Research To Improve Water Management Practices At Golf Courses In A Changing Climate

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Declaration

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organisations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability and climate action across the region.

This project was conducted under the mentorship of Vancouver Park Board / City of Vancouver staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Vancouver Park Board / City of Vancouver or the University of British Columbia.

Acknowledgement

The author acknowledges that the work for this project took place on the unceded ancestral lands of the Musqueam, Squamish, and Tsleil-Waututh peoples.

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Project Scope

This project focuses on improving water management practices at Vancouver's three publicly owned championship golf courses, managed by the Vancouver Park Board. The work aligns with the six strategic objectives in the City's Water Priority Action Plan (2023–2028) and aims to enhance water efficiency, resilience, and environmental stewardship.
The scope includes:

- Reviewing current site conditions
- Identifying how existing practices align with and can be improved to meet Water Priority Action Plan objectives
- Developing a decision-making tool
- Applying the toolkit to assess and recommend conceptual improvements for one Golf Course based on its specific conditions
- Providing preliminary cost estimates for the construction and maintenance of proposed solutions

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Executive Summary

This project examines 2019–2024 water use, temperature, and rainfall data for Vancouver's championship golf courses to identify strategies for reducing peak irrigation demand. It assesses storage options, including detention ponds and underground systems, to supplement irrigation during dry months.

Fraserview Golf Course's irrigation demand consistently peaks during the summer months, driven by high evapotranspiration rates and limited rainfall. In 2023, water consumption in June and July reached approximately 20,000–25,000 m^3 per month, above the average of 10,000–15,000 m^3 recorded between 2019 and 2024.

Analysis indicates that installing a detention system with a storage capacity of 10,000 m^3 could significantly mitigate peak-season demand. By supplementing irrigation supply during high-use months, such a system would reduce peak consumption to align with the course's historical average, lowering July demand from ~25,000 m^3 to approximately 15,000 m^3. This adjustment would not only ease reliance on municipal water but also improve resilience to extended dry periods and extreme heat events.

The proposed improvement supports long-term water sustainability goals, optimizes resource use during critical periods, and enhances the course's ability to maintain turf quality under changing climatic conditions.

Introduction and Background

Introduction

Vancouver's golf courses represent a large area of the city's green space. They provide recreation, support wildlife, and help manage stormwater. At the same time, they use much potable/drinking water, especially in summer when rainfall is low. In recent years, hotter and drier summers, along with record-breaking heat, have made it more important for these courses to use water wisely.

This project supports the Vancouver Park Board's work on the Water Priority Action Plan (2023–2028). It looks at ways to reduce potable water use, increase storage, improve water quality, and manage user expectations through education. Fraserview Golf Course is used as the main case study. The work is based on site visits, water use data from 2019–2024, and examples from other places.

The recommendations include both small changes, like blue roofs, and bigger projects, like underground detention systems and nature-based solutions such as bioswales and floating wetlands. The goal is to make sure every drop of water counts, while keeping the courses sustainable and ready for the future.

Background

Water Priority Action Plan 2023–2028:

Vancouver's water comes from three mountain-fed reservoirs, but warmer, drier summers and shrinking snowpacks are putting them under strain. The Park Board uses uses about 1.1 billion litres of water across 240+ parks, making it the city's single largest potable/drinking municipal water user, and with our population continuing to grow, demand will only rise. Much of the irrigation network dates back to the mid-20th century, so leaks can waste up to 30 percent of the water we pump. Starting in 2025, every litre lost will translate into real costs under the new user-pay billing model. (Water Priority Action Plan 2023–2028, 2023)

There are six strategic objectives stated in Vancouver's Water Priority Action Plan (2023–2028) to improve water conservation.

1. Achieve Regulatory Compliance
- Retrofit, convert, or remove non-compliant "once-through" features
- Prevent Fisheries Act violations

2. Retrofit & Upgrade Systems
- Install low-flow fixtures and pressure-reducing valves
- Develop a facility-upgrade schedule

3. Nature-Based Solutions
- Reduce irrigation through xeriscaping and site-specific plans
- Convert decorative water features into wetlands or green infrastructure

4. Preventative Maintenance Program
- Inventory all water infrastructure (features, piping, marinas, golf courses)
- Schedule lifecycle maintenance to avoid costly failures

5. Water-Smart Design
- Develop a Park Board-wide "water budget"
- Guide new park designs and redevelopments

6. Interdepartmental Collaboration
- Form a working group across Planning, Operations, REFM, and Engineering
- Engage community stewards
- Launch a public-communications plan

Background of Vancouver public golf courses

Golf courses draw millions of litres each season. As some of the most significant irrigated landscapes under civic management, they set the standard for how public green spaces balance playability with sustainability. Beyond fairways and greens, they support urban forest canopy, groundwater recharge zones, and wildlife habitat. That ecological value makes it even more important to reduce dependence on potable water. (Vancouver Board of Parks and Recreation, 2025)

There are six publicly owned golf courses in Vancouver. Each course follows a continuous improvement approach based on a five-year rolling average review to find new water conservation opportunities. For the three championship courses, Langara already taps mostly non-potable groundwater, while Fraserview still relies almost entirely on drinking water, and McCleery falls in between:

- **Fraserview Golf Course** has an annual budget of 65,531 m³. In 2020, it consumed 55 percent of its allocation, which equals 35,915 m³, and 33 percent of that volume (11,790 m³) came from non-potable water. (Vancouver Board of Parks and Recreation, 2021)
- **McCleery Golf Course** is allocated 59,772 m³ of water each year. During 2020, it used 58 percent of its allotment, or 34,105 m³, and non-potable sources supplied 34 percent of that volume (11,468 m³). (Vancouver Board of Parks and Recreation, 2021)
- **Langara Golf Course** has an annual water budget of 72,647 m³. In 2020, it used 50 percent of its allowance. All of the water was drawn from non-potable sources. (Vancouver Board of Parks and Recreation, 2021)

Trend in climate change

Vancouver now faces an average stretch of 21 dry days each summer, and climate models show that will climb to 26 days by the 2050s and 29 days by the 2080s, with dry-spell length growing by roughly 22 percent mid-century and 37 percent by the end of the century. At the same time, we will see only a modest rise in total rainfall but more of it falling in heavy bursts. The single wettest day could deliver 17 percent more rain by the 2050s and 32 percent more by the 2080s, and the wettest five-day stretch could increase by 12 percent then and 25 percent later (Metro Vancouver Regional District, 2016).

Longer dry spells and heavier downpours mean we need water systems that can hold on to every drop when it falls and stretch supply through drought. That means expanding underground storage, capturing more stormwater on site, and dialing in our irrigation schedules so we recharge reservoirs, manage flood risk, and keep landscapes healthy.

Trend of water conservation in golf courses

In 2025, the Langara golf course uses 100% groundwater for its irrigation. When interviewing golf courses' superintendents, they all expressed the urge to conserve water and find multiple water resources to face the changing climate of Vancouver.

In conclusion, with summers growing drier and rainstorms becoming more intense, publicly owned golf courses need to align their irrigation strategies with the Water Priority Action Plan 2023 – 2028.

Data Analysis

* Vancouver Park Board provides the data on water consumption of public-owned golf courses.

Irrigation Demand in Relation to Monthly Temperature and Rainfall Patterns

This section looks at irrigation demand, temperature, and rainfall for public owned golf courses from 2020 to 2024. The goal is to see how weather changes, seasonal turf needs, and site conditions affect water use.

In all years, water use stayed low in winter and early spring, then increased in late spring when turf greened up and the golf season started. Peak demand usually happened in July or August, when temperatures were highest and rainfall was lowest. Even in years with more total rainfall, summer was still dry, and the courses relied on stored or supplied water to keep turf playable.

The numbers show apparent differences between the courses. Fraserview often had the highest summer demand, especially in dry, hot months. Langara had the lowest use, helped by 100% non-potable groundwater irrigation. High use often continued into September, which shows the need for better water storage, capture, and efficiency to get through more extended dry periods.

2019 Temperature change, Precipitation, and Water Consumption of Golf Courses

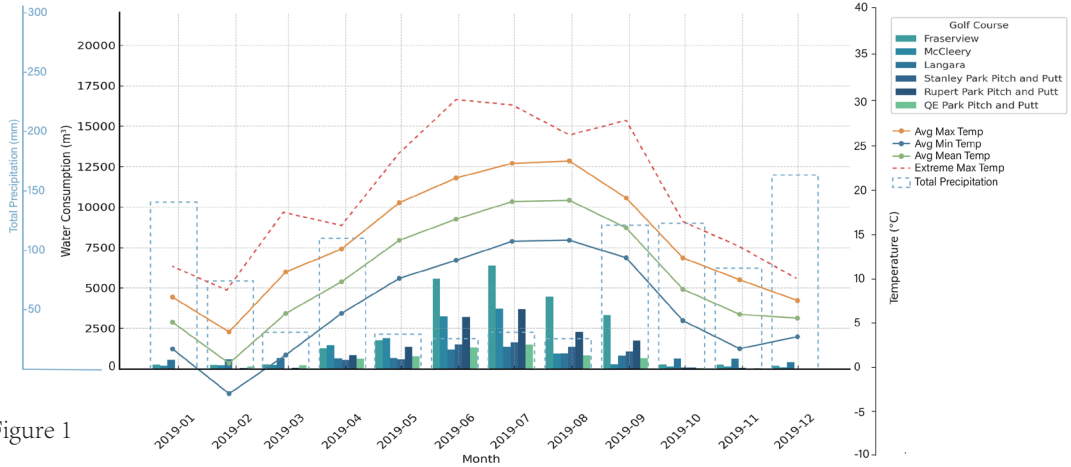


Figure 1

Water consumption

- Jan–Apr 2019: Used under 1,000 m³ per month.
- May: Fraserview 1,271 m³, McCleery 1,456 m³, Langara 636 m³.
- June: Fraserview 5,574 m³, McCleery 3,232 m³, Langara 1,190 m³.
- **July: Peak monthly,** Fraserview 6,374.62 m³, McCleery 3,702.73 m³, Langara 1,372.80 m³.
- September: Fraserview still used 3,300.91 m³.

Precipitation

- June: Lowest rainfall of the season, coinciding with a high demand in irrigation.
- September: More rainfall occurred, but irrigation demand at Fraserview remained high due to evapotranspiration and turf needs.

Temperature change

- Average daily temperature rose steadily from spring into summer.
- August: Peak average temperature for the year.
- June and one September day recorded extreme heat spikes, exceeding August's record highs.
- Maximum temperature spikes contrasted with smoother trends in mean and minimum temperatures.

2020 Temperature change, Precipitation, and Water Consumption of Golf Courses

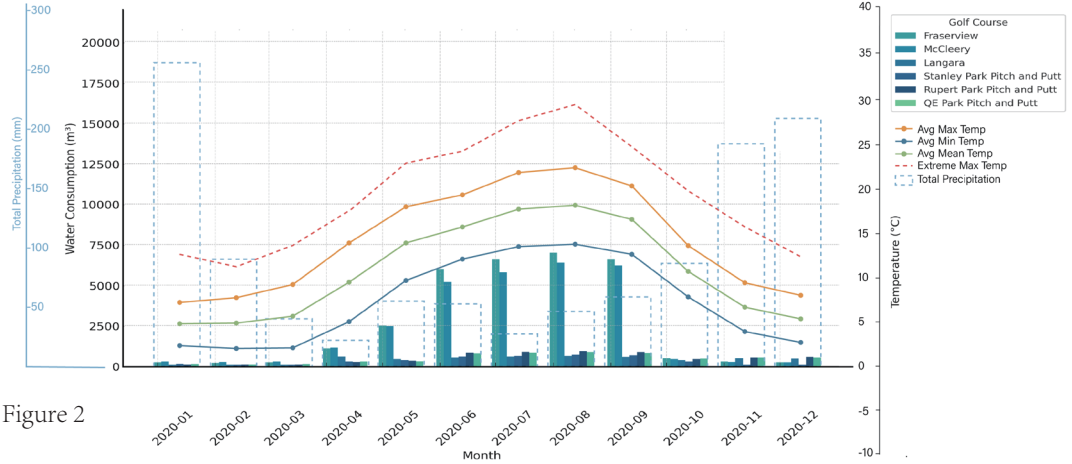


Figure 2

Water consumption

- Jan–Apr 2020: Minimal irrigation.
- May: Fraserview 1,004 m³, McCleery 2,440 m³, Langara 432 m³.
- June: Fraserview 6,004 m³, McCleery 5,201 m³, Langara 576 m³.
- **August: Peak usage**, Fraserview 6,690 m³, McCleery 4,974 m³, Langara 640 m³.
- September: Still high despite rainfall, Fraserview 6,356 m³, McCleery 4,743 m³, Langara 649 m³.

Precipitation

- Rainfall concentrated in January, November, and December.
- Lowest rainfall occurred in April.
- May–September had variable precipitation, yet high water use continued.

Temperature change

- Steady rise from spring into summer.
- Peak average and extreme heat both occurred in August.
- Seasonal ramp-up was more gradual than in 2019.

2021 Temperature change, Precipitation, and Water Consumption of Golf Courses

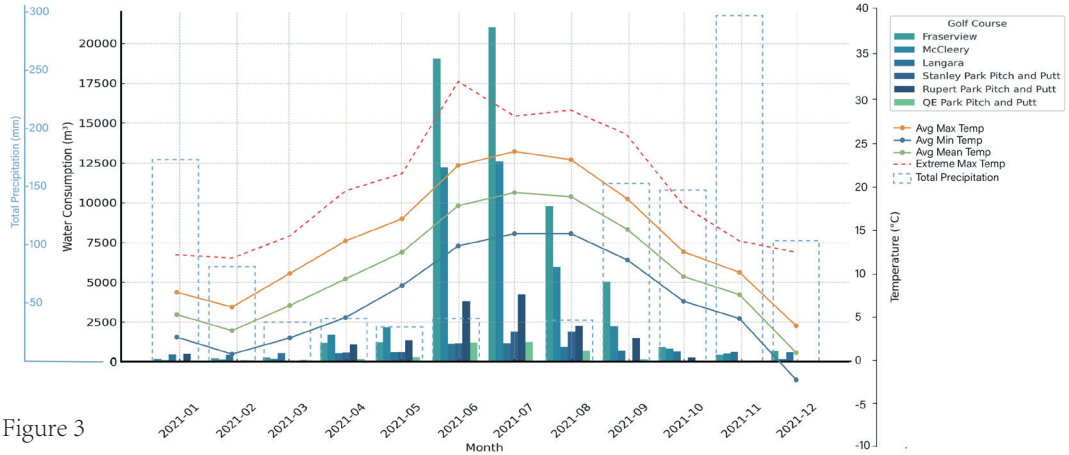


Figure 3

Water consumption

- Jan–Apr 2021: Low irrigation use.
- May: Fraserview 1,182 m³, McCleery 1,692 m³, Langara 536 m³.
- June: Fraserview 19,047 m³, McCleery 12,203 m³, Langara 1,129 m³.
- **July: Peak usage,** Fraserview 21,004 m³, McCleery 12,600 m³, Langara 1,152 m³.
- September: Fraserview 5,035 m³, more than half July's maximum, despite some late-summer rain.

Precipitation

- Heavy rainfall in January and November.
- Zero rainfall in July.
- Brief rainfall in June and August.

Temperature change

- Steady rise into midsummer.
- Average highs peaked in July.
- Most extreme heat occurred in June (record-breaking day exceeding July highs).
- Mean and minimum temperatures rose more smoothly compared to maximum spikes.

2022 Temperature change, Precipitation, and Water Consumption of Golf Courses

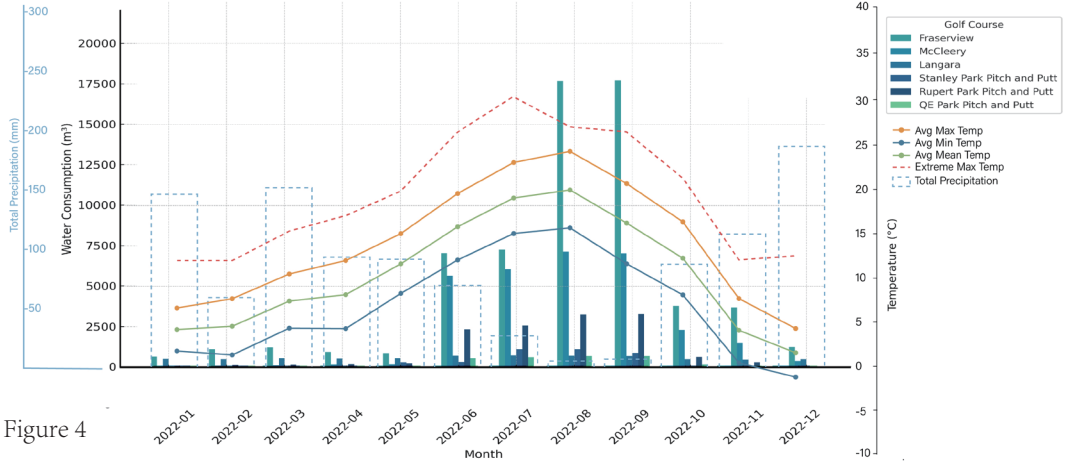


Figure 4

Water consumption

- Jan–Apr 2022:Low irrigation use.
- May: Fraserview 884.71 m³, McCleery 221.03 m³, Langara 584.09 m³.
- June: Fraserview 7,059.36 m³, McCleery 5,668.12 m³, Langara 738.36 m³.
- **August: Peak usage,** Fraserview 17,679.20 m³, McCleery 7,166.00 m³, Langara 741.98 m³.
- September: Fraserview is still high at 17,700.98 m³.

