woody plants shall be chipped on site for use in landscape works.

The second phase shall consist of spraying out existing fairway grass and other plant material on each hole, with Weedmaster 360 (active constituent: 360 gms/litre Glyphosate) or similar approved, at an application rate of 6 litres/ha in accordance with the manufacturer’s recommended practice. Spraying equipment shall be fitted with shrouds to prevent overspraying. A minimum of 10 days shall elapse before any subsequent activities take place, eg rotary hoeing. Spraying of each hole will be in accordance with the staking and set-out plans and the irrigation plans.

3.2 Protection of Plants and Trees

All plants and trees to be retained will be protected by the Contractor from injury to their roots and to their limbs. No grading, trenching, pruning or storage of materials or equipment may occur in this area, except as approved by the Architect. The Contractor will replace, at the Contractor's expense, any plant or tree removed from the site which has not been designated by the Architect for removal. The Contractor shall also be held accountable for damage to plants and trees resulting from placement of fill or removal of soil, except as directed by the Architect.

3.3 Disposal

Disposal of all trees, branches, stumps, and debris resulting from the clearing and grubbing shall be the responsibility of the Contractor. Burning *may* be allowed within the proposed fairway areas. However, the disposal of all materials cleared and grubbed will be in accordance with the laws and regulations of the relevant local authorities and the securing and cost of permits shall be the responsibility of the Contractor.

3.4 Demolition

All existing tee boxes, and several bridges no longer required that cross the existing creek, shall be demolished and all debris removed from the site. NO RUBBISH, INCLUDING CONCRETE OR ANY OTHER CONSTRUCTION MATERIALS MAY BE DISPOSED OF ON SITE AND MUST BE REMOVED AND CARTED TO THE MAINLAND FOR DISPOSAL. Burial of any construction material on site is strictly prohibited.

4. Section 4 - Bulk Earthworks and Rough Shaping

4.1 Topsoil Stripping and Stockpiling

No stripping of topsoil or stockpiling is required.

4.2 Cut and Fill and Rough Shape

All golf course shaping must be approved by the Architect, this includes all tees, fairways, rough areas, and greens. Specific instructions will be given when shaping begins based on the Architect direction. The Architect reserves the right to adjust any proposed grades, or tee, bunker and green locations, to meet field conditions or to enhance the character of the golf course.

All cuts and fills shall closely follow the grading plans unless otherwise directed by the Architect. Filled areas shall be sufficiently compacted to prevent future settling, and all grading shall be done in such manner that no water-holding pockets are produced. Natural drainage swales shall be used wherever possible.

Where fill material is obtained from borrow areas, such areas shall be graded to provide surface drainage and to blend with the surrounding contours. In all grading, it is necessary to keep the soil as clean of debris as possible. This is particularly true of soil used in tee and green construction.

All fairways and rough areas should have a minimum slope of 5% for good surface drainage. Usually, all landing areas and associated hazards will be visible from the tees, and all greens and associated hazards will be visible from the landing area. The entire green complex (including the green surface, adjacent mounds and bunkers) will be rough shaped before digging out the green cavity, unless otherwise directed by the Architect.

The Architect may direct the Contractor to place fill material, for the construction of mounds and other features within the golf course, in areas other than those shown on the plans.

All slopes around tees, greens, bunkers, and mounds shall not be steeper than 1 in 3 (33%) unless otherwise shown on plans or directed by the Architect. Cut and fill slopes in fairways, rough, and non-play areas shall not be steeper than 1 in 4 unless otherwise directed by the Architect. The man made shapes should taper into the natural terrain.

Lake outlines shall carefully follow the drawings and/or the Architect's directions. Grassed slopes immediately above design water level shall not be steeper than 1 in 3 (25%) unless directed by the Architect. Slopes below water level shall not generally be steeper than 1:3 (33%) unless otherwise specified and/or detailed on the drawings. Where existing lakes are being used or adjusted, in most cases the existing lake level will not change. Where there is a discrepancy between existing and designed water levels the superintendant is to confirm the final level in consultation with the Project Engineer.

4.3 Conformity with Drawings

The following indicates the degree of conformity with drawings required at this bulk earthworks/rough shaping stage.

- Greens and bunker sites ± 100 mm
- Tee sites ± 100 mm
- Fairways and rough areas ± 200 mm

The degree of conformity with drawings required at the fine shaping stage will be to a far greater degree so the contractor should attempt to achieve conformity close to the design intent.

4.4 Rock Picking and Stick Raking

Rock picking and stick raking shall be a periodic and ongoing activity. All Soils within 200 mm of the proposed finish grade shall be clean of rock or other debris. Rock picking and stick raking may be accomplished by hand or by mechanical means. Rock and stick debris shall be disposed of in a manner approved by the Architect.

4.5 Grading and Rough Shaping of Fairways and Rough Areas

Grading and rough shaping of fairways and rough areas shall consist of blending the mounding and contours of the green sites, tee areas, sand bunkers, fairway mounds and swales in a natural flowing condition into the fairway and rough areas. No special distinction shall be made between fairway areas and rough areas within the scope of this section of the Specification. Finish subgrades are to be established during this process.

4.6 Grading and Rough Shaping of Tee Areas

Grading and rough shaping of the teeing areas shall consist of forming the areas as indicated on the Grading Plans. On site modification of the tee shapes and elevations to fit unanticipated terrain features or for any other reason shall be made as directed by the Architect.

4.7 Grading and Rough Shaping of Greensites

Grading and rough shaping of greensites within this specification shall consist of stockpiling, shaping and compacting the mounds, swales, aprons and approach areas around the putting green in conjunction with the 10 individual hole construction details.

The section dealing with fine shaping and feature construction will fully detail the method of greens construction. During the bulk earthworks stage the green site shall be rough shaped as per the final shape intended for the green. During the fine shaping stage the green will be excavated then compacted and sand profile installed.

The outer slopes of the greensites shall blend naturally, smoothly and harmoniously into the adjacent surrounding soil and undisturbed areas regardless of the existing natural grades. The points of union of greensite mounding and adjacent soil must be continuous and unobtrusive. Any question of condition of greensite shaping with existing grades beyond the greensite must be directed to the Architect by the Contractor.

4.8 Fairway and Rough Drainage Swales

Grading and rough shaping for drainage swales shall consist of smoothing the contours and excavations remaining from the grading process. The side slopes of all drainage swales shall be smooth and natural in appearance. The swales should drain to outlets, catch basins, lake or stream edges where indicated. The slope flow gradients within these swales are to be a minimum of 5 per cent (1:20) from point of origin to discharge. The slopes and width of swales may be variable.

4.9 Subgrade Preparation

Not applicable to this Contract

4.10 Rock on Site

During the bulk earthworks stage it is anticipated that some areas of rock *may* be encountered. The Contractor shall liaise with the Architect who may direct the following:

- If any sheet rock or outcrops are exposed near to the finished levels the Architect may wish to retain these for incorporation within the design as a "natural feature", for landscaping.

The Architect will nominate agreed sites for stockpiling rocks. Alterations may be needed to the design of a hole or portions of a hole to accommodate a decision to retain sheet rock and this will be done in association with the Principal.

4.11 Place and Compact Clay in Lakes

Not applicable to this Contract

4.12 Construction of the 'Creek'

Construction of the 'Creek' should be achieved with an excavator to finished design levels. There should be consistent fall from north to south to avoid pooling of water. The creek should be constructed to appear as natural as possible with no straight lines, and lots of variation in grades along its length. ie, the batters should vary in steepness and the top of batter should not be a straight line. Some on-site variation to the final creek alignment may be required.

5. Section 5 - Fine Shaping and Feature Construction

5.1 Greens

5.1.1 General

The Architect's instructions regarding the design of greens shall be closely followed according to the greens detail plans. The method of construction will be done according to the sand on sand method, in which a cavity is constructed and 250mm of imported clean sand is installed to finished design levels.

5.1.2 Materials

All finished surfaces (with the exception of the putting greens) shall be achieved using the site soil and sands. Finished putting greens shall be finished with imported sand located and sourced on the island. Amendments to the sand shall be according to this specification.

Mixing of the approved sand and organic materials shall be done on site. It is recommended that a qualified soil blending contractor be used to insure proper mixing. After the initial mixing, and prior to any placement of the materials in the green cavities, samples of the mix shall be taken by the Contractor and submitted to an approved and registered testing lab to obtain verification that the rootzone mix meets the original mix specifications. Periodic and additional samples shall be taken by the Contractor to ensure quality control throughout the entire mixing and placement process.

5.1.3 Green Construction Sequence

The following is a recommended sequence for green construction:

a) Rough shaping

b) Irrigation pipework (Separate Contractor)

c) Excavation and subgrade fine shaping of the green cavity and surrounds

d) Greensmix (sand and amendment mix)

e) Topsoiling of surrounds simultaneously with f) and g)

f) Fertilizer and soil amendments

g) Compaction and final shaping including tie in with surrounds

h) Installation of sprinkler heads (by Separate Contractor)

i) Inspection and acceptance by Architect

j) Hand over to Grassing Contractor

5.1.4 Excavation of the Green Cavity

Once the putting surface is rough shaped, the Contractor is then responsible for excavating to sub-grade. The contours of the sub-grade shall conform as closely as possible to within plus or minus 10 mm of the reflected design finish grade. The sub-grade shall be constructed at an elevation below the design finish grade equivalent to the compacted design thickness of the combined gravel and greensmix layers, and thoroughly compacted so that no future settling occurs and drainage trenches may be excavated cleanly to design profile without overbreak. All filled areas shall be compacted to 95%. Approval of the sub-grade by the Architect shall be required prior to commencement of any subsequent work in the green cavity.

5.1.5 Green Drainage

Not applicable to this Contract

5.1.6 Greensmix (Green seedbed material)

Greensmix shall be transported to the rear of the green site and placed within the cavity at various points around the perimeter. The greensmix shall be moved from the edges to the centre. Many techniques are acceptable for spreading the mix, including shovels, boards, and small equipment. A small crawler-type tractor suitably equipped with a blade, for example, is useful for pushing the greensmix out onto the prepared sub-base. If a crawler-type tractor is always operated on the greensmix, it will decrease the possibility of disturbing the green base. Machines must be free of mud, cakes of dry soil, and other debris which could contaminate the greensmix. The greensmix shall be spread uniformly in the green cavity reflecting the sub-base contours previously approved by the Architect. The depth of the greensmix will be a minimum of 250 mm after compaction. Some variation to final grades may be required, and hence the 250mm depth can vary slightly if required.

5.1.7 Fumigation

Not applicable to this Contract

5.1.8 Fertilizer

Basic fertilizer for greens shall be 12-24-14 analysis top grade product, (-14 +35 Tyler mesh size) containing monoammonium phosphate as the phosphate source with a minimum of fifty percent (50%) of the total nitrogen twelve percent (12%) derived from Poly Plus sulfur coated urea and a minimum of twenty-four percent (24%) from monoammonium phosphate. The fertilizer shall be delivered to the site in bags or other convenient containers, each fully labeled, conforming to applicable state fertilizer laws, and bearing the name, trade name or trademark, and warranty of the producer.

5.1.9 Soil Amendments

The sand to be used for the growing medium for putting greens has been tested and the test results are available. The sand requires the addition of amendments to slow the rate of drainage, improve its nutrient content and to reduce its pH. The sand to be used for fairways is the in-situ sand however the same amendments are to be added to improve its quality.

The following amendments need to be incorporated (rotary hoed) into ALL areas that will be grassed and irrigated.

- Fine organic material (chicken manure) at a 10% incorporation rate per volume of sand.
- Super-phosphate at 8 kg/100m2.
- Potassium sulphate at 5 kg/100m2.
- Granular trace element mix at 2 kg/100m2.
- **Sanoplant** soil amendment at the following rates
    - Greens and surrounds: 2kg/m3 or 400g/m2 worked into the top 200mm

(All areas where Bent grass will be used – 9000m2 - should have Sanoplant mixed into the top 200mm)

After all specified soil amendments and fertilizers have been properly applied, all surfaces shall be prepared to the satisfaction of the Architect, and finished in a condition suitable for planting. The final planting bed must be smooth and sufficiently soft in order for seeds or stolons to be planted therein, but sufficiently compacted to avoid further settlement or rutting. The final surfaces must also be free of debris such as sticks and stones. The condition of the planting bed and the putting surfaces must be approved by the Architect prior to planting.

5.2 Tees

5.2.1 General

Tees shall be built to the design contour plans. All filled areas shall be compacted to 95% so that no future settling occurs. To ensure proper grading, the Contractor will laser level all tee surfaces. The finished surface will be perfectly level unless otherwise directed by the Architect.

5.2.2 Tee Drainage

Not applicable to this Contract

5.3 Fairways

5.3.1 General

Fairways will NOT be sprayed out with herbicide – however some spot sspraying of weeds may be required at least 10 days prior to the commencement of any earthworks. Fairways will then be rotary hoed to a minimum depth of 200mm. Soil amendments should then be spSread on the surface before a second rotary hoeing to mix the amendments into the top 200mm of soil. All fairways should then be smoothed using a Sand Pro in preparation for grassing.

5.3.2 Fairway Drainage

Not applicable to this Contract

5.4 Roughs

Prepared as for fairways

5.4.1 Rough Drainage

Not applicable to this Contract

5.4.2 Non irrigated areas

Areas that will not be irrigated are to remain untouched. No removal of any vegetation of any earthworks should occur in these areas.

5.5 Application of Soil Amendments to Tees, Fairways & Roughs

After completion of all shaping, the surfaces of tees, fairways and roughs shall be cleared of all stones, stumps, debris or other objects. The amendments shall be spread evenly over the entire area requiring such and thoroughly incorporated into the soil, at a depth determined by the Architect by means of discing, harrowing, or other acceptable methods within 24 hours following application. Amendments will be applied prior to the application of fertilizer.

5.6 Bunkers

Not applicable to this Contract

5.7 Sandy Waste Areas

Sandy waste areas shown on the plans will be constructed under the direction of the architects. Prior to the commencement of work, the contractor and architect will confirm the desired appearance and finish of these areas. Some variation to the location of sandy waste areas may be required to achieve the best result.

5.8 Grassing

5.8.1 Greens:

Pencross Bent

5.8.2 Tees

Santa Ana Couch sods

5.8.3 Fairway grassing

Fairways will be sprigged with Wintergreen Couch

Tees will be solid turfed with Santa Ana. Tee surrounds will be sprigged

Greens will be hydroseeded with Pencross Bent

6. Section 6 – Drainage

Not applicable to this Contract

7. Section 7 – Landscape Structures

Note: Design and specification of all miscellaneous elements is the responsibility of the Principal's engineers and specialist designers. The following is set down as an aid to such design work.

7.1 Bridges

A number of bridges are to be constructed within the golf course. These bridges will be built using recycled railway sleepers. These railway sleepers are located at the Rottnest Island recycling plant which is located adjacent to the airport, about 1 kilometre from the golf course site.

8. Section 8 – Irrigation

8.1 Design and installation

REFER SEPARATE DOCUMENT FOR SPECIFICATIONS

FINAL

Rottnest Island Golf Course Project

Schedule 1

Schedule of Quantities - Earthworks

Item	Description	Qty	Unit	Rate	Amount
1	**Preliminaries**				
a	Contractor’s overheads, site establishment/mobilisation utilising existing infrastructure where possible, insurance, work cover, supervision, management, etc.	Item	1		
b	Demolish / dismantle existing, tee structures, bridges and fences as applicable. Remove all material and rubble from site.	Item	-		
c	Removal of trees as necessary, mulching and stockpiling as required	Item	-		
d	Traffic control tree protection fencing.	Item	-		
e	Construct and maintain traffic and haul roads.	Item	-		
f	Golf course construction survey and set out.	Item	-		
2	**Preparatory works**				
a	Rotary hoeing of proposed fairways, tees (not all), roughs and greens (areas that will be grassed and irrigated) to a depth of 200mm over golf course works area.	85,000	m2		
b	Addition of sand/soil amendments as specified to all areas to be grassed (as per Specification). All amendments to be rotary hoed into top 200mm		m3		
c	Import sand fill from local source for use in greens construction and some fairway areas (transport cost only)	4,580	m3		
d	Import sand fill from local source for use in tees construction (transport cost only)	130	m3		
e	Earthworks cut to fill for all the proposed tees	1,140	m3		
f	Earthworks cut to fill for the greens to golf course design levels, construction of the creek, and all earthworks (with the exception of tees)	2,000 (approx)	m3		
	Variations				
	Sub-total				

Rottnest Island Golf Course Project

Schedule 2

Schedule of Quantities and Prices - Golf Course

Item	Description	Qty	Unit	Rate	Amount
3	**Shaping Works for Putting Greens**				
a	Transport from stockpile, place, spread minimum 250mm thick and trim to finished levels all putting greens, as shown on the drawings and as specified.	Refer BOQ	m3		
b	**Shaping Works for Tees**				
	Transport from stockpile (where applicable), finish, trim and laser level to finished levels all tees, as shown on the drawings and as specified.	Refer BOQ	m3		
4	**Sandy Waste Areas**				
	Construct sandy waste areas as shown on plans	as per plan			
5	**Finishing work for fairways**				
	After mixing in amendments to top 200mm layer, clear all debris, including stones and sticks. 'Sand-pro' finish all fairways for a smooth, compacted finish ready for grassing				
6	**Access Paths**				
a	Perform sub-grade preparation, smooth, remove debris, compact	1300 lineal metres			
7	**Miscellaneous Works**				
a	Bridges for pedestrian and cart use	6	-		
8	**Turfgrassing Works**				
	Perform grass planting as shown on the drawings and as specified for the following turf grasses:				
a	Hydromulch selected Bent Grass to putting surfaces (incl collar as shown on drawings).	9,000	m2		
b	Stolonise (Wintergreen) grass to fairways and primary roughs.	76,000	m2		
c	Hydromulch wheat (or similar perenial) to control erosion to all sprigged areas	76,000	m2		
d	Solid turf (Wintergreen) grass to tees.	2,500	m2		
	Variations				
	Sub-total				
	TOTAL PRICE				

Rottnest Island
Golf Course

Schedule 3

Schedule of Quantities and Areas

Earthworks (fairways and greens) m3				**Areas (m2)**	
Hole	**Cut**	**Fill**	**Shortfall**	**Greens**	**Tees (total)**
Hole 1	120	750	630	590	210
Hole 2	310	510	200	520	200
Hole 3	150	350	200	620	210
Hole 4	230	430	200	575	195
Hole 5	100	570	470	570	260
Hole 6	50	550	500	620	360
Hole 7	150	800	650	670	205
Hole 8	100	300	200	615	225
Hole 9	250	450	200	605	320
APG	200	1000	800	1315	
Creek	270	670	400	na	
Subtotal	**1930**	**6380**	**4450**	**6700**	**2185**
Tees					
	Cut	**Fill**	**Shortfall**		
Hole 1	60	60	0		
Hole 2	20	70	50		
Hole 3	80	80	0		
Hole 4	120	140	20		
Hole 5	250	250	0		
Hole 6	100	120	20		
Hole 7	160	160	0		
Hole 8	100	100	0		
Hole 9	120	160	40		
Subtotal	**1010**	**1140**	**130**		
TOTAL m3	**2940**	**7520**	**4580**		
Grassing					
Rotary Hoe all areas			85000m2		
Sprigging fairways, roughs (Wintergreen)			76000m2		
Hydromulching all sprigged areas			76000m2		
HydroSeeding greens (Pencross Bent)			9000m2	allows for collar	
Solid turfing tees (Santa Ana)			2500m2	allows for steep edges	

Rottnest Island Golf Course

Construction documentation

May 2012

Drawing Schedule:

Drawing No.	Drawing Name	Status
RI-OP	Overall Plan	Final
RI-SC	Staking, Clearing and Demolition	Final
RI-EW1	Setout and Grading (North-West section)	Final
RI-EW2	Setout and Grading (North-East section)	Final
RI-EW3	Setout and Grading (South)	Final
RI-EW4	Cut-fill explanatory plan	Final
RI-G1	Green 1 detail	Final
RI-G2	Green 2 detail	Final
RI-G3	Green 3 detail	Final
RI-G4	Green 4 detail	Final
RI-G5	Green 5 detail	Final
RI-G6	Green 6 detail	Final
RI-G7	Green 7 detail	Final
RI-G8	Green 8 detail	Final
RI-G9	Green 9 detail	Final
RI-AG	Adventure Green detail	Final
RI-details	Bridge details	Final

Prepared by Davey Shearer Golf Design for the Rottnest Island Authority

1:1500@A1

LEGEND

- Irrigated fairway areas and putting greens
- Areas of natural exposed sand with native ground-covering vegetation
- Existing vegetation to be retained
- Drainage creek from Lockeys Lake to Garden Lake - intermittent water only

SCORECARD

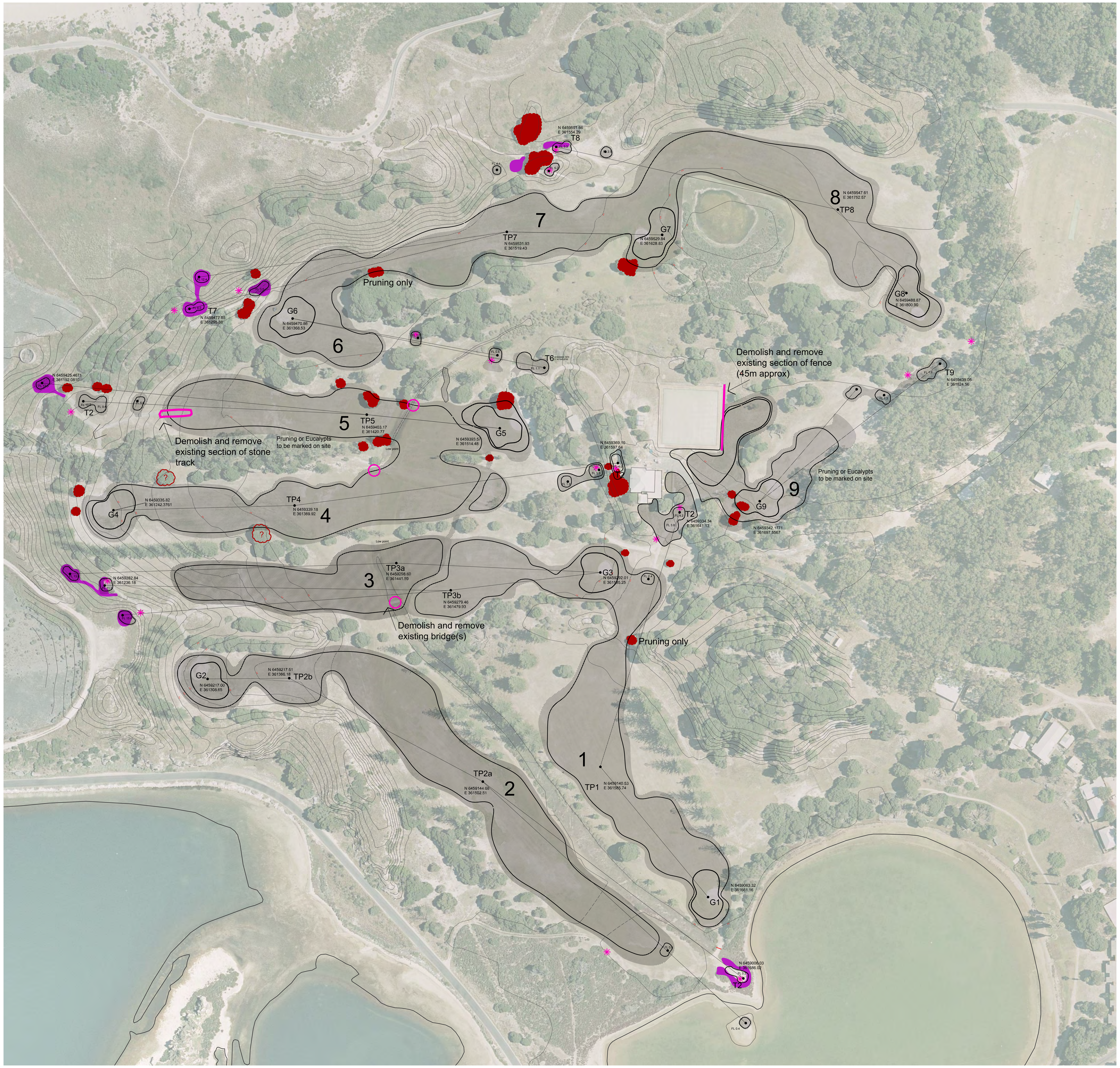
Hole	Metres	Par	Hole	Metres	Par
1	300	4	10	300	4
2	450	5	11	475	5
3	370	4	12	335	4
4	350	4	13	350	4
5	300	4	14	330	4
6	145	3	15	180	3
7	325	4	16	335	4
8	285	4	17	320	4
9	110	3	18	160	3
OUT	2635	35	IN	2785	35
			OUT	2635	35
			TOTAL	5420	70

Rottnest Island Golf Course

Overall Site Plan

Drawing RI-OP

May 2012



1:1500@A1

Legend

Fairway areas to be rotary hoed - all fairway areas to be prepared for grassing as per the Specification

Trees to be removed (note: trees will be marked on site by architect)

Other native vegetation requiring removal

Existing brick tee structures to be demolished - location approximate only (contractor to allow for all tee structures)

Notes:

1. Contractors must allow for the demolition of all existing brick teeing boxes and their surrrounds, bridges that become obsolete and any other built structure that is no longer required - even if they are not indicated on this plan. Contractors must make themselves familiar with the site and allow for all demolition. Any queries should be directed to the Architect for clarification.
2. Tree removal must include the removal of all roots and debris.
3. Some pruning of limbs will also be undertaken. These will be marked on site.

Revisions:

Rottnest Island Golf Course

Drawing name:

Staking, Clearing and Demolition

Drawing No.

RI-SC

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:750 @ A1

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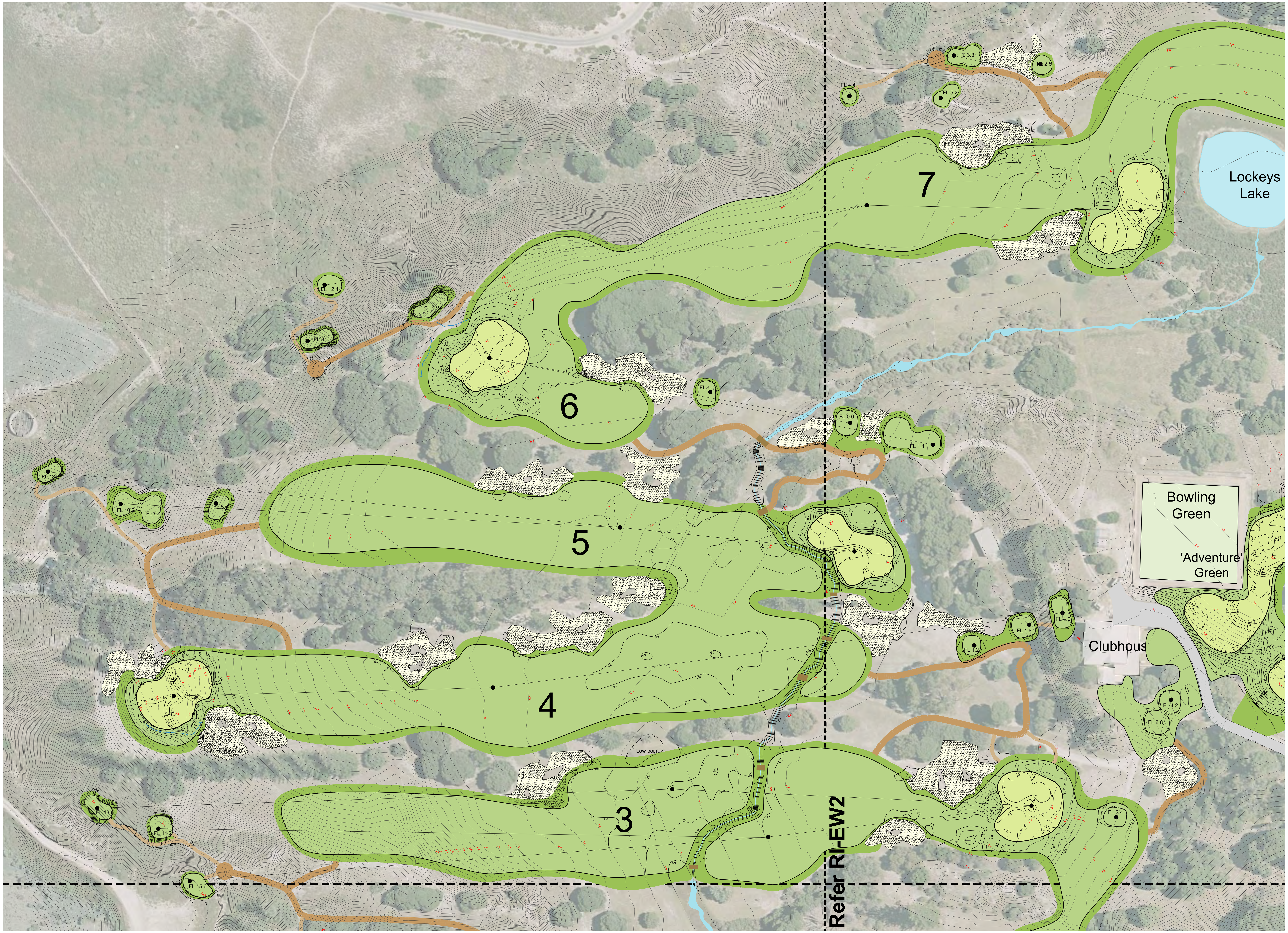
PO Box 311
Mount Martha 3934
AUSTRALIA

ABN 48135154577



Notes:

1. Set out of all golf features to be confirmed by Architect on site.
2. All final levels and grades to be approved by Architect on site.
3. All levels indicated are finished design levels. Allowance should be made for topsoil replacement and imported materials for green, tee, bunker and path construction.
4. All greens, tees and bunkers to be constructed according to construction details and specifications.
5. This plan to be read in conjunction with all other plans and specifications.

Revisions:

Rottnest Island Golf Course

Drawing name:

Golf Course Set-out and Grading

Drawing No.

RI-EW1

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:750 @ A1

Davey Shearer Golf Design Pty Ltd
PO Box 311
Mount Martha 3934
AUSTRALIA

ABN 48135154577

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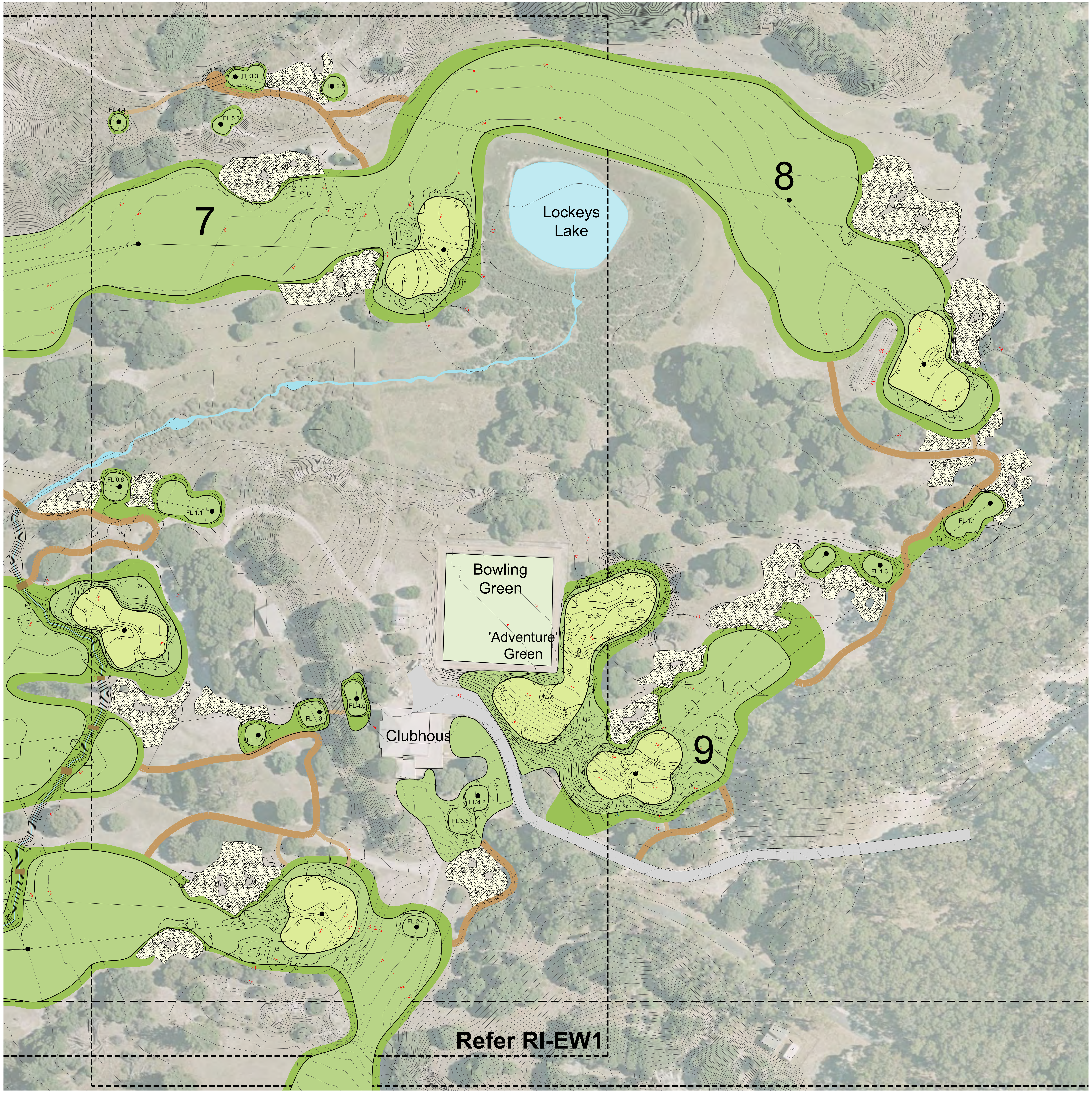

Notes:

1. Set out of all golf features to be confirmed by Architect on site.
2. All final levels and grades to be approved by Architect on site.
3. All levels indicated are finished design levels. Allowance should be made for topsoil replacement and imported materials for green, tee, bunker and path construction.
4. All greens, tees and bunkers to be constructed according to construction details and specifications.
5. This plan to be read in conjunction with all other plans and specifications.

