Protocol C1
Water Assessment Manual for Category 1 Facilities

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Version: January 15, 2024

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Subject: Protocol C1- Water Assessment Manual
Protected Agriculture Stewardship – National Auditable Standards

1.0 Introduction

This manual was prepared by Baird AE on behalf of CropLife Canada to assist greenhouse operators in validating the integrity of closed loop chemigation systems. This water assessment protocol shall be used in conjunction with the Protected Agriculture Stewardship - National Auditable Standards (PAS) to mitigate risks associated with pesticide application in protected agriculture environments. This protocol is intended to be used by operators of closed-loop systems within Canada.

The PAS National Auditable Standards version 2.0 was released in June 2023. As of June 30, 2024, all category 1 (closed-loop) greenhouses or protected agricultural operations, as defined in the National Auditable Standard, who wish to purchase PCP registered products labelled for greenhouse use will need to be certified under the mandatory aspects of the standard.

By undertaking the water assessment to validate the integrity of chemigation system(s), operators shall:

- ensure the system is functioning properly;
- ensure that there are no intentional or unintentional cross-connections between the system and the stormwater management system in both the outgoing and return pipe networks;
- prevent loss of product into the environment.

2.0 Definitions

The following terms will be used throughout this manual:

Auditor is defined as the person completing the Protected Agriculture Stewardship – National Auditable Standards.

Chemigation system: All components of the water irrigation system used to apply chemicals to the growing medium of a crop including feedwater and transfer piping, mixing and holding tanks, injectors/pumps, mixing, anti-siphon and backflow devices. Also referred to as fertigation or recirculation systems.

Closed chemigation system: A water irrigation system designed to not allow transfer of treated irrigation water outside of the operation as discharges into the environment or storm water management systems including ebb and flow benches, trough benches, flooded floor systems, chemigated water capture and return lines, filter and disinfecting systems, catchment tanks, active floor drains and waste water lines. Also referred to as recirculation systems.

Operator is defined as the owner/ operator/ owner's representative of a protected agriculture facility utilizing closed chemigation systems for the duration of the assessment.

Qualified Person (QP) is defined as person with a combination of technical training and experience in greenhouse infrastructure, who is a third party to the farm ownership. Further, a QP may include a plumber with Red Seal certification or Master Plumber Licence (or equivalent), a Professional Engineer, a Certified Engineering Technologist or a Greenhouse Irrigation Specialist. If required, the PAS Steering Committee will approve the addition of other professions as QPs.

Third Party is defined as person who is a third party to the farm ownership. The Third Party may either deliver the water assessment or observe the water assessment. If the Third Party delivers the water assessment, they should also meet the definition of a QP. If they Third Party observes the water assessment, they must declare that they understand what they are observing. A waiver will be provided for this declaration.

PAS Technical Committee: A committee formed as a sounding board to inform decisions related to the delivery of the standard. The committee may include any or all of the following: operator organization representatives, individual operators, government extension staff, crop protection industry representatives, ag-retail representatives, auditors, technical experts. Membership will be defined by the Committee's Terms of Reference.

Physical Testing Methods are defined as testing protocols developed to assess the physical integrity of the closed-loop system. Three physical testing methods are described in Appendices C through F of this manual. If Operators are unable to complete one of physical testing methods in this guide, they are welcome to propose an alternative physical testing method. Details can be found in Section 4.0.

Alternative Non-physical Testing Methods are defined as non-physical testing methods used as a proxy to assess the integrity of closed-loop system. Any operation that is unable to complete a physical assessment of their closed-loop system will need to submit a rationale as to why physical methods cannot be used to the PAS Technical Committee. Details can be found in Section 4.0.

Protocol C1 is defined as follows:

> Operation has undertaken a water-management assessment that has either been delivered or observed by an independent third party every six years that validates the facility's closed recirculation system - this may include a dye test or alternatives.
>
> **IF** a renovation or reconfiguration of the chemigation system occurs, a water management assessment must be undertaken and passed upon the modifications being completed.

Protocol C1 – Water Assessment Manual (The Manual) is defined as the document describing testing methods to satisfy Protocol C1 prepared by Baird AE.

Third Party Witness Declaration – If the water assessment is witnessed by a Third Party, the Third Party must declare that they are third party to the farm's ownership, that they understand what they have observed and that they attest to the delivery and completion of the water assessment, including any necessary corrective actions.

3.0 Water Assessment Phases

The water assessment has been divided into three (3) phases: prior to the test, during the test and after the test. Each phase is generally described below. Further detailed information is provided in the appendices specific to each testing method.

Prior to the test

a) The Operator and the Third Party should discuss timing of the test. A decision should be made as to whether the Third Party will deliver or observe the test;

b) The Operator should complete the Greenhouse Information Summary;

c) The Operator or Third Party shall review aerial images (i.e. Google maps images or

equivalent) of the subject property;

d) The Operator or Third Party shall select desired testing method.

During the test

a) The Operator or Third Party shall review as-built and utility drawings to identify the various chemigation systems and stormwater management systems related to the greenhouse being tested;

b) The Operator or Third Party shall complete Infrastructure Summary and Visual Inspection and Floor Drain Log. Any deficiency that could lead to loss of product to the environment shall be recorded and identified in the report as requiring corrective action;

c) The Operator and Third Party shall complete the physical test;

d) The Operator or Third Party shall record results of test;

e) The Operator or Third Party shall create a deficiency list;

After the test

f) The Operator or Third Party shall complete a report per Section 5.0 of this manual. Both the Operator and Third Party will attest to the delivery and results of the test (using the Third Party Witness Declaration form);

g) The Operator and Third Party shall provide written confirmation that any deficiencies noted have been addressed. Written confirmation to be attached to report. Both the Operator and Third Party will attest that the repairs have been completed (using the Third Party Witness Declaration form).

