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– A scope and project plan for lab and field test of the effectiveness of CEN TR-17519:2020 Risk Management Measures (RMM) for granulate infill at sports facilities with synthetic turf

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Content

1 INTRODUCTION

1.1 Prerequisites

This work has been carried out by Ecoloop on behalf of Genan. Genan is interested in a design scope for valid documentation of the RMMs for infill containment, achieved by measuring containment efficiency. Ecoloop is hereby pleased to submit a report on this work.

1.2 Aim and objective

The aim is to develop a generic scope to test and analyze the spread of granulate infill from synthetic turf with the use of Risk Management Measures (RMM) as stated in CEN TR-17519.

The overall objective is to implement RMM as stated in the CEN TR-17519 and to test, measure and analyze granulate spread from synthetic turf to document and further minimize granule migration and optimize material reuse.

Participants following the project scope will increase the level of on-site information about best practice and value of investments in connection with RRM – e.g. in relation to daily routines, maintenance equipment and machines as well as spread related to pitch users (infill in/on shoes or clothing ending up in the environment or in people's homes as waste).

1.3 Methodology

The suggested project will apply and test RMM as stated in CEN TR-17519, published in the summer of 2020. These RMM cover events and activities that may lead to infill migration from the synthetic turf field during the life cycle of the field.

The suggested project consists of four parts:

1. **Field design for optimized RMM as stated in CEN TR-17519, integrating test and measurements capabilities (procurement phase)**
   CEN standard design helps minimize infill spreading, and the design must provide the right conditions for the sampling and measuring of infill spreading.

2. **A plan for RMM and monitoring during construction, use, maintenance, and decommissioning**
   RMM need to be monitored, and responsibilities must be clarified.

3. **Quantitative measurements and analysis prior to project and onwards**
   Methods must be valid, relatively easy to implement and transparent.

4. **Evaluation of additional containment measures**
   Constant evaluation of implemented containment measures is important. If any weaknesses are identified, additional measures must be taken and re-evaluated.

1.4 Limitations

This project is focused on analyzing the effectiveness of RMM as described in the CEN TR-17519 report. There are other potential measures that can be used to increase containment of infill, e.g. to extend gates at player entrance points or to increase the height of containment barriers. The efficiency of such measures is currently unknown, but as further knowledge is gained through innovation, such measures may also be implemented and evaluated as part of the project.

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2 INFILL CONTAINMENT THEORY

2.1 System boundaries and definitions

This study is focused on infill containment where infill is under control within the field area – without spreading to uncontrolled zones outside the field area. These zones are illustrated in Figure 1 below.

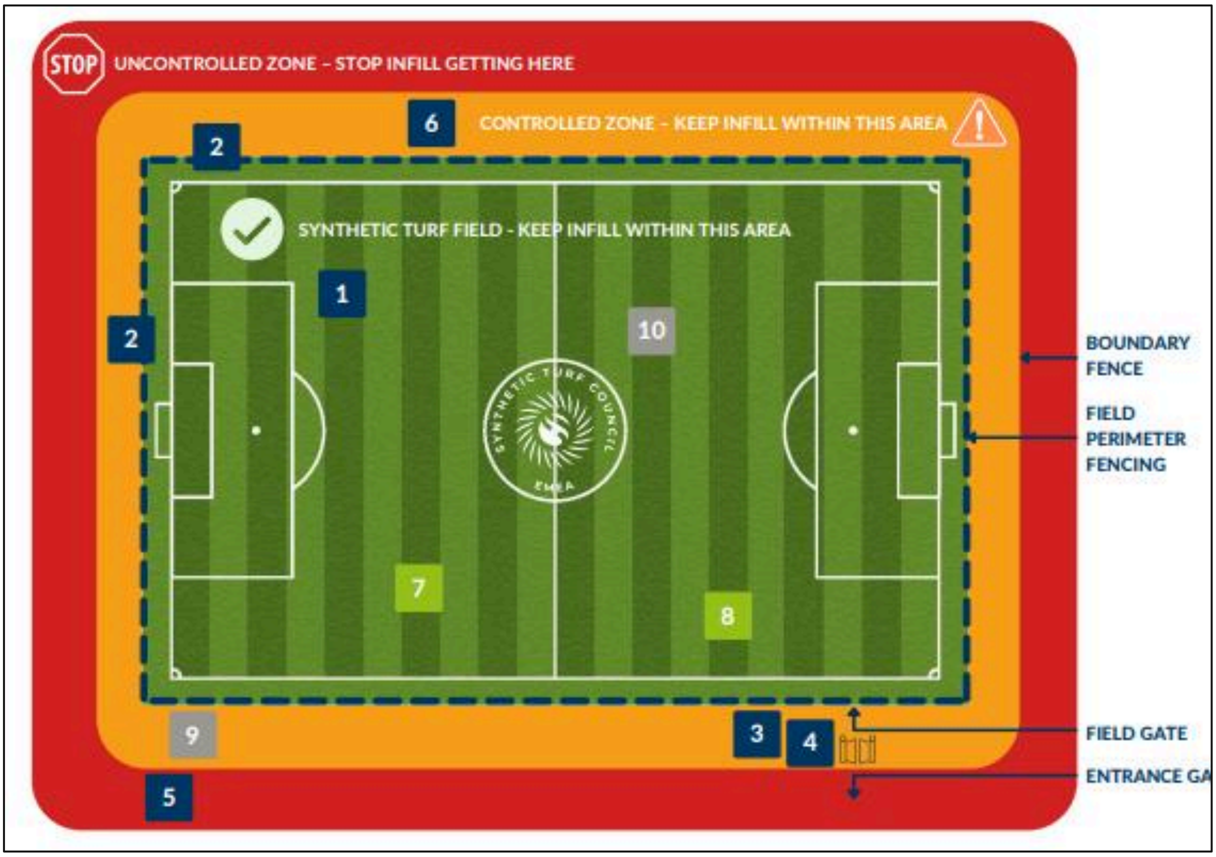

Figure 1. System zones (Source: ESTC 2021)

Many football fields consist of the actual synthetic turf field and sometimes a paved margin surrounding the field. The simplest turf fields often have a narrow-paved surface, while others have wider paved surfaces and fences. Well-equipped facilities may have stands, lighting, changing rooms, surfaces for operating vehicles, snow storage and the like. The paved area around the turf field usually has drains to capture surface water run-off. Depending on field design, the potential for infill containment will vary. A more general illustration is provided in Figure 2.