Revisions:

Rottnest Island Golf Course

Drawing name:

Golf Course Seout and Grading

Drawing No.

RI-EW2

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:750 @ A1

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AUSTRALIA

ABN 48135154577

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Notes:

1. Set out of all golf features to be confirmed by Architect on site.
2. All final levels and grades to be approved by Architect on site.
3. All levels indicated are finished design levels. Allowance should be made for topsoil replacement and imported materials for green, tee, bunker and path construction.
4. All greens, tees and bunkers to be constructed according to construction details and specifications.
5. This plan to be read in conjunction with all other plans and specifications.

Revisions:

Rottnest Island Golf Course

Drawing name:

Golf Course Setout and Grading

Drawing No.

RI-EW3

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:750 @ A1

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PO Box 311
Mount Martha 3934
AUSTRALIA

ABN 48135154577

Notes:

1. Set out of all golf features to be confirmed by Architect on site.
2. All final levels and grades to be approved by Architect on site.
3. All greens, tees and bunkers to be constructed according to construction details and specifications.
4. This plan to be read in conjunction with all other plans, Bill of Quantities and specifications.

Revisions:

Rottnest Island Golf Course

Drawing name:

Cut-fill explanatory plan

Drawing No.

RI-EW4

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:750 @ A1

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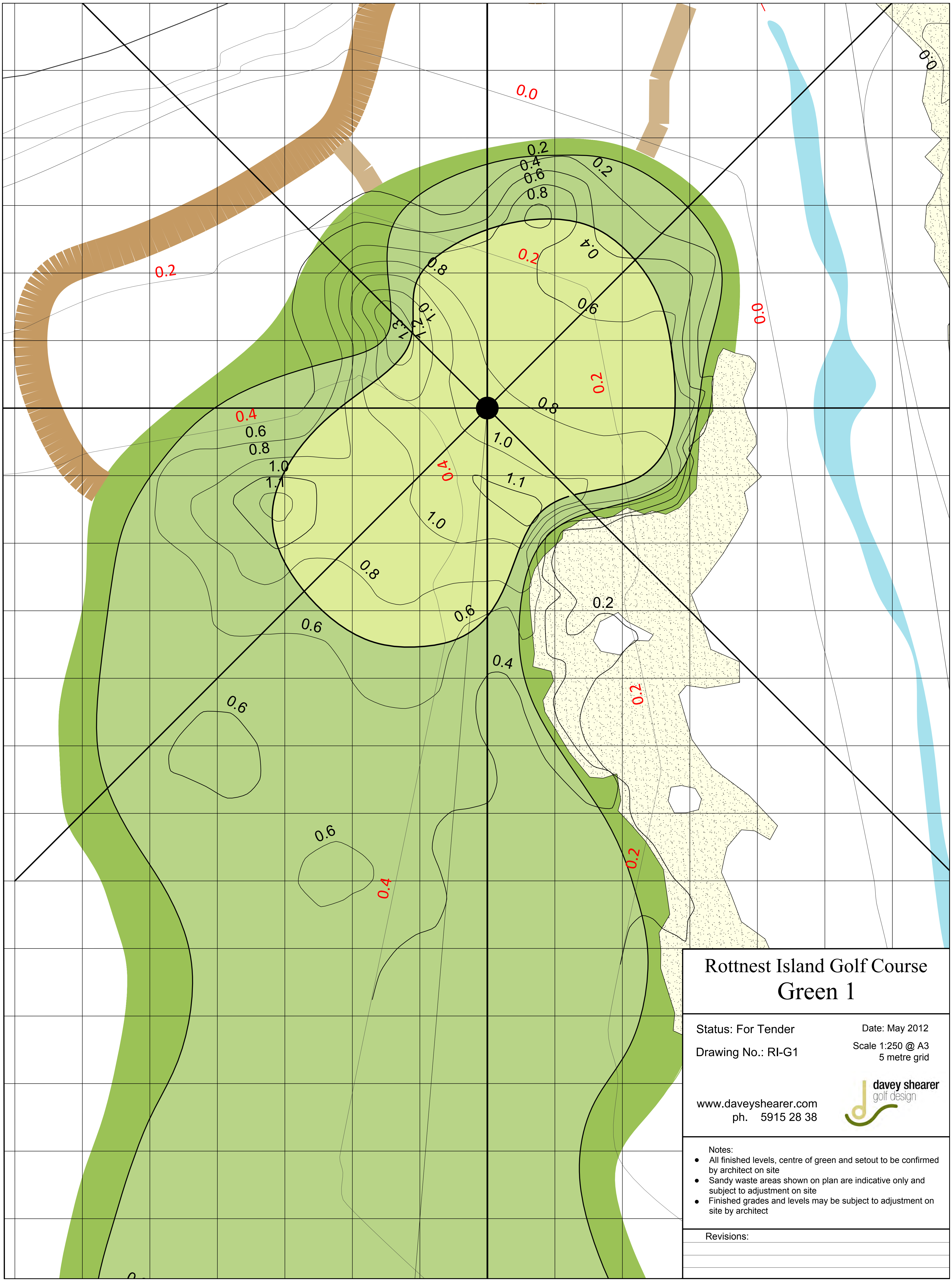
AUSTRALIA

ABN 48135154577



Rottnest Island Golf Course
Green 1

Status: For Tender

Drawing No.: RI-G1

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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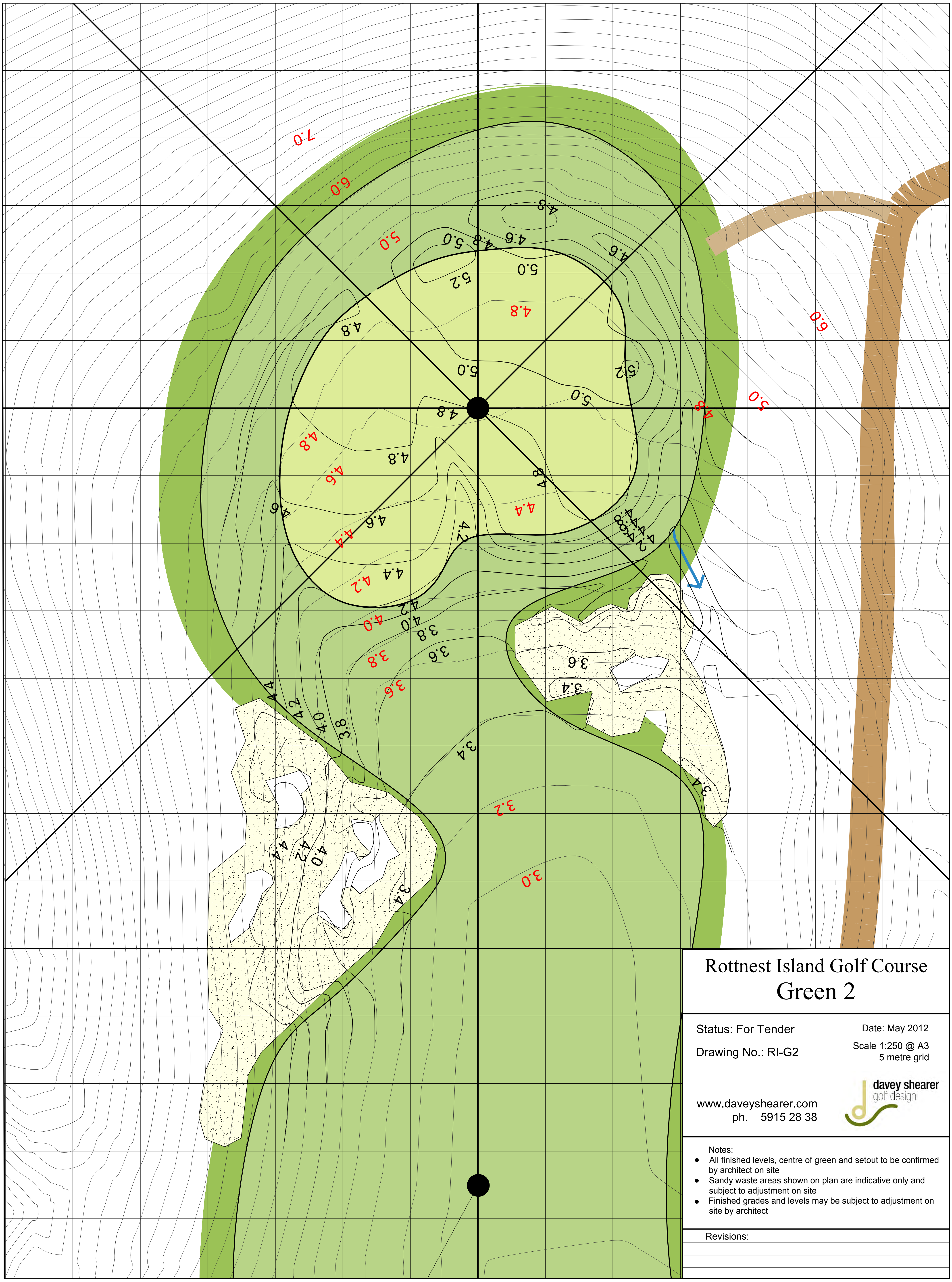
ph. 5915 28 38

Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 2

Status: For Tender

Date: May 2012

Drawing No.: RI-G2

Scale 1:250 @ A3
5 metre grid

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Notes:
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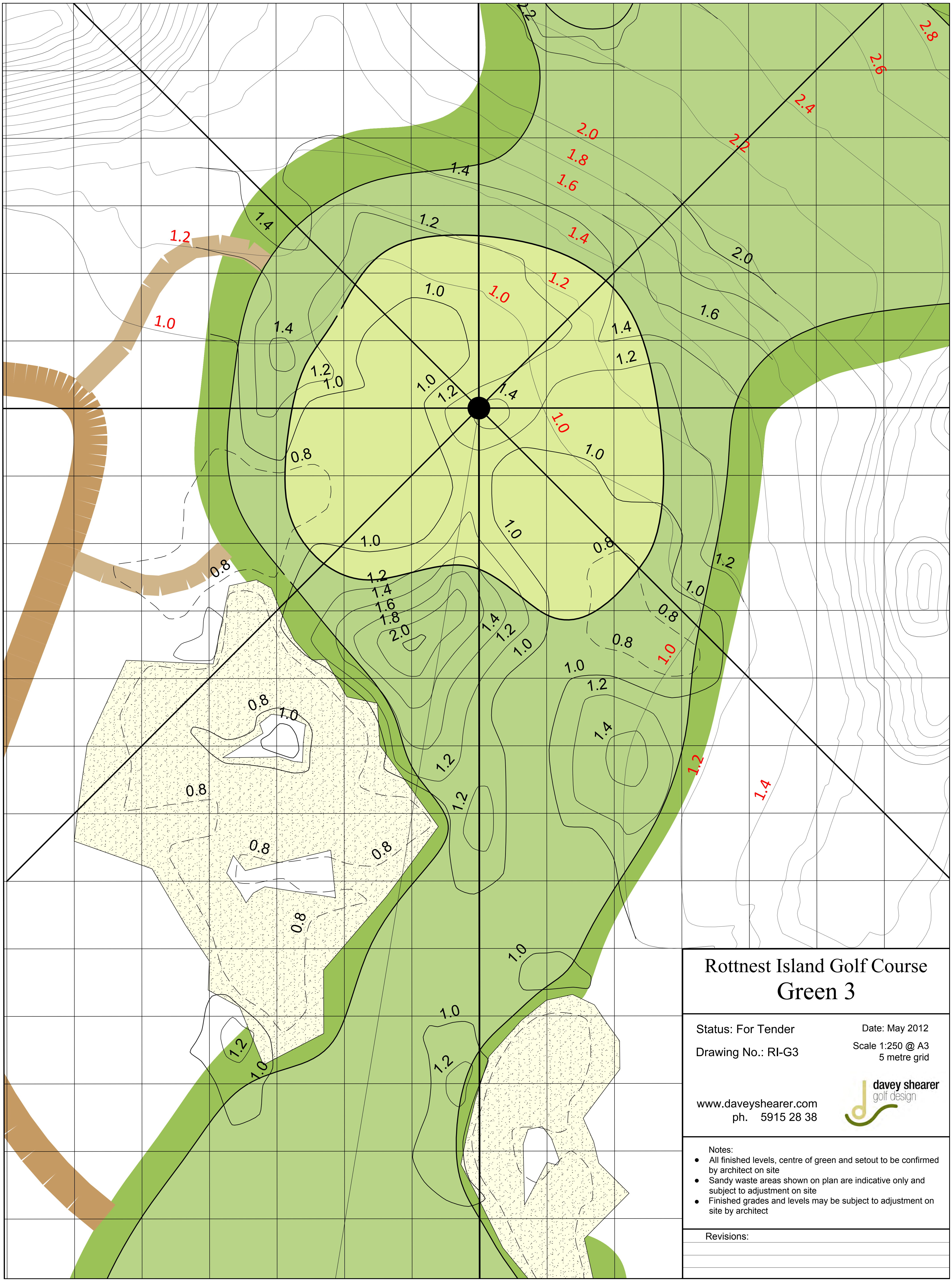
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 3

Status: For Tender

Drawing No.: RI-G3

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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Notes:

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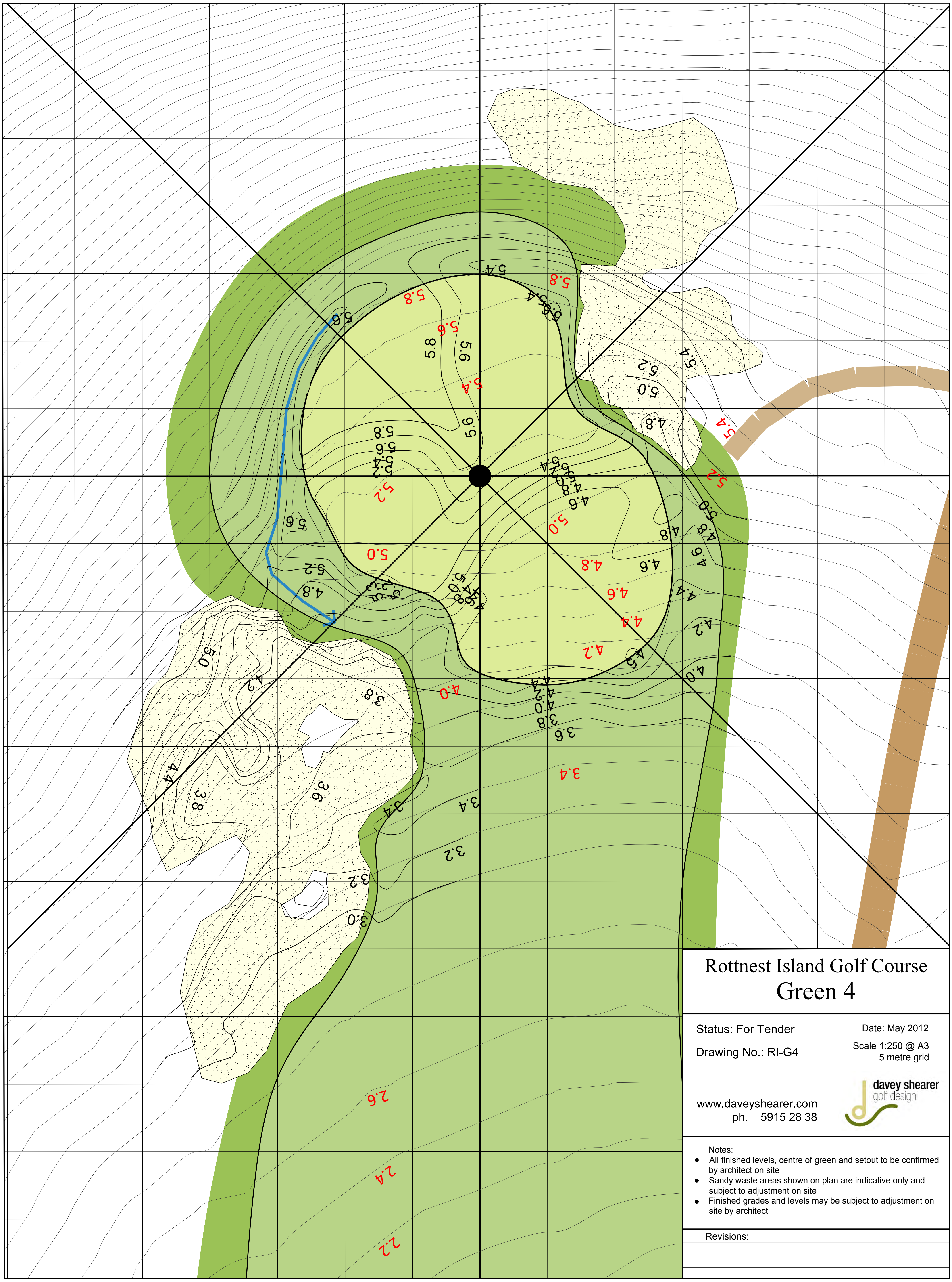
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 4

Status: For Tender

Drawing No.: RI-G4

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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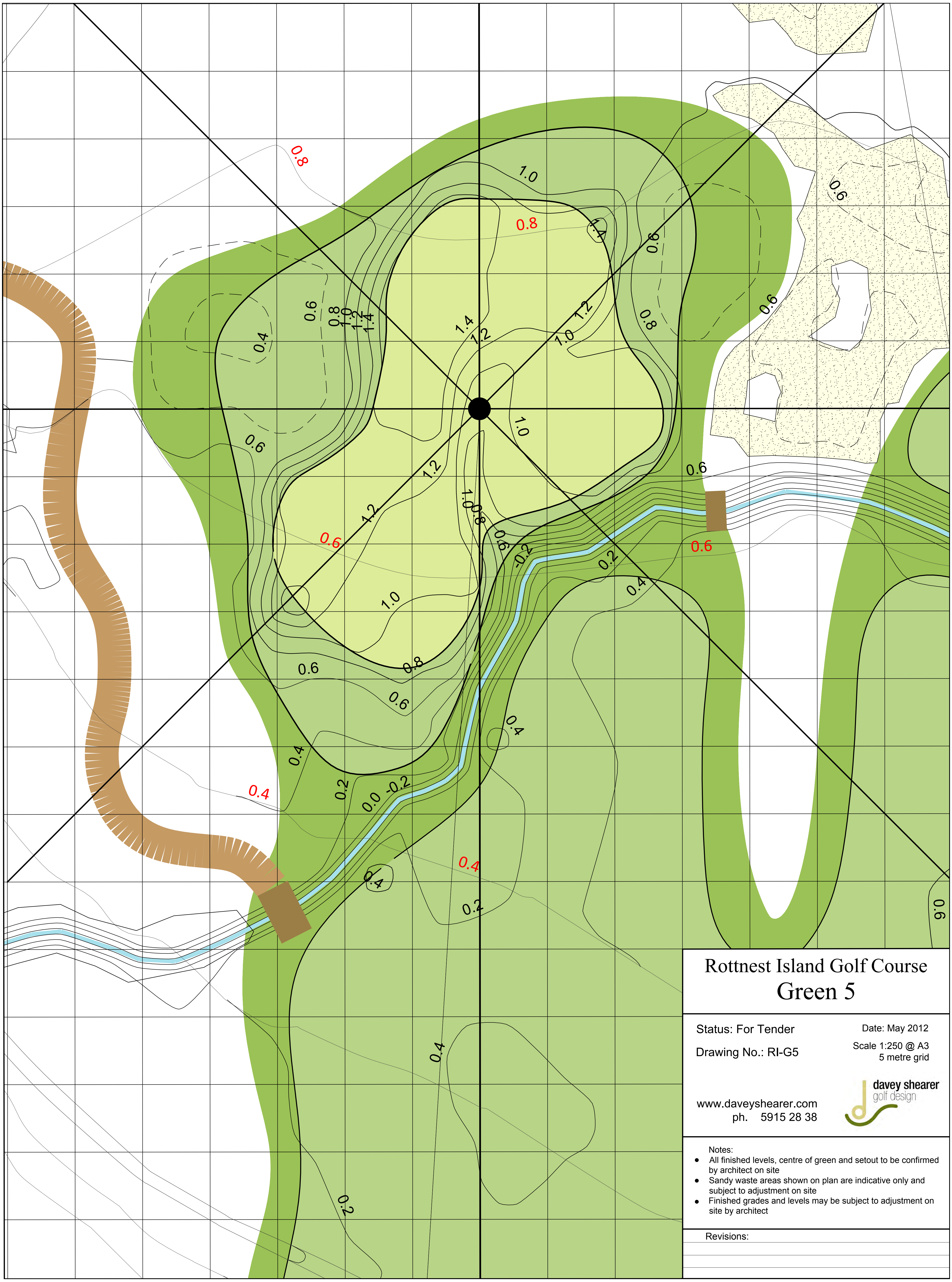
Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 5

Status: For Tender

Drawing No.: RI-G5

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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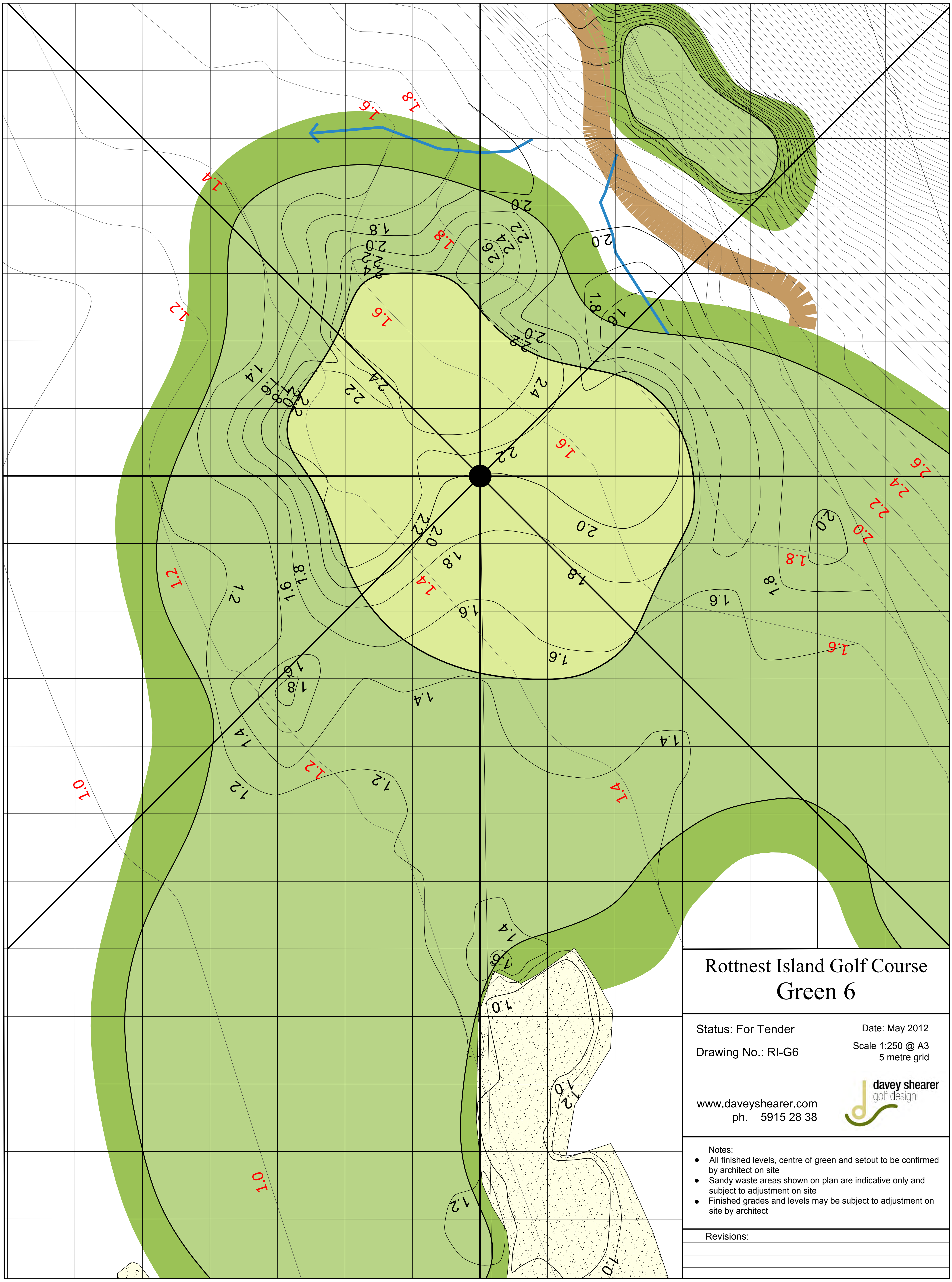
Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 6

Status: For Tender

Drawing No.: RI-G6

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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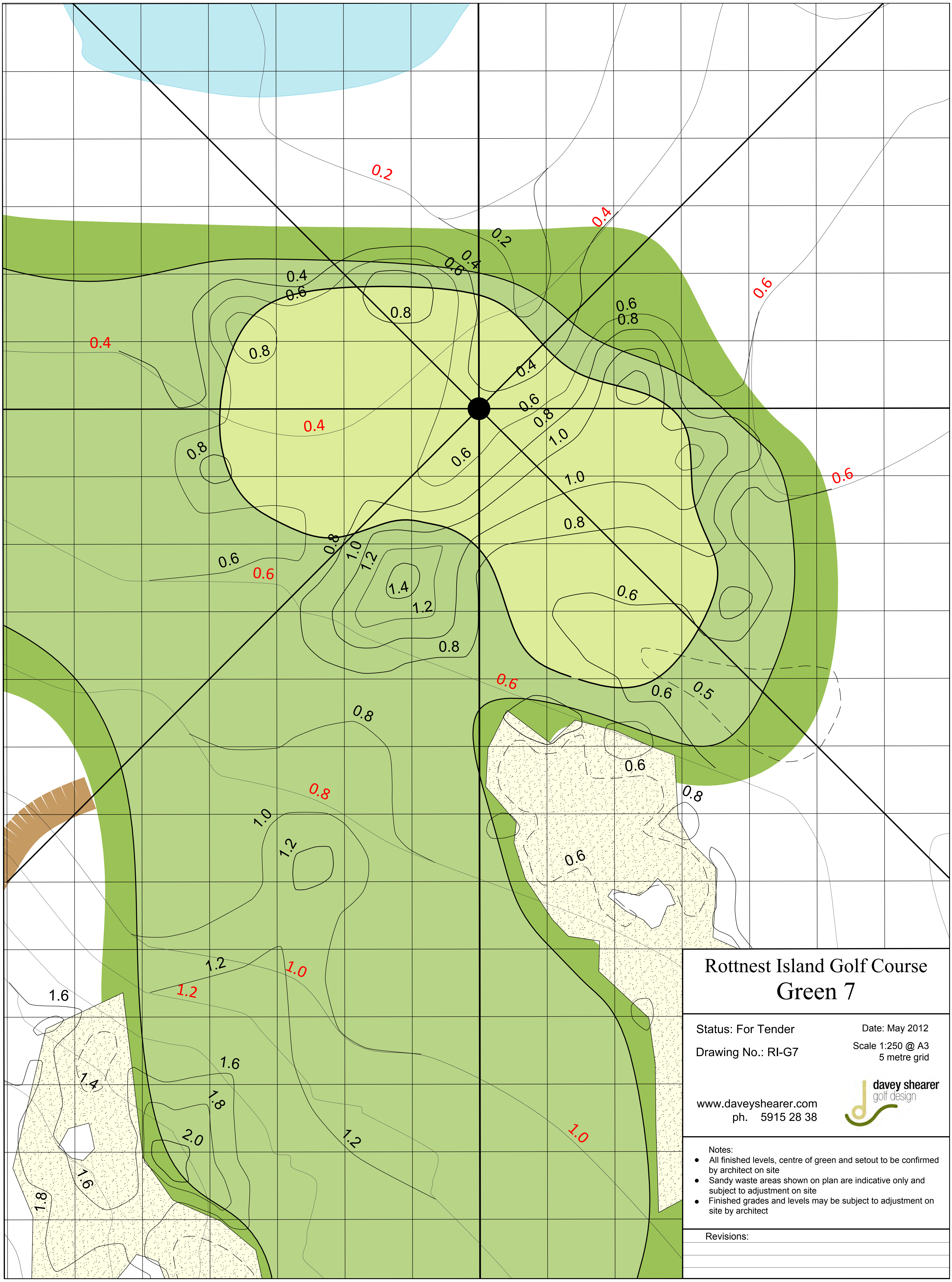
Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 7

Status: For Tender

Drawing No.: RI-G7

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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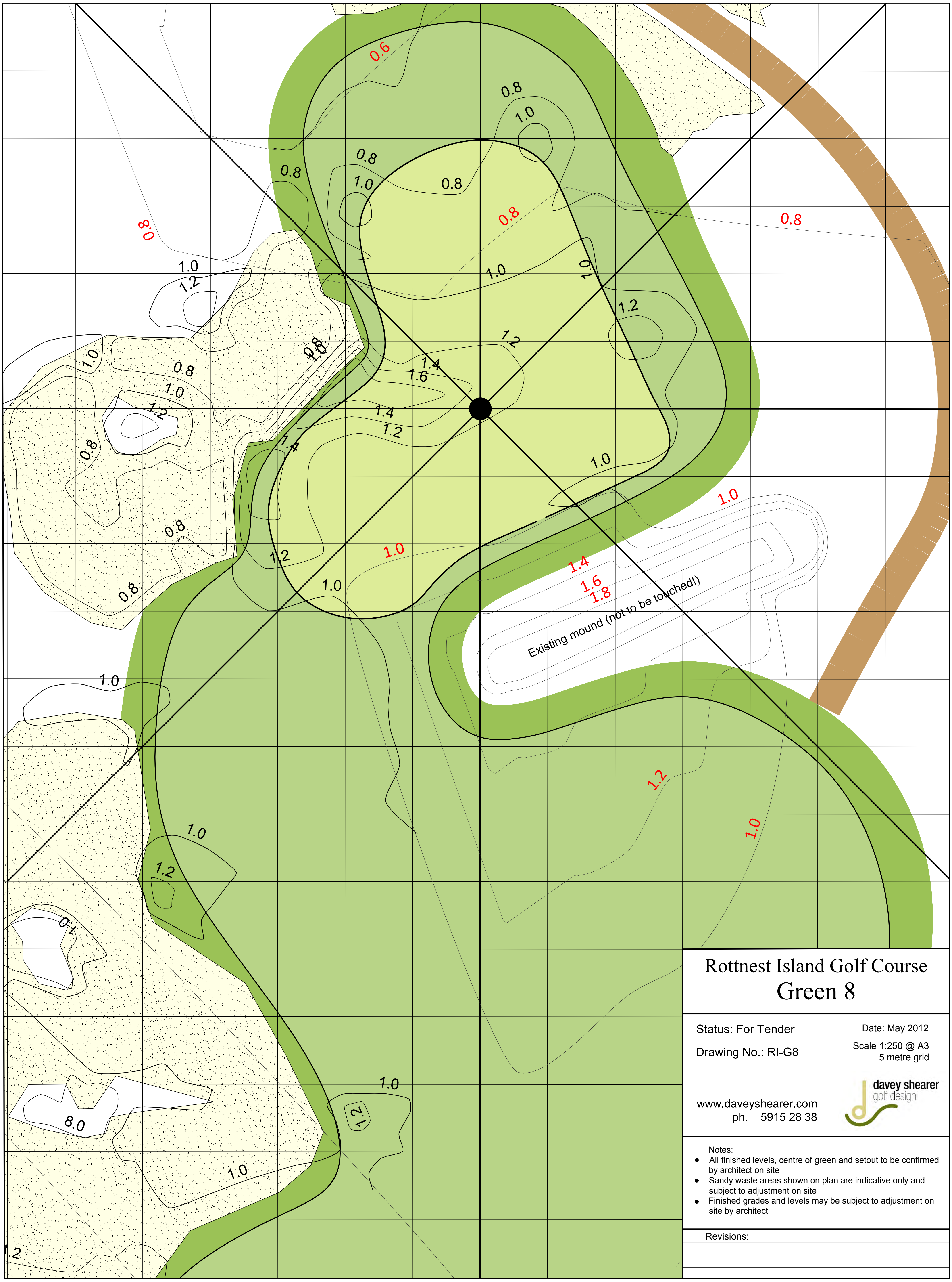
Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 8