Precipitation

- April: About 75 mm rainfall.
- August–September: Below 50 mm per month.
- July: Some rainfall (unlike 2021's zero), but still low.
- Rainfall rose again in late autumn.

Temperature change

- Steady rise from spring into midsummer.
- Average daily highs and extreme heat peaked in July.
- Despite small July rainfall, sustained high water use continued through September.

2023 Temperature change, Precipitation, and Water Consumption of Golf Courses

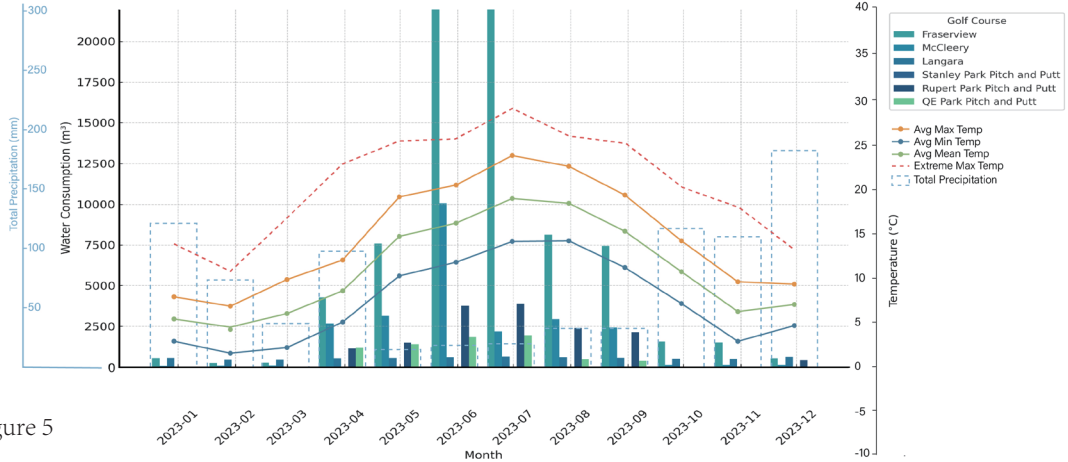


Figure 5

Water consumption

- April: Higher usage than in previous years.
- May: Fraserview 4,274.58 m³, McCleery 2,676.59 m³, Langara 533.61 m³.
- June: Fraserview 23,784.11 m³, McCleery 10,057.38 m³, Langara 633.92 m³.
- July: Peak usage, Fraserview 25,788.23 m³, McCleery 2,182.78 m³, Langara 661.46 m³.

Precipitation

- July: ~20 mm rainfall.
- August: ~40 mm rainfall.
- January and December: High rainfall totals.
- March, May, June, July, August, September: Dry months.

Temperature change

- Gradual rise from spring into midsummer.
- Mean highs peaked in July.
- Most extreme heat also occurred in July.

2024 Temperature change, Precipitation, and Water Consumption of Golf Courses

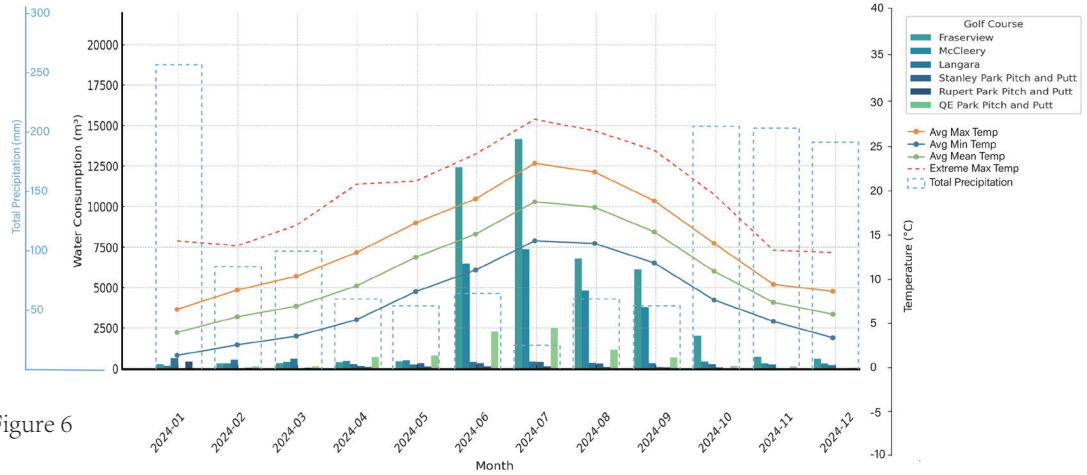


Figure 6

Water consumption

- Jan–May 2024: Low irrigation demand across all courses.
- June: Fraserview 12,424 m³, McCleery 6,474 m³, Langara 410 m³.
- July (peak): Fraserview 14,182 m³, McCleery 7,373 m³, Langara 442 m³.
- August: Fraserview 6,807 m³.
- September: Fraserview 6,114 m³.

Precipitation

- Concentrated in January, October, November, and December.
- Sharp drop from February through September.
- July recorded the lowest rainfall of the year.
- August and September each received ~50 mm rainfall.

Temperature change

- Steady climb from spring into midsummer.
- Mean highs and extreme highs both peaked in July.

Conclusion to Irrigation Demand in Relation to Monthly Temperature and Rainfall Patterns

The five-year data shows that extreme heat, dry springs, and long summer droughts all increase irrigation demand. Record-breaking hot days, like the June 2021 heatwave, caused the biggest jumps, and a dry spring can mean higher water use as early as April. Even when there is some rain in late summer, a few millimetres in September is not enough to reduce irrigation.

What used to be a short peak in June and July now often runs into August and September in the driest years, like 2022 and 2023. This keeps pressure on both drinking water and backup sources.

The numbers also show differences between courses. Langara uses 100% non-potable groundwater and stays low in demand, while Fraserview's smaller storage and use of potable water lead to higher summer use. These patterns show the need for more storage, better runoff capture, and more efficient irrigation to handle hotter, drier summers.

Monthly Water Use Patterns 2019-2024

This section looks at monthly water use patterns from 2019 to 2024 for each championship golf course and pitch & putt course. The goal is to compare how irrigation demand changes through the year, and to see how weather, site conditions, and water sources affect each site's use.

Across all sites, water use stays low from October to April, then rises in late spring as the irrigation season starts. Peak demand usually happens between June and August, although in drier years it often extends into September. Fraserview and McCleery show similar seasonal trends, with the highest peaks in years with prolonged dry weather, like 2021–2023. Langara's pattern is different because it uses 100% non-potable groundwater for irrigation, which may influence both the timing and volume of use.

The pitch & putt courses, Rupert Park and Stanley Park, also follow a summer peak pattern, but with lower overall volumes. Even so, they show apparent differences between high-use and low-use years, often linked to summer rainfall and temperature conditions. Looking across the data, it is possible to identify not only when the highest demands occur, but also which courses maintain more stable irrigation patterns under varying conditions.

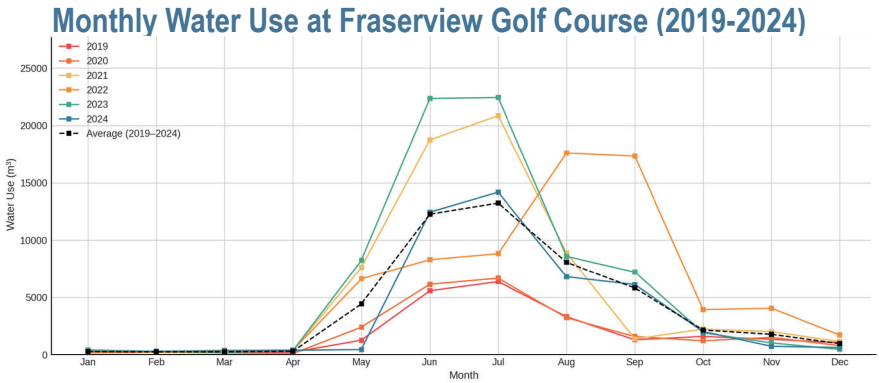


Figure 7

The monthly water consumption at Fraserview Golf Course shows seasonal patterns across the six years:

Peak Season (May–August): Water use begins to rise in May and usually peaks in June or July. This period reflects the highest irrigation demand is regular each year.
High-Use Years: 2021, 2022, and 2023 all show significantly higher water use compared to the six-year average. In 2021, the peak occurred in July, when there was zero rainfall. In 2022, the highest water use extended into August and September, when there was a longer dry season. In 2023, water use rose sharply starting in May, peaking early in June and July.
Moderate Year: 2024 closely follows the six-year average, indicating typical conditions or possible improvements in water management.
Low-Use Years: 2019 and 2020 consistently stayed below the average, due to wetter weather and lower irrigation needs.

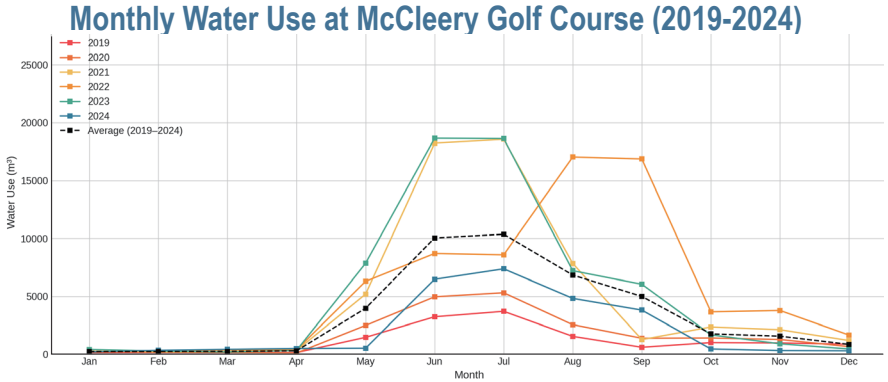


Figure 8

The monthly water consumption at McCleery Golf Course follows a clear seasonal trend, which is similar to Fraserview Golf Course.

Peak Irrigation Period (May–August): Water use increases sharply beginning in May and usually peaks in July. This pattern is consistent with the dry season.
High-Use Years: 2021 and 2022 reached their highest consumption in July. In 2022, elevated usage extended into August and September, due to prolonged dry conditions. 2023 showed an early and substantial increase starting in May, peaking in June and July, but water use was still high in September.
Low-Use Years: 2019, 2020, and 2024 remained consistently below the average throughout the irrigation season. When consistent rain events in spring and a dry summer existed in 2024, McCleery Golf Course had a less dramatic variation in water consumption compared with Fraserview.

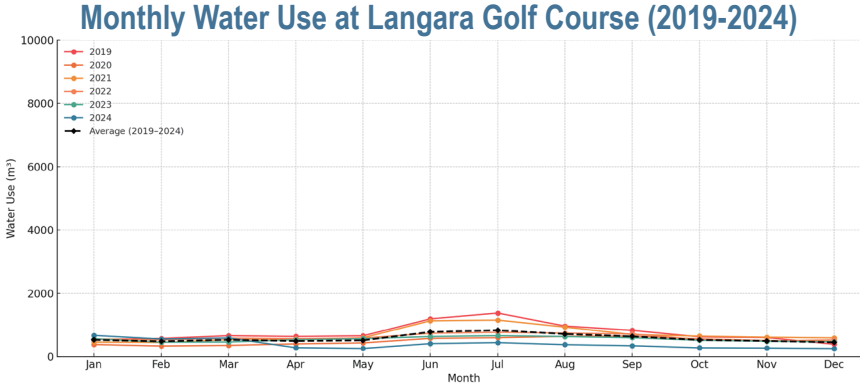


Figure 9

Langara Golf Course is using groundwater as its primary resource for irrigation, so its water consumption pattern is different from other golf courses.

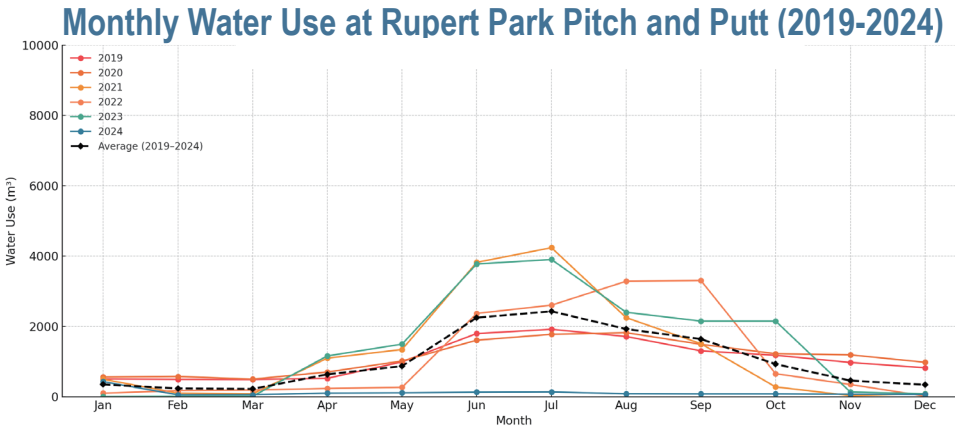


Figure 10

In Rupert Park Pitch and Putt, water use typically begins to rise in April, peaks in June or July, and then gradually declines toward the end of the year. The pattern is similar to McCleery Golf Course. 2021 and 2023 recorded the highest water consumption, especially from June to August, with peak values nearing or exceeding 4000 m³ in July. These years stayed consistently above the six-year average throughout the irrigation season.

Monthly Water Use at Stanley Park Pitch and Putt (2019-2024)

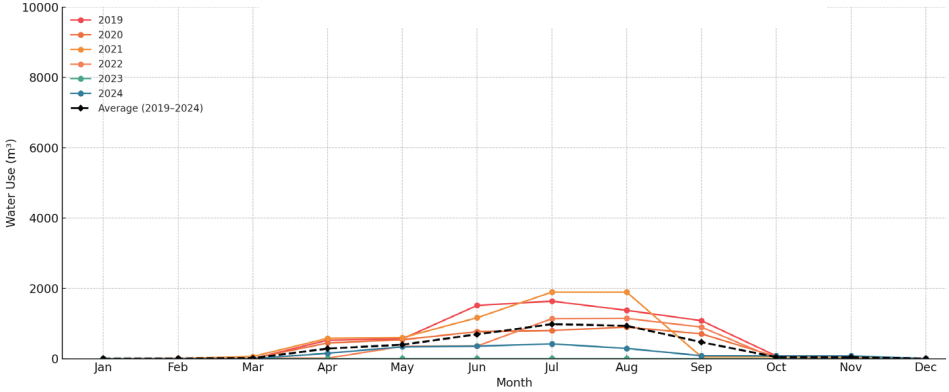


Figure 11

Water use starts to rise around April, peaks in the summer months (June to August), and drops off sharply after September.
Peak Years:
2021 and 2019 had the highest water consumption, particularly in July and August, with values close to or above 1,800 m³.
Moderate Years:
2020 and 2024 showed moderate consumption patterns, staying slightly below or near the average.

Monthly Water Use at QE Park Pitch and Putt (2019-2024)

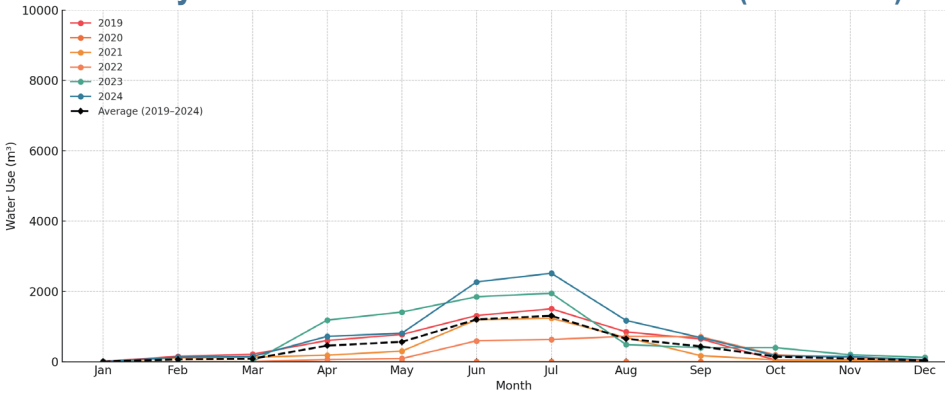


Figure 12

Water use begins to rise in April, peaks in July, and tapers off by September.
Peak Year:
2024 had the highest water consumption, especially from June to August, with a notable July peak exceeding 2,500 m³.
Moderate Years:
2020 and 2021 saw substantially lower usage, especially in 2021, which remained well below the average throughout all months.

