GC2030

## Golf Course 2030

# The Climate Impact of Golf Courses

### A Case Study from Minchinhampton Golf Club, England, UK (Version 2, 2025)

# Contents.



This report is part of the series of Golf Course 2030 publications on the Climate Impact of Golf Courses. The other reports in this series are:

- The Climate Impact of Golf Courses: Carbon Balances in Golf Course Landscapes
- The Climate Impact of Golf Courses: A Sampling Protocol to Determine Golf Course Soil Carbon Fluxes

**Case Study venue:**

Minchinhampton Golf Club, England, UK

www.minchinhamptongolfclub.co.uk

When estimating carbon sequestration, carbon emissions and the resulting carbon balance of golf courses, it is critical to clearly define which parts of the golf facility are included in these calculations. Carbon emission estimates from golf courses could include emissions from the clubhouse, event buildings and even from the transport of golfers and employees to the facility. Conversely, carbon sequestration estimates could include sequestration from non-turf areas of the golf course. In this series of reports, we focus solely on carbon emissions from golf course maintenance activities and carbon sequestration from golf course turfgrass surfaces.


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# Introduction.

This is the first time that golf courses in the UK have been tested to determine their soil carbon stocks.

## Determining the soil carbon stock of two UK golf courses

The potential for golf courses to sequester atmospheric carbon has excited many in the industry. However, studies on the carbon sequestration potential of golf courses are severely limited. As such, further research is required to better resolve the sequestration potential that golf courses provide. Golf Course 2030 aims to help fill this research gap through supporting more studies of golf course soil carbon cycling, such as this case study of two golf courses in the UK.

This case study also quantifies carbon emissions of the two golf courses which participated in the study. Through quantification of both carbon stocks and emissions, this study estimates the carbon balance of both golf courses from the time they were constructed to today.

The results of this study can help in guiding future management of golf courses, especially by providing insight of how they can be operated in a carbon neutral or carbon negative manner. In addition, case studies such as these help the golf industry set realistic targets for climate action, mitigation and offsetting.

This case study tested an early draft of what is now the ***Golf Course 2030 Soil Carbon Sampling Protocol*** (henceforth referred to as the GC2030 Protocol). Results and learning from this case study helped inform the development of the GC2030 Protocol, which is now published alongside this case study.

# Methods.

## Methods

The Tier 1 methodology of the GC2030 Protocol was used in this study. However, the methods employed in this case study differ slightly from the published GC2030 Protocol because an earlier draft of the protocol was used to guide this study. Please refer to the GC2030 Protocol for a full description of the Tier 1 methodology.

## Site selection

Minchinhampton Golf Club (MGC) was selected as the site for this case study because the historical land use of the golf course was well known (ie agricultural crop production) and the surrounding landscape is still used for agricultural production. These traits of a known historical land use and a surrounding landscape that is still under the historical land use are important when applying the Tier 1 methodology of the GC2030 Protocol.

In addition, Minchinhampton was chosen because the facility had golf courses of three different ages, which provided us the opportunity to study the effect of time since construction on the golf courses' carbon stocks.

## Site description

MGC is located in southwest England near the village of Stroud (Figure 1). The club has three courses - the Old Course built in 1889, the Avening course built in 1975, and the Cherington course built in 1993. The Avening and Cherington courses are the focus of this study. Because of limited time during the sampling campaign, the Old Course was not sampled, but this may yet occur.