Status: For Tender

Drawing No.: RI-G8

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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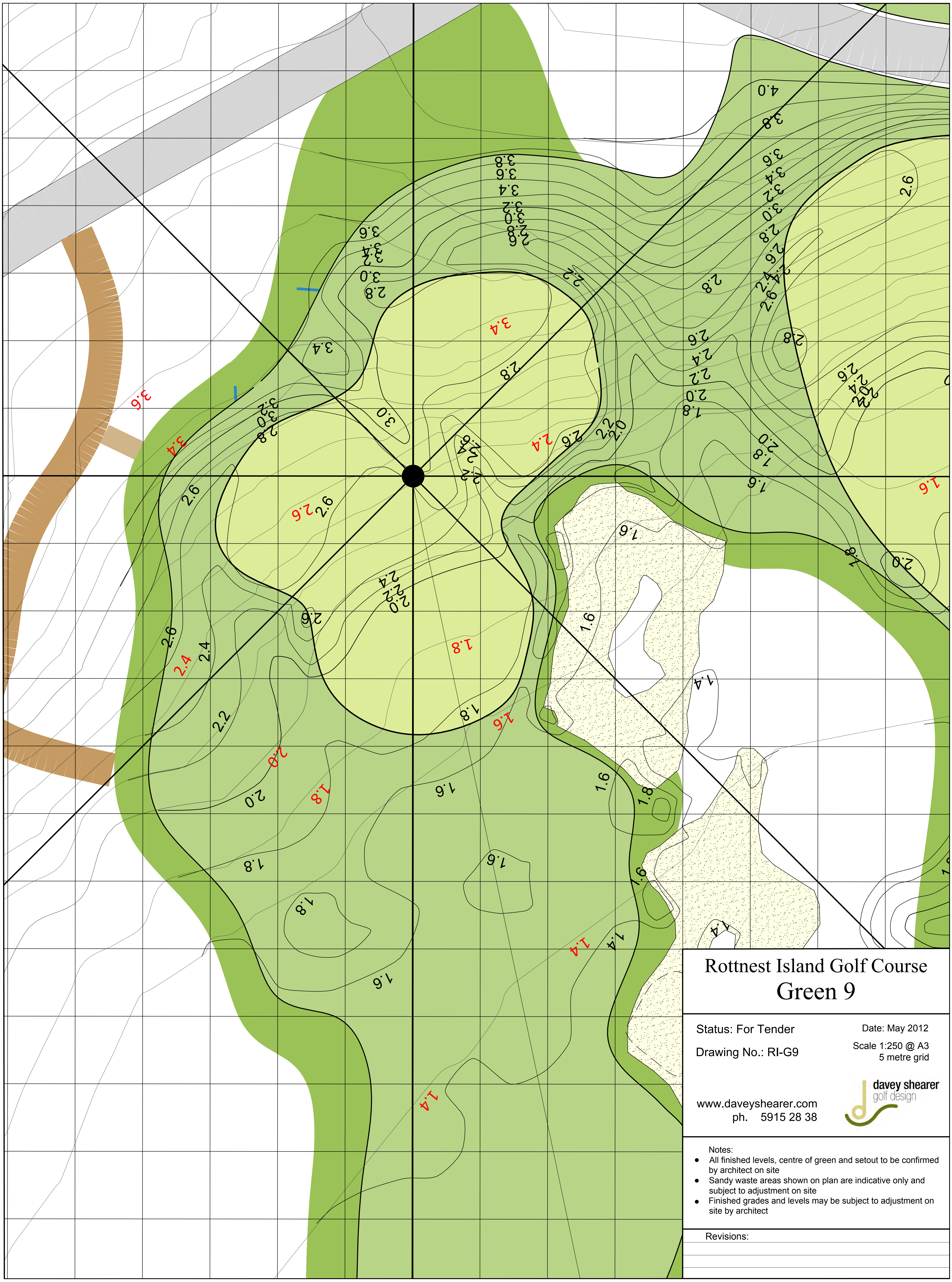
Notes:
- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
Green 9

Status: For Tender

Drawing No.: RI-G9

Date: May 2012

Scale 1:250 @ A3
5 metre grid

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golf design

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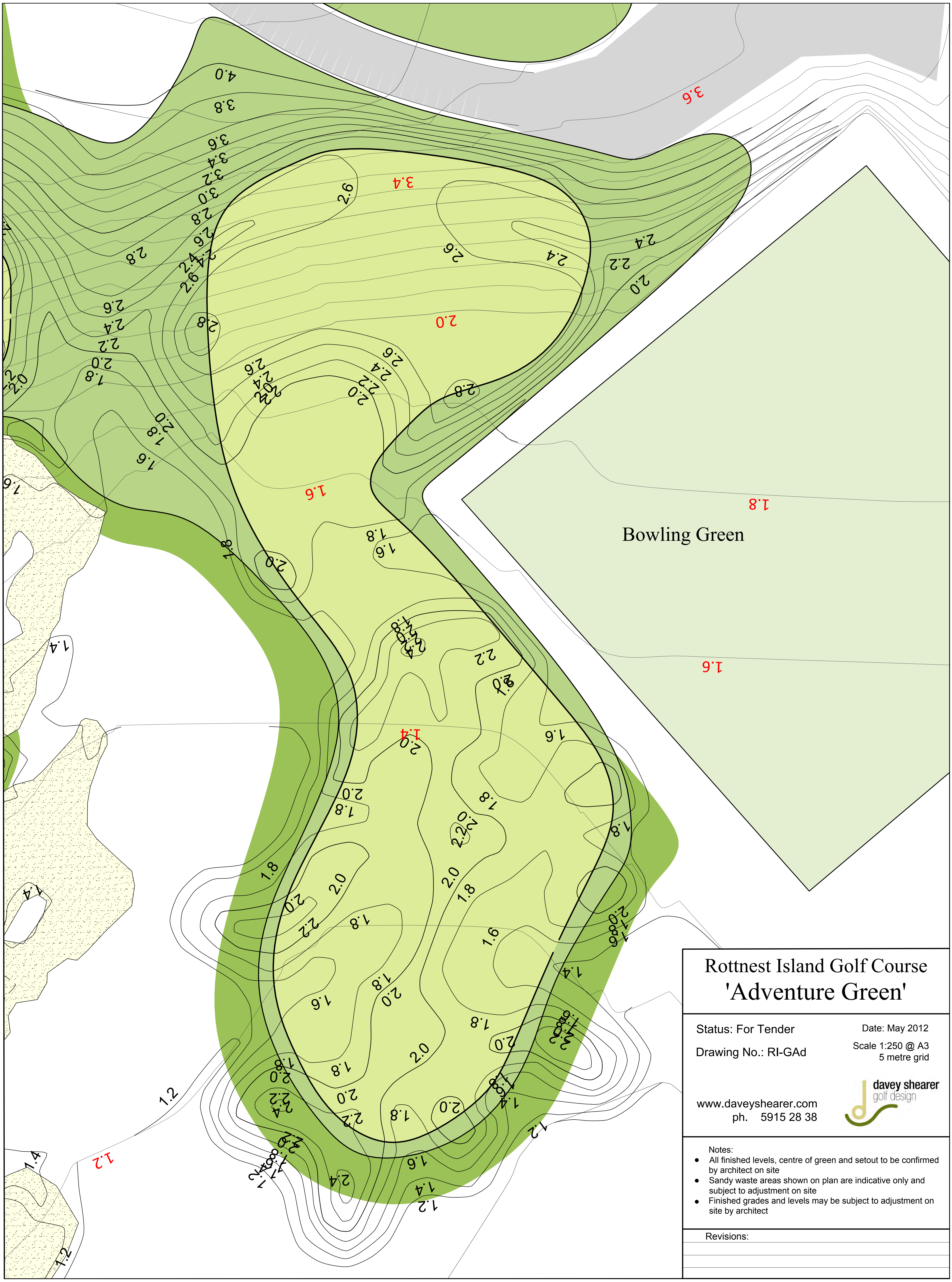
Notes:
- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Rottnest Island Golf Course
'Adventure Green'

Status: For Tender

Date: May 2012

Drawing No.: RI-GAd

Scale 1:250 @ A3
5 metre grid

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golf design

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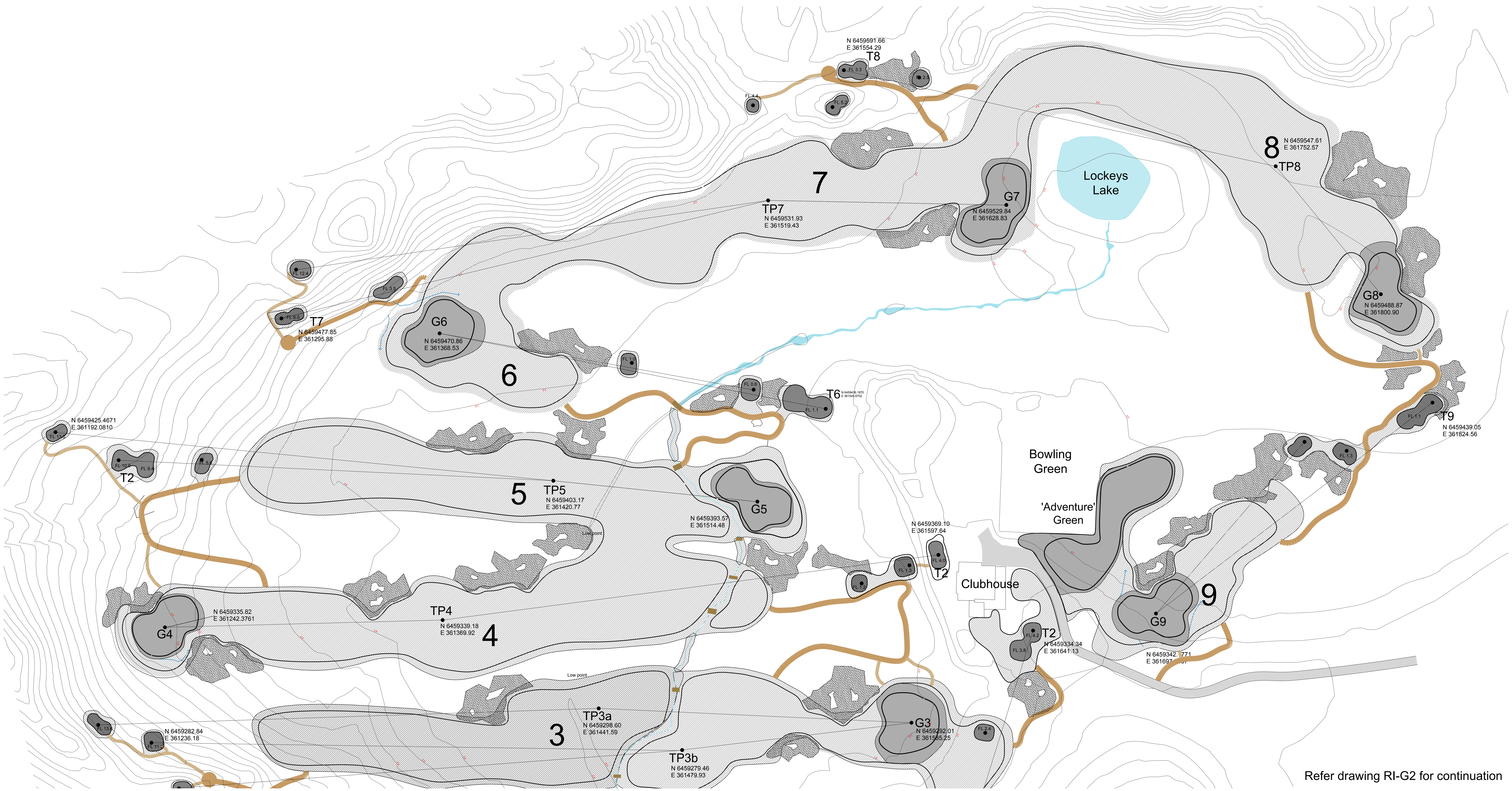
Notes:

- All finished levels, centre of green and setout to be confirmed by architect on site
- Sandy waste areas shown on plan are indicative only and subject to adjustment on site
- Finished grades and levels may be subject to adjustment on site by architect

Revisions:



Refer drawing RI-G2 for continuation

Wintergreen couch (sprigged as per specification) - defines edge of rotary hoeing
(85,000m2 rotary hoe, sprig 76,000m2)
AND
Hydromulching with wheat or similar perenial seed to act as a wind erosion barrier (76,000m2)

Bent Grass (Pencross) to green and immediate surrounds - hydroseeded as per Specification (9,000m2)

Santa Ana couch (solid turfing of tees) of 2,500m2) with allowance for turfing of steeper slopes

Sandy 'waste' areas (areas of exposed or partially exposed sand) - boundary shown is indicative only

All other areas (white areas shown) are to remain untouched. Existing grasses to be retained.

Pathways (sand base only) strip vegetation and organic matter and smooth

For cart access - 2.5 metres width x 1100 lineal metres approx

For pedestrian access only - 1.5 metres x 200 metres approx

Notes:

1. Set out of all golf features including edge of fairway, centre of greens and tees to be confirmed by Architect on site.
2. Edge of area to be grassed and irrigated defines the boundary of area to be rotary hoed. All other areas are to remain untouched.
3. The boundary of 'sandy waste' areas shown on the plan is indicative only. The contractor will work with the architects on site to construct these areas to give the best aesthetic result. The *general* location and total combined area will not change.

Revisions:

Rottnest Island Golf Course

Drawing name:
Grassing/surface finishes

Drawing No.
RI-G1

Status.
For Tender

Date:
May 2012

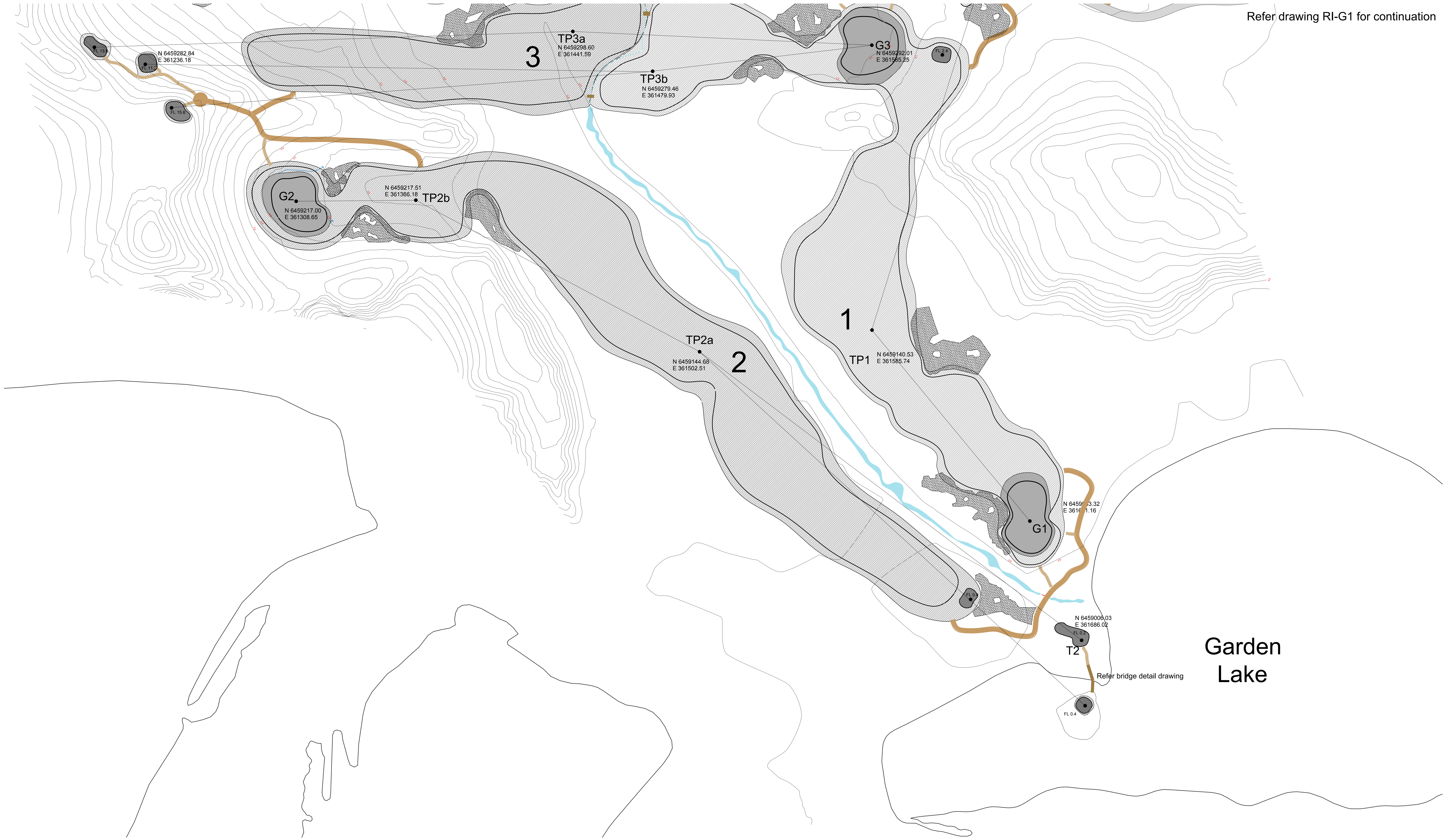
NORTH

Scale 1:1000 @ A1

Davey Shearer Golf Design Pty Ltd
PO Box 311
Mount Martha 3934
AUSTRALIA

ABN 48135154577

Refer drawing RI-G1 for continuation



Notes:

1. Set out of all golf features including edge of fairway, centre of greens and tees to be confirmed by Architect on site.
2. Edge of area to be grassed and irrigated defines the boundary of area to be rotary hoeing. All other areas are to remain untouched.
3. The boundary of 'sandy waste' areas shown on the plan is indicative only. The contractor will work with the architects on site to construct these areas to give the best aesthetic result. The *general* location and total combined area will not change.

Revisions:

Wintergreen couch (sprigged as per specification) - defines edge of rotary hoeing
(85,000m2 rotary hoe, sprig 76,000m2)
AND
Hydromulching with wheat or similar perenial seed to act as a wind erosion barrier (76,000m2)

Bent Grass (Pencross) to green and immediate surrounds - hydroseeded as per Specification (9,000m2)

Santa Ana couch (solid turfing of tees) of 2,500m2) with allowance for turfing of steeper slopes

Sandy 'waste' areas (areas of exposed or partially exposed sand) - boundary shown is indicative only

All other areas (white areas shown) are to remain untouched. Existing grasses to be retained.

Pathways (sand base only) strip vegetation and organic matter and smooth

For cart access - 2.5 metres width x 1100 lineal metres approx

For pedestrian access only - 1.5 metres x 200 metres approx

Rottnest Island Golf Course

Drawing name:

Grassing/surface finishes

Drawing No.

RI-G2

Status.

For Tender

Date:

May 2012

NORTH

Scale 1:1000 @ A1

Davey Shearer Golf Design Pty Ltd
PO Box 311
Mount Martha 3934
AUSTRALIA

ABN 48135154577

Appendix B

Soil profiles

Soil profile summary page

Borehole logs

Project: Rottnest Island Recycled Water Scheme
Subject: Golf course and oval soil layers from field investigations

Depth below surface (m)	GCS01	GCW01	GCS02	GCW02	GCS03	GCW03	GCS04	GCW04	GCS05	GCW05
0.0	Grass	Grass	Grass	Grass	Grass	Grass	Grass	Grass	Grass	Grass
0.1	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil	Topsoil
0.2	some lime gravel	some lime gravel				some lime gravel		shells and gravel	some lime gravel	shells and gravel
0.3	Sand								Gravelly sand	
0.4	shells and gravel		Sand	Silty sand	Gravelly sand	Sand	Gravelly sand	Silty sand	shells and gravel	Sand
0.5			some shells	some shells	shells	some lime gravel	strongly	some shells		shells and gravel
0.6	Sand	Sand				water	cemented shells			
0.7	shells and gravel	some shells	water	water	water			Cemented	Gravelly sand	
0.8							Sand	limestone	shells	
0.9							some shells	Sand		
1.0							small gravels	shells and gravel		
1.1						Gravelly sand			Sand water	
1.2	water					lime gravel	water		some shells	
1.3	Gravelly sand									
1.4	lime gravel							water		
1.5		water								
1.6										
1.7										
1.8										
1.9										
2.0										
2.1										
2.2										
2.3							Gravelly sand			
2.4							lime gravel			
2.5										water
2.6							Sand			Sand
2.7										fewer gravels
2.8				Cemented						
2.9				limestone						
3.0				Silty sand						
3.1	end of hole	Sand	end of hole	some shells	end of hole		end of hole		end of hole	
3.2		some shells								
3.3										
3.4										
3.5										
3.6				end of hole		end of hole		end of hole		
3.7										
3.8										
3.9										
4.0										
4.1		end of hole								
4.2										
4.3										
4.4										
4.5										
4.6										end of hole

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCS01

Page: 1 of 1

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361911.891
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459473.342
Project No.: 3128991	Rig Type: Hydraulic Hammer	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3	Elevation: 0
Date Drilled: 29/05/2012 to: 29/05/2012	Diameter (mm): 50	Logged by: L.Navarrete Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA		GCS01_0-0.15			GRASS	M	L		0.00
						SAND Dark brown, fine to medium grained, poorly graded, subrounded-subangular; some limestone gravel fine to medium grained, poorly graded, subangular-subrounded. Top soil				-0.15
			GCS01_0.15-0.5			SAND Pale brown/pale yellow, fine to medium grained, poorly graded, subrounded-subangular; some shell fragments and limestone gravel fine to medium grained, fine to coarse grained, well graded, subangular-subrounded.	M	L	No odour noted throughout profile.	0.15
			GCS01_0.5-1.2			SAND Pale yellow, fine to medium grained, poorly graded, subrounded-subangular; some shell fragments and limestone gravel fine to medium grained, fine to coarse grained, well graded, subangular-subrounded.	M	L		-0.50 / 0.50
1.0										
			GCS01_1.2-3.0	▼		gravelly SAND Pale white, fine to coarse grained, well graded, subangular-subrounded becoming fine to medium grained, subrounded at 2.7m.	W	L		-1.20 / 1.20
2.0										
3.0						Bottom of hole at 3.0m				-3.00 / 3.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:

RW(x)	Rotary Wash	PSC(x)	Percussion Simultanous Casing
RT(x)	Rotary Triple Tube	AS	Augering - Solid Flight
PC(x)	Percussion Cable Tool	AH	Augering - Hollow Flight
PD(x)	Percussion Down Hole	H	Hand Augering

Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils		Cohesive Soils	
(VL) Very Loose	(D) Dense	(VS) Very Soft	(ST) Stiff
(L) Loose	(VD) Very Dense	(S) Soft	(VST) Very Stiff
(MD) Medium Dense		(F) Firm	(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCS02

Client: Rottnest Island Authority
Project: Golf Course and Oval Assessment
Project No.: 3128991
Location: Golf Course and Oval
Date Drilled: 29/05/2012 to: 29/05/2012

Drill Co: Ecoprobe
Driller: S.Norrie
Rig Type: Hydraulic Hammer
Total Depth (m): 3
Diameter (mm): 50

Easting: 361634.941
Northing: 6459107.39
Grid Ref:
Elevation: 0
Logged by: L.Navarrete Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA					GRASS	D	VL	No odour noted throughout profile.	0.00
			GCS02_0-0.25			SAND Brown/grey, fine to medium grained, poorly graded, subangular-subrounded. Top Soil				-0.25
						SAND Pale yellow becoming pale grey at 0.5m, fine to coarse grained, well graded, subangular-subrounded; some shells present.	M	L		0.25
				▼			W			
1.0	Hydraulic Hammer									
			GCS02_0.25-3.0							
2.0										
3.0						Bottom of hole at 3.0m				-3.00 3.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCS03

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361476.558
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459173.619
Project No.: 3128991	Rig Type: Hydraulic Hammer	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3	Elevation: 0
Date Drilled: 29/05/2012 to: 29/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA		GCS03_0-0.25			GRASS	M	L	Some organic matter present.	0.00
						SAND Brown, fine to medium grained, poorly graded, subrounded-subangular. Top soil				-0.25 0.25
						SAND Pale yellow, fine to coarse grained, subangular-subrounded, well graded; some shells present. Becoming pale grey and less shells with depth.			No odour noted throughout profile.	
				▼			W	L		
1.0	Hydraulic Hammer									
			GCS03_0.25-3.0							
2.0										
3.0						Bottom of Hole at 3.0m				-3.00 3.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCS04

Page: 1 of 1

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361306.468
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459406.004
Project No.: 3128991	Rig Type: Hydraulic Hammer	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3	Elevation: 0
Date Drilled: 30/05/2012 to: 30/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA		GCS04_0-0.3			GRASS	M	L	Some organic matter present.	0.00
						silty SAND Brown, fine grained, poorly graded, subrounded-subangular. Top Soil				-0.30
	Hydraulic Hammer		GCS04_0.3-0.7			SAND Pale yellow, fine to coarse grained becoming fine to medium grained with depth, subangular-subrounded, well graded; some shells and limestone gravel fine to coarse grained, well graded, subangular-subrounded.		L	No odour noted throughout profile.	0.30
							W			
1.0										
			GCS04_0.7-2.2	▼						
2.0										
			GCS04_2.2-2.5							
			GCS04_2.5-3.0							-3.00
3.0						Bottom of hole at 3.0m				3.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCS05

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361559.851
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459535.104
Project No.: 3128991	Rig Type: Hydraulic Hammer	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3	Elevation: 0
Date Drilled: 30/05/2012 to: 30/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA					GRASS	M	L	Some organic matter present - rootlets.	0.00
			GCS05_0-0.2			silty SAND Brown, fine grained, poorly graded, subrounded-subangular. Top Soil				-0.20 0.20
			GCS05_0.2-0.6			SAND Pale brown becoming pale yellow with depth, fine to medium grained, subangular-subrounded, poorly graded; some shells and limestone gravel fine to coarse grained, well graded, subangular-subrounded.		L	No odour noted throughout profile.	-0.60 0.60
			GCS05_0.6-1.0			SAND Pale brown becoming pale yellow with depth, fine to medium grained, subangular-subrounded, poorly graded; some shells and limestone gravel fine to coarse grained, well graded, subangular-subrounded. Strongly cemented.		L		-1.10 1.10
1.0	Hydraulic Hammer			▼						
2.0			GCS05_1.0-3.0			SAND Pale grey, fine to coarse grained, well graded, subrounded-subangular, some shells and shells fragments present.	W	L		-3.00 3.00
3.0						Bottom of hole at 3.0m				

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCW01

Page: 1 of 1

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361913.565
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459465.973
Project No.: 3128991	Rig Type: Hollow Auger	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 4	Elevation: 0
Date Drilled: 29/05/2012 to: 29/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				
0.0	HA		Cement			SAND Dark brown/pale yellow, fine to medium grained, subangular-subrounded, some limestone gravel, fine grained, poorly graded, subangular-subrounded.	D	L	Some roots present.	0.00 0.00
	AH		Bentonite			SAND Pale yellow, fine to coarse grained, well graded, subangular-subrounded, some shell fragments present.	M	L	No odour noted throughout profile.	-0.50 0.50
1.0										
2.0			Gravel							
3.0						SAND Pale yellow/grey, fine to medium grained, subangular-subrounded, some shell fragments present.	W	L		-3.00 3.00
4.0						Bottom of hole at 4.0m				-4.00 4.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils		Cohesive Soils	
(VL) Very Loose	(D) Dense	(VS) Very Soft	(ST) Stiff
(L) Loose	(VD) Very Dense	(S) Soft	(VST) Very Stiff
(MD) Medium Dense		(F) Firm	(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCW02

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361702.672
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459106.46
Project No.: 3128991	Rig Type: Hollow Auger	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3.5	Elevation: 0
Date Drilled: 29/05/2012 to: 29/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				0.00
0.0	HA		Cement + Bentonite			clayey SAND Dark brown, fine to medium grained, subangular-subrounded, poorly graded, low plasticity.	M	L	Some organic matter present.	0.00
						silty SAND Pale grey, fine to coarse grained, well graded, subrounded-subangular, some shells and shells fragments present.		L	No odour noted throughout profile.	-0.25 0.25
1.0	AH		Gravel				W			
2.0										
						LIMESTONE Pale white, well cemented.		H		-2.70 2.70
3.0						SAND Pale grey, fine to coarse grained, well graded, subrounded-subangular, some shells and shells fragments present.		L		-2.90 2.90
						Bottom of hole at 3.5m				-3.50 3.50
4.0										

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCW03

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361443.818
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459149.151
Project No.: 3128991	Rig Type: Hollow Auger	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3.5	Elevation: 0
Date Drilled: 29/05/2012 to: 29/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				
0.0	HA		Cement + Bentonite			SAND Dark brown, fine to medium grained, poorly graded, subangular-subrounded, some limestone gravel fine to medium grained, poorly graded, subangular-subrounded.	M	L	Some organic matter present - few roots.	0.00 0.00
						SAND Pale yellow, fine to coarse grained, well graded, subangular-subrounded, some limestone gravel fine to medium grained, poorly graded, subangular-subrounded.		L	No odour noted throughout profile.	-0.25 0.25
1.0	AH		Gravel			gravelly SAND Pale grey, fine to coarse grained, well graded, subrounded-subangular, some limestone gravel fine to medium grained, poorly graded, subangular-subrounded.	W	L		-1.00 1.00
2.0										
3.0										
						Bottom of hole at 3.5m				-3.50 3.50
4.0										

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:

RW(x)	Rotary Wash	PSC(x)	Percussion Simultanous Casing
RT(x)	Rotary Triple Tube	AS	Augering - Solid Flight
PC(x)	Percussion Cable Tool	AH	Augering - Hollow Flight
PD(x)	Percussion Down Hole	H	Hand Augering

Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils		Cohesive Soils	
(VL) Very Loose	(D) Dense	(VS) Very Soft	(ST) Stiff
(L) Loose	(VD) Very Dense	(S) Soft	(VST) Very Stiff
(MD) Medium Dense		(F) Firm	(H) Hard

BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCW04

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361309.215
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459435.609
Project No.: 3128991	Rig Type: Hollow Auger	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 3.5	Elevation: 0
Date Drilled: 30/05/2012 to: 30/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				
0.0	HA		Cement + Bentonite			silty SAND Brown, fine grained, subrounded-subangular, poorly graded, some small shells, shell fragments and limestone gravel fine grained, poorly graded, subangular-subrounded.	M	L	Some organic matter present - fine roots.	0.00 0.00
	AH					SAND Pale brown/grey, fine to medium grained, poorly graded, subrounded-subangular, some shell fragments present.		H	No odour noted throughout profile.	-0.50 0.50
						LIMESTONE Pale grey, well cemented.				-0.60 0.60
1.0			Gravel			silty SAND Pale brown/pale grey, fine to coarse grained, well graded, subangular-subrounded, some shells and limestone gravel fine grained poorly graded, subangular-subrounded.	W	L		-0.80 0.80
2.0										
3.0										
						Bottom of hole at 3.5m				-3.50 3.50
4.0										

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
PD(x) Percussion Down Hole
PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

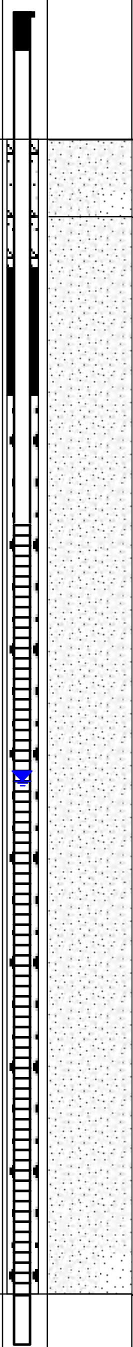
BOREHOLE LOG

ENVIRONMENTAL - SOIL BORE

Bore No.: GCW05

Client: Rottnest Island Authority	Drill Co: Ecoprobe	Easting: 361567.198
Project: Golf Course and Oval Assessment	Driller: S.Norrie	Northing: 6459574.011
Project No.: 3128991	Rig Type: Hollow Auger	Grid Ref:
Location: Golf Course and Oval	Total Depth (m): 4.5	Elevation: 0
Date Drilled: 30/05/2012 to: 30/05/2012	Diameter (mm): 50	Logged by: L.Ellis Checked by: A.Sutherland

Depth (m)	Drilling Method	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/ CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
						Ground Surface:				
0.0	HA		Cement			SAND Brown, fine to medium grained, poorly graded, subrounded-angular, some shells, shell fragment and limestone fine griained, subangular-subrounded, poorly graded.	M	L	Some organic matter present.	0.00 0.00
			Bentonite			SAND Mottled brown and pale yellow, fine to coarse grained, well graded, subangular-subrounded, some shells, shell fragments and limestone fine grained, poorly graded, subangular-subrounded; becoming pale yellow with depth and less gravels.	W	L		-0.30 0.30
1.0	AH		Gravel							
2.0										
3.0										
4.0										
						Bottom of hole at 4.5m				-4.50 4.50
5.0										



NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Drilling Abbreviations:
RW(x) Rotary Wash
RT(x) Rotary Triple Tube
PC(x) Percussion Cable Tool
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PSC(x) Percussion Simultanous Casing
AS Augering - Solid Flight
AH Augering - Hollow Flight
H Hand Augering
Where "x" is flushing medium: (W) Water, (M) Mud, (A) Air, (F) Foam.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:
Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

Appendix C

Laboratory reports

Soils analysis report

Phosphorus isotherms

Acid sulphate soils analysis report

Groundwater analysis report

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Report of Analysis

TW12-04936

Client:

GHD PTY LTD
PO BOX 3106
ADELAIDE TERRACE
PERTH WA 6832

Order Number: 3128991
Report Date: 16-August-2012
Received Date: 06-June-2012

Analysis	Unit	TW12-04936.001 GCS01_0.15-0.5 SOIL	TW12-04936.003 GCS02_0.25-3.0 SOIL	TW12-04936.005 GCS03_0.25-3.0 SOIL	TW12-04936.006 GCS04_0-0.3 SOIL
Organic Nitrogen	mg/kg	**720**	**650**	**710**	**960**
ACIDITY					
pH - Water	pH units	**8.69**	**9.40**	**9.27**	**8.57**
MAJOR ELEMENTS					
Ammonium Nitrogen	mg/kg	**1.0**	**0.75**	**0.80**	**1.5**
Nitrate + Nitrite	mg/kg	**15**	**4**	**1**	**2**
Nitrate Nitrogen	mg/kg	**15**	**4**	**1**	**2**
Nitrite Nitrogen	mg/kg	**<1**	**<1**	**<1**	**<1**
Potassium	mg/kg	**15**	**6**	**55**	**18**
Phosphorus - Colwell extr	mg/kg	**19**	**8**	**6**	**33**
Nitrogen	mg/kg	**738**	**654**	**716**	**966**
Total Kjeldahl Nitrogen	mg/kg	**723**	**650**	**715**	**964**
SECONDARY ELEMENTS					
Calcium Carbonate	%	**82**	**97**	**96**	**87**
Calcium	mg/kg	**4150**	**3950**	**3790**	**4650**
Magnesium	mg/kg	**160**	**147**	**319**	**104**
TRACE ELEMENTS					
Copper	mg/kg	**<0.1**	**<0.1**	**<0.1**	**0.1**
Zinc	mg/kg	**0.5**	**0.6**	**0.3**	**0.7**
Manganese	mg/kg	**<1.0**	**<1.0**	**<1.0**	**<1.0**
Iron	mg/kg	**7.9**	**1.5**	**3.2**	**7.2**
Boron	mg/kg	**2.0**	**0.4**	**1.2**	**0.8**
ORGANIC MATTER					
Organic Carbon	%	**1.4**	**<0.3**	**<0.3**	**1.9**
SALINITY					
Chloride	mg/kg	**110**	**140**	**3000**	**69**
Electrical Conductivity	dS/m	**0.17**	**0.14**	**1.81**	**0.13**
Sodium	mg/kg	**129**	**115**	**1160**	**123**
Total Soluble Salts	%	**0.06**	**0.05**	**0.62**	**0.04**
EXCHANGEABLE CATIONS					
Cation Exchange	meq/100g	**22.7**	**21.5**	**26.8**	**24.7**
Exchangeable Sodium	meq/100g	**0.56**	**0.50**	**5.06**	**0.54**
Exchangeable Sodium Percent	%	**2.5**	**2.3**	**18.9**	**2.2**
Exchangeable Potassium	meq/100g	**0.04**	**0.01**	**0.14**	**0.05**
Exchangeable Potassium Percent	%	**0.2**	**<0.1**	**0.5**	**0.2**
Exchangeable Calcium	meq/100g	**20.8**	**19.7**	**19.0**	**23.3**

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Report of Analysis

TW12-04936

Analysis	Unit	TW12-04936.001 GCS01_0.15-0.5 SOIL	TW12-04936.003 GCS02_0.25-3.0 SOIL	TW12-04936.005 GCS03_0.25-3.0 SOIL	TW12-04936.006 GCS04_0-0.3 SOIL
Exchangeable Calcium Percent	%	**91.5**	**91.9**	**70.7**	**94.2**
Exchangeable Magnesium	meq/100g	**1.33**	**1.22**	**2.65**	**0.86**
Exchangeable Magnesium Percent	%	**5.9**	**5.7**	**9.9**	**3.5**
Exchangeable Aluminium	meq/100g	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**
Exchangeable Aluminium Percent	%	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**
Calcium/Magnesium Ratio		**15.60**	**16.15**	**7.14**	**26.95**
WET CHEMISTRY					
Phosphorus	mg/kg	**811**	**301**	**277**	**580**
Sulphur	mg/kg	**1130**	**1560**	**1730**	**944**
OTHER					
Phosphorus Buffer Index		**92.7**	**615.0**	**87.6**	**210.4**
P Sorption Index		**22**	**24**	**23**	**20**
Air Dry Moisture	%	**0.7**	**0.4**	**0.5**	**1.0**
PHYSICAL TESTS					
Calcium Chloride treated Category		**1**	**1**	**1**	**1**
Water treated Category		**3**	**3**	**2**	**3**
Large Particles <20mm >10mm	%	**7.5**	**6.1**	**2.1**	**0.5**
Large Particles >20mm	%	**0.8**	**<0.1**	**<0.1**	**<0.1**
Bulk Density	g/L	**1200**	**1000**	**1000**	**1200**
Subcontracted Analysis					
Field Capacity	%	**15.8**	**13.4**	**24.0**	**12.3**
Wilting Point	%	**6.4**	**4.3**	**11.2**	**5.8**
Water at Saturation	%	**33.8**	**36.4**	**39.3**	**43.0**

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Report of Analysis

TW12-04936

Analysis	Unit	TW12-04936.007 GCS05_0.2-0.6 SOIL	TW12-04936.009 QAGC_1 SOIL		
Organic Nitrogen	mg/kg	**830**	**730**		
ACIDITY					
pH - Water	pH units	**9.18**	**9.20**		
MAJOR ELEMENTS					
Ammonium Nitrogen	mg/kg	**1.0**	**1.0**		
Nitrate + Nitrite	mg/kg	**6**	**5**		
Nitrate Nitrogen	mg/kg	**5**	**5**		
Nitrite Nitrogen	mg/kg	**<1**	**<1**		
Potassium	mg/kg	**11**	**5**		
Phosphorus - Colwell extr	mg/kg	**9**	**7**		
Nitrogen	mg/kg	**833**	**739**		
Total Kjeldahl Nitrogen	mg/kg	**827**	**734**		
SECONDARY ELEMENTS					
Calcium Carbonate	%	**95**	**94**		
Calcium	mg/kg	**4090**	**4090**		
Magnesium	mg/kg	**162**	**149**		
TRACE ELEMENTS					
Copper	mg/kg	**<0.1**	**<0.1**		
Zinc	mg/kg	**0.7**	**0.3**		
Manganese	mg/kg	**<1.0**	**<1.0**		
Iron	mg/kg	**2.0**	**2.0**		
Boron	mg/kg	**0.6**	**0.4**		
ORGANIC MATTER					
Organic Carbon	%	**0.4**	**0.4**		
SALINITY					
Chloride	mg/kg	**29**	**27**		
Electrical Conductivity	dS/m	**0.10**	**0.09**		
Sodium	mg/kg	**94**	**93**		
Total Soluble Salts	%	**0.03**	**0.03**		
EXCHANGEABLE CATIONS					
Cation Exchange	meq/100g	**22.3**	**22.1**		
Exchangeable Sodium	meq/100g	**0.41**	**0.40**		
Exchangeable Sodium Percent	%	**1.8**	**1.8**		
Exchangeable Potassium	meq/100g	**0.03**	**0.01**		
Exchangeable Potassium Percent	%	**0.1**	**<0.1**		
Exchangeable Calcium	meq/100g	**20.5**	**20.5**		
Exchangeable Calcium Percent	%	**92.0**	**92.5**		
Exchangeable Magnesium	meq/100g	**1.35**	**1.24**		
Exchangeable Magnesium Percent	%	**6.0**	**5.6**		
Exchangeable Aluminium	meq/100g	**Not Applicable**	**Not Applicable**		
Exchangeable Aluminium Percent	%	**Not Applicable**	**Not Applicable**		
Calcium/Magnesium Ratio		**15.20**	**16.51**		
WET CHEMISTRY					

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Report of Analysis

TW12-04936

Analysis	Unit	TW12-04936.007 GCS05_0.2-0.6 SOIL	TW12-04936.009 QAGC_1 SOIL		
Phosphorus	mg/kg	**299**	**289**		
Sulphur	mg/kg	**1130**	**1070**		
OTHER					
Phosphorus Buffer Index		**114.1**	**112.0**		
P Sorption Index		**26**	**26**		
Air Dry Moisture	%	**0.5**	**0.5**		
PHYSICAL TESTS					
Calcium Chloride treated Category		**1**	**1**		
Water treated Category		**3**	**3**		
Large Particles <20mm >10mm	%	**2.3**	**5.3**		
Large Particles >20mm	%	**<0.1**	**<0.1**		
Bulk Density	g/L	**1100**	**1100**		
Subcontracted Analysis					
Field Capacity	%	**11.6**	**9.6**		
Wilting Point	%	**4.7**	**4.3**		
Water at Saturation	%	**37.6**	**37.3**		

Results are on an 'air dried' basis.

Analysed Between 06/06/2012 - 16/08/2012

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Report of Analysis

TW12-04936

Method of Analysis

Analysis	Unit	Det.Lim.	Method
Phosphorus	mg/kg	10	MIN001
Sulphur	mg/kg	10	MIN001
Copper	mg/kg	0.1	SOL001/9/10/12
Zinc	mg/kg	0.1	SOL001/9/10/12
Manganese	mg/kg	1.0	SOL001/9/10/12
Iron	mg/kg	1.0	SOL001/9/10/12
Boron	mg/kg	0.2	SOL001/13
Ammonium Nitrogen	mg/kg	0.05	SOL030
Chloride	mg/kg	1	SOL030
Nitrate + Nitrite	mg/kg	1	SOL030
Nitrate Nitrogen	mg/kg	1	SOL030
Nitrite Nitrogen	mg/kg	1	SOL030
pH - Water	pH units	0.01	SOL003/SOL001/2
Electrical Conductivity	dS/m	0.01	SOL003/SOL001/2
Calcium Carbonate	%	1	SOL004
Sodium	mg/kg	1	SOL044
Potassium	mg/kg	1	SOL044
Calcium	mg/kg	1	SOL044
Magnesium	mg/kg	1	SOL044
Cation Exchange	meq/100g	0.01	SOL044
Exchangeable Sodium	meq/100g	0.01	SOL044
Exchangeable Sodium Percent	%	0.1	SOL044
Exchangeable Potassium	meq/100g	0.01	SOL044
Exchangeable Potassium Percent	%	0.1	SOL044
Exchangeable Calcium	meq/100g	0.01	SOL044
Exchangeable Calcium Percent	%	0.1	SOL044
Exchangeable Magnesium	meq/100g	0.01	SOL044
Exchangeable Magnesium Percent	%	0.1	SOL044
Exchangeable Aluminium	meq/100g	0.01	SOL044
Exchangeable Aluminium Percent	%	0.1	SOL044
Calcium/Magnesium Ratio		0.01	SOL044
Organic Carbon	%	0.3	CAR002/SOL002/1
Phosphorus - Colwell extr	mg/kg	1	SOL005/001/4
Phosphorus Buffer Index		0.1	SOL014
P Sorption Index		1	SOL026
Calcium Chloride treated Category			AS4419-2003 Appendix G
Water treated Category			AS4419-2003 Appendix G

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Report of Analysis

TW12-04936

Field Capacity	%	0.1	
Wilting Point	%	0.1	
Water at Saturation	%	0.1	
Large Particles <20mm >10mm	%	0.1	
Large Particles >20mm	%	0.1	
Nitrogen	mg/kg	300	PRN002
Organic Nitrogen	mg/kg	1	PRN001/SOL030
Total Kjeldahl Nitrogen	mg/kg	1	
Total Soluble Salts	%	0.01	SOL003/SOL001/2
Bulk Density	g/L		SOL029
Air Dry Moisture	%	0.1	

The analyses presented in the report refer exclusively to the samples analysed.

The presented report can only be reproduced in its entirety.

Keegan Roache - PSW Section Manager

For and on behalf of SGS Australia Pty Ltd

P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.007 **Marking:** GCS05_0.2-0.6

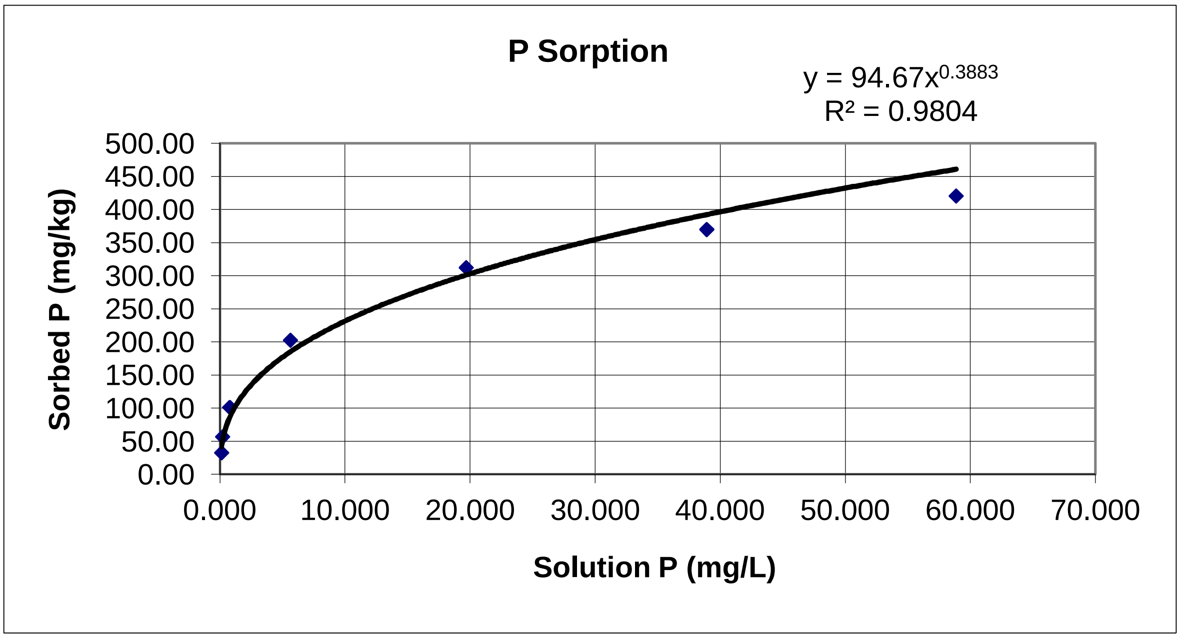
Colwell P mg/kg	9.14

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	1.22147	2.5	0.122	32.92	41.85
50	2.12388	5	0.212	57.02	51.87
100	7.76559	10	0.777	101.37	85.82
250	56.304	25	5.630	202.84	185.19
500	196.743	50	19.674	312.40	301.02
750	389.069	75	38.907	370.07	392.26
1000	588.543	100	58.854	420.60	460.65

a	94.670
b	0.388
R^2	0.980

Equilibrium P Concentration mg/L					
0.5	1	5	10	20	50
P Sorbed mg/kg Estimated					
72	95	177	231	303	432



P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.009
Marking: QAGC_1

Colwell P mg/kg	7.44

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	1.46833	2.5	0.147	30.97	43.17
50	2.00036	5	0.200	55.44	48.72
100	7.1996	10	0.720	100.24	80.42
250	56.0587	25	5.606	201.38	179.53
500	200.209	50	20.021	307.23	295.44
750	398.256	75	39.826	359.18	386.68
1000	596.689	100	59.669	410.75	452.96

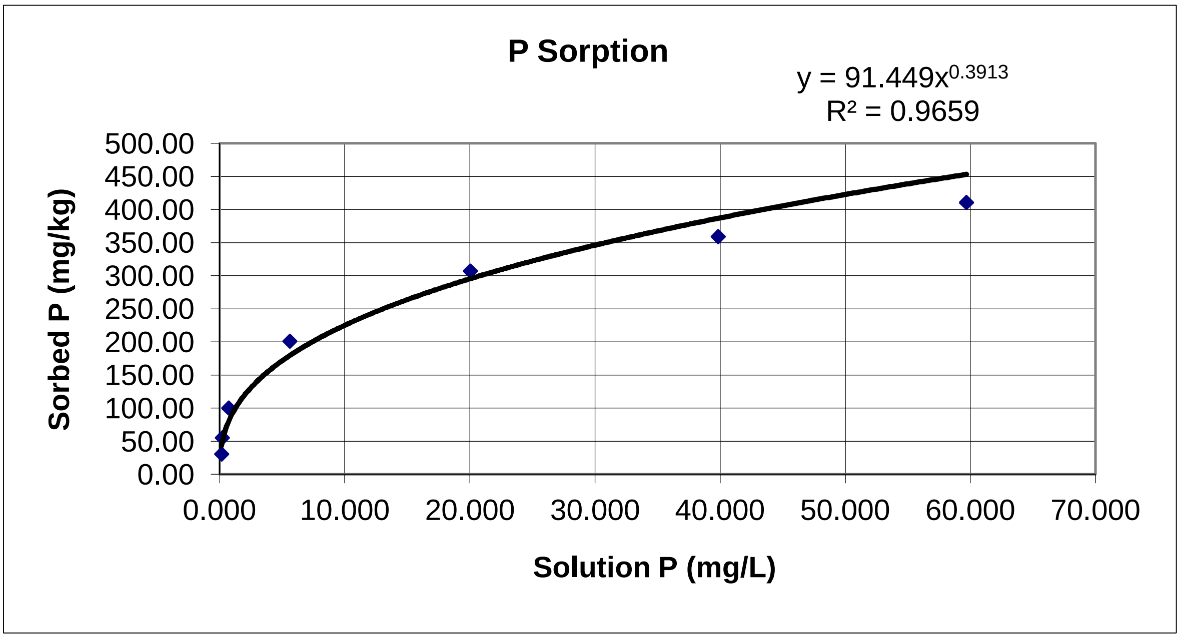
a	91.449
b	0.391
R^2	0.966

Equilibrium P Concentration mg/L

0.5	1	5	10	20	50

P Sorbed mg/kg Estimated

70	91	172	225	295	423



P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.001 **Marking:** GCS01_0.15-0.5

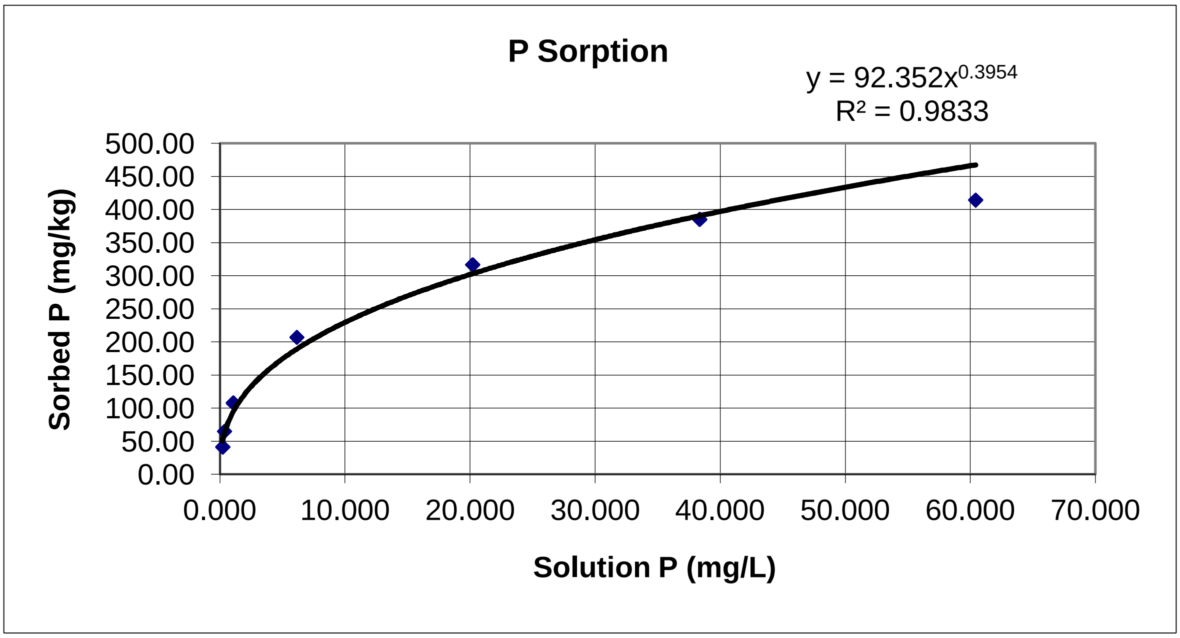
Colwell P mg/kg	18.59

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	2.15035	2.5	0.215	41.44	50.30
50	3.55212	5	0.355	65.04	61.34
100	10.5937	10	1.059	108.00	94.48
250	61.3233	25	6.132	207.27	189.16
500	201.976	50	20.198	316.61	303.04
750	383.437	75	38.344	385.15	390.45
1000	604.129	100	60.413	414.46	467.33

a	92.352
b	0.395
R^2	0.983

Equilibrium P Concentration mg/L					
0.5	1	5	10	20	50
P Sorbed mg/kg Estimated					
70	92	174	230	302	434



P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.003
Marking: GCS02_0.25-3.0

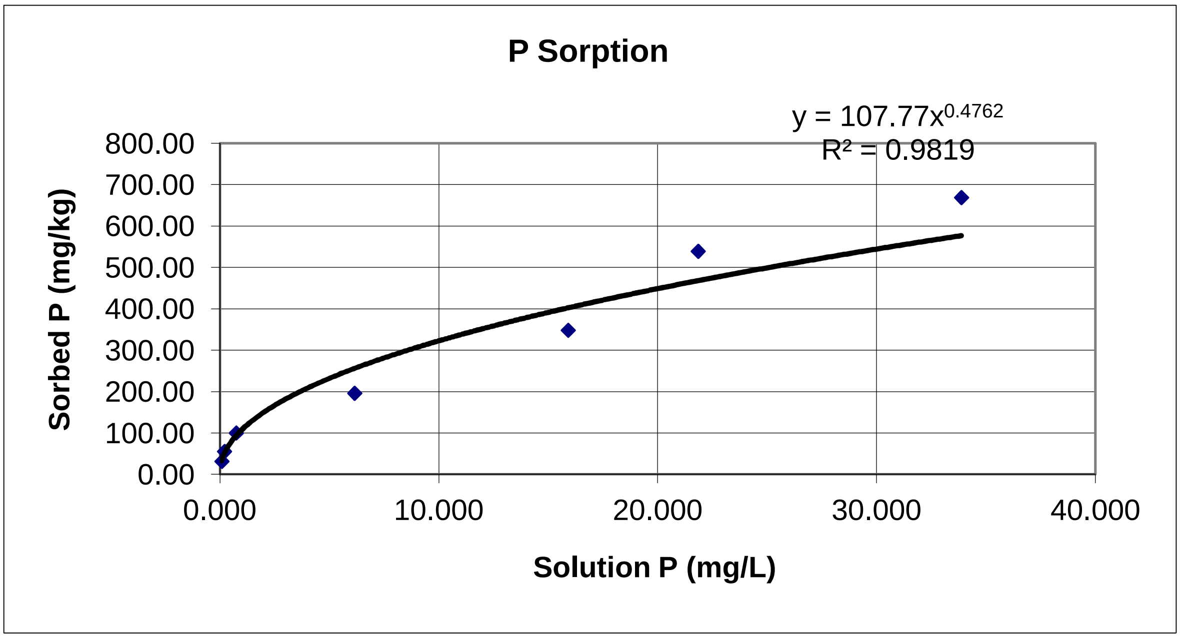
Colwell P mg/kg	7.64

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	0.823498	2.5	0.082	31.82	32.82
50	2.07796	5	0.208	55.56	51.00
100	7.46967	10	0.747	100.17	93.79
250	61.4931	25	6.149	196.15	255.95
500	159.083	50	15.908	348.56	402.47
750	218.48	75	21.848	539.16	468.11
1000	338.718	100	33.872	668.92	576.81

a	107.771
b	0.476
R^2	0.982

Equilibrium P Concentration mg/L					
0.5	1	5	10	20	50
P Sorbed mg/kg Estimated					
77	108	232	323	449	694



P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.005 **Marking:** GCS03_0.25-3.0

Colwell P mg/kg	5.54

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	0.677287	2.5	0.068	29.86	36.30
50	1.49747	5	0.150	54.04	48.12
100	7.34465	10	0.734	98.20	84.68
250	63.8345	25	6.383	191.71	182.62
500	242.561	50	24.256	262.98	293.49
750	439.324	75	43.932	316.22	362.47
1000	557.009	100	55.701	448.53	394.38

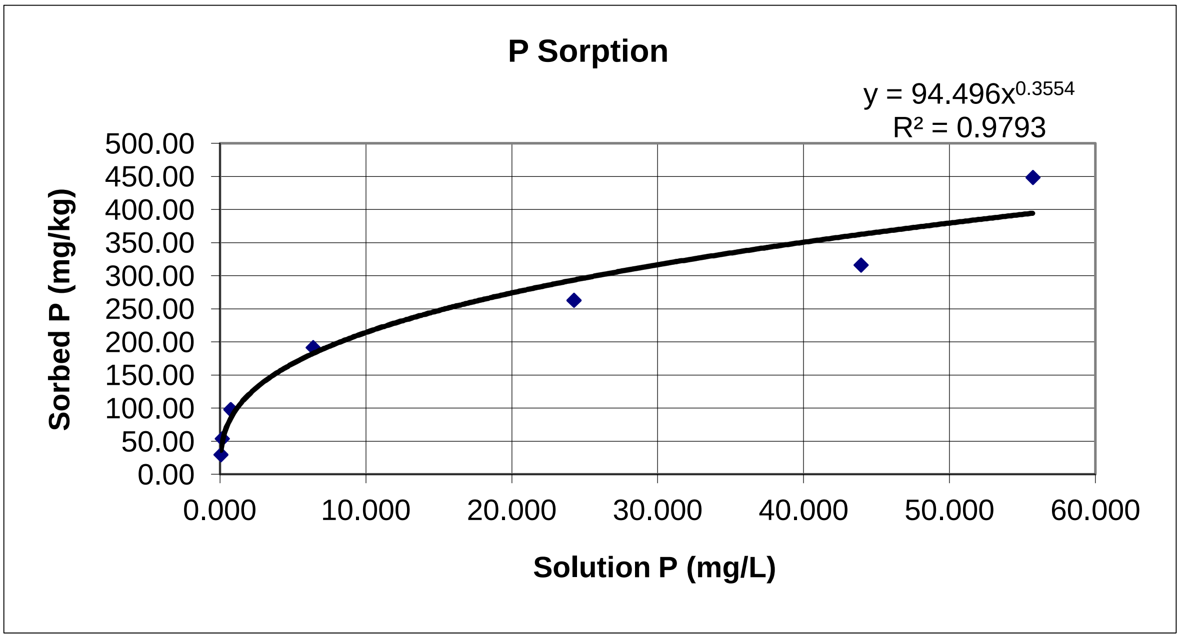
a	94.496
b	0.355
R^2	0.979

Equilibrium P Concentration mg/L

0.5	1	5	10	20	50

P Sorbed mg/kg Estimated

74	94	167	214	274	380



P ISOTHERM RESULTS

Client: GHD
Laboratory No: TW12-04936.006
Marking: GCS04_0-0.3

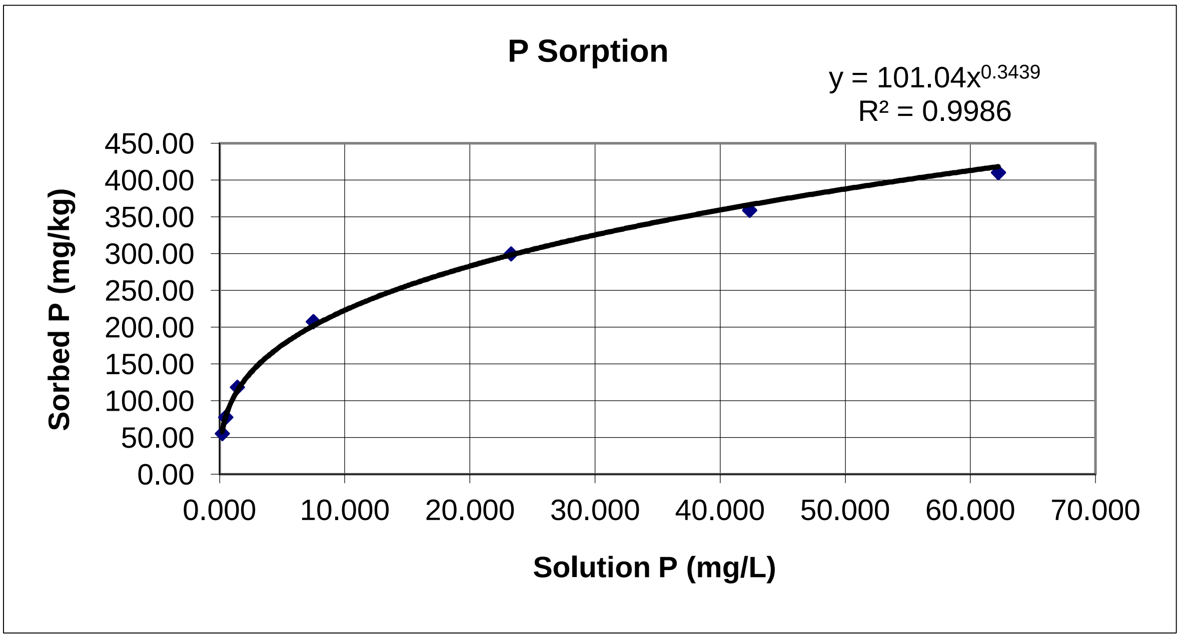
Colwell P mg/kg	32.58

P Sorbed = a x Equilibrium P Conc.^{b}

Initial P mg/kg	Final P mg/kg	Initial P mg/L	Final P mg/L	P Sorbed mg/kg	P Sorbed Estimated
25	1.97194	2.5	0.197	55.61	57.81
50	4.70545	5	0.471	77.87	77.97
100	13.9758	10	1.398	118.60	113.37
250	74.8155	25	7.482	207.76	201.87
500	232.771	50	23.277	299.81	298.25
750	423.487	75	42.349	359.09	366.40
1000	622.178	100	62.218	410.40	418.23

a	101.043
b	0.344
R^2	0.999

Equilibrium P Concentration mg/L					
0.5	1	**5**	10	20	50
P Sorbed mg/kg Estimated					
80	101	176	223	283	388



CERTIFICATE OF ANALYSIS

Work Order	: **EP1204381**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR ASHLEY SUTHERLAND	Contact	: Scott James
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: ashley.sutherland@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 03 8687 8000	Telephone	: +61-8-9209 7655
Facsimile	: +61 03 8687 8111	Facsimile	: +61-8-9209 7600
Project	: Rottnest Island- Golf Course and Oval Assesment	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 31/28991		
C-O-C number	: ----	Date Samples Received	: 01-JUN-2012
Sampler	: L.E.	Issue Date	: 13-JUN-2012
Site	: ----		
		No. of samples received	: 9
Quote number	: ----	No. of samples analysed	: 9

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ASS: EA003 (NATA Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Vigorous; 4 - Very Vigorous**
- **ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.**
- **ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5**

Analytical Results

Sub-Matrix: **SOIL**			Client sample ID	RASS1-0.3-0.6	RASS1-0.9-1.2	RASS2-0.2-0.5	RASS2-1.2-1.5	RASS3-0.2-0.7
			Client sampling date / time	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EP1204381-001	EP1204381-002	EP1204381-003	EP1204381-004	EP1204381-005
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	9.8	9.8	9.8	9.9	9.9
pH OX (23B)	----	0.1	pH Unit	8.0	8.3	8.3	8.3	8.3
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.04	0.03	0.03	0.06	0.05
Peroxide Sulfur (23De)	----	0.005	% S	0.18	0.22	0.12	0.26	0.17
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.14	0.18	0.09	0.19	0.12
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	87	115	57	121	74
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.24	0.21	0.22	0.24	0.22
Peroxide Calcium (23Wh)	----	0.005	% Ca	27.7	32.7	30.1	33.5	30.7
Acid Reacted Calcium (23X)	----	0.005	% Ca	27.5	32.5	29.9	33.2	30.5
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	13700	16200	14900	16600	15200
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	22.0	26.0	23.9	26.6	24.4
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.06	0.06	0.06	0.10	0.08
Peroxide Magnesium (23Tm)	----	0.005	% Mg	1.20	1.40	0.85	1.57	0.92
Acid Reacted Magnesium (23U)	----	0.005	% Mg	1.13	1.34	0.79	1.47	0.84
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	932	1100	651	1210	690
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	1.49	1.76	1.04	1.93	1.11
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	76.6	78.7	74.1	81.8	79.2
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	15300	15700	14800	16400	15800
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	24.5	25.2	23.7	26.2	25.4
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5

Analytical Results

Sub-Matrix: SOIL			Client sample ID	RASS1-0.3-0.6	RASS1-0.9-1.2	RASS2-0.2-0.5	RASS2-1.2-1.5	RASS3-0.2-0.7
			Client sampling date / time	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00
Compound	CAS Number	LOR	Unit	EP1204381-001	EP1204381-002	EP1204381-003	EP1204381-004	EP1204381-005
EA029-H: Acid Base Accounting - Continued								
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.14**	**0.18**	**0.09**	**0.19**	**0.12**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**87**	**115**	**57**	**121**	**74**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**6**	**9**	**4**	**9**	**6**