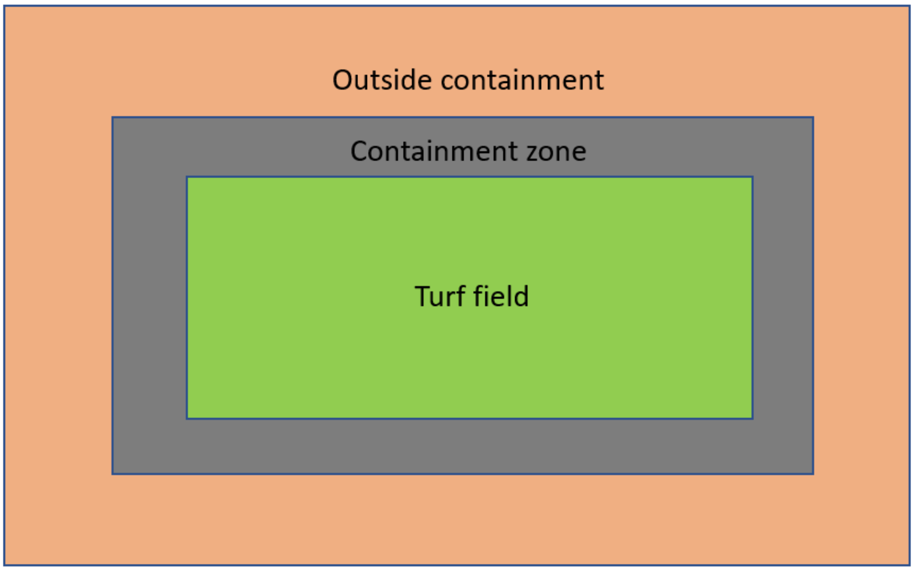

Figure 2. Illustration of turf mat and containment zone where it is possible to prevent infill loss as well as the area outside the containment zone where there is little possibility to prevent infill loss.

Some definitions used in this report are listed below:

Containment zone

The containment zone includes the turf field itself and the surrounding zone where maintenance measures can prevent infill from spreading any further. An efficient containment zone includes accumulation zones where infill is easily reclaimed. (Magnusson & Macsik 2020)

Outside the containment zone

This uncontrolled zone is wherever it is difficult for the field owner to reclaim infill material, e.g. ditches, grass, soil and when infill is transported to the private homes of players etc. – in their footwear and clothing. Infill from these accumulation areas is at risk of being further migration to the environment. (Magnusson & Macsik 2020)

Managed and uncontrolled infill transport

Infill transport is defined as any relocation of infill from the turf field, such as infill transported by shoes, maintenance equipment, runoff etc. Managed infill transport means that maintenance measures are implemented to reclaim infill to the field – or to manage it properly as waste. Uncontrolled infill transport means that the field owner takes no measures to reclaim the transported infill. (Magnusson & Macsik 2020)

Infill containment efficiency

The *efficiency* of infill containment will depend on how well infill transport is managed and kept in the containment zone. (Magnusson & Macsik 2020)

Accumulation zones

Infill transported off the field will accumulate in different places such as player passages, at storage surfaces for maintenance machinery and in well filters etc. These accumulation sites must be under control for infill to be reclaimed to the turf field or handled properly as waste. Infill accumulation zones can be both within and outside the containment zone and are illustrated in **Fel! Hittar inte referenskälla.**. Accumulation sites outside the containment zone are a source of further infill transport to the environment. (Magnusson & Macsik 2020)

2.2 Implementing a risk management plan and monitoring

The risk management plan suggested is based on the risk management plan developed by Magnusson and Macsik (2020). The plan was developed by using a systematic risk analysis methodology and analyzing the CEN report in relation to where activities and events for infill spreading are identified, risks sorted and prioritized. For each identified activity, the risk management plan describes the following:

- Type of event
- Probability of events
- Consequences of events (ranging from large infill loss to small infill loss)
- Proactive measures to be taken to prevent events
- The risk of infill spreading when proactive measures are in place
- The person responsible for monitoring the proactive measures
- What to do if measures do not work as intended

3 FIELD DESIGN FOR OPTIMIZED RMM AND FOR THE FACILITATION OF MEASURMENTS

The CEN TR-17519 report provides guidance on many different aspects for the reduction of infill migration, such as the shape of infill material, carpet design, design of barriers and entrance points etc. In this chapter, we have focused on the most important aspects for the minimization of infill spread and for facilitating the measurements of infill spreading.

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3.1 Containment barrier

A physical barrier around the containment zone is a must. The barrier must be completely impenetrable. See section *6.3.6 Margins between the synthetic turf playing surface and field boundaries* in the CEN report.

To facilitate measurements of the efficiency of boundaries, there should be a 2-meter-wide area along the outside of the boundaries that can be surfaced with a light cover, such as a geotextile, which makes it possible to detect, collect and measure infill.

3.2 Margins between the synthetic turf playing surface and field boundaries

The zone between turf field and fences/barrier can accumulate infill. This zone is often surfaced with asphalt, concrete tiles, or a synthetic turf mat. See *Section 6.3.6 Margins between the synthetic turf playing surface and field boundaries* in the CEN report.

Avoid open wells in the containment zone. If there will be open drainage wells for surface water in the containment zone, install infill traps in wells. See *section 6.3.2.2 Drainage silt traps* in CEN report.

3.3 Field drainage

Drainage water passing through the carpet and drainage water passing through open surface wells within the containment zone should have separated drainage systems. A sampling well is needed for each flow, as well as a common sampling well for both flows, see Figure 3. To allow additional filtration of drainage water and surface water, a well for the installation of an extra filter must be installed before the common sampling well, se Figure 3. The well for additional filtering must be dimensioned to allow the installation of filter types such as a Flexiclean filter.

If requested, it is possible to measure the flow rate of surface water and drainage water. Water flow meters can be installed in additional wells. For reference, wireless, digital water measureing devices were installed in wells in Bergavik in Kalmar, Sweden, in connection with a similar study. Such devices must be calibrated prior to use.

