SCS ENGINEERS

Preliminary Evaluation and Engineering Assessment Renaissance Park Golf Course

Presented to:

Ratcliffe Golf Services, Inc.

800 Radio Road
Charlotte, NC 28216

Presented by:

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August 9, 2017
File No. 02217302.00

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1.0 INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

The Renaissance Park Golf Course is located at 1525 West Tyvola Road in Charlotte North Carolina. The course is owned by the City of Charlotte (City) and managed by the Mecklenburg County Parks and Recreation Department (MCPR). The golf course was designed by golf course architect Mike Hurdzan and built in 1986.

Prior to redevelopment of the property as a golf course, the site was a municipal solid waste disposal facility known as the York Road Landfill. The City operated the landfill from approximately 1968 to 1986. Approximately 6 million tons of waste are reported to have been disposed at the landfill[1]. No waste has been removed from site to our knowledge and it was closed and capped in 1987. The waste disposal operations have been reported by others as occurring in six areas, referred to as Area A to F. Based on the historical disposal limits, approximately 128 acres of the site was used for landfilling activities. According to Ref. #1 cited below, a geomembrane liner was installed below the greens

1.2 PURPOSE

Ratcliffe Golf Services, Inc. retained SCS Engineers to conduct an assessment of the Renaissance Park Golf Course in support of a potential significant course renovation project. The focus of our assessment was the impact that existing landfill disposal areas would have on a renovation project. This report provides a summary of our initial site assessment and discusses recommendations for addressing proposed improvements to golf course.

1 Article titled “Garbage to Golf: Too Much Trash? Too Little Golf”, Schmidt, Edward, Jr. (Golf Journal: Official Publication of the United States Golf Association, pp. 35-38; Jan-1991.

2.0 PHASE 1 ASSESSMENT AND EVALUATION ACTIVITIES

Phase 1 assessment and evaluation activities began with a site reconnaissance of the entire golf course focusing on the holes constructed over solid waste disposal areas (Holes 1 to 10). An initial site visit was conducted by Steve Lamb and Adam Smith in April 2017. A second site reconnaissance was conducted in May 2017 by Steve Lamb, Adam Smith, and Bob Isenberg, who is a senior geotechnical engineer. A third site visit was conducted by Steve Lamb on August 3, 2017.

In preparation for the site visits, we reviewed available existing site plans, drawings, and reports about the golf course/landfill. We also reviewed previous remedial designs that SCS prepared for the City of Charlotte in 2004.

2.1 EXISTING CONDITIONS SITE PLAN

The primary objective during Phase 1 was to develop an overall Existing Conditions Site Plan that depicts current site conditions overlaid on key golf course features and to gather information on the history of landfilling activities.

The following table summarizes the landfill area designations and their years of operations, and assumed waste thickness. This information is useful in that age of waste is an important factor is predicting future settlement.

Table 1
Waste Area Disposal Information

Landfill Area	Years Operated as a Landfill	Area (ac)	Assumed Thickness [1] (feet)
A	1968-1972	23	20-50
B	1974-1980	42	20-50
C	1968-1972	24	20-50
E	1983-1984	25	20-50
F	1984-1985	14.5	20-50
	Total	128.5	

[1] Limited information is readily available on waste thickness and we are currently reviewing historical maps and aerials to estimate waste depths. Although based on the elevation of Sugar Creek and the South Tributary to Sugar Creek, we can estimate the waste depth is likely in the 20 to 50 feet range which equates to 4 to 10 million cubic yards of waste.

The 2015 topographic map with 1-foot contours, provided by the City, serves as our base map. The Existing Conditions Site Plan (Drawing No. 2) is provided in **Attachment A** which shows the following features:

- Approximate limits of waste.
- Limits of tee boxes, greens, sand traps and fairways.
- Cart paths.
- Maintenance building and club house.
- Driving range.
- Soil stockpile.