Analytical Results

Sub-Matrix: SOIL			Client sample ID	RASS3-1.0_1.5	RASS4-0.4_0.6	RASS4-1.0_1.2	GCS04-0.7_2.2	----
			Client sampling date / time	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	30-MAY-2012 15:00	----
Compound	CAS Number	LOR	Unit	EP1204381-006	EP1204381-007	EP1204381-008	EP1204381-009	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	9.9	9.8	9.9	9.8	----
pH OX (23B)	----	0.1	pH Unit	8.3	8.2	8.2	8.2	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	<2	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	<2	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.10	0.05	0.14	0.01	----
Peroxide Sulfur (23De)	----	0.005	% S	0.29	0.19	0.32	0.11	----
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.20	0.14	0.18	0.10	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	123	86	111	63	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.24	0.21	0.27	0.21	----
Peroxide Calcium (23Wh)	----	0.005	% Ca	35.6	29.2	32.9	36.2	----
Acid Reacted Calcium (23X)	----	0.005	% Ca	35.4	29.0	32.6	36.0	----
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	17600	14400	16300	18000	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	28.3	23.2	26.1	28.8	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.10	0.06	0.14	0.04	----
Peroxide Magnesium (23Tm)	----	0.005	% Mg	1.31	1.13	1.13	0.94	----
Acid Reacted Magnesium (23U)	----	0.005	% Mg	1.20	1.07	0.99	0.90	----
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	989	881	818	741	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	1.58	1.41	1.31	1.19	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	81.8	81.4	78.4	79.4	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	16300	16300	15700	15900	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	26.2	26.1	25.1	25.4	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	RASS3-1.0_1.5	RASS4-0.4_0.6	RASS4-1.0_1.2	GCS04-0.7_2.2	----
			Client sampling date / time	31-MAY-2012 15:00	31-MAY-2012 15:00	31-MAY-2012 15:00	30-MAY-2012 15:00	----
Compound	CAS Number	LOR	Unit	EP1204381-006	EP1204381-007	EP1204381-008	EP1204381-009	----
EA029-H: Acid Base Accounting - Continued								
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	----
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.20**	**0.14**	**0.18**	**0.10**	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**123**	**86**	**111**	**63**	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**9**	**6**	**8**	**5**	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1205271**	Page	: 1 of 15
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR ASHLEY SUTHERLAND	Contact	: Scott James
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: ashley.sutherland@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 03 8687 8000	Telephone	: +61-8-9209 7655
Facsimile	: +61 03 8687 8111	Facsimile	: +61-8-9209 7600
Project	: 3128991 GOLF COURSE & OVAL ASSESSMENT	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 29-JUN-2012
Sampler	: LN	Issue Date	: 09-JUL-2012
Site	: Rottnest Island		
		No. of samples received	: 6
Quote number	: EN/005/09	No. of samples analysed	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Agnes Szilagyi	Senior Organic Chemist	Perth Organics
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics
Chas Tucker	Inorganic Chemist	Perth Inorganics
Cicelia Bartels	Metals Instrument Chemist	Perth Inorganics
Rassem Ayoubi	Senior Organic Chemist	Perth Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **WATER**			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**384**	**472**	**300**	**494**	**371**
Total Alkalinity as CaCO3	----	1	mg/L	**384**	**472**	**300**	**494**	**371**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**166**	**862**	**1380**	**294**	**151**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**789**	**9320**	**10800**	**2320**	**732**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**116**	**481**	**344**	**117**	**108**
Magnesium	7439-95-4	1	mg/L	**70**	**555**	**679**	**215**	**52**
Sodium	7440-23-5	1	mg/L	**463**	**4480**	**5140**	**1250**	**438**
Potassium	7440-09-7	1	mg/L	**49**	**195**	**233**	**54**	**36**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	**0.01**	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	**0.007**	**0.004**	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0001**	**0.0001**	**0.0001**	**0.0001**	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.007**	**0.011**	**0.007**	**0.002**
Nickel	7440-02-0	0.001	mg/L	**0.013**	**0.034**	**0.014**	**0.006**	**0.007**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.016**	**0.022**	**9.40**	**0.021**	**0.010**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**3.48**	**0.87**	**0.38**	**0.17**	**2.81**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	<0.01	**0.05**	**0.05**
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	<0.01	<0.01	**2.78**	**0.47**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.01**	<0.01	<0.01	**2.83**	**0.52**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.49**	**0.23**	**0.60**	**0.82**	**0.82**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**33.4**	**290**	**339**	**81.4**	**31.2**
Total Cations	----	0.01	meq/L	**32.9**	**270**	**302**	**79.3**	**29.6**
Ionic Balance	----	0.01	%	**0.67**	**3.71**	**5.74**	**1.35**	**2.58**

Analytical Results

Sub-Matrix: WATER			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	CAS Number	LOR	Unit	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
EP026ST: Chemical Oxygen Demand (Sealed Tube)								
Chemical Oxygen Demand	----	5	mg/L	**49**	**198**	**371**	**70**	**36**
EP030: Biochemical Oxygen Demand (BOD)								
Biochemical Oxygen Demand	----	2	mg/L	<2	<2	<2	<2	<2
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	----	1	µg/L	<1	<1	<1	<1	<1
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDT	50-29-3	2	µg/L	<2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	µg/L	<2	<2	<2	<2	<2
^ Total Chlordane (sum)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of DDD + DDE + DDT	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP074A: Monocyclic Aromatic Hydrocarbons								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
Styrene	100-42-5	5	µg/L	<5	<5	<5	<5	<5
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
Isopropylbenzene	98-82-8	5	µg/L	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: WATER			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	CAS Number	LOR	Unit	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
EP074A: Monocyclic Aromatic Hydrocarbons - Continued								
n-Propylbenzene	103-65-1	5	µg/L	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	<5	<5	<5	<5
sec-Butylbenzene	135-98-8	5	µg/L	<5	<5	<5	<5	<5
1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	<5	<5	<5	<5
tert-Butylbenzene	98-06-6	5	µg/L	<5	<5	<5	<5	<5
p-Isopropyltoluene	99-87-6	5	µg/L	<5	<5	<5	<5	<5
n-Butylbenzene	104-51-8	5	µg/L	<5	<5	<5	<5	<5
EP074B: Oxygenated Compounds								
Vinyl Acetate	108-05-4	50	µg/L	<50	<50	<50	<50	<50
2-Butanone (MEK)	78-93-3	50	µg/L	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	<50	<50	<50	<50
2-Hexanone (MBK)	591-78-6	50	µg/L	<50	<50	<50	<50	<50
EP074C: Sulfonated Compounds								
Carbon disulfide	75-15-0	5	µg/L	<5	<5	<5	<5	<5
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	5	µg/L	<5	<5	<5	<5	<5
1.2-Dichloropropane	78-87-5	5	µg/L	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	<5	<5	<5	<5
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	<5	<5	<5	<5
EP074E: Halogenated Aliphatic Compounds								
Dichlorodifluoromethane	75-71-8	50	µg/L	<50	<50	<50	<50	<50
Chloromethane	74-87-3	50	µg/L	<50	<50	<50	<50	<50
Vinyl chloride	75-01-4	50	µg/L	<50	<50	<50	<50	<50
Bromomethane	74-83-9	50	µg/L	<50	<50	<50	<50	<50
Chloroethane	75-00-3	50	µg/L	<50	<50	<50	<50	<50
Trichlorofluoromethane	75-69-4	50	µg/L	<50	<50	<50	<50	<50
1.1-Dichloroethene	75-35-4	5	µg/L	<5	<5	<5	<5	<5
Iodomethane	74-88-4	5	µg/L	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	<5	<5	<5	<5
1.1-Dichloroethane	75-34-3	5	µg/L	<5	<5	<5	<5	<5
cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	<5	<5	<5	<5
1.1-Dichloropropylene	563-58-6	5	µg/L	<5	<5	<5	<5	<5
Carbon Tetrachloride	56-23-5	5	µg/L	<5	<5	<5	<5	<5
1.2-Dichloroethane	107-06-2	5	µg/L	<5	<5	<5	<5	<5
Trichloroethene	79-01-6	5	µg/L	<5	<5	<5	<5	<5
Dibromomethane	74-95-3	5	µg/L	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: **WATER**			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
EP074E: Halogenated Aliphatic Compounds - Continued								
1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	<5	<5	<5	<5
1.3-Dichloropropane	142-28-9	5	µg/L	<5	<5	<5	<5	<5
Tetrachloroethene	127-18-4	5	µg/L	<5	<5	<5	<5	<5
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	<5	<5	<5	<5
Pentachloroethane	76-01-7	5	µg/L	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	<5	<5	<5	<5
Hexachlorobutadiene	87-68-3	5	µg/L	<5	<5	<5	<5	<5
EP074F: Halogenated Aromatic Compounds								
Chlorobenzene	108-90-7	5	µg/L	<5	<5	<5	<5	<5
Bromobenzene	108-86-1	5	µg/L	<5	<5	<5	<5	<5
2-Chlorotoluene	95-49-8	5	µg/L	<5	<5	<5	<5	<5
4-Chlorotoluene	106-43-4	5	µg/L	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	541-73-1	5	µg/L	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	106-46-7	5	µg/L	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	95-50-1	5	µg/L	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	120-82-1	5	µg/L	<5	<5	<5	<5	<5
1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	<5	<5	<5	<5
EP074G: Trihalomethanes								
Chloroform	67-66-3	5	µg/L	<5	<5	<5	<5	<5
Bromodichloromethane	75-27-4	5	µg/L	<5	<5	<5	<5	<5
Dibromochloromethane	124-48-1	5	µg/L	<5	<5	<5	<5	<5
Bromoform	75-25-2	5	µg/L	<5	<5	<5	<5	<5
EP074H: Naphthalene								
Naphthalene	91-20-3	7	µg/L	<7	<7	<7	<7	<7
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-Methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0

Analytical Results

Sub-Matrix: **WATER**			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	CAS Number	LOR	Unit	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
EP075(SIM)A: Phenolic Compounds - Continued								
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (WHO)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
C6 - C10 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2

Analytical Results

Sub-Matrix: WATER			Client sample ID	GCW01	GCW02	GCW03	GCW04	GCW05
			Client sampling date / time	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00	28-JUN-2012 15:00
Compound	CAS Number	LOR	Unit	EP1205271-001	EP1205271-002	EP1205271-003	EP1205271-004	EP1205271-005
EP080: BTEXN - Continued								
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	1330-20-7	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	34.0	34.0	34.0	32.0	36.0
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	60.6	65.0	63.3	60.4	70.9
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	57.6	64.6	60.7	57.2	65.5
EP074S: VOC Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	104	102	106	111	111
Toluene-D8	2037-26-5	0.1	%	98.6	100	103	98.0	95.5
4-Bromofluorobenzene	460-00-4	0.1	%	95.6	94.4	98.8	96.1	94.6
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	27.4	34.9	31.8	32.7	31.5
2-Chlorophenol-D4	93951-73-6	0.1	%	60.2	67.3	65.8	67.9	67.4
2.4.6-Tribromophenol	118-79-6	0.1	%	77.0	84.6	87.9	80.8	87.7
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	50.8	68.9	60.1	62.6	67.4
Anthracene-d10	1719-06-8	0.1	%	90.9	80.5	85.2	86.3	88.7
4-Terphenyl-d14	1718-51-0	0.1	%	92.5	82.4	91.5	86.6	95.0
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	103	102	107	111	110
Toluene-D8	2037-26-5	0.1	%	99.1	101	102	98.8	95.8
4-Bromofluorobenzene	460-00-4	0.1	%	92.6	93.1	95.9	95.7	96.1

Analytical Results

Sub-Matrix: WATER			Client sample ID	QA01	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1205271-006	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	312	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	312	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1370	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	10900	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	370	----	----	----	----
Magnesium	7439-95-4	1	mg/L	714	----	----	----	----
Sodium	7440-23-5	1	mg/L	5350	----	----	----	----
Potassium	7440-09-7	1	mg/L	242	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.010	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.014	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	9.30	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.39	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.71	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	342	----	----	----	----
Total Cations	----	0.01	meq/L	316	----	----	----	----
Ionic Balance	----	0.01	%	3.98	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**			Client sample ID	**QA01**	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1205271-006**	**----**	**----**	**----**	**----**
EP026ST: Chemical Oxygen Demand (Sealed Tube)								
Chemical Oxygen Demand	----	5	mg/L	**422**	----	----	----	----
EP030: Biochemical Oxygen Demand (BOD)								
Biochemical Oxygen Demand	----	2	mg/L	**7**	----	----	----	----
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	----	1	µg/L	<1	----	----	----	----
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	----	----	----	----
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	----	----	----	----
beta-BHC	319-85-7	0.5	µg/L	<0.5	----	----	----	----
gamma-BHC	58-89-9	0.5	µg/L	<0.5	----	----	----	----
delta-BHC	319-86-8	0.5	µg/L	<0.5	----	----	----	----
Heptachlor	76-44-8	0.5	µg/L	<0.5	----	----	----	----
Aldrin	309-00-2	0.5	µg/L	<0.5	----	----	----	----
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	----	----	----	----
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	----	----	----	----
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	----	----	----	----
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	----	----	----	----
Dieldrin	60-57-1	0.5	µg/L	<0.5	----	----	----	----
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	----	----	----	----
Endrin	72-20-8	0.5	µg/L	<0.5	----	----	----	----
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	----	----	----	----
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	----	----	----	----
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	----	----	----	----
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	----	----	----	----
4.4`-DDT	50-29-3	2	µg/L	<2	----	----	----	----
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	----	----	----	----
Methoxychlor	72-43-5	2	µg/L	<2	----	----	----	----
^ **Total Chlordane (sum)**	----	0.5	µg/L	<0.5	----	----	----	----
^ **Sum of DDD + DDE + DDT**	----	0.5	µg/L	<0.5	----	----	----	----
^ **Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	0.5	µg/L	<0.5	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
Styrene	100-42-5	5	µg/L	<5	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
Isopropylbenzene	98-82-8	5	µg/L	<5	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

			Client sample ID	QA01	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1205271-006	----	----	----	----
EP074A: Monocyclic Aromatic Hydrocarbons - Continued								
n-Propylbenzene	103-65-1	5	µg/L	<5	----	----	----	----
1.3.5-Trimethylbenzene	108-67-8	5	µg/L	<5	----	----	----	----
sec-Butylbenzene	135-98-8	5	µg/L	<5	----	----	----	----
1.2.4-Trimethylbenzene	95-63-6	5	µg/L	<5	----	----	----	----
tert-Butylbenzene	98-06-6	5	µg/L	<5	----	----	----	----
p-Isopropyltoluene	99-87-6	5	µg/L	<5	----	----	----	----
n-Butylbenzene	104-51-8	5	µg/L	<5	----	----	----	----
EP074B: Oxygenated Compounds								
Vinyl Acetate	108-05-4	50	µg/L	<50	----	----	----	----
2-Butanone (MEK)	78-93-3	50	µg/L	<50	----	----	----	----
4-Methyl-2-pentanone (MIBK)	108-10-1	50	µg/L	<50	----	----	----	----
2-Hexanone (MBK)	591-78-6	50	µg/L	<50	----	----	----	----
EP074C: Sulfonated Compounds								
Carbon disulfide	75-15-0	5	µg/L	<5	----	----	----	----
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	5	µg/L	<5	----	----	----	----
1.2-Dichloropropane	78-87-5	5	µg/L	<5	----	----	----	----
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	----	----	----	----
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	----	----	----	----
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L	<5	----	----	----	----
EP074E: Halogenated Aliphatic Compounds								
Dichlorodifluoromethane	75-71-8	50	µg/L	<50	----	----	----	----
Chloromethane	74-87-3	50	µg/L	<50	----	----	----	----
Vinyl chloride	75-01-4	50	µg/L	<50	----	----	----	----
Bromomethane	74-83-9	50	µg/L	<50	----	----	----	----
Chloroethane	75-00-3	50	µg/L	<50	----	----	----	----
Trichlorofluoromethane	75-69-4	50	µg/L	<50	----	----	----	----
1.1-Dichloroethene	75-35-4	5	µg/L	<5	----	----	----	----
Iodomethane	74-88-4	5	µg/L	<5	----	----	----	----
trans-1.2-Dichloroethene	156-60-5	5	µg/L	<5	----	----	----	----
1.1-Dichloroethane	75-34-3	5	µg/L	<5	----	----	----	----
cis-1.2-Dichloroethene	156-59-2	5	µg/L	<5	----	----	----	----
1.1.1-Trichloroethane	71-55-6	5	µg/L	<5	----	----	----	----
1.1-Dichloropropylene	563-58-6	5	µg/L	<5	----	----	----	----
Carbon Tetrachloride	56-23-5	5	µg/L	<5	----	----	----	----
1.2-Dichloroethane	107-06-2	5	µg/L	<5	----	----	----	----
Trichloroethene	79-01-6	5	µg/L	<5	----	----	----	----
Dibromomethane	74-95-3	5	µg/L	<5	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**			Client sample ID	QA01	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1205271-006**	**----**	**----**	**----**	**----**
EP074E: Halogenated Aliphatic Compounds - Continued								
1.1.2-Trichloroethane	79-00-5	5	µg/L	<5	----	----	----	----
1.3-Dichloropropane	142-28-9	5	µg/L	<5	----	----	----	----
Tetrachloroethene	127-18-4	5	µg/L	<5	----	----	----	----
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L	<5	----	----	----	----
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L	<5	----	----	----	----
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L	<5	----	----	----	----
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L	<5	----	----	----	----
1.2.3-Trichloropropane	96-18-4	5	µg/L	<5	----	----	----	----
Pentachloroethane	76-01-7	5	µg/L	<5	----	----	----	----
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L	<5	----	----	----	----
Hexachlorobutadiene	87-68-3	5	µg/L	<5	----	----	----	----
EP074F: Halogenated Aromatic Compounds								
Chlorobenzene	108-90-7	5	µg/L	<5	----	----	----	----
Bromobenzene	108-86-1	5	µg/L	<5	----	----	----	----
2-Chlorotoluene	95-49-8	5	µg/L	<5	----	----	----	----
4-Chlorotoluene	106-43-4	5	µg/L	<5	----	----	----	----
1.3-Dichlorobenzene	541-73-1	5	µg/L	<5	----	----	----	----
1.4-Dichlorobenzene	106-46-7	5	µg/L	<5	----	----	----	----
1.2-Dichlorobenzene	95-50-1	5	µg/L	<5	----	----	----	----
1.2.4-Trichlorobenzene	120-82-1	5	µg/L	<5	----	----	----	----
1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	----	----	----	----
EP074G: Trihalomethanes								
Chloroform	67-66-3	5	µg/L	<5	----	----	----	----
Bromodichloromethane	75-27-4	5	µg/L	<5	----	----	----	----
Dibromochloromethane	124-48-1	5	µg/L	<5	----	----	----	----
Bromoform	75-25-2	5	µg/L	<5	----	----	----	----
EP074H: Naphthalene								
Naphthalene	91-20-3	7	µg/L	<7	----	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	----	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	----	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	----	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	----	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	----	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	----	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	----	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	----	----	----	----
4-Chloro-3-Methylphenol	59-50-7	1.0	µg/L	<1.0	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

			Client sample ID	QA01	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1205271-006	----	----	----	----
EP075(SIM)A: Phenolic Compounds - Continued								
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	----	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	----	----	----	----
^ Benzo(a)pyrene TEQ (WHO)	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
C6 - C10 Fraction	----	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: WATER			Client sample ID	QA01	----	----	----	----
			Client sampling date / time	28-JUN-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1205271-006	----	----	----	----
EP080: BTEXN - Continued								
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	1330-20-7	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	**34.0**	----	----	----	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	**67.5**	----	----	----	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	**60.3**	----	----	----	----
EP074S: VOC Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**108**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	**95.9**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	**95.8**	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	**30.3**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%	**62.6**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%	**87.2**	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	**55.0**	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%	**81.7**	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	**84.4**	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**108**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	**95.6**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	**93.7**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	27.4	136.2
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	50.0	146.3
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	26.8	153.4
EP074S: VOC Surrogates			
1.2-Dichloroethane-D4	17060-07-0	62.3	133.9
Toluene-D8	2037-26-5	74.5	124.3
4-Bromofluorobenzene	460-00-4	63.9	118.5
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	67.2
2-Chlorophenol-D4	93951-73-6	29.4	119.5
2.4.6-Tribromophenol	118-79-6	10.0	130.8
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	33.8	130.7
Anthracene-d10	1719-06-8	42.7	126.5
4-Terphenyl-d14	1718-51-0	40.5	142.4
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	60.5	141.2
Toluene-D8	2037-26-5	73.4	126
4-Bromofluorobenzene	460-00-4	59.6	125.3

Appendix D

Irrigation design (Paul F. Jones & Associates, 2012)

Irrigation layout plan

Irrigation control system wiring plan

Irrigation installation details

Irrigation pump station details

Irrigation design water balance

Irrigation design construction specification

LEGEND

- Type A sprinkler - electric valve in head - full circle
- Type B sprinkler - electric valve in head - part circle
- Type C sprinkler - electric valve in head - full circle
- Type D sprinkler - electric valve in head - part circle
- Type E sprinkler - check valve in head - full circle
- Type F sprinkler - check valve in head - part circle
- Lateral Pipework
- Mainline Pipework - Sizes as shown
- Quick Coupling Valve
- Automatic Control Valve (50mm)
- Mainline Isolation Valve
- Lateral Isolation Valve
- Air Valves
- Scour Valves
- 240 volt cables and conduit (2-core plus earth)
- Weather Station
- 240 volt power source
- Grounding plate/rod
- Station Numbers - hole number / station number
- Conduits - Sizes as shown
- M-NI Moisture Sensor
- Moisture Sensor - Repeater(for RF systems)
- Moisture Sensor - Base Station
- Decoder Cable Switch Device

LATERAL PIPE AND CONTROL VALVE SIZING (PVC)

Sprinkler Type	Number of Sprinklers						
	1	2	3	4	5	6	7
Sprinklers A & B	40	50	50	50	-	-	-
Sprinklers C & D	40	50	50	50	-	-	-
Sprinklers E & F	32	40	40	50	50	50	50
Control Valve Size	25	25	40	40	50	50	50

LATERAL PIPE AND CONTROL VALVE SIZING (POLY)

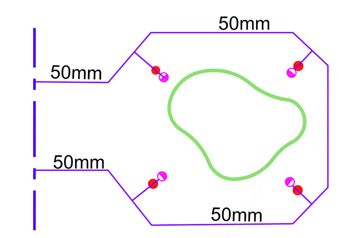
Sprinkler Type	Number of Sprinklers						
	1	2	3	4	5	6	7
Sprinklers A & B	50	63	63	63	-	-	-
Sprinklers C & D	50	63	63	63	-	-	-
Sprinklers E & F	40	50	50	63	63	63	63
Control Valve Size	25	25	40	40	50	50	50

EQUIVALENT PIPE SIZES

PIPE TYPE	Nominal Pipe Size							
PVC Pipe	32	40	50	80	100	150	200	250
P.E. Pipe	40	50	63	110	125	160	250	280

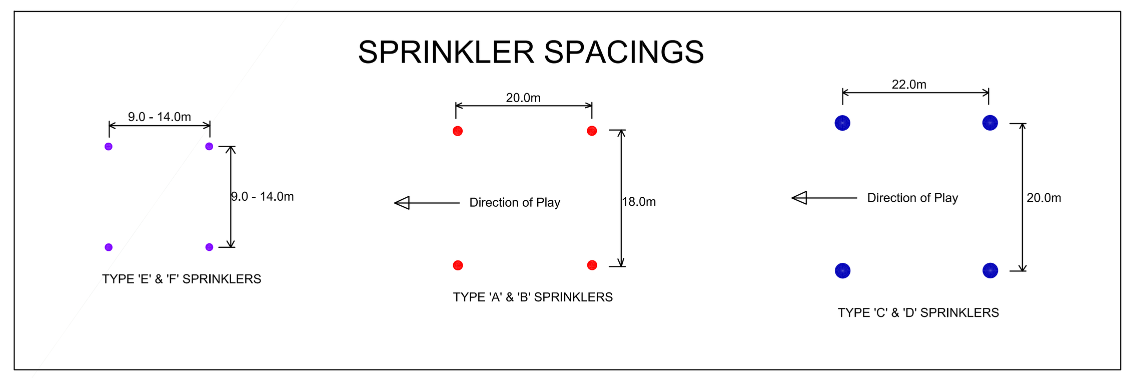
NOTES
1. Final placement of sprinklers, valves and mainline pipework to be determined on site.
2. Refer to drawing number 182.544.1 for Irrigation Layout Plan, 182.544.2 for Control Wiring Plan, 182.544.3 for Pump Station Plan and 182.544.4 for Installation Details drawing.
3. All equipment used to be suitable fro use with Class 'A' treated water & shall be lilac colour coded to conform to current guidelines.
4. Power for pump station shall be provided by others.
5. Pipe sizes shown on plan are for PVC pipe.

TYPICAL GREEN DETAIL



0 10 20 30 40 50 100
SCALE IN METRES

SPRINKLER SPACINGS



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REVISIONS

DATE	REV	DESCRIPTION

NOTES

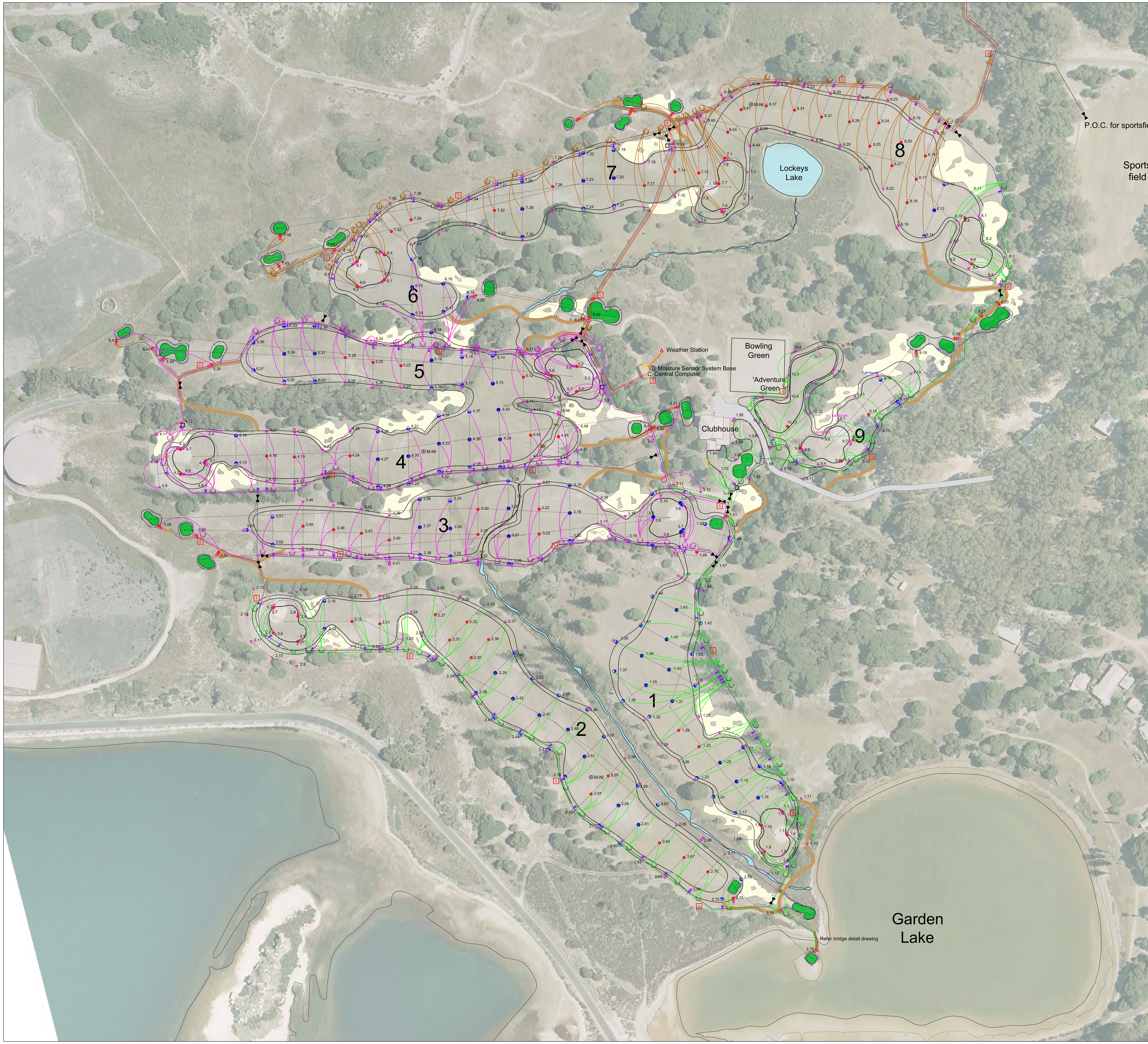
ROTTNEST ISLAND GOLF COURSE

Irrigation Layout Plan

DATE: May, 2012
SCALE: as shown above
REVISION:
DRAWING No. 183.544.1

NORTH

Sheet 1 of 1



LEGEND

- Type A sprinkler - electric valve in head - full circle
- Type B sprinkler - electric valve in head - part circle
- Type C sprinkler - electric valve in head - full circle
- Type D sprinkler - electric valve in head - part circle
- Type E sprinkler - check valve in head - full circle
- Type F sprinkler - check valve in head - part circle
- Lateral Pipework
- Mainline Pipework - Sizes as shown
- Quick Coupling Valve
- Automatic Control Valve (50mm)
- Mainline Isolation Valve
- Lateral Isolation Valve
- Air Valves
- Scour Valves
- 240 volt cables and conduit (2-core plus earth)
- Communication cable
- C Central Computer
- Weather Station
- 240 volt power source
- Decoder - Path 1
- Decoder - Path 2C
- Decoder - Path 2D
- Grounding plate/rod
- Station Numbers - hole number / station number
- Conduits - Sizes as shown
- M-NI Moisture Sensor
- Moisture Sensor - Repeater(for RF systems)
- Moisture Sensor - Base Station
- Decoder Cable Switch Device

LATERAL PIPE AND CONTROL VALVE SIZING (PVC)

Sprinkler Type	Number of Sprinklers						
	1	2	3	4	5	6	7
Sprinklers A & B	40	50	50	50	-	-	-
Sprinklers C & D	40	50	50	50	-	-	-
Sprinklers E & F	32	40	40	50	50	50	50
Control Valve Size	25	25	40	40	50	50	50

LATERAL PIPE AND CONTROL VALVE SIZING (POLY)

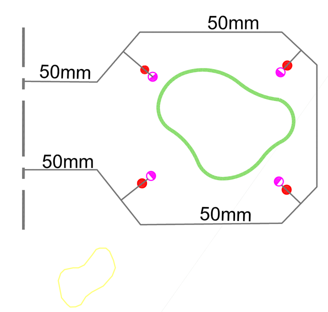
Sprinkler Type	Number of Sprinklers						
	1	2	3	4	5	6	7
Sprinklers A & B	50	63	63	63	-	-	-
Sprinklers C & D	50	63	63	63	-	-	-
Sprinklers E & F	40	50	50	63	63	63	63
Control Valve Size	25	25	40	40	50	50	50

EQUIVALENT PIPE SIZES

PIPE TYPE	Nominal Pipe Size							
PVC Pipe	32	40	50	80	100	150	200	250
P.E. Pipe	40	50	63	110	125	160	250	280

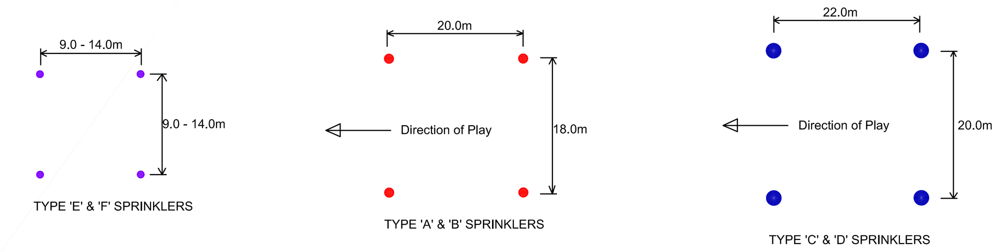
NOTES
1. Final placement of sprinklers, valves and mainline pipework to be determined on site.
2. Refer to drawing number 182.544.1 for Irrigation Layout Plan, 182.544.2 for Control Wiring Plan, 182.544.3 for Pump Station Plan and 182.544.4 for Installation Details drawing.
3. All equipment used to be suitable fro use with Class 'A' treated water & shall be lilac colour coded to conform to current guidelines.
4. Power for pump station shall be provided by others.
5. Pipe sizes shown on plan are for PVC pipe.

