Agricultural Water for Production Overview

Agricultural water used to grow fresh produce can carry and distribute human pathogens. Surface water is more likely to be contaminated by human and animal fecal material than ground water because it is open to the environment. Therefore, it poses a much greater risk to human health when surface water used for irrigation or protective sprays directly contacts the edible portion of the crop. Surface water available for fresh fruit and vegetable production has been found to be contaminated with human pathogens such as *Salmonella, Escherichia coli* O157:H7, *Giardia*, and *Cryptosporidium*.[1, 2, 3, 4] Water distribution systems are also of concern, because these systems distribute water throughout the farm and can become contaminated if pipes, backflow devices, or other pieces of the distribution system are not in good condition and functioning properly.

Actions can be taken on the farm to reduce the risks of contamination from agricultural water used during the production of fresh produce.

1. Map and inspect all water sources and distribution systems.
2. Select water application methods that reduce risks by reducing direct contact with the edible portion of the crop.
3. Test all agricultural water for quantified generic *E. coli*.
    a. Identify a water testing laboratory
    b. Sample collection
    c. Delivering samples to the laboratory
4. Keep records of all water management actions and test results.

Map and Inspect All Water Sources and Distribution Systems

Create a map of all water sources and distribution systems to identify how water moves throughout the farm. All water sources, such as surface water and wells, should be inspected at the beginning of the growing season and periodically throughout the season. Surface water sources, such as ponds, lakes, rivers, reservoirs, and canals, should be assessed to determine if wildlife or adjacent land uses pose any contamination risk. Well casings should be inspected to make sure they are intact and well recharge areas should be inspected to make sure no risks are present. Any identified risks should minimized before the water is used for fresh produce production (e.g., repairing broken equipment, treating the water, or using filtration to assure water is sufficiently clean for its intended use).

All distribution systems, as well as equipment used to move water, should be inspected at the beginning of and throughout the growing season to ensure the lines are clear and not likely to introduce microbial risks to the crop receiving the water. This includes repairing broken lines and emitters as well as removing any debris in the lines, such as nesting wildlife, which could lead to contamination. Repairing damaged equipment is very important because broken water emitters can turn a drip system into an overhead system, thereby bringing water in direct contact with the edible portion of the crop. If bacterial pathogens are present in the irrigation water and the water sits stagnant in the pipe between irrigation applications in warm weather, pathogens can multiply in the pipe and potentially become incorporated into a biofilm. Water should be drained from the pipe between irrigation applications.

Select Water Application Methods that Reduce Risks

Drip irrigation is the least risky method of water distribution because the water normally does not contact the edible portion of the crop, unless you are growing root vegetables or the drip line develops a leak. Overhead irrigation and the application of topical crop sprays result in direct water contact with the edible portion of most crops, so safety is

influenced by the quality of water that is applied. If you are using a surface water source for overhead irrigation or for mixing sprays, you should test this water before using it and throughout the production season.

If you have concerns about the quality of your water that comes in direct contact with the crop, there are other actions that can be taken to reduce microbial risks. Test your water so you understand the quality, but you can also:

1. Apply any water that contacts the edible portion of the crop before harvest to allow drying and treatment by UV from sunlight to reduce potential pathogens on the crop.
2. Use water application methods that do not result in direct contact with the edible portion of the crop, such as drip or trickle irrigation. The longer the interval between application of water and harvest, the more risk reduction is possible.

Test all Agricultural Water for Quantified Generic *E. coli*

Water that directly contacts the edible portion of the plant is most important to food safety because water can carry pathogens and contaminate the crop. The source of any water that directly contacts the edible portion of the crop must be tested for quantified generic *E. coli*. This means the test will indicate the number of *E. coli* in the sample, not just if *E. coli* is present or absent. Testing for generic *E. coli* is not the same as testing for total coliforms, so be sure to ask specifically for a quantified generic *E. coli* test. The Food Safety Modernization Act (FSMA) proposed produce safety rule specifies if the source is surface water, such as a river, lake, pond, or stream, it must be tested once every week throughout its use if it contacts the harvestable (edible) portion of the crop. If the source is a well, it must be tested at the beginning of the growing season and every three months during the growing season. If the source is a municipal water source, a copy of the municipality's tests or certification of the quality is acceptable as verification of water quality. These are proposed water testing schedules, but they provide an idea of what may be appropriate or required in the future.