Conclusion to Monthly Water Use Patterns 2019-2024

The monthly water use patterns from 2019 to 2024 show clear seasonal trends at all golf courses and pitch & putt sites, with low demand in the winter months and peak irrigation in summer. In most years, demand begins to rise in May or earlier, peaks in June, July, or August, and tapers off by September.

Fraserview and McCleery follow similar patterns, but Fraserview consistently shows higher summer peaks, especially in years with extended dry periods. McCleery's usage is more moderate in wet years like 2024 when summer received more rain. This pattern shows that McCleery has more water storage capacity compared with Fraserview. Langara maintains consistently low demand due to its 100% non-potable groundwater source, although its seasonal pattern is still visible.

Rupert Park and Stanley Park show smaller overall volumes, but their peaks can still be high relative to their size, especially in hot, dry years like 2021, 2023, and 2024. The data highlights how weather conditions, water source, and site management influence irrigation needs, and shows that in drier years, high water demand can extend well into September across all sites. These patterns reinforce the importance of improving water storage, capturing runoff, and adjusting irrigation schedules to match site-specific conditions.

Current Conditions and Existing Practices

* To make the improvement recommendations more practical and site-specific within the short time of this project, visits were conducted to all three large championship golf courses, as these courses have higher water usage than the City's pitch and putt courses. These visits helped document current water infrastructure, identify challenges unique to each site, and understand how staff manage irrigation in different weather conditions. Conversations with superintendents also provided insight into operational priorities, space limitations, and opportunities for new water-saving practices.

*The site visit was conducted in June 2025.

Fraserview Golf Course

Figure 13

Overall, Fraserview Golf Course lacks sufficient water storage capacity, even though a high amount of water flows through the site.

The superintendent suggested adding another retention area, hoping it would not disturb Vivian Creek.

Currently, the only retention pond collects water from the storm sewer along Kerr Street, but this supply is minimal during the summer when irrigation demand is at its peak.

Although Fraserview remains the highest user of potable water among the golf courses, its consumption has decreased from 54,605 m^3 in 2021 to 38,308 m^3 in 2024.

Irrigation System

- The irrigation system consists of PVC pipes that are over 30 years old, and leaks were observed during the site visit.
- Leaks on lateral lines can be isolated relatively easily, leaks on mainlines are more challenging to manage and isolate.
- The golf course team is continually replacing old sprinkler heads to improve irrigation coverage.
- Additional isolation valves are being installed to reduce water loss during maintenance and repairs.
- During summer months, staff hand-water green areas when turf requires extra maintenance.

Water Storage Capacity

- The golf course has one retention pond located on its east side, which appeared to be at a high level during the site visit.
- Vivian Creek runs through the course, with its main stream on the west side.
- The superintendent stated that any improvements should avoid disturbing the creek.
- The retention pond has a liner and collects greywater runoff from an adjacent street.
- Before entering the pond, the runoff is filtered through an oil separator.
- The superintendent expressed interest in capturing more runoff from nearby neighborhoods to support irrigation needs.
- The course uses both potable water and water from the retention pond, but the pond alone cannot meet the course's full irrigation demand.

Turf Conditions

- The superintendent mentioned an interest in testing drought-tolerant turf seed used in Kamloops; however, there is concern that this seed may not tolerate Vancouver's wetter climate.
- Turf areas benefit from the shade provided by the site's rich tree canopy, which can help reduce water demand.
- Overseeding is regularly carried out on tees, fairways, and roughs to maintain turf health and density.
- The primary turfgrass species present include Poa annua, bentgrass, and perennial ryegrass.

User-centered Thinking

- The superintendent promotes water conservation awareness among users. He emphasized that green turf is not essential for quality play.

McCleery Golf Course

Figure 14

McCleery Golf Course's water consumption sits between that of Fraserview and Langara.

It has several retention ponds fed by multiple water sources, including rainwater, groundwater, and runoff from Marive Drive.

Located next to the Fraser River and at low elevation, the site needs better drainage and increased water storage capacity to handle Vancouver's heavy rains.

From 2021 to 2024, its potable water use dropped from 33,808 m^3 to 20,612 m^3.

The site's low-lying topography makes it difficult to build a large standalone reservoir to capture water moving on the site.

Similar to Fraserview, the irrigation pipes at McCleery are PVC and over 30 years old.

Irrigation System

- The irrigation system consists of PVC pipes that are over 30 years old, and leaks were observed during the site visit.
- Leaks on lateral lines can be isolated easily, leaks on mainlines are more challenging to manage and isolate.
- The golf course is replacing some 360-degree sprinkler heads with 180-degree heads to reduce overspray and improve efficiency.
- A new block system with smaller spray heads is being added to enhance control over water distribution.
- McCleery Golf Course practices targeted watering, applying more water only to areas that need it.
- During summer months, staff hand-water green areas when turf requires extra maintenance.

Water Storage Capacity

- The main retention pond is located in the northeast corner of the course and is fed by multiple sources, including seepage from higher topography and runoff from Marine Drive.
- Several smaller retention ponds are in the course, connected by leveling pipes to regulate water levels.
- Water from these ponds eventually drains into the Fraser River.
- The site also includes seasonal wetlands that help retain water and provide ecological habitat.
- Invasive plant species are present around the retention ponds. When plants die back, they release large amounts of nitrogen and phosphorus, which can trigger algal blooms and further oxygen depletion.
- Trees surrounding the ponds are sometimes removed by beavers, which also occasionally build dams that disrupt the water-leveling system.
- The high water table of the Fraser River can cause drainage problems on the golf course.

Turf Conditions

- The turf species on this golf course include Poa annua, Bent grass, Perennial rye, and Fescue.
- The soil is mainly sandy, which helps with drainage.
- A trench on the east side collects seepage and improves soil drainage to support healthy turf conditions for playability.
- Overseeding is done on tees and fairways to maintain turf quality.
- Canopy coverage can improve turf quality by providing shade and reducing evapotranspiration. However, beavers living on the site make it difficult to establish and maintain trees, as they often remove them.

User-centered Thinking

- Staff members maintain a friendly relationship with players and engage in conversations during work.

Langara Golf Course

Figure 15

Langara Golf Course is the only one fully using non-potable water for irrigation.

It relies on groundwater, which is pumped into two retention ponds and a large bioswale that also collects surface runoff.

By 2023, the course completed drainage improvements to better handle Vancouver's rainy season.

The irrigation pipes for the green areas were recently upgraded, but the rest of the system still uses PVC pipes that are more than 30 years old.

Irrigation System

- While leaks on lateral lines can be isolated relatively easily, leaks on mainlines are more challenging to manage and isolate.
- Most of the irrigation system still uses PVC pipes that are around 30 years old.
- The lateral pipes in the green areas were recently upgraded.
- Staff hand-water the greens and tees when extra moisture is needed.
- The course uses 100 percent non-potable water for irrigation.
- A new Osmac control system was installed to improve irrigation precision and efficiency.

Water Storage Capacity

- Langara Golf Course has two retention ponds. The larger one, located in the center of the course, serves as the main water storage area.
- The primary water source for these ponds is groundwater drawn from the aquifer.
- It is the only golf course among the three that uses 100% non-drinking water for irrigation.
- The superintendent mentioned the potential to collect more stormwater from surface runoff to diversify water sources, rather than relying too heavily on groundwater.

Turf Conditions

- The golf course plans to add more naturalized areas to reduce the space that requires irrigation.
- Overseeding is regularly carried out on tees, fairways, and roughs to maintain turf health and density.
- The primary turfgrass species present include Poa annua, bentgrass, and perennial ryegrass.

User-centered Thinking

- The golf course was already active during the 7 am visit, with players having warm conversations with staff.
- Large, well-designed signs were placed throughout the site to let people know that Langara Golf Course uses 100 percent non-potable water for irrigation.

Conclusion to Current Conditions and Existing Practices

Common Practices Across the Golf Courses

All three courses irrigate at night and early morning (after 10 pm, before 6 am) to reduce evaporation during summer and drought periods. They use soil wetting agents to help water move more efficiently into the root zone and retain moisture. Cultural practices like venting and aerating are used to improve water and air movement into the soil. All three courses use Field Scout TDR moisture meters to monitor soil moisture and daily evapotranspiration (ET) rates for irrigation scheduling. Irrigation pipes are all PVC and buried underground, with leaks or breaks isolated by closing zone valves unless they are on the mainlines.

Fraserview Golf Course

Located along the Fraser River, with varied topography and high tree canopy cover.
Irrigation currently relies heavily on potable water during peak summer months.
Has a retention pond with an oil separator for stormwater, but limited capacity to store additional water.
Superintendent is open to trials of new turf varieties and multi-department planning for stormwater capture.
Has activities to boost its connections with users, encouraging players at Fraserview Golf Course to embrace dormant, browning grass during the summer months

McCleery Golf Course

Situated near sensitive natural features, including wetlands and ponds.
Moderate tree canopy coverage, with flatter topography than Fraserview.
Irrigation demand varies, with some years showing extended high use into late summer. However, it has better water storage capacity than Fraserview.
Staff maintain strong relationships with players and communicate actively during course maintenance.

Langara Golf Course

High public visibility due to its up-to-date drainage system and uses no potable water to irrigate golf course.
Uses 100% groundwater for irrigation, so its water use patterns differ from the other two courses.
There is lower irrigation demand overall, but limited capacity for capturing stormwater.
Clear signage and staff engagement with players support public understanding of water use practices

Water Management Toolkit for Vancouver Municipal Golf Courses

Figure 16

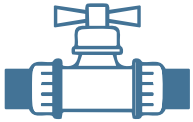
This toolkit includes suggestions for:

Enhancing The Irrigation System

Enhancing Water Storage Capacity and Quality

Improving Turf Conditions

Managing User Expectations



Enhancing Irrigation System

- **Prioritize irrigation system improvements in green areas**
- **Installation of new mainline pipes and sprinklers**
- **Hybrid Irrigation Piping Facilitates Off-Season Installation**

Enhancing Irrigation System: Prioritize irrigation system improvements in green areas

In golf course water management and daily maintenance, greens are the highest priority, followed by tee areas. When irrigation systems reach the end of their service life, typically after about 30 years, many golf courses choose to upgrade the system in phases. The first phase usually focuses on replacing irrigation pipes in the green and tee areas, where turf quality is most critical to playability and user satisfaction.

Time and Finance cost

2 months (depends on size of site)

Low-Moderate cost

Service and materials available locally

Area of Improvement

Green and Tee

The Green Areas in Golf Courses have the highest priority in water and maintenance.

Influence on Playability

Low

If upgrades are done in phases, the influence on playability is generally low to moderate.

Field Observations from Golf Courses

Langara Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Langara Golf Course has renewed its irrigation pipes in the green areas.
- In some areas, sprinklers are paired on a single pipe section, which makes it difficult to replace or repair when one part of the pipe or sprinklers is leaking.

McCleery Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Leaking issues were observed during the site visit.
- Staff hand-water the greens when necessary to maintain turf quality.
- Smaller spray heads have been installed in some tee areas to enhance irrigation efficiency as of summer 2025.

Fraserview Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Leaking issues were observed during the site visit.
- Staff hand-water the greens when necessary to maintain turf quality.

Enhancing Irrigation System

Butte Creek Country Club focused on targeted irrigation system upgrades, particularly around the greens, to optimize water use and enhance turf health in the most critical playing zones.

Key Improvements

Green and Tee

- New irrigation service line installed for green.
- Additional sprinkler heads (100–150 feet in front of greens) to improve coverage
- Installation of new piping of greens

Pros

Consistent turf quality on greens

Trigger more upgrades across course

Keep the course open during the upgrade

Cons

Current system is inadequate, causing uneven turf conditions

The construction crew needs to be flexible to deal with the weather and the course needs to be available for weekend events

Sourcing from
https://www.golfcourseindustry.com/article/irrigation-improvements/
https://www.linkedin.com/company/buttecreekcountryclub

Figure 17

Enhancing Irrigation System: Installation of new mainline pipes and sprinklers

In golf course water management, greens have the highest priority, followed by tee areas. As irrigation systems age, often reaching 30 years, many courses upgrade them in phases, starting with greens and tees. Fairways and roughs are usually not prioritized. When mainline pipes leak, it is difficult to isolate the issue, and irrigation on greens and tees often continues, even if water is being flushed out. While many courses focus first on greens and tees, some prioritize upgrading the mainline irrigation pipes to prevent widespread leakage and water loss.

Time and Finance cost

4 months (depends on size of site)

High cost

Service and materials available locally

Area of Improvement

Greens, Tees, Friways, Roughs

If the system is outdated, it may not be possible to isolate sections of the mainline during a leak. Upgrading the mainlines can improve water efficiency of entire golf course.

Influence on Playability

Moderate

If upgrades are done in phases, the influence on playability is moderate.

Some golf courses choose to offer players a discount when part of the course is closed.

Field Observations from Golf Courses

Langara Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- There are concerns about leaks along the mainlines, especially since the current system makes it difficult to isolate specific sections for repair.

McCleery Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Leaking issues were observed during the site visit.
- Staff were able to isolate the leaking line, but they expressed concern about potential leaks in the mainlines, which are much harder to isolate with the current system.

Fraserview Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Leaking issues were observed during the site visit.
- Fraserview Golf Course relies on potable water due to its large size and limited retention pond capacity, making water efficiency especially important.

Enhancing Irrigation System

Naperbrook Golf Course underwent a critical irrigation upgrade by prioritizing the installation of new mainline pipes and sprinklers, aiming to improve water efficiency, system reliability, and turf quality across the course.

Sourcing from
https://golfnaperville.org/naperbrook-golf-course-fall-irrigation-system-replacement-project/

Figure 18

Key Improvements

Greens, Tees, Friways, Roughs

- Replace original 1990 irrigation system to improve water efficiency and turf quality
- Green fee discounts applied when closures happen
- Minimal disruption to play during installation

Pros

Work mainly occurs in out-of-play areas and roughs.No full-course closures; limited hole impact

Prepares the course for later upgrades to lateral lines and sprinklers without redoing major groundwork

Discounts show the course values players' experience

Cons

Trenched areas may require monitoring and re-leveling after installation

If follow-up upgrades (like sprinkler installation) are delayed, the full benefits of new mainlines may not be realized soon

Enhancing Irrigation System: Hybrid Irrigation Piping Facilitates Off-Season Installation

Upgrading irrigation pipes can impact golf course operations to varying degrees, whether done in phases or all at once. Using a combination of PVC and HDPE pipes can help shorten installation time, as HDPE pipes can be installed even during winter months.

Time and Finance cost

6 months (depends on size of site)

High cost

Service and materials available locally

Area of Improvement

Greens, Tees, Friways, Roughs

The golf course will need to partially close during mainline upgrades. Installing HDPE pipes on lateral lines during the winter can help reduce disruptions to playability in the following season.

Influence on Playability

Moderate

If upgrades are done in phases, the influence on playability is moderate.
Some golf courses choose to offer players a discount when part of the course is closed.

Field Observations from Golf Courses

Langara Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Langara Golf Course has upgraded its underground drainage system across the entire site through a phased approach.
- Langara Golf Course has renewed its irrigation pipes in the green areas.

McCleery Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- When upgrading the irrigation system, a balance between providing good drainage to the soil and keeping the soil moist in summer is needed.

Fraserview Golf Course

- The irrigation pipes, approximately 30 years old, are beginning to show signs of leakage due to age.
- Fraserview Golf Course was highly active during the site visit due to its Free Golf Day for Women. This highlights the importance of considering impacts on playability when planning irrigation upgrades across the entire course.

Enhancing Irrigation System

In Phase One of its irrigation system renovation, The Ohio State University Golf Club replaced its aging PVC mainline with a hybrid piping system, combining HDPE pipe and PVC lateral connections. This action enables winter installation while enhancing long-term reliability.

Sourcing from
https://www.usga.org/content/usga/home-page/course-care/water-resource-center/bmp-case-studies/2018/hybrid-irrigation-piping-facilitates-off-season-installation.html
https://archive.lib.msu.edu/tic/usgamisc/cs/301194.pdf

Figure 19

Key Improvements

Greens, Tees, Friways, Roughs

- Full irrigation system redesign including new pump station
- Installation scheduled for Fall 2015–Spring 2016 to reduce disruption
- Irrigation uniformity and efficiency significantly improved

Pros

Hybrid system supports phased repairs

Hybrid piping system used:

PVC (≥4") for mainlines → open trenching

HDPE (≤3") for lateral lines → vibratory plow (allowed winter work)

Cons

Required coordinating two pipe materials and installation methods

Hybrid systems demand careful project management and contractor oversight

Enhancing Water Storage Capacity and Quality

- Containment Liners
- Native Grasses Help Save Water
- Solar-powered Pond Aeration
- Rainwater Harvesting: Small Scale
- Green Roof
- Stormwater Wetlands for Golf Courses
- Retention Pond to Detention Lake
- Underground Detention System
- Neighborhood Stormwater Reuse
- Sewer Mining for Golf Course Irrigation

Water Storage Upgrade: Containment Liners

Adding a liner to an existing retention pond on a golf course with sandy soil helps prevent water loss through infiltration. Liners create a barrier that improves water retention, supports consistent irrigation supply, and increases overall water use efficiency, especially in areas where sandy soils drain quickly.

