

Best Management Practices and Self-Assessment Water and Fertilizer Use for Greenhouse Floriculture Production



Canada



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Getting Started

Water and nutrient management is fundamentally important to the profitable production of greenhouse floriculture crops. Best management practices (BMPs) can help you improve production efficiency and protect our environment by making best use of water and nutrient resources.

BMPs are voluntary tools that can help you:

- Evaluate the current use of water and fertilizer at your production facility
- Identify possible improvements to current usage patterns
- Record ongoing improvements to measure progress over time

Greenhouses commonly generate three types of water: process water (which includes greenhouse nutrient feedwater and other non-production wastewater), stormwater, and sanitary sewage. This document deals with process water and stormwater. Wastewater loss directly from greenhouses or from the stormwater pond can have levels of phosphorus and nitrate that exceed the Provincial Water Quality Objectives. These nutrients can negatively impact the lakes and streams that receive the discharges by promoting the growth of algae and cyanobacteria (blue-green algae).

Implementation of the BMPs provided in this document helps to reduce the risk of nutrient loss to the environment, but does not remove the operator's responsibility to ensure compliance with applicable legislation, including municipal, provincial and federal requirements. Greenhouse floriculture operations must be managed in accordance with applicable legislation such as the *Conservation Authorities Act*, *Environmental Protection Act*, *Lakes and Rivers Improvement Act*, *Nutrient Management Act*, *Ontario Water Resources Act*, *Pesticides Act* and the *Building Code Act*.

To assist you in looking at water and nutrient management throughout crop production in the greenhouse, BMPs in this self-assessment guide have been organized into four categories. These categories separate the BMPs into those that are good practice in general, and those that are practiced A) before water and nutrients are applied to the crop in **Pre-production**, B) as water and nutrient are applied to the crop in **Production**, and C) after water and nutrients leave the crop in **Post-production**.

It is important to note that every BMP will not be suitable for every operation or goal. Use of both your completed Environmental Farm Plan (EFP) and this Self-Assessment can help you determine which BMPs to implement in your greenhouse production system.

Self-Assessment

The self-assessment guide is designed to help you take a comprehensive and critical overview of your production areas. The various sections of the guide are designed to assist you with:

- Knowing your water quality and quantity
- Managing water and nutrient inputs efficiently
- Maximizing collection and reuse of water
- Maximizing storage capacity and integrity to keep water contained

Through completing this self-assessment, you should be able to:

1. Map all water sources, storage and post-production water movement on and off your property.
2. Review all fertilizer and chemical storage and mixing areas to ensure proper containment.
3. Identify areas on your property where current production practices may impact surface or ground water.
4. Test all irrigation, runoff, collected and stored water.
5. Measure and record your current water and fertilizer use per unit area of production, per year or crop rotation.
6. Describe how water and fertilizer are collected and stored for reuse.
7. Develop and review contingency plans for when water availability is restricted or quality reduced.
8. Prepare a plan for managing post-production water after it can no longer be reused.
9. Implement continuous improvements to conserve water and nutrient inputs.

How it Works

For most self-assessment questions in this guide, there are four possible answers listed in separate columns. Each column has a number ranking: 4, 3, 2 or 1.

In some instances, where the answer is either Yes-4 or No-1, only two columns are listed. Check the box that most accurately describes the current situation for your operation.

Practices described under Columns 3 and 4 improve nutrient and water use by reducing the amount of water and nutrients requiring management post-production.

Practices identified in Columns 1 and 2 can be improved upon by implementing the BMPs listed under each Self-Assessment question.

After completing the Self-Assessment, review the practices you identified as candidates for improvement (ranked as 1 or 2). Document your Self-Assessment score and create a plan for improving your score.

Consider the suitable BMPs, and choose those that you can apply in the next 1-3 years. Improving the management of water and nutrients in your greenhouse should be an ongoing progress.

GENERAL ENVIRONMENTAL ASSESSMENT FOR FLORICULTURE GREENHOUSES

The BMP questions in this first section of the self-assessment guide indicate general best practices for operation of a floriculture greenhouse. Knowing the layout of your farm, and its construction history can assist you with future upgrades or building additions.

1. Do you have an up-to-date, completed and reviewed environmental farm plan (EFP)?	
4	1
<input type="checkbox"/> Yes	<input type="checkbox"/> No
<p>BMPs:</p> <p>Complete an EFP for your greenhouse operation. Attend an EFP workshop and create an action plan.</p> <p>The EFP is a voluntary education and awareness program designed to help Ontario farmers prepare confidential and self-administered risk assessments on their farms. Action plans are developed to address identified concerns. Certain funding opportunities require an up-to-date EFP. Check with the Ontario Soil and Crop Improvement Association (OSCIA) for the most current edition.</p>	



An Environmental Farm Plan (EFP) helps participating farmers verify their good production practices and identify areas requiring improvement. Having an up-to-date completed EFP may be a requirement to access cost share-based funding.

SELF-ASSESSMENT

2. Do you have an up-to-date map or schematic of your facility showing all incoming and outgoing surface and subsurface water on and off your property?

4

1

 Yes

 No

BMPs:

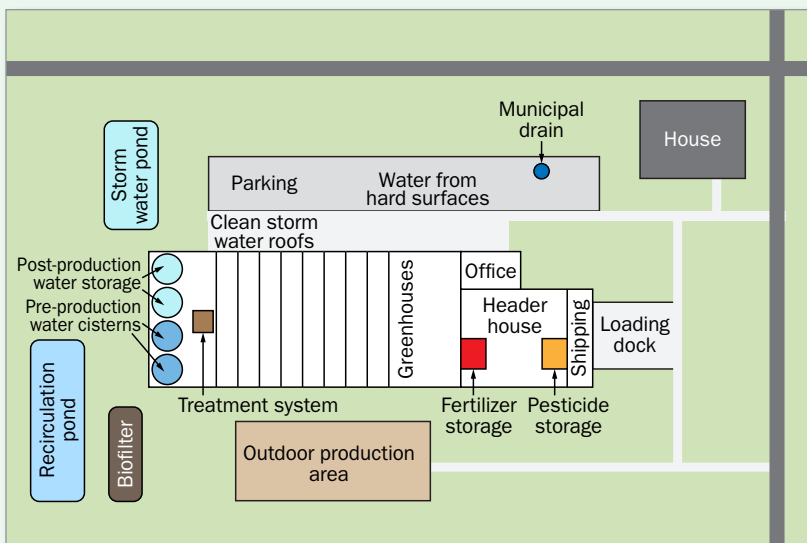
Know where water enters and drain water leaves your operation, as well as how water moves through your operation.

Begin by identifying all water inputs and outputs on a map of your operation:

- Inputs may include municipal water, wells, surface water, rain water, etc.
- Outputs may include surface runoff, surface and subsurface drainage* (pre-existing and ones you have installed), catch basins, pond overflows and driveways.

Ensure your map also indicates:

- All locations of surface water (streams, creeks, ponds and wetlands) and both active and decommissioned wells.
- All sources of storm-water runoff from hard surfaces outside the greenhouse (outdoor production areas, loading docks, driveways, parking lots, compacted soil and roofs).
- Surface and subsurface drains and water collection areas both inside and outside the greenhouse (for example; drip gutters, shipping drench floor drains, boiler water and condensate collection, cut flower pail water, tray and trough wash water, filter backwash, planting line water, drip-line wash water, roof white-wash rinsate, ponds, cisterns, silos).
- How water moves through your farm (for example; collection, storage, and pre-treatment; distribution system — sumps, pumps, and pipes; trays, troughs, flood floors; filters, injectors, mixing tanks and treatment systems).
- Water movement through subsurface drainage pipes (more commonly known as tile drains; often remaining from pre-existing field agriculture operations) including those installed prior to greenhouse or outdoor production area construction, and those installed as part of the outdoor production area.
- All nutrient feedwater (fertilizer stock tanks, mixing tanks, irrigation systems, leachate, recirculating tanks, treatment systems and storage tanks).
- Fertilizer and chemical storage mixing area(s), including fuel storage tanks.
- Discharges to the natural environment.



Create a drawing, aerial map or schematic of your farm property, similar to this example. Clearly label all places where fertilizer and water are stored. Use arrows to indicate the movement of water throughout the property, including all types of potential runoff.

3. Does the greenhouse and associated production facility comply with municipal, conservation authority and provincial requirements with respect to siting, construction, precipitation collection and stormwater management?

4	1
<input type="checkbox"/> Yes, comply with all provincial, municipal, and conservation authority requirements with respect to the greenhouse operation	<input type="checkbox"/> No or not sure OR <input type="checkbox"/> Comply with some but not all municipal, conservation authority and provincial requirements

BMPs:

Comply with all provincial, municipal, and conservation authority requirements with respect to the greenhouse operation.

For example, provincial requirements may include:

- Permit to Take Water (PTTW) if you take more than 50,000 L on any day from a surface or ground water source under the Ontario Water Resources Act.
- An Environmental Compliance Approval (ECA) under the Ontario Water Resources Act for the discharge of post-production waters or changes to stormwater collection.

