

RESEARCH & DEVELOPMENT  
PROGRAMME WITHIN

# SUSTAINABLE WATER MANAGEMENT

*Sterf*



Photo: Agnar Kvalbein

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## SUSTAINABLE WATER MANAGEMENT FOR GOLF

### **Water helps maximise turf quality and playability**

Water is an essential component in the management and maintenance of high quality turf, for golf courses in Scandinavia, elsewhere in Europe and internationally. It serves to control the growth and quality of fine turf, to maximise playability required by the players and to deal with the vagaries of summer weather (unpredictable rainfall). It is also important for other sports turf management practices (e.g. fertiliser applications, top dressing). Without it, many golf clubs would simply not survive; from both an agronomic and economic perspective. But increasing regulation, droughts and the longer-term risks associated with a changing climate threaten the availability and reliability of water supplies, and thus the golf industry and rural livelihoods it supports (Strandberg *et al.*, 2012).

However, golf is not only at risk from droughts and water scarcity, but also the challenges in dealing with ‘too much’ water – coping with more frequent, high intensity rainfall events and flooding. With demands for all year round playability, managing water on courses means drainage and ir-

rigation systems need to be much more integrated, to cope with both peaks in water shortage and/or water excess. Achieving sustainable water management in golf by improving our understanding of the technology, management and engineering aspects of water is thus a key priority for STERF and the industry it represents.

Following discussion between STERF Board Members and key informants, the need for a water strategy was identified - its purpose to ensure that the Scandinavian golf sector receives a fair share of water resources and importantly uses it in the most environmentally sustainable and efficient way.

This report sets out that strategy - it provides a framework for identifying the key water priorities at club and industry levels, the research and strategic actions required and the timescales for implementation.

### Water demand for golf in Europe

As in Europe, most golf courses in Scandinavia have an irrigation system, but only irrigate a small proportion of the total course area. The majority of courses only irrigate the fine turf areas on the greens and tees, which typically cover 1.5 to 2.0 ha. For courses that irrigate the approaches, this area rises to 2.5 to 3.0 ha, and with fairways the total irrigated area is usually between 10 and 13 ha. In more arid environments, such as Spain, the irrigated area is much larger (~35 ha), as the rough areas are also irrigated (Rodriguez-Diaz et al., 2007).

Whilst average irrigation water use varies significantly across Europe depending on local agroclimatic conditions, the average irrigation water demand for golf is around 44,000 m<sup>3</sup> per annum (Table 1). In Scandinavia, demand is much less due to lower evapotranspiration (ET) rates. Demand for a typical 18 hole golf course irrigating greens and tees is estimated to be between 4000 and 5000 m<sup>3</sup> annum (Table 1).

In similar humid or temperate climates (UK), demand is also around 5000 per annum (Rodriguez-Diaz et al., 2007). Based on the turfed areas, irrigating the approaches would increase demand up to around 6000-7000 m<sup>3</sup>. Courses with full fairway irrigation systems in similar northern latitudes would be expected to use between 15000 and 50000 m<sup>3</sup>. Golf courses are also important rural businesses and employers. In Europe, a typical 18 hole golf course typically contributes around €830,000 per annum into the rural economy (Knox and Rodriguez Diaz, 2013) (Table 1).