Time and Finance cost

2-3 months (depends on size of site)

Moderate cost

Service and materials available locally

Area of Improvement

Retention Areas

Adding a liner to an existing retention.

Influence on Playability

Low

The upgrade only happens in the retention pond area without a liner.

Field Observations from Golf Courses

Langara Golf Course

- The retention ponds at Langara Golf Course do not have liners.
- The Langara Golf Course relies mainly on groundwater.
- Water seepage from the retention ponds may contribute to the replenishment of the underlying groundwater resources.

McCleery Golf Course

- McCleery Golf Course has one main retention pond and several smaller ponds, none of which are lined.
- The golf course uses multiple water sources for irrigation, including potable water.

Fraserview Golf Course

- With only one retention pond, the golf course relies heavily on potable water as its primary irrigation source.
- The retention pond has a liner.

Enhancing Water Storage Capacity and Quality

During the development of a golf course at Sylvan Resort in Gaylord, Michigan, the sandy soil posed a significant challenge for constructing water features. To retain water in designated pond areas, the resort installed custom-fabricated 20-mil PVC geomembrane liners, enabling the creation of three aesthetically pleasing and functional ponds.

Sourcing from
https://www.geomembrane.com/case-studies/golf-courses/containment-liners.html
https://westernliner.com/liner-materials/reinforced-polyethylene/

Figure 20

Key Improvements

Retention Areas

- Soil conditions required an alternative water containment method
- 20 mil PVC liner selected for its flexibility, durability, and water retention ability

Pros

Provided an effective water containment solution for sandy soil that couldn't naturally retain water

Liners were custom-fabricated to match each pond's irregular shape, improving fit and reducing waste

Cons

PVC liners may degrade over time with UV exposure if not properly covered or maintained

PVC welding and handling may be restricted in cold temperatures, limiting flexibility in some regions

Water Storage Upgrade: Native Grasses Help Save Water

Vegetation coverage and tree canopy around retention ponds help reduce evaporation by providing shade, which lowers water temperature and slows water loss. Additionally, plant roots stabilize the soil and filter runoff, thereby improving water quality by reducing the entry of sediment, nutrients, and pollutants into the pond.

Time and Finance cost

1-2 months (depends on size of site)

Low-Moderate cost

Service and materials available locally

Area of Improvement

Retention Areas

Adding vegetation coverage to an existing retention pond, needs 1–2 growing seasons to establish.

Influence on Playability

Low

The upgrade only happens around the retention pond area.

Field Observations from Golf Courses

Langara Golf Course

- The retention ponds collect water that is pumped from groundwater sources.
- The Langara Golf Course relies mainly on groundwater.
- A fountain was installed by staff to aerate the retention pond and increase oxygen levels in the water.

McCleery Golf Course

- The vegetation in the retention ponds and wetlands at this golf course is affected by invasive species.
- Beavers can disturb wetland vegetation and damage trees around the golf course.
- A fountain was installed by staff to aerate the retention pond and increase oxygen levels in the water.

Fraserview Golf Course

- The retention pond at Fraserview Golf Course collects runoff from Kerr Street, which passes through an underground filtration system before entering the pond.
- Tree canopy coverage is high on this golf course.

Enhancing Water Storage Capacity and Quality

The Lonnie Poole Golf Course at NC State University was designed with strong environmental sustainability principles. It includes wet ponds, natural wetlands, and a constructed stormwater wetland (CSW) that treats runoff from the course.

Sourcing from
https://content.ces.ncsu.edu/stormwater-wetlands-for-golf-courses
https://www.usga.org/course-care/water-resource-center/bmp-case-studies/2017/native-grasses-help-save-water.html

Figure 21

Key Improvements

Retention Areas

- Total nitrogen loads reduced by 47%
- Total phosphorus loads reduced by 59%
- Pollutant removal mainly achieved by internal wetland processes, not just volume reduction

Pros

Wetlands reduce outflow by evaporation, plant transpiration, and infiltration

The vegetation around and within stormwater wetlands helps reduce water loss

Built under strict environmental regulations protecting streams, buffers, and wetlands

Cons

Wetlands require ongoing monitoring and management to maintain ecological balance and prevent invasive species buildup

Standing water can create breeding grounds for mosquitoes, affecting player comfort, especially in warm months

Water Storage Upgrade: Solar-powered Pond Aeration

A solar-powered floating panel system can provide renewable energy for the golf course while also helping to reduce water evaporation. The innovative dual-purpose installation supports both energy self-sufficiency and water conservation goals. Unprotected solar panels within the range of play may sustain impact damage from golf balls, which can reduce panel efficiency, shorten lifespan, and increase maintenance costs.

Time and Finance cost

1-2 month once permits and equipment are ready

Moderate-high cost

The USA has well-established services and materials

Area of Improvement

Retention Areas

If not properly maintained, debris or oil from components could affect water quality.

Influence on Playability

Low

The upgrade only happens around the retention pond area.

Field Observations from Golf Courses

Langara Golf Course

- The retention ponds collect water that is pumped from groundwater sources.
- Langara has the best resource for groundwater among the three golf courses.
- There is currently no measurement of preventing water evaporation from the retention pond.

McCleery Golf Course

- The vegetation in the retention ponds and wetlands at this golf course is affected by invasive species.
- Beavers can disturb floating solar panel installations, especially if the system is placed in natural or semi-natural ponds where beavers are active.
- There is currently no measurement of preventing water evaporation from the retention pond.

Fraserview Golf Course

- Tree canopy coverage is high on this golf course.
- The upgrade of the retention pond should not disturb Vivian Creek.
- The retention pond is located next to a Tee and is quite open, making it visible to players. Therefore, aesthetic considerations should be taken into account when planning the installation.

Enhancing Water Storage Capacity and Quality

The Preserve Golf Club in Carmel Valley has implemented a solar-powered floating panel system to provide renewable energy for the golf course, while also helping to reduce water evaporation. This innovative dual-purpose installation supports both energy self-sufficiency and water conservation goals.

Key Improvements

Retention Areas

- 1,178 floating panels installed by Applied Solar Energy company
- Provide about 80% of electricity to the golf course, clubhouse, and comfort stations
- Panels provide shade to reduce water loss from the pond

Pros

Minimal land use impact (uses pond surface)

Renewable energy and evaporation reduction

Enhances sustainability credentials of the golf course

Cons

Limited to courses with suitable pond size and solar exposure

Initial cost is High

Panels are hard to recycle. If landfilled, they can leach harmful chemicals

Sourcing from
https://golfbusinessnews.com/news/innovation-centre/solar-installation-puts-golf-club-on-path-to-self-sustainability/

Figure 22

Water Storage Upgrade: Small Scale Rainwater Harvesting

Roof structures on driving ranges and clubhouse buildings can be designed to collect rainwater by directing runoff into gutters, filters, and storage tanks for later use in irrigation. A simple roof collection system utilizes standard roofing with drainage. In contrast, a green roof incorporates soil and vegetation layers that absorb rainfall, slow runoff, and improve water quality before any excess is collected. Green roofs also provide insulation and aesthetic benefits, but are more complex and costly to install.

Time and Finance cost

1-2 months for simple structure on roof, 3-4 months for Green roof

Low cost for simple sturcture on roof to collect water, higher cost for green roof

Service and materials available locally

Area of Improvement

Clubhouse and Driving range

Upgrading roof structures and adding a ground-level or underground storage tank can help capture rainwater or divert it to the existing retention pond.

Influence on Playability

Moderate

The upgrade only happens around the clubhouse and driving range.

Field Observations from Golf Courses

Langara Golf Course

- Even though Langara Golf Course relies mainly on groundwater, the superintendent emphasized during the site visit that every bit of water counts.
- The clubhouse roof currently has no structure in place to collect rainwater.

McCleery Golf Course

- The clubhouse roof currently has no structure in place to collect rainwater.
- Rainwater is one of the sources that supply the retention pond.

Fraserview Golf Course

- The clubhouse roof currently has no structure in place to collect rainwater.
- The golf course needs additional space for water collection, as it currently relies heavily on potable water.

Enhancing Water Storage Capacity and Quality

Portmore Golf Park in Barnstaple implemented a cost-effective rainwater harvesting system to reduce water use and promote sustainability. By capturing rainwater from rooftops and reusing it on-site, they significantly reduce water bills and enhance operational efficiency.

Sourcing from
https://golfcourse2030water.com/solutions/44
https://golfcourse2030water.com/case-studies/22

Figure 23

Key Improvements

Clubhouse and Driving range

- Rainwater harvesting from driving range roof (550 m²); Supplies 1–1.5 m³/day
- Club is self sufficient for water apart from drinking water for clubhouse and kitchen use/washing.

Pros

Provides free, sustainable water for flushing toilets and washing balls

Less dependency on mains water; supports water conservation goals

Storage tanks in roof space; overflow redirected to lake system

Cons

Integration of roof runoff, tanks, and filter beds may require skilled design and installation

Not suitable for drinking or kitchen use, still partially reliant on external water supply

Enhancing Water Storage Capacity and Quality

At Richmond Park Golf Club in London, a green roof was installed on the clubhouse as part of a broader sustainability initiative. The project aimed to blend the building into the surrounding landscape, enhance biodiversity, and reduce stormwater runoff while improving thermal insulation and visitor experience.

Key Improvements

Clubhouse and Driving range

- Blend with the surrounding acid grassland ecosystem
- Minimize visual and ecological disruption and support local biodiversity
- Improved insulation and stormwater management

Pros

The roof absorbs and stores water in its substrate and vegetation, gradually releasing it through evapotranspiration

The selected plants and acid grassland turf are low-water-use species adapted to local dry periods

The green roof helps improve the quality of runoff entering adjacent ecosystems

Cons

Higher upfront design/testing cost

During long dry periods, the roof may not retain enough moisture for plant health without supplemental water

Sourcing from
https://golfcourse2030water.com/solutions/19
https://ecogreengroup.co.uk/2024/02/20/richmond-park-golf-club-case-study/

Figure 24

Water Storage Upgrade: Stormwater Wetlands for Golf Courses

In low-lying areas, integrating wetlands and retention ponds into golf course design helps manage excess runoff, reduce flooding, and improve water quality. These systems also help lower the water table and redirect surface water, reducing soggy turf conditions and improving playability. When new wetlands and channels are added, they can enhance the overall retention system by increasing storage capacity and slowing runoff.

Time and Finance cost

3-4 month (depending on size)

Moderate-high cost

Service and materials available locally

Area of Improvement

Retention Areas

Creating new wetlands and channels enhances the overall retention system by increasing water storage capacity, improving flow distribution, and providing natural filtration.

Influence on Playability

Moderate to High

The upgrade involves excavating new wetlands and channels, which may occupy parts of the play area both during construction and after the upgrade is complete.

Field Observations from Golf Courses

Langara Golf Course

- This golf course does not currently have a wetland system as part of its drainage or retention infrastructure.
- The Langara Golf Course relies mainly on groundwater.
- There is a swale to collect surface runoff

McCleery Golf Course

- McCleery Golf Course has one main retention pond and several smaller ponds and wetlands. There are pipes to control the leveling, but the Fraser River's fluctuating water level still poses a threat.
- The golf course collects seepage and surface runoff from the adjacent Marine Drive Golf Club.

Fraserview Golf Course

- This golf course does not currently have a wetland or canal system as part of its drainage or retention infrastructure.
- Fraserview Golf Course currently has only one retention pond, and any future planning for the retention system should ensure that Vivian Creek, which runs along the west side of the course, is not disturbed.

Enhancing Water Storage Capacity and Quality

Golf courses across North Carolina have adopted stormwater wetlands as a sustainable solution to manage runoff, improve water quality, and enhance course resilience. These wetlands were strategically placed in low-lying or eroded areas, existing ponds, or near primary drainage outlets.

Sourcing from
https://content.ces.ncsu.edu/stormwater-wetlands-for-golf-courses#section_heading_9264
https://www.hillendalecc.com/

Figure 25

Key Improvements

Retention Areas

- Provide water storage away from playing areas.
- Improve water quality by filtering nutrients and solids. Improve drainage response, reducing course downtime after rain.

3-4 month (depending on size)

Moderate-high cost

Pros

Reduces runoff and flooding by storing stormwater during peak flows

Minimizes water outflow through evaporation and transpiration, potentially reducing irrigation demand

Improves drainage response, reducing course closures after rainfall

Cons

Requires upfront planning and coordination with designers and superintendents

Seasonal variation in water levels could affect visual appearance or ecological performance

Site Selection for Retention Ponds and Wetlands

Figure 26

Low-Lying Areas

Low-lying areas are landforms located at or near sea level, making them susceptible to flooding. These areas can include coastal regions, floodplains, and areas with poor natural drainage.

Figure 27

Drainage Outlets

Existing swales or channels are suitable for detention or treatment.

Figure 28

Retrofit Existing Ponds

Improve water quality and expand storage. Retrofitting is cost-effective and eco-friendly.

Figure 29

Eroding Ditches

Eroding ditches are common problems, in areas with heavy rainfall or steep slopes. Erosion can be caused by various factors, including excessive water flow, lack of vegetation, and poor soil composition. Convert to wetlands to stabilize and improve aesthetics/playability.

Sourcing from
https://content.ces.ncsu.edu/stormwater-wetlands-for-golf-courses#section_heading_9264
https://www.hillendalecc.com/

McCleery Golf Course is adjacent to the Fraser River

Figure 30

Water Storage Upgrade: Retention Pond to Detention Lake/Underground Detention System

Increasing storage can be achieved by converting an existing retention pond into a large detention area, which involves lowering or modifying the outlet structure, reducing the permanent pool, and grading banks to allow greater short-term stormwater storage before gradual release. Additional capacity can also be provided through an underground detention system, where large pipes, vaults, or modular units are installed beneath open spaces to store runoff temporarily and release it at a controlled rate.

Time and Finance cost

3-6 months for detention lake, 6-12 months for underground detention system

High cost

Service and materials available locally

Area of Improvement

Retention Areas

Retention system improvements may include extending the existing pond, adding a new detention lake, or installing an underground detention system.

Influence on Playability

Moderate to High

The addition of a new detention lake may reduce available space for play. In the case of an underground detention system, the construction process will require excavation of the selected area, which could temporarily impact course operations. The underground detention system will not influence playability after it is established.

Field Observations from Golf Courses

Langara Golf Course

- Even though Langara Golf Course relies mainly on groundwater, the superintendent emphasized during the on-site visit that there may be opportunities to collect and use stormwater as an additional resource.

McCleery Golf Course

- McCleery Golf Course collects runoff from Marine Drive, with a significant volume of water flowing through the site.
- Due to the site's topography, it is challenging to excavate a large detention area at McCleery Golf Course.

Fraserview Golf Course

- The upgrade of the retention pond should not disturb Vivian Creek.
- The golf course needs additional space for water collection, as it currently relies heavily on potable water.
- Planning for a new retention area should consider preserving existing trees.

Enhancing Water Storage Capacity and Quality

The project aimed to convert an existing retention pond into a detention lake, enhancing stormwater management while preserving playability. The detention lake was engineered with timed outflow structures to hold stormwater temporarily before controlled release, balancing hydrologic function with golf course aesthetics and usage.