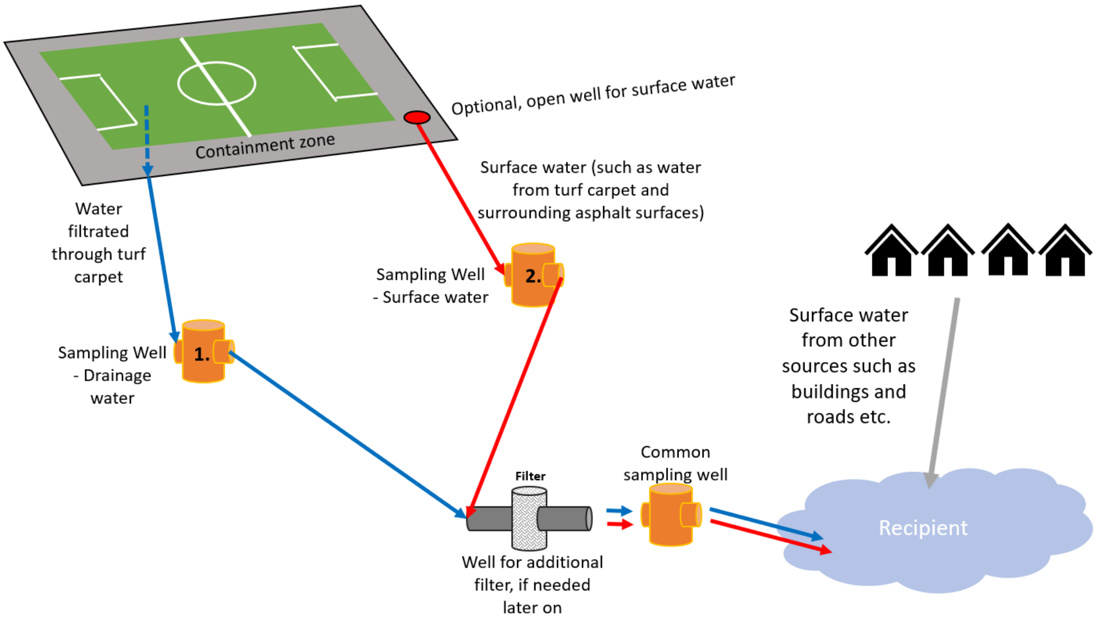


Figure 3. Water flows and sampling wells for drainage water and surface water.

It must be possible to access and open all sampling wells and extract a sample of the water with a 1-liter sampling bottle. Sampling wells should be easily accessible for sampling. There is a risk that infill accumulates in the joints between the well and the lid – and that infill then falls into the well when water samples are extracted. To minimize this risk, sampling wells should thus be located outside the containment zone.

Before the drainage pipe system is installed, the soil / gravel layers can be compacted to reduce infiltration to ground water – and to increase flow through drainage pipes and hence optimize conditions for water sampling.

The drainage system should be designed to reduce the risk that ground water infiltrates the drainage system, and the drainage system should thus be installed above ground water level.

To reduce water flow to ground water and increase water flow to drainage, thus improving conditions for water sampling, a section of the drainage system can be designed as a separate system where a waterproof membrane covers the ground underneath the separated drainage system. About 10-20% of the area underneath the turf field could be a separate drainage system with a separate drainage well for water sampling.

3.4 Drainage silt traps

If there are open wells within the containment zone, the drainage silt traps must be accessible, so they can be loosened, emptied, cleaned, and reinstalled. These silt traps typically comprise a filter bucket, which provides primary filtration of heavier silts, and, in some cases, a secondary micro-filter that captures any remaining, small particles. Both the filter bucket and the secondary micro-filter should be easily removable for maintenance purposes.

See *section 6.3.2.2 Drainage silt traps* in the CEN report.

3.5 Field entrance/exit points

All field entrance/exit points should have decontamination grates to prevent infill spreading – but also to allow measurement of infill accumulating in the grates. These should be the full width of the entrance gate and at least 1.5 m in length. Follow the instructions in section *6.3.7 Field entrance points* in the CEN report.

It must be easy to remove, separate and replaces grates to collect and measure the amount of infill accumulated in/below these grates.

To be able to measure the amount of infill stuck on players and maintenance equipment after they have passed through the field exit points and the cleaning stations, it is suggested to install three consecutive grate sections, each 1.5 m in length. See Figure 4 below.

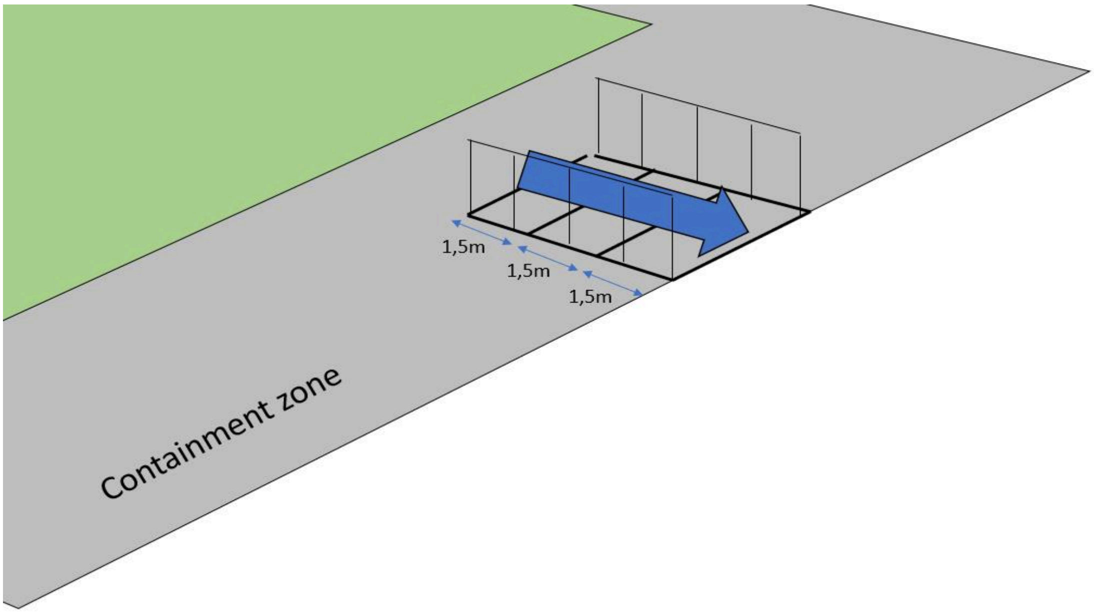


Figure 4. Exit pathway from the field consisting of three grate sections.

