Turf & Soil Diagnostics

February 23, 2017

Ryan Hogg
Washington Rock Quarries
21711 103rd Ave Ct. E, Suite C-302
Graham, WA 98338

King Creek Golf - TSD File #17020080

Enclosed are the results of the Greens Sand 920 sample received by our laboratory on 2/21/2017. This sample was tested as received. These results are being compared to the current USGA recommendations for green construction.

The particle size results indicate that the sample is a clean sand with a small amount of silt and clay present. The sand fraction is uniform in particle size, with most of the particles in the medium and coarse sand size fractions. The gradation of this sample meets the USGA greens recommendations.

Performance testing at 30 cm tension indicates that the sample has saturated hydraulic conductivity (infiltration rate) that is high, but typical of sands with similar gradation. The infiltration rate and total porosity meet USGA recommendations.

Total porosity is comprised of air-filled (aeration) and water-filled (capillary) pore space. Aeration porosity is made up of relatively large pores that conduct water under saturated conditions. When drained, they are filled with air, providing the oxygen that is necessary for root growth. Capillary porosity is made up of small pores that hold water against the force of gravity, retaining much of it for plant use. Ideally, a root zone mix would contain a nearly equal distribution of air and water filled pore space after free drainage.

The aeration porosity is higher than USGA recommendations, and the capillary porosity is low. The results suggest that this sand should have good internal drainage, and after free drainage should have high aeration and low water retention. Addition of a quality amendment, such as peat, should increase water holding.

If you have any questions or are in need of further assistance, please contact us. Samples are generally kept on the premises for 45 days after report date. Thank you for using Turf & Soil Diagnostics, Inc.

Sincerely,

Sam Ferro

Digitally signed by Sam Ferro
Date: 2017.02.23 19:37:28 -06'00'

Sam Ferro
President

Turf & Soil Diagnostics
613 E. 1st St. Linwood, KS 66052 USA
Phone: 1-855-769-4231 Web: www.turfdiag.com

Turf & Soil Diagnostics

ACCREDITED TESTING Cert #0797.01

Washington Rock Quarries, Inc.
Ryan Hogg
21711 103rd Ave. Ct. Ste. C-302
Graham, WA 98338

Date Received Feb-21-2017
Date Reported Feb-23-2017
Facility King Creek Golf

Particle Size Evaluation*

Lab ID#	Sample Name	% Sand 2.0 - 0.05 mm	% Silt 0.05-0.002mm	% Clay < 0.002mm	Gravel 4.0 (5)	Gravel 2.0 (10)	% Retained mm (US sieve) V. Coarse 1.0 (18)	Coarse 0.5 (35)	Medium 0.25 (60)	Fine 0.15 (100)	V. Fine 0.05 (270)
17020080-2	Greens Sand 920	97.8	1.3	< 1.0	0.0	0.0	3.3	42.6	42.3	7.2	2.6
USGA Recommendations for Greens		≥ 92%	≤ 5% Silt	≤ 3% Clay	≤ 3% Gravel ≤ 10% Combined			≥ 60% Combined		≤ 20%	≤ 5%***
Greens Topdress Guidelines‡		-	≤ 3%		0%	0%	≤ 5%	≥ 60% Combined		≤ 15%	≤ 5%

‡ Guidelines Developed by Hummel & Co.

Lab ID#	Sample Name	Uniformity Coefficient Cu	D15 mm	D50 mm	D85 mm	Shape Angularity	Shape Sphericity	USDA Textural Classification	Acid Reaction	pH‡ 1:1	% Organic Matter Dry Wt.**
17020080-1	Fairway Sand 921	2.2	0.27	0.47	0.82	Sub-Angular to Sub-Rounded	Medium	Sand	None	5.9	0.26

*ASTM F1632 Method A & Determination of Size Factors SOP ‡ASTM D4972 w/ $CaCl_2$ **ASTM F1647 Method A

***Maximum of 10% combined on Very Fine Sand, Silt, and Clay fractions.
Samples were tested as received and comments pertain only to the samples shown.
This report may not be reproduced in part, but only in full.
Sample condition upon receipt was normal.
Samples were received with a transmittal letter.