TYPICAL GREEN DETAIL



0 10 20 30 40 50 100
SCALE IN METRES

SPRINKLER SPACINGS



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REVISIONS

DATE	REV	DESCRIPTION

NOTES

ROTTNEST ISLAND GOLF COURSE

Control System Wiring Plan

DATE:	May, 2012
SCALE:	as shown above
REVISION:	
DRAWING No.	183.544.2

NORTH

Sheet 1 of 1

PAUL F. JONES & ASSOCIATES PTY. LTD.
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REVISIONS

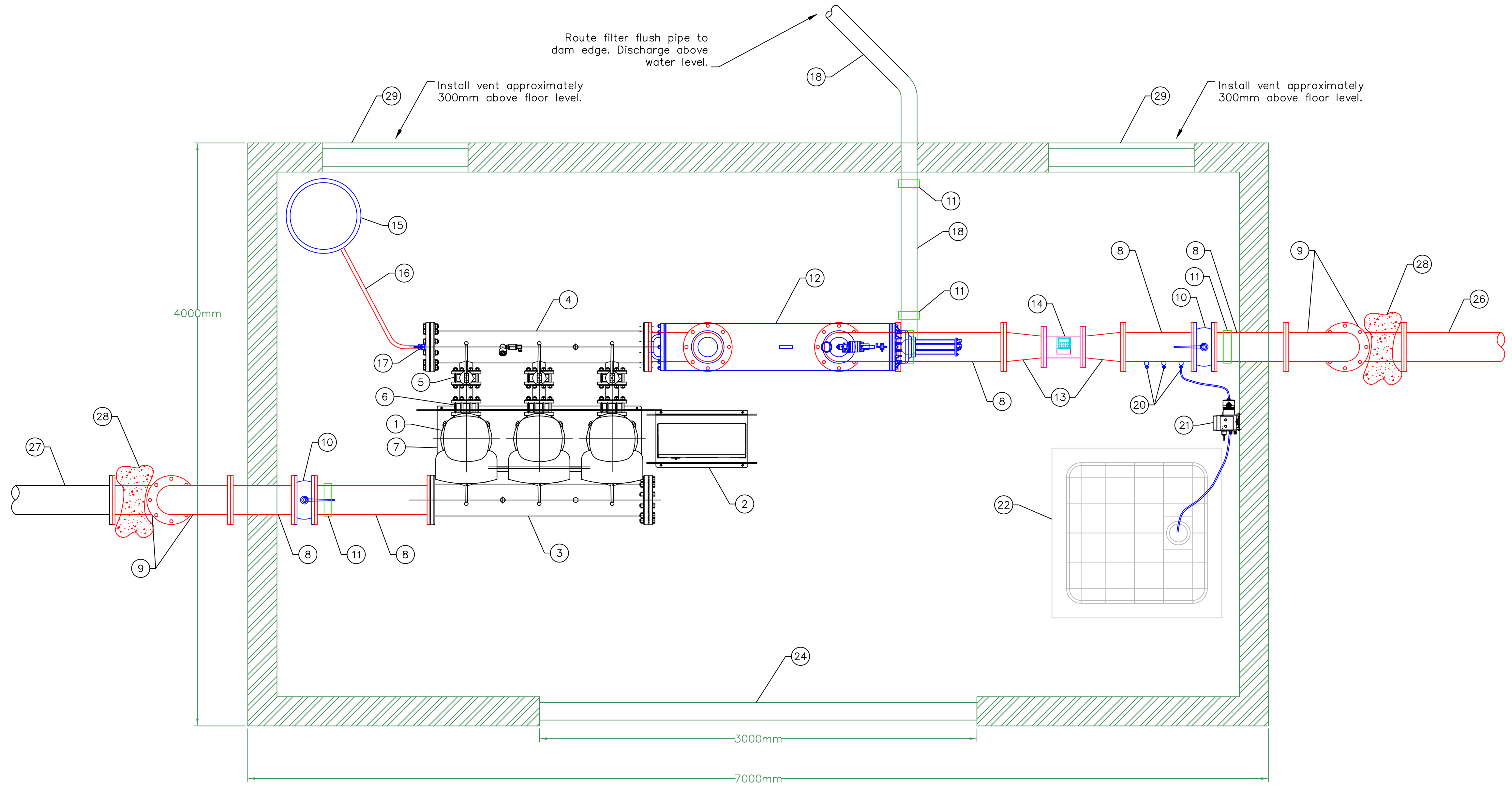
DATE	REV	DESCRIPTION

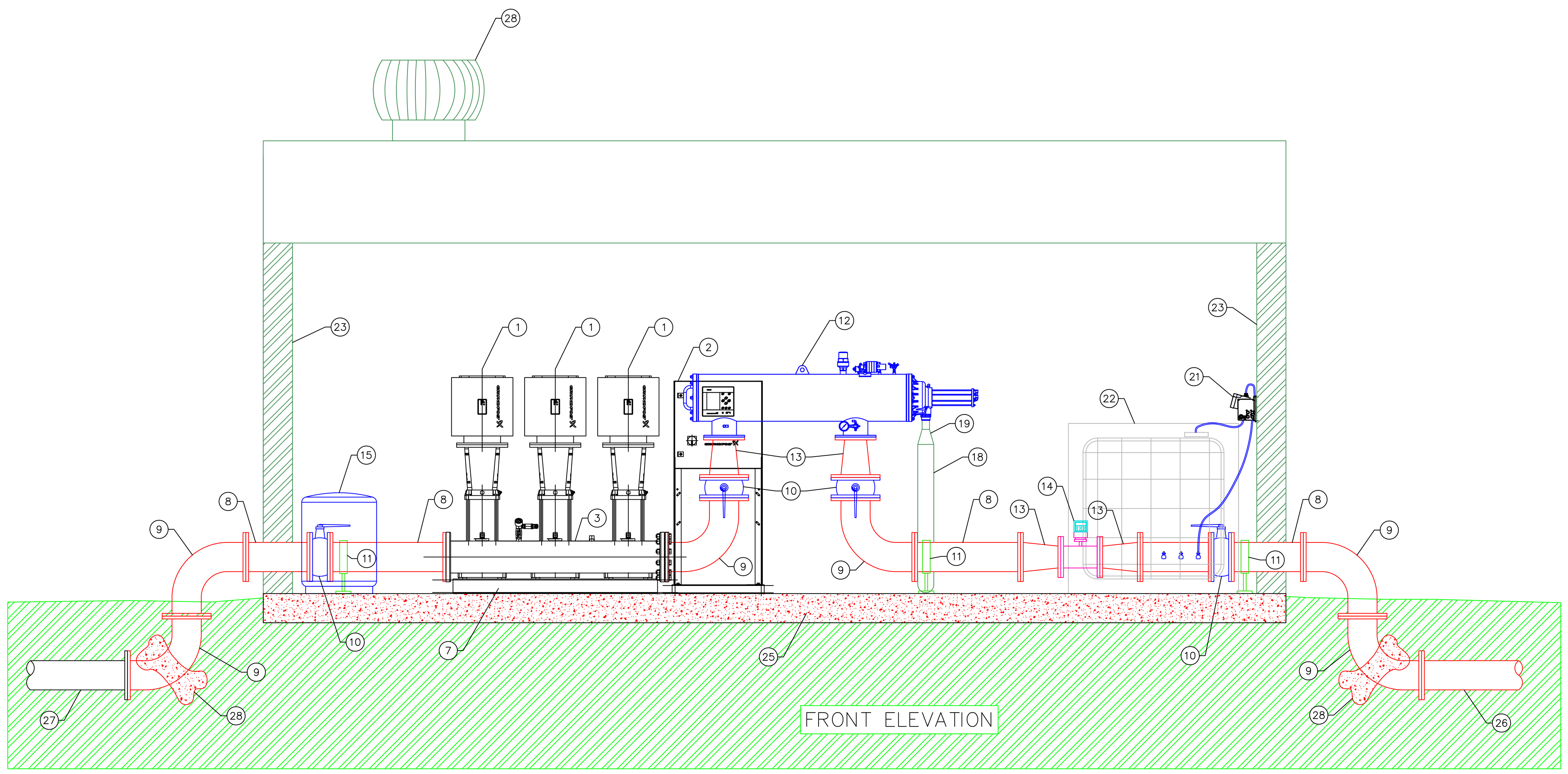
NOTES

ROTTNEST ISLAND GOLF COURSE

Installation Details

DATE: May 2012
SCALE: Not To Scale
REVISION:
DRAWING No. 188.544.4





LEGEND

ITEM	DESCRIPTION	SIZE	MANUFACTURER	MODEL
1	PUMPS 1–3 & MOTORS	Refer Specs	Grundfos	CRNE45–4
2	ELECTRICAL CONTROL PANEL – PUMPS	Refer Specs	Grundfos	MPC–E
3	SUCTION MANIFOLD	200mm		
4	DISCHARGE MANIFOLD	200mm		
5	BUTTERFLY VALVE	80mm		
6	CHECK VALVE	80mm		
7	STEEL SKID BASE	Engineered to suit		
8	STEEL PIPE – GALVANISED	200mm		
9	90 DEGREE STEEL ELBOW – GALVANISED	200mm		
10	BUTTERFLY VALVE	200mm	C.I. epoxy coated	
11	PIPE COLLAR & SUPPORT	Refer pipe size		
12	FILTER	150mm	FILTAWORX	FW–150
13	CONCENTRIC TAPER, STEEL (FL–FL) ≤ 8 degrees	150mmx200mm	CREVET	C063.2015
14	MAGFLOW WATER METER	200mm	SIEMENS MAG 5100W+MAG 6000	
15	PRESSURE DIAPHRAGM TANK	200 LITRES	Grundfos	
16	PRESSURE HOSE	25mm	Grundfos	
17	BALL VALVE	25mm		
18	FILTER FLUSH PIPE	100mm Steel or 110mm Poly		
19	TAPER/ADAPTER 50mm FILTER OUTLET – 100mm FLUSH PIPE			
20	HOSE POINT/INJECTION POINT–Gate or ball valve	25mm		
21	DOSING PUMP – WETTING AGENT/FERTILISER	Refer Specs	Grundfos	DDA 12–10
22	IBC CHEMICAL STORAGE			
23	PUMPHOUSE WALL	Engineered to suit		
24	PUMPHOUSE DOOR	Engineered to suit		
25	REINFORCED CONCRETE PAD	Engineered to suit		
26	PVC MAINS PIPE	200mm		
27	SUPPLY PIPE– HIGH DENSITY POLYETHYLENE	225mm		
28	THRUST BLOCK	Engineered to suit		
29	VENT	1m x 0.5m or equivalent area		
28	TURBINE VENTILATOR			

Notes:
1. Pump house to be Colourbond steel or concrete block construction
2. Provide twin fluorescent light fitting.
3. Concrete pad to be 7.0 m x 4.0 m.
4. Penetrations though pump house walls to be sealed.
5. Pumping equipment to be installed by irrigation contractor
6. 415 Volt power supply to be provided by others. Irrigation contractor shall connect to this supply.
7. Discharge shall be steel until outside pump house and thrust blocked below ground.
8. Filter flush pipe to be routed back to pond and have no obstruction to flow.
9. Pump house as per Engineers design.
10. Provide twin 240 Volt GPO for Dosing pump power supply.
11. Pump station output: 32 litres/sec @ 80 m head.

0 100 200 300 400 500 1000
Scale in millimetres

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REVISIONS

DATE	REV	DESCRIPTION

NOTES

ROTTNEST ISLAND GOLF CLUB
Irrigation Pump Station

DATE: May, 2012
SCALE: (as shown above) 1:20 @ AO
REVISION:
DRAWING No. 182-544-4

MAINTENANCE IRRIGATION REQUIREMENTS

© Paul F. Jones & Associates

DATE: 23/03/2012

PROJECT NAME : Rottnest Island Golf Course

Source Data: BOM
Golf Course

AREA OF COVER	Initial	Final	
GOLF Greens	0.25	0.25	Hectares
GOLF Tees	0.25	0.25	Hectares
GOLF Fairways	8.00	8.00	Hectares
GOLF Roughs	0.00	0.00	Hectares
Oval	1.10	1.10	Hectares
Landscape Area 2	0.00	0.00	Hectares
Landscape Area 3	0.00	0.00	Hectares
Landscape Area 4	0.00	0.00	Hectares
Landscape Area 5	0.00	0.00	Hectares
Practice	0.00	0.00	Hectares
Lakes	0.50	0.50	Hectares

	Crop Factor	Scheduling Factor %
Greens	0.83	100
Tees	0.61	100
Fairways	0.61	60
Roughs	0.61	100
Oval	0.61	60
Landscape Area 2	0.61	0
Landscape Area 3	0.61	0
Landscape Area 4	0.61	0
Landscape Area 5	0.61	0
Practice	0.61	75

Lake Evap. Factor %: 75

Comments:
Golf areas based on sprinkler coverage

Turfgrass Species	Crop Factor
Creeping Bentgrass	0.83
Tall Fescue	0.84
Perennial Ryegrass	0.81
Kentucky Bluegrass	0.79
Fine Fescue	0.86
Paspalem Vaginatum	0.66
Buffalo	0.62
Kikuyu	0.61
Couch	0.61
Zoysia Japonica	0.59

Description	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	31	31	30	31	30	31	31	28	31	30	31	30
Evaporation/Month (mm./month)	62.00	77.50	105.00	161.20	216.00	238.70	291.40	246.40	210.80	129.00	80.60	60.00
Evaporation/Day (mm./day)	2.00	2.50	3.50	5.20	7.20	7.70	9.40	8.80	6.80	4.30	2.60	2.00
Rainfall/Month	148.3	104.1	60.3	38.9	16.9	9.8	6.8	12.5	13.8	36.7	106.2	156.0
(mm./month) % of average	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Effective Rainfall %:	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Rain Days/Month	18	14	11	6	3	8	2	2	4	15	18	20
Rainfall/Rain day(aver.) (mm./day)	8.24	7.44	5.48	6.48	5.63	1.23	3.40	6.25	3.45	2.45	5.90	7.80
Irrigate Days/Month												
Greens	0	0	13	24	28	30	30	27	29	22	0	0
Tees	0	0	7	21	27	29	30	26	28	19	0	0
Fairways	0	0	4	13	16	18	18	16	17	11	0	0
Roughs	0	0	7	21	27	29	30	26	28	19	0	0
Oval	0	0	4	13	16	18	18	16	17	11	0	0
Landscape Area 2	0	0	0	0	0	0	0	0	0	0	0	0
Landscape Area 3	0	0	0	0	0	0	0	0	0	0	0	0
Landscape Area 4	0	0	0	0	0	0	0	0	0	0	0	0
Landscape Area 5	0	0	0	0	0	0	0	0	0	0	0	0
Practice	0	0	6	16	20	22	23	20	21	14	0	0
Depth of Irrigation/Day (mm/day)												
Greens	2.08	2.59	3.63	5.40	7.47	7.99	9.75	9.13	7.06	4.46	2.70	2.08
Tees	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Fairways	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Roughs	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Oval	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Landscape Area 2	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Landscape Area 3	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Landscape Area 4	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Landscape Area 5	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Practice	1.53	1.91	2.67	3.97	5.49	5.87	7.17	6.71	5.19	3.28	1.98	1.53
Potential Daily Vol (Ml)												
Greens	0.005	0.006	0.009	0.013	0.019	0.020	0.024	0.023	0.018	0.011	0.007	0.005
Tees	0.004	0.005	0.007	0.010	0.014	0.015	0.018	0.017	0.013	0.008	0.005	0.004
Fairways	0.122	0.153	0.214	0.317	0.439	0.470	0.573	0.537	0.415	0.262	0.159	0.122
Roughs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oval	0.017	0.021	0.029	0.044	0.060	0.065	0.079	0.074	0.057	0.036	0.022	0.017
Landscape Area 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Practice	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Potential Daily Volume (Ml/day)	**0.148**	**0.185**	**0.259**	**0.384**	**0.532**	**0.569**	**0.695**	**0.650**	**0.502**	**0.318**	**0.192**	**0.148**
Monthly Volume (Ml)												
Greens	0.000	0.000	0.122	0.321	0.518	0.595	0.739	0.608	0.512	0.243	0.000	0.000
Tees	0.000	0.000	0.049	0.210	0.370	0.431	0.538	0.438	0.367	0.154	0.000	0.000
Fairways	0.000	0.000	0.949	4.033	7.094	8.266	10.339	8.418	7.053	2.960	0.000	0.000
Roughs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oval	0.000	0.000	0.130	0.554	0.975	1.137	1.422	1.158	0.970	0.407	0.000	0.000
Landscape Area 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Landscape Area 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Practice	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lake Evaporation Losses	0.000	0.000	0.092	0.410	0.726	0.846	1.059	0.862	0.722	0.300	0.000	0.000
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Monthly Volume (Ml/month)	**0.00**	**0.00**	**1.34**	**5.53**	**9.68**	**11.27**	**14.10**	**11.48**	**9.62**	**4.06**	**0.00**	**0.00**

1878.60 Yearly Total Evaporation (mm)

710.30 Yearly Total Rainfall (mm)

	Yearly Volume (Ml)
Greens	3.66
Tees	2.56
Fairways	49.11
Roughs	0.00
Oval	6.75
Landscape Area 2	0.00
Landscape Area 3	0.00
Landscape Area 4	0.00
Landscape Area 5	0.00
Practice	0.00
Lakes	5.02
Yearly Volume (Ml)	0.00
Total Yearly Volume (Ml)	**67.09**

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ROTTNEST ISLAND GOLF COURSE

Specifications For:

GOLF COURSE IRRIGATION

May, 2012

Prepared by

PAUL F. JONES & ASSOCIATES PTY LTD

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Prepared for

Davey Shearer Golf Design
45 Lempriere Avenue,
Mount Martha, 3934
AUSTRALIA
On behalf of the
Rottnest Island Authority

SECTION 1. GOLF COURSE IRRIGATION SYSTEM CONSTRUCTION SPECIFICATIONS

Irrigation & Water Transfer Systems Construction Specifications

1.1 General

1.1.1 Scope

This specification shall be read in conjunction with the following Drawing No's:-

182-544-1	Irrigation Layout Plan	(A0 Sheet)
182-544-2	Control System Wiring Plan	(A0 Sheet)
182-544-3	Irrigation Pump Station Layout	(A0 Sheet)
182-544-4	Typical Installation Details	(A1 Sheet)

The works covered by these documents in general terms are as follows:-

1. Supply & install irrigations system to greens tees & fairways.
2. Supply & install integrated moisture sensor system.

1. The irrigation system shall provide fully automatic control of pop-up sprinklers on greens, greens surrounds, tees, fairways and light roughs with quick coupling valves to be placed at each green and tee as well as strategically along both sides of each fairway.

   Ultimately, the control system shall comprise a central or master computer located in the superintendent's office, and shall work in conjunction with field decoders located in close proximity to the sprinklers or control valves they control. The entire watering program shall be governed by an integrated on-site weather station that forms part of this contract.

   The Irrigation Pump Station will be located adjacent to sewage water treatment plant. Supply of water will be Class ‘A’ treated effluent water.

   The Pump Station will consist of Three (3) vertical multi-stage centrifugal pumps (3 main pumps of equal performance) that shall be Demand Driven, the pumps shall be fitted with motors which have integrated Variable Frequency Drives (pump and integrated VFD are to be one manufacturer). The pump station will provide a range of flow options from zero to 32.0 litres/second.
2. A series of moisture sensors are required to assist in irrigation scheduling.

All items of equipment to be used shall be selected not only for their suitability for the project, but also on the availability of spare parts and service.

This document represents the technical aspects of the Irrigation Contract.

1.1.2 Australian Standards

All works shall be carried out to the appropriate Australian Standards for installation of the total system other than conditions covered in these specifications. Wherever there is conflict between these specifications and the Australian Standards, the Australian Standards shall be adopted.

The following standards apply:-

1. Municipal Water Supply By-Laws.
2. Local By-Laws & Regulations.
3. AS4765, MPVC pipes and fittings manufactured for pressure application,
4. AS2033 & interim AS4130, Installation of polyethylene pipe systems,
5. AS 2032, Codes of practice for installation of UPVC.
6. AS 1477, UPVC pipes and fittings manufactured for pressure application, .
7. AS. 35001, Latest edition of The Electrical Rules & Regulations.
8. AS/NZS 3500: 2003-Plumbing & Drainage.
9. AS2053, UPVC wire conduits.
10. Western Australian State Electrical Authority, electrical specifications and codes.
11. AS 1345, Identification of the contents of Pipes, Conduits and Ducts.
12. Any other relevant **Australian *or* Western Australian Standard or code** of practices associated with supply and installation of any components proposed.

1.1.3 Materials And Workmanship

Whenever any material is specified by name and/or number thereof, such specifications shall be deemed to be used for the purpose of facilitating a description of the materials and establishing quality and shall be deemed and construed to be followed by the words **"or approved equal"**. However, no substitutions will be permitted which have not been submitted for prior approval. All materials shall be new and without flaws or defects and shall be the best of their class and kind. All materials shall be guaranteed for a minimum period of one year against material defects and workmanship.

1.1.4 Permits & Inspections

All costs for permits such as radio licence pump house structure and or inspections relative to the irrigation system associated with the completion of this contract shall be arranged and paid for by the contractor.

1.1.5 System Staking

The contractor shall stake out the location of all sprinkler heads and mainline pipework in conjunction with the irrigation consultant or construction supervisor. Before installation is started in any given area, approval to proceed must be obtained from the owner's representative after he has inspected the staking. Any changes made by the owner’s authorised representative after approval and work commencement shall be at the owner's expense.

1.1.6 Works As Executed Drawings

The contractor shall maintain one set of plans to document Draft "Works as Executed" changes during the progress of installation. All the following items shall be **surveyed** and drawn up in AUTOCAD for the Client.

The following items shall be documented:-

- Sprinklers.
- Valve boxes.
- All pipework.
- Changes of direction of mainline.
- Intersection points of mainline.
- QCV's.
- Air Valves.
- Isolation valves
- Scour valves.
- Controllers.
- Sensors & Repeaters
- Cable paths not in pipe trench.
- Any other significant items.

Draft "Works as Executed" changes are to be documented on a daily basis by the Contractor. Failure to do so will enable the Contract Superintendent to suspend the work until the "Works As Executed" drawings are completed by the Contractor. One reproducible set of "Works as Executed" drawings shall be presented to the owner at or before practical completion in hard copy and .dwg electronic format.

1.1.7 Interpretation Of Specifications

Where the contractor has any doubt to the meaning or intent of any part of the specifications or drawings, he should outline the basis for which he is tendering with a full description of his interpretation. Failure to do so will render the contractor responsible for any costs associated with bringing the construction process back into line with the intention of the specifications or Australian Standards. If there are any discrepancies, they shall be brought to the attention of the Contract Superintendent immediately so an immediate decision can be made about the discrepancy. The contractor should not proceed with any work associated with a discrepancy until it is resolved.

1.1.8 Existing Utilities & Structures

The exact location of all existing utilities and structures which may not be shown on the drawings where possible shall be determined by the contractor in conjunction with the owner's authorised representative. Minor adjustments in the system will be permitted to clear existing obstructions subject to the approval of the owner's authorised representative. Repair costs of existing services that are damaged will be the responsibility of the contractor.

The exception to this will be where the contractor has made an adequate attempt to locate these utilities or services but has been provided with incorrect or inadequate information.

1.1.9 On Site Alterations

From time to time alterations may be necessary. If these alterations or adjustments are within the scope of the specification and require no additional materials or labour, they shall be performed at no cost to the owner.

1.1.10 System Tests

As work progresses the mainline pipework will require testing and approval from the Contract Superintendent's authorised representative. Any defects shall be rectified (if necessary with new materials) before the next section of pipe is laid.

Test 1 - Progressively, as mainline is installed, along with control valves, gate valves and thrust blocks, all outlets shall be closed and the piping shall be tested to maintain 1200 kPa for a duration of 2 hours. If work is defective, the same test must be made after remedial work is completed.

Test 2 - When system is complete the contractor shall thoroughly flush the system and make operational tests on all components ensuring that all part circle sprinkler arcs are accurately set and any pressure regulators, reduction or relief valves are set at their design pressures.

Test 3.- The entire control system shall be **tested and commissioned** by the controller manufacturer.

Test 4.- The Pump Station shall be **tested and commissioned** by the manufacturer.

Costs of all such testing shall be born by the Contractor.

The Contractor shall provide to the Contract Superintendent copies of all test results prior to Practical Completion.

1.1.11 System Inspections

The Contract Superintendent shall inspect and approve all materials, trenching, pipe joining, thrust blocking, cable joining prior to backfilling. All other works shall be inspected and approved as appropriate.

After all works are finished and the system has been flushed, tested and in the contractor's opinion, ready for final inspection, the contractor and the Contract Superintendent shall walk the site and list any aspects that require further work or alterations to bring the system into line with the specifications or contract limits. These alterations should all be remedied within ten (10) days so that final inspection Practical Completion can be reached.

1.1.12 Acceptance & Practical Completion

When all items listed on the first inspection have been remedied and the Contract Superintendent is satisfied that the operation of the system is as intended by the drawings and specifications, the handover can be approved. The following items are to be supplied by the contractor on or before Practical Completion :-

(i) Warranty certificates on all guaranteed items.

(ii) One set of "Works As Executed" drawings in hard copy and .dwg electronic format.

(iii) One set of all operation and maintenance manuals of all materials used in the system in hard copy and Word .doc electronic format.

1.1.13 Operation & Maintenance

Immediately following practical completion the contractor shall at his cost carry out instruction, to appointed course personnel, of the operation and routine maintenance of the irrigation system. This instruction shall be carried out over 5 working days to ensure total understanding of all aspects of the system is achieved.

1.1.14 Spare Parts & Tools

The contractor shall provide the following spare parts and tools at Practical Completion:-

5	only	Sprinkler internal assemblies of each sprinkler type.
5	only	Solenoid assemblies.
5	only	Decoders.
2	only	Sets of each type of lightning protectors.
25	only	Wire connectors.

2	only	Compression joints for each pipe size.
1	set	Of any specialised sprinkler and remote control valve tools applicable to the equipment used.
2	sets	Maintenance manuals for all equipment with exploded views and spare parts lists.
25	only	25mm Quick Coupling Valve keys.
10	only	25mm x 50m long hoses, nuts & tails.
10	only	Sprinklers on stands (Impact type 1 litre/sec)

1.2 Water Storage & Supplies

Water storage for the system shall be from the Storage Tank located at the sewage treatment plant. Supply will be class "A" treated effluent water.

1.3 Power for Control System & Pump Stations

240 volt power for the Central Computer shall be available from the maintenance building for the irrigation control system computer.

415 volt 3-phase power for the Irrigation Pump Stations shall be provided to the Pump Station location by others.

Provision of these power sources shall be by others. However, the contractor shall be responsible to connect to these supplies and thereby carry out supply and installation of the appropriate cables required to connect to the new Pump Stations and the Irrigation Control Equipment.

CT meters etc will be provided by others.

1.4 Sprinklers

1.4.1 Greens

In general, each green shall have a minimum of four (4) Type A or C full circle sprinklers placed to ensure uniform coverage of the playing surface and the green surrounds.

A second set of Type B or D sprinklers shall be placed on the green perimeter and faced onto the green surface to enable separate programs for the green surface to the surrounds.

All Green sprinklers shall be operated individually under the general irrigation program but an entire green shall have the ability to call on either all full circle sprinklers or all part circle sprinklers simultaneously under special irrigation programs required for such tasks as fertiliser wash in, syringing etc.

1.4.2 Tees

Tees shall generally have Type F part circle sprinklers placed to ensure tee surfaces are adequately watered. Configuration of the sprinklers essentially provides cover in accordance with the Turfgrass Planting Plan.

1.4.3 Fairways

The fairways generally shall have a combination of Type A or C sprinklers and Type B or D part circle sprinklers at selected edges of the light rough. All sprinklers shall be placed in accordance with the fairway and short rough shapes. Part circle sprinklers have been used to avoid spraying into sensitive areas and adjoining residential areas.

Each Valve in Head sprinkler shall be individually controlled.

1.4.4 Clubhouse Surrounds

The area around the clubhouse has not yet been designed. Ultimately there will be an appropriate arrangement of sprinklers that will irrigate this area and be connected to the system.

1.4.5 Landscaped Surrounds

Quick coupling valves shall be strategically located for the connection of either hoses, sprinklers on stands, drip or micro irrigation or whatever is deemed suitable for the establishment and maintenance of these areas.

1.5 Quick Coupling Valves

Each green shall have two (2) 25mm quick coupling valves and each tee complex shall have two or three, placed to enable supplemental watering or fertilising etc. Quick coupling valves shall also be strategically located along both sides of each fairway; approximately at each fourth lateral.

1.6 Risers

All valve-in-head sprinklers and quick coupling valves shall be mounted on the threaded 'O'-ring seal type articulated swing joint risers (Refer Detail E).

All riser sizes are to match the sprinkler inlet threads for both diameter and thread type.

1.7 Pipework

Generally all pipework shall be MPVC Class 12 RRJ for mainlines and either MPVC SWJ or Polyethylene PE100 PN12.5 SDR13.6 with compression joints for laterals. All mainline pipework shall be run in roughs where possible to keep major pipework off heavy play areas.

1.8 Bridge and Road crossings

Pipework on bridge crossings shall be either steel or butt welded polyethylene mounted on support brackets attached to the bridge. At each end of the crossing, anchor/thrust blocks shall be installed where the pipework leaves and re-enters the ground.

All bridge pipework and conduits for cables shall be supplied & fitted by the bridge contractor.

At road crossings all pipework and associated cabling shall be housed in a PVC or polyethylene conduit (sleeve). A separate conduit adjacent to the pipework shall be placed through the sleeve. The pipe through the sleeve shall be a single length of pipe or shall have solvent welded joints, if more than one pipe length involved. After pipework and electrical conduit for cables are installed the conduit (sleeve) shall be sand packed around the pipe and cable conduit. The conduit (sleeve) shall be installed by either open trenching or boring. If bitumen or pavement is disturbed it shall be reinstated to its original condition by the irrigation contractor.

1.9 Isolation Valves

Isolation valves shall be placed at each of the following locations.

(a) At each lateral off take for sprinklers and quick coupling valves.

(b) At each off take for automatic control valves (if applicable).

(c) At each off take for sub-mains (e.g. greens and tees).

(d) Strategically located along the mainline pipework to avoid the need to shut down the total system if mainline maintenance is required. These locations are as shown on the Irrigation Layout Plan.

1.10 Control System

The control of the system shall be achieved by the use of a Central Computer and Decoder system.

Decoders are to be located in valve boxes with lateral isolation valves or solenoid control valves, alternatively, single station decoders may be located at the sprinkler head.

The Central and interface shall be located in the Golf Course Superintendents Office inside the Maintenance facility. The control system shall to operate in conjunction with an on-site weather station that can monitor the daily Evapotranspiration (ET) rates and adjust watering programs in accordance with the daily site conditions. Supply & installation of the weather station forms part of this contract and shall be located near the Maintenance Compound.

The Central Computer and software shall be furnished with a modem for remote monitoring of the control system as well as paging alert feature and additionally the system shall have two hand held radios for remote operation.

1.10.1 General Watering Program

The recommended depth of application for the golf course requires that a peak season high of **9.7mm/day** of water be applied to all greens, **7.2mm/day** for tees and **7.2mm/day** for fairways and short roughs.

(a) To apply this **9.7mm** of water each day to greens, the Type A sprinklers shall operate for

23 minutes/night to provide sufficient water to surrounds and the Type B sprinklers at 180 degree arcs shall operate for **4 minutes/night** to provide additional ‘top up’ to the greens.

(b) To apply **7.2mm** of water each day to fairways and short roughs, the Type A sprinklers shall operate for **23 minutes/night** and Type B sprinklers at 180 degree arcs for **11.5 minutes/night**.

(c) To apply **7.2mm** of water each day to fairways and short roughs, the Type C sprinklers shall operate for **25 minutes/night** and Type D sprinklers at 180 degree arcs for **12.5 minutes/night**.

The system has been designed to apply the entire watering requirement to all 18 holes each night during the peak watering season within a watering window between **11.00PM to 7.00AM**.

1.11 Valve Boxes

All isolation valves for lateral pipes and quick coupling valve pipework shall be housed in round valve boxes as detailed.

All isolation valves for mainlines, automatic control valves with isolation valves, air valves, electrically operated motorised control valves and pressure regulation valves, if required, shall be housed in rectangular valve boxes with boxes to be aligned with long side in the direction of the mainline. All lateral isolation valves shall be housed in 250mm round boxes.

All Quick Coupling Valves shall be housed in 150mm valve boxes.

1.12 Air Valves

50mm double acting air valves shall be installed at local high points around the mainline pipework. Final location shall be made on site by the irrigation consultant or supervisor and the contractor (refer to the Layout Plan 182-544-1.

1.13 Electrical Cabling

1.13.1 Power Cables

The Central Computer and Interface Units as well as the Weather Station shall be powered by 240 volt AC from the Golf Course Superintendent's office.

All **240 volt** power cabling shall be installed in underground heavy duty electrical conduit. Cables shall have no below ground cable joins. All 240 volt cabling shall be laid in accordance with Australian Standards and with marker tape 200mm below the surface.

All **415 volt** cabling for the Pump Station shall be run in accordance with local Electrical Authority Code of Practice (installed by others).

1.13.2 Communication Cable

A twin pair communication cable shall be run from the Central computer to Interface Units and to the weather station. It shall be without any below ground joins (generally laid alongside the mainline pipe).

The communication cable must be separated from all other cables by a minimum of 200mm if laid in the same trench as pipework and must be supplied and installed as per the manufacturers recommendations.

A twin pair communication cable is to be run from the Irrigation Pump Controller to the Irrigation Central Computer to enable remote communication and monitoring of the pump station. This is to be used in conjunction with the Grundfos software or Rain Bird Smart Pump Module to interface with the Central Irrigation Computer.

1.13.3 2-Wire Paths

The 2 wire cable shall be carefully installed alongside the mainline pipework with expansion loops at each change of direction and at each point where decoders are to be installed. Adequate slack must be allowed along the trench lines to prevent stressing the cables during the backfilling process. The Decoder Wire Paths shall be 2-wire and conductors shall be a minimum of 2.5mm^2 . Decoder wire paths are to be run in 'Star' configuration.

1.13.4 Decoder to Sprinkler or Control Valve

The cables from the decoder outlet to valve-in-head sprinkler or control valve should be a minimum of 1.5mm^2 as per manufactures specifications either active and common for an AC system or pair for a DC system.

1.14 Scour Valves

Scour Valves shall be placed at suitable low points in the system to enable emptying of the system should servicing be required. The valves shall be sized 80mm. diameter and shall be routed to water bodies or nearest drainage pits.

All scour valves shall be the same type as the mainline isolation valves and shall be finally located by the contractor and the irrigation consultant.

1.15 Irrigation Pump Station (IPS)

The Irrigation Pump Station will be located adjacent to the sewage treatment plant. Supply of water will be Class 'A' treated effluent water from one of the storages at the STP.

The Pump Station will consist of Three (3) vertical multi-stage centrifugal pumps (3 main pumps of equal performance) that shall be Demand Driven, the pumps shall be fitted with motors which have integrated Variable Frequency Drives (pump and integrated VFD are to be one manufacturer). The pump station will provide a range of flow options from zero to 32.0 litres/second.

1.16 Injection System

Provision of three 25mm stainless steel isolation valves set 200mm apart downstream of the filter shall be provided in the pump station. One for connection of a single dosing Grundfos fertiliser injection unit to enable metered dosing through the irrigation system, one spare as prevision for a future additional injection unit, and one for a hose point connection.

Control of the dosing system is to be proportional to pump station flow, the dosing pump is to receive an input signal from the flow meter.

1.17 Equipment Specifications

1.17.1 General

This part of the specifications describes the equipment to be used in the construction of the irrigation system. Where trade names are specified, it shall be deemed to mean and/or equivalent. However, if an alternative to that specified is offered it must be supported with appropriate documentation and be approved by the Contract Superintendent. Where trade names do not appear then all materials selected must conform to the performance specifications. All equipment shall be suitable for use with the Treated Water and shall have the appropriate marking identification where applicable.