By separately measuring the amount of infill accumulated in the first, second and third grates, it is possible to analyze the effectiveness of extending grates beyond the minimum length of 1.5 m as stated in the CEN report.

To facilitate the measuring of infill stuck on players and maintenance machinery/personnel, there must be a 6x3 m surface area outside the grates at each entrance/exit point, where a geotextile or similar can be laid out to collect infill brushed off shoes and clothing, tractors, and maintenance equipment.

3.6 Boot cleaning stations

Boot cleaning stations should be integrated at the entrance/exit points. See *section 6.3.8 Boot cleaning stations* in the CEN report.

3.7 Recovery of dirty/muddy infill

There should be a designated surface within the containment zone where infill that is reclaimed from accumulation zones such as asphalt paving, grates, shoe cleaning stations etc. can be stored, cleaned from dirt/contaminants before it is returned to the field. There are techniques for separating infill from sand, soil etc. – for example through density separation. These techniques can also be used to measure the amount of infill accumulated in the grates or in other accumulation zones.

4 A PLAN FOR RMM AND MONITORING DURING CONSTRUCTION, USE, MAINTENANCE AND DECOMMISSIONING

4.1 Responsibilities

The plan should include clarifications in respect of the responsibilities held by for example maintenance personnel and measuring / sampling personnel. Someone should be responsible for coordinating this work.

4.2 Construction and installation of infill

See Chapter 7 Installation of infill in the CEN report.

Implement a risk management plan according to section 2 of the RISK MANAGEMENT TABLE FOR SYNTHETIC TURF INFILL CONTAINMENT in the appendix.

The risk management measures taken, and the monitoring should be documented. The documentation should consist of a duly filled in table with photos.

4.3 Use and maintenance

See Chapter 7-11 in the CEN report.

Implement a risk management plan according to section 1-5 of the RISK MANAGEMENT TABLE FOR SYNTHETIC TURF INFILL CONTAINMENT in the appendix.

The risk management measures taken, and the monitoring should be documented. The documentation should consist of a duly filled in table with photos.

4.4 Decommissioning

See Chapter 11 in the CEN report.

Implement a risk management plan according to section 5 of the RISK MANAGEMENT TABLE FOR SYNTHETIC TURF INFILL CONTAINMENT in the appendix.

The risk management measures taken, and the monitoring should be documented. The documentation should consist of a duly filled in table with photos.

5 QUANTITATIVE MEASUREMENTS AND ANALYSIS PRIOR TO PROJECT AND ONWARDS

5.1 Reference measurements

In urban areas, most land is to some extent contaminated by human activities – such as pollution from industry, traffic etc. Reference measurements are thus of importance to determine the scope of contamination prior to project launch. Results from reference measurements should be taken into consideration when evaluating measurements from the turf field. Make an in-depth analysis of the place where the synthetic turf is to be built. The study should include a description of the sub-catchment area, what the site and nearby sites have been used for historically (anthropogenic activity such as traffic, industry etc.) and how such prior use relates to the substances and anthropogenic particles that can be found in the soil and the water recipient of the area.

Make an in-depth analysis of the site and analyze what run-off water and recipient water contain in respect of unwanted substances and microplastics. Take soil and water samples and analyze the content of primarily microplastics – but also of unwanted substances that may be interesting as reference values. Sample sizes should be sufficient to give a good picture of the status of the site.

5.2 Players

Measurements of infill spread via players consist of several different measuring to provide a detailed quantification of:

1) infill accumulated at/below grates at entrance/exit points – left behind by players
2) infill transported outside the containment zone on the external part of players' shoes
3) infill transported outside the containment zone inside players' shoes
4) infill transported outside the containment zone on the clothing and skin of players

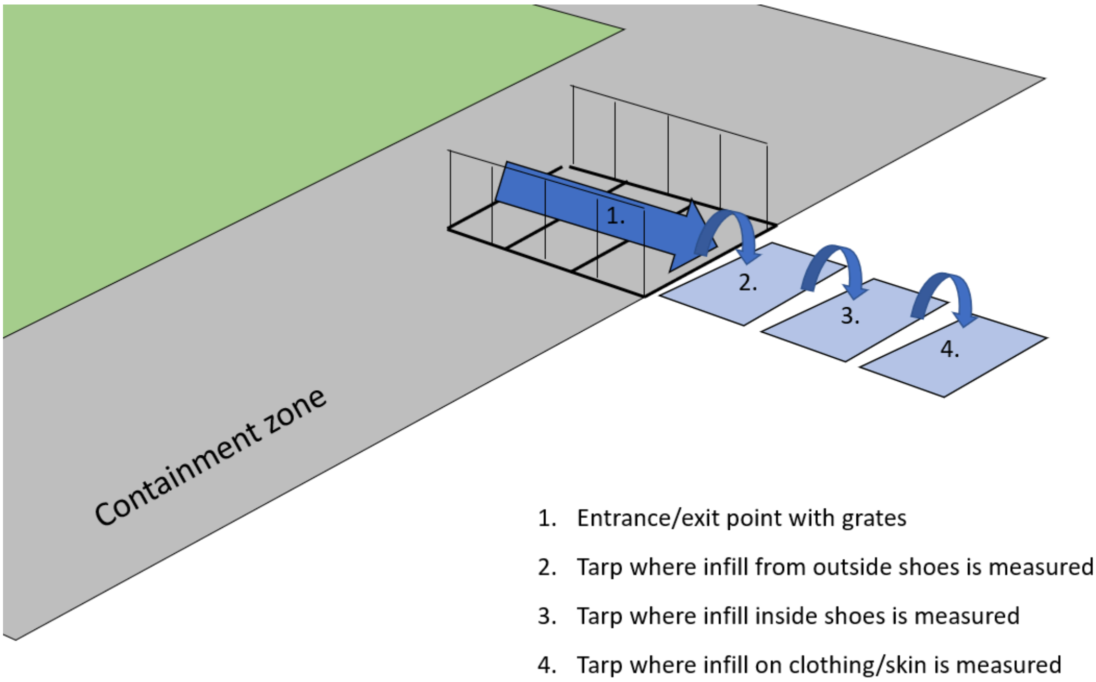


Figure 5. Projection of points where infill transported by players are measured

Investigate the annual number of players who will use the synthetic turf field.

A sampling should preferably include measuring the spread of infill from all players at a training session or match session. Dates for sampling should be randomized, and the number of sampled trainings and matches should be **sufficient** to quantify the annual infill spread – including different weather conditions.