The proposed produce safety rule's water standards state that any agricultural water that directly contacts the edible portion of the crop must have less than 235 colony forming units (CFU) or most probable number (MPN) of generic *E. coli* per 100 milliliters (mls) of water sampled for any single sample. The five most recent water samples must have a rolling geometric mean of less than 126 CFU or MPN *E. coli* per 100 mls of water sampled. These standards are derived from EPA recreational water quality standards and have been adapted for the produce industry by the California Leafy Greens Marketing Agreement as well as in the FSMA proposed produce safety rule.[5, 6, 7] The FDA is scheduled to release a revision of the water section of the FSMA proposed produce safety rule, so these requirements may change. The final rule will not be released until fall of 2015. By starting to test and understand your water source now, you will be better prepared to respond to the final FSMA produce rule.

One way to compare your water tests to these standards is to look at the quantified *E. coli* number on your test results. Is it higher than 235 CFU (or MPN) per 100 mls? If so, you should discontinue use of the water immediately. If the sample is below 235 CFU (or MPN) per 100 mls, then you will need to calculate the rolling geometric mean (n=5) using the last 5 test results you have.

The easiest way to calculate this is to put the numbers into a Microsoft Excel spreadsheet (one number per cell), then click on the Formulas tab and select the GEOMEAN calculation under the Statistical Formulas. Alternatively, you can calculate the geometric mean by multiplying all the numbers together, then take the 5th root of this number. T his will give you the rolling geometric mean in CFU (or MPN) per 100 mls. If the rolling geometric mean is less than 126 CFU (or MPN) per 100 mls, you can use the water. If not, you should not use this water in any way that directly contacts the edible portion of the crop unless it is

treated (e.g. filtration, UV, chemically) and confirmed through re-testing to meet these standards. Chemically treating water has its own risks so all treatment options should be evaluated for their effectiveness and appropriateness for the farm and the crops grown.

The only way to know the water quality is to test the water. We recommended testing all agricultural water, but if the water is delivered through drip, it does not have to meet the same standards as water that directly contacts the edible portion of the crop. Some buyers and audit companies have established water standards even for water that does not directly contact the edible portion of the crop. Understanding water quality allows growers to make informed water management decisions, especially once a normal baseline has been established from season to season.[8, 9]

Identify a Water Testing Laboratory

Find a laboratory that is capable of providing the analysis you need. Currently, testing for quantified generic *E. coli* is the industry standard and included in the proposed FSMA produce safety rule. Tests that can achieve this type of analysis with quantified measurement to 235 *E. coli*/100 ml include Colilert Quantitray 2000 and modified TEC (EPA method 1603). There may be other types of tests that can be used, but be certain to specify the type of water source since many labs are not prepared to handle surface water sources.

Sample Collection and Delivery

Follow the sampling and delivery guidelines required by the laboratory doing the water analysis. This includes using designated sampling containers, sampling methods, and delivery times. Please review the *sample SOP* in this portfolio for basic sampling instructions.

Keep Records of All Water Management Actions and Test Results

Records should be kept for all water tests as well as any water management actions that are taken to identify and reduce risks that may be present in the water or the water delivery system. Template logs are provided to assist you with this recordkeeping process.