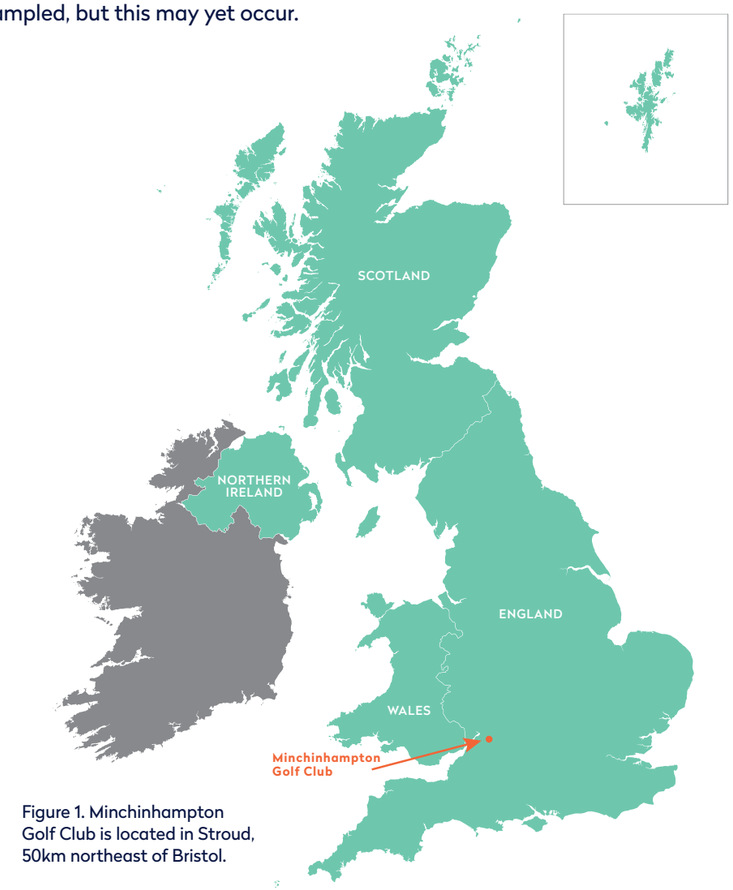


Figure 1. Minchinhampton Golf Club is located in Stroud, 50km northeast of Bristol.


Figure 2. The site of the Avening and Cherington courses in December 1945 (left) and July 2021 (right). Imagery from Google Earth Pro (2022).

## Land use history

Prior to the construction of the Avening course in 1975 and the Cherington course in 1993 both sites were used for agriculture (Figure 2). The area surrounding the golf courses is still used for agriculture. Today these fields are cropped with a rotation of rapeseed, oats, spring and winter barley, linseed, and wheat. The farm uses "minimal tillage".

## Soils & construction

The native soil at Minchinhampton Golf Club contains course fragments of rock. Coarse fragments in soil include particles larger than 2mm and smaller than 25cm. The original plan was to sample to a 30cm depth, however the course fragments in the soil made pounding the soil sampling probes to this depth impossible. Thus, soil samples were taken to a 10cm depth. For the carbon stock estimates in this study we assume a course fragment fraction of 10% on the golf course and the agricultural fields.

The coarse fragment content at the soil surface on the Avening course was originally a problem for both turfgrass establishment and for golfers playing the course. As such, the fairways were heavily topdressed with both sand and organic material to bury the native soil profile. In addition, crates were placed in the fairways where golfers playing the course could place loose rocks.

During the construction of the Cherington course, the topsoil was ploughed, and a potato picker was used to separate out the largest coarse fragments. A stone burying machine was also used to push coarse fragments deeper into the soil profile. At the end of this process there were no coarse fragments on the soil surface that were more than 7.5cm.

## Soil sampling

The soil corer used in this study was 5cm in diameter. Three soil samples were taken from the fairways and roughs on five holes of each golf course. Three subsamples were collected for each sample. Above ground biomass was removed, and all three soil core subsamples were placed in a bucket, well mixed and 500g of soil was placed in a sample bag for analysis (Note: the laboratory that did the analyses for this study required 500g of soil for each sample, however make sure to check with your soil testing laboratory before sampling to determine the weight of soil needed for each sample). Organic matter and soil organic carbon (SOC) content were determined using a C:N analyser at European Turfgrass Laboratories. Carbon stocks were calculated as is specified in the GC2030 Protocol.

## Soil carbon fluxes

**The difference between counterfactual carbon storage (CFCS) and carbon sequestration**

The counterfactual carbon storage (CFCS), as quantified by the Tier 1 method of the GC2030 Protocol, is the difference between the carbon stock of the golf course and the carbon stock of the historical land use of the golf course. Conversely, carbon sequestration as quantified by the Tier 2 method of the GC2030 Protocol, is the transfer of carbon from the atmosphere to soil organic carbon (SOC). When the Tier 1 method is used, and the off-site sampling location and golf course are sampled, the difference in the resulting carbon stocks are representative of the carbon stock trajectories that each land use has taken, however the difference in these two carbon stocks is not necessarily representative of carbon sequestration. The reasons for this are explained in detail in the GC2030 Protocol. In short, it is possible that the carbon stock of the golf course remains unchanged, but that the carbon stock of the off-site sampling location has decreased. In this situation, the golf course would have a positive CFCS but would not have sequestered carbon, which is why CFCS and carbon sequestration are not synonymous. In general, we expect the CFCS and carbon sequestration to be similar, but this may not always be the case, which is why we draw the distinction.