1.17.2 Sprinklers

All sprinklers shall have been tested by an independent test authority such as Centre for Irrigation Technology, Fresno, USA and all sprinklers shall have a Distribution Uniformity Coefficient in the range of 80 to 85%. The Contractor shall provide the Contract superintendent with certifications prior to Practical Completion.

Type A sprinkler (for greens, fairways & surrounds) shall be twin nozzle, full circle gear drive and must come complete with an electric valve-in-head incorporated in the sprinkler. The sprinkler shall have the following performance:-

Radius	22.6m.
Discharge	1.9litres/sec
Operating Pressure	450kPa

It shall be: **Toro 835-56-34 6 E DL or Rain Bird 900-E-48-4.8-ACME**

Type B sprinkler (for greens, fairways & surrounds) shall be adjustable part circle sprinkler with an electric valve-in-head incorporated in the sprinkler. The sprinkler shall have the following performance:-

Radius	22.3 m
Discharge	1.9 litres/sec
Operating Pressure	450kPa

It shall be: **Toro 835S-56-34 6 E DL or Rain Bird 950-E-22-4.8-ACME**

Type C sprinkler (for greens & fairways) shall be twin nozzle, full circle gear drive and must come complete with an electric valve-in-head incorporated in the sprinkler. The sprinkler shall have the following performance:-

Radius	23.2m
Discharge	2.13 litres/sec
Operating Pressure	450kPa

It shall be: **Toro 855-56-55 6 E or Rain Bird Eagle 900-E-52-4.8-ACME**

Type D sprinkler (for fairways & surrounds) shall be adjustable part circle sprinkler with an electric valve-in-head incorporated in the sprinkler. The sprinkler shall have the following performance:-

Radius	23.2m
Discharge	2.13 litres/sec
Operating Pressure	450kPa

It shall be: **Toro 855S-56-55 6 E or Rain Bird Eagle 950-E-24-4.8-ACME**

Type E and Type F sprinklers (for tees or green surrounds) shall be full/part circle gear drive and must come complete with a check valve in the sprinkler. The sprinkler shall have the following performance:-

Radius	11.9m
Discharge	0.43 litres/sec
Operating Pressure	450kPa

The sprinklers shall be: **Toro 725G or Rain Bird Eagle 351-B-40-BSP**

NB. All sprinklers to have lilac caps or inserts in cover

1.17.3 Automatic Control Valves

Solenoid operated control valves shall be used for the landscaped clubhouse surrounds, lake filling points and any future landscaped areas.

The control valves shall be electrically operated solenoid valves and shall be fitted with Pressure Regulation Modules set at 450 kPa.

The valves shall be **Toro P220 series or Rain Bird PEB-PRS series**, all with adjustable pressure regulators.

1.17.4 Quick Coupling Valves

The quick coupling valves shall be 25mm inlet. They must be of brass/bronze or gunmetal construction and shall be two piece type with vinyl cover **Toro Model 474-01 or Rain Bird Model 5-NP**.

1.17.5 Control System

The control system shall comprise of a Central Computer and Interface Unit which communicates via a communication cable to Field decoders which in turn operate control valves or valve-in-head sprinklers.

The system shall have the following features:-

(a) Full manufacturers recommended lightning and surge protection and conditioning.

Central:

- Power supply in.
- Grounding grid.
- Internal components
- Communication cable out

Interface Unit:

- Power supply in.
- Internal components
- Communication cables in and out

Decoders:

- Communication path - install surge protectors and grounding rods every 200-250 metres, as per manufacturers recommendation as shown on Control Wire Plan 182-544-2

(b) Central Computer

The central computer shall be as specified by the control system manufacturer and included as part of the control system.

(c) Software

The software shall be a proprietary product that is Windows based and has:

- Graphical representation & on screen operation of the irrigation system.
- Complete reporting facility.
- Alarm raising & paging feature.

- Non delay program linking.
- Remote pump monitoring capability.
- A weather station input capability.
- Full programming capability from central.
- Flow management capability.

The software shall be **Toro SITE-PRO 2000 or Rain Bird Nimbus 2 with Smart Weather and all other associated modules**

NOTE: 1. Each Tenderer is to include the cost to set up all data bases and graphical input from the Work As Executed Autocad drawing.

The Irrigation Central computer shall interface with the Grundfos MPC Controller via a communication cable or Rain Bird Smart Pump Module..

(d) Decoders

Decoders for the project shall be single or multi output type to suit the control system offered. Decoders are to be placed in the lateral valve boxes in close proximity of decoders control valves and strapped to each VIH sprinkler.

Decoders shall be **Toro DEC-01, DEC-02, DEC-04 or Rain Bird FD-101, FD-202, FD-401, FD-601.**

(e) Weather Station

The weather station shall be a **Weather Watch WW-2000,** as manufactured by Campbell Scientific Pty. Ltd, with the following features:

- Capable of updating all weather station data daily.
- Log all records into computer program data banks to enable amendment of watering Programs.
- according to evapotranspiration rate changes on a daily basis.
- Modem linked to the Central computer.
- Shall be 240 volt powered.

(f) Hand Held Radio

The control system shall be capable of being operated using hand held radios.

Two radios and associated hardware & software will be supplied.

1.17.6 Risers

All type A, B, C & D sprinklers and quick coupling valves are to be mounted on threaded 'O'-ring seal type which comprise of:-

2 only 90 degree elbow slip x F (threaded gasket seal)

1 only 90 degree elbow M x F (threaded gasket seal)

1 only Male adaptor slip x M (threaded gasket seal)

1 only PVC Schedule 80 pipe (solvent weld) x 200mm long(Due to 300mm cover requirement)

1 only PVC Schedule 80 pipe - slip x M x 100mm long

All threads on riser must be compatible and male thread on 100mm long schedule 80 pipe must be compatible with the sprinkler inlet that and diameter to be used. For further information refer to detail E.

1.17.7 Isolation Valves

(a) Mainline:

Valves shall be Ductile Iron fusion bonded epoxy coated, either gate or sluice, sized the same as the pipe diameter on which it is to be installed. Valves shall be selected to have pressure losses not exceeding the equivalent of 10m of pipe. All valves up to 80mm diameter may be threaded. All valves greater than 80mm diameter shall be flanged to Table D.

Valves shall be **Crevet** flanged type or similar

(b) Laterals and off takes for Quick coupling valves:

Valves shall be FIP Plastic ball type. All valves shall be constructed with materials suited to the site water and soil conditions and rated to not less than 1000 kPa.

1.17.8 Valve Boxes

All valve boxes shall have either lilac coloured lids or metal plates fixed to their lids with marking in mauve “Treated Water, Not for Drinking” . Signage in accordance with AS 1319.

(a) Rectangular boxes for control valves with isolation valves and air valves and shall be Carson Model 1419B or equal.

(b) Round boxes for lateral **valves** shall be Carson Model 910-12B or equal.

(c) Round valve boxes for Quick Coupling Valves shall be Carson Model 610-12 or equal.

1.17.9 Air Valves

Air valves shall be A.R.I. 'Barak' Model D-040 (50mm) double acting including ball valve.

1.17.10 Pipe and Fittings

Mainline pipework shall be either rigid “Rhino” PVC to AS 1477 and shall be rubber ring jointed, and shall be rated for pressures of 120.0 metres (minimum) or butt welded MDPE PN80-12.5 as an alternative.

All Mainline bends are to be cast iron.

All mainline pipe to be lilac coloured for use with Treated Effluent Water and have identifying marker tape installed above.

Lateral pipework shall be either rigid PVC AS 1477 and shall be Solvent Welded for sizes 50mm and below, also rated for pressures of 120.0 metres (minimum) or MDPE PN80-12.5 0

Lateral pipework for drip in landscaped garden beds shall be Low density polyethylene.

All lateral pipe to have lilac marking for use with Treated Effluent Water.

Fittings for PVC mainline pipe shall be Ductile Iron rubber ring jointed.(other than lateral pipe off-takes for valve-in-heads and quick coupling valves for which stainless steel tapping saddles with stainless steel bolts, nuts & washers (as manufactured by Wang) are acceptable.

All mainline fittings for MDPE shall be electro-fusion or butt welded. (other than lateral pipe off-takes for valve-in-heads and quick coupling valves for which tapping saddles stainless steel bolts shall be used)

All PVC lateral fittings shall be solvent weld. All MDPE lateral fittings shall be compression.

1.17.11 Electrical Cables

(a) 415 & 240 volt

All 415 and 240 volt cable shall be multi-stranded 0.6/1kv PVC double insulated with copper conductors. All 415 and 240 volt cable shall be layed in heavy duty PVC electrical conduits.

(b) Two Wire Paths

The 2-wire cables can be either individual polyethylene insulated single conductors, twisted pair with polyethylene insulation or twin conductors with polyethylene insulation as per the control system manufacturer’s recommendation.

(c) Communication Cables

The communication cable shall be a Paige communication cable shall be shielded direct burial armoured cable (16 AWG) two (2) wire conductor 600 volt copper wire PVC/NYLON insulated aluminium shielded and drain wire to drain off electrical, magnetic or RF interference and a stainless steel helically wrapped armour over the core and a direct burial sunlight resistant PVC jacket.

The cable shall be **Paige P7162-A Type TC or as approved by the control system manufacturer.**

(d) 24 volt

All 24 volt cable shall be either Polyethylene insulated single conductor or polyethylene insulated and PVC sheathed multicore cable. Minimum conductor size for common wire is to be **1.5 sqmm** and for active wire is to be **1.5 sqmm**.

1.17.12 Cable Joints

(a) 240 volt power cable joins must be made in accordance with Australian Standards.

(b) 24 volt cable joints shall be DBY or DBYR type in accordance with Detail 'L'.

(c) Communication cable in Interface Units or Weather Station only.

(d) 2-wire path cable joints shall be DBY or DBYR type in accordance with Detail 'L'.

1.17.13 Soil Moisture Monitoring System

A soil moisture monitoring system comprising field sensors that can remotely monitor the soil moisture content at each location and send via a radio frequency system or signal via hardwire communication back to the central irrigation controller.

The system will be used primarily to inform the system operator of the moisture content infiltration rates in the soil.

Tenderers shall submit technical details of the systems offered with their tender.

1.18 Installation

1.18.1 Sprinklers

No sprinklers shall be installed until all mains and lateral lines have been tested in accordance with this specification and flushed.

All sprinklers shall then be mounted on swing joint risers of the types specified in 1.18.6 and the contractor shall ensure all joints are tightened to prevent leaks.

In areas where the topsoil has been placed then all sprinklers shall be set flush with the surface and the soil around sprinkler must be compacted to same density as adjacent soil (Refer Detail E). In areas where topsoil has not yet been placed all sprinklers shall be set to allow placement of topsoil.

1.18.2 Automatic Remote Control Valves

All automatic valves shall be installed in valve boxes (rectangular) with adequate support under valve box to prevent heavy maintenance machinery knocking the valve box out of alignment or onto the pipework. Support for these boxes shall be either concrete or brick and **the bottom of the support work, as well as a weed-mat type cloth wrap, shall ensure that no backfill material or soil is allowed to enter the valve box**. Furthermore a 100mm bed of gravel shall be compacted and used as a base for the box support.

Alignment of the valve box shall make sure the valve is centrally located.

Control wire should be of adequate length and coiled to allow easy removal of solenoid coil if service is required.

Pressure regulators should be adjusted to provide the specified sprinkler operating pressure (Refer Detail G).

1.18.3 Quick Coupling Valves

All quick coupling valves shall be installed on threaded O-ring seal swing joint risers (refer 1.18.6) and rotation of the valve must be prevented when being opened. This shall be achieved by using an anti-rotation collar. Soil must be compacted around valve to same density as adjacent soil.

1.18.4 Control Equipment

(a) The central computer shall be installed in the Golf Course Superintendents office. It shall have a UPS provided.

(b) The interface unit shall be wall mounted adjacent and shall be furnished with an incoming power isolation switch as well as lightning/ surge protection. The unit shall be wall mounted at a suitable viewing height.

(c) Lightning & Surge Protection.

The central, interface units must have lightning protection equipment provided on incoming and outgoing circuits as well as grounding grids at each location. Also, protection for the power supply and communication cable is required, as recommended by the controller manufacturer.

The communication cable path shall have the control system manufacturer’s recommended lightning protection from the central end and at the Interface Units end.

The minimum protection for the control system is specified below or as recommended by the manufacturer.

(i) Power supply

Protection surge arrester and UPS line conditioner.

(ii) Central

Grounding grid (as per detail J) with a **maximum of 5 ohms** resistance in conjunction with the manufacturers recommendation (refer to manufacturers installation details).

(iii) Interface Unit

240 volt power supply is to be protected using surge arresters.

The grounding grid is as per detail J (one grid only required for each unit, however the grid must attain a **maximum of 5 OHMS** resistance). If 5 ohms cannot be achieved with 3 stakes then additional stakes will be required until this is achieved.

Comm. Cable outputs are all to have built-in surge arresters.

240 volt isolation switch.

(iv) Decoders & Wire Paths

Wire path protection the form of earth stakes or grounding plates shall be placed at intervals shown on the Control Wire Plan 182-544-2

Decoders are to be located in valve boxes with lateral isolation valves or solenoid control valves, alternatively, single station decoders may be located at the sprinkler head.

1.18.5 Risers

All risers must be installed to ensure correct sprinkler height. All threads must be adequately tightened (but not over tightened) to ensure there are no leaks. In the case of the O-ring seal type, if the riser is to be totally assembled by the contractor, the procedure outlined in Detail E must be observed.

1.18.6 Isolation Valves

All isolation valves on the mainline must be installed with spindles or levers having adequate room to be operated and install top of valve no less than 100mm from top of valve box.

All mainline valves must be thrust blocked and strapped as per detail H. Straps shall be galvanised steel rod.

1.18.7 Valve Boxes

Valve boxes are to be installed with lids flush with finished grade. Each box must have either bricks or concrete blocks placed under to support box and prevent the box from resting on pipework. **This support work as well as plastic or other sheet material must ensure that backfill material or surrounding soil does not enter the valve box.**

Furthermore, a 100mm bed of gravel shall be compacted to support the bricks or timber base of the box (see Detail G).

1.18.8 Air Valves

Air valves may be installed above ground where they are not obtrusive. In prime viewing areas, place valve underground in a rectangular valve box as per Detail M. A 25mm. hole should be drilled into the valve box lid to allow air to vent from the box.

1.18.9 Excavation and Backfill

In general, the contractor must excavate in materials as found in the sub grade to a sufficient depth to ensure a minimum cover of 450mm over mainlines and 300mm lateral pipework to the finished surface level.

Backfill material shall be placed in layers of 150mm compacted to the same density as adjacent soil to eliminate any subsequent subsidence.

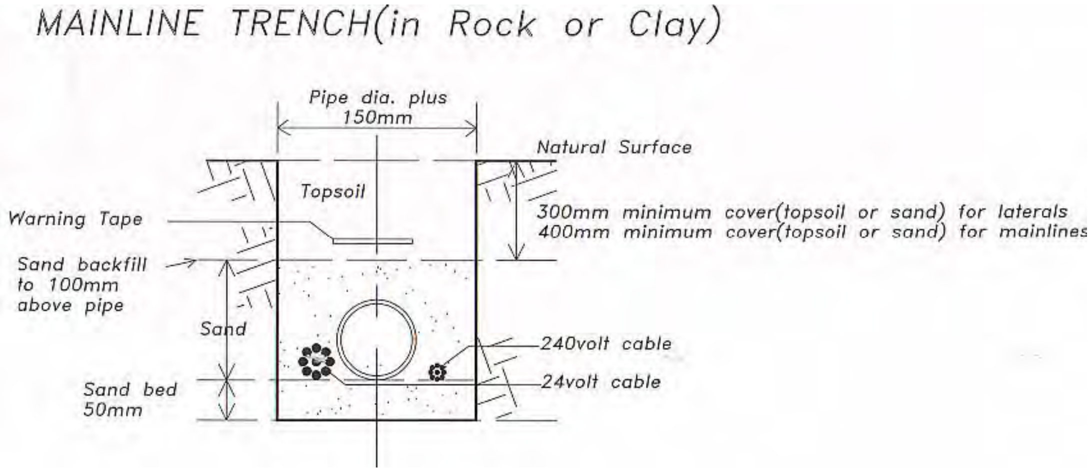
Where excavation is in clay, the pipework shall be laid on a bed of sand and sand placed around the pipe to a depth of a minimum of 50mm above the top of the pipe. Then selected backfill shall be used for the remainder.

Furthermore if the base material is clay it should not be mixed with top soil and used as backfill material for the entire profile. If topsoil is a different material to base material then the trench shall be backfilled with the excavated material to the existing level of the base and the remainder shall be backfilled with topsoil.

If rock is encountered, then approved friable backfill material or sand shall be used as bedding material.

In rocky areas the trenching depth shall be 50mm below normal trench depth to allow for this bedding. Sand or selected backfill shall be placed to 50mm above the pipe and the remainder of the backfill shall contain no lumps or rocks larger than 50mm. The top 150mm of backfill shall be free of rocks larger than 25mm. All trenches that are opened during any particular working day shall be closed and backfilled on the same day after Works As Executed information has been collected. No open trenches or partially backfilled trenches shall be left overnight.

Backfill material shall be placed in layers of 150mm compacted to the same density as adjacent soil to eliminate any subsequent subsidence.



The Contractor shall remove all excess trench material and incorporate in earthworks in general as part of the price.

Mainline pipework shall be open trenched with a chain digger or excavator and lateral pipework can be either open trenched with chain digger or mole ploughed.

1.18.10 Pipework

Unless otherwise specified or shown on the drawings, the construction of sprinkler lines and installation of control cables shall include excavation and backfill compaction, the furnishing, installing and testing of pipework and restoration of existing utilities and all other works in accordance with the plans and specifications.

Unless otherwise indicated on the drawings or required, all pipework shall be installed with a minimum cover of 450mm over all mainline pipework and 300mm over lateral pipework based on finished surface level. Generally, piping under concrete or asphalt shall be installed by jacking, boring or hydraulic driving. Where any cutting or breaking of pathways, concrete and/or asphalt is required approval shall be obtained from those having proper jurisdiction. Where piping is shown under paved areas, but running parallel and adjacent to planted or turf areas, the intent of the drawing is to install the piping in the planted or turf areas.

Minimum cover under roadways or paving shall be 600mm and pipe shall be bedded and covered with sand to a minimum of 100mm above the pipe. The remainder shall be backfilled with DBG20 crushed rock compacted to 100% standard dry density and all road or path surfaces must be restored to its original condition. Pressure pipes to be inserted within enveloper pies and have no joints within enveloper section.

Where conduits are required under roads, they shall be installed as described in the above paragraph.

Plastic pipe shall be installed in a manner to provide for expansion and contraction as recommended by the manufacturer and in accordance with the Australian Standard.

(a) Rubber Ring Jointed Pipework:

All mainline pipework shall be thrust blocked in accordance with the Australian Standards (or the guide inserted as appendix A in this specification) at all changes of direction of the pipework, pipework junctions, pressure regulation valves and isolation valves.

Installers must use the manufacturer’s lubricant and observe the witness mark on the spigot end.

If pipes need to be cut the spigot end must be chamfered with a taper of approximately 15 degrees and inserted into the socket end minus the rubber ring and pushed home. A pencil mark should be made on the outside of the spigot end in line with the socket mouth. A further bolder pencil mark should be made after withdrawing the pipe 10mm. The pipe is then withdrawn and the procedure below is to be followed:-

(i) Clean any dirt or grit from socket (particularly ring groove).

(ii) Insert rubber ring so it seats evenly.

(iii) Clean spigot back to witness mark and apply lubricant to chamfer. Do not apply lubricant to rubber ring as this could cause misplacement when spigot is inserted.

(iv) Align spigot and socket and push pipe home until witness mark is just visible at socket mouth.

(b) Solvent Welded Pipework:

The following solvent cement types shall be used:

(i) **Fast**- For small diameters and cool conditions.

(ii) **Medium** - For general purpose and ambient temperatures below 30 degrees C.

(iii) **Slow** - For large diameter(200mm upwards) and hot conditions.

Joints made with fast or medium solvent should not be disturbed for 10 minutes or pressure tested for 24 hours. Joints made with slow solvent should not be disturbed for 20 minutes or pressure tested for 30 hours.

Procedure:

(i) Ensure spigot end is cut square.

(ii) Mark spigot with pencil where socket mouth will end.

(iii) Clean and degrease both inside of socket and outside of spigot with priming fluid.

(iv) Using a clean dry brush apply an even coat of solvent cement, first to the socket, then to the spigot. Care should be taken to prevent ponding of solvent cement at back of socket.

(v) The spigot should be quickly pushed into the socket squarely and held for a few seconds.

(vi) Wipe off excess solvent cement.

At no stage should any pipework be installed in greens surface.

All pipework shall have lilac marking stripe or be coloured lilac.

(c) Butt welded and Electrofusion Pipework:

All mainline pipework shall be thrust blocked in accordance with the Australian Standards (or the guide inserted as appendix A in this specification) at all changes of direction of the pipework, pipework junctions, pressure regulation valves and isolation valves.

(d) Thrust Blocks

All mainline pipework shall be thrust blocked in accordance with the Australian Standards (or the guide in Section 1.20 in this specification) at each change of direction of the pipework, pipework junctions, pressure regulation valves and isolation valves.

Plastic sheeting must be placed between the fitting and the concrete to simplify access to fittings in the event repair work is required in the future.

1.18.11 Electrical Cables

(a) 415 & 240 volts :

All 415 volt and 240 volt cable must be installed in underground conduit strictly in accordance with the relevant Electrical Authority Code and Australian Standards. All cable paths shall have indicator tape placed above the cable 250mm below the surface level.

(b) 2-Wire Decoder Wire Path Cable :
The 2 wire cable shall be carefully installed alongside the mainline pipework with expansion loops at each change of direction and at each point where decoders are to be installed. Adequate slack must be allowed along the trench lines to prevent stressing the cables during the backfilling process.

(c) Decoder to valve or valve-in-head wiring shall be direct buried alongside pipework and coiled at each solenoid valve or valve-in-head. All changes of direction shall incorporate an expansion coil. Refer detail 'I'. Adequate slack must be allowed along the trench lines to prevent stressing the cables during the backfilling process.

1.19 Pump Station Fit Out

1.19.1 General

The Irrigation Pump Station will be located adjacent to the sewage treatment plant.

Supply of water will essentially be a and Class 'A' treated effluent water.

The Pump Station will consist of Three (3) vertical multi-stage centrifugal pumps (3 main pumps of equal performance) that shall be Demand Driven, the pumps shall be fitted with motors which have integrated Variable Frequency Drives (pump and integrated VFD are to be one manufacturer). The pump station will provide a range of flow options from zero to 32.0 litres/second. The polyethylene supply pipe is included in the irrigation contract.

Each pump shall be manifolded into the header pipe and isolated by gate or butterfly valves on both the suction and delivery sides and check valves on the discharge side. The header pipe and all pumping equipment shall be mounted onto a suitable steel skid base.

Other ancillary equipment include a filter, pressure tank, water meter, and switchboard .

The total duty of the pump stations shall be:

32.0 litres/sec. @ 80.0m head and shall be **Grundfos Turf MPC-E pre-packaged unit.**

1.19.2 Equipment

(i) Pumps and Motors

Depending on the sprinkler equipment selected for the project, the pump duty may need to be adjusted accordingly.

Duty for pumps 1, 2 & 3: **10.6 litres/sec. at 80.0 metres head**

Each pump shall be a **Grundfos Model CRNE45-4** pump with a **15 kW** motor.

(ii) Manifold Pipework & Fittings

Schedule 316 stainless Steel.

(iii) Isolation Valves

Keystone flanged butterfly F2 type.

(iv) Check Valves

Moyes and Groves Wafer check non slam type (flanged).

(v) Filter

An electric self flushing filter shall be installed on the discharge manifold.

The filter shall be a Triangle Filterworx FW 150 (150mm.) with 80 mesh screen.

(vi) Meter

A Siemens Sitrans F-M 5100W & 6000 (150mm.) Magflow water meter shall be installed on the delivery manifold.

(vii) Dosing Pumps

1 x Grundfos Digital Dosing Pump Model DDA 12-10 – Configured for dosing proportional to flow. Signal input taken from Siemens Magflow meter.

1.19.3 Control – Irrigation Pumps

The Controller shall be a Grundfos MPC-E Controller with communication interface with central computer or Smart Pump Module for Rain Bird Nimbus 11 software to provide pump controller monitoring at central PC.

Communication to the central computer shall be by a communication cable.

The Control to facilitate the switching and sequencing of each pump in the system shall be by purpose driven software as produced by Grundfos, to give system operation as described.

A Variable Frequency Drive shall operate each pump in accordance with the motor manufacturer's recommendations and with the Local Electricity Board's Code applicable to the kilowatt rating of each motor .

A weatherproof enclosure shall house all electrical components and a cable tray shall house all wiring from the enclosure to the pump motors.

<u>Lightning/surge protection must be fitted to the incoming power supply that will isolate and protect the entire system as well as all components in the pump station.</u>

The pressure transducer shall be a Danfoss Model MSB33 or similar with an operating range to suit the application.

The Control Panel shall be a Grundfos MPC-E as manufactured by Grundfos.

The lead pump shall be a controlled by the set pressure of its pressure sensor(transducer) set at **785 kPa (80.0 m.)**.

Starting of the lead pump is carried out by the incorporated VFD controller and each subsequent pump shall start in accordance with the "Field Demand".

Each electrical motor selected shall be chosen to ensure non overload condition occur under any circumstances.

A suitable base of high grade steel or cast iron shall be provided for mounting pumps and motors as well as for the suction manifold and header pipe works.

1.19.4 Operation

(a) Irrigation Pump Set

System Set Point Operating pressures (Set Point) is 785 kPa (80.0m).System operating pressure is set into PLC.

If pressure drops below Set Point, **Pump 1** starts and **Pump 2** is on standby. If **Pump 1** is at full speed and the pressure continues to drop below Set Point, **Pump 2** will start and ramp up under the control of its VFD to whatever speed is required to maintain the set pressure. The procedure is repeated for **Pump 3 until** all pumps reach maximum speed.

Shutdown is the reverse of the procedure described above.

The following should be considered as minimum requirements for the pumps. Any additional protection that is recommended by the pump and motor manufacturer must be included.

- Loss of Suction Cut Out Indicator lights shall show 'Loss of Suction Cut Out'.
- No Flow Cut Out Indicator lights shall show 'No Flow Cut Out'.
- High/Low Pressure Cut Out Indicator lights shall show 'High/Low Pressure Cut Out'.
- Incorrect Motor Temperature Indicator lights shall show 'Incorrect Motor Temperature'.
- Phase failure Indicator lights shall show "Phase failure".
- Incorrect Motor Current Indicator lights shall show 'Incorrect Motor Current'.
- Low Level shut down
- Any other protection recommended by the motor manufacturer pertinent to this installation. Any further protection should have indicator lights.
- All functions such as ramp up speed, set point pressure, delay between pump starts, friction loss compensation, corrective action sequences and emergency cut outs are fully programmable and adjustable in the field through the keypad of each Pump controller.
- A lightning/surge arrestor for the entire incoming power & electrical system must be fitted.
- The system shall be furnished with a modem link to the manufacturer to enable remote troubleshooting.

A complete wiring circuit drawing shall be provided to the Contract Superintendent at Practical Completion.

1.19.5 Installation

(a) Irrigation Pump Station Fit Out

(i) Pumps and motors shall be installed so that they are aligned to ensure no vibration with discharge flanges vertical.

(ii) All electrical wiring shall be in accordance with the Australian Standards.

(iii) All manifold pipework is to be suitably supported by pedestals and strapping to ensure no movement or vibration and shall be of suitable material for use with the water condition and rated greater than 1400kPa.

(iv) The structure shall be furnished with ventilation , two(2) No. 240volt GPO, one(1) being 15amp and dual fluorescent lighting with external light sensor controller.

(v) Upon completion of the pumping set, the contractor shall provide qualified personnel to test the plant, ensuring that all components are correctly set and operating in accordance with the testing procedure required by the Specification.

All components to form part of the pump station equipment are to be compatible with the irrigation water to be used and be rated for pressures greater than 1400 kPa.

1.20 A Guide to Thrust Block Sizing

The following table provides a guide to the bearing area of thrust blocks for varying pipe sizes and fitting types:

Pipe Diameter	90^o Bend	45^o Bend	22.5^o Bend	11.25^o Bend	Tee/End/Valve
50	0.06m^2	0.03m^2	0.01m^2	0.01m^2	0.04m^2
65	0.09m^2	0.05m^2	0.03m^2	0.01m^2	0.06m^2
80	0.13m^2	0.07m^2	0.03m^2	0.02m^2	0.09m^2
100	0.20m^2	0.11m^2	0.05m^2	0.03m^2	0.14m^2
125	0.32m^2	0.17m^2	0.09m^2	0.04m^2	0.22m^2
150	0.45m^2	0.24m^2	0.12m^2	0.06m^2	0.32m^2

1.21 Installation Details (Refer Dwg. No. 182-544-3)

Detail E	Swing Joint Riser - O-ring Seal Type
Detail F	Quick Coupler Valve
Detail G	Solenoid Valve Assembly
Detail H	Isolation Valves
Detail I	Typical Trenching
Detail J	Controller
Detail K	Typical Thrust Block
Detail L	Typical Wire Connector
Detail M	Air Valve Assembly
Detail N	Scour Valve Assembly
Detail Q	Control Room Detail
Detail R	Pressure Regulation Valve
Detail T	Decoder with grounding
Detail U	Central Control System Concept
Detail W	Weather Station

1.22 Tender Schedule of Rates

Spread Sheet Attachment

Appendix E

Nutrient balance modelling using MEDLI

Water and nutrient balance modelling using MEDLI

Introduction to MEDLI

The Model for Effluent Disposal using Land Irrigation (MEDLI) was used to assess the water and nutrient balance of irrigation at the Rottnest golf course and sports oval using recycled water. MEDLI was developed by Cooperative Research Centre Program for Waste Management and Pollution Control Ltd, the Queensland Department of Natural Resources and Mines and the Queensland Department of Primary Industries. It was developed to address the need for a scientifically justifiable, site specific, quantitative planning tool to assess land disposal of effluent, but can easily be applied to water recycling projects involving irrigation of recycled effluent.

Irrigation with nutrient rich water has the potential to impact on the environment (through for example contamination of groundwater, surface waters and soil). For this project, the water quality, irrigation area and plant type are fixed, and information on these was combined with site specific (environmental and climatic) data gathered for the MEDLI modelling exercise to assess the likely impact on the local environment. The results of the water and nutrient balance modelling are presented here.

The MEDLI model was used to simulate a water and nutrient balance at the irrigation site based on the following:

- The local climatic conditions;
- The crop type to be irrigated;
- The area available for irrigation; and
- The site-specific soil conditions and properties.

Model inputs

Climate

Climate data was sourced from the Queensland Government Department of Environment and Resource Management (DERM) for Rottnest Island for use in MEDLI (GHD requested the SILO climate dataset for MEDLI). The data is extracted by DERM from grids of data interpolated from point observations by the Bureau of Meteorology, which provides a continuous and complete climate data set for a specific location. Rottnest Island weather station (BoM 9193) is the nearest weather station and opened in 1983. The MEDLI model was run for the 20 year period 1992 – 2011.

Irrigation Water

Treated wastewater from the Rottnest WWTP is to be recycled to irrigate the redeveloped golf course and to irrigate the sports oval. The volume of water available for irrigation is seasonally variable, because as previously discussed visitor numbers (and sewage inflows) fluctuate from high in summer to low in winter. The available volume of recycled water in MEDLI was based on average monthly data from the Annual Environmental Report 2010-2011, submitted to DEC to meet the WWTP licence conditions. The monthly WWTP estimated outflow volumes as input to the MEDLI model are displayed in Table A.1 below.

Table A.1 Monthly estimated WWTP outflow (recycled water volumes)

Month	Estimate based on data from year	Estimated outflow (kL/month)
January	2011	17,987
February	2011	14,087
March	2011	10,028
April	2011	20,279
May	2011	11,361
June	2011	9,051
July	2010	10,482
August	2010	7,524
September	2010	11,797
October	2010	13,831
November	2010	14,456
December	2010	21,866
TOTAL annual		**162,749**

The recycled water quality was estimated from the DEC licence conditions and actual recent monitoring data and input to the MEDLI model as displayed in Table A.2 below.

Table A.2 Estimated treated wastewater quality

Water quality parameter	Adopted value	Information source
Total nitrogen (mg/L)	10	DEC licence condition WWTP
Nitrate (%)	43	Treated wastewater quality data (averaged July 2011 – April 2012)
Ammonium (%)	44	Treated wastewater quality data (averaged July 2011 – April 2012)
Organic (%)	13	Remainder of nitrogen
Total phosphorus (mg/L)	1	DEC licence condition WWTP
Total solids (mg/L)	7.4	Treated wastewater quality data (averaged July 2011 – April 2012)
Volatile solids (mg/L)	5.6	Assumed 75% of TSS
TDS (mg/L)	583	Treated wastewater quality data (averaged July 2011 – April 2012)

Water quality parameter	Adopted value	Information source
EC (dS/m)	0.911	Calculated by MEDLI from TDS

MEDLI has a pond module which can be used to determine a water balance for a system based on irrigation water availability, demand, and evaporation and rainfall on storage ponds. This can be used to assess storage requirements for schemes. For this project, the balancing storage requirements have been determined separately (Kingston Water Engineering, 2011). Adequate balancing storage capacity is not currently available. For the purpose of assessing the nutrient cycling at the irrigation site, it was assumed that the balancing storage requirements will be met with the installation of a basin with capacity 8,112 kL, equal to the current storage available at the WWTP including the evaporation basins currently used for wastewater disposal (Kingston Water Engineering, 2012). This assumption had the effect in the model of irrigation not being limited by balancing storage capacity. Instead, irrigation was controlled by supply (WWTP outflow) and demand (of the turf). The purpose of modelling a larger storage than is currently in place was to assess the potential for nutrient leaching if irrigation was not limited. It is expected that the storage issue will be rectified before the scheme is implemented and so this modelling adequately represents the ultimate (as built) scenario.