Using the Existing Conditions Site Plan, the historical waste boundaries, and site aerial photograph (Drawing No. 3, Attachment A), the areas of tee boxes, fairways, bunkers and greens were measured. These are summarized in **Table 2.** Based on this evaluation, about 11 acres of fairway are situated within the historical waste limits and less than one acre of the tee boxes and greens are situated over waste. Areas below in ***bold italics*** (although outside of the historical waste boundaries) are believed to be constructed over waste based on site observations and discussions with MCPR personnel. These areas should be investigated during future assessment activities (See Section 4.0).

It should be noted that rough turf areas over waste were not measured, and likely account for 20+ acres. Holes 1 to 10 include areas within the historic waste footprint; Holes 11 to 18 are not within the historic waste footprint.

As additional information becomes available, the Existing Conditions Site Plan will be updated with the following:

- Confirm and refine the horizontal limits and depths of waste employing borings, test pits, and electrical geophysics methods such as EM or magnetic surveys.

- Perform field survey to add locations of storm water culverts, subsurface drains, and catch basins.

Table 2
Golf Course Areas On and Off Waste Disposal Areas

Area	Tee Boxes Areas (ft^2)		Fairway Areas (ft^2)		Bunker Areas (ft^2)		Green Areas (ft^2)		Total (ft^2)	acres
Hole #	On Waste	Outside Waste	On Waste	Outside Waste	On Waste	Outside Waste	On Waste	Outside Waste		
1		7,921	53,891	44,837	2,585	1,121	5,984		116,339	2.67
2		2,603	72,471		1,747		3,352		80,172	1.84
3	4,099	330				***3,187***		***4,569***	8,087	0.19
4	2,206		81,463		9,669		5,273		96,405	2.21
5	5,625				2,219		5,640		7,859	0.18
6	1,769		76,010		4,984		4,743		85,738	1.97
7	4,586		45,506	22,660	2,039	1,563	3,950		75,718	1.74
8	2,781		65,322		4,628		3,574		73,523	1.69
9	1,723	***1,135***	76,145	***5,364***		***1,765***		***4,758***	89,166	2.05
10	3,292	2,855		***58,557***		1,475		3,082	65,969	1.51
11		6,357		0		2,795		4,408	13,560	0.31
12		2,195		50,952		1,505		3,641	58,292	1.34
13		3,348		6,078		1,131		3,374	13,932	0.32
14		2,124		98,130		3,413		4,173	107,840	2.48
15		3,066		77,491		4,010		2,871	87,438	2.01
16		2,919		70,011		5,350		3,397	81,676	1.88
17		2,915		47,272				***2,857***	53,044	1.22
18		1,352		***53,849***		***1,212***		***5,008***	61,420	1.41
Totals	**26,081**		**470,808**		**27,871**		**32,517**		**531,195**	**12.19**

2.2 PRELIMINARY LANDFILL SETTLEMENT ANALYSIS

One of the most critical aspects of redeveloping sites on old municipal landfills is addressing the long-term settlement that occurs due to decomposition of organic matter that remains in the waste and settlement from additional physical loadings. The decomposition-related settlement occurs over many years or decades, but decreases in rate each succeeding year as the amount of organic matter becomes diminished. The combination of decomposition settlement and load related settlement is usually large enough to alter surface grades and impact structures built over the waste. For this Phase of the work we considered the time-related component of landfill settlement by comparing the 2002 and 2015 topographic surfaces using AutoCAD. From this information, we were able to quantify the magnitude and location of landfill settlement that occurred over a 13-year period. This settlement is graphically illustrated on Drawing No. 4 in **Attachment A.**

Based on this information, we calculate that the landfill/golf course surface settled between about 1 to 5 feet between 2002 and 2015, and was reduced in volume by approximately 240,000 cubic yards. (Note: The relative accuracy of the aerial topographic maps is typically 1 to 2 feet and the actual settlement over the 13-year period may be slightly more or less than indicated.) However, it can be concluded that this amount of landfill settlement, and resulting volume reduction, is due primarily to waste compression resulting from on-going organic decomposition. Based on the rate that organic matter decomposes, the magnitude of future settlement over the next 13 year period will be roughly one-half of the amount previously measured and in the range of 6-inches to 3 feet, more or less. If there are additional physical loadings from new fill, the amount of settlement will be greater.