## A map of soil carbon and bulk density sampling locations at the Avening and Cherington courses

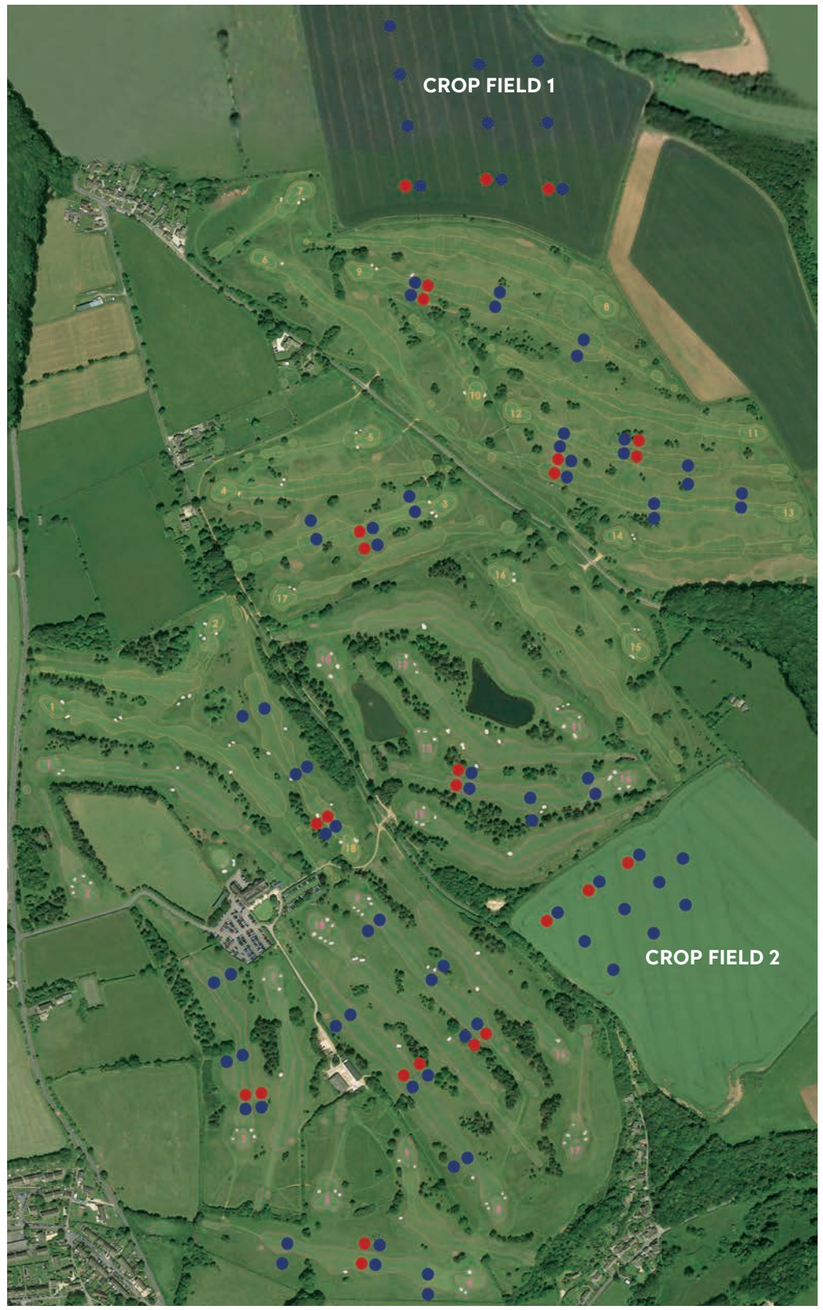


Figure 3. Blue dots indicate where soil organic carbon (SOC) samples were taken and red dots indicate where bulk density samples were taken.

# Results.

## Soil texture

The soil texture of the golf course and the crop fields (the off-site sampling location) was similar. However, the golf courses had higher sand content and a lower silt and clay content. This is very likely due to the golf course receiving sand topdressing applications.

| Site | Sand (%) | Silt (%) | Clay (%) | Textural classification |
|---|---|---|---|---|
| Crop fields (n=4) | 11.7 | 63.8 | 24.5 | Silty clay loam |
| Avening (n=4) | 21.7 | 57.1 | 21.3 | Clay loam |
| Cherington (n=4) | 21.1 | 56.8 | 22.1 | Clay loam |

**List of unit abbreviations**

| | |
|---|---|
| **Mg** | Megagram (1Mg = 1000000g or 1000kg) |
| **ha** | Hectare (1ha = 10000$m^2$) |
| **$m^3$** | Cubic meter |
| **m** | Meter |
| **yr** | Year |
| **n** | Sample number |

The term ‘carbon sequestration’ refers to a carbon flux that transfers carbon from the atmosphere to the soil.

The term ‘carbon emission’ refers to a carbon flux that transfers carbon from the soil or from a fossil fuel back into the atmosphere.