Players may be susceptible to such sampling and temporarily change their behavior if they are informed that infill measurements are to be carried out. Players who do not normally brush off their shoes should e.g. not do so during measurements. Those carrying out the measurements must therefore ensure that players understand that they should not alter their behavior during measurements.

Measuring 1: Accumulation of infill in grates

Players leaving the synthetic turf pitch will pass through the entrance/exit points. All field entrance/exit points will be equipped with decontamination grates to prevent infill from spreading – but also to allow the measuring of infill accumulating in/below the grates. All infill that accumulates in/below the grates should be collected at regular intervals, and the dry weight of collected infill should be measured in grams per year.

Grates should be emptied at a rate that ensures that their function is not reduced due to overflowing of infill. Measuring the accumulation of infill in/below grates should facilitate quantification in grams per year. The grates may contain organic material such as leaves, turf fibers and inorganic materials such as sand. Such components should be separated from the infill to facilitate a correct measuring.

Measuring 2: Spreading of infill via the shoes of players – infill stuck on the external part of shoes

Players who pass through an entrance/exit point with grates, will still bring some infill outside the containment zone. Infill that is stuck on the external part of shoes should be measured. To measure the amount of infill stuck on the external part of players' shoes, players passing through the grates at entrance/exit points should step directly onto a cover, tarp, geotextile, cloth, or the like, where players brush off all infill stuck onto the external part of the shoes (**Do not** brush infill off clothing and **do not** empty out infill from inside the shoes). All the infill accumulating on the tarp, geotextile, cloth, or the like should be collected, and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measurement.

Measuring 3: Spreading of infill via players shoes –infill stuck inside shoes

When players have brushed off infill from the external parts of their shoes, they should immediately step onto a second cover, tarp, geotextile, or cloth where the players empty their shoes, pouring all infill into a large bucket (**Do not** brush infill off clothing). All the infill in the bucket and all the infill on the tarp, geotextile or cloth should be collected, and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measuring.

Measuring 4: Spreading of infill via players' clothing and skin – infill stuck on clothing such as shirts, shorts as well as on legs.

When players have emptied their shoes for infill, they should immediately step onto a third cover, tarp, geotextile, or cloth where players brush of all infill stuck on clothing such as shirts, shorts, trousers and on skin (bare legs, arms etc.). All infill on the tarp, geotextile or cloth should be collected, and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measuring.

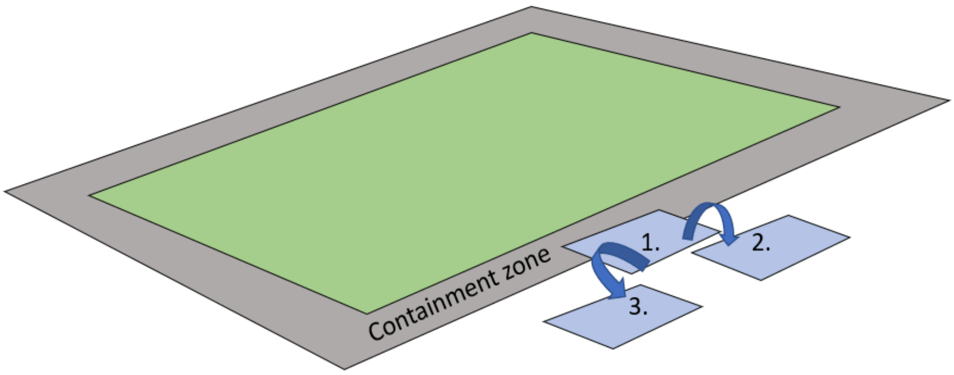
5.2.1 Equipment

Equipment such as balls, vests, cones etc. should be included in measurements. To measure infill stuck on equipment, a cover, tarp, geotextile, cloth, or the like should be placed on the ground within the containment zone. Brush off all infill stuck on equipment used. All the infill accumulating on the tarp, geotextile, cloth or similar should be collected and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measuring.

5.3 Field maintenance

Measuring of infill spread during maintenance consist of several different measuring to allow detailed quantification of

1) infill accumulated at/below grates at entrance/exit points due to maintenance vehicles and maintenance equipment leaving the containment zone
2) infill stuck on maintenance vehicles such as tractors – and further transported outside the containment zone
3) infill stuck on maintenance equipment such as brushes or harrowing equipment – and further transported outside the containment zone



1. Entrance/exit point with grates
2. Tarp where infill stuck on maintenance vehicles can be measured
3. Tarp where infill stuck on maintenance equipment can be measured

Figure 6. Projection of points where infill transported by maintenance are measured

Record the number of times per year that the synthetic turf field will be used and identify which machines will be in operation (e.g. for field brushing, harrowing and snow clearance). The recording could be done manually or digitally through electronic systems available for registration of e.g. users and time. Determine whether vehicles or equipment are designated for one field only – or used for several fields, thus leaving the containment zone regularly.

A sampling should preferably include measuring the spread of infill from all vehicles and maintenance equipment leaving the containment zone after a maintenance routine. Sampling dates should be random, and the number of sampled maintenance routines should be sufficient to quantify the annual infill spread – Including different weather conditions and different maintenance routines.

Maintenance personnel may be susceptible to such sampling and temporarily change their behavior, if they are informed that infill measuring is to be performed. Those carrying out the measuring must thus ensure that maintenance personnel understands that they should not alter their behavior during measuring.

Measuring 1: Accumulation of infill in grates

Maintenance vehicles leaving the containment zone should be thoroughly cleaned from infill. However, since cleaning may not be 100% effective, some infill will still be stuck on vehicles. Maintenance vehicles and maintenance machines leaving the synthetic turf pitch will pass through an entrance/exit point. All field entrance/exit points will be equipped with decontamination grates to prevent infill spreading – but also to facilitate the measuring of infill accumulating in/below the grates. All the infill that accumulates in/below the grate used for maintenance machines and maintenance equipment should be collected at regular intervals, and the dry weight of collected infill should be measured. Grates should be emptied at a rate that ensures that their function does not deteriorate due to overflowing of infill. Measurement of accumulation of infill in/below grates should allow quantification the accumulation in/below grates in grams per year. The grates may contain organic materials such as leaves, turf fiber, and inorganic materials such as sand. Such components should be separated from the infill to allow a correct measurement.