Municipalities may require capture and storage of rain water as part of a building permit to offset the impact on municipal water sources.

Regional conservation authorities may require permits for the preservation of natural heritage features, for erosion control structures and for flood plain management.

4. Is the current greenhouse facility designed to collect and recycle all water enriched with nutrients?

4	2	1
<input type="checkbox"/> Yes, production facility is completely closed system	<input type="checkbox"/> Production facility consists of both open and closed systems	<input type="checkbox"/> No, production facility is an entirely open system

BMPs:

In designing a new facility or retrofitting an existing one, aim for 100% closed-loop irrigation systems regardless of the crops being produced.

In a *closed system*, all nutrient feedwater is captured for reuse. This includes the collection of leachate and nutrient rich feedwater in all production areas.

In an *open system*, leached or irrigated nutrient feedwater is not captured for reuse. Soil based production systems are generally open systems, unless sub-surface drainage has been installed to intercept any leachate that may get below the crop rooting zone. Some greenhouse facilities may be a combination of closed and open systems depending on crops being produced or stage of new technology adoption.

Open systems which discharge wastewater (nutrient feedwater and/or stormwater) into the natural environment without the appropriate approvals are in violation of the *Ontario Water Resources Act*.



Closed systems may include technologies such as flood benches and troughs, which collect nutrient feedwater for reuse.

5. In Question 4, if you have ranked your greenhouse facility as 1 or 2, answer the following question. If you ranked your facility as 4, then proceed to Question 6.

In the construction of the greenhouse and site preparation for open systems, how have you reduced the potential for nutrients to be lost to the natural environment?

4	3	2	1
<input type="checkbox"/> Impermeable liner and leachate is captured	<input type="checkbox"/> Compacted clay and leachate is captured	<input type="checkbox"/> Compacted loam, silt loam or sandy loam and leachate is captured	<input type="checkbox"/> Uncompacted soil or compacted sand and gravel and leachate is not captured

BMPs:

When selecting a site for new facility, ensure that plans are designed to reduce the potential for nutrients to be lost to the environment. For example, assessing the soil texture prior to construction can assist you in choosing management methods that can minimize the leaching of nutrient rich water in soil based production areas.

Impermeable production surfaces such as polyethylene, concrete, trays, or compacted clay can minimize leaching of nutrient feedwater to ground water. Ensure the collection of leachate is above the impermeable layer.

Nutrient feedwater leachate can be directed to collection drains using gravel-filled channels made from impermeable or compacted materials.

6. Which one of the following best describes the features of your outdoor container production area that are designed to reduce ground infiltration and maximize the capture of runoff?

not applicable

4	3	2	1
<input type="checkbox"/> Containers placed on compacted soil or impermeable surface Outdoor production area and all runoff pathways covered with an impermeable barrier and graded to direct water All nutrient-enriched water is collected and managed Stormwater diverted from container production area and erosion managed	<input type="checkbox"/> Containers placed on compacted soil or impermeable surface Outdoor production area covered with a semi-permeable barrier All nutrient-enriched water is collected and managed	<input type="checkbox"/> Containers placed directly on un-compacted soil surface Outdoor production area covered with a semi-permeable barrier Some nutrient-enriched water collected and managed	<input type="checkbox"/> Containers placed directly on un-compacted soil surface Outdoor production area is not covered with a semi-permeable barrier No nutrient-enriched water is collected

BMPs:

Prior to constructing the outdoor production area, assess site features: soil texture, topography, depth to water table and bedrock, and distance to surface water sources (creeks, streams and ditches). Select or modify the site as needed to help protect ground water and surface water.

Grade the outdoor container production area to direct stormwater away from the area. Manage soil erosion from stormwater both around and within the outdoor container production area. Use check dams, riprap or permanent synthetic or living ground covers.

Minimize water infiltration under the outdoor container production area and maximize surface runoff collection from the area. Use a gradual slope, compacted soil, or other impermeable surface to divert all water containing nutrients to a lined collection pond or cistern. Alternatively, retrofit outdoor container production areas with subsurface drainage to collect and divert nutrient containing water to a lined collection pond or cistern.



A compacted surface and an impermeable barrier will assist in collecting any nutrient rich water from your outdoor collection area.

7. Are subsurface drain pipes* located below greenhouse production areas?

4	3	2	1
<input type="checkbox"/> Subsurface drainage pipes are mapped and sub-surface drainage water collected, stored and reused	<input type="checkbox"/> Subsurface drainage pipes and pre-existing subsurface drainage pipes and outlets are mapped	<input type="checkbox"/> There are pre-existing subsurface drainage pipes but do not have them mapped or am unable to locate	<input type="checkbox"/> Do not know if there are any pre-existing subsurface drainage pipes

BMPs:

Ensure subsurface drainage pipes installed under the production area are not connected to pre-existing subsurface drainage pipes*. This will allow for management of water moving from the production area.

All water from subsurface drain pipes installed under the production area should be collected, stored, assessed for reuse and properly managed. Ensure any retrofits or additions to the greenhouse are designed with the current subsurface collection system in mind.

**Pre-existing subsurface drainage pipes* are remaining tile drains from previous agricultural operations located on the same site as the current greenhouse operation. These tiles were installed for field agriculture. They are generally deeper than tiles installed to manage the water table under greenhouse or outdoor container production areas. Their outfalls are usually located in municipal drainage ditches or surface water courses.



Knowing where subsurface drainage pipes are and if or how they connect to existing systems will help to determine water flow in and around your operation.

A PRE-PRODUCTION WATER AND NUTRIENT MANAGEMENT

Dealing with water and nutrients before they are applied to the crop

Water Source:

Know your water quality before it becomes part of your production system. If you are aware of any undesirable attributes and nutrients in your source water, you can take pre-emptive measures to improve the quality or reduce the quantity of water and nutrients that will have to be managed.

A.1 What is your main water source for greenhouse floriculture production?

4	3	2	1
<input type="checkbox"/> Municipal water or stored rain water (in silos or cisterns)	<input type="checkbox"/> Well water	<input type="checkbox"/> Lake or pond	<input type="checkbox"/> Stream or open ditch

BMPs:

Water quality is dependent on water source. Improving water quality to meet crop requirements requires additional technological resources and/or can increase the amount of post-production water requiring management. For example, the more water you need to treat, the more post-production waters you may need to manage.

Water source can affect water quality:

- Stream, lake or pond water quality may vary over the year
- Well water can have consistent water quality depending on the geographic location and well depth. Water may have high EC, sulphate, iron, or bicarbonates
- Municipal water or rain water source quality are generally consistent over the year

Where possible, capture and store rain water in a silo or cistern for use. This water can be used on its own as irrigation water or used to dilute poorer quality water sources for use in production.

Note that collected rain water is also known as stormwater. Changes to how you collect and use stormwater may require an Environmental Compliance Approval (ECA) or a permit to take water (PTTW). Check with your local Ministry of the Environment, Conservation and Parks (MOECP) district office for current ECA or PTTW requirements.



Collecting rainwater from greenhouse roofs and storing it for irrigation use is a good water management practice.

A.2 How do you protect your water sources? (Give yourself a point for each practice you employ.)

4	3	2	1
<input type="checkbox"/> On farm wells are protected from contamination <input type="checkbox"/> Any runoff or spillage from fertilizer, fuel or pesticide mixing area is contained and managed appropriately <input type="checkbox"/> Systems in place (e.g. berms, drainage ditches, vegetative buffers, hard engineering) to divert contamination sources away from irrigation water sources <input type="checkbox"/> Poor quality water is kept separate from irrigation water sources	<input type="checkbox"/> Any three of the practices in column 4	<input type="checkbox"/> Any two of the practices in column 4	<input type="checkbox"/> One or none of the practices in column 4

BMPs:

For all production systems:

Make sure production water sources are not contaminated through greenhouse (i.e. accidental pesticide contamination) or off-farm activities (i.e. road salt).

Oil and grit separators may be needed to treat un-usable stormwater runoff from parking lots or loading dock areas before they leave your property. Ensure that contaminated stormwater remains separate from water used in production. Do not discharge collected stormwater into the natural environment without the appropriate provincial approvals.

Equip all water taking systems with anti-backflow devices to prevent unintentional contamination of the water source. Floor drains in pesticide and fertilizer storage and mixing areas must divert to containment.

For water wells:

Inspect, monitor and maintain wells that are on your property. Where necessary, slope the ground surface away from the well and mound the earth around it, so surface water quickly flows away from the casing. For more information on protecting water well quality, see OMAFRA's publications *Best Management Practices for Water Wells* or *Water Supply Wells: Requirements and Best Practices*.

Follow EFP guidelines for separation distances from potential contaminant sources and wells. Test well water regularly. Properly decommission (plug and seal) any unused wells according to the Wells Regulation [R.R.O. 1990, Regulation 903 (Wells) as amended under the Ontario Water Resources Act, R.S.O. 1990, c.0.40.].

For ponds, cisterns or water silos:

Construct appropriately sized lined ponds, below ground concrete cisterns or above-ground lined water silos to capture and store water for use in the greenhouse.

Vegetate or line open waterway collection systems. The installation of dams or riprap will help to slow water down, preventing erosion and promoting sedimentation with the end result to improve the quality of stored water.

Install safety fencing around all ponds; check with your municipality for current regulations or bylaws.



Ensure that on-farm wells are protected from contamination.



Lined ponds can be used to capture and store water for use in the production system.

A.3 Do you test your source water for its nutrient and other chemical attributes?

4

1

 Yes

 No

BMPs:

Test source water before it becomes a part of your production system. Knowing your water quality can help manage undesirable attributes and nutrients post production.

Take source water samples throughout the year or when changing water sources to identify chemical analyses and manage the water accordingly for optimal crop production.

Test water for:

- Macronutrients: nitrate-nitrogen ($\text{NO}_3\text{-N}$) phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca)
- Micronutrients: manganese (Mn), molybdenum (Mo), copper (Cu), boron (B), zinc (Zn), iron (Fe)
- Other components: electrical conductivity (EC), pH, bicarbonates, sodium (Na), chloride (Cl), sulphates (SO_4)

Frequency of water chemistry testing depends on water source:

- Monthly: stream, municipal drain
- Seasonally: Well, water stored in pond, lake, municipal, rainwater stored in cistern/water silo
- More often in cases where warranted (e.g. water borne pathogen concerns, fluctuating bicarbonate levels)



Knowing your water quality can identify potential risks, and allow you to manage them.

A.4 If filtering source water prior to irrigation, which physical treatment do you use before any other treatment technology?

not applicable

4	3	2	1
<input type="checkbox"/> Macro screening (e.g. >1cm particles cannot pass through) and pre-treatment of clean irrigation water such as stainless steel stationary screens with a rapid sand filter and a fabric filter	<input type="checkbox"/> Macro screening and pre-treatment of clean irrigation water such as stainless steel stationary screens with a rapid sand filter or a fabric filter	<input type="checkbox"/> Macro screening at intake pipe and no other screening or filtration	<input type="checkbox"/> Do not screen irrigation water before irrigation use in production area

BMPs:

Remove debris and sediments to maintain integrity and delivery uniformity of your irrigation system. Debris can be anything that might plug your irrigation system such as algae, biofilm, fish or frogs. Sediments include suspended silts and clays.

Initial physical treatment of water allows for more effective chemical treatment, and will improve the functionality of irrigation equipment.



Physical pre-treatment systems help to keep your irrigation system clear of particles which may clog lines and emitters leading to uneven water and nutrient delivery.



A.5 Do you have a contingency plan if water access is restricted, inadequate, or water quality becomes poor?

4

1

Yes

No

BMPs:

Develop and update a contingency plan to ensure you have accessible production water during periods of low water or poor water quality. A contingency plan should include: alternative water sources, any necessary approvals, logistics for delivery, backup storage, and permanent water storage capacity to compensate for variability in water quantity and quality.

Be familiar with your local conservation authority’s Low Water Response Plan and the members of their Low Water Response Team. Grower participation in regional water management teams can benefit both the team and the agricultural sector.

If your operation is on municipal water, always have at least one day’s supply stored on property.

Clean rain water collected from greenhouse roofs can be stored in properly sized cistern(s), above ground silos, and/or lined ponds as an alternative water source.

Test wells for sustainable pumping rates, draw down and yield.

Install flow meters and other devices to monitor volumes used for irrigation and other purposes such as calculating irrigation nozzle outputs. Keep records of dates, times and daily water volumes used. This information is important when determining the amount of water you may need in a low water period.

Irrigation Water:

Following initial treatment or filtering of source water, further treatment may be necessary before source water is applied as irrigation to the crop. Regular monitoring of both source and irrigation water quality as well as any treatment systems can prevent issues in the greenhouse.

A.6 What is your Irrigation Water Quality Class?			
4	3	2	1
<input type="checkbox"/> Class 1	<input type="checkbox"/> Class 2	<input type="checkbox"/> Class 3	<input type="checkbox"/> Don't know
EC < 0.5 mS/cm Na < 30 ppm Cl < 50 ppm SO ₄ < 100 ppm HCO ₃ < 60ppm	EC 0.5 – 1.0 mS/cm Na 30 – 59 ppm Cl 50 – 99 ppm SO ₄ 100 – 199 ppm HCO ₃ 60 – 150 ppm	EC 1.0 – 1.5 mS/cm Na 60 – 90 ppm Cl 100 – 150 ppm SO ₄ 200 – 300 ppm HCO ₃ > 150 ppm	
<p>Class 1: Used for all purposes Class 2: Used in substrate or soil culture where adequate leaching can take place or short cycle crops grown in a sub-irrigation system Class 3: Not recommended for salt sensitive crops, sub or top watered recirculating irrigation systems. If EC exceeds 1.5 mS/cm it is marginally suitable for irrigation in outdoor production</p>			
<p>BMPs:</p> <p>Test your irrigation water source. If the water quality class is unsuitable and requires a significant amount of treatment for the crop being grown, find an alternate source or blend the poor quality water with a water source of better quality such as collected rain water to meet required parameter limits. Analyze water sources and mixed fertilizer throughout year or when changes are made to identify its quality and manage accordingly.</p> <p>Note that these irrigation water quality classes were derived from a protocol which is published in the <i>Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses</i>. They were published previously in OMAFRA Publication 370, <i>Guide to Greenhouse Floriculture Production</i>.</p>			



Irrigation water quality can affect the health of your crop. Ensure that water sources are analyzed regularly to minimize risk.

A.7 Do you use water treatment technologies to improve source water chemistry (Cl, Na, SO₄, pH, HCO₃)?

4	2	1
<input type="checkbox"/> Yes, I do treat, or <input type="checkbox"/> I do not need to treat because water quality is good	<input type="checkbox"/> I need to, but don't treat	<input type="checkbox"/> I don't know if I should treat, and I do not treat for any parameters

BMPs:

Routinely test water after treatment to ensure you are meeting your water quality objectives and that the treatment system is working effectively. Not correcting for poor incoming water quality can have negative impacts on crop growth and limit the re-use potential of irrigation water. This leads to reduced water efficiency and increased treatment volumes and costs.

Match the treatment technology to the water quality parameter you are trying to manage or adjust. Resources such as the *Water Treatment Guide for Greenhouses and Nurseries*, available through Flowers Canada Growers (Ontario) Inc., may be helpful for comparing treatment options prior to speaking with a technology company or contractor.

Acidification of source water is often required for optimal use in the greenhouse.

Technologies to remove undesirable ions for plant growth could include rapid sand or cloth filters, reverse osmosis, nano-filtration or capacitive deionisation.

Know how to properly manage and dispose any water treatment by-products.

A.8 Do you test and treat water for plant or human pathogens*?

4	3	1
<input type="checkbox"/> Yes, I test and treat my source water as applicable for my operation	<input type="checkbox"/> I do not treat because I have tested and there is low or no plant or human pathogen risk for crop being grown	<input type="checkbox"/> No, I don't treat because I haven't tested my irrigation source water

BMPs:

Test and match the treatment technology to the pathogens identified. Disinfection technologies for pathogens can include: chlorination, UV and ozone among others.

Monitor and maintain treatment technology to make sure it is working properly. Regularly send pre-treatment and post-treatment water samples to a lab that test for water quality. If in-house testing is done, send selected samples to a lab to ensure the methods used are both accurate and consistent.

Alternatively, routine monitoring with simple on-farm tests is an effective method to evaluate the performance of disinfection technologies. These tests are simple, affordable, and can indicate when a water treatment system is not performing as it should. Proactive detection of potential plant pathogen issues before the crop shows damage is a good defence strategy to employ in the greenhouse. For best results, use both analytical and on farm-testing to check your water quality.

Keep clean treated water free of contamination. Fertilizer stock tanks, water storage tanks and cisterns can be a source of recontamination to clean treated water. Ensure water storage is cleaned regularly. Regular testing can help to identify potential problems early on.

*If you produce edible flower, herb, fruit and/or vegetable plants, you should follow irrigation standards for food safety. More information on food safety standards can be found in the *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*.

B PRODUCTION WATER AND NUTRIENT MANAGEMENT
Dealing with water and nutrient application to the crop

Maintaining water quality and minimizing unnecessary nutrient applications within the greenhouse facility during crop production reduces the quantity of water and nutrients that need to be managed post-production. Improving your water use efficiency improves your bottom line.

Irrigation:

Irrigation systems are designed to bring water and nutrients to plants. A properly designed system should be controlled, uniform and regularly maintained. Irrigation should ideally occur only when needed, so careful crop monitoring is important.

Ensure that your irrigation delivery system is designed for maximum interception efficiency, leachate collection and recycling if possible. Improving interception efficiency can reduce fertilizer loss from the system, resulting in cost savings. More information on how to calculate irrigation and interception efficiency can be found in the appendix of this document.