## Soil carbon stock calculations

Below are the soil carbon flux calculations to determine the soil carbon fluxes at the Avening and Cherington courses.

**Determining the areas of the Avening and Cherington courses.**

| Area | Avening | Cherington |
|---|---|---|
| $A_F$ (ha) | 13.0 | 15.3 |
| $A_R$ (ha) | 11.1 | 16.5 |
| $A_T$ (ha) | 24.1 | 31.6 |
| $P_F$ (%) | 54% | 48% |
| $P_R$ (%) | 46% | 52% |

**$A_F$** area of fairway
**$A_R$** area of rough
**$A_T$** total area (sum of fairway and rough)
**$P_F$** percentage of fairway
**$P_R$** percentage of rough

**Calculating the soil organic carbon content and bulk density of the Avening and Cherington fairways and roughs.**

| | Avening | Cherington |
|---|---|---|
| $SOC_{GCF}$ (%) | 6.13 | 6.77 |
| $SOC_{GCR}$ (%) | 6.81 | 6.55 |
| $BD_{GCF}$ (Mg $m^{-3}$) | 0.91 | 0.94 |
| $BD_{GCR}$ (Mg $m^{-3}$) | 0.85 | 0.88 |

**$SOC_{GCF}$** average soil organic carbon content of golf course fairways
**$SOC_{GCR}$** average soil organic carbon content of golf course roughs
**$BD_{GCF}$** average bulk density of golf course fairways
**$BD_{GCR}$** average bulk density of golf course roughs

**Calculating the golf course wide soil organic carbon content and bulk densities of the Avening and Cherington courses.**

| | Avening | Cherington |
|---|---|---|
| $SOC_{GC}$ (%) | 6.44 | 6.66 |
| $BD_{GC}$ (Mg $ha^{-1}$) | 0.88 | 0.91 |

**$SOC_{GC}$** average golf course wide soil organic carbon content
**$BD_{GC}$** average golf course wide bulk density

**Calculating the average soil organic carbon content and bulk density of the off-site sampling location.**

| | Crop field 1 | Crop field 2 |
|---|---|---|
| $SOC_{OS}$ (%) | 4.44 | 3.24 |
| $BD_{OS}$ (Mg $m^{-3}$) | 0.93 | 1.00 |

**$SOC_{OS}$** average off-site sampling location soil organic carbon
**$BD_{OS}$** average off-site sampling location bulk density

**Calculating the carbon stock of the Avening and Cherington courses and the off-site sampling location.**

| | Avening | Cherington |
|---|---|---|
| $CS_{GC}$ (Mg C $ha^{-1}$) | 56.8 | 60.5 |
| $CS_{OS}$ (Mg C $ha^{-1}$) | 37 | |

**$CS_{GC}$** average golf course carbon stock
**$CS_{OS}$** average off-site sampling location carbon stock

Carbon sequestration on golf courses primarily occurs via the turfgrass-soil system, while carbon emissions primarily occur through the combustion of fossil fuels on golf courses.

## Counterfactual Carbon Storage (CFCS) at the Avening course

The estimated carbon stock of the Avening course was 56.8 Mg C $ha^{-1}$ and the estimated carbon stock of the crop fields was 37.0 Mg C $ha^{-1}$. Therefore, we estimate that the CFCS of the Avening course was 19.8 Mg C $ha^{-1}$ from the time the course was constructed to when the soil sampling for this project occurred in the summer of 2023.

$$CFCS = 56.8\ Mg\ C\ ha^{-1} - 37.0\ Mg\ C\ ha^{-1}$$

$$CFCS = 19.8\ Mg\ C\ ha^{-1}$$

The total CFCS is equal to the area of the golf course (24.1 ha) multiplied by the total change in carbon stock. The total CFCS of the Avening course was 477 Mg C.

$$CFCS_{total} = 19.8\ Mg\ C\ ha^{-1} * 24.1\ ha$$

$$CFCS_{total} = 477\ Mg\ C$$

If we divide the CFCS by the age of the golf course (GCA), we can derive the average yearly CFCS ($CFCS_{yearly}$) for the Avening course from 1974 (the year the golf course opened) to 2023 (the year the soil sampling occurred).

$$GCA = 48\ yr$$

$$CFCS_{yearly} = 0.41\ Mg\ C\ ha^{-1}\ yr^{-1}$$

## Counterfactual Carbon Storage (CFCS) at the Cherington course

The average carbon stock of the Cherington course was 60.5 Mg C $ha^{-1}$ and the average carbon stock of the crop fields was 37.0 Mg C $ha^{-1}$. Therefore, we estimate that the CFCS of the Cherington course was 23.5 Mg C $ha^{-1}$ from the time the course was constructed to when the soil sampling for this project occurred in the summer of 2023.