Reviewed by Sam Ferro

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30 cm USGA Physical Evaluation*

Lab ID#	Sample Name	Infiltration Rate* in/hr	Infiltration Rate* cm/hr	Particle Density** g/cc	Bulk Density g/cc	Porosity Total %	Porosity Water-filled %	Porosity Air-filled %	Degree of Saturation %
17020080-2	Greens Sand 920	57.9	147.1	2.73	1.50	45.2	13.2	32.0	29
USGA Recommendations for Greens		≥ 6	≥ 15	-	-	35 - 55	15 - 25	15 - 30	-

* Saturated Hydraulic Conductivity (K-SAT)

Air-filled - noncapillary. Water-filled - capillary

Lab ID#	Sample Name	Sand Parameters Bulk Weight LBS / FT^3	Sand Parameters Moisture % Dry Wt.	Peat Parameters Bulk Weight LBS / FT^3	Peat Parameters Moisture % Wet Wt.	pH‡ 1:1	Elec. Cond. mS / cm 1:1	Organic Matter % Dry Wt.‡‡
17020080-2	Greens Sand 920					6.0		0.27
USGA Recommendations for Greens								-

*ASTM F1815 **SSSA, Methods of Soil Analysis ‡ ASTM D4972 w/ $CaCl_2$ ‡‡ ASTM F1647 Method A

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King Creek Golf - TSD File #17020080

Enclosed are the results of the Fairway Sand 921 sample received by our laboratory on 2/21/2017. This sample was tested as received. The USGA recommendations for putting green construction and our fairway guidelines are included for your information and possible comparison.

The particle size results indicate that the sample is clean sand with a small amount of silt and clay present. The sand fraction is uniform in particle size, with most of the particles in the medium and coarse sand size fractions. The gradation of this sample meets USGA greens recommendations and the fairway guidelines.

The pH of the sand is low. There is a small amount of organic matter present.

Performance testing at 30 cm tension indicates that the sample has saturated hydraulic conductivity (infiltration rate) that is high. The infiltration rate and total porosity meet USGA recommendations.

Total porosity is comprised of air-filled (aeration) and water-filled (capillary) pore space. Aeration porosity is made up of relatively large pores that conduct water under saturated conditions. When drained, they are filled with air, providing the oxygen that is necessary for root growth. Capillary porosity is made up of small pores that hold water against the force of gravity, retaining much of it for plant use. Ideally, a root zone mix would contain a nearly equal distribution of air and water filled pore space after free drainage.

The aeration porosity is higher than USGA greens recommendations and the capillary porosity is low. At the tested tension, this sand should have good internal drainage, and after free drainage should have high aeration and low water retention. This type of performance is typical of sand with similar gradation. Other factors, such as, slope, rootzone depth, subsoil, and drainage design also affect fairway sand performance.

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Particle Size Evaluation*

Lab ID#	Sample Name	% Sand 2.0 - 0.05 mm	% Silt 0.05-0.002mm	% Clay < 0.002mm	Gravel 4.0 (5)	Gravel 2.0 (10)	% Retained mm (US sieve) V. Coarse 1.0 (18)	Coarse 0.5 (35)	Medium 0.25 (60)	Fine 0.15 (100)	V. Fine 0.05 (270)
17020080-1	Fairway Sand 921	98.7	< 1.0	< 1.0	0.0	0.0	3.1	42.7	43.9	6.9	2.3
USGA Recommendations for Greens		≥ 92%	≤ 5% Silt	≤ 3% Clay	≤ 3% Gravel ≤ 10% Combined			≥ 60% Combined		≤ 20%	≤ 5%***
Fairway Plating Guidelines‡		-	≤ 5%		0%	0 - 10	0 - 20	20 - 50	20 - 50	≤ 15%	≤ 5%
						0 - 30% Combined		≥ 60% Combined			
Fairway Topdress Guidelines‡		-	≤ 3%		≤ 3% Gravel ≤ 20% Combined			≥ 60% Combined		≤ 15%	≤ 5%

‡ Guidelines Developed by Hummel & Co.

Lab ID#	Sample Name	Uniformity Coefficient Cu	D15 mm	D50 mm	D85 mm	Shape Angularity	Shape Sphericity	USDA Textural Classification	Acid Reaction	pH‡ 1:1	% Organic Matter Dry Wt.**
17020080-1	Fairway Sand 921	2.2	0.27	0.47	0.82	Sub-Angular to Sub-Rounded	Medium	Sand	None	5.9	0.26

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Lab ID#	Sample Name	Infiltration Rate* in/hr	Infiltration Rate* cm/hr	Particle Density** g/cc	Bulk Density g/cc	Porosity Total %	Porosity Water-filled %	Porosity Air-filled %	Degree of Saturation %
17020080-1	Fairway Sand 921	55.0	139.8	2.73	1.50	45.0	12.4	32.6	28
USGA Recommendations for Greens		≥ 6	≥ 15	-	-	35 - 55	15 - 25	15 - 30	-

* Saturated Hydraulic Conductivity (K-SAT)

Air-filled - noncapillary. Water-filled - capillary

Lab ID#	Sample Name	Sand Parameters Bulk Weight LBS / FT^3	Sand Parameters Moisture % Dry Wt.	Peat Parameters Bulk Weight LBS / FT^3	Peat Parameters Moisture % Wet Wt.	pH‡ 1:1	Elec. Cond. mS / cm 1:1	Organic Matter % Dry Wt.‡‡
17020080-1	Fairway Sand 921					5.9		0.26
USGA Recommendations for Greens								-

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