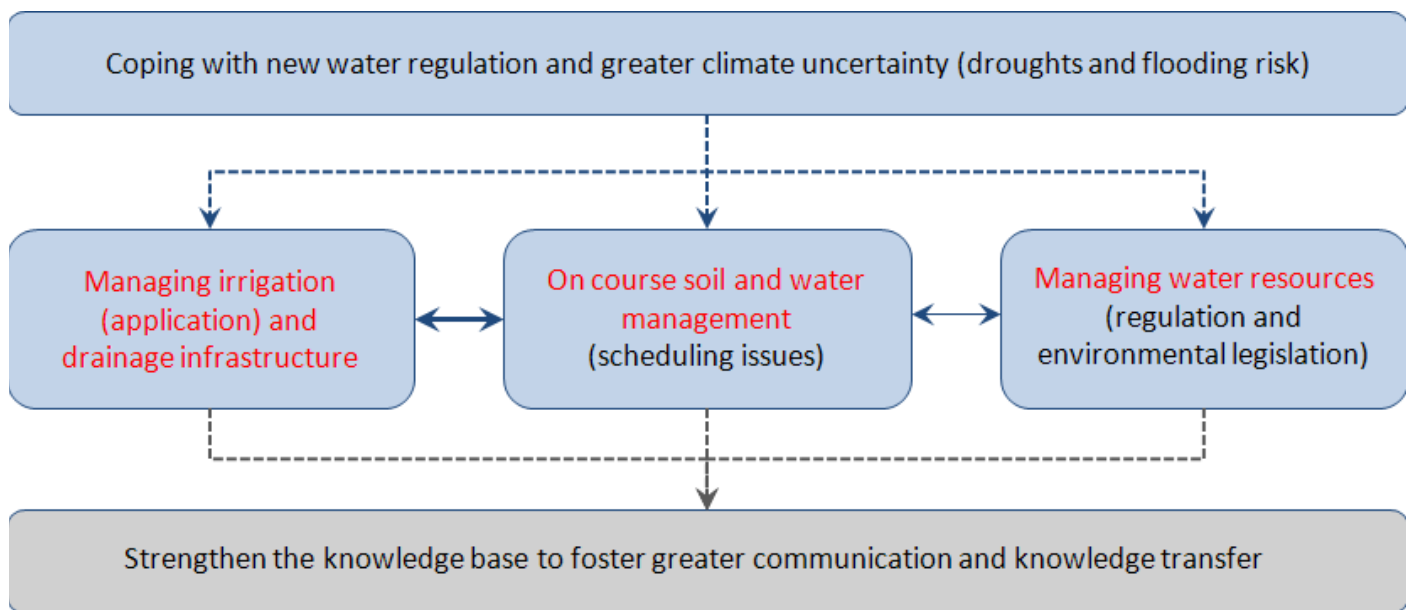
### Identifying future water risks for golf

Irrigation is critical for maintaining fine turf quality and optimising soil water status with consequent impacts on turf playability (bounce and speed). Golf clubs also provide important environmental and ecological benefits, and are recognized as wildlife corridors from urban to rural areas. Water implicitly helps to maintain these businesses, and their social and environmental functions. But access to water is under threat. Increasing demand and competition from other users, increasing restrictions coupled with environmental regulation and climate change are all exerting pressure on available supplies. Failure to maintain irrigation on fine turf areas would lead to serious deterioration or loss of grass cover and playing quality, which in turn would lead to more frequent course closure. It is in response to these risks, that STERF has developed this water strategy for the golf industry.

The proposed key themes and priorities for action are identified below.

Country	Golf courses (n)	Water demand (Mm <sup>3</sup> )	Ave water use (course, m <sup>3</sup> )
Sweden	489	2.13	4356
Denmark	184	1.32	7174
Finland	128	0.47	3672
EU27 Total	6930	172.1	-
EU27 Ave	-	6.88	44,451

**Table 1.** Estimated water demand (Mm<sup>3</sup>) and water value (€/m<sup>3</sup>) for golf for selected countries in Scandinavia and Europe (EU27). Source: Knox and Rodriguez Diaz (2013).



**Figure 1** Key themes identified for the water strategy for golf in Scandinavia.

## DEFINING THEMES FOR A GOLF WATER STRATEGY

Water use in golf spans a number of key areas, including managing water resources for irrigation and drainage (application equipment and infrastructure), matching water requirements to agronomic needs (irrigation scheduling) to maximise turf quality, and managing the off-site impacts of course management on the aquatic environment (quantity and quality). Dealing with increased climate uncertainty including weather extremes, droughts and flooding and keeping abreast of changes in environmental water regulation and legislation are also identified as being key priorities. It is also important to distinguish where these risks and challenges are evident, whether at golf club (course management) level or at an industry or national (strategic) level. Three main themes have therefore been defined for this water strategy for golf:

1. **Managing irrigation and drainage infrastructure** (including application equipment, distribution systems and drainage network);
2. **On-course soil and water management (scheduling)** (including methods and technologies to control turf growth and quality), and;
3. **Managing water resources** (including abstraction, storage, monitoring, regulation and water policy).

Over-arching all of these is the need to manage greater climate uncertainty (including increased drought and flooding risks) and to foster greater communication and knowledge transfer (to disseminate research outputs) to both the golf and associated industries (internally) and to other stakeholders (externally) (Figure 1).

Each theme involves action – for some the onus will be on individuals; for others, require collective action and strong external support and from representative governing bodies will be needed. Collectively, the actions should help reduce water wastage and maximise the value of water used by the golf industry for the benefit of both the rural economy and the natural environment.

A brief description of each theme and key actions STERF needs to undertake is given below.