The analysis also estimated that 1,100,000 cubic yards of fill material was placed from 2002 to 2015. The majority of the fill material is located in the soil stockpile area (420,000 cubic yards) and the driving range area (225,000 cubic yards). Note: Actual records of fill material imported and placed on the driving range greatly exceed what was estimated in our analysis. Since both of these areas are located over waste load related landfill settlement likely has already occurred under these fill materials, therefore, the actual volume of fill materials placed at the soil stockpile area and driving range area is more than indicated above.

The following is a summary of the some of the observed settlement and drainage problems.

Hole No. 1 (Par 5)

Large differential settlements were observed in Hole No. 1 fairway starting about 200 yards from the green which is manifested in significant grade changes over short distances, depressions (some closed and with ponded water), and appeared hummocky in places. The orientation and magnitude of the settlements suggest “trench-style” landfilling occurred in this location in which case waste depths may vary significantly in short distances.

As shown in the photo to the right, the grade of the cart path is abruptly steep and undulating, which can pose a safety hazard for golf carts rolling over.

Hole No. 1 green slopes significantly from front to back, which is different from the original design, and confirms that significant landfill settlement has occurred at the back of the green. Based on our settlement analysis, the front of the green settled about 1 foot between 2002 and 2015 while back of the green settled over 4 feet during this same time period. MCPR personnel suggest that the actual settlement at the back of Hole No. 1 green may be even greater than we measured and approaching 6 feet.

The significant amount of settlement on Hole No. 1 green negatively impacts the playability of this hole as the approach shot into the green is considered a “blind shot” since the golfer cannot see the green surface from the fairway.

Hole No. 2 (Par 4)

Irregular surface conditions, manifested as including random undulations and abrupt depressions, were observed in the fairway and along the entire cart path on Hole No. 2. The irregular cart path and turf areas make for a very unpleasant and “bumpy” drive in a golf cart, contributes to poor drainage and localized ponding. The resulting sloping lies, localized depressions and ponding negatively impact the playability of this hole, which is regarded as poor.

The settlement pattern suggests the waste was disposed as an “area fill” as opposed to trench fill like Hole No. 1.

Hole No. 4 (Par 5)

Differential landfill settlement and poor drainage has caused obvious damage to the cart path near the tee box at Hole No. 4. The turf areas in this area also has signs of excess landfill settlement and poor drainage, while the paved cart paths show distress from settlement in the form of open cracks, loose pieces of pavement, small dips and undulations. In addition, the landfill settlement in Hole No. 4 fairway negatively impacts drainage and playability.

The playability of the green at Hole No. 4 has been negatively impacted by landfill settlement over the years. Similar the change in grade at the green on Hole No. 1, MCRP personnel report the No. 4 green now slopes from left to right, but used to slope right to left.

Hole No. 5 (Par 3)

Numerous circular-shaped closed depressions, some including ponded water, were observed at Hole No. 5's tees and fairway on this par 3. The ponded water is unsightly (murky and silty), results in soft ground conditions, poor vegetative growth and are breeding areas of insects and thus not desirable for many reasons. Ponded water on a landfill is not good.

The photos below were taken on the tee box looking towards the green. While such depressions occur in most landfills, regardless of waste depth variations, and usually results from localized and variable compression properties or types of waste disposed, the resulting depressions are not conducive to a golf course.

Due to localized variations in waste composition, properties and depths, localized settlement is common and results in depressions and can collect surface drainage water. This subsequently leads to infiltration of water through the soil cover and ultimately into the underlying waste, which increases the moisture content of the waste and increases the rate of organic decomposition. This "cycle" will continue until ponding of liquid is eliminated.