References

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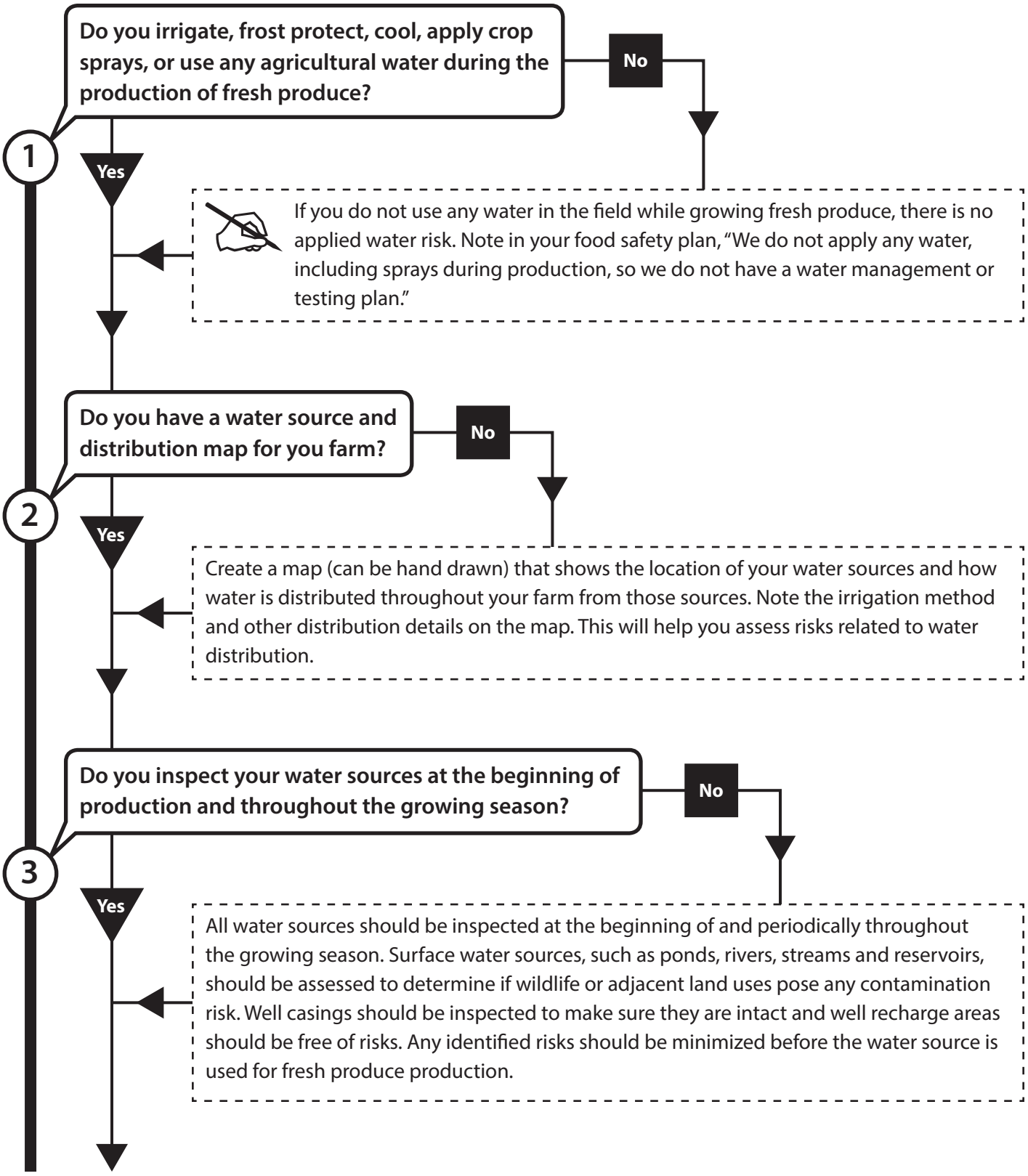
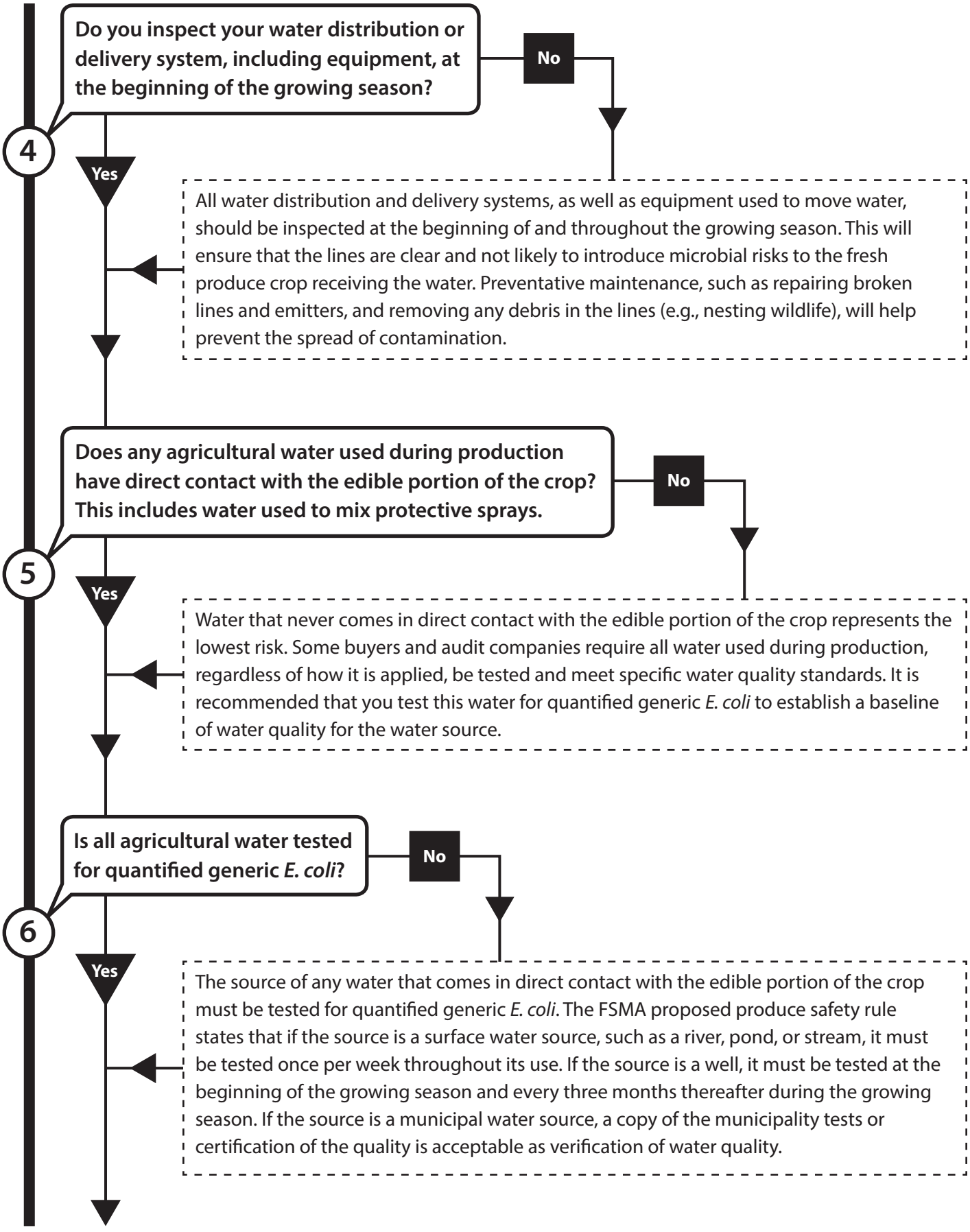
8. Amundson, S., G. McCarty, F. Critzer, and A. L. Wszelaki. 2012. UT Extension SP740-A Good Agricultural Practices Series: Testing Water for Fruit and Vegetable Production. 4 p.
9. Amundson, S., G. McCarty, F. Critzer, D. W. Lockwood, A. L. Wszelaki, and E. Bihn. 2012. UT Extension SP740-B Good Agricultural Practices Series: Interpreting Water Quality Test Results for Fruit and Vegetable Production. 4 p.