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## MANAGING IRRIGATION AND DRAINAGE INFRASTRUCTURE

Modern irrigation systems used on golf courses are already engineered to save water and maximize efficiency, by using permanent pipework and irrigating mostly at night. Many courses are also actively pursuing agronomic practices aimed to promote grass species which are better suited to cope with more arid conditions. Nevertheless even drought tolerant species need sufficient moisture to replace evaporation (transpiration) losses. But there is always scope for improvement in managing irrigation systems in golf, and importantly matching course drainage systems to cope with greater peaks in water excess.

The fundamental question in this theme therefore is “What are the main irrigation (application technology or equipment) and drainage issues facing golf course management?”

Research priorities were identified using a combination of literature review, expert opinion, and discussion with key informants within the golf sector.

The following four key priorities were defined in terms of **irrigation application equipment:**

1. Understand and quantify better the links between poor irrigation application uniformity, turf growth and turf quality;

2. Improve the efficiency of irrigation application equipment (energy and water) to reduce the carbon and water footprints within the golf sector;
3. Evaluate new and emerging technologies to improve irrigation water use efficiency and reduce energy consumption;
4. Improve our understanding of the potential for water harvesting and water re-use options for golf course irrigation, and the risks to their implementation.

The following key priorities were defined in terms of **improving drainage infrastructure:**

1. Assess the impacts of turf irrigation management practices on performance of drainage systems and the risks associated with nitrate and pesticide leaching;
2. Assess the impacts of a changing climate on irrigation and drainage infrastructure;

STERF needs to consider how best each these individual industry priorities can be addressed through a combination of targeted research (applied), supported by dissemination of best practices drawing on existing (international) evidence.



Photo: Agnar Kvalbein

## IMPROVING SOIL AND WATER MANAGEMENT

The fundamental question in this theme is “What are the main soil and water management (scheduling) issues facing the golf sector?”

As above, the research priorities were identified using a combination of literature review, expert opinion, and discussion with key informants from the golf sector.

The following four key priorities were defined in terms of **turf soil and water management**:

1. Improve information on the optimum irrigation schedules for specific parts of the golf course (including monitoring and auditing water use);
2. Improve soil management to understand the agronomic links between soil heterogeneity (variability), soil water availability and turf survival/growth/disease risk;
3. Support the development of improved innovative scheduling technologies coupled with new approaches to scheduling (e.g. deficit irrigation) to improve turf quality and reduce dependence on water.

STERF needs to consider how best each these industry priorities can be addressed through a combination of targeted research (applied), supported by dissemination of best practices drawing on existing (international) evidence.



# MANAGING WATER RESOURCES (REGULATION AND LEGISLATION)

If golf courses in Scandinavia are to continue to provide high quality playing surfaces, it is vital that the industry works together to justify and protect its existing use of water resources. Many clubs have started to recognise these risks and taken measures to manage their **existing** supplies more efficiently, including better monitoring and auditing.

The recent droughts in Europe have also highlighted the delicate balance that exists between supply and demand and the increasing risks associated with securing **future** water supplies for leisure, including golf. Climate change is expected to exacerbate the stresses in the demand-supply situation.

New European legislation to provide greater protection to the aquatic environment will also inevitably have major implications for golf.

The fundamental question in this theme is “What are the main water resource (quality and quantity) and regulatory issues facing the golf sector under a changing legislative and environmental climate?”

Four key priorities have been defined:

1. Improve knowledge of the impacts of new national and European water regulation on water availability and reliability for golf;
2. Improve knowledge of the impacts of golf course irrigation on diffuse pollution including nitrate leaching and pesticide losses;
3. Improve knowledge of the risks associated with using low irrigation water quality on golf turf surfaces;
4. Improve knowledge on alternative water sources (e.g. grey/waste water) its impacts on water quality and suitability for golf.

STERF needs to consider how best each these industry priorities can be addressed through a combination of targeted research (applied), supported by dissemination of best practices drawing on existing (international) evidence.

## Pathway to efficiency (making better use of water resources)

It is also vital that all golf clubs make best use of water resources currently available to them. Making best use reduces water needs and minimises the impacts of water abstraction on others. The objective here should be that all golf clubs become ‘self-sufficient’ in their water consumption. All clubs should have adequate, reliable supplies, which cause minimal environmental impact, and are used efficiently.

STERF should promote irrigation technologies and practices that will secure and make best use of available water resources, based on a hierarchy of water resource options (Figure 2).