Although not calculated by the comparison of the 2002 and 2015 topographic maps, MCRP report the green at Hole No. 5 has experienced settlement is some areas. Further, the cart path on this hole is severely distressed from landfill settlement and exhibits cracking and loose material at the surface.

Hole Nos. 6 and 7

Stressed vegetation is present in Hole No. 6 fairway and which is likely caused by landfill gas intrusion into the root zone. Mild odors from landfill gas were observed in front of Hole No. 6 green. The tee box at Hole 6 is uneven and not level. The fairway also has some localized circular settling which results in ponded water.

Poor drainage in front the Holes 6 and 7 greens has contributed to very saturated turf and unplayable conditions. The poor drainage and saturated conditions are likely a result of landfill settlement, or potentially leaky irrigation pipes. Landfill settlement would likely contribute to leaky irrigation pipes. The cart path at Hole No. 7 when leaving the tee box is significantly slanted to the right.

Hole No. 8 (Par 4)

At Hole No. 8, the cart path has cracked pavement, settlement and poor drainage which impacts the playability of this hole.

Similar to the fairway on Hole No. 2, the turf areas on Hole No. 8 are irregular, poorly shaped with abrupt depressions. Drainage on this hole is poor due to settlement and the turf in the fairway is saturated. Stressed vegetation was also observed on this hole which may be caused by landfill gas intrusion into the root zone.

Hole No. 18 (Par 4)

Based on the historical waste limits, Hole No. 18 fairway is not located on waste. However, landfill related settlement appears at this hole. Portions of the cart path exhibit signs of distress similar to paths on the front nine. Further assessment to determine if this hole is situated over waste is recommended during Phase 2 assessment activities.

Soil Stockpile

The soil stockpile, which was placed between 2013 and 2014, is located west of Hole No. 5 alongside Sugar Creek. As stated above, the stock pile contains approximately 240,000 cubic yards of soil. The footprint of the stockpile is about 15 acres and is situated over landfilled areas.

During our site reconnaissance, SCS personnel examined portions of the stockpile. The top area and western slopes were viewed and overall the condition of the vegetative cover was suitable and surface erosion was minimal. The terraces on the northwest side of the stockpile appear intact, did not exhibit obvious signs of instability, and storm water pipes were in-place. The southern toe of slope, which is heavily vegetated, was also examined. There were no obvious signs of slope instability, sloughing, excess erosion, exposed waste, or landfill leachate seepage.

The material in the stockpile is an asset and should be used for filling and grading when mitigating the landfill settlement issues (Discussed in Section 3.0). Furthermore, the stockpile could be partially excavated and regraded and used for future golf holes.

2.3 PERMITTING

The York Road Landfill was closed in 1987 according to available records. Based on the landfill regulations, the regulatory requirements included landfill gas control, water quality management, and cover maintenance. Since exploration of the site using borings or tests pits may cause distress to the surface or penetrate the existing cover, we recommend contacting personnel from North Carolina Department of Environmental Quality (NCDEQ). Locations of borings or test pits, areas where heavy equipment may cause damage to the surface vegetation, should be identified.

In addition to NCDEQ, erosion and sediment (E&S) control permitting will be needed before any large earthwork type construction project like renovating the golf course.

3.0 POTENTIAL SETTLEMENT MITIGATION MEASURES

Although waste depths are known only approximately, the settlement history between 2002 and 2015 as measured from old topographic maps and observations of site personnel, along with our first-hand site observations and understanding of waste settlement mechanics, the following mitigation alternatives are worth consideration to achieve the project goals:

- Routine grading and maintenance in areas exhibiting limited settlement (basically, similar to current approach) but enhanced with geogrids, light weight aggregate, etc. to reduce the impact of future settlement.
- In-place compaction using Deep Dynamic Compaction (DDC) or similar methods such as geopiers.
- Surcharging (pre-loading).
- Waste removal and replacement with clean fill.

The following sections discuss these potential mitigation strategies that could be incorporated into the renovation design.