4.0 Testing Methods

Physical Testing Methods: This document includes four physical testing methods. If Operators are unable to complete one of physical testing methods in this guide, they are welcome to propose an alternative physical testing methodology to Agrichemical Warehousing Standards Association (AWSA) via email at manager@awsa.ca. AWSA will respond to the initial request within five (5) business days. The methodology will be reviewed by the PAS Technical Committee and a decision communicated to the Operator within fourteen (14) days. The proposed method should meet the intent of the physical testing methods included in this guide.

Non-Physical Testing Methods: Physical testing is the preferred method for determining the integrity of the closed-loop system. If Operators are unable to complete a physical test of their system, they should submit a rationale to AWSA via email at manager@awsa.ca as to why physical methods cannot be used. AWSA will respond to the initial request within five (5) business days. The rationale will be reviewed by the PAS Technical Committee and a decision communicated to the Operator within fourteen (14) days. Upon approval the Operator should provide an alternative non-physical testing methodology that meets the intent of testing methods included in this guide. The PAS Technical Committee will make a determination as to the rigour of the approach and

communicate a decision to the Operator within 14 days. The rationale and the alternative non-physical testing method can be submitted at the same time to streamline the process.

Although chemigation systems used at each facility vary, it is anticipated that at least one of the following methods shall be suitable.

The physical testing methods presented below are the preferred protocols that will provide the most conclusive results.

Testing methods are described in the following appendices:

Testing Method	Appendix
Dye Testing	C
Fog Testing	D
Pressure Testing	E
Enhanced Nutrient Testing	F

5.0 Test Report

In order to satisfy Protocol C1, a report prepared by the Operator or Third Party documenting the testing method and results is required. This report shall be retained by the Operator and provided to the auditor(s) as part of the PAS audit. The report should contain, at a minimum, the following:

1. A statement confirming that testing or verification was required and completed including description of method;

2. The aerial images and as-built and utility drawings, the completed Greenhouse Information Summary, Infrastructure Summary and Visual Inspection Log;

3. A complete Testing or Analysis Log and Floor Drain Log for each system tested;

4. A description of deficiencies, timeline for repair(s) and additional tests, if any, required to satisfy C1;

5. The report shall be signed by the Operator and Third Party who oversaw the testing protocol;

6. Drawing of all chemigation systems tested. Include a separate drawing for each system. Tested fixtures and drains should be labelled on the plan and correspond to those reported in the appropriate testing log and Floor Drain Log. Sample testing logs and floor drain logs are included in Appendix G;

7. Written confirmation of completed repairs signed by the Operator and Third Party, if required. A separate letter may be attached to the report, if required. The Third Party Witness Declaration form should be completed and attached to the report if the water assessment was observed by a third party.

6.0 Satisfying Protocol C-1 as part of the PAS – National Auditable Standard

As per the PAS Standards (Full Manual), all mandatory protocols must be satisfied for certification to be granted. The PAS audit shall be conducted every two (2) years and the Water Assessment shall be conducted every six (6) years.

The water assessment (Protocol C1) may be completed prior to the PAS audit, after or in parallel. The PAS audit cannot be finalized until the water audit has been completed and a report prepared.

The PAS auditor shall request the water assessment report prepared by the Operator or Third Party. The auditor shall review the document to confirm use of approved testing method, required corrective actions and completion of same.

The auditor shall assign a Yes/ No to Compliance of Protocol C1: Water Management Assessment in Section C: Water Assessment and Equipment Management of the National Auditable Standard auditing document. The auditor shall only assign a passing score once all concerns noted in the report have been addressed and rectified.

APPENDIX A
OPERATOR INFORMATION SUMMARY

OPERATOR INFORMATION SUMMARY

Greenhouse Owner Information		
Owner Name	Phone	Email
Address		
Greenhouse Operation Information		
Greenhouse Operating Name		
Physical Address		
Primary Contact	Phone	Email
Municipality		
Types of crops grown/ product description		

APPENDIX B
INFRASTRUCTURE SUMMARY AND VISUAL INSPECTION LOG
FLOOR DRAIN LOG

INFRASTRACTURE AND VISUAL INSPECTION SUMMARY

Item	Description				Details and Notes
Interior Inspection					
1	Describe incoming water source. Describe treatment steps, if any.				
2	Describe the chemigation system, record type(s) of irrigation system(s) used, irrigation system layout, area covered by each and recirculation system. Obtain as-built and utility drawings for each greenhouse to be tested. Locate the chemigation system drain furthest from the main collection point to ensure entire network is being tested.				
Example	a)	Flood Floors	Area:	ha	
	b)				
	c)				
	d)				
	e)				
	f)				
3	Describe additives to irrigation system (i.e. Water, nutrients, pesticides, etc.				

OPERATOR INFORMATION SUMMARY

Item	Description	Details and Notes
4	Is feedwater used indefinitely? Is storage adequate to contain the excess chemigation water collected or is disposal required? Describe disposal methods.	
5	Describe pesticide application methods, i.e. foliar, if different from irrigation system.	
6	Describe subsurface drainage, if any.	
7	Describe production cycle(s) (i.e. year-round) and when zones may be empty.	

OPERATOR INFORMATION SUMMARY

Item	Description	Details and Notes
8	Examine each area and room of each greenhouse, particularly those areas where pesticides are stored and mixed including sprayer wash areas and irrigation rooms. Look for drains, pipes, holes in the floor, cracks or gaps in floor, overall maintenance level and care of irrigation system. Determine drain discharge location, if able. Note location (or evidence) of spills. Be aware of skids or objects covering floor drains. Document presence of floor drains in Floor Drain Log. Utilize same Floor Drain Log during physical testing. A site map as required in A1 and E1 of the PAS National Auditable Standards may aid in this process.	
9	Describe any major repairs to the chemigation supply and return system made since the last water assessment.	