From this, a set of key actions have been identified, summarised below.

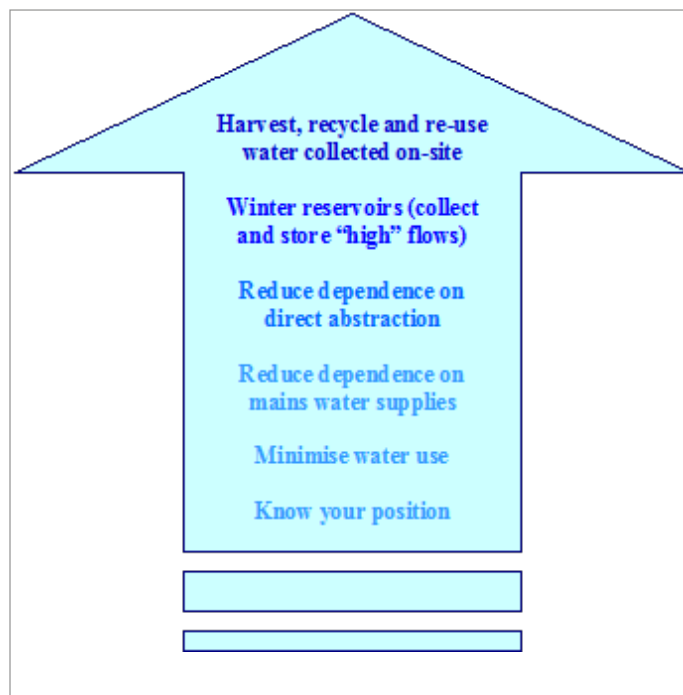


Figure 2 Identified hierarchy of water resource options for golf.





Photo: Agnar Kvalbein

### **Know your position**

Understanding your current position is the critical starting point on the “pathway to efficiency”. It is the key to getting the best out of the equipment, soil and water management practices. This stage requires a facility to ensure that all necessary data collection, meter readings and record keeping relating to irrigation are compliant with national regulations.

Water audits may soon be required by some authorities for clubs in catchments where the environment and water resources are under threat due to unsustainable abstraction regimes. All clubs should be aware of their water resource position and environmental status in their catchment.

STERF should ensure that all clubs dependent on water undertake the necessary data collection and monitoring and are aware of local water and environmental regulations.

### **Minimise water use**

Minimising the water required both avoids conflict and potentially saves money. However this must be achieved without excessively impacting on the quality of fine turf surfaces. A vital first step is to know how much water is really required (compared to how much is actually being applied) and then how much efficiency could be raised. This requires achieving a better understanding of the external factors that impact on turf water demand (climatic and agronomic) and then matching turf water requirements to the availability of equipment and management (irrigation scheduling). In this context, water auditing might play an important role. A water audit can be described as a short-term operational tool used to monitor and compare patterns of water use.

STERF should promote awareness of water auditing not only as a tool for improving understanding of water use, but also more critically in relation to demonstrating sustainable use and abstraction.

Efficient use of water also requires adoption of best irrigation practice using appropriate equipment with accurate scheduling. As technology advances, it is important for clubs to keep themselves updated on international developments, whether in the sports-turf sector or elsewhere.

STERF should promote actions to alert members to international developments across a range of topics including irrigation technology and water management.

### **Reduce dependence on mains water supplies**

Using mains water for irrigating fine turf is likely to become less acceptable unless the financial and other (rural employment) benefits are more clearly explained to the general public and regulators. There is a public relations mountain to be climbed by the golf industry in raising awareness of the value of water to its industry as a reasonable and justifiable use, to water suppliers, the regulatory agencies and general public.

Where alternatives exist, STERF should support facilities to move away from dependence on mains water for irrigation. The emphasis should be on avoiding mains water in stressed catchments.

However, where this is not possible, a good case can still be made in comparison to many other uses, but this is often over-looked.

STERF should work with others to act as a focus for establishing the value of water use in golf irrigation, and ensuring this use is robustly justified and defended to the public and regulators.

### **Reduce dependence on direct abstraction**

In some catchments it may be difficult to obtain permission for direct (summer) abstraction. Subject to hydrological and environmental constraints, there are opportunities for clubs to obtain water by trading or sharing water with neighbours. Both enhance opportunities for conjunctive use of surface water, groundwater and reservoirs, thus increasing reliability.

STERF should promote actions to identify the opportunities and any issues involved. In water stressed catchments, the emphasis should be on protecting existing golf uses.