3.1 BACKFILLING AND GRADING

This option involves re-grading to maintain positive drainage, filling in low or depressed areas prone to ponding. This could involve one or more of the following actions:

- Refilling to original grades could utilize lightweight aggregate material such as foam, ash, or similar products
- Refilling could be reinforced with geogrids to minimize local, differential settlement in the future.

- For fills more than a few feet thick, filling will induce additional settlement in the waste, but this load-related component of settlement will be diminished in a few months.

This option could be used to repair depressed areas with ponding (such as Hole No. 5). This option could also be used to re-construct tee boxes. The costs for the routine grading and maintenance option will be a function of the future settlement rates and the volume of material required to re-grade areas.

3.2 IN PLACE DENSIFICATION USING DEEP DYNAMIC COMPACTION

Deep Dynamic Compaction (DDC) is a proven method to stabilize soft or weak soil materials and has been used for several decades in the US and internationally. The method is simple and involves repeatedly raising and dropping a large heavy (concrete) mass on top of compressible or weak soils a sufficient number of times to compact and strengthen the material. The number of drops, height of each drop, and weight of the hammer is a function of the depth and type of material to be impacted. For pure refuse materials, containing mostly organic matter, the maximum depth of influence only approaches 25 to 30 feet. Therefore, for areas where waste is deeper than about 25 feet, the lower portion of the waste will not be improved by DDC.

After the DDC process is completed, depressions (craters from the concrete weight drops) will remain in the uppermost portion of the material that may be several feet deep. These depressions would need to be backfilled with compacted soil to re-level the surface. Geogrids may be included in the compacted fill to provide further resistance to local, differential settlement.

As this method will disturb (compress) material below and to the sides of the heavy concrete mass, it should not be performed where sensitive underground structures or utilities are present. The allowable safe distance between the DDC impact areas and underground structures will vary from site to site, depending on the material encountered and utility design, and should be discussed with the contractor.

DDC does not eliminate settlement since the waste remains in place, but it will significantly limit future settlement to relatively low and more tolerable levels. DDC could be used to stabilize tee boxes, greens and cart paths.

An option to DDC is geopiers, which is a method that reinforces soft materials through installation of a grid of closely spaced, gravel piers that displace and compress soft materials. Geopiers may be suitable in areas where highly localized ground improvement is needed and where drainage is significant.

3.3 SOIL SURCHARGING (PRELOADING)

Surcharging is another widely used and reliable method of improving soft ground conditions, including landfilled waste. The surcharge process involves placing several feet of soil across a surface or area to surcharge (or pre-load) the waste. The surcharge remains in place for a period of time (6 to 12 months, more or less) depending on the compressibility properties of the waste and the depth. The weight of the soil surcharge is selected to be high enough to compresses the underlying soft soil or waste such that when the surcharge is removed, the potential for future settlement is within tolerable limits.

The height of the surcharge, and lateral extent, are functions of the proposed loads and tolerable rate and magnitude of future settlement. Typical guidance is for a surcharge loading (pressure) to be equal to 1.5 to 2 times the planned pressure of the new structure (load) and that the surcharge remains in place until the rate of settlement is reduced to an acceptable level.

An important advantage of surcharging over the other methods is that monitoring of settlement rates is performed as part of the method. This allows the engineer to track the progress of settlement and make quantitatively based predictions as to when the surcharge may be removed and how much settlement remains. Typically, the initial rate and magnitude of surcharge-induced settlement will be relatively large; however, as time passes, the rate and magnitude will be reduced and eventually begin to level off. The disadvantage of surcharging is the time to complete the surcharge is not known until several sets of readings are available, and cost of bringing in and removing fill may be high in areas where fill is costly, or not readily available near the site.

Soil surcharging could be used to stabilize fairways, tees and greens.

3.4 WASTE REMOVAL AND CLEAN FILL

This is generally assumed to be a relatively expensive option that involves the complete (or partial) removal of waste materials from the area and extending down to stable, native soil. The excavated waste would be replaced with compacted engineered fill (soil, not waste). This option may be cost effective at waste depths less than 15 feet. Side slopes for such excavations must be laid back for safety and stability, or supported with bracing or trench boxes.