Irrigation in the model was triggered when plant available water reached 50%, and water was applied to 90% of the soil's drained upper limit (field capacity). This schedule allows for a 10% soil water deficit (rainfall buffer) and is recommended to reduce the risk of excessive runoff or deep drainage when it rains (Myers, et al., 1999).

Soil

Model inputs for the soil water and soil nutrient modules were taken from laboratory or field results of soil testing at five sites around the golf course and oval as discussed in Section 3. MEDLI default values were used for parameters where data was unavailable. The modelled soil profile was 1400 mm thick. Although MEDLI can model soil profiles up to 2000 mm, a narrower profile was adopted due to the shallow groundwater table encountered at the golf course during the field investigations. It was assumed that water (and associated nutrients) infiltrating through the bottom of the modelled soil profile would enter the groundwater. The modelled soil profile consisted of a topsoil layer (sand with some organic matter) which overlaid a soil layer made up of sand with shells. Model inputs for wilting point, field capacity, saturated water content, initial nitrogen content, initial phosphorous content and phosphorus adsorption and desorption parameters were adopted using laboratory results (Appendix C) of five soil samples collected from different depths in the soil profile at five locations on the golf course fairways and at the oval. Where no site specific data was available, MEDLI defaults for sand were used. Soil amendments were not considered, because for the majority of the irrigated area (fairways and oval), only manure will be applied. This initial fertiliser application was not considered to be significant for the ongoing water and nutrient cycling at the site.

Plant

The fairways are to be planted with wintergreen couch, as discussed in Section 4.1.1. As the fairways account for the majority of the area of the golf course, MEDLI was used to simulate irrigation of the couch turf over the entire irrigated area of the golf course and oval, which equates to 9.6 hectares (Paul F. Jones & Associates Pty Ltd, 2012). Temperature response and harvest trigger parameters were adjusted in MEDLI for this particular couch variety and the golf course application.

Water and nutrient balance model results

Results of the 20 year simulation of irrigation of 9.6 hectares of couch turf on a soil water deficit (demand) basis are presented below. Results from the first year were not analysed as turf establishment was occurring during this time, and MEDLI simulates plant establishment from seed. Annual average irrigation, transpiration, runoff (from the soil surface), and deep drainage (below the modelled profile) volumes are presented in Table A.3. Runoff was not predicted to occur except in the first year of the simulation when the turf was establishing. From the second year of the simulation, the turf had established full cover. The average annual irrigation was predicted to be 79.8 ML, which is almost 20% higher than the 67.1 ML proposed in the 60% scheduling factor (for fairways and oval) water balance by Paul F Jones (irrigation designer). There are a number of differences between the calculation methods of the irrigation design water balance and MEDLI which can account for the difference in volumes. The monthly average irrigation volumes as calculated in MEDLI are compared in Figure A.1 with the monthly irrigation volumes proposed in the irrigation design water balance. The seasonality of irrigation demand is comparable, but MEDLI predicts some irrigation will be required in May, and very little irrigation in June to September. Paul F Jones' water balance predicts no irrigation in May to August. In reality, the application of irrigation will be managed according to turf performance and prevailing climatic conditions; the integration of the site weather station with the irrigation control system is discussed in Section 4.1.2.

Figure A.1 Monthly irrigation volumes predicted by irrigation design and MEDLI modelling

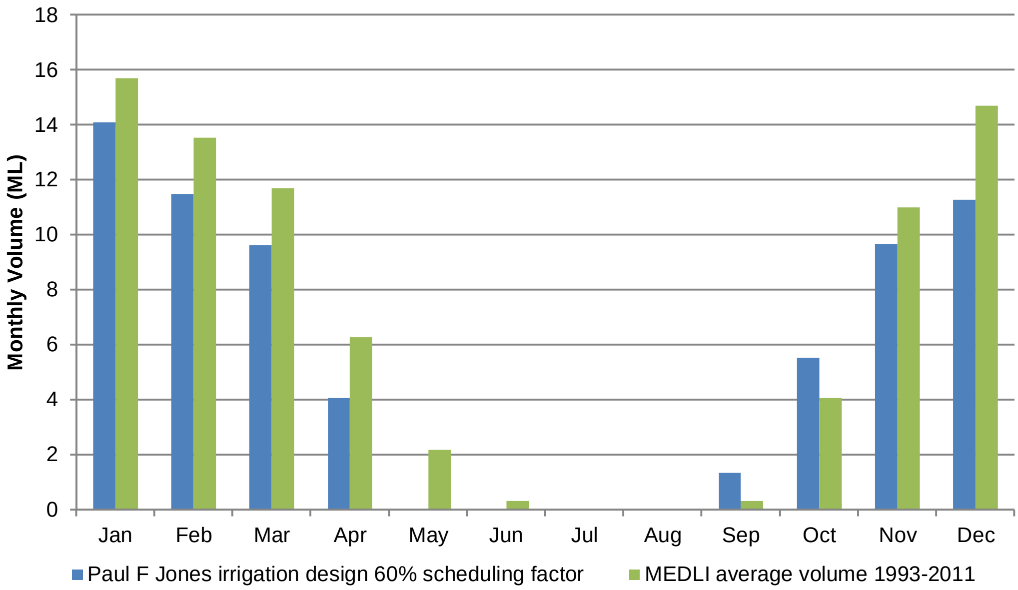


Table A.3 MEDLI water balance results

MEDLI water balance parameter	Average annual depth of water (1993-2011)
Irrigation (mm/y)	827
Rainfall (mm/y)	584
Transpiration (mm/y)	1151
Deep drainage (mm/y)	231

MEDLI water balance parameter	Average annual depth of water (1993-2011)
Runoff (mm/y)	2

The fate of nitrogen and phosphorus applied to the site via irrigation of recycled water is determined by MEDLI. Nutrients are taken up by plants, which can be harvested (i.e. via turf mowing) and the nutrients within can be effectively exported off-site. A portion of the nutrients applied may also enter the local environment by partitioning to the soil, leaching to groundwater or volatilising to the atmosphere. The key nutrient balance results of the modelling are displayed in Table A.4 and show that minimal impact on groundwater is predicted.

Table A.4 MEDLI nutrient balance results – major sources and environmental receptors (average 1993-2011)

MEDLI nutrient balance parameter	Nitrogen	Phosphorus
Applied via irrigation (kg/ha/y)	70	9
Volatilised (to atmosphere, kg/ha/y)	7	n/a
Denitrified (to atmosphere, kg/ha/y)	<1	n/a
Uptake by turf (kg/ha/y)	136	7
Adsorbed to soil (kg/ha/y)	0	2
Leached below profile (to groundwater, kg/ha/y)	<1	0
Concentration of nutrient leached below profile (to groundwater, average mg/L)	$[NO_3^-] < 0.1$	n/a

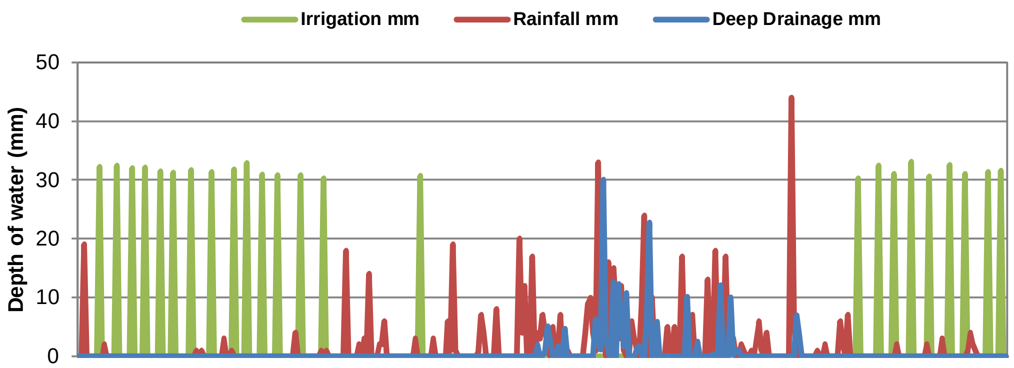
The nutrient balance results indicate that minimal leaching of nutrients to groundwater will occur if irrigation of recycled water occurs to meet demand only, as was simulated in MEDLI. The results of the simulation (averaged over 19 years of data) show the following:

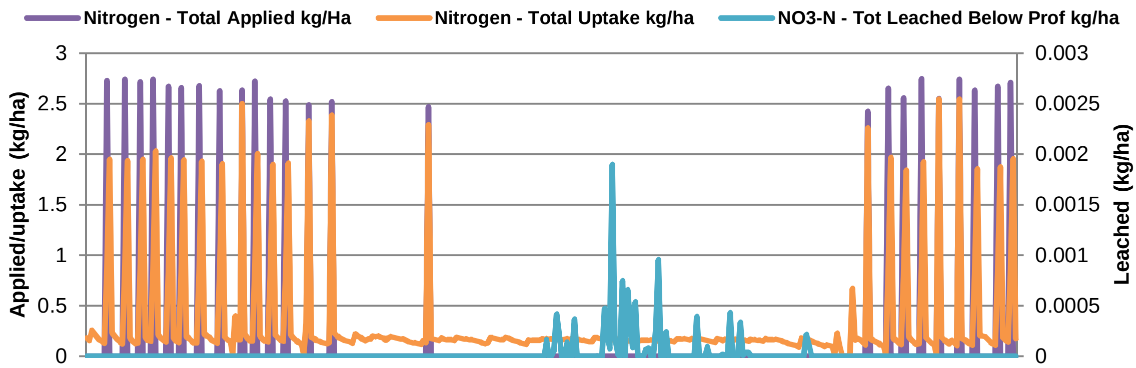
- Nitrogen uptake by turf is significantly higher than that which is applied via irrigation: the remainder of the consumed nitrogen is taken from the soil, causing the organic nitrogen in the soil to be depleted over time. Fertilisation of the irrigation area with nitrogen will be required.
- A very small amount of nitrogen is leached below the modelled soil profile and it can be assumed that this enters the groundwater as nitrate. The amount of nitrogen leached accounts for a very small proportion of the nitrogen applied, and analysis of the temporal data shows that leaching occurs during winter, when typically no irrigation is being applied and is triggered instead by rainfall.
- The majority of phosphorus applied in irrigation water is taken up by the turf and the remainder is adsorbed to the soil. The soils at Rottnest golf course and oval were found to have variable capacity for adsorbing phosphorus (see Section 3.2). The modelling results show that no phosphorus was predicted to be leached below the modelled soil profile in the 19 years of results analysed, with the unused phosphorus adsorbing to the soil.

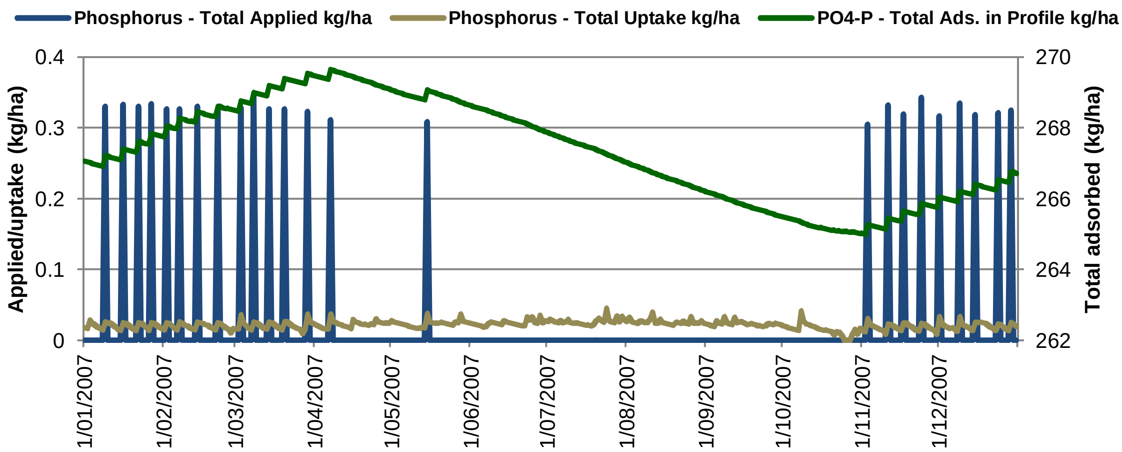
The daily results for key water and nutrient balance parameters are plotted in Figure A.2 for the year 2007, which was selected for display because the annual rainfall total was very close to the average annual rainfall from the modelled 20 year period.

The plots show that irrigation occurs predominantly in the summer months, and that deep drainage (water that infiltrates below the modelled soil profile – presumably reaching groundwater) follows rain events rather than irrigation. The turf can survive on rain water alone for the winter, and this annual break in irrigation will help to prevent salt building up in the soil. The soil is effectively "flushed" of salts in the winter by the rain that infiltrates through the profile.

Figure A.2 Key MEDLI results (water and nutrients) for 2007, an average rainfall year







The nitrogen results indicate that leaching (which accounts for only a small proportion of applied nitrogen, note different axis scales) occurs at the same time as deep drainage following rain events. Leaching of nitrogen is not associated with excess irrigation in this simulation. Nitrogen uptake by turf appears to be responsive to application via irrigation, although a low rate of uptake occurs constantly. The phosphorus uptake is less responsive to application, and the excess is adsorbed to the soil over heavy irrigation periods (summer) and then desorbed over winter when no irrigation is occurring. Analysis of results from the entire 19 year simulation period showed that there was a net increase in the adsorbed phosphorus in the soils below the golf course and oval irrigation sites.

MEDLI also predicts the change in soil solution electrical conductivity (EC), which can be an issue for some effluent irrigation schemes where a build-up of salts causes a decline in plant health. No decrease in yield was predicted although a small increase in salinity was predicted. The EC in the soil profile fluctuates throughout the simulation period due to variations in climate. Over the 20 years simulated, MEDLI predicted an increase in EC at the base of the modelled soil profile to 3.9 dS/m. This salinity is within the range of EC values measured in groundwater in the first rounds of monitoring the golf course and oval bores (see Section 3.3.1).

MEDLI predicted vegetation growth stress, particularly due to insufficient nitrogen application. Fertilisation is recommended and management of nutrient application is discussed further in Section 4.2.3. Temperature stress was recorded over winter, as expected, which causes the turf growth to slow in cooler temperatures. Irrigation demand is significantly decreased and the need for turf mowing over the winter period is minimal. Water stress is predicted only in very dry years in MEDLI, which demonstrates that if the appropriate storage is created, this scheme can be effectively managed.

A number of simulations were run to determine the sensitivity of model results to parameter values. These are described in Table A.5 and increase the confidence with which MEDLI modelling results are converted into nutrient management strategies for this irrigation system. The results showed that the minimal leaching outcome achieved in the design model was robust. The system was not sensitive to increased salt application in irrigation water. As expected, turf growth improved with additional nitrogen application but no significant leaching was predicted as a result.

Table A.5 Sensitivity analyses conducted on MEDLI model

Result of interest	Description of sensitivity analysis conducted	Result of model simulation
Nutrient leaching	To assess the impact of shallow groundwater on nutrient leaching, a model simulation was conducted with a soil profile 600 mm deep (equivalent to the shallowest depth to water measured on site).	Irrigation demand increased with a shallow soil profile, and plant cover and yield increased as a result of increased water and nutrient application. Leaching of nitrogen increased slightly but most of the additional nitrogen applied was taken up by the turf. No phosphorus leaching occurred.
Nutrient leaching and water use	Irrigation trigger parameters were adjusted so that watering occurred more frequently and the soil did not dry out as much between irrigation events.	Irrigation volume increased to 88 ML/year. Plant growth improved slightly, with higher yield and slightly more frequent mowing required. Nitrogen leaching increased slightly. No phosphorus leaching occurred.
Phosphorus leaching	Phosphorus sorption parameters were altered within the modelled soil profile to match the minimum (the lowest) phosphorus sorption capacity of the laboratory analysed samples.	Less phosphorus became adsorbed to the soil, but there was an increase in the amount taken up by the turf. No phosphorus leaching occurred as a result of this change.
Phosphorus leaching	Recycled water phosphorus concentration was doubled.	The phosphorus taken up by the turf also doubled, as did the amount adsorbed to the soil. No phosphorus leaching occurred as a result of this change. No difference noted in turf condition (assessed by turf cover, number of mowing events predicted and yield removed per mow).
Nitrogen leaching and turf growth	Recycled water nitrogen concentration was doubled.	More nitrogen uptake by turf, more denitrification in the soil and slightly more leaching (still very minor proportion of total applied or consumed). Turf yield and number of mowing events increased showing more vigorous plant growth.
Salt build-up in soil	Total dissolved solids concentration of recycled water was increased to 1000 mg/L (the maximum recorded at the WWTP from July 2011 – April 2012).	No decrease in yield was predicted. Over the 20 years simulated, MEDLI predicted an increase in EC at the base of the modelled soil profile to 6.6 dS/m (compared to 3.9 dS/m in the design model).

Appendix F

Environmental incident standard operating procedure (RIA, 2012)

Rottnest Island Authority

Standard Operating Procedure

Environmental Incidents

SOP No: (TRIM number?)

Prepared by:

Helen Shortland-Jones, Conservation Officer, Marine and Terrestrial Reserve

Prepared for:

Rottnest Island Authority, volunteers, external contractors and Facilities Management

Version 2.0 (May 2012)

Revision History Log			
Version #	**Revision Date**	**Author**	**Changes**
1.0	1 May 2012	Helen Shortland-Jones	Comments provided by Shane Kearney. Format of SOP changed.
2.0		Helen Shortland-Jones	

Approvals
Version 2.0

Approved by:____________________________________ Date: ________
{Title and name}
{Position and organisation}

Approved by:____________________________________ Date: ________
{Title and name}
{Position and organisation}

Approved by:____________________________________ Date: ________
{Title and name}
{Position and organisation}

Table of Contents

1 Purpose

This Standard Operating Procedure (SOP) details the recommended procedure to follow when an environmental incident occurs. This SOP is to be provided to all individuals or organisations conducting works on Rottnest, including, but not restricted to RIA business units, contractors (in induction packages), volunteers and Facilities Management.

2 Scope

For the purpose of this SOP, an environmental incident includes administrative breaches and/or an environmental disturbance whereby an event has occurred that has caused, or has the potential to cause adverse environmental impacts. More specific definitions are outlined below.

3 Definitions

Administrative Breach

- Where data is collected according to specific licence conditions and the results are outside acceptable limits;
- if data is not being collected for specific licence conditions;
- if an environmental incident is not reported; AND/OR
- if appropriate approvals aren't applied for prior to works commencing (e.g. ground disturbance, bringing flora/fauna to the Island).

For example:

a) *Waste Water Treatment Plant (WWTP) Licence No. L8189/2007/1*
   - Licence Condition #W4 Operational Performance – where Total Nitrogen (TN) must be less than 10m/L and Total Phosphorus (TP) must be less than 1mg/L for at least 3 out of 4 consecutive samples taken. An administrative breach occurs if samples are not taken or parameters are above acceptable levels.

b) *Landfill Licence No. L6994/1997/9*
   - Licence Condition #W3(c) Groundwater Monitoring – where groundwater samples must be collected at particular frequencies (quarterly/annually) and analysed for specific parameters. Failure to collect samples and conduct analyses according to the licence condition constitutes an administrative breach.

c) *Wadjemup Borefield Licence to Take Water GWL172015(1)*
   - Licence Condition #13 Annual Environmental Report – where an Annual Environmental Report using data collected under the Rottnest Island Groundwater, Lakes and Freshwater Monitoring Program must be submitted to the Department for approval by 30th September. Failure to collect data according to GLFMP requirements constitutes an administrative breach.

d) *Construction works*
   - If construction works involve ground disturbance of any kind or removal/disturbance to flora, failure to submit a ground disturbance form or tree pruning request form constitutes an administrative breach.

Environmental Disturbance
An environmental disturbance is an event that has caused, or has the potential to cause adverse impacts on the quality of groundwater, marine water, soil, wildlife & their habitat and/or air. Examples of environmental disturbances include, but are not restricted to:

- Unauthorised leak, spill or escape of petrochemical, toxic or hazardous substances;
- Sudden and uncontrolled emission or discharge of air pollutants (e.g. NOx – nitrogen oxides), or sudden and uncontrolled gaseous releases (e.g. H_2, propane, compressed CO_2, natural gas);
- Discharge of harmful substances into water;
- Injury, illness or death of wildlife at greater than natural mortality rates; and
- Damage to wildlife habitat.

Incident Coordinator
RIA staff member appointed to manage the incident, including advising on management recommendations, guidance with legislative requirements and liaison with relevant government departments.

4 Procedure Outline

An environmental incident must be reported as soon as it is identified. See Appendix 1 for a flow chart of the procedure to follow in the event of an environmental incident.

4.1 Action 1
Identify environmental incident (administrative or environmental disturbance).

4.2 Action 2
- If immediate response is required (e.g. fuel or chemical spill), take actions to contain the incident according to emergency response plans/SOPs.
- **If any aspect of an environmental incident involves a fire, injury, explosion or may be a health hazard to humans, request assistance from the police, fire department, nursing post and/or Rottnest Rangers as necessary.**
- Notify RIA Environment Coordinator or RIA Environment staff member on XXXX or email.
- Ensure all immediate response actions and reasons for implementing those actions are documented.

4.3 Action 4
Collect evidence (photographs, data, maps).

4.4 Action 5
Complete and submit an environmental incident report form (Appendix 2). The incident report form must be very detailed as information may be submitted to Department of Environment and Conservation, Department of Water and/or Department of Health.

4.5 Action 6
Receive instruction from the RIA Environment team, advising on the following:
- the Incident Coordinator; and
- the incident management process, including the level of involvement of the reporting individual/organisation in managing the incident, whether further investigation is required under legislative/licence requirements (e.g. sampling of

groundwater or soils), whether relevant government departments need to be notified and/or any remedial actions required to address the incident.

4.6 Action 7

If required, undertake any actions to remediate or respond to the incident in accordance with appropriate legislative requirements.

4.7 Action 8

Complete any documentation required to close the incident.

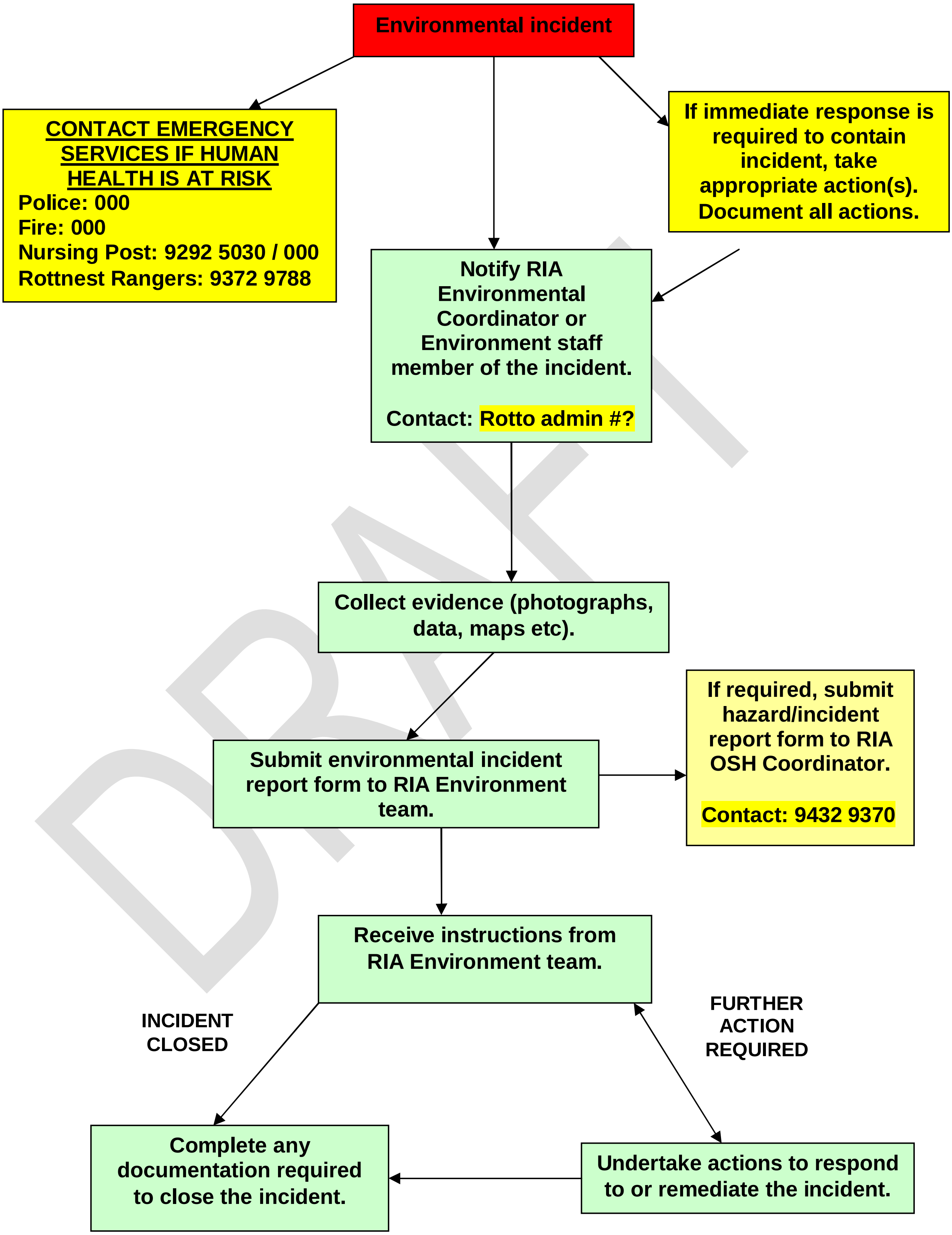
5 Occupational Health and Safety

When an environmental incident occurs, all personnel involved with collecting evidence, response or management of incidents must ensure Rottnest-specific, state and federal OSH legislation, procedures, policies and requirements are complied with.

When an incident occurs that has the potential to harm human health, a Hazard/Incident/Near-Miss report form must also be completed and submitted to the RIA OSH Coordinator (Appendix 3).

6 Appendices

APPENDIX 1 – ENVIRONMENTAL INCIDENT SUMMARY OF RESPONSE



APPENDIX 2 – ENVIRONMENTAL INCIDENT REPORT FORM TEMPLATE

ROTTNEST ISLAND AUTHORITY ENVIRONMENTAL INCIDENT REPORT FORM			
Employee Name & Company (Person Reporting)		Time/Date	
Persons Involved (Contact Details)			

Incident Description

Definition of an environmental incident: *administrative breaches AND/OR an environmental disturbance whereby an event has occurred that has caused, or has the potential to cause adverse environmental impacts.*

Date: **Time:** **Location:**

Licence Number (if applicable):

Licence Condition Breached (if applicable):

Regulator:

Date and Time RIA Notified:

Description:

Details, Actions Taken, Outcomes and Planned Actions

<u>Details:</u>

<u>Immediate Actions Taken (remedial):</u>

<u>Outcomes of Immediate Actions:</u>

Environmental Impact/Potential Regulatory Impact (e.g. non-compliant with licence conditions):

Cause of incident:

Laboratory Results (if applicable):

Planned Actions: (mitigation of adverse environmental effects, action taken to prevent re-occurrence)

	Planned Action	Outcome
1.	.	
2.		
3.		

Related Documents and Files:

HAZARD/INCIDENT/NEAR-MISS (HIN) REPORT FORM

UNDER NO CIRCUMSTANCES DISCUSS RESPONSIBILITY OR LIABILITY WITH A THIRD PARTY OR WITNESS.

Instructions on completing this form.	Ref Number:

This form is to be used to report and track the management of all hazards, incidents or near misses.

- Part A is completed by the worker or contractor reporting the hazard, incident or near miss. The form is then submitted to their Supervisor.
- Part B1 is completed by their Supervisor who then submits the form to the RIA OSH Coordinator for registration and investigation of the causes of the hazards (B2).
- Part C is completed by the OSH Coordinator in consultation with the Delegated Department Manager and the Supervisor in the development of corrective actions.

* The Coordinator, Risk & Emergency Management must be notified of any incidents that have potential for litigation, insurance ramifications or matters of Strategic Organisational Risk.

Part A – Describe the Hazard, Incident or Near Miss.
(To be completed by the hazard, incident or near miss reporter)

Employee/Contractor Name (Person Reporting)		Time/Date	
Persons Involved (Contact Details)			
Witnesses (Contact Details)			

Describe the hazard, incident or near miss.
Detail what the hazard is or what happened – injuries involved, damage or other consequences. Try and include information on the area, persons involved, job tasks, behaviours, equipment used, environmental factors and other contributing conditions.

Date: ___________TIME: ________ Location:

Details:

Remedial Actions Undertaken or Possible Solutions Preventing Recurrence
Have any remedial actions been undertaken? Do you have any suggestions for controlling the hazard and/or preventing a recurrence of the incident/near miss?

Details:

Signature of person completing the Form_______________Print_____________Date______

HAZARD/INCIDENT/NEAR-MISS (HIN) REPORT FORM

UNDER NO CIRCUMSTANCES DISCUSS RESPONSIBILITY OR LIABILITY WITH A THIRD PARTY OR WITNESS.

Part B – Investigation. (To be completed by the Supervisor and RIA OSH Coordinator)

Results of investigation	Investigate what factors contributed to and caused the incident or whether the hazard is likely to cause an injury. (Attach extra documentation where required)

B1) Supervisor:

B2) OSH Coordinator:

Part C – Corrective Actions.

(To be completed by the RIA OSH Coordinator in conjunction with the Department Manager and Supervisor)

The RIA OSH Coordinator in conjunction with the Department Manager and Supervisor develops and agrees on corrective actions to eliminate the hazard and/or prevent recurrence of the incident.

Actions	Responsible Person	Completion Date

OSH Coordinator		DATE	
Supervisor/Manager		DATE	
Delegated Department Manager (Owners of the Corrective Actions)		DATE	

APPENDIX 3 – HAZARD/INCIDENT/NEAR-MISS (HIN) REPORT FORM

HAZARD / INCIDENT / NEAR-MISS (HIN) REPORT FORM

UNDER NO CIRCUMSTANCES DISCUSS RESPONSIBILITY OR LIABILITY WITH A THIRD PARTY OR WITNESS.

Appendix 1: Hazard Sources/Mechanisms of Injury

Gravitational/Pressure	**Mechanical/Machinery**	**Electrical**	**Chemicals & Radiation**	**Microbiological**
☐ Falling ☐ Falling Debris ☐ Slips & Trips ☐ Physical Obstructions - Impacts ☐ Explosive Force	☐ Entanglement ☐ Sharps & Cuts ☐ Pinch & Crush Points ☐ Impact with machinery parts ☐ Pokes, vibrations	☐ Electric Shock ☐ Burns ☐ Heart Attacks	☐ Short-term Exposure ☐ Long Term Exposure ☐ Industrial Diseases ☐ Radiation	☐ Infections ☐ Diseases
Thermal	**Bio-Mechanical**	**Psycho- Social**	**Fatigue**	**Human Behaviours**
☐ Heat – burns ☐ Dehydration ☐ Fires – smoke inhalation	☐ Inadequate Manual Handling Techniques ☐ Static Postures ☐ Excessive vibration ☐ Inadequate Ergonomics ☐ Occupational Overuse Syndrome (OOS)	☐ Stress ☐ Bullying ☐ Harassment ☐ Traumatic Events	☐ Excessive hours worked ☐ Lack of rest	☐ Skylarking & Unsafe Activities ☐ Assault ☐ Abuse ☐ Human Error
Noise & Vibration	**Environmental Conditions**	**Drugs & Alcohol**	**Vehicles/Vessels**	**Confined Spaces**
☐ Excessive Noise Levels & Exposure Durations. ☐ Extended exposure to vibration.	☐ Dust in eyes, Dust inhalation ☐ Wind & Storms ☐ Earthquakes ☐ Dangerous Fauna ☐ Tsunami ☐ Drowning in water	☐ Overdose ☐ Impairment of judgement	☐ Collisions ☐ Drowning in water. ☐ Fires/Thermal Hazards ☐ Electrical Hazards ☐ Mechanical Hazards ☐ Chemical Hazards – CO3	☐ Engulfment ☐ Getting stuck ☐ Suffocation ☐ Microbiological Hazards ☐ Chemical Hazards eg. - CO2, CO3

Appendix 2: Injury Guide

☐ Fractures	☐ Traumatic joint/ligament and muscle/tendon injury.	☐ Drug Overdose	☐ Intracranial injuries	☐ Heat Dehydration & Heat Distress
☐ Wounds – Laceration, amputations, impaling.	☐ Foreign body	☐ Bruising	☐ Injury to nerves and Spinal Cord	☐ Drowning or Suffocation
☐ Chemical exposure & Poisoning	☐ Stress/Anxiety/ Trauma	☐ Diseases	☐ Respiratory	☐ Contusion and Crushing Injuries
☐ Eyesight Damage	☐ Burn/Scald	☐ Puncture	☐ Hearing damage	☐ Other injuries
☐ Bites, Stings and scratches	☐ Electric Shock	☐ Heart Attack	☐ Internal Organ Damage	

Appendix 3: Locations of Injury

☐ Head	☐ Neck	☐ Trunk	☐ Upper limbs	☐ Hands & Fingers
☐ Lower Limbs	☐ Feet & Toes	☐ Internal Organs	☐ Unspecified Locations	☐ Non Physical Location
☐ Eyes	☐ Mouth	☐ Respiratory	☐ Hearing	☐ Bodily Functions

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