Agricultural Water for Production Decision Tree

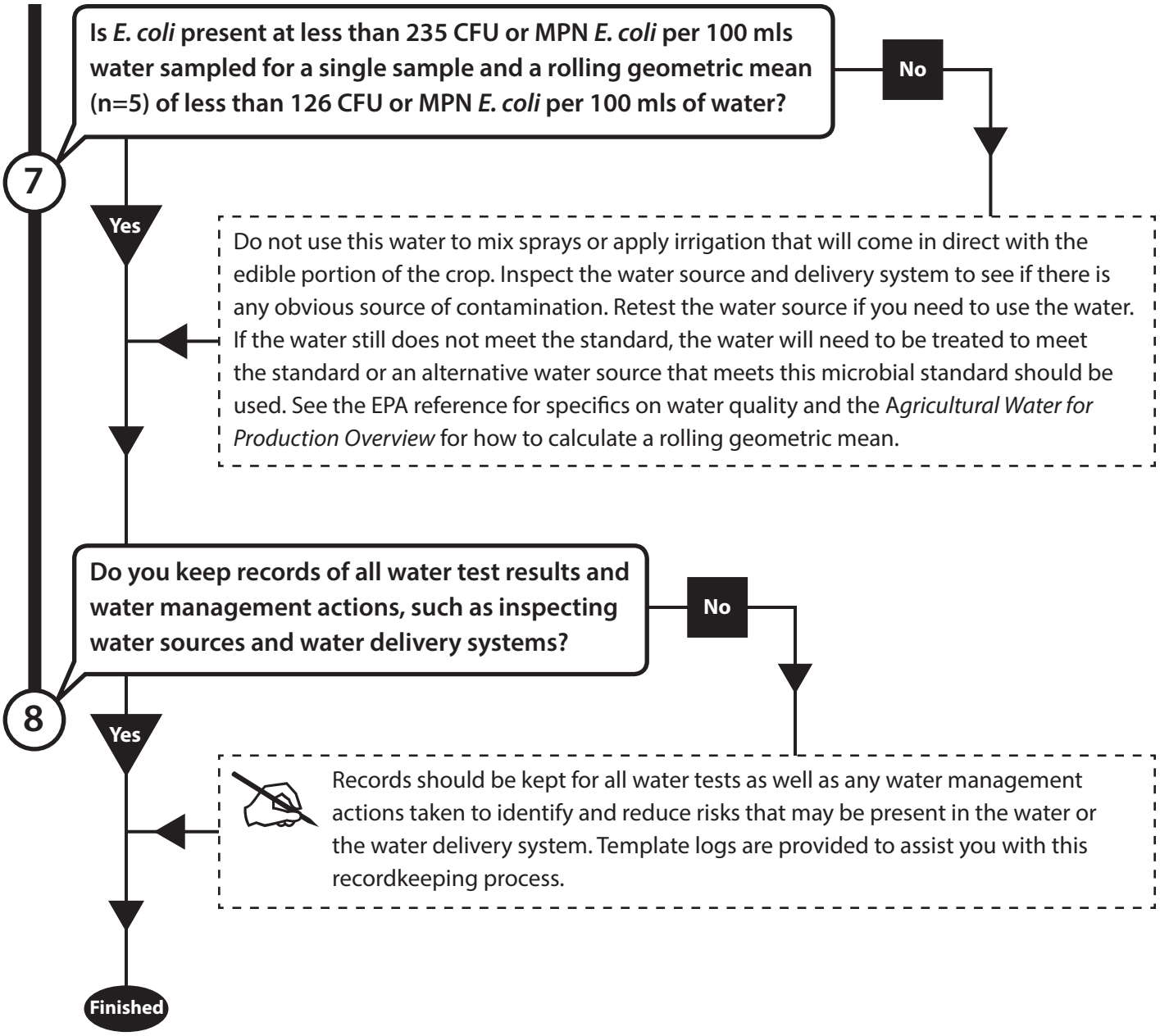


Agricultural Water for Production Decision Tree



On-Farm Decision Tree Project: Agricultural Water for Production—v4 7/17/2014
E.A. Bihn, M.A. Schermann, A.L. Wszelaki, G.L. Wall, and S.K. Amundson, 2014 www.gaps.cornell.edu

Agricultural Water for Production Decision Tree



Sample SOP:
Agricultural Water for Production Testing

Revision: 2.0
Date: 7/16/14

1—Purpose

Describes how to sample surface water for generic *E. coli* analysis. It can also be used when sampling well or municipal water.

2—Scope

Applies to any farm personnel responsible for sampling water and submitting it to a laboratory for analysis.

3—Responsibility

Anyone responsible for sampling water or submitting the samples to a laboratory should understand this SOP. Anyone responsible for keeping records of water tests results should also be familiar with the SOP in case there are unusual test results so they might be able to identify a problem with the sampling, shipping, or analysis.

4—Materials

- Marker for labeling sampling container
- Water sampling stick (not required but helpful for sampling surface water)
- Disposable gloves
- Sealed, sterile sampling container (1 Liter bottle or lab provided container)
- Cooler
- Ice packs
- Tape
- Zipper-seal bags
- Garbage/disposal bag for waste
- Shipping labels (if mailing to lab)

5—Procedure

**Always follow instructions provided by selected lab regarding container and sampling protocol.*

Water Sampling Protocol for Surface Water

1. Label container with sampler name, water source, date, and time of collection.
2. Identify good sampling area, sampling as close to water use point as possible.
3. If using a sampling stick, assemble bottle on sampling stick.
4. Put on gloves.

5. Open collection container as close to sampling area as possible. Do not place fingers on the container lip or inside the container.
6. Dip container into source and collect water. If sampling from irrigation equipment, it may be necessary to let the water run for a while to ensure you are getting water that has not been sitting in the pipes. Do not let container lip contact irrigation equipment. Collect at least 100 mls of water from each location. Sample the water after it flows through the irrigation filter (if applicable).
7. When the container is full, seal the container. Do not to touch the inside or lip of the container.
8. Double check container label to be sure it is correct.
9. Place the sample in a 1 gallon zipper-seal bag and seal (only critical if shipping samples).
10. Place in cooler with ice packs.
11. If shipping, label cooler and seal.
12. Deliver to selected lab or drop off at shipping company for shipment. Be sure delivery meets the hold-time requirement set by the laboratory; otherwise, test results may not be accepted by the buyer, auditor, or regulatory agency.