OPERATOR INFORMATION SUMMARY

Item	Description	Details and Notes
Exterior Examination		
1	Describe key exterior features such ditches, ponds, wells. If water level is high, return to inspect when water level is lower. Refer to the aerial images.	
2	Describe visible pipes and identify origin, if able.	
3	Describe evidence of erosion at pipe outlet, if any.	
4	Describe location and volume of septic beds and septic tank.	

OPERATOR INFORMATION SUMMARY

Item	Description	Details and Notes
5	Review stormwater management plan as-built drawings. Identify all manholes and catchbasins that receive stormwater from the subject greenhouse.	
6	Determine if the stormwater collection system(s) discharge to a stormwater management pond or directly to a receiving watercourse.	
7	Based on above information, is the subject system a closed-loop system?	Y/ N

*See Excel Workbook for Floor Drain Testing Log

APPENDIX C: PHYSICAL TESTING
DYE TESTING
DYE TESTING LOG

DYE TESTING

The dye testing method has been described in a document, prepared by Heide Mikkelsen, P.Eng. for the Ontario Greenhouse Vegetable Operators, entitled “Dye Testing for Greenhouse Nutrient Feedwater Facilities: Operation Manual” and dated August 26, 2019. Though written for use in Ontario, minor adaptations allow for use throughout Canada.

Operators in Ontario that have previously used the Dye Testing method presented in the Mikkelsen manual may continue to do so.

In the following method, the term nutrient feedwater collection system is used in place of chemigation system.

Dye Testing Preparation

1. Request and review as-built and utility drawings for nutrient feedwater system(s) and stormwater management system.
2. Examine the nutrient feedwater system(s) and the stormwater collection system(s) for the greenhouse to be tested.
3. Complete Infrastructure and Visual Inspection Summary and Floor Drain Log.
4. Select a day for testing when the water in the pond or watercourse is clear with very low turbidity.
5. Prepare the following materials prior to testing:

    a) Tracer Dye

    All dyes utilized for testing must be non-toxic, biodegradable and National Sanitation Foundation Certified (N.S.F.). Multiple colours are recommended for complex sites. Dyes that are ultraviolet sensitive, or that have not been tested for their effect on produce, should only be used in situations where the collection systems can be completely flushed out and there is no risk of contamination. Selection of an appropriate tracer dye is the responsibility of the operator. Suppliers, provincial extension staff or grower organization may be able to provide further guidance on the selection process.

    b) Communication devices (radio or cellphone);
    c) Staff to observe the various testing points;
    d) Tools to open manholes, floor drains/covers, sump lids, etc.;
    e) Hose(s) to extend from the water supply to the top end(s) of the nutrient feedwater collection system;
    f) Rubber test ball plug(s) with a diameter matching that of the nutrient feedwater collection system outlet pipe into the sump;
    g) Compressor to inflate test ball to desired pressure;
    h) Flashlight;
    i) Camera;
    j) Blacklight (if using ultraviolet sensitive dye);
    k) Dye Test Log.

Dye Testing Notification and Personnel

1. It is the responsibility of the parties delivering the water assessment to ensure the appropriate agencies and authorities have been notified of testing that may impact local water bodies. Notification shall be provided at least two (2) days prior to commencing the planned testing. This

will allow the governing agencies to better handle any public inquiries about unidentified substances in the watercourse.

2. Additional personnel will be required to administer the testing protocol and document the results. Typical roles will include:
    a) Assisting in completion of the Infrastructure and Visual Inspection Summary and Floor Drain Log;
    b) Recording the location and time that dye is introduced into the nutrient feedwater collection system;
    c) Monitoring the nutrient feedwater collection points to observe and document the outcome of the dye testing;
    d) Monitoring and documenting the outcome of the dye testing at the receiving stormwater drains, manholes, catch basins, pond, etc.

Dye Testing Procedure

1. Mark the location of each fixture where dye is to be introduced on the record drawing. (Note: Drains/fixtures to be tested shall be left to the discretion of the staff present on site. All drains/fixtures within the greenhouse shall be tested unless staff can visually confirm that all the nutrient feedwater pipes drain to the same location.).

2. Ensure that the main nutrient feedwater collection point being tested has been drained (pumped) down prior to any testing commencing.

3. Plug the outlet pipe using the rubber test ball plug at the identified manhole, sump, cleanout, outfall or other appropriate locations needed to fill the nutrient feedwater collection system. Note any sharp protrusions (i.e. Screws) into the pipe as they may puncture the test balls. Ensure the plug is inflated to 25 psi or the maximum pressure stated on the supplier label for the plug.

4. Mix approximately 30mL (2 tbsp) of dye powder (or as directed by the manufacturer's recommendations) with approximately 8L of water and add the mixture to the furthest (highest) collection point in the nutrient feedwater collection system being tested. Repeat the mixing and adding procedure up to 5 times for systems with large nutrient feedwater pipes or systems which travel a long distance to reach the outlet pipe. Make sure to record the time the dye was added on the Dye Testing Log.

5. Begin to fill the nutrient feedwater collection system with a hose at the same collection point that the tracer dye was added. Note the slope of the ground and low points to determine points to check to ensure the system does not overflow and cause a false positive result.

6. Station personnel at the outlet pipe to ensure the rubber test ball plug does not leak or become removed as the water pressure in the system increases.

7. Inspect multiple points along the collection system to ensure dyed water is flowing along the path outlined in the as-built drawings. If water is observed to be flowing without colour from the dye, more dye may need to be added at the highest collection point. The system does not need to be drained to do so, simply add more dye at the same concentration outlined in step 4 and then continue to fill the system.

8. Continue filling the system with water until the lowest collection point in the nutrient feedwater collection system is full. Record the time the system was full on the Dye Testing Log.

9. At this time, the entire stormwater management system must be inspected for any traces of dye. This inspection should be done before the rubber test ball plugs are removed. Record observations on the Dye Testing Log.