### **Promote storage reservoirs to collect and store high flows**

Environmental pressures are forcing some abstractors to move from summer (low flow) to winter (high flow) abstraction. Even in water-stressed catchments, there are often periods when rivers are in flood. Storage tanks and reservoirs can provide golf clubs with an opportunity to benefit from these peak flows, as well as being essential for rainwater harvesting. However, they require major investments in fixed assets.

STERF should support actions to help clubs learn from others, identify legal, contractual and other issues that might not be apparent, investigate reservoir funding options, and suggest ways forward.

### **Harvest, re-cycle and re-use water collected on-site**

Seasonal restrictions from companies supplying public mains water and/or environmental regulators can be avoided by making better use of water resources already on the club facility. Re-use of “grey” water from clubhouses and workshop areas provides a resource as well as minimising disposal and treatment costs. Most facilities have roofed areas suitable for rainwater harvesting. Hard standing areas for car parking can provide usable supplies after removal of oil films. Depending on soil types, it may also be possible to collect surface drainage from the golf course itself.

STERF should support research and information exchange between facilities with other organisations to identify and resolve issues relating to the best use of harvested and re-cycled water.

STERF should work to ensure any changes to regulations support rather than impede such uses, and build acceptance among golf clubs for the re-use of grey water.





Photo: Gert Straschewski





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## KNOWLEDGE TRANSFER AND COMMUNICATION: DISSEMINATING RESEARCH

It is essential that golf course management staff and those engaged in the industry stay informed and have access to the latest information on a range of management aspects, including water, at the right time. Yet in spite of the priority given to improving water efficiency in the public domain it is surprising just how little information is available that relates to golf. A knowledge base is needed so that the golf industry has access to the latest information to improve their water management skills and knowledge.

This theme includes (i) establishing demonstration sites for water management, (ii) a web-based information gateway and (iii) developing a programme for continuing professional development.

### **Learning from leading experience**

Experience in other countries where golf course irrigation represents a significant component of abstraction (e.g. USA, Spain) highlights the importance of providing the right information on water management in a form that can be readily accessed by staff. For example, in the USA, dedicated websites provide clubs with access to practical

information on irrigation equipment, scheduling and other media (e.g. videos) to enable them to pick up new ideas and put them to immediate use. They also provide training programmes for green-keeping staff to gain certificated qualifications that demonstrate competence in water management, recognised by the golf industry. A similar water information gateway for golf might have a useful role to play in Scandinavia and beyond (Europe), particularly as water resources for golf come under increasing scrutiny.

### **Using golf demonstration sites as exemplars for water management**

In agriculture, there are leading examples (farms) that showcase techniques that demonstrate how profitable management practices can co-exist with sustainable environmental practices (e.g. conserving water, protecting water quality and enhancing the local environment). The concept has real potential within the golf sector, for example, by highlighting clubs where sustainable course management techniques are being pursued for the benefit of both business and the environment. Extrapolating the concept of a demonstration site would be innovative and help the golf industry in

addressing some of the public relations issues it faces in terms of reconciling water use whilst demonstrating environmentally sustainable best management practices.

Unfortunately many course management and green-keeping staff are unaware of the range of water management options available to them. The opportunity to visit a golf club demonstrating water management to learn new ideas and identify the potential for similar practices on their own course is an excellent means for technology transfer. Spreading the word from one course to another via a demonstration golf club would be a useful spin-off.

Demonstration golf clubs for water management could also inform and educate a wider range of stakeholders that have limited knowledge of the importance and value of water in the sports-turf sector. Educational visits, guided tours and open days would provide the public and others with an opportunity to discover how water is essential component in the management and maintenance of modern golf courses. It would also help:

- Demonstrate a variety of turf management activities that promote sound stewardship of the interaction of water with land;
- Showcase the use of appropriate technology in water management and conservation, and how innovative solutions can address water problems (e.g. storage, scheduling etc);
- Provide a blueprint for best practice, for example, on how to improve water efficiency and developing adaptations to water scarcity (e.g. reservoirs, re-use, water harvesting);
- Provide a practical teaching aid for the sportsturf industry, and a suitable venue for water related industry technical meetings;
- Provide sportsturf management staff with an opportunity to network and discuss the benefits and practical implications of new ways of working, and;
- Provide a mechanism for educating the public and policy makers so that the challenge of understanding why water is important in sportsturf may be more widely appreciated.