Key Improvements

Retention Areas

- Reuse of stormwater for irrigation
- Reduced need for constant pumping from a deep well
- a small hilltop retention pond was replaced with a large detention lake in a low-lying area

Pros

Saved 7–8 million gallons/year in this case

Captures and holds stormwater runoff from both the golf course and the nearby airport

Converted a grassy out-of-play area (previously mowed) into water

Cons

High investment required to construct a 3.85-acre lake

Large open water surfaces can increase water loss unless mitigated

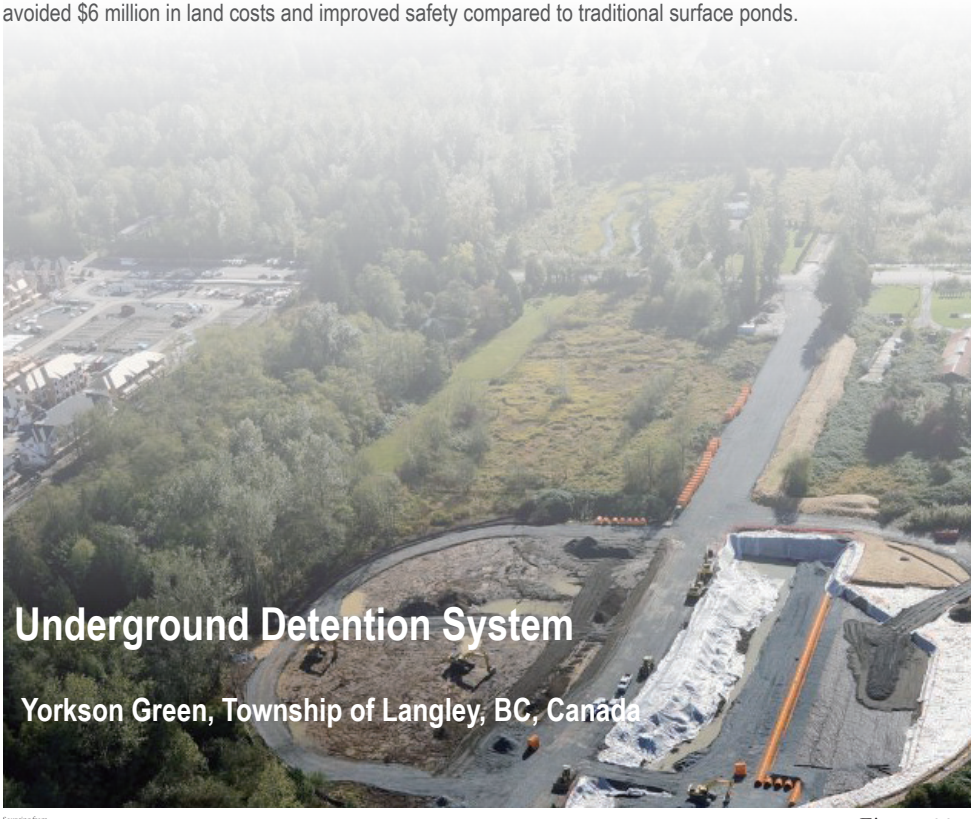
Possible play disruption during excavation and drainage installation

Sourcing from
https://asgca.org/wp-content/uploads/2018/02/Water_Golf_Vol-II_LR.pdf
https://www.golfpass.com/travel-advisor/courses/22921-the-country-club-of-oxford

Figure 31

Enhancing Water Storage Capacity and Quality

Designed by McElhanney, this project combines one of Canada's largest underground stormwater detention systems (21,200 m³) with natural grass soccer fields in Yorkson Green Park, Langley, BC. The innovative design enabled the system to manage runoff from a 56-hectare development while conserving land, reducing costs, and preserving public access to the surface. By integrating the facility beneath the park, the project avoided $6 million in land costs and improved safety compared to traditional surface ponds.



Sourcing from
https://www.canadianconsultingengineer.com/awards/pdfs/2020/C-10_McElhanneyDualUseStormwaterFacility.pdf
https://www.mcelhanney.com/project/yorkson-stormwater-detention/

Figure 32

Key Improvements

Retention Areas

- Eliminated the need to purchase additional land (saving ~$6M)
- Reduced construction costs by ~$1M
- Releases cooler, oxygenated water into Yorkson Creek, benefiting salmon spawning and improving creek ecosystem health

Pros

No algae growth like in surface ponds

One of the largest underground systems in North America

The sports field remains fully usable during all storm events

Cons

Underground systems are typically more expensive to construct than surface ponds

Required precise engineering to address sediment buildup and pipe blockage risks

Modifying or upgrading the system in the future would require: disrupting the playing surface and excavating buried structures

Water Storage Upgrade: Neighborhood Greywater Reuse

Stormwater reuse involves capturing, treating, and storing runoff from urban areas for non-potable uses, such as golf course irrigation. Sewer mining extracts wastewater directly from municipal sewers, treats it on-site, and reuses it locally. In Canada, stormwater reuse is more common. In contrast, Australia has more advanced sewer mining systems, driven by long-term drought, strict water restrictions, and strong policy support for alternative water sources. These conditions make decentralized reuse solutions, such as sewer mining, more practical and widely adopted.

Time and Finance cost

6-12 month (depending on size)

High cost

Sewer mining is not widely used in Canada. Canada focuses more on centralized wastewater treatment and stormwater reuse than on decentralized sewer mining.

Area of Improvement

Creating new wetlands and channels enhances the overall retention system by increasing water storage capacity, improving flow distribution, and providing natural filtration.

Influence on Playability

Moderate

Upgrading the retention system may involve excavating new wetlands and channels within the golf course. In contrast, a sewer mining system would not disturb the course, as it operates independently from the surface layout.

Field Observations from Golf Courses

Langara Golf Course

- The superintendent emphasized during the on-site visit that there may be opportunities to collect and use more stormwater as an additional resource.
- Langara Golf Course uses a bioswale and a lower pond to slow, filter, and release stormwater back to the system. Some runoff from the upper course is diverted into the irrigation pond for reuse.

McCleery Golf Course

- McCleery Golf Course receives significant water flow and needs more space to manage runoff and fluctuations in the adjacent river's water table.
- The golf course collects seepage and surface runoff from the adjacent Marine Drive Golf Club.

Fraserview Golf Course

- During the wet season, water from the retention pond is gradually released back into the stormwater system.
- At Fraserview Golf Course, stormwater is diverted from Kerr Street through an oil separator before entering the irrigation pond. This system helps slow the flow of stormwater along Kerr Street and improves water quality before reuse.

Enhancing Water Storage Capacity and Quality

This project involved building stormwater harvesting systems at Eagle Valley and Prestwick Golf Clubs in Woodbury, Minnesota. Funded by the South Washington Watershed District and Clean Water Fund, the system collects runoff from surrounding neighborhoods, roads, and the golf courses, storing it in large ponds for irrigation reuse.

Sourcing from
https://stormwater.pca.state.mn.us/index.php/Case_studies_for_stormwater_and_rainwater_harvest_and_use/reuse
https://www.golfpass.com/travel-advisor/courses/8460-eagle-valley-golf-course

Figure 33

Key Improvements

Neighborhood

Retention Areas

- Manage stormwater from road and neighborhoods
- Conversion of existing ponds into large centralized storage ponds. Neighborhoods benefit by reduced runoff and cleaner water entering nearby lakes

Pros

Reuses up to 40 million gallons of stormwater annually, reducing reliance on groundwater aquifers

Supports broader green-blue infrastructure and water reuse goals of the city

Reduces environmental footprint by using existing ponds and natural slopes

Cons

Pump systems still use energy, though less than pumping from deeper aquifers

Careful hydrological modeling and site planning needed to balance playability and storage needs

Enhancing Water Storage Capacity and Quality

Pennant Hills Golf Club has built a water reclamation plant extracts and treats wastewater directly from the sewer system that produces up to 100 million liters of recycled water annually for irrigation. Before this, the course used drinking water. It was the first sewer mining project of its kind at a privately run golf club in Australia.

Key Improvements

Neighborhood

Retention Areas

- Annual Output up to 100 million litres of recycled water.
- Using local sewage system (greywater extraction and treatment)

Pros

Reduces reliance on municipal potable water, aligns with circular water economy

Supports NSW Metropolitan Water Plan and Water Industry Competition Act

Captures nutrients that would otherwise enter waterways, improving watershed health

Cons

Initial setup, treatment plant, and infrastructure require high investment

If not managed properly, may cause local odour nuisances

Needs regular system monitoring, maintenance, and skilled operation

Sourcing from
https://www.golfnsw.org.au/golf-clubs/pennant-hills-golf-club/
https://www.golfpass.com/travel-advisor/courses/8460-eagle-valley-golf-course
https://www.sydneywater.com.au/content/dam/sydneywater/documents/guideline-sewer-mining-how-to-set-up-a-sewer-mining-scheme.pdf

Figure 34

Improving Turf Conditions

- Establishing Warm-Season Grasses
- Coco Peat
- Hybrid Grass Technology
- Cocoturf

Improving Turf Conditions: Establishing Warm-Season Grasses

Establishing warm-season grasses in Vancouver golf courses involves testing drought-tolerant species to reduce summer irrigation needs. The focus is typically on greens and tees. A key challenge is that grasses suited to dry conditions often struggle to adapt to heavy rainfall common in the region.

Time and Finance cost

4 months

High cost if change of grass is for entire site

Service and materials available locally

Area of Improvement

Greens, Tees, Friways, Roughs

The establishment of warm-season grasses is typically limited to greens and tee areas, where improvements can reduce water use, enhance drought tolerance, and lower maintenance demands.

Influence on Playability

Moderate

Establishment may involve temporary play disruptions during the grow-in.

Field Observations from Golf Courses

Langara Golf Course

- Greens are planted with Poa annua and Bentgrass, while tees use a mix of Poa annua, Perennial Ryegrass, and Bentgrass.
- These grasses require extra maintenance during hot, dry periods, and staff often hand-water the greens to maintain turf health.

McCleery Golf Course

- Greens are planted with Poa annua and Bentgrass, while tees use Poa annua and Perennial Ryegrass.
- These grasses require extra maintenance during hot, dry periods, and staff often hand-water the greens to maintain turf health.

Fraserview Golf Course

- Greens are planted with Poa annua and Bentgrass, while tees use Poa annua and Perennial Ryegrass.
- These grasses require extra maintenance during hot, dry periods, and staff often hand-water the greens to maintain turf health.
- The superintendent mentioned exploring grass species used in Kamloops, a region with dry summers and cold winters, to see if they could successfully establish at this site.

Improving Turf Conditions

The Virginia Country Club in Long Beach replaced its inconsistent mix of warm and cool-season grasses with drought-tolerant bermudagrass to enhance playability and reduce water usage. The 110-day renovation included spraying out the old turf, tilling organic matter back into the soil, sodding the fairways, hydroseeding the roughs, and upgrading the greens.

Key Improvements

Greens, Tees, Friways, Roughs

- Full turf renovation during a 110 day course closure
- Greens converted to a more heat- and drought-tolerant bentgrass
- Reflects a trend in Southern California golf courses shifting to hybrid bermudagrass for sustainability and cost-effectiveness

Pros

High reduction in water usage due to drought-tolerant bermudagrass and bentgrass

Recycled organic matter improved soil structure and reduced compaction

Lower irrigation and maintenance needs over time

Cons

110 day shutdown impacted revenue and golfer access

Success tied to warm Southern California conditions but less applicable in cooler or wetter regions

Sourcing from
https://www.vcc1909.org/golf
https://www.usga.org/content/usga/home-page/course-care/water-resource-center/bmp-case-studies/establishing-warm-season-grasses-to-improve-playability-and-drou.html

Figure 35

Online Resources and Guides for selecting grass species for golf courses

Selecting Grasses for Golf Courses in Cold Climates from USGA

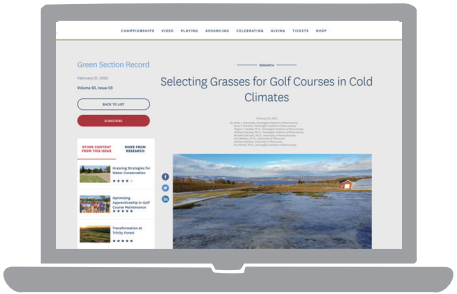


Figure 36

To help golf course superintendents in cold climates select turfgrass species and varieties that require minimal fungicide use, improving sustainability and reducing costs.

Link

https://www.usga.org/content/usga/home-page/course-care/green-section-record/63/issue-03/selecting-grasses-for-fungicide-free-golf-courses-in-cold-climat.html

Golf Course 2030 Grass Selection Guide Handbook for Sustainable Golf Courses

Figure 37

This guide emphasizes choosing turfgrass based on local climate, resource availability, and course use. It recommends matching grass types to temperature and rainfall patterns, prioritizing drought-tolerant and pest-resistant species to reduce inputs. Selecting the right grass improves sustainability, playability, and maintenance efficiency.

Link

https://assets-us-01.kc-usercontent.com/c42c7bf4-dca7-00ea-4f2e-373223f80f76/b0923312-4cfd-4595-a6bc-271e0d87aa3e/Grass%20Selection.pdf

Improving Turf Conditions: Coco Peat

Adding organic matter like coco peat to golf course soils helps improve water retention and soil structure, encouraging grasses to develop deeper root systems for better drought resilience and turf health. Applying coco peat to sandy soil helps improve its water-holding capacity by increasing organic content and moisture retention.

Time and Finance cost

1-3 months

Low-Moderate cost

Service and materials available locally

Area of Improvement

Green and Tee

Applied only to greens and tees on golf courses. These areas receive the most maintenance attention and are prioritized for soil improvement to enhance turf health, water retention, and playability.

Influence on Playability

Moderate

Adding coco peat to soil may slightly influence playability in the short term, especially if applied to playing surfaces like greens or tees during active use.

Field Observations from Golf Courses

Langara Golf Course

- Current methods to improve soil quality and support turf health include using soil wetting agents to help water move more efficiently into the root zone and retain moisture. Cultural practices such as venting and aeration also improve water and air movement within the soil.
- The soil is primarily sandy, which drains quickly and retains less moisture.
- Soil wetting agents are applied on greens, and tees.

McCleery Golf Course

- Current methods to improve soil quality and support turf health include using soil wetting agents to help water move more efficiently into the root zone and retain moisture. Cultural practices such as venting and aeration also improve water and air movement within the soil.
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Fraserview Golf Course

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- The soil is primarily sandy, which drains quickly and retains less moisture.
- Soil wetting agents are applied on greens, tees, and fairways.

Improving Turf Conditions

Greens built with coco peat mixed into sand need less water, nutrients, and maintenance. It also helps reduce runoff and works well in hot climates.

Figure 38

Key Improvements

Green and Tee

- Coconut coir provided a sponge-like matrix aiding moisture, air, and nutrient retention
- 1% organic fiber treatments (including coir) enhanced water infiltration for 6 months post-installation

Pros

Provides better moisture balance and high infiltration, combines retention with drainage

Stronger root systems, reducing compaction

Environmentally friendly and reduces nutrient leaching and runoff

Cons

Even top-grade coco peat may contain salts, pre-washing or buffering is necessary

Field-scale, long-term golf course studies are limited, most applications are small-scale or commercial

Sourcing from
https://onlinelibrary.wiley.com/doi/full/10.1002/ttz2.107
https://purecocopeat.com/pages/about-coco-peat
https://boyceagro.com/cocopeat-for-green-turf-construction.html

Improving Turf Conditions: Hybrid Grass Technology

Hybrid turf technology blends natural grass with synthetic fibers to enhance durability and reduce maintenance in high-traffic areas of golf courses. While it improves playability and surface stability, some concerns remain about its environmental impact due to the use of plastics. As a more sustainable alternative, coco turf, made from natural coconut fibers, offers a biodegradable and low-maintenance solution that reduces water use and environmental harm.

Time and Finance cost

1-3 months

Moderate-high cost

The UK currently leads in both materials and installation techniques due to broader adoption in sports fields and more mature supplier networks.

Area of Improvement

Green and Tee

Applied only to greens and tees on golf courses. These areas are also smaller and easier to manage, which helps offset the higher installation cost of hybrid systems.

Influence on Playability

Low

The installation process will temporarily affect greens and tees, but the impact is short-term. Once completed, hybrid turf blends with natural grass and allows for quick recovery and continued play.

Field Observations from Golf Courses

Langara Golf Course

- The tee areas exhibited uneven turf conditions, caused by frequent swings, with visible patches of exposed soil where the grass cover had worn away.
- The soil is primarily sandy, which drains quickly and retains less moisture.
- Soil wetting agents are applied on greens, and tees.
- Green areas require hand watering during the summer to maintain adequate moisture levels.

McCleery Golf Course

- The tee areas exhibited uneven turf conditions, caused by frequent swings, with visible patches of exposed soil where the grass cover had worn away.
- The soil is primarily sandy, which drains quickly and retains less moisture.
- Soil wetting agents are applied on greens, and tees.
- Green areas require hand watering during the summer to maintain adequate moisture levels.

Fraserview Golf Course

- The tee areas exhibited uneven turf conditions, caused by frequent swings, with visible patches of exposed soil where the grass cover had worn away.
- The soil is primarily sandy, which drains quickly and retains less moisture.
- Soil wetting agents are applied on greens, tees, and fairways.
- Green areas require hand watering during the summer to maintain adequate moisture levels.

Improving Turf Conditions

SIS Pitches' hybrid grass technology, known as SISGrass Lite, was successfully trialled at Long Ashton Golf Club in Bristol, UK. The hybrid turf, featuring 90mm deep-stitched fibres, was installed on the tee of the par 3 13th hole. The goal was to improve surface consistency, durability, and appearance.

Sourcing from
https://www.sispitches.com/case-study/long-ashton-golf-club-benefits-from-sis-grass-hybrid/
https://www.longashtongolfclub.co.uk/

Figure 39

Key Improvements

Green and Tee

- Hybrid turf with 90mm deep synthetic fibre stitching
- the tee on the par 3 13th at Long Ashton has seen improved surface consistency and stability
- Fibres blend naturally into the grass

Pros

Quicker turf regeneration reduces labor-intensive repair

Improved stability and consistency of the surface regardless of weather or season

The 90mm stitching depth still allows for future renovations without full removal

Cons

Synthetic fibres can retain more heat than natural grass in hot climates (though minimal in the UK context)

Synthetic fibres can slowly release microplastics into the soil, especially with mowing, aeration, or foot traffic, which is a growing concern for sustainability-focused clubs

Improving Turf Conditions

CocoTurf is an eco-friendly playground surface composed of 100% natural coconut husk fibers and a natural rubber backing. Designed as a sustainable alternative to synthetic turf, it offers a safe, cushioned, and durable play area that is free from microplastics and harmful chemicals. It aims to create greener, healthier outdoor spaces while ensuring safety and comfort for users.