10. Once step 9 is complete, remove the plug and ensure that the water draining from the system contains tracer dye (it may take a few minutes for the dyed water to appear as there may have been some standing water in the system before the test began). Record the time the system was drained on the Dye Testing Log.

11. The entire stormwater management system must then be re-inspected for any traces of dye. Note that at this time traces of dye may be observed from any overflows in the sumps or pumping system. Record observations in the Dye Testing Log.

12. If multiple collection systems feed back to the same main nutrient feedwater collection point, repeat steps 2 through 11 with an alternate colour dye.

12. Review previously completed Floor Drain Log for drain and overflow locations. Record locations on as-built drawings.

13. If floor drains and/or overflows are observed to be in the areas specified, tracer dye must be run through the system at the same concentration as outlined in step 4. Run water through the system following the dye and perform an inspection of the entire stormwater management system. Record observations on the Floor Drain Log.

14. Document all observations and submit report to maintenance staff to fix any deficiencies within the system observed.

15. Once the Dye Testing protocol has been completed, the tested nutrient feedwater collection system must be flushed thoroughly with water until no signs of the tracer dye are visible.

Dye Testing Tips

a) Examples of common dye tracers include:

1. Coloured Tracer Dye (Powder) **Name:** Blue Tracer Dye (10165) Red Tracer Dye (11249)	**Available from: Plant Products Inc.** 1520 Sandhill Dr Ancaster, ON L9G 4v5 800 387-2449
2. Fluorescent Tracer Dye Name: C.I. Acid Yellow (CAS#528-47-8)	**By: Cole Parmer Instrument Company** 625 East Bunker Court Vernon Hills, Illinois 60061 1-800-363-5900 **By: Cole Parmer Canada** 210-5101 Buchan Street Montreal QC H4P 2R9 (514) 355-6100

b) Test each drain individually by adding dye to the drain and waiting to observe in manhole or sump before proceeding to the next drain.

c) When multiple colours of dye are utilized, alternate the colours of dye so observers know what coloured water is seen coming from the current drain being tested.

d) Fluorescent dye tracer will glow in ultra violet light. For those in Ontario, OGVG has an ultra violet light that can be signed out upon request.

e) Continue to monitor the Storm Drainage System for hours or even days afterwards to ensure that no leaks or bypasses are detected.

f) The dye can be neutralized from the solution by adding chlorine. Check manufacturer documentation for ratio of dye to chlorine. Keeping track of the amount of dye used in each case will allow for accurate dosing of chlorine.

g) Ensure dye is observed at the final nutrient feedwater outfall of the site.

h) Ensure that dyed water that needs to be removed from the system is properly disposed of and not introduced into the storm drainage system.

Interpreting Testing Results

If dye is observed in the nutrient feedwater sump, cleanout or manhole and no dye is observed in the stormwater management system (i.e. Cleanout, manhole, catch basins or pond), then the test was a success. Ensure that the storm outfall or pond is continued to be monitored on a daily basis until the next rainfall event, in case the storm system was slow to respond. Record the results and submit a report as noted below.

If any dye is observed in the stormwater management system, immediately notify the Operator (if not directly involved in the test) and proceed with the following steps (unless directed otherwise):

a) Narrow the search by retesting about half of the nutrient feedwater access points.

b) Keep retesting until it is determined which fixture(s) or drain(s) is cross-connected with the stormwater management system.

c) Immediately remedy the cross-connected fixture(s) or drain(s) to ensure proper disconnection from the stormwater management system. These solutions must be permanent and cannot be undone or changed in the future. Examples of proper solutions include permanent removal, redirection to a holding tank or filling of the cross- connected fixture(s) or drain(s) with concrete.

If an immediate solution is not possible, the Operator should implement mitigation measures to prevent chemigation water from reaching the environment until such time as a permanent solution can be implemented.

*See Excel Workbook for Dye Testing Log

APPENDIX D: PHYSICAL TESTING
FOG TESTING
FOG TESTING LOG

FOG TESTING

Fog testing consists of blowing a harmless coloured vapour into the closed loop system and observing where the fog exits from the system.

The fog has no odour, is non-staining, is not harmful to health and will dissipate after a few minutes.

Fog Testing Preparation

1. Request and review as-built and utility drawings for chemigation system(s) and stormwater management system.
2. Examine the chemigation system(s) and the stormwater collection system(s) for the greenhouse to be tested.
3. Complete Infrastructure and Visual Inspection Summary and Floor Drain Log.
4. Prepare the following materials prior to testing:

    a) Fog testing may be completed by a licenced plumber or technician familiar with this activity. Materials required may include manhole ventilator and fog generator. Organic farms shall confirm with their certifier that incidental contact of fog within the system is allowable.
    b) Communication devices (radio or cellphone);
    c) Staff to observe the various testing points;
    d) Tools to open manholes, floor drains/covers, sump lids, etc.;
    e) Hose(s) to extend from the water supply to the top end(s) of the system for rinsing after test completion;
    f) Rubber test ball plug(s) with a diameter matching that of the chemigation pipes and outlet pipe into the sump;
    g) Compressor to inflate test plug(s) to desired pressure;
    h) Flashlight;
    i) Camera;
    j) Fog Testing Log.

Fog Testing Notification and Personnel

1. Notification shall be provided to appropriate authorities depending on local and provincial requirements. Notification shall be provided at least two (2) business days prior to any planned testing. This will allow the governing agencies to better handle any public inquiries about unidentified substances in or near the watercourse.

2. Additional personnel will be required to administer the testing protocol and document the results. Typical roles will include:
    a) Establishing test sections, if required;
    b) Assisting in completion of the Infrastructure and Visual Inspection Summary and Floor Drain Log;
    c) Recording the location and time that fog is introduced into the collection system;
    d) Observing the test plug(s) to ensure they do not dislodge during testing;
    e) Monitoring the collection points to observe and document the outcome of the testing;
    f) Monitoring and documenting the stormwater management system for signs of fog.