### **Web-based information gateway and professional development**

A web-based information portal would provide a focal point where golf management staff go to obtain the latest information on water management. This would become a resource centre for a wide range of material to help them improve water efficiency. It could provide information on a range of subjects, including:

- Statistics on water use in sportsturf (for water resource planners and policy makers);
- Guidelines for best practice, water saving, water conservation and water auditing;
- Benchmarking water use between individual golf facilities;
- Fact-sheets on irrigation performance, scheduling, water quality, soil management;
- Research notes summarizing key findings from relevant research, and;
- Information on water policy and regulation.

This would also support the delivery of professional development training.

**STERF and other sportsturf organisations should support the development an 'information gateway' to serve the spectrum of businesses on all aspects relating to water resources.**

Organisation of a programme of professional development training would also provide clubs with an opportunity to gain access to new skills, knowledge and help build capacity.

**STERF should undertake a training needs assessment to assess the demand for training in the golf sector as well as the ability of organisations across Scandinavia/Europe to support water management training.**

**STERF should support actions to increase water security by improving communications and dialogue between golf clubs, the regulatory agencies and other stakeholders.**

**STERF and key informants in the industry should identify a suitable 'water champion' and support them in implementing this water strategy.**

# ROADMAP FOR STRATEGY IMPLEMENTATION

This strategy proposes a rational way forward to help reduce water wastage, maximise the value of water used and reduce the impacts of the golf sector in Scandinavia on the water environment. It sets out what needs to be done by both individual golf clubs and the wider industry, working at individual and national levels. The strategy has three main themes. Within each, a set of key actions were proposed. For each, an assessment of its relative priority in terms of its relevance to either an individual golf club business or to the industry as a whole has been estimated (using the following legend for assigning relative importance:

= low;
  = medium;
  = high)

In order to address each priority, a range of costed options and approaches is available. For example, some priorities (e.g. synthesis of evidence) might best be tackled by a technical specialist as a short-term (<3 month) assignment (consultancy). Other activities will require a much longer time-frame, particularly if new research or field work is required. There are also different modes of operation including using contract research or funded studentships, either MSc thesis (3 month), MSc by Research (1 year) or PhD (3 years). The following tables summarise the relative importance of each key priority, suggested approach and indicative cost. This information is useful in support of developing a medium term (5 year) ‘roadmap’ for implementation, by aligning the priorities against available funding.

Theme	Key priority	Relative importance		Suggested approach
		Golf Club	Industry	
Managing irrigation and drainage infrastructure	Understand and quantify better the links between poor irrigation application uniformity, turf growth and turf quality			PhD
	Improve efficiency of irrigation application equipment (energy and water) to reduce carbon and water footprints in golf sector			C
	Evaluate new and emerging technologies to improve irrigation water use efficiency and reduce energy consumption			MT
	Improve understanding of potential for water harvesting and water re-use options for golf course irrigation, and risks to implementation			MT
	Assess impacts of turf irrigation management on drainage systems and risks associated with nitrate and pesticide leaching			PhD
	Assess the impacts of a changing climate on irrigation and drainage infrastructure			MSc

Note: C = consultancy; MT = Master thesis; MScRes = MSc by Research; CRP<sub>s</sub> = Contract Research Project (short-term); CRP<sub>L</sub> = Contract Research Project (long-term).



Theme	Key priority	Relative importance		Suggested approach
		Golf Club	Industry	
On course soil and water management	Improve information on optimum irrigation schedules for specific parts of the golf course (including monitoring and auditing water use)			CRP <sub>L</sub>
	Improve soil management to understand agronomic links between soil heterogeneity, water availability and turf growth/disease risk			PhD
	Support development of innovative technologies with new scheduling (e.g. deficit irrigation) to improve turf quality			CRP <sub>L</sub>
Managing water resources (regulation)	Improve knowledge of impacts of new national and European regulation on water availability for golf			C, MT
	Improve knowledge of impacts of golf course irrigation on diffuse pollution including nitrate leaching and pesticide losses			PhD, MSc by Res
	Improve knowledge of the risks associated with low irrigation water quality on turf surfaces and turf quality			C, MT
	Improve knowledge on alternative water sources (e.g. grey/waste water) its impacts on water quality and suitability for golf			C, MT

Note: C = consultancy; MT = Master thesis; MScRes = MSc by Research; CRP<sub>s</sub> = Contract Research Project (short-term); CRP<sub>L</sub> = Contract Research Project (long-term).

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