Sourcing from https://cocoturf.co.uk/

Figure 40

Key Improvements of coco turf

- Made from renewable coconut husks, a biodegradable agricultural by-product
- Reduces reliance on synthetic, plastic-based materials
- Provide a sustainable and safe alternative to traditional plastic or rubber playground surfaces

Pros

Made from coconut husk and natural rubber backing, free from microplastics and PFA

Non-toxic, cushioned surface ideal for playgrounds and recreational areas

Having cooler surface temperature compared to traditional artificial turf (52.4°C vs 69.8°C)

Cons

Fewer long-term case studies in golf courses and high-traffic public parks compared to synthetic turf systems

Natural and sustainable products often come with a higher installation price compared to synthetic turf

Managing User Expectations

- **Brown is The New Green**

Managing User Expectations: Brown is the New Green

"Brown is the New Green" is a water-wise approach that embraces natural turf color changes during dry seasons. Instead of overwatering to keep grass bright green, courses allow turf to go dormant, turning brown while staying healthy. This method saves water, supports sustainability, and maintains playable conditions without compromising turf health.

Time and Finance cost

1-3 months

Low-Moderate cost

Service and materials available locally

Area of Improvement

Clubhouse and Driving range

To encourage the "Brown is the New Green" mindset in the clubhouse, use clear informational signage and engaging digital slides or posters to help staff and players understand the benefits.

Influence on Playability

Low

Players may notice a firmer surface and faster ball roll, which some even prefer. The change is primarily visual and does not significantly affect the quality of play.

Field Observations from Golf Courses

Langara Golf Course

- During the site visit, a strong and friendly connection exists between the staff and players, marked by regular greetings and easy, ongoing conversations.
- Maintenance takes place between 4:30 and 6:00 a.m., minimizing any disruption to players.

McCleery Golf Course

- During the site visit, a strong and friendly connection exists between the staff and players, marked by regular greetings and easy, ongoing conversations.
- Maintenance takes place in the morning, with staff often engaging in friendly conversations with players as they work.

Fraserview Golf Course

- During the site visit, a strong and friendly connection exists between the staff and players, marked by regular greetings and easy, ongoing conversations.
- The superintendent shared that he has already been encouraging players at Fraserview Golf Course to embrace the use of brown grasses.
- Fraserview Golf Course was highly active during the site visit due to its Free Golf Day for Women.

Managing User Expectations

Embracing a natural aesthetic, Bernardus shifts away from the traditional lush look, encouraging golfers to appreciate brown, drier landscapes that require less water, chemicals, and mowing. Inspired by Scottish links courses on free-draining soils, their strategy reflects golf's origins and promotes firm, fast surfaces with minimal maintenance.

Sourcing from
https://bernardusgolf.com/news-and-events/is-brown-the-new-green

Figure 41

Key Improvements

Clubhouse and Driving range

- Inspired by traditional links courses, brown fairways offer a more strategic and challenging golf experience
- Bernardus positions itself as a role model for sustainable golf design and maintenance
- 50% of the course is managed as nature area, providing habitats for native flora and fauna

1-3 month

Low cost

Pros

Reduced irrigation needs by embracing drought-tolerant turf (e.g., fescue) and accepting brown coloration during dry periods

Educates players and the public on redefining what "healthy" turf looks like, brown can be beautiful and ecologically sound

Cons

Drier turf may still require localized irrigation or care during extreme droughts to maintain playability

Requires clear communication with members, guests, and maintenance teams to explain the ecological and play-related benefits

Online Decision-Making Tool

Figure 42

The tool works on both phone and computer, guiding users through a series of questions about golf course conditions to recommend solutions from the Toolkit.

Scan the QR code or copy the link to access

https://form.typeform.com/to/MR3Bnnzz

Summary of Current Practices – Objectives & Opportunities

Match the Objective and Opportunity

As large green spaces managed by the Vancouver Park Board, the city's championship golf courses play an important role in both ecology and recreation. Considering the goals outlined in Vancouver's Water Priority Action Plan (2023–2028), it is worth looking at how these courses already support some of the six strategic objectives, and where there is still room to improve. This section highlights how golf courses fit within the broader city strategy and explores opportunities to strengthen their contribution to long-term water sustainability.

There are six strategic objectives stated in Vancouver's Water Priority Action Plan (2023–2028) to improve water conservation.

1. Achieve Regulatory Compliance
Retrofit, convert, or remove non-compliant "once-through" features (fountains, ponds, spray parks), and prevent Fisheries Act violations.

2. Retrofit & Upgrade Systems
Install low-flow fixtures and pressure-reducing valves; develop a facility-upgrade schedule.

3. Nature-Based Solutions
Reduce irrigation through xeriscaping and site-specific plans; convert decorative water features into wetlands or green infrastructure.

4. Preventative Maintenance Program
Inventory all water infrastructure (features, piping, marinas, golf courses), then schedule lifecycle maintenance to avoid costly failures.

5. Water-Smart Design
Develop a Park Board-wide "water budget" to guide new park designs and redevelopments.

6. Interdepartmental Collaboration
Form a working group across Planning, Operations, REFM, and Engineering; engage community stewards; and launch a public-communications plan.

1. Achieve Regulatory Compliance

Fraserview Golf Course

Match the Objective

Lined pond with an oil separator, the position of the retention pond avoids creek disturbance.

Could Improve

There is no runoff quality monitoring, and the water quality in the retention pond is unclear.

McCleery Golf Course

Match the Objective

The multi-pond system, seasonal wetlands, had no fisher present during the site visit.

Could Improve

Fountains are located on the retention pond, but their purpose is to put oxygen into the water to improve its quality.

Langara Golf Course

Match the Objective

Uses only non-potable groundwater; bioswale filters runoff

Could Improve

Fountains are located on the retention pond, but their purpose is to put oxygen into the water to improve its quality.

2. Retrofit & Upgrade Systems

Fraserview Golf Course

Match the Objective

Plans to upgrade panels, pumps, and isolation valves.

Could Improve

However, the overall PVC pipes are more than 30 years old, and leaks on the mainlines are hard to isolate.

McCleery Golf Course

Match the Objective

Retrofit of sprinkler heads; targeted watering with new spray zones will be installed.

Could Improve

The overall PVC pipes are more than 30 years old, and leaks on the mainlines are hard to isolate.

Langara Golf Course

Match the Objective

Upgraded Osmac system and some pipe replacements

Could Improve

Green areas have new pipes. The pipes on the mainline for irrigation are more than 30 years old.

3. Nature-Based Solutions

Fraserview Golf Course

Match the Objective

Dense tree canopy shades turf, cutting evapotranspiration and irrigation demand. Rough and "Other Naturally Managed Areas" already exist around fairways.

Could Improve

Retrofit the retention pond into a planted wetland fringe to enhance infiltration and habitat. Add a bio-sswale to treat runoff.

McCleery Golf Course

Match the Objective

On-site seasonal wetlands function as natural retention/infiltration features. Naturally managed buffer zones around ponds support habitat.

Could Improve

There are invasive plant species near the ponds. When plants die back, they release large amounts of nitrogen and phosphorus, which can trigger algal blooms and further oxygen depletion.

Langara Golf Course

Match the Objective

A large bioswale collects and filters runoff. Two ponds are integrated with groundwater recharge rather than being purely decorative.

Could Improve

Instead of a fountain, native plants and floating ecosystems can improve the water quality of retention ponds.

4. Preventative Maintenance Program

Fraserview Golf Course

Match the Objective

Leaking pipes will be isolated immediately by the staff. Irrigation infrastructure and soil moisture are monitored.

Could Improve

Irrigation PVC pipes need upgrading.

McCleery Golf Course

Match the Objective

Leaking pipes will be isolated immediately by the staff. Irrigation infrastructure and soil moisture are monitored.

Could Improve

Irrigation PVC pipes need upgrading.

Langara Golf Course

Match the Objective

Upgraded Osmac system. Irrigation infrastructure and soil moisture are monitored.

Could Improve

Irrigation PVC pipes on mainlines need upgrading.

5. Water-Smart Design

Fraserview Golf Course

Match the Objective

Tracks annual potable use (dropped from 54,605 m^3 in 2021 to 38,308 m^3 in 2024). Superintendent discusses capturing more runoff to meet irrigation needs.

Could Improve

Need to capture more water and need more space for retention.

McCleery Golf Course

Match the Objective

Monitors potable use (33,808 m^3 → 20,612 m^3 from 2021 to 2024). Uses multiple water sources (rain, groundwater, seepage) and understands relative contribution.

Could Improve

Much water goes through the site. It needs more space to manage its water resources and raise the water table of the Fraser River.

Langara Golf Course

Match the Objective

Completely transitioned to non-potable irrigation. Installed a new control system (Osmac) for precise meter-based scheduling.

Could Improve

Capturing more stormwater could reduce reliance on aquifers.

6. Interdepartmental Collaboration

Fraserview Golf Course

Match the Objective

Superintendent supports water conservation discussions with players.

Could Improve

"Brown is the New Green" could be a regular activity at golf courses to promote sustainability.

McCleery Golf Course

Match the Objective

Staff communicate well with players during maintenance.

Could Improve

Natural features offer potential for community stewardship.

Langara Golf Course

Match the Objective

Clear signage promotes 100% non-potable water use.

Could Improve

While signage is strong, Langara could host seasonal events to build public awareness.

Conclusion

Overall, the three championship golf courses share several opportunities to become more water-wise:

Upgrading irrigation infrastructure, such as using adjustable sprinkler heads to match plant types and micro-zone needs.
Enhancing on-site water storage and reuse.
Improving turf resilience by testing hybrid grass cultivars or artificial turf in high-traffic areas such as the Tees.
Retrofitting low points with swales or French drains to direct runoff into storage features and habitat areas.
In addition, regular activities could help share with players the message that “brown is the new green.”

The overall aspects of improvement based on current conditions of golf courses match these objectives of Vancouver's Water Priority Action Plan (2023–2028):

Retrofit & Upgrade Systems
Install low-flow fixtures and pressure-reducing valves; develop a facility-upgrade schedule.

Nature-Based Solutions
Reduce irrigation through xeriscaping and site-specific plans; convert decorative water features into wetlands or green infrastructure.

Water-Smart Design
Develop a Park Board-wide "water budget" to guide new park designs and redevelopments.

Interdepartmental Collaboration
Form a working group across Planning, Operations, REFM, and Engineering; engage community stewards; and launch a public-communications plan.

Recommendations for Improvement

Identify Areas for Detention System

Based on site findings and discussions with the superintendent at Fraserview Golf Course, a significant amount of water flows through the site. However, the course lacks sufficient storage capacity to meet irrigation demands during the summer months. To address this, surface runoff patterns and the alignment of Vivian Creek were analyzed to identify potential locations for underground water storage. This approach aims to increase water capture without disrupting play or compromising the site's extensive tree canopy.

Legends and Annotations

The direction of water movement, water will be collected by the bio-swale and then go into the underground detention space.

Underground detention areas will not disturb golf play when fully established

Vivian Creek Mainstream, the improvement of the golf course should not disturb the Vivian Creek

Bio-swale, the space will collect runoff from topography

Vivian Creek Seasonal Stream, the dashed lines are seasonal

Surface runoff, water's movement on this land due to changes of topography

Detention System Site Options

Bio-swale and underground detention space option A

On the northern side of the golf course, there will be a bio-swale to collect runoff from adjacent Rosemont Dr. The new swale occupies some no-play rough area. The water will go into the underground detention system from the bio-swale.

Bio-swale and underground detention space option B

A bioswale and detention system are placed on the east side of the golf course. The swale will collect surface water mainly from inside the golf course and store water in the underground detention space for irrigation needs.

Surface Runoff and Potential Sites for New Retention Areas

Bioswale Option A: The bio-swale will capture runoff from Rosemont Drive on the North side of the Fraserview Golf Course.

Underground Detention Option A: The detention chamber underground will store water collected from the bioswale option A, and feed the retention pond during the dry season.

Bioswale Option B: The bio-swale will capture surface water from the topography change of the golf course.

Underground Detention Option B: The detention chamber underground will store water collected from the bioswale option B and outflow of the retention pond. It will feed the retention pond during the dry season.

Figure 43

Conceptual Plan for Potential Improvements

Greens

Add organic matter such as Coco Peat. Establish warm-season grass if there is time before the golf season to overseed.

Tees

Using Hybrid Turf Technology on the Tee areas to reduce patches and scars.

Clubhouse& Driving Range

Using Small-scale Rain Harvesting Structures to collect water from the roofs of the clubhouse and the driving range, and store water in tanks.

Retention Pond

Can add Native aquatic plants in floating islands to the retention pond to clean up the water.

Underground Detention System

Bio-swale is connected to the underground detention system to collect surface runoff.

The Underground Detention System captures runoff from the bioswale, then discharges it into the municipal stormwater network if the system is full.

Irrigation System

Irrigation pipes are about 30 years old. These pipes will need to be replaced. The operation can progress in phases.

Figure 44

Forest and Other Naturally Managed Areas

Fairways

Rough

Sand Trap

Pond and Water Bodies

Pathways and Parking Lot

These recommendations are based on site conditions observed at Fraserview Golf Course during the summer of 2025. Given the number of areas that have potential for improvement, a phased implementation approach is suggested to minimize disruption to playable areas.

Images of Precedents

Details about the proposed underground detention system and floating island will be provided on the following page.

Organic matter in soil Figure 46

Hybrid Turf Technology Figure 47

Small-scale Rain Harvesting

Figure 48

Bio-swale

Figure 49

Conceptual Renders: Underground Detention System

The diagram explains how the system works when the underground detention chamber connects to the bio-swale: runoff water will be collected by the swale, directed to the detention chamber. When the chamber is full, water will enter the multicile sewer system, or feed the retention pond in dry summer.

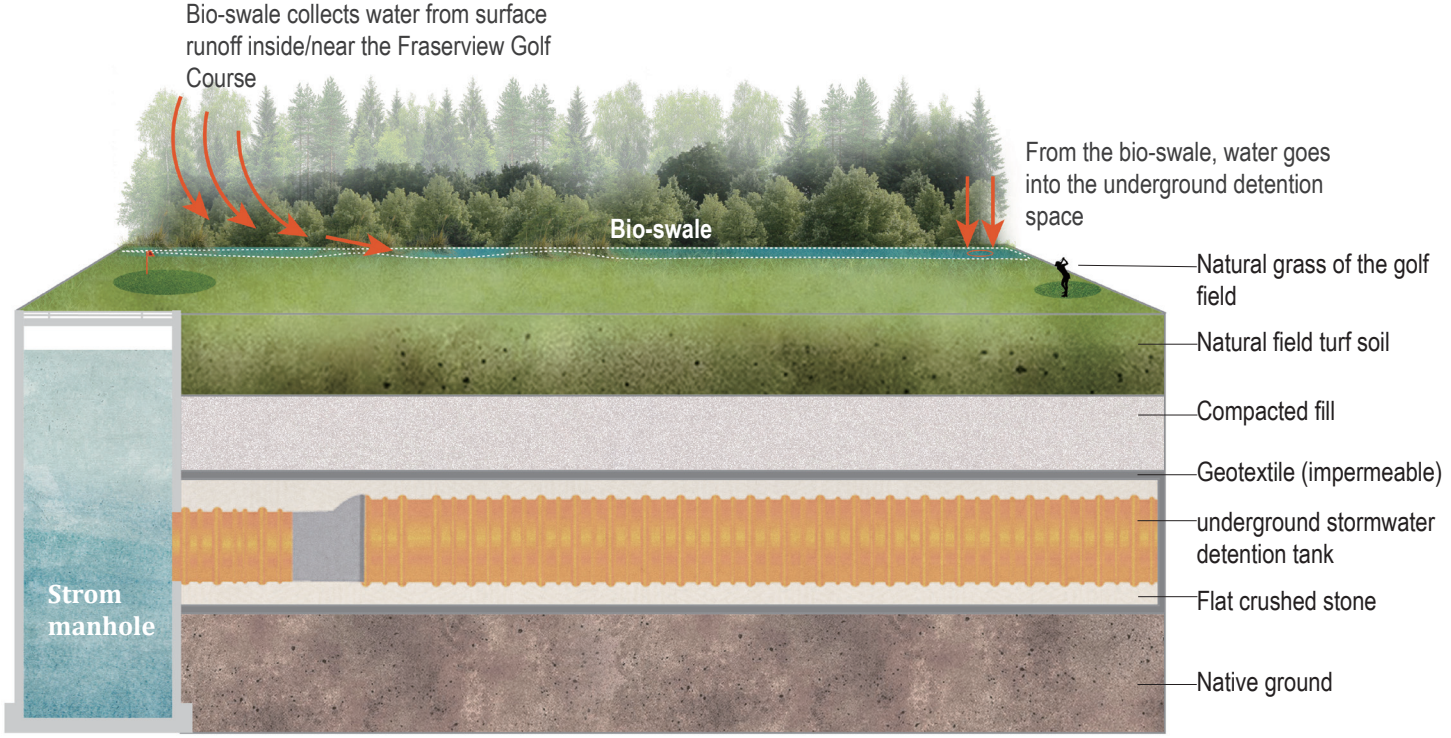

Figure 50

The system will not disturb the play area once established

Conceptual Renders: Floating Wetland On A Retention Pond

The diagram shows that adding a floating wetland to the existing retention pond of Fraserview Golf Course can improve its water quality. When the site has plenty of tree canopy and Vivian Creek, better water quality is important for this potential habitat. In some cases, floating wetlands can help reduce evaporation when they partially cover a retention pond. In this case, because the pond is located near an area already shaded by tree canopy, the floating island is designed primarily for water treatment rather than evaporation control.