Fog Testing Procedure

1. Using utility drawings, indicate location of each fog entry point. Depending on the size of the system, it may be divided into smaller sections for testing purposes. Use rubber test plug(s) to establish sections.

2. Pump down or drain the section being tested. Standing water in the lines may impede the movement of the fog within the section.

3. Commence testing at the highest point in the section.

4. Insert rubber test plug at the any manhole, sump, cleanout or other location needed to fill the collection system. Ensure that no object will pierce the rubber plug. Inflate per manufacturer's instructions.

5. Introduce fog into system using a manhole ventilator and fog generator. Record time on the Fog Testing Log.

6. Place observers at the downstream end of the section being tested to ensure the rubber test plug does not become dislodged during the test.

7. Observe multiple points along the section being tested to ensure fog is moving through the system. If no fog is observed, continue adding fog to the system or create smaller sections using additional test plugs.

8. Continue filling the system with fog until the lowest collection point in the section or system is full. Record the time the system was full on the Fog Testing Log.

9. Place observers inside and outside the facility. Inspect the stormwater management system. Fog visible from a catch basin or any part of the stormwater management system indicates a cross-connection with the chemigation system. Fog visible elsewhere may indicate a leak.

10. Upon completion of step 9, remove the plug and allow fog to dissipate. Fog should dissipate quickly.

11. Should multiple collection systems utilize the same collection point, repeat steps 2 to 10 for each section. Allow all fog to dissipate prior to commencing another test.

12. Reference previously completed Floor Drain Log for floor drain and overflow locations. Record locations on as-built drawings.

13. Drains and overflows found in areas listed in step 12, must be tested, unless otherwise determined by the Operator or Third Party or a visual inspection confirms that all chemigation pipes drain to the same location. Introduce fog into these systems and inspect stormwater management system as described in steps 2 to 10. Record observations on Floor Drain Log.

14. Flush system with water thoroughly after testing.

15. Document all observations and list deficiencies. Provide to Operator (if not directly involved in the test).

Interpreting Testing Results

If fog is observed in the chemigation system and no fog is observed in the stormwater management system or at the pond inlet, the test was a success. Use recorded results to prepare a report as described in Section 5.0 of the manual.

If fog was observed in the stormwater management system or at the pond inlet, immediately notify the Operator (if not directly involved in the test) and repeat the test as follows (unless otherwise directed):

a) Retest one half of the system or create smaller sections using test plugs. Continue testing until cross-connection is isolated.
b) Immediately remedy the cross-connected fixture(s) or drain(s) to ensure proper disconnection from the stormwater management system. These solutions must be permanent and cannot be undone or changed in the future. Examples of proper solutions include permanent removal, redirection to a holding tank or filling of the cross- connected fixture(s) or drain(s) with concrete.

   If an immediate solution is not possible, the Operator should implement mitigation measures to prevent chemigation water from reaching the environment until such time as a permanent solution can be implemented.

*See Excel Workbook for Fog Testing Log

APPENDIX E: PHYSICAL TESTING
PRESSURE TESTING
PRESSURE TESTING LOG

PRESSURE TESTING

Pressure testing shall be completed by a licensed plumber or technician familiar with this testing method. Confirm allowable testing pressure with pipe manufacturer and technician prior to commencing test.

Use caution when employing this method.

Pressure Testing Preparation

1. Request and review as-built and utility drawings for chemigation system(s) and stormwater management system.
2. Examine the chemigation system(s) and the stormwater collection system(s) for the greenhouse to be tested.
3. Complete Infrastructure and Visual Inspection Summary and Floor Drain Log.
4. Confirm pipe type and pressure rating prior to commencing test. Confirm desired testing pressure with technician.
5. Prepare the following material prior to testing:
    a) Compressor with necessary fittings, valves and gauge to fill system with pressure. Coordinate with technician performing the test to ensure all required materials are available and ready for use;
    b) Staff to observe the various testing points;
    c) Communication devices (radio or cellphone);
    d) Tools to open manholes, floor drains/covers, sump lids, etc.;
    e) Rubber test ball plug(s) with a diameter matching that of the chemigation pipes and the outlet pipe into the sump;
    f) Compressor to inflate test plug(s);
    g) Flashlight;
    h) Camera;
    i) Pressure Testing Log.

Pressure Testing Notification and Personnel

1. Notification of appropriate authorities is not required for pressure testing.
2. Additional personnel will be required to administer the testing protocol and document the results. Typical roles will include:
    a) Establishing test sections, if required;
    b) Assisting with completion of Infrastructure and Visual Inspection Summary and Floor Drain Log
    c) Recording the location and time of system pressurization;
    d) Observing test plug(s) to ensure they do not dislodge during pressurization of the system;
    e) Observing and documenting test outcomes.

Pressure Testing Procedure

1. Using utility drawings, indicate location of point where compressed air will be added to system. Depending on the size of the system, the system may have to be divided into sections for testing purposes. Use rubber test plugs to establish sections.

2. Pump down or drain the section being tested.

3. Insert rubber test plug at the any manhole, sump, cleanout or other location needed to establish and fill the section. Ensure that no object will pierce the rubber plug. Inflate per manufacturer's instructions.

4. Attach pressure gauge, air compressor hose and fittings to a cleanout or similar. Using an air compressor, fill section with air until attached pressure gauge reads the desired test pressure (ex. 5 to 7 psi). If a large section of the system is being tested, it may take hours to fill the section with compressed air.

5. Position observers at the outlet pipe or section end to ensure the rubber test plug does dislodge as the air pressure in the system increases.

6. When desired pressure is achieved, stop adding compressed air to system, remove hose, and record pressure reading and time on the Pressure Testing Log.

7. Set a timer for 15 minutes. The system must hold the desired pressure for 15 minutes. Observers may hear air escaping form the system if there is a leak.

