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SD-00349

Sent Via: **HAND DELIVERED**

July 23, 2004

Mr. Hal Hicks
Golf Course Superintendent
Seminole Golf Club, Inc.
901 Seminole Boulevard
Juno Beach, Florida 33408

SGC_RO-F1

RE: SEMINOLE GOLF CLUB, INC.
FLORIDAN AQUIFER WELL
WATER QUALITY ANALYSIS

Dear Mr. Hicks:

The following letter is Gerhardt M. Witt & Associates, Inc.'s ("GMW&A") analysis of selected water quality parameters from the Floridan aquifer well located at the Seminole Golf Club, Inc. ("Seminole") and from the water treated by the reverse osmosis ("RO") water treatment plant. This letter report addresses chemical and physical parameters, as well as Silt Density Index ("SDI") measurements.

INTRODUCTION

GMW&A was contracted by Seminole to provide an evaluation of the water quality obtained from their Floridan aquifer well and RO treated water. Seminole had previously contracted Diversified Drilling Corporation ("Diversified") to drill a 12-inch diameter well into the Floridan aquifer. This well was completed on October 25, 2002. Water quality sampling was performed during the construction/drilling and testing of the well. After the well was completed, Seminole contracted Water Equipment Technologies, Inc. ("WET") to design and build an RO water treatment plant. The Floridan aquifer well and the RO plant are used for obtaining and treating Floridan aquifer water for irrigation purposes at Seminole.

This investigation was conducted to assess the quality of water delivered to the RO plant. Regular monitoring of water quality from the Floridan aquifer allows the timely detection of potential problems related to water quality and water treatment plant operation.

GMW&A collected water samples from the Floridan aquifer irrigation well for physical and chemical analysis by Envirodyne, Inc. ("Envirodyne") and for microbiological analysis by Micrim Labs, Inc. ("Micrim"). Field water quality tests were conducted by GMW&A personnel on the raw well water and the stored RO treated water. GMW&A also performed SDI testing on the Floridan aquifer well.

FIELD WATER QUALITY ANALYSIS

On June 9, 2004, personnel from GMW&A arrived at Seminole to conduct field water quality analyses of raw water from the Floridan aquifer well and the RO treated (finished) water from the 30,000 gallon holding tank beneath the RO plant. For comparison purposes, field water quality data from analyses performed on October 14, 2002, are presented with data from June 9, 2004, in **Table 1: Field Water Quality**. Temperature, salinity, conductivity, and specific conductance were determined using a YSI-30 electronic probe. Total dissolved solids ("TDS") and pH were determined using electronic meters. Chloride, sulfate, hydrogen sulfide, and iron concentrations were determined using Hach kits. Field water quality measurements are intended to provide general results while in the field and are not as precise as laboratory analyses.

Table 1
Field Water Quality

Parameter	Floridan Aquifer Well (10/14/02)	Floridan Aquifer Well (6/9/04)	RO Treated Water (6/9/04)
Temperature (°C)	24.0	23.3	23.7
Conductivity (μS/cm)	5,730	2,931	194.7
Specific Conductance (μS/cm)	5,830	3,016	200.1
Salinity (ppt)	3.2	1.6	0.1
pH (pH units)	TNP	8.1	8.5
Total Dissolved Solids (ppm)	TNP	4,200	103

Parameter	Floridan Aquifer Well (10/14/02)	Floridan Aquifer Well (6/9/04)	RO Treated Water (6/9/04)
Chloride (mg/L)	2,000	1,750	55
Sulfate (mg/L)	>200	>200	0
Hydrogen Sulfide (mg/L)	5.8	6.6	5.3
Iron (mg/L)	0.08	0	0

°C degrees Celsius
µS/cm micro Siemens per centimeter
ppt parts per thousand
TNP Test Not Performed
ppm parts per million
mg/L milligrams per liter

The most significant results from the field water quality testing were the specific conductance, salinity, hydrogen sulfide, pH, and TDS. Floridan aquifer water typically has elevated levels of these parameters, and the RO treatment plant is designed to accommodate this water quality. The specific conductance of a solution is its ability to conduct an electrical current. Current flows in ionized water (water with dissolved solids) because the ions move towards a charge that will neutralize them. In ground waters, the specific conductance varies almost directly with the amount of dissolved minerals present. Therefore, TDS, specific conductance, and salinity (amount of dissolved salts) are inter-related parameters which provide a rough estimate of the raw Floridan aquifer water quality.

Of particular interest is the persistence of hydrogen sulfide between the raw, Floridan aquifer water and the treated water. Hydrogen sulfide produces an offensive odor and may adversely impact plumbing within the water treatment plant. Hydrogen sulfide may also may contribute to RO membrane fouling by the precipitation of sulfur particles. Water from the Floridan aquifer generally contains some amount of hydrogen sulfide, as it is associated with subsurface water supplies that are depleted of oxygen. Aeration and/ or chemical treatment (hydrogen peroxide) of the raw and/or treated water should help mitigate the hydrogen sulfide concerns. The water is currently treated with hydrogen peroxide before it enters the holding tank; however, the level of hydrogen sulfide in the treated water (holding tank) seems the indicate inadequate hydrogen peroxide treatment. Further investigation is required. Additionally, the membrane treatment process involves some hydrogen

Parameter	October 14, 2002 Results	June 9, 2004 Results
Strontium (mg/L)	6.5	6.4
Sulfate (mg/L)	390	200
Total Alkalinity (mg/L)	160	160
Total Dissolved Solids (ppm)	3,500	3,900
Total Organic Carbon (mg/L)	BDL	0.68
Turbidity (ntu)	4.1	0.15

† Telephone conversation with Envirodyne indicated that hydrogen sulfide and sulfide test results were equivalent.
* Test performed in the field by Envirodyne
ntu nephelometric turbidity unit

The most significant results from the Envirodyne water quality testing were barium, calcium, magnesium, strontium, sulfate, sodium, turbidity, and TDS. Sulfate, calcium, barium, and strontium are significant parameters because sulfate forms low solubility compounds with calcium, barium, and strontium and may present RO membrane fouling problems. Calcium may also form insoluble salts with common ions like carbonate.

In the Envirodyne sampling, TDS has increased by 400 milligrams per liter ("mg/L") between the October 14, 2002, sampling and the June 9, 2004, sampling. This approximate 10% increase in TDS concentration does not correlate to a significant increase in "problem" parameters for RO treatment (those listed in this report); however, TDS should be monitored, and if an additional increase is noted, Seminole should contact GMW&A.

The Envirodyne results indicated significant decreases in turbidity, sodium, and sulfate between the October 14, 2002, sampling and the June 9, 2004, sampling. The decrease in turbidity is likely due to continued pumping of the well, which rids the formation of fine material that clouds the water.

Increased magnesium and calcium concentrations indicated in the Envirodyne results are likely caused by the steady dissolution of the limestone rock at the well's open hole (production zone) interval. Limestone in the aquifer typically contains elevated concentrations of these ions. The decrease in sodium and sulfate concentrations may a result of natural variation in the wateer quality of the aquifer and/or inaccurate laboratory measurements.