$$CFCS = 60.5\ Mg\ C\ ha^{-1} - 37.0\ Mg\ C\ ha^{-1}$$

$$CFCS = 23.5\ Mg\ C\ ha^{-1}$$

The total CFCS is equal to the area of the golf course (31.8 ha) multiplied by the total change in carbon stock. The total CFCS of the Cherington course was 734 Mg C.

$$CFCS_{total} = 23.1\ Mg\ C\ ha^{-1} * 31.6\ ha$$

$$CFCS_{total} = 743\ Mg\ C$$

If we divide the CFCS by the age of the golf course (GCA), we can derive the average yearly CFCS ($CFCS_{yearly}$) for the Cherington course from 1993 (the year the golf course opened) to 2023 (the year the soil sampling occurred).

$$GCA = 30\ yr$$

$$CFCS_{yearly} = 0.78\ Mg\ C\ ha^{-1}\ yr^{-1}$$

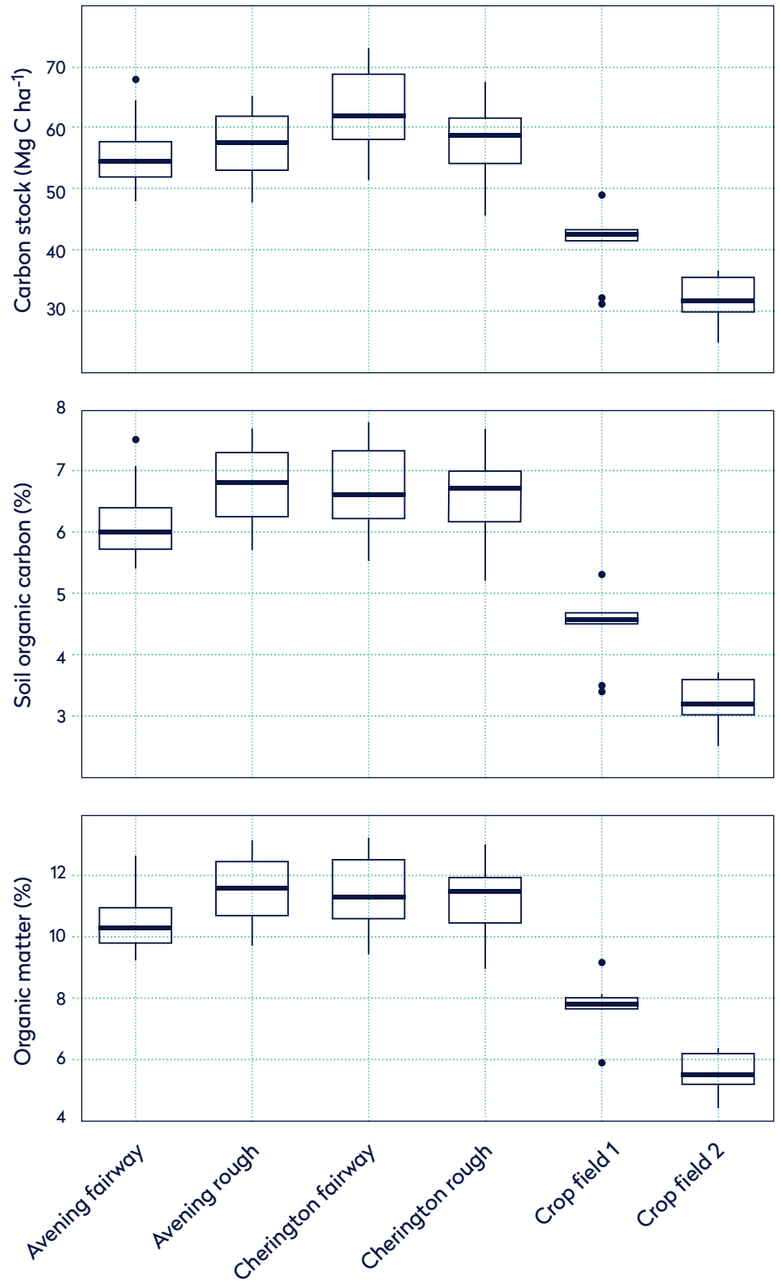


Figure 4. Organic matter, soil organic carbon (SOC) and carbon stock on the Avening fairways, Avening rough, Cherington fairway, Cherington rough, Crop field 1, and Crop field 2. All three graphs are related but are all showing different indices. Organic matter varies in its SOC content but is typically between 50 and 60% carbon. The carbon stock is highly dependent on SOC content but is influenced by the depth over which the stock is estimated, the bulk density and the coarse fragment content.