8. After 15 minutes, record pressure gauge reading in the Pressure Testing Log.

9. Open valve to release pressure from system. When gauge reads zero (0), carefully remove plug(s). There may be pressure remaining in the system.

10. Should multiple collection systems utilize the same collection point, repeat steps 2 to 9 for each section.

11. Reference previously completed Floor Drain Log for floor drain and overflow locations. Record locations on as-built drawings.

12. Drains and overflows found in areas listed in step 11 must be tested unless otherwise determined by the Operator or Third Party or a visual inspection confirms that all chemigation pipes drain to the same location. Repeat steps 2 to 9 for each drain and record observations in Floor Drain Log.

13. Document all observations and list deficiencies. Provide to Operator (if not directly involved in the test).

Interpreting Testing Results

If the test pressure was maintained for the entire 15 minutes in the section being tested, the test was a success. Use recorded results to prepare a report as described in Section 5.0 of the manual.

If the test pressure was not maintained for the duration of the test, immediately notify the Operator (if not directly involved in the test) and repeat the test as follows (unless otherwise directed):

a) Retest one half of the system or create sections using test plugs. Continue testing until cross-connection or leak is isolated.
b) Immediately remedy the cross-connected fixture(s) or drain(s) to ensure proper disconnection from the stormwater management system. These solutions must be permanent and cannot be undone or changed in the future. Examples of proper solutions include permanent removal, redirection to a holding tank or filling of the cross- connected fixture(s) or drain(s) with concrete.

If an immediate solution is not possible, the Operator should implement mitigation measures to prevent chemigation water from reaching the environment until such time as a permanent solution can be implemented.

*See Excel Workbook for Pressure Testing Log

APPENDIX F: PHYSICAL TESTING
ENHANCED NUTRIENT TESTING
ENHANCED NUTRIENT TESTING LOG

The following Appendix was prepared by the Ontario Greenhouse Vegetable Growers

GREENHOUSE ENHANCED NUTRIENT TESTING

Enhanced Nutrient Testing focuses on assessing the physical integrity of the closed-loop system using a nutrient (or another element/chemical indicator) that can identified in the environment. The nutrient is introduced as part of normal irrigation practices (i.e., nutrient feedwater), or as an elevated nutrient "spike", and subsequently measured for within defined and rigorous samples, completing measurements at the same critical points as the dye test. This test complements the ongoing monitoring, required under C2 – System Monitoring, and may sample the same nutrient(s). This protocol validates the same sample points as for a dye test, including sampling of floor drains, and provides a quantitative measurement in place of a qualitative visual measurement where the observation of dye is replaced by the quantitative measurement of a nutrient.

To complete the Enhanced Nutrient Test, all pipes leaving the Greenhouse property must be monitored and any observed flows must be sampled. If the pipework to the stormwater pond is submerged, or any observed flows are otherwise inaccessible, the Enhanced Nutrient Testing cannot be completed, and different testing must be completed.

In the case of floor drains, testing may require a hybrid approach with a different method being used on the floor drains, such as the use of a tracer dye or product to identify their outflows.

In the following method, the term nutrient feedwater collection system is used in place of a chemigation system.

Enhanced Nutrient Testing Suitability – Is this the right test for my operation?

1. Request and review as built and utility drawings for nutrient feedwater system(s) and stormwater management system.

2. Examine the nutrient feedwater system(s) and the stormwater collection system(s) for the greenhouse to be tested.

3. Complete Infrastructure and Visual Inspection Summary and Floor Drain Log.

4. If the pipework to the stormwater pond is submerged, or any observed flows are otherwise inaccessible, the enhanced nutrient testing cannot be completed, and different test must be completed.

5. Where floor drains are connected to the nutrient feedwater collection system, this testing protocol can be used (Procedure, Step 9-10). Where floor drains are not cross-connected, determination of their outflow is necessary and may be completed by hybridizing the nutrient test with another physical testing protocol, e.g. dye test, fog test, etc.

   Are my present nutrients acceptable or do I need to add another nutrient or a spike? The nutrient/chemical must be present in the system in sufficient quantity (nominally a defined as 1/3 or 33% above the nutrient feedwater and environmental waters) to differentiate between nutrient feedwater and environmental waters (Procedure, Step 6). If no, or insufficient, nutrients are present in the nutrient feedwater, a nutrient spike is required. The level of differentiation will depend on several factors including the element, the testing equipment, etc.

6. Which nutrient/element is suitable/acceptable? A few examples are provided below. Minimum criteria when choosing an appropriate nutrient/element and its concentration include that it is:
   a) not damaging to crop, and
   b) not problematic in a surface water course.

7. How does my available technology/personnel support this test? Do I have nutrient test kits, continuous monitoring probes, or spectrofluorometers available? Will the samples be tested in house, or sent away for analysis? Do I have staff and time to commit to the monitoring timeframe?

8. Background information should be collected on the nutrient levels in the irrigation system, as well as typical levels in the surrounding surface waters to verify sufficient difference will be noticeable.
   Option 1 – Historical data from at least three sampling dates should be considered, or
   Option 2 – If taking background samples as part of this protocol at least three samples should be taken from various points along the stormwater system on the sampling date, ahead of the testing, and the results averaged.

   For example: if total phosphorus is used, and the background level (as outlined above option 1 or 2) in the environmental waters is 3 mg/L units, then the nutrient feedwater must be at least 4.0 mg/L. If not, an assessment with a different element should be made, or a nutrient spike will be required that meets a nominal 33% above baseline for the test evaluation and interpretation.

