



APPENDIX F:
Considerations for Assessing the Effects of
Weather Conditions on Environmental Sources
of Human Pathogens



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Some leafy green crops may be more susceptible to microbial contamination under acute and excessive environmental conditions. There is ongoing research to determine what may make some leafy greens more susceptible to human pathogens than others. For example, weather conditions such as freezing temperatures may cause wounds on romaine lettuce making it more susceptible to contamination if human pathogens are present in the environment. Wind and rain may serve to disperse vectors such as dust particles containing human pathogens from nearby sources onto the production area. If human pathogens are airborne on dust particles, precipitation can also deposit pathogens onto crop areas.

Awareness of these conditions and related potential contamination are an important part of evaluating food safety risks in leafy green production areas during pre-harvest and harvest environmental assessments. When conducting routine monitoring and your pre-harvest and harvest assessments, include an evaluation of how weather conditions may transport human pathogens to your fields under acute or excessive weather-related environmental circumstances. When assessing weather-related food safety risk in leafy green production areas, consider the following:

- Temperature: Leafy green crops may be adversely affected by abnormal temperatures. Evaluate crops for wounds, lesions or growth issues such as stunting, leaf damage, etc. that may increase vulnerability to contamination and