# Carbon emissions.

## Estimating carbon emissions

To calculate the carbon balance of the Minchinhampton Golf Club (MGC) we calculated the carbon emissions of the golf course maintenance activities using the model presented in Bekken and Soldat (2021), which was developed collaboratively with GEO Foundation. This model calculates carbon emissions from golf course maintenance activities and does not estimate emissions from the clubhouse or other facilities at the golf course. The model includes emissions from the maintenance equipment, maintenance facility and the irrigation pump, and estimates Scope 1, 2, and 3 emissions. We present the emissions data in six categories: Electricity, Fertiliser, Fuel, Machinery, Pesticide and Sand.

| Emissions category | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| **Electricity** | | Carbon emissions from the generation of grid electricity in the UK that is used at MGC. | Carbon emissions of electricity that is lost during the transmission and distribution of electricity in the UK. |
| **Fertiliser** | Emissions from denitrification of nitrogen fertilisers after application. | | Carbon emissions from the manufacturing of nitrogen, phosphorus and potassium fertilisers. |
| **Fuel** | Carbon emissions from the combustion of all fuels at MGC. This includes fuels to power all machinery and heat the maintenance facility. | | Carbon emissions from the manufacturing of fuels used at MGC. |
| **Machinery** | | | Carbon emissions from the manufacturing, transport and repair of machinery at MGC. |
| **Pesticide** | | | Carbon emissions from the manufacturing of herbicides, insecticides and fungicides used at MGC. |
| **Sand** | | | Carbon emissions from the mining and transport of sand to the facility. |

### Quantifying carbon fluxes as carbon (C) or carbon dioxide ($CO_2$)

Quantifying carbon fluxes can be achieved by using the weight of elemental carbon (C) or the weight of carbon dioxide ($CO_2$). Soil carbon stocks are typically quantified as the weight of C, because the C in soil is chemically bonded to many different elements, making it simplest to track the weight of C in the soil. However, when that soil carbon is respired by soil microbes, the carbon is released into the atmosphere primarily as $CO_2$. Similarly, when fossil fuels are combusted, the carbon is also released into the atmosphere primarily as $CO_2$. This is why carbon emissions are typically quantified in terms of the weight of $CO_2$. However, we can convert between units of C and $CO_2$ by accounting for the differences in molar mass between the two molecules. The molar mass of $CO_2$ is 44 g $mol^{-1}$, while the molar mass of C is 12 g $mol^{-1}$. As such, 1 g of C is equivalent to 3.6 g of $CO_2$, making this quantity comparable to the weight of $CO_2$ emitted by maintenance of the golf courses. With both sequestration and emissions in units of $CO_2$, a carbon balance for the Avening and Cherington courses can be determined.

## Carbon emissions

Carbon emissions to maintain the golf courses totalled 178 Mg $CO_2$ $yr^{-1}$. Fuel use accounted for 96 Mg $CO_2$ $yr^{-1}$ or 54% of all carbon emissions from the golf course maintenance activities at MGC. Sand was the second highest emitting category of emissions (32 Mg $CO_2$ $yr^{-1}$), followed by fertiliser (24 Mg $CO_2$ $yr^{-1}$), electricity (18 Mg $CO_2$ $yr^{-1}$), machinery (7.1 Mg $CO_2$ $yr^{-1}$), and pesticide (0.2 Mg $CO_2$ $yr^{-1}$).

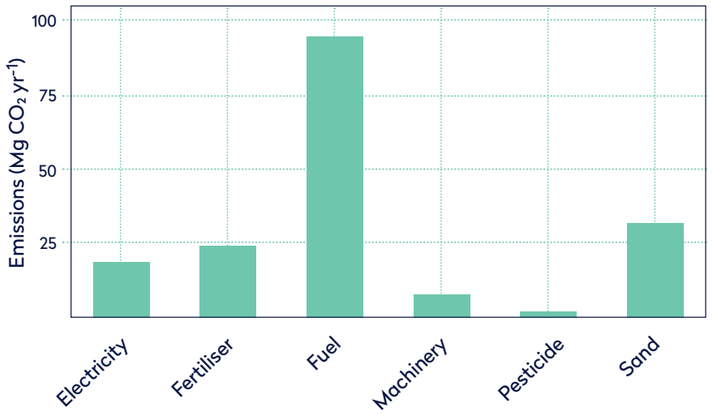


Figure 5. Carbon emissions in Mg $CO_2$ $yr^{-1}$ from Minchinhampton Golf Club across the six emissions categories.