Enhanced Nutrient Testing Preparation

1. Select a day for testing when the water in the pond or watercourse is clear with very low turbidity.

2. Prepare the following materials prior to testing:

   a) Communication devices (radio or cellphone);
   b) Staff to observe the various testing points;
   c) Tools to open manholes, floor drains/covers, sump lids, etc.;
   d) Flashlight;
   e) Camera;
   f) Nutrient feedwater collection containers (Cup, container, etc.) i.e., in the case of non-continuous sampling.
   g) Nutrient test kit (Total Phosphorus, Total Nitrates, Chelated Iron, etc.)
      - The name, brand, and sensitivity of the kit must be noted for the screening and must be able to distinguish between the positive and negative controls.
      - Examples of available supplies:
        - Hach – Multi Parameter Test Kits https://ca.hach.com/
        - Hanna Instruments https://hannacan.com/
   h) Enhanced Nutrient Test Log.
      - If using continuous monitoring probes, the **last date/frequency** of re-calibration must be recorded.
      - If using handheld meters, the **make/model/year** must be recorded.
      - If sent out for analysis, the results must include name of the lab (SGS, A&L, etc.) and the lab results must be appended.

   IF needed to seal sections for testing – as guided by Procedure, Steps 3 to 6:
   i) Rubber test ball plug(s) with a diameter matching that of the nutrient feedwater collection system outlet pipe into the sump;
   j) Compressor to inflate test ball to desired pressure;

   IF needed to test floor drains – as guided by Procedure, Step 9 to 10
   k) Hose(s) to extend from the water supply to the top end(s) of the nutrient feedwater collection system;

Enhanced Nutrient Testing Personnel

1. Additional personnel will be required to administer the testing protocol and document the results. Typical roles will include:
    a) Assisting in completion of the Infrastructure and Visual Inspection Summary and Floor Drain Log;
    b) Recording the presence/absence of flows and measure nutrient levels with test kits;
    c) Monitoring the nutrient feedwater collection points to observe and document the outcome of the enhanced nutrient testing;
    d) Monitoring and documenting the outcome of the enhanced nutrient testing at the receiving stormwater drains, manholes, catch basins, pond, etc.

Enhanced Nutrient Testing Procedure

1. Mark the location of each fixture to define the sections of the test. (Note: Drains/fixtures to be tested shall be left to the discretion of the Operator and/or their staff, present on site. All drains/fixtures within the greenhouse shall be tested unless staff can visually confirm that all the nutrient feedwater pipes drain to the same location.)

2. Collect **control sample(s)** from the stormwater system (longitudinal historical data sampled over several dates is sufficient) and nutrient feedwater system. If using a spike, collect a sample from the nutrient feedwater system after introducing the spiked element. All locations must be sampled within the same day.
    - Ensure that the nutrient being screened is present in the nutrient feedwater system in sufficient quantities, nominally ≥33% higher, to differentiate from stormwater.
    - When using a test kit, dosing the system with a nutrient or chemical indicator, spike, or a nutrient that is not normally present, is recommended to avoid repeating the test.

    If test kits are used, record the selected nutrients to be observed in the Enhanced Nutrient Testing Log. If the samples are sent out for laboratory analysis (SGS, A&L, etc.), append the testing results to the Enhanced Nutrient Testing Log.

3. **If required,** plug the outlet pipes using the rubber test ball to section off testing areas and momentarily stop nutrient feedwater from moving through the system. Note any sharp protrusions (i.e. Screws) into the pipe as they may puncture the test balls. Ensure the plug is inflated to 25 psi or the maximum pressure stated on the supplier label for the plug.
    - Make sure to record the time the system was plugged and observe the level of the nutrient feedwater in the Enhanced Nutrient Testing Log.

4. Inspect multiple points along the collection system to ensure water/nutrient feedwater is flowing along the path outlined in the as-built drawings.

5. Ensure the system is sufficiently full so that the lowest collection point in the nutrient feedwater collection system is full. Record the time the system was full on the Enhance Nutrient Testing Log.

6. At this time, the entire stormwater management system must be inspected for any traces of extraneous flows. Monitoring timeframe (start/stop) and sampling will vary to some degree, depending on the nutrient/element used, and its appropriate concentration (nutrient feedwater, or spike), the overall volume of water, and distance to plug or outflow. Monitoring should not be

conducted until the target nutrient has been introduced and circulated in the system to allow leaching into extraneous flows. Provided the nutrient is present in the system over a 24-hour period prior to the test, there is no wait time required and sampling can begin immediately. The nutrient spike strategy requires testing at a point at which the nutrient would be expected to be moving through the system.

Collect a sample(s) from any observed flow and test them for the presence of the selected nutrient(s). In the case of continuous sampling probes, record at regular intervals. Record observations on the Enhance Nutrient Testing Log.

Once step 6 is complete, remove the plug (if applicable) and ensure that the water/nutrient feedwater is draining from the system.

7. If the rubber stopper was used, the entire stormwater management system must then be re-inspected for any flows. Collect any new flows and record observations in the Enhanced Nutrient Testing Log.

8. If multiple collection systems feed back to the same main nutrient feedwater collection point, repeat steps 2 through 7 as needed.

9. Review previously completed Floor Drain Log for drain and overflow locations. Record locations on as-built drawings.

10. Where floor drains and/or overflows are observed to be in the areas specified and are connected to the nutrient feedwater collection system run enough water through the system to perform an inspection return feed while assuring there is no outflows from cross connections with the stormwater management system. The volume of water can be reduced by using a tracer or dye (as appropriate) to demonstrate the absence of a cross connection. Observe the outflow of the stormwater system and document the results of in the Floor Drain Log.