Note also that a major excavation into the landfill would also require a significant environmental evaluation, due to the potential of odor and other air quality impacts associated with large surfaces of partially decomposed, exposed waste.

Removal of the upper portion of the waste, say the uppermost 10 feet of a 20 foot waste column, does not resolve the problem as material used to replace the excavated waste is typically twice as heavy as waste, which will trigger more settlement

3.5 MITIGATION SELECTION PROCESS

Factors to consider when deciding which improvement methods would be best include the following:

- Type and extent of improvement needed (localized vs. general, deep vs. shallow)
- Thickness and depth of waste.
- Type/character of waste (age, organic content, moisture content).
- Proposed new loadings from fill and allowable design settlement (from the architect).
- Cost (construction, maintenance and monitoring).

For purposes of discussion, below is a preliminary selection process based on waste thicknesses:

- Waste thicknesses greater than ~25 feet: Surcharging would be generally more effective than DDC since surcharging will impact waste at greater depth. DDC has a limit of 25 feet, more or less, depending on weight and weight drop height. Geopiers would also be an option to surcharging a large area (say, anything more than 50 feet by 50 feet). It is anticipated that between 6 and 12 months are needed with surcharges, but there is no minimum timeframe for geopiers to be effective.

- Wastes ~15 to ~25 feet: DDC, geopiers and surcharging are comparable options, but if time is crucial DDC and geopiers have the advantage. DDC would be good for use on cart paths (which are narrow), but surcharging would have a slight edge for a large green or tee box.

- Wastes ~5 to ~15 feet: In this range, before deciding on a method, the amount of remaining settlement should be estimated and may turn out to be tolerable, depending on the structure. To this end, the architect should provide some guidelines on how much settlement is tolerable over time.

- Waste ~5 feet or less: plenty of options available, ranging from excavation/replacement to geogrids to heavy surface compaction to do-nothing.

The aerial extent of the proposed repairs, and anticipated differential waste thicknesses are also crucial factors in selection of an improvement methodology. Large areas, such as entire fairways or greens, may be more cost effectively improved by surcharges, whereas smaller, localized problem areas may be treated with geopiers, geogrids, or waste removal. In areas where the waste thickness varies significantly from one-side to the other, differential settlement will be a key factor in selecting a method that reduces the potential for future differential settlement as long as the waste remains in place. Geogrids, for example, can be helpful in spanning across areas of differential movement, but they are limited in that ability. Geopiers that can be installed at variable depths, may be more suitable.

Overall, the selection of ground improvement methods should be based on a combination of factors including settlement history, waste depth, waste type, area of improvement and type of improvement necessary, initial construction and long-term maintenance costs.

4.0 FUTURE ASSIGNMENTS

This report concludes our Phase 1 scope of work. Phase 2 assignments will cover geotechnical and civil engineering assignments to develop conceptual remedial designs that address landfill-related problems, such as waste settlement, storm water management, and landfill gas at the golf course. SCS will also address cart paths designs and materials, and provide an evaluation of the large soil stockpile currently on site.

Phase 2 will also include getting a better understanding of the materials in the stockpile, waste depths and waste location. To accomplish this borings and/or test pits are recommended. As stated above it is important to establish the waste disposal areas and depths of waste. Geophysics can also work, but only if we have some ground-truthing.

During Phase 2, our engineering assumptions, analysis, and recommendations will be shared with Ron Garl Golf Designs as they prepare preliminary grading/filling plans and conceptual renovation plans. A construction cost estimate will be prepared by SCS and Ron Garl Golf Designs at the conclusion of this phase. We anticipate several meetings during this phase to aid in our design and to keep all interested parties up to date.

Future phases may include the following:

- Phase 3 - Final Construction Drawings, Specifications, and Permits
- Phase 4 - Field Engineering, Construction Administration
- Phase 5 - Post Construction Monitoring & Maintenance Plan

ATTACHMENT A