Water Sampling Protocol for Well Water

1. Label sampling container with sampler name, water source, date, and time of collection.
2. Sample nearest point of use as possible.
3. Turn faucet on. Let the water run long enough so that you are testing water from the well and not just the water that has been sitting in the pipes or hose. Depending on your water system, this could be as long as 10 minutes or as short as 1 minute. If you know the volume of your system and flow rate, allow 2-3 times the volume of the system to evacuate prior to sampling.
4. Put on gloves.
5. Open sampling container as close to point of use as possible. Do not place fingers on the container lip or inside of the container.
6. Place sampling container into running water and collect at least 100 mls of water.
7. When the container is full to shoulder or fill line*, seal container. Do not to touch the lip or inside of the container. *Leaving a little head space makes it easier for the laboratory to pour the sample once it arrives.
8. Double check container labeling to be sure it is correct.
9. Place the sample in a 1 gallon zipper-seal bag and seal (only critical if shipping samples).
10. Place in cooler with ice packs.
11. If shipping, label cooler and seal.
12. Deliver to selected lab or drop off at shipping company for shipment. Be sure delivery meets the hold-time requirement set by the laboratory; otherwise, test results may not be accepted by the buyer, auditor, or regulatory agency.

Sample Water Testing Log

Name of farm: *Pleasant Valley Farm*

See farm policy and SOP for specific water sampling procedures.

Date/Time sampled	Name of sampler	Water Source/ Sample location	Date/Time S = Shipped D = Dropped off	Laboratory name	Quantified Generic *E. coli* results and method	Date results received	Exceed 126 CFU per 100ml (yes/no)	Corrective actions taken (yes/no)	Initials
5/22/13 13:15	*Jack Smith*	*Pond/off the dock*	*5/22/12 15:00 D*	*Wedo Poo*	*10 CFU/100 mls Quantitray 2000*	*5/25/12*	*No*	*No*	*EAB*
Notes:									
Notes:									
Notes:									
Notes:									
Notes:									

Reviewed by: _____ **Title:** _____ **Date:**_____

Sample Water Source Inspection Log

Name of farm: *Pleasant Valley Farm*

See farm policy for specific water source inspection procedures.

Date	Water Source	Observations	Corrective Actions Taken	Initials
4/22/13	*Well*	*Well casing in good shape, recharge area clear.*	*None*	*EAB*
4/22/13	*Pond*	*Significant geese presence.*	*Introduced swan decoys. Will monitor.*	*EAB*

Reviewed by: _____ **Title:** _____ **Date:**_____

Sample Water Distribution Inspection Log

Name of farm: *Pleasant Valley Farm*

See farm policy for specific water distribution inspection procedure.

Date	Water Distribution System	Observations	Corrective Actions Taken	Initials
4/23/13	*Overhead pipes*	*Nothing broken, but some debris in the lines.*	*Blew out lines with high pressure air.*	*EAB*

Reviewed by: _____ **Title:** _____ **Date:**_____

Template Language for Agricultural Water for Production Section of a Farm Food Safety Plan

Risk Assessment

Agricultural water used to produce fresh fruits and vegetables is a concern because water can carry and distribute human pathogens. Surface water is more likely to be contaminated because it is open to the environment. Overhead irrigation or crop spray applications are of most concern because they contact the edible portion of the crop. Our farm uses water from ***[identify sources here]***. We use ***[type of irrigation]*** and apply sprays mixed with ***[source of water]*** water.

Actions to Reduce Risks

We inspect our water sources and distribution system at the beginning of each season and ***[insert frequency]*** per season. Any problems that are identified and corrective actions taken are recorded in the *Water Source Inspection* or *Water Distribution Inspection Logs*.

All agricultural water is tested for quantified generic *E. coli*. Surface water sources are tested ***[enter frequency]*** and/or well water sources are tested ***[enter frequency]***. The sampling details and test results are documented on the Water Testing Log. When we use municipal water, we request copies of tests done by the municipality and keep copies of these tests on file.

If any single water sample is above 235 *E. coli* per 100 mls of water sampled or if the rolling geometric mean is above 126 *E. coli* per 100 mls, we do not use the water in any way that directly contacts the edible part of the crop. Should water treatment or use of an alternative water source be necessary, we document all actions we take on our *Water Testing Log*.

All sprays are mixed with potable water. All overhead irrigation applications with surface water are completed at least ***[enter interval here]*** prior to harvest.

All water management and water testing logs are kept on file ***[enter location here]*** for at least ***[2 years – or enter duration here]***.