11. Document all observations and submit report to maintenance staff to fix any deficiencies within the system observed.

Interpreting Testing Results

1. The test is a success:
   - If a nutrient spike is used and the nutrient is absent in the outflows, OR
   - If an external/outside lab test demonstrates that the ratio of nutrients in the outflows is inconsistent with the irrigation system AND the concentration of nutrients is consistent with stormwater,

2. Record the results and submit a report as noted below.

IMPORTANT: If nutrient ratios matching the nutrient feedwater are measured in the stormwater management system outflows, the nutrient spike is detected, or nutrient levels exceed allowable/expected values, such as under provincial regulations, e.g., Ontario Environmental Compliance Approvals (ECA), immediately notify the Operator (if not directly involved in the test) and proceed with the following steps (unless directed otherwise):

a) Determine the likely sources for a limited physical test, such as a dye test, to determine the source of the nutrients.

b) Consider quantitative testing methodologies as appropriate to locate and determine which fixture(s) or drain(s) is cross-connected with the stormwater management system.

c) Immediately remedy the cross-connected fixture(s) or drain(s) to ensure proper disconnection from the stormwater management system. These solutions must be permanent and cannot be undone or changed in the future. Examples of proper solutions include permanent removal, redirection to a holding tank or filling of the cross- connected fixture(s) or drain(s) with concrete.

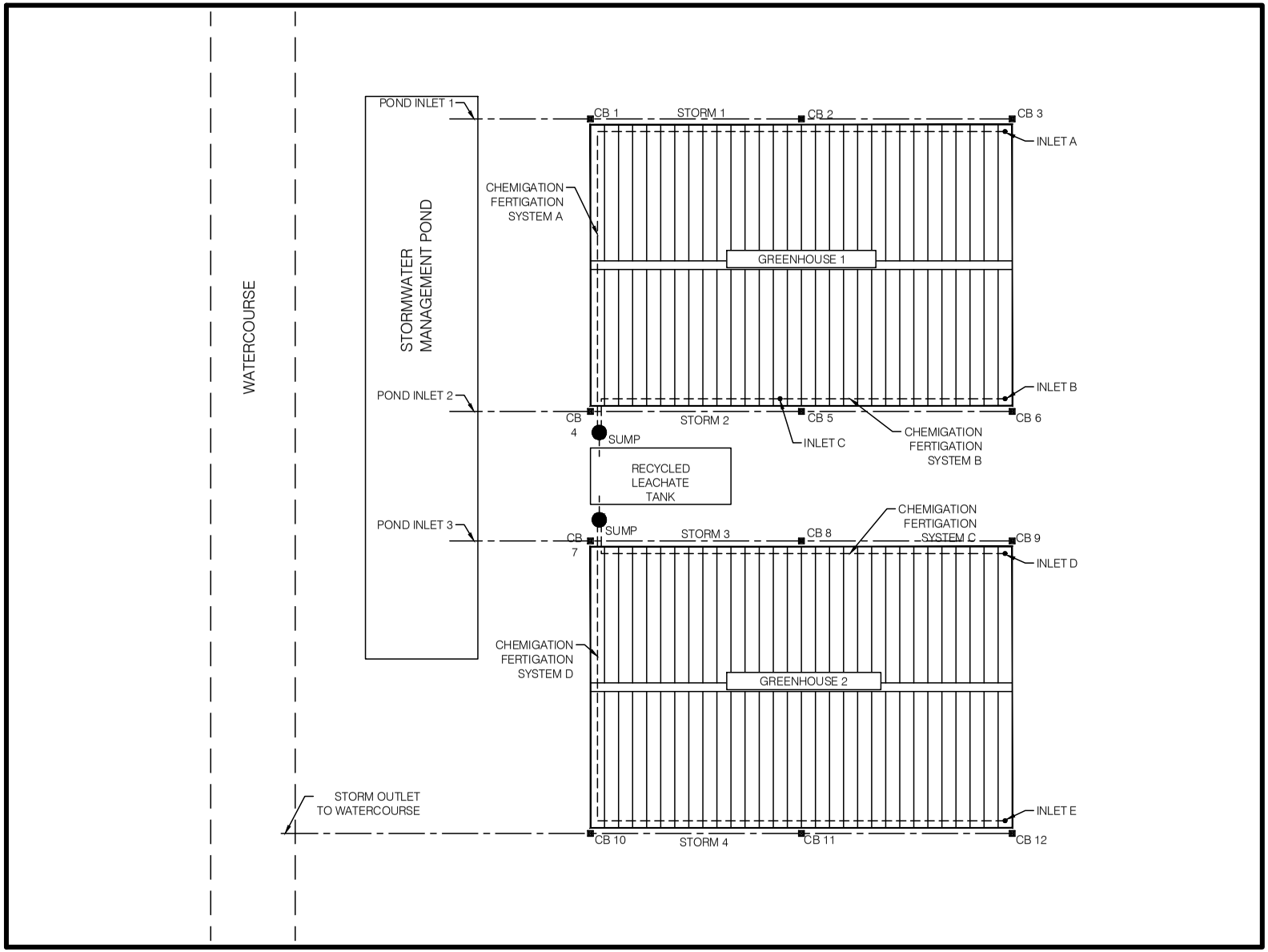
   If an immediate solution is not possible, the Operator should implement mitigation measures to prevent chemigation water from reaching the environment until such time as a permanent solution can be implemented.

*See Excel Workbook for Nutrient Testing Log

APPENDIX G
SAMPLE TESTING LOGS
SAMPLE FLOOR DRAIN LOG

*See Excel Workbook for Sample Testing Logs and Sample Floor Drain Logs

APPENDIX H
SAMPLE DRAWING


WATERCOURSE
STORMWATER MANAGEMENT POND
POND INLET 1
POND INLET 2
POND INLET 3
CB 1
STORM 1
CB 2
CB 3
INLET A
CHEMIGATION FERTIGATION SYSTEM A
GREENHOUSE 1
INLET B
CB 4
SUMP
STORM 2
CB 5
CB 6
INLET C
CHEMIGATION FERTIGATION SYSTEM B
RECYCLED LEACHATE TANK
SUMP
CB 7
STORM 3
CB 8
CHEMIGATION FERTIGATION SYSTEM C
CB 9
INLET D
CHEMIGATION FERTIGATION SYSTEM D
GREENHOUSE 2
STORM OUTLET TO WATERCOURSE
CB 10
STORM 4
CB 11
CB 12
INLET E

APPENDIX I
REFERENCES

REFERENCES

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