Measurement 2: Spreading of infill stuck on maintenance vehicles such as tractors

Vehicles that pass entrance points with grates will still bring some infill outside the containment zone. Infill that is stuck on vehicles should be measured. To measure the infill stuck on vehicles, vehicles passing through the grates at entrance points should directly disconnect and leave maintenance equipment and then roll over to a press, geotextile, cloth or similar where all infill is brushed off. All infill accumulating on the press, geotextile, cloth or similar should be collected and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measurement.

Measuring 3: Spreading of infill stuck on maintenance equipment such as brushes and harrowing equipment

Maintenance equipment that passes through entrance/exit points with grates will still bring some infill outside the containment zone. Infill stuck on maintenance equipment should be measured. To measure the amount of infill stuck on equipment, vehicles passing the grates at entrance/exit points should immediately turn off maintenance equipment, which is then rolled onto a tarp, geotextile, cloth or the like where all the infill from the maintenance equipment is brushed off. All the infill accumulating on the tarp, geotextile, cloth, or the like should be collected, and the dry weight of collected infill should be measured in grams per year. Contaminants such as leaves, turf fibers or sand should be separated from the infill to allow a correct measuring.

5.4 Drainage water and surface water

Drainage water and surface water could potentially transport fine infill particles outside the containment zone – even when filter buckets are installed in surface wells. To measure infill material transported to drainage water and surface water, two types of measuring are needed:

1) Measuring of infill particles in drainage water
2) Measuring of infill particles in surface water

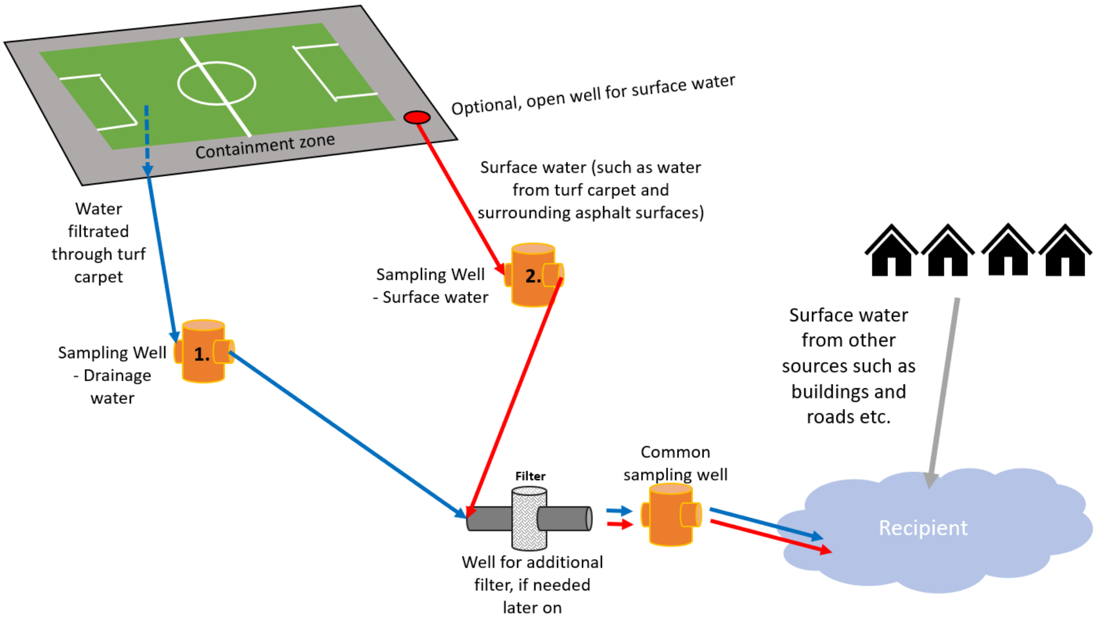


Figure 7. Sampling wells for drainage water (1) and surface water (2).

The common sampling well does not need to be sampled if no additional filter is installed later (if additional water filtration is needed).

Water sampling should take place during or after rain events. As a synthetic turf field can retain rainwater, some fields experience low water discharge rates even in rainy conditions. The number of samplings needs to be dimensioned considering that there is sometimes not sufficient water for sampling.

When sampling, the person handling the sampling must bear in mind that samples may be contaminated by plastic particles from the sampler's clothing. The sampler should thus refrain from wearing clothing with plastic / rubber material. When sampling, check that no infill is stuck between the well and the lid, since this infill could drop into the wells and contaminate water samples. Water samples should only be taken when water is flowing through the well. Record the time needed to fill up sample bottles to estimate flow rate (liter/h).

Depending on which analysis method for microplastics in water is chosen, the amount of water needed for sampling will vary. A larger water sample will give a more representative picture of microplastics content compared to a smaller water sample. However, the amount sampled may depend on limitations in sample preparations and the analysis methods for microplastics in the lab – as well as how clean the water is.

5.5 Accumulation zones outside containment

Infill can spread outside the containment zone due to e.g. insufficient barriers, mistakes in maintenance, etc. All infill that accumulates outside the containment should be collected at regular intervals, and the dry weight of collected infill should be measured in grams per year.

To facilitate measurements, there should be a 2-meter-wide area along the outside of the boundaries that can be surfaced with a light cover, such as a geotextile, which makes it possible to detect, collect and measure infill.

5.6 Methods for measuring infill in water and contaminated infill

There is no international standard for measuring microplastics in water, but standards will be made. See the appendix for more information on microplastics standards and methods.

5.6.1 Microplastics in water

It is recommended that microplastics are analyzed to quantify the mass of infill spreading to water. A combination of sampling and analysis methods can be used to measure microplastics in water. To quantify the mass, a lab analysis method can be used to identify the number of microparticles as well as the average particle size and type of the plastics and rubber-like particles per liter of water. Such lab analysis is offered by accredited laboratory specialized in measuring microplastics. Based on the size of the particles and tyre-rubber and plastic density, the total mass of particles can be quantified. This method requires a relatively small sample volume (less than 1 liter of water per sample). To analyze the mass of microplastics, there are methods that heat and gasify the particles in the sample and then examine the spectra in the gases and based on reference libraries, identify, and estimate the total mass of different types of plastic. This method may work for some rubber materials. Accredited laboratories specialized in measuring microplastics offers such lab analysis. For such analysis, the amount of sampled water needed is probably greater (> 1 liter per sample). A combination of these methods can give a relatively good picture of the mass of infill particles in the water samples. Each lab will have different detection and quantification limits. It is recommended to select analysis methods that also identify the smaller microplastics. Each lab gives specific recommendations for the sampling procedure. The sampling procedure should be documented in written form and with photos.