There is a total of 55.7ha of maintained turf between the Avening and Cherington courses at MGC, meaning that the average carbon emissions per hectare of maintained turf across both courses was 3.2 Mg $CO_2e$ $ha^{-1}$ $yr^{-1}$. If we assume that the amount of carbon emitted to maintain the Avening and Cherington golf courses has stayed constant in every year since they were constructed, we can estimate the total amount of carbon emitted in the maintenance of both golf courses since they opened for play.

Total lifecycle emissions from the Avening course ($E_A$) to date were estimated to be 3702 Mg $CO_2$. Total lifecycle emissions from the Cherington course ($E_C$) to date were estimated to be 3702 Mg $CO_2$.

$E_A$ = 3.2 Mg $CO_2$ $ha^{-1}yr^{-1}$ * 24.1 ha * 48 yr = 3702 Mg $CO_2$

$E_C$ = 3.2 Mg $CO_2$ $ha^{-1}yr^{-1}$ * 31.6 ha * 30 yr = 3034 Mg $CO_2$



# Carbon balance.

## Carbon balance

To establish a carbon balance, we need to convert the CFCS at the Avening and Cherington courses from the weight of carbon (C) to the weight of carbon dioxide ($CO_2$).

$$CSOE_A = 477 \text{ Mg C} * \frac{44 \frac{\text{g } CO_2}{\text{mol}}}{12 \frac{\text{g C}}{\text{mol}}} = 1749 \text{ Mg } CO_2$$

$$CSOE_c = 743 \text{ Mg C} * \frac{44 \frac{\text{g } CO_2}{\text{mol}}}{12 \frac{\text{g C}}{\text{mol}}} = 2724 \text{ Mg } CO_2$$

We define the carbon balance for the Avening and Cherington courses as the carbon emissions of maintenance minus the CFCS from the time the golf courses opened for play until the time soil carbon sampling occurred in 2023. During its 48 years of operation, from 1975 to 2023, the Avening course emitted 3702 Mg $CO_2$ and has a CFCS of 1753 Mg $CO_2$. The CFCS offset 47% of the carbon emissions. For the golf course to be carbon neutral over the study period (1975-2023) emissions would have needed to have been reduced by over 200%.

During its 30 years of operation, from 1993 to 2023, the Cherington course has emitted 3034 Mg $CO_2$ and has a CFCS of 2724 Mg $CO_2$. The CFCS offset 89% of the carbon emissions. For the golf course to be carbon neutral over the study period (1993-2023) carbon emissions would have needed to have been reduced only slightly.

**Carbon balance = Emissions – CFCS**

**Emission, CFCS, and carbon balance of the Avening course from 1975 to 2023**

**Total emissions:** 3702 Mg $CO_2$

**Total CFCS:** 1753 Mg $CO_2$

**Carbon balance:** 1949 Mg $CO_2$

**Emission, CFCS, and carbon balance of the Cherington course from 1993 to 2023**

**Total emissions:** 3034 Mg $CO_2$

**Total CFCS:** 2724 Mg $CO_2$

**Carbon balance:** 309 Mg $CO_2$


Figure 6. The carbon balance, carbon emissions and CFCS of the Avening and Cherington courses from their construction to the time of soil sampling in 2023.

# Discussion.

In this study, we followed the Tier 1 methodology as outlined in the GC2030 Protocol. This gives us an estimate of the counterfactual carbon storage (CFCS), which is a comparison of the golf course carbon stock to the carbon stock of the counterfactual land use. To measure carbon sequestration, the Tier 2 methodology of the GC2030 Protocol is needed. In 2028, five years from the initial sampling that took place in 2023, the Tier 2 methodology can be completed at MGC.

In all scientific investigations there will inevitably be factors that limit the accuracy of the results obtained. Limitations in this study included the coarse fragment content in the soil which meant that sampling was only possible to 10cm and not the originally planned 30cm. In addition, the fairways of both golf courses were topdressed after construction, which limited the accuracy of the golf course carbon stock estimates. However, with these limitations, the results obtained in this study are reasonable and within the range of what previous studies have found.

While CFCS rates and carbon sequestration rates are not the same metric, they are similar enough to warrant comparison. The annual CFCS rates ($CFCS_{yearly}$) that this study found were 0.42 Mg C $ha^{-1}$ $yr^{-1}$ at the Avening course and 0.77 Mg C $ha^{-1}$ $yr^{-1}$ at the Cherington course. These rates were slightly lower than, but comparable to, the average sequestration rate found in nine previous studies of golf course carbon sequestration (0.96 Mg C $ha^{-1}$ $yr^{-1}$). In these nine studies, sequestration rates ranged from 0.22 Mg C $ha^{-1}$ $yr^{-1}$ to 3.55 Mg C $ha^{-1}$ $yr^{-1}$.

If the Tier 2 methodology is applied to the MGC golf courses in the future, the CFCS rates in this study are likely higher than the carbon sequestration rates occurring at MGC today. Previous studies indicate that golf course soil carbon sequestration rates are highest in the first 25-30 years after they are converted from agricultural land. Thereafter, soil carbon sequestration rates decrease as organic matter levels in the soil reach a new steady state. Given that the golf courses at MGC are both more than 30 years old, the rate of carbon sequestration at the courses is likely decreasing.

Conversely, cumulative emissions from the maintenance activities at MGC increase each year and will only be reduced by making the necessary investments in low carbon technology. This report finds that 54% of all carbon emissions from the maintenance of the Avening and Cherington courses are from fuel use. As such, phasing out the use of fuels at MGC will be the most effective way of reducing emissions.

Currently, fuels are used to power maintenance equipment and to heat the maintenance facility. Fuel consumption could be reduced by the adoption of electric maintenance equipment and electric heating for the maintenance facility. The electricity needed to power this equipment does also have a carbon cost, but it is much lower. Assuming the electricity is sourced from the UK electricity grid, the lifecycle carbon cost of electric maintenance equipment, including manufacturing and a lifetime of charging and use, are currently about one quarter of what they are for petrol maintenance equipment. Fortunately, the UK electricity grid is quickly decarbonising, meaning that emissions from charging electric equipment will continue to decrease even further. MGC could also choose to become grid independent by the installation of on-site solar panels, which could eliminate all electricity-based emissions.

The results of this study confirm previous research which indicates that emissions from golf course maintenance activities need to be reduced from current levels for golf courses to be carbon neutral or carbon negative.

**A review of golf course sequestration studies (adapted from Braun et al., 2023)**

| Golf course location | Carbon sequestration rate (Mg C $ha^{-1}$ $yr^{-1}$) | Time to equilibrium | Reference |
|---|---|---|---|
| England, UK | 0.42 | | This study |
| England, UK | 0.77 | | This study |
| Colorado, USA | 0.9 – 1.0 | 45 | Qian and Follett (2002) |
| Colorado, USA | 0.9 – 1.2 | 30 | Bandaranayake et al., (2003) |
| New Zealand | 0.69 | | Huh et al., (2008) |
| Nebraska, USA | 0.32 – 0.78 | | Qian et al., (2010) |
| Ohio, USA | 2.64 – 3.55 | 12 - 91 (depth dependent) | Selhorst and Lal (2011) |
| North Carolina, USA | 0.72 | | Wang et al., (2014) |
| Kansas, USA | 0.98 – 1.05 | | Braun and Bremer (2019) |
| Texas, USA | 0.22 | | Gautam et al., (2020) |
| Kansas, USA | 0.42 – 1.0 | 40 | Hong et al., (2023) |

# Conclusion.

There is potential for emissions to be quickly and significantly reduced through investment in low carbon technologies.

## The future of Minchinhampton Golf Club's carbon balance

The work completed here estimates the carbon balance of the Avening and Cherington courses from their construction in 1975 and 1993, respectively, to 2023 when soil sampling for this project occurred.

In summary, the lifecycle carbon balance of the Avening and Cherington courses is positive for both courses (total emissions are higher than total CFCS). The carbon balance of the two courses will only become more positive as the courses age unless emissions are reduced through investment in low carbon technologies. Fortunately, low carbon technologies such as electric maintenance equipment, are becoming more economical and widely available across the golf industry.

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The R&A group of companies was formed in 2004 to take on The Royal and Ancient Golf Club of St Andrews' responsibilities for governing the Rules of Golf, staging The Open, golf's original championship, and developing the sport. The World Golf Museum in St Andrews is part of The R&A group.

Together The R&A and the USGA govern the sport of golf worldwide, operating in separate jurisdictions with a commitment to a single code for the Rules of Golf, Rules of Amateur Status and Equipment Standards. The R&A, through R&A Rules Ltd, governs the sport worldwide, outside of the United States and Mexico, on behalf of over 41 million golfers in 144 countries and with the consent of 159 organisations from amateur and professional golf.

The R&A has responsibility for running a series of world class amateur events and international matches in women's and girls' as well as men's and boys' golf. The R&A stages the AIG Women's Open and works with the DP World Tour to stage the Senior Open presented by Rolex.

The R&A is committed to investing £200 million over ten years in developing golf and supports the growth of the sport internationally, including the development and management of sustainable golf facilities. For more information, visit www.randa.org.

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