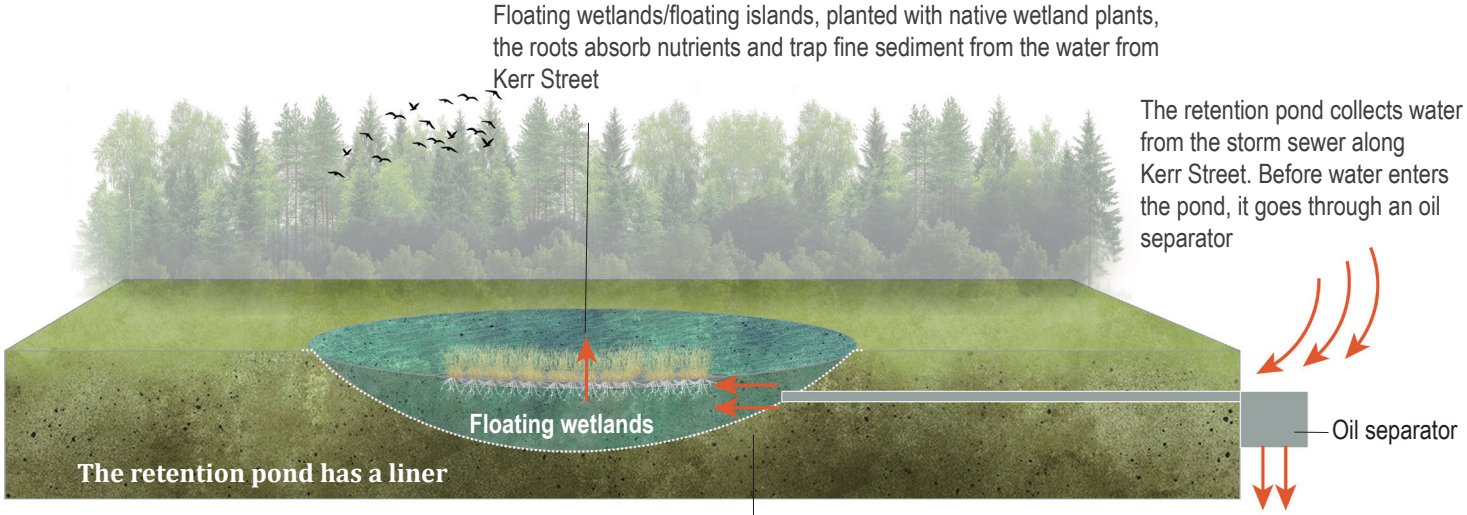

Figure 51

Preliminary Cost Estimate Based on Conceptual Plan

Figure 52

	Estimated space/size based on data from the COV GIS team
Greens	12,783.6 m²
Tees	10,944 m²
Underground Detention System Option A	Bio-swale: 3,096 m² Detention space: 10,376 m²
Clubhouse& Driving Range Roof	Clubhouse: 696.6 m² Driving Range: 615.6 m²
Retention Pond	6,061 m²
Underground Detention System Option B	Bio-swale: 1,609 m² Detention space: 10,385 m²
Bio-swale	
Proposed Underground Detention Area	

* The areas are estimated based on a 1:6000 plan from the GIS database of the City of Vancouver. It is hard to estimate the length of irrigation pipes, so the cost estimate does not include the upgrade of the irrigation system.

Potential Upgrade Area	Cost per m²: Construction and Maintenance		Overall Construction and Maintenance Cost	
	Construction	Maintenance	Construction	Maintenance
Greens Add organic matter such as cocopeat 12,783 m²	5 cm application depth per m² CA $2.00 ●	4-year maintenance per m² $1. – $1.9	CA $25,567	CA $13,668 to CA $24,024
Tees Using hybrid turf technology 10,944 m²	Artificial grass CA$79 to CA$291 per m² for materials and installation ●	Lasts 8–12 years , replacement cost is close to the initial installation cost.	At least CA $864,576	
Underground Detention System Option A Bio-swale: 3,096 m² Detention space: 10,376 m²	Bioswale ● ~$59–$258 CAD per m² * Cost of underground detention is missing	Bioswale ~$0.6–$2.3 CAD per m² yearly	CA $182,664 to CA $798,768	CA $2,012 to CA $6,997
Clubhouse& Driving Range Roof Clubhouse: 696 m² Driving Range: 615 m²	Blue roof ● $14-29 CAD/m² Green roof ● $144-346 CAD/m²	The ongoing maintenance cost of a blue roof is minimal Green roof $3.0-4.5 CAD/m²/year	Blue roof, CA $18,878 to CA $37,756 Green roof, CA $188,735 to CA $453,553	Green roof CA $3,933 to CA $5,846
Retention Pond 6,061 m² 54 m² is size of floating island * Based on case studies and data from the International Institute for Sustainable Development (IISD) in Canada, a retention pond collecting stormwater requires approximately 0.9% of its surface area to be covered by floating wetlands in order to improve water quality.	floating island cost CA $505/m²	5–10% of installation cost each year The cost is based on the usual wetland maintenance cost	CA $27,552	CA $1,377 to CA $2,755
Underground Detention System Option B Bio-swale: 1,609 m² Detention space: 10,385 m²	Bioswale ● ~$59–$258 CAD per m² * Cost of underground detention is missing	Bioswale ~$0.6–$2.3 CAD per m² yearly	CA $94,931 to CA $415,122	CA $1,045 to CA $3,636

● The services and materials are available in Canada

Conclusion to Recommendations for Improvement

Overall, Fraserview Golf Course has strong potential to improve its irrigation system, expand water storage capacity, enhance water quality, and manage users' expectations. Since the course already hosts different weekly activities, one opportunity is to educate golfers on the benefits of browning turf as firmer, faster conditions lead to more ball roll and longer drives in the summer.The conceptual improvement plan includes both small-scale and large-scale water harvesting and storage options, reflecting the superintendent's comment that every drop of water matters.

For the cost estimate, two key reference cases were used to inform the detention system improvement costs and size of areas: the underground retention system by McElhanney Company in Langley, and the retention pond project in Pasco County, Florida, United States.

For the underground detention system, the reference case in Langley, BC, used permeable geotextile to allow water from the detention chambers to seep into the ground, as the primary goal of the project was drainage. After consulting with the Division Manager at McElhanney Company, it was noted that costs would vary if impermeable geotextile were used instead, as this would allow the system to retain more water for golf course irrigation. The Langley project has a capacity of 21,200 m^3, the largest in Canada, and the construction of the facility, along with related pipeworks, cost $8.8 million in 2020. This figure does not include consulting fees, charges, or taxes.

At Fraserview Golf Course, there is not enough space to store 21,200 m^3 underground due to the presence of Vivian Creek and the extensive tree canopy. The conceptual improvement plan identifies a system approximately half that size, with a capacity of around 10000 m^3. Because costs vary with site conditions, McElhanney has not provided a precise estimate for this installation.

The retention pond project in Pasco County, Florida, United States, offers a helpful reference for determining floating wetland size in small retention ponds designed to improve water quality through infiltration. In that project, a 1.6-hectare retention pond required floating wetlands covering 0.9% of its surface area for effective treatment. Fraserview Golf Course's retention pond is approximately 0.6 hectares, and the conceptual improvement plan similarly recommends covering 0.9% of its surface area with floating wetlands to enhance water quality.

Moving Forward and Next Steps

Water-use Improvement

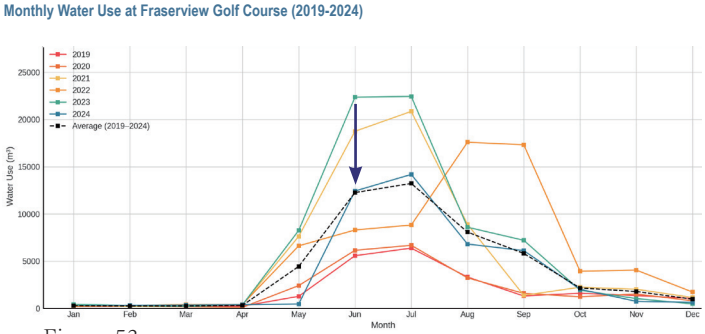

Figure 53

Looking back at Fraserview Golf Course's water consumption, the peak season in June and July 2023 reached about 20,000–25,000 m³ per month. From 2019 to 2024, the average monthly water use for the course was around 10,000–15,000 m³. If there is a detention system that could store about 10000 m³ of water, it could reduce one of the peak months' consumption down to its average level in the future.

* The assumption of a 10,000 m³ detention capacity is based on using half the size of the detention system from the Langley case.

Infiltrate Stormwater

Currently, the retention pond at Fraserview Golf Course has only an oil separator for infiltration, while the underground detention system in Langley relies solely on an upstream sediment collection system.

Moving forward, it will be important to consider whether an additional infiltration treatment system is needed, beyond proposed nature-based solutions such as bioswales and floating wetlands, to improve water quality further. However, since irrigation at the golf course takes place between 10 pm. and 6 am, the cost of adding new infiltration systems would need to be weighed carefully against the actual benefits during operating hours.

Alternative method

When the high capital and maintenance costs of an underground detention system make it less feasible, a surface detention pond can be considered as an alternative. Detention ponds provide temporary stormwater storage and gradual release at a lower cost, while also offering potential ecological and aesthetic benefits.

Cost estimate and space estimate of water retention upgrade based on:

Consulting McElhanney Company.

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Appendix

The Appendix outlines the decision-making process used in the online tool. Each yes or no response directs the user to a different result, with green tags indicating ‘yes’ and orange tags indicating ‘no’.


Y
N
1-4 months
15 output
Prioritise irrigation system improvements in green areas
Installation of new mainline pipes and sprinklers
2
Most irrigation PVC piping lasts 25-30 years if buried and maintained. After 20-30 years, it's common to see: Leaks, Joint failures, Reduced efficiency.
Are the irrigation PVC pipes on the golf course more than 30 years old?
Establishing Warm-Season Grasses
Coco Peat
4
Does your maintenance schedule allow for seeding or turf upgrades ahead of the high-traffic months?
5
Sandy soil provides good drainage for turf areas, but it can potentially reduce the efficiency of retention ponds by allowing water to seep into the ground.
Is the soil around the golf course's retention pond area primarily sandy?
Containment Liners
6
Are there any liners in the retention ponds of the golf course?
Native Grasses Help Save Water
Solar-powered Pond Aeration
7
During hot and dry seasons, water in the retention ponds of golf courses is likely to evaporate.
Are there any measures in place to reduce this evaporation?
Brown is The New Green
8
Are there any strategies in place to manage user expectations when turf areas on the golf course are not entirely green, especially during dry seasons?
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Please go to Page 4
Please go to Page 6 and page 30
Please go to Page 15
Please go to Page 39
page 30
page 15
page 39
page 33
page 15
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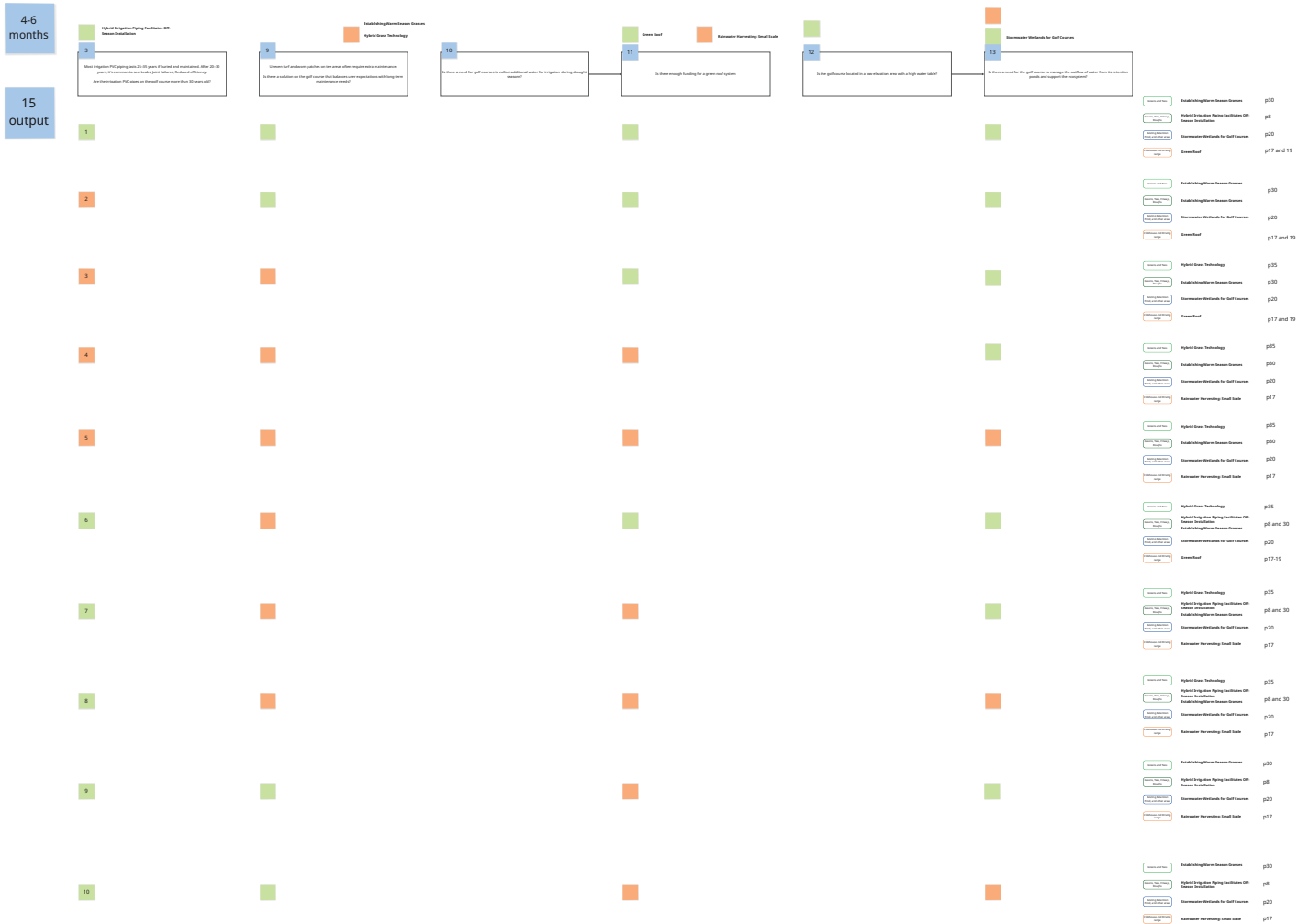
page 33
page 11
page 15
page 39
page 33
page 11
page 13
page 39
Please go to Page 4
Please go to Page 6 and page 33
page 15
page 39
Please go to Page 4
Please go to Page 6 and page 33
page 11
page 15
page 39
Please go to Page 4
Please go to Page 6 and page 33
page 11
page 13
page 39
Please go to Page 4
Please go to Page 6 and page 30
page 11
page 15
page 39
Please go to Page 4
Please go to Page 6 and page 30
page 11
page 13
page 39

No.	Area	Recommendation	Reference
11	Greens and Tees		
	Greens, Tees, Friways, Roughs	Establishing Warm-Season Grasses	Please go to Page 30
	Existing Retention Pond	Containment Liners Native Grasses Help Save Water	page 11 page 13
	Clubhouse	Brown is The New Green	page 39
12	Greens and Tees		
	Greens, Tees, Friways, Roughs	Establishing Warm-Season Grasses	Please go to Page 30
	Existing Retention Pond	Containment Liners Solar-powered Pond Aeration	page 11 page 15
	Clubhouse	Brown is The New Green	page 39
13	Greens and Tees		
	Greens, Tees, Friways, Roughs	Establishing Warm-Season Grasses	Please go to Page 30
	Existing Retention Pond	Native Grasses Help Save Water	page 13
	Clubhouse	Brown is The New Green	page 39
14	Greens and Tees Greens, Tees, Friways, Roughs	Coco Peat	Please go to Page 33
	Existing Retention Pond	Native Grasses Help Save Water	page 13
	Clubhouse	Brown is The New Green	page 39
15	Greens and Tees	Prioritize irrigation system improvements in green areas	Please go to Page 4
	Greens, Tees, Friways, Roughs	Installation of new mainline pipes and sprinklers Establishing Warm-Season Grasses	Please go to Page 6 and page 30
	Existing Retention Pond	Native Grasses Help Save Water	page 13
	Clubhouse	Brown is The New Green	page 39