5.6.2 Contaminated infill

Infill will accumulate in grates, silt traps, boot cleaning stations, snow storages etc. This infill can be contaminated with e.g. soil, sediment, and mud. Density separation can be used to separate infill particles from soil and mud. There can be techniques such as using buckets with water for separating infill on site before drying and weighing infill before the infill is returned to the field.

5.7 Calculations

Calculations should include:

- Based on measurements of microplastics transported from the site before and after construction of the synthetic turf field (reference measurements and measurements in the surface and drainage water of the field), the change in total microplastics load to water should be calculated.
- Based on the measurements of infill transported by players, the amount of infill that will annually leave the containment zone should be calculated in grams per year. The calculation should distinguish between infill transported on shoes, inside shoes and on clothing and skin.
- Based on the measurements of infill transported by maintenance vehicles / equipment, the amount of infill that will annually leave the containment zone should be calculated in grams per year. The calculation should distinguish between infill transported by maintenance vehicles and by maintenance equipment.
- Based on the measurements of infill transported by water, the amount of infill that will annually leave the containment zone should be calculated in grams per year. The calculation should distinguish between drainage water and surface water.
- The infill accumulated outside the containment zone should be measured and calculated in grams per year.

A template for the registration of results can be found in the appendix.

APPENDIX

The *RISK MANAGEMENT TABLE FOR SYNTHETIC TURF INFILL CONTAINMENT* below has been developed by Magnusson & Macsik (2020) in the ESTC-report.

RISK MANAGEMENT TABLE FOR SYNTHETIC TURF INFILL CONTAINMENT							
Activity	No. of activities during a 10-year period	**Event and Probability of event** Green = Small probability Blue= Medium probability Red= high probability	**Consequence of event** Green = Small infill loss (<10kg) Blue= Medium infill loss (10s of kgs) Red= Large infill loss (100s of kgs)	**Proactive measure & infill containment efficiency** **Risk of infill loss after proactive measure:** Green= Eliminated risk Blue= Medium risk Red= High risk	**Quantification of containment efficiency**	**Responsibility**	**Monitoring and follow up**
1. Containment barriers							
Infill leaving the field due to migration to the sides		Infill spread due to absence of containment zone around the field	Infill can spread by players and maintenance equipment. Infill spreading to the environment increases.	Install boards around the field	~ 100%	Responsible for field design	If boards do not work as intended, take action to prevent infill spreading
Infill thrown off the field due to maintenance		Infill spread due to absence of containment zone around the field	Infill can be spread by maintenance equipment. Infill spreading to the environment increases.	Install boards around the field	~ 100%	Responsible for field design	If boards do not work as intended, take action to prevent infill spreading
Infill carried by wind from the field		Infill spread due to absence of containment zone around the field	Infill can spread by wind. Infill spreading to the environment increases.	Install boards around the field	~ 100%	Responsible for field design	If boards do not work as intended, take action to prevent infill spreading

2. Infill installation and refilling							
Ordering infill bags	10	Infill leakage from damaged infill bags	Infill may leak every time the bag is handled, from production plant to turf field. Infill spreading to the environment increases.	Infill materials should be supplied to site in suitable heavy–duty bags that are not torn or open. Check that there are no holes in the bags and that the correct type of bags is used.	~ 100%	Responsible for ordering infill bags	If there are damaged bags, take action to prevent infill spreading.
Storing infill bags	10	Infill bags are vandalized	Vandalism of infill bags can lead to infill leakage. Infill spreading within field area increases.	Infill materials should be stored in secure compounds. Check that infill bags are not damaged.	~ 100%	Responsible for storing infill bags	If there are damaged bags, take action to prevent infill spreading.
Opening infill bags	10	Infill bags are opened outside the field	Infill may leak every time the bag is handled. Infill spreading to the environment increases.	Only open bags within the confines of the field; do not transport loose infill from outside the field to the installation equipment.	~ 100%	Responsible for handling infill bags	If there are open bags outside the field, take action to prevent infill spreading.
Handling emptied bags	10	Emptied infill bags are not contained	Infill may leak every time the bag is handled. Infill spreading to the environment increases.	Collect and contain emptied infill bags before they leave the field area.	~ 100%	Responsible for handling infill bags	If there are uncontained emptied infill bags, take action to prevent infill spreading.

Transporting filling equipment from the field	10	Uncleaned filling equipment leaves the field	Infill can be carried by filling machines and brushes for infill distribution and fall off. Infill spreading to the environment increases.	Thoroughly clean equipment before they leave the field area.	~ 100%	Responsible for filling/refilling	If there is uncleaned filling equipment, take action to prevent infill spreading.

3. Maintenance							
Transporting maintenance equipment from site	1 000	Uncleaned maintenance equipment leaves the field	Infill can be found on maintenance equipment from where it may fall off. Infill spreading to the environment increases	Thoroughly clean maintenance equipment before such equipment leaves the field area.	~ 95% *	Responsible for maintenance	If maintenance equipment is not thoroughly cleaned, take action to prevent infill spreading.
Storing maintenance equipment	1 000	Maintenance equipment is not stored at designated area	Infill can be found on maintenance equipment from where it may fall off. Infill spreading within the field area increases.	Store maintenance equipment at designated, paved location; return accumulated infill to field.	~ 100%	Responsible for maintenance	If maintenance equipment is not stored at designated area, take action to prevent infill spreading.
Using rotary brushes and leaf blowers	30	Rotary brushes and leaf blowers are used incorrectly	Infill can be flicked up and thrown out of the field containment zone. Infill spreading to environment increases.	Adjust brushing / leaf blowing pattern so that such flicked-up infill does not leave the field containment zone.	~ 100%	Responsible for maintenance	If rotary brushes and leaf blowers are used incorrectly, take action to prevent infill spreading.
Snow clearance	Special case	Inadequate snow clearance routines	Snow is transported off the field or leaked outside the containment zone, as snow scaling the fence. Infill spreading to the environment increases.	Store snow inside a designated containment area and limit the height of snow piles, so that infill cannot scale the fence.	~ 100%	Responsible for maintenance	If snow clearance routines are inadequate, take action to prevent infill spreading.
Filtering surface water	Continuous	Leakage of unfiltered surface water from field area	Surface water from rain and snow can carry infill to drainage, where it is accumulated or lost outside the	Assure that surface water leaves the field by ground infiltration or through wells with filters.	~ 100%	Responsible for maintenance and design	If unfiltered surface water leaks from the field, take action to prevent infill spreading.

			containment zone. Infill spreading to the environment increases.				
Filtering shower/sink water	Continuous	Leakage of unfiltered water from locker rooms	Water from showers and sinks can carry infill to drainage where it is lost outside the containment zone. Infill spreading to the environment increases.	Install filters in showers and sinks	~ 100%	Responsible for maintenance and design	If unfiltered shower/sink water is leaking from the locker room, take action to prevent infill spreading.
Filtering surface or shower/sink water	Continuous	Leakage of unfiltered water due to clogging	Filters around the field and in showers can be clogged with sediment, hair and infill etc., which reduces the efficiency of filtering. Infill spreading to the environment increases.	Ensure that all filters around the field and in locker rooms are regularly checked and emptied to ensure that they remain operational.	~ 100%	Responsible for maintenance	If filters are clogged, take action to prevent infill spreading.
4. Use							
Relocation of infill due to playing	Continuous	Overfilling	Too thick layer of infill makes top infill layer more mobile which can increase infill accumulation on the sides of the field. Infill spreading within the field area increases.	Restore infill depth through maintenance. Brush infill back onto the field	~ 100%	Responsible for maintenance	If the field is overfilled, take action to prevent infill spreading.
	Continuous	Inadequate distribution of infill	Infill disperses from the higher center of the field to the lower field sides where it accumulates. Infill spreading within the field area increases.	Restore infill depth through maintenance. Brush infill back onto the field	~ 100%	Responsible for maintenance	If infill is unevenly distributed, take action to prevent infill spreading.

Users leaving the field	585 000	Boot cleaning stations are not cleaned or not working	Infill can accumulate at cleaning stations. Worn-out brushes can lead to reduced efficiency when cleaning boots. Infill spreading to the environment increases.	Remove accumulated infill and replace worn-out brushes.	~ 100%	Responsible for maintenance	If boot cleaning stations are not cleaned or do not work adequately, take action to prevent infill spreading.
		Inadequate or ignored boot/clothing cleaning routine	Infill can be found on shoes / clothing from where it may fall off. Infill spreading to the environment increases.	Inform players and trainers how to use the boot cleaning stations.	~95%*	Users	If users do not brush off shoes and clothing, take action to prevent infill spreading.
Visitors /spectators /staff leaving the field	10 000	Inadequate or ignored boot/clothing cleaning routine	Infill can be found on shoes / clothing from where it may fall off. Infill spreading to the environment increases.	Inform visitors, spectators, and staff how to use the boot cleaning stations.	~95%*	Visitors/ spectators/ staff	If visitors/spectators/staff do not brush off shoes and clothing, take action to prevent infill spreading.

5. End-of-life disposal							
Removing turf mat and infill	1	Leakage during turf removal	Leakage due to inadequate turf mat handling when unrolled from the field and loaded on a truck. Infill spreading to the environment increases.	Loading to truck should be done on the turf field, so leaked infill stays at the turf field.	~100%	Responsible for decommissioning	If loading onto trucks takes place outside the field, take action to prevent infill spreading.
Transporting turf mat/ infill by truck	1	Leakage during transport to disposal/recycling	Infill is not contained properly when infill is transported to disposal/recycling. Infill spreading to the environment increases.	Decommissioned turf and infill should be transported to recycling/disposal in suitable heavy–duty bags that are not torn or open. Check that there are no holes in the bags and that the correct type of bags is used.	~100%	Responsible for decommissioning	If there are damaged bags, take action to prevent infill spreading.

*Assumption based on measurements by Regnell, 2019

Standardization work for microplastics

According to and Jenny Fagerland (project leader for the plastics committee) at SIS (Swedish Standards Institute), there is currently no standard for the analysis of microplastics. However, this work is ongoing, cf. *ISO/NP 24 606-1*.

There are standards for water sampling – but not specifically for microplastics. According to Jenny Fagerlund, *TK 424 Kemiska vattenundersökningar* may be used.

Commercially available analysis methods for microplastics

Down below are two different analysis methods for measuring microplastics accounted for. They have been highlighted as the laboratories are well respected and the methods are commercially available. Analyzing and identifying microplastics are however not limited to these two methods, and it is therefore recommended to follow future development of different methods.

An accredited laboratory specialized in measuring microplastics is offering an analysis method where microplastics in water can be measured. The method is more uncertain for rubber particles. To identify rubber, markers such as polyisoprene and polybutadiene are used. The method used measures the mass of the microplastics.
https://www.eurofins.se/tjaenster/miljoe-och-vatten/nyheter-miljo/mikroplast-bestaemning-av-gummikomponenter-i-vatten/

Another accredited laboratory specialized in measuring microplastics is offering a method where microplastics in water can be measured. The method used is a SEM analysis combined with EDX and FTIR. The method can identify single rubber particles. Based on the number of particles, the size and known density of them, the mass of rubber particles can be calculated. This method was used in the Kalmar project.

This laboratory also conducted an analysis for the KG2021 project about microplastics in soil.
https://www.ntnu.no/documents/11601816/1285177107/%5BKG2021%5D+Mikroplast+og+tungmetaller+under+Mell%C3%B8s+kunstgressbane+i+Moss.pdf/b69d4070-e6f1-5f06-e4d8-ff6ac4d136e3?t=1602076450667

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Template for registration of results

	Microplastic load from the site before construction
Reference measurements	
Surface water from the site (grams/year)	
Accumulation in soil (gram/m^2)	
	Infill transported Outside containment (grams/year)
Players	
On shoes	
In shoes	
On clothing/skin	
On Equipment (e.g. Balls, vests etc.)	
Maintenance	
On Vehicle A (e.g. Tractor)	
On Vehicle B (e.g. Car)	
On Equipment A (e.g. Brush)	
On Equipment B (e.g. Harrow)	
Water	
In Drainage water	
In Surface water	
In joint water (drainage + surface) (only if additional water filtration is used)	
Accumulation zones outside containment	
Infill accumulated on surfaces outside containment zone, e.g. outside barriers	

	Infill transported within containment (grams/year)
Accumulation zones inside containment	
Grates	
Silt traps	
Snow removal area	
Other potential accumulation zone	

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