B.1 Which of the following best describes your overall irrigation system design?			
4	3	2	1
<input type="checkbox"/> 100% of the irrigation system designed by a qualified irrigation designer*, to meet production crop requirements, (e.g. different container sizes, water requirements, media or crops)	<input type="checkbox"/> Greater than 50% of the irrigation system designed by qualified irrigation designer*	<input type="checkbox"/> Less than 50% of the irrigation system designed by qualified irrigation designer*	<input type="checkbox"/> None of the irrigation system designed by a qualified irrigation designer* to meet production crop requirements
<p>BMPs:</p> <p>Use a qualified irrigation designer familiar with the irrigation delivery system you require to design your system. The irrigation delivery system design should optimize irrigation efficiency and conserve water through uniform application and optimal timing of irrigation events.</p> <p>*A qualified irrigation designer has formal training and/or experience in the design and layout of irrigation systems. Expertise is required to ensure that the system applies water in appropriate volumes to all cropped areas and avoids non-cropped areas and that pumping and transmission piping are sized to ensure energy and cost efficiencies.</p>			



Irrigation systems should be designed to efficiently meet the requirements of crops at various stages of the production cycle.



Inspection and maintenance of irrigation equipment should take place regularly. Ensure that irrigation is uniform and volumes are recorded. This information can be used for early detection of malfunctioning equipment.

B.2 How often do you monitor your irrigation system for delivery uniformity and perform routine maintenance of your irrigation system?

4	3	2	1
<input type="checkbox"/> Irrigation system is monitored during each irrigation event; repairs completed immediately if necessary; regular irrigation maintenance completed	<input type="checkbox"/> Irrigation system is monitored weekly; repairs completed immediately if necessary; regular irrigation maintenance completed	<input type="checkbox"/> Irrigation system is monitored monthly or seasonally; repairs completed immediately if necessary; regular irrigation maintenance completed	<input type="checkbox"/> Irrigation system is not regularly monitored; maintenance completed only as required

BMPs:

Monitor and visually inspect the system regularly during each irrigation event.

Have a regular maintenance plan, at least annually, for pumping equipment.

Repair and clean filters, lines, nozzle heads of stationary or movable misting systems. Acid treat low volume (LV) pressure compensated drip emitters to remove possible salt buildup at least annually.

Install monitoring equipment (water volumes/pressure gauges/flow meters) to detect changes in water volumes and application rates. Test output for delivery uniformity. This is especially important for sub-irrigation systems such as flood benches or floors.

Keep maintenance records and output volumes.

B.3 Which of the following decision tools are used to schedule irrigation events?

4	3	2	1
<input type="checkbox"/> By comprehensive crop monitoring*. Use an irrigation scheduling model where possible; monitor your crop throughout the day, and keep detailed records to calculate and initiate an irrigation event	<input type="checkbox"/> By comprehensive crop monitoring*. Hands-on crop and greenhouse climate monitoring. Manual record keeping or automatically by irrigation programs within an environmental control system	<input type="checkbox"/> Intuitive approach, no comprehensive monitoring, no scheduling or no record keeping	<input type="checkbox"/> System initiated on time schedule (e.g. management by calendar) with no consideration for environmental conditions, media, light, etc. No record keeping.

BMPs:

Schedule irrigation events by monitoring greenhouse conditions, crop needs and container moisture levels. Collect and record environment and substrate moisture data for decision making around irrigation scheduling.

When growing outdoors, time over head irrigation events for early morning when possible, to reduce evaporative losses and foliar disease. Evapotranspiration models help direct irrigation scheduling particularly in outdoor grown crops.

Schedule irrigation events by using a combination of the following: Container weight, evapotranspiration data (e.g. solar radiation, relative humidity (RH) or vapour pressure deficient (VPD), temperature etc.), moisture sensors, remote plant monitoring and/or EC of leachate.

*Comprehensive crop monitoring combines collecting and interpreting data and observations of plant visual clues such as leaf or bloom wilting, root development and changes in colour of growing media for each irrigation zone.

See also: *BMP Water Management* and *BMP Irrigation Management*



Greenhouse conditions, weather (such as light levels and temperature) and crop needs should be factored into your irrigation event schedule.



Ensure that irrigation and sanitation waters are kept separate. Volumes of each type should be known and tracked over time.

B.4 How is excess water managed within the facility? Excess water may be from irrigation sources or from other non-production water sources such as boiler blow down, or wash water from floors, tables or equipment.

4	3	2	1
<input type="checkbox"/> Non-production and irrigation waters are stored separately for future reuse dependant on quality. Volumes generated are known for each type.	<input type="checkbox"/> Irrigation, non-production and/or other wastewaters from the greenhouse facility are combined and stored for reuse. Volumes generated are known for each type.	<input type="checkbox"/> Irrigation, non-production and/or other wastewaters from the greenhouse facility are combined and stored for reuse. Volumes are not known or monitored.	<input type="checkbox"/> Excess water is not managed and volumes are not known or monitored

BMPs:

Keep records of the volume of water used for irrigation and other production related purposes and its corresponding analysis.

Wash water used for sanitizing carts, floors, benches and other equipment may need to be stored separately from irrigation water dependant on its quality. Ensure that water is monitored and treated as necessary. If non-production waters need to be disposed of, ensure it is done according to regulations.

Monitoring is important to improve the efficiency of your irrigation system. Over time it can assist with reducing the amount of excess water from irrigation events. Measure and record leaching fraction and interception efficiency throughout crop production cycles and record your results. See the worksheets in the appendix of this document for help with determining these parameters.

B.5 If you use top-irrigation systems (e.g. boom, stationary mist line, dripper, low volume drip tape) in your greenhouse operation, is your leachate collected and recycled?

4	1
<input type="checkbox"/> Collected by either surface or subsurface drain system, stored and reused	<input type="checkbox"/> Not collected

BMPs:

Reduce leachate by increasing irrigation frequency, and reducing application volume, or move to a pressure compensated low volume drip irrigation system. Program your system to only irrigate areas where crops are present.

Routinely add wetting agent to irrigation water to improve wettability of peat substrates.

Measure leaching fractions periodically, record them and work towards continuous improvements through modification of irrigation events. Methods to calculate leaching fraction can be found in the appendix of this document.

Collect and store subsurface drainage water for treatment and reuse or discharge in accordance with the conditions in your Environmental Compliance Approval.

B.6 What percentage of your top-irrigated production area is closed? A closed system is where irrigation and propagation water is collected, stored and reused for a future irrigation event.

4	3	2	1
<input type="checkbox"/> Greater than 90%	<input type="checkbox"/> 50 – 90%	<input type="checkbox"/> Less than 50%	<input type="checkbox"/> 0%

BMPs:

Design your operation to collect and recycle irrigation water enriched with nutrients within your operation. (e.g. excess irrigation water is collected by subsurface drainpipe or surface drainage systems or a combination of both then stored and re-used for irrigation).

Check flow rate and manage volumes going into and leaching out of containers. Track these volumes over crop cycles. Reduced leachate volume is possible in a top irrigated system with an increased level of management.

Stay informed on the latest fertilizer research. Emerging formulations may offer benefits such as timed nutrient release which can be helpful for reducing nutrient levels in leachate overall.



Overhead applied irrigation water is collected in a closed irrigation system.



Collect and reuse leachate from overhead applied nutrient rich water applications if possible.

B.7 If you use a top-irrigation system, what is your estimated water interception efficiency*?

4	3	2	1
<input type="checkbox"/> Greater than 90%	<input type="checkbox"/> 76 – 90% interception	<input type="checkbox"/> 50 – 75% interception	<input type="checkbox"/> Less than 50% interception
<p>Examples:</p> <p>Single pot emitter system (i.e. drippers)</p> <p>Programmable watering booms with automatic shut off where crop is grown pot- to-pot</p> <p>Low volume drip tape system placed adjacent to plants</p>	<p>Examples:</p> <p>Spray nozzle system</p> <p>Misting line system for full bench</p> <p>Hand watering system for full bench of pot-to-pot material</p>	<p>Examples:</p> <p>Hand watering system for individual pots, open space between pots</p>	<p>Examples:</p> <p>Overhead mist emitters or stand emitters in summer outdoor pot production</p>

*Water interception efficiency is volume of water applied / volume intercepted by container surface area or plant growing media area. See the appendix worksheets to see how to calculate this value.

BMPs:

Create management zones by grouping plants according to similar irrigation and nutrient requirements.

Apply irrigation as smaller volume but more frequent pulsed cycles to reduce total water used and improve the wetting uniformity of growing media.

Use flow meters to determine total daily volume of irrigation water used. Ideally, use one flow meter for each crop management zone.

Consider a computer or automatically controlled injection system to improve water delivery accuracy.

Consolidate plant spacing as plants are shipped out of the greenhouse. Large gaps without plants in production areas can result in lower interception efficiencies.

Increase interception efficiency by adjusting sprinklers to apply only to areas where plants are standing. Turn off valves in areas where no plants are growing.

Use a pressure-compensated low volume drip system to minimize water and nutrient losses for container and soil grown crops (uses approximately 50% less water than overhead). In widely spaced crops, this system will eliminate water loss between containers. Manage the system so that a minimal amount of the water applied leaches through the container.

When overhead irrigation must be used, place containers in a staggered pattern with minimal distances between the containers so plant canopies can allow for maximum interception.



Pressure compensated low volume drip systems use less water and eliminate water loss between pots.



Sub-irrigation systems will only conserve water and nutrients in greenhouse production if water is collected, stored and reused.

B.8 If you use sub-irrigation, what percentage of your sub-irrigated production area is closed? A closed system is where irrigation water is collected, stored and reused for a future irrigation event.

4	3	2	1
<input type="checkbox"/> Greater than 90%	<input type="checkbox"/> 50 – 90%	<input type="checkbox"/> Less than 50%	<input type="checkbox"/> 0%

BMPs:

Design new expansions or retrofits to existing production areas to collect and recycle nutrient rich water.

Sub-irrigation systems will only conserve water and nutrients in greenhouse production if water is collected, stored and reused. A sub-irrigation system that is not collecting and recycling irrigation water is not utilizing the technology as it was intended.

If pathogens are a concern, treat with one or more treatment technologies prior to re-use or use on a different, non-susceptible crop.

If your water is not being recirculated, any discharge will need to be in accordance with the conditions of your Environmental Compliance Approval.

Fertilizer:

Fertilizer products consume a large portion of the production budget for many producers. A greenhouse fertigation system should be adaptable to many different crops and their nutritional needs throughout the production cycle. Proper fertilizer storage and spill prevention protocols can reduce the risk of environmental contamination.

B.9 How flexible is your fertigation system to match crop needs? For example, can you adjust for pH and EC? Can it provide nutrient balance for multiple crops or growth stages?

4	3	2	1
<input type="checkbox"/> Very flexible The system is easily able to change between multiple fertilizer solutions as required. Changes to feedwater EC and pH are easily accomplished.	<input type="checkbox"/> Flexible The system is able to change between at minimum two fertilizer solutions as required. Changes to feedwater EC and pH are easily accomplished.	<input type="checkbox"/> Somewhat flexible The system is able to change between fertilizer solutions as required. Changes to feedwater EC and pH can be made, although they may be difficult or time consuming to implement.	<input type="checkbox"/> Not flexible The system is not able to handle more than one fertilizer solution at a time. Changes to feedwater EC and pH can be made, although they may be difficult or time consuming to implement.

BMPs:

Match nutrient needs to crop type, growth stage (e.g. vegetative vs. flowering) and the potential influence of crop species on media pH. Adjust the pH and electrical conductivity (EC) of your nutrient solutions to suit the needs of each specific crop.

Create crop management zones within your greenhouse that include not only temperature and light requirements but also nutrient demand of different crops.

The use of an A-B tank system, multi-head injectors, and access to nutrient solutions that have varied EC levels will make your fertigation system more flexible.

Use water soluble fertilizers with trickle, micro-spray or drip irrigation systems only in a closed system or where leachate can be collected.

Adjust fertilizer rates to account for nutrients remaining in recycled irrigation water.

When top irrigating, reduce the volume of water applied during each irrigation event to minimize the leaching fraction.

Minimal leaching of nutrients occurs when growing plants in sub-irrigation. Sub-irrigated plants require less water and nutrients (30 – 50% less depending on crop species) than top irrigated plants.



Flexible fertigation systems can match nutrients to crop specific needs, allowing for more efficient use of fertilizers.



B.10 How much fertilizer do you store on your property at any one time?

4	3	2	1
<input type="checkbox"/> Less than 1 month's supply	<input type="checkbox"/> Between 1 – 7 months	<input type="checkbox"/> Between 7 – 12 months	<input type="checkbox"/> A year's supply or more

BMP:

Maintain an inventory of the amount of fertilizer purchased and used, and the location of storage. An inventory will help with assessing use efficiency and reordering timelines.

Minimize the amount of fertilizer stored on your property.



Maintain an inventory of fertilizer products stored on site.

B.11 How and where are fertilizer products stored?

4	3	2	1
<input type="checkbox"/> Locked and stored in a separate and designated area of the greenhouse or packing shed on an impermeable surface	<input type="checkbox"/> Stored in a designated area of the greenhouse or packing shed on an impermeable surface	<input type="checkbox"/> Stored in the greenhouse or packing shed but not separate from day-to-day operations (i.e. pallets are stacked in high traffic area)	<input type="checkbox"/> Stored on farm premises with no cover or protection

BMPs:

Safely store all fertilizer material in a facility where a spill can be contained and would not be able to seep into surface and ground water systems.

Ensure no floor drains from any fertilizer or pesticide storage or mixing areas lead to the outside environment. Close off floor drains or direct them to a separate isolated containment. Ensure secondary containment around concentrated fertilizer storages is in place.

Keep fertilizer bags intact and protected from elements. Keep substrate mixes containing fertilizer dry and protected from elements on an impermeable surface.

Conduct regularly scheduled inspections of all fertilizer storage, injection and application equipment. Document these inspections for your records.

Contain and clean up any fertilizer spills during all phases of transport, storage and application immediately. Use appropriate technology and techniques (e.g. spill kits with portable barrier) to clean up solution spills.

Fertilizer storage should be located no less than 30 metres to surface water, no less than 15 metres from a drilled well and no less than 30 metres from a bored well.

Keep MSDS information in an easily accessible location.

Have a written and posted contingency plan for fertilizer spills.

In the case of a spill, the controller and the person who causes a spill has a duty under the Environmental Protection Act to report the spill to the MOECP Spills Action Centre (1-800-268-6060) as well as to the local municipality.



Ensure fertilizer is stored safely with no chance to contaminate water sources.

Growing Media:

The type of soil or growing media used in production can significantly influence nutrient uptake by the plant. Ensure your crop is getting all required nutrients in appropriate levels by regularly analyzing your media, and adjusting feed rates if necessary.

B.12 If you are growing cut flowers in soil, what is the soil texture?

not applicable

4	3	2	1
<input type="checkbox"/> Clay	<input type="checkbox"/> Clay loam	<input type="checkbox"/> Loam and silt loam	<input type="checkbox"/> Sand and sandy loam

BMPs:

Ensure that you are aware how soil type can impact nutrient leaching or runoff.

Take soil type and texture into account when designing irrigation strategies for your crop such as volume and timing. Knowing your soil can help in managing water and nutrients on your farm. For example:

- Clay soils have a fine texture and are slower draining; therefore, there is a decreased risk of nutrient leaching through the soil profile, although they may have an increased risk for surface runoff following high volume irrigation events.
- Sand and sandy loam soils have a coarse texture and are fast draining; therefore, there is a greater risk of nutrient leaching through the soil profile.

Regularly incorporate organic matter into the soil to improve soil structure and water and nutrient holding capacity between production cycles.

B.13 How frequently do you analyze your growing media in-house for EC and pH?

4	3	2	1
<input type="checkbox"/> Every 1-2 weeks	<input type="checkbox"/> Every 3-4 weeks	<input type="checkbox"/> Only when a problem is observed	<input type="checkbox"/> Never

BMPs:

Routinely test growing substrates in-house for EC and pH using pour-through method or other technique. Be consistent with technique used for interpretation purposes.

If growing in ground, test and sterilize soils between production cycles. Monitor EC, and adjust pH and nutrients as required.



Know your soil type and regularly monitor EC and pH of growing beds.



Regular testing of both irrigation water and media EC and pH can help to avoid nutrition and disease problems before they occur.



Regular testing of growing media parameters can be used to track the uptake of nutrients by your crop, giving an indication of its general health.

B.14 How frequently do you submit a growing media sample to an accredited laboratory for complete analysis?

4	3	2	1
<input type="checkbox"/> Frequently (e.g. every 2 – 4 weeks)	<input type="checkbox"/> Seasonally (four or more times per year)	<input type="checkbox"/> Once a year	<input type="checkbox"/> Never

BMP:

Sample, test, and record growing substrate for macro-nutrients, micro-nutrients, pH and EC throughout each production or cropping cycle.

B.15 Do you use media analysis results to adjust your nutrient solution composition?

4	1
<input type="checkbox"/> Yes	<input type="checkbox"/> No

BMPs:

Alter applied fertilizer rates based on the results of media analyses. These analyses should be utilized to track the use and uptake of nutrients by plants throughout the cropping cycle.

A qualified soil laboratory professional or greenhouse crop specialist can assist you in interpreting growing media analysis reports.

Recirculation:

Ensuring the reuse of nutrient-rich production water in the greenhouse is a great method of improving water use efficiency and reducing fertilizer costs. Ensure recirculation storage is adequately sized and contained. Regular testing of recirculating water quality and nutrient levels will assist in determining if it is suitable for greenhouse production or needs to be adjusted before being applied to a crop.

If you are land applying greenhouse nutrient feedwater (GNF), you may need to follow additional requirements as summarized in your approval document.

B.16 Where are the recirculating water tanks located in the greenhouse and how are they contained?

4	3	2	1
<input type="checkbox"/> On an impermeable surface away from moving equipment, with thick walled containment and sensor monitoring for leaks	<input type="checkbox"/> On an impermeable surface away from moving equipment, with thick walled containment. The tank is visually monitored for leaks on a regular basis.	<input type="checkbox"/> On an impermeable surface away from moving equipment, with thick walled containment but no way of monitoring for leaks OR <input type="checkbox"/> On an impermeable surface, with thick walled containment visually monitored, but located in a high traffic area of the greenhouse with increased risk of accidental puncture	<input type="checkbox"/> On a permeable surface, with thick walled containment but no way of monitoring for leaks

BMPs:

Ensure recirculating nutrient-rich feedwater is stored appropriately to avoid leaks. The first line of protection is a thick walled, liquid tight storage tank or cistern.

The risk of spills can be further reduced by:

- A monitoring system that allows leaks to be identified either electronically or visually.
- A secure location for feedwater storage, where it is separated from moving equipment such as forklifts and moving tray systems, to lower the risk of puncture.

Secondary containment, if appropriate, reduces the risk of leaks to the outside environment even further, should there be leaks or tank failures in the initial storage.

Ensure recirculated nutrient rich feedwater storage is located away from surface water and wells. Floor drain locations within the same storage area should be noted and mapped in case of leaks.

Ensure any spills of recirculated nutrient rich feedwater are collected and dealt with appropriately. Have a written, posted and communicated contingency plan for spills.



Ensure recirculated nutrient rich feedwater is stored appropriately.

B.17 If you collect water for recirculation, do you analyze for nutrients, EC, pH and/or plant pathogens on a routine basis?

4

1

 Yes

 No

BMPs:

Complete water quality and nutrient analyses to adjust fertilizer injection levels to account for available nutrients in the recirculating feedwater.

Testing recirculation water for plant pathogens on a regular basis is an important preventative measure which may save you time, plants and treatment products in the long term.

B.18 If you answered yes in Question B.17, how frequently do you complete a nutrient solution analysis on collected recirculating water?

4

3

2

1

 Frequently (at least monthly)

 Seasonally (four or more times per year)

 Once a year

 Never

BMPs:

Sample, test, and record nutrient solutions for macro- & micronutrients, pH, and EC throughout the production cycle.

Adjust fertilizer rates to account for nutrients remaining in recycled irrigation water and specific crop or plant developmental stages in production. While an EC level can be informative, knowing the status of individual nutrients is critical to ensure your crop is getting the nutrients it needs to grow efficiently. Levels of individual nutrients in recycled irrigation water may be constant or change over time, so regular analysis is important to understand what is available to the plant.

B.19 Do you treat recycled water for plant disease pathogens?

4	1
<input type="checkbox"/> Yes — treat in addition to using appropriate cultural practices	<input type="checkbox"/> No — rely on appropriate cultural practices only.

BMPs:

Install disinfection systems for recycling greenhouse feedwater onto disease-prone crops. Match the treatment technology used to the pathogens of concern for your particular operation.

More than one treatment option maybe required to ensure water is safe for re-use. Producers often choose to use several treatment options in series before reusing water in the greenhouse. Examples of treatment systems include:

- Physical treatment (e.g. filtration or ultraviolet radiation)
- Chemical treatment (e.g. ozone, chlorination or stabilized hydrogen peroxide)
- Biological treatment systems (e.g. Constructed wetlands, woodchip bioreactor, slow sand filtration)

Monitor and maintain treatment technology to make sure it is functioning properly.

Management of diseases can also be done culturally. For example, monitoring pH and maintaining a well aerated growing media is a production best practice that can assist maintaining pathogen control.

B.20 If you grow edible crops do you test recycled water for human pathogens?

not applicable

4	1
<input type="checkbox"/> Yes	<input type="checkbox"/> No

BMPs:

Managing for pathogens includes monitoring, recording and following-up.

Maintain irrigation water quality to minimize human pathogen risk (E. coli, Coliform) for edible flower, herbs and vegetable bedding transplants.

Consult food safety guidelines defined in the *Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*.

B.21 Do you ever remove recirculation water, for eventual disposal, from your system?

4	1
<input type="checkbox"/> Yes	<input type="checkbox"/> No

B.22 If you answered yes in Question B.21, on what criteria do you base your decision to remove recirculation water?

4	3	1
<input type="checkbox"/> Poor plant performance based on high levels of dissolved salts (e.g. SO ₄ /Cl/Na), poor levels of physical water quality (turbidity, total suspended solids, debris) or microbial pathogens OR To dispose of remaining tank volume (usually < 10% volume) for periodic tank cleaning	<input type="checkbox"/> Recirculation water is removed after a set specific time period, or when storage capacity is reached. Analysis of water quality may or may not occur.	<input type="checkbox"/> Routine removal with no analysis completed

BMPs:

Sample, test, and record leachate and recycled/reused irrigation water throughout the production/cropping cycle for the following crop production limiting parameters: EC, SO₄, Cl, Na and plant pathogens.

Water removed from the recirculation system must be managed appropriately. This may include several different treatment, storage or disposal options (See Section C). If discharging, ensure any water removed from the system meets the conditions of your Environmental Compliance Approval.

C POST PRODUCTION WATER AND NUTRIENT MANAGEMENT

Dealing with water and nutrients after they have been applied to the crop

There are three types of **wastewater** that come from greenhouse operations (not including sanitary sewage). Proper management and storage of post-production waters should be a key component of your greenhouse design. Always work towards reducing the volumes of these waters produced. All three water types must be managed according to regulations.

1. **Nutrient Feedwater.** This water no longer meets requirements for crop production, but it may still be rich in nutrients. It may include single irrigation event water which cannot be recirculated for pathogen concerns or water that has been recirculated several times and now contains high levels of limiters (such as salts) to crop production.
2. **Other non-production wastewaters.** This water comes from sources such as gutters, shipping drenches, boiler water and condensate, cut flower pail water, tray and trough wash water, filter backwash, planting line water, wash water, roof white-wash rinsate, and any tanks, pond or cistern water that contains any of these wastewaters.
3. **Stormwater.** This water includes all waters that at one time would have touched the ground before the greenhouse was present, including collected rainwater and water that collects in parking lots or loading docks.

C.1 How do you manage post-production wastewater?

4	3	1
<input type="checkbox"/> No nutrient feedwater leaves the greenhouse. The facility is a completely closed loop with all water treated and reused.	<input type="checkbox"/> Any nutrient feedwater that leaves the facility is treated, stored and either land applied, discharged or disposed of according to appropriate regulations	<input type="checkbox"/> Discharge or disposal without adherence to appropriate regulations (e.g. an approved Environmental Compliance Approval)

BMPs:

Collect, store and prevent offsite discharge of untreated post production nutrient feedwater.

Land Application under the Nutrient Management Act is an alternate use of post-production wastewater that is removed from a closed circulation system. This allows for the nutrients to be used by field crops. Land application requires a GNF Strategy (outlining generation and storage) and a GNF Plan (covers land application). To learn more about the necessary approvals, review the information on the OMAFRA website.

Analyze your post-production wastewater for nutrient concentrations. Know the volumes in order to design the best treatment system(s) for your operation or nutrient management strategy and plan for land application.

Note: A discharge of post-production nutrient feedwater into the natural environment (even after treatment) without the appropriate approvals is a violation of the *Ontario Water Resources Act*.

The following treatment options require an Environmental Compliance Approval (ECA) issued by the Ministry of the Environment, Conservation and Parks (MOECP) under the *Ontario Water Resources Act*:

- Woodchip bioreactors
- Inorganic filters
- Constructed wetland
- Vegetated filter strips
- Bio-retention swales
- Bio-retention basin
- Buffer strips
- Grassed waterways



A vegetative filter strip (left) and a woodchip bioreactor (right) are water treatment options.



Ensure collected post-production nutrient feedwater and other non-production wastewaters are stored properly before recirculation or approved treatment and disposal.

C.2 How do you manage other non-production wastewaters such as boiler blow down, wash water from floors, equipment or containers, and/or any other water used within the greenhouse not directly involved in irrigating or fertilizing the crop?

4	3	1
<input type="checkbox"/> No non-production greenhouse wastewater leaves the greenhouse. The facility is a completely closed loop with all water treated and reused.	<input type="checkbox"/> Non-production greenhouse wastewater is treated or stored, and its disposal is managed in accordance with applicable legislation	<input type="checkbox"/> Discharge or disposal of non-production greenhouse wastewater without adherence to the appropriate approvals

BMPs:

Maximize capture of all non-production wastewater.

Collect and store nutrient feedwater separately from other non-production greenhouse wastewaters such as boiler blow down and wash water from tables, benches and equipment.

Nutrient feedwater storage should be designed to contain total volume of nutrient feedwater produced, and to ensure that the stored waters do not reach surface water or groundwater resources.

All greenhouse wastewater (including nutrient feedwater and non-production greenhouse wastewater) must be managed in accordance with applicable legislation. A discharge of wastewater into the natural environment (even after treatment) without the appropriate approvals is a violation of the *Ontario Water Resources Act*.

Acceptable disposal methods include:

- Treatment by septic system (if approved by municipality or MOECP)
- Haulage to municipal wastewater treatment plant (if approved by municipality)
- Discharge into sanitary sewer (if approved by municipality)
- Treatment and then discharge to environment (if approved by MOECP)
- Land application under the Greenhouse Nutrient Feedwater (GNF) regulation. A strategy and/or plan must be developed (as applicable and if GNF Plan approved by OMAFRA)
- Disposal by land application of any process waters under an Environmental Compliance Approval (if approved by MOECP)

C.3 How do you manage stormwater at your operation?

4	2	1
<input type="checkbox"/> No collection of stormwater. Direction and discharge into municipal stormwater drains using swales, drainage paths or other appropriate management features. OR <input type="checkbox"/> Collection of stormwater for use in the greenhouse. Stormwater is managed for both quality and quantity based on appropriate storage sizes, treatment options and the appropriate approvals.	<input type="checkbox"/> Collected stormwater for use in the greenhouse is managed for quality or quantity but not both. Storage may be undersized for regular or unprecedented weather events.	<input type="checkbox"/> No methods used to manage or direct stormwater on the farm property, whether it is collected or not.

BMPs:

Manage all storm-water on your farm appropriately. Ensure storage cisterns/containers are sized appropriately; ponds must be sized for 50 year storm events at minimum. If rainwater is collected from the greenhouse roof for irrigation purposes, ensure that its quality is acceptable for production use.

Changes to how stormwater is collected, stored or treated on your farm may require a new or amended Environmental Compliance Approval (ECA) or Permit to Take Water (PTTW) from MOECP. Check with your local district office for current guidelines if you are planning a renovation, expansion or change to your stormwater management system.

C.4 How do you store post-production water (which is no longer acceptable for plant production) from your operation?

4	2	1
<input type="checkbox"/> Storage is impermeable (e.g. steel, concrete, fiberglass, etc.) or pond that is properly designed and constructed to ensure it is sealed from leakage. May include an impermeable, synthetic or clay liner. Regular/frequent visual inspection and monitoring for leaks.	<input type="checkbox"/> Storage is impermeable (e.g. steel, concrete, fiberglass, etc.) or pond that is properly designed and constructed to ensure it is sealed from leakage. May include an impermeable, synthetic or clay liner. Infrequent or no visual inspection or monitoring for leaks.	<input type="checkbox"/> Storage is leaky or pond not properly designed for storage. No visual inspection or monitoring.

BMPs:

Construct post-production water storage structures that are impermeable to leakage.

Regular visual inspection and monitoring of above ground storage should include inspection for structural defects (visual cracks), wetness, or leaks. Examples of appropriate storage containers include: corrugated metal tanks, high density (HD) plastic containers, properly sealed earthen ponds with a minimum of 1m of free board.

Ensure that the storage method chosen is in accordance with any approvals necessary. Amendments to storage size or method may require further approvals or the establishment of an Environmental Compliance Approval (ECA).



Ensure storage is sized appropriately and impermeable to leakage.

C.5 What is the capacity of your storage structures (e.g. tanks, cisterns or collection pond) to contain post-production water (which is no longer appropriate for plant production) from your greenhouse?

4	2	1
<input type="checkbox"/> Storage is properly sized and never overflows following a weather event or unexpected increase in volume	<input type="checkbox"/> Storage has the potential to overflow following a weather event or unexpected increase in volume.	<input type="checkbox"/> Storage is not properly sized and regularly overflows following a weather event or increase in volume.

BMPs:

Know your water quantity applied and captured throughout the production system.

Store post-production water in storage structures that are sized to reduce the chance of overflow events.

Nutrient feedwater storage should be designed to contain total volume of nutrient feedwater produced, and to ensure that the stored waters do not reach surface water or ground water resources.

Have a contingency plan for when storage needs may exceed capacity.

Appendix

GLOSSARY OF TERMS

In a **closed system**, all nutrient feedwater is captured for reuse. This includes the collection of irrigation, leachate and nutrient rich feedwater under all production areas and benches and subsurface drainage.

In an **open system**, leached or irrigated nutrient feedwater is not captured for reuse. Soil based production systems are generally open systems, unless sub-surface drainage has been installed to intercept any leachate that may get below the crop rooting zone.

Wastewater

All water to be disposed of that is generated on the operation. It includes: greenhouse nutrient feedwater, drip gutter water, shipping drench water, boiler water and condensate, cut flower pail water, tray and trough wash water, filter backwash, planting line water, drip-line wash water, roof white-wash rinsate, and any tanks, pond or cistern water that contains any of these wastewaters.

Nutrient feed water

Any water in your greenhouse operation that contains nutrients. This can include: fertilizer stock tanks, mixing tank water, irrigation water, leachate from pots, baskets, flats and planters, nutrient rich water from flood floors, trays and troughs, and any treatment tanks or storages that have any water contaminated by nutrients in it. This water can be recirculated, can be land applied and must be treated before discharge to the natural environment. Permits may be required, check with your local MOECP district office or OMAFRA environmental specialist.

Leachate

Any water that comes out the bottom of a pot, basket or other growing container. This water is likely to carry nutrients and must be managed as greenhouse nutrient feed water.

Rainwater

Water that does not touch the ground and is not contaminated with nutrients that is collected and stored for use in the greenhouse.

Stormwater

All water that would have touched the ground outside the greenhouse before it existed. Note that this includes water that touches the roof of the greenhouse. If collected for use in the production cycle, it must be managed in accordance with appropriate regulations. Check with your local MOECP district office.

Top-irrigation

Water and nutrients are delivered to the top of the container (i.e. hand, sprinklers, mist, boom, drip emitters and tape). Also referred to as overhead irrigation.

Sub-irrigation

Water and nutrients are delivered through the bottom of the container (i.e. trays, troughs and flood floors).

WORKSHEET 1: TOTAL MAXIMUM DAILY WATER APPLIED

This worksheet explains how to estimate peak water use to irrigate your entire production area in one day. A peak use day is a day with a high solar radiation, in a low relative humidity greenhouse, under high temperatures. The same calculation can be used to determine the average amount of water applied daily.

It is important to know the total maximum daily water use when:

- designing an irrigation system
- designing an irrigation/stormwater recycling pond
- recording and estimating daily water use for reporting

To calculate the maximum water applied per day through the whole operation, consider:

- The volume of water emitted in each production area during one irrigation event
- The number of irrigation events per day
- Total area in production to be irrigated on peak use day

Tips

Use a water meter to track output in each production area over the course of one irrigation event.

Specific crops may be irrigated several times per day, while others are not. It may be helpful to calculate irrigation volumes and events based on different production areas or crops with different requirements (i.e. overhead irrigated potted container crops, sub-irrigated potted container crops or propagation benches).

Example calculation

Total Maximum Daily Water Applied =

$$\begin{aligned}
 &\text{Propagation Production Area [(Volume per irrigation event) x (Number of irrigation events)]} \\
 &\quad + \\
 &\text{Stock Plant Production Area [(Volume per irrigation event) x (Number of irrigation events)]} \\
 &\quad + \\
 &\text{Production Area [(Volume per irrigation event) x (Number of irrigation events)]} \\
 &\quad + \\
 &\text{Finishing Area [(Volume per irrigation event) x (Number of irrigation events)]}
 \end{aligned}$$

Note: All operations will be different — consider the areas present in your operation. Other production areas may also be present and production space in use and crop needs may change depending on the season or crop stage.

Note: When calculating the volume required for an irrigation/stormwater collection pond, take into consideration the average annual precipitation and historical storm events in your area.

**This worksheet has been adapted from the Best Management Practices and Self-Assessment for Water and Fertilizer Use for Outdoor Container Production.*

WORKSHEET 2: LEACHING FRACTION FOR POTTED CONTAINER CROPS

Leaching fraction (LF) is commonly used to assess the irrigation efficiency of container crop production. It helps to measure whether too much, or not enough irrigation water is being applied to the crop. The lower the number, the lower the volume of water being lost out the bottom of the container.

Periodically, growers may need to leach their crops (e.g. to remove an accumulation of fertilizer salts in the media). However, on average, growers are working towards minimizing percent leaching fraction.

Several unrelated factors can affect the leaching fraction data. For instance, media that is not evenly or regularly moistened tends to have dry “cracks” that channel irrigation water rapidly through the container, exaggerating the leachate volume. Potted container crops with dense or relatively tall canopies can deflect overhead irrigation water, preventing it from landing on the surface of the media of some of the pots container within the irrigation zone. Drip lines and emitters can be clogged and pressures unregulated, creating a scenario where plants are watered until the driest plant is wet.

By knowing and paying attention to these limitations, growers can use % leaching fraction to help make decisions about irrigation method, timing and duration in order to help conserve water and nutrients lost through leaching.

Example

For this exercise, choose overhead, hand-watered, or drip irrigated production areas that have crops that are similar in age, size and canopy shape.

You will need the following for each area tested:

- 40–60 clean, empty containers identical to those used to grow the crops
- 40–60 small plastic bags (e.g. small garbage bags)
- 40–60 large elastic bands
- 20–30 medium-sized stones (5–10 cm in diameter)
- wide-mouth 1–2 L jug, graduated cylinder, flags, notebook and writing utensil

Step 1:

Place 10–20 empty containers lined with an impermeable barrier (e.g. plastic bag) randomly throughout the area being tested. Try to have some containers from the outer edges and middle of the area. These empty, lined containers are the “interception” containers. Only use containers identical to those used in the crop you are testing. The “interception” container approximates how much of the overhead irrigation water actually makes it onto the surface of the media. (Tip: Use elastic bands to secure the impermeable barrier to the top rim of the container.)

Step 2:

Place 10–20 empty, bag-lined containers directly underneath the same number of crop plant containers. Place a 5 cm stone inside to give room for drainage. These containers are the “leachate” containers, and will catch the volume of water that drains from the crop containers. The “leachate” containers are identical to the crop containers and fit tightly under the crop container. Place these crop plant + “leachate” containers beside the empty “interception” containers. (Tip: Flag the plants so you can find them more easily after the irrigation event.)

Step 3:

After an average irrigation event, collect and measure all “leachate” and “interception” container water volumes, and record them in a chart so you can refer back to individual container volumes. (Tip: Collect water into a wide-mouthed vessel before pouring into the graduated cylinder for measurement.)

Step 4:

Use the water volumes collected to calculate percent leaching fraction (%LF).

Individual Container % Leaching Fraction = (“leachate” container volume / “interception” container volume) x 100

Average % Leaching Fraction for the Production Area =

(“Total leachate” container volumes) / (“Total interception” container volumes) x 100

Interpreting the results:

Review the individual %LF for various containers throughout the production area. Do they differ in relation to their location? Do specific crops, spacing or container sizes affect the results?

Guidelines for Interpreting Average Leaching Fraction

%LF = 0–15% Very Good	%LF = 16–25% Good	%LF = 26–40% Inefficient	%LF = >40% Excessive
This indicates a conservative use of irrigation water	Review crop quality, wetness of the media and any other factors that could be exaggerating %LF. Then consider reducing the length of the irrigation cycle.	Review crop quality, wetness of the media and any other factors that could be exaggerating %LF. Then consider reducing the length of the irrigation cycle.	Review crop quality, wetness of the media and any other factors that could be exaggerating %LF. Strongly consider reducing the length of the irrigation cycle.

**This worksheet has been adapted from the Best Management Practices and Self-Assessment for Water and Fertilizer Use for Outdoor Container Production.*

WORKSHEET 3: INTERCEPTION EFFICIENCY

Percent interception efficiency (%IE) is commonly used to describe the spacing and configuration of container crops. It indicates the container surface area in relation to the area of production space they are growing on. However, the true value of this measurement is to quantify the effective use of the production area and the efficient use of overhead-applied irrigation water. The higher the %IE, the lower the volume of water being lost between containers. %IE is a simple calculation based on container spacing in two directions. Container crop spacing will depend on key management factors.

Container crops with tall or wide canopies will deflect irrigation water and prevent it from landing on the surface of the media, and may require containers to be placed farther away from each other to achieve adequate wetting of the media. Some floral crops are susceptible to foliar diseases that can be reduced by using wider container spacing patterns. Container and flat spacing may need to be adjusted several times throughout the crop cycle as plants mature, get transplanted and are shipped, leaving production areas with low interception efficiencies.

By measuring %IE throughout the growing season for various crops, growers can use the data to help make decisions about irrigation types and timing, both of which will help conserve water and nutrients lost through run-off.

What you will need:

- measuring tape
- a notebook

Step 1. Pick your sites

For this exercise, choose top- irrigated container crops that are similar in container size, and growth stage. By organizing %IE data into groups, growers can gain more meaningful data to help manage their different crops.

Step 2. Calculate your areas

Start by envisioning a rectangle or square that includes one quarter of each of 4 containers (see Pg. 42). Measure the length and width of the rectangle that intersects with the centres of the 4 containers and record it as ground area. In staggered container spacing, you will need to draw an imaginary vertical line to make the parallelogram into a rectangle and measure length and width. These length and width dimensions will be used to calculate the area of the rectangle that reaches the centre of 4 containers. There are 4 quarters of a container surface in each rectangle, which adds up to one full container surface area. Calculate surface area (A) of one container by measuring the diameter of the container and then dividing it in half to determine the radius. The radius is used to calculate the container surface area using the formula:

$$A = \pi r^2$$

where A = surface area

$$\pi = 3.14$$

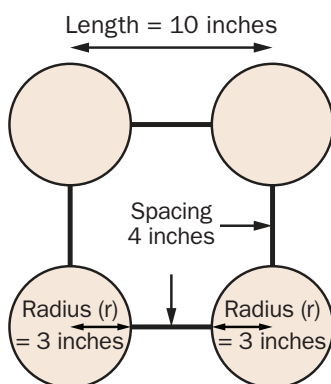
r = radius

If the container is square or a rectangle, simply calculate the area of the container using length x width.

Step 3. Do the calculations

%IE = Surface area of 1 container / Rectangle area x 100

Sample calculation:



Length = radius (3) = spacing (4) + radius (3)

Because pots are round, there is already a significant loss in interception, even when the crop is grown using 'pot-to-pot' tight spacing.

6 inch (15.24 cm) diameter containers spaced at 4 inches (10.16 cm) in each direction

$r = \text{one half the diameter} = 1/2 \text{ 6 inch (15.24 cm)}$
 $= 3 \text{ inches (7.62 cm)}$

Container surface area: $A = \pi r^2 = \pi (3)^2$
 $= 3.14 \times 9$
 $= 28.26 \text{ sq. inches (182.41 cm}^2\text{)}$

Rectangle area = Length x Width
 $= 10 \text{ inches} \times 10 \text{ inches}$
 $= 100 \text{ sq. inches (645.16 cm}^2\text{)}$

%IE = Surface area of 1 container / Rectangle area x 100
 $= 28.26 \text{ sq. inches} / 100 \text{ sq. inches} \times 100$
 $= 28.26\%$

Maximum % Interception Efficiency Possible for Typical Containers used in Commercial Production

Container Size (Diameter)	Container Surface Area	Rectangle Area (pot-pot tight)	Maximum Potential %IE
Flats	—	—	100%
4" (10.16 cm)	12.56 sq. inches (81.03 cm ²)	4" x 4" = 16 sq. inches (103.23 cm ²)	78.5%
6" (15.24 cm)	28.26 sq. inches (182.41 cm ²)	6" x 6" = 36 sq. inches (232.26 cm ²)	78.5%

Note the drop in interception efficiency as plants are spaced out from propagation flats to larger containers.

Step 4. Complete this several times during the growing season for several different production zones and crops

Use the data to optimize irrigation interception efficiency.

WORKSHEET 4: TRACKING YOUR PROGRESS

Keeping track of your self-assessment scores each year is a great way to see where improvements can or have been made over time. Scoring in the chart below has been broken down into pre-production, production and post-production areas which can be totalled to give an overall score.

You may wish to indicate years in which major upgrades to production systems took place as well as any changes to the type of crops grown in the greenhouse.

Progress chart					
Year	<i>e.g. 2018</i>				
Notes on production year	<i>e.g. Installed new flood floor in Range 3</i>				
GENERAL ENVIRONMENTAL ASSESSMENT FOR FLORICULTURE GREENHOUSES					
1					
2					
3					
4					
5					
6					
7					
Total section score					
A. PRE-PRODUCTION WATER AND NUTRIENT MANAGEMENT					
A.1					
A.2					
A.3					
A.4					
A.5					
A.6					
A.7					
A.8					
Total section score					

APPENDIX

Year					
B. PRODUCTION WATER AND NUTRIENT MANAGEMENT					
B.1					
B.2					
B.3					
B.4					
B.5					
B.6					
B.7					
B.8					
B.9					
B.10					
B.11					
B.12					
B.13					
B.14					
B.15					
B.16					
B.17					
B.18					
B.19					
B.20					
B.21					
B.22					
Total section score					
C. POST PRODUCTION WATER AND NUTRIENT MANAGEMENT					
C.1					
C.2					
C.3					
C.4					
C.5					
Total section score					
Total overall score					

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FOR MORE INFORMATION

Many sources of supplementary information are available from the Ministry of Agriculture, Food and Rural Affairs. Most can be found online at ontario.ca/omafra or ordered through ServiceOntario.

INQUIRIES TO THE ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

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