4-6 months
15 output
Hybrid Irrigation Piping Facilitates Off-Season Installations
Establishing Warm-Season Grasses
Hybrid Grass Technology
Green Roof
Rainwater Harvesting: Small Scale
Stormwater Wetlands for Golf Courses
3
Most irrigation PVC piping lasts 25-30 years if buried and maintained. After 20-30 years, it is common to see Leaks, Joint failures, Reduced efficiency.
Are the irrigation PVC pipes on the golf course more than 30 years old?
9
Uneven turf and worn patches on tee areas often require extra maintenance.
Is there a solution on the golf course that balances user expectations with long-term maintenance needs?
10
Is there a need for golf courses to collect additional water for irrigation during drought seasons?
11
Is there enough funding for a green roof system
12
Is the golf course located in a low-elevation area with a high water table?
13
Is there a need for the golf course to manage the outflow of water from its retention ponds and support the ecosystem?
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Users and Ties
Hybrid Grass Technology p35
Establishing Warm-Season Grasses p30
Stormwater Wetlands for Golf Courses p20
Rainwater Harvesting: Small Scale p17
Users and Ties
Hybrid Grass Technology p35
Establishing Warm-Season Grasses p30
Stormwater Wetlands for Golf Courses p20
Green Roof p17-19
Users and Ties
Hybrid Grass Technology p35
Hybrid Irrigation Piping Facilitates Off-Season Installation p8
Establishing Warm-Season Grasses p30
Stormwater Wetlands for Golf Courses p20
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Users and Ties
Establishing Warm-Season Grasses p30
Hybrid Irrigation Piping Facilitates Off-Season Installation p8
Stormwater Wetlands for Golf Courses p20
Green Roof p17 and 19
Users and Ties
Establishing Warm-Season Grasses p30
Hybrid Irrigation Piping Facilitates Off-Season Installation p8
Stormwater Wetlands for Golf Courses p20
Green Roof p17 and 19
Users and Ties
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Establishing Warm-Season Grasses p30
Stormwater Wetlands for Golf Courses p20
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Establishing Warm-Season Grasses p30
Stormwater Wetlands for Golf Courses p20
Rainwater Harvesting: Small Scale p17
Users and Ties
Hybrid Grass Technology p35
Hybrid Irrigation Piping Facilitates Off-Season Installation p8 and 30
Establishing Warm-Season Grasses
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Establishing Warm-Season Grasses p30
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Users and Ties
Establishing Warm-Season Grasses p30
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Rainwater Harvesting: Small Scale p17

11

Waters and Taxa — Establishing Warm-Season Grasses — p30
Planting Time / Climate Thoughts — Establishing Warm-Season Grasses — p30
Planning Watershed Retrofit and other scales — Stormwater Wetlands for Golf Courses — p20
Continuous and Minimally Design — Rainwater Harvesting: Small Scale — p17

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Waters and Taxa — Establishing Warm-Season Grasses — p30
Planting Time / Climate Thoughts — Establishing Warm-Season Grasses — p30
Planning Watershed Retrofit and other scales — Stormwater Wetlands for Golf Courses — p20
Continuous and Minimally Design — Rainwater Harvesting: Small Scale — p17

13

Waters and Taxa — Establishing Warm-Season Grasses — p30
Planting Time / Climate Thoughts — Establishing Warm-Season Grasses — p30
Planning Watershed Retrofit and other scales — Stormwater Wetlands for Golf Courses — p20
Continuous and Minimally Design — Green Roof — p17-19

14

Waters and Taxa — Hybrid Grass Technology — p35
Planting Time / Climate Thoughts — Establishing Warm-Season Grasses — p30
Planning Watershed Retrofit and other scales — Stormwater Wetlands for Golf Courses — p20
Continuous and Minimally Design — Green Roof — p17-19

15

Waters and Taxa — Establishing Warm-Season Grasses — p30
Planting Time / Climate Thoughts — Hybrid Irrigation Piping Facilitates Off-Season Installation — p8
Planning Watershed Retrofit and other scales — Stormwater Wetlands for Golf Courses — p20
Continuous and Minimally Design — Green Roof — p17-19


6-12 months
line 15 18 20 22
4 output
line1
default
15
Is there any existing retention pond?
Stormwater Wetlands for Golf Courses
Retention Pond to Detention Lake
18
Is there a need for the golf course to manage the outflow of water from its retention ponds and support the ecosystem?
default
20
Are there any existing green-blue infrastructure systems and greenways in the surrounding community that the golf course could potentially connect to or align with?
Sewer Mining for Golf Course Irrigation
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat greywater for irrigation use?
1
2
3
4
Stormwater Wetlands for Golf Courses p20
Sewer Mining for Golf Course Irrigation p26-p28
Retention Pond to Detention Lake p23-p25
Sewer Mining for Golf Course Irrigation p26-p28
Retention Pond to Detention Lake p23-p25
Back to Q1 and select 1-6 months or 6-6 months
Stormwater Wetlands for Golf Courses p20
Back to Q1 and select 1-6 months or 6-6 months


Rehabilitating Warm Season Grasses p30
Rehabilitating Warm Season Grasses
Retention Pond to Detention Lake p23
Rainwater Harvesting: Small Scale p17


Rehabilitating Warm Season Grasses p30
Rehabilitating Warm Season Grasses
Retention Pond to Detention Lake p23
Green Roof p17-19


Hybrid Grass Technology p35
Rehabilitating Warm Season Grasses p30
Retention Pond to Detention Lake p23
Green Roof p17-19


Rehabilitating Warm Season Grasses p30
Hybrid Irrigation Piping Facilitates UAV Swarm Installation p8
Retention Pond to Detention Lake p23
Green Roof p17-19

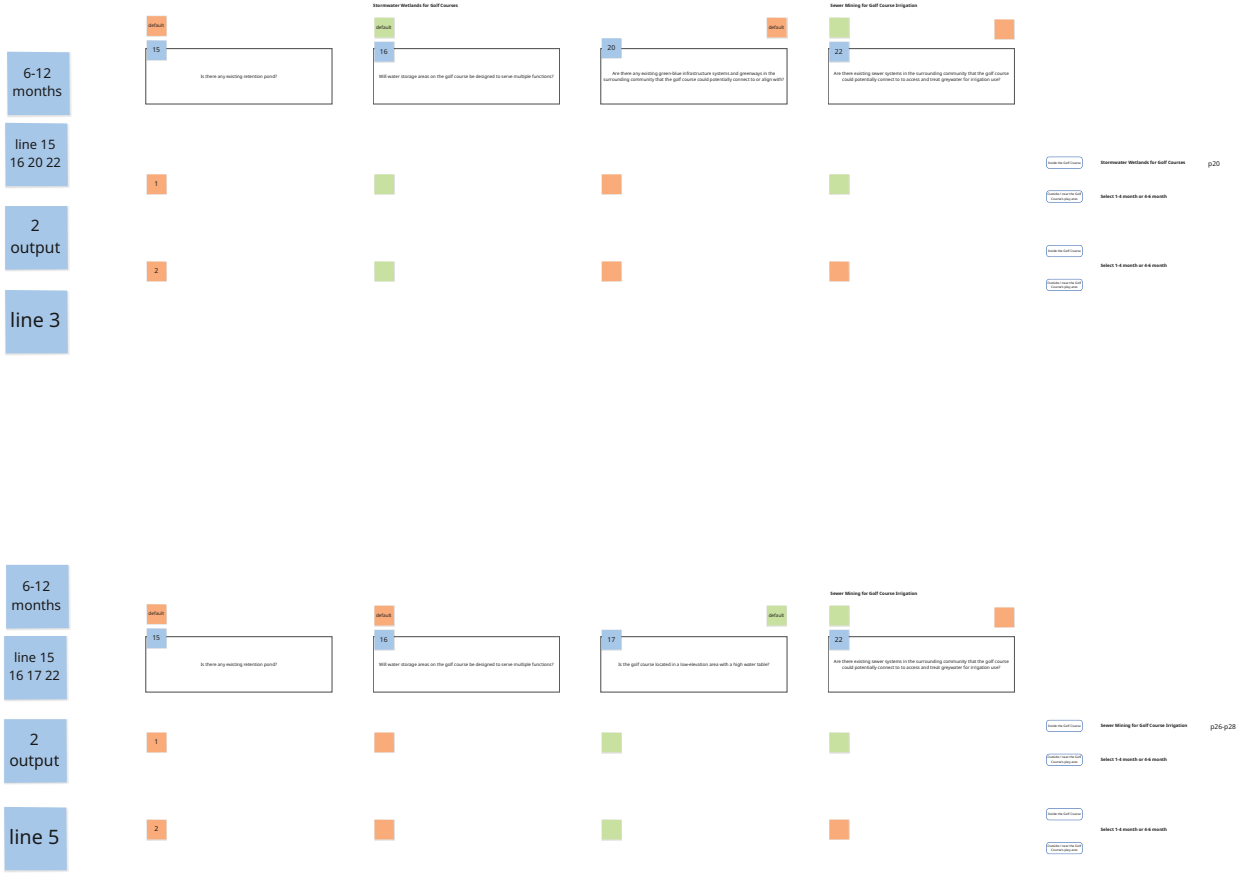
wednesday

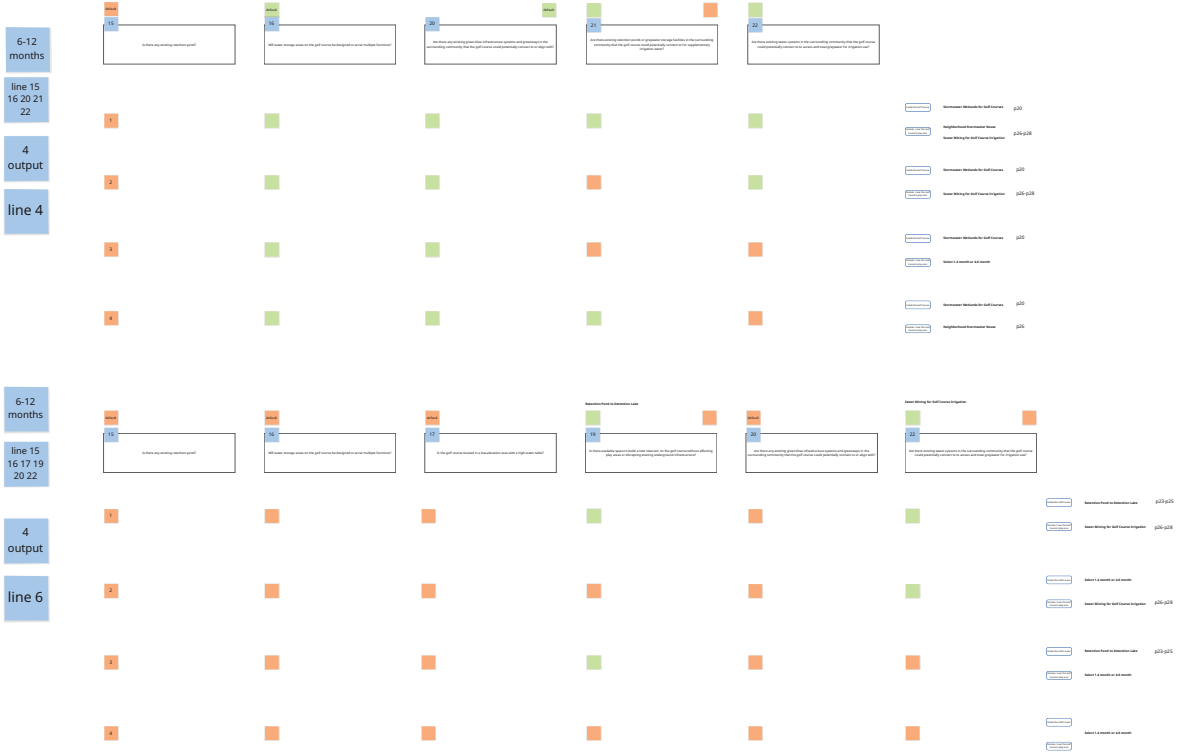
6-12 months

line 15 18 20 21 22

9 output

line 2


6-12 months
line 15 16 20 22
2 output
line 3
default
15
Is there any existing retention pond?
Stormwater Wetlands for Golf Courses
default
16
Will water storage areas on the golf course be designed to serve multiple functions?
default
20
Are there any existing green-blue infrastructure systems and greenways in the surrounding community that the golf course could potentially connect to or align with?
Sewer Mining for Golf Course Irrigation
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat greywater for irrigation use?
1
2
Inside the Golf Course
Outside / near the Golf Course's play area
Stormwater Wetlands for Golf Courses
p20
Select 1-4 month or 4-6 month
Inside the Golf Course
Outside / near the Golf Course's play area
Select 1-4 month or 4-6 month
6-12 months
line 15 16 17 22
2 output
line 5
default
15
Is there any existing retention pond?
default
16
Will water storage areas on the golf course be designed to serve multiple functions?
default
17
Is the golf course located in a low-elevation area with a high water table?
Sewer Mining for Golf Course Irrigation
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat greywater for irrigation use?
1
2
Inside the Golf Course
Outside / near the Golf Course's play area
Sewer Mining for Golf Course Irrigation
p26-p28
Select 1-4 month or 4-6 month
Inside the Golf Course
Outside / near the Golf Course's play area
Select 1-4 month or 4-6 month


6-12 months
line 15 16 20 21 22
4 output
line 4
default
15
Is there any existing retention pond?
16
Will water storage areas on the golf course be designed to serve multiple functions?
20
Are there any existing green blue infrastructure systems and greenways in the surrounding community that the golf course could potentially connect to or align with?
21
Are there existing retention ponds or graywater storage facilities in the surrounding community that the golf course could potentially connect to for supplementary irrigation water?
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat graywater for irrigation use?
Stormwater Wetlands for Golf Courses p.20
Neighborhood Stormwater Reuse p.26-p.28
Sewer Wiring for Golf Course Irrigation
Stormwater Wetlands for Golf Courses p.20
Sewer Wiring for Golf Course Irrigation p.26-p.28
Stormwater Wetlands for Golf Courses p.20
Select 1-4 monitor at AA month
Stormwater Wetlands for Golf Courses p.20
Neighborhood Stormwater Reuse p.26
6-12 months
line 15 16 17 19 20 22
4 output
line 6
15
16
17
Is the golf course located in a low-elevation area with a high water table?
Retention Pond to Detention Lake
19
Is there available space to build a new reservoir on the golf course without affecting play areas or the existing existing watershed infrastructure?
20
Are there any existing green blue infrastructure systems and greenways in the surrounding community that the golf course could potentially connect to or align with?
Sewer Wiring for Golf Course Irrigation
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat graywater for irrigation use?
Retention Pond to Detention Lake p.23-p.25
Sewer Wiring for Golf Course Irrigation p.26-p.28
Select 1-4 month or AA month
Sewer Wiring for Golf Course Irrigation p.26-p.28
Retention Pond to Detention Lake p.23-p.25
Select 1-4 month or AA month
Select 1-4 month or AA month


6-12 months
line 15 16 17 19 20 21 22
8 output
line 7
default
14
Is there any existing retention pond?
default
15
Will water storage areas on the golf course be designed to serve multiple functions?
default
17
Is the golf course located in a low elevation area with a high water table?
Retention Pond to Detention Lake
19
Is there available spaces to build a new reservoir on the golf course without affecting play, areas or disrupting existing underground infrastructure?
default
20
Are there any existing greenbelt or infrastructure systems and greenways in the surrounding community that the golf course could potentially connect to or align with?
Neighborhood Stormwater Reuse
21
Are there existing retention ponds or greywater storage facilities in the surrounding community that the golf course could potentially connect to for supplementary irrigation reuse?
Sewer Mining for Golf Course Irrigation
22
Are there existing sewer systems in the surrounding community that the golf course could potentially connect to to access and treat greywater for irrigation use?
Retention Pond to Detention Lake
p.223-p.225
Sewer Mining for Golf Course Irrigation
p.226-p.228
Neighborhood Stormwater Reuse
Value it: 6 onwards or 6.6 month
Sewer Mining for Golf Course Irrigation
p.226-p.228
Neighborhood Stormwater Reuse
Retention Pond to Detention Lake
p.223-p.225
p.226
Value it: 6 onwards or 6.6 month
Neighborhood Stormwater Reuse
p.226
Value it: 6 onwards or 6.6 month
Sewer Mining for Golf Course Irrigation
p.226-p.228
Retention Pond to Detention Lake
p.223-p.225
Sewer Mining for Golf Course Irrigation
p.226-p.228
Retention Pond to Detention Lake
p.223-p.225
Value it: 6 onwards or 6.6 month
Value it: 6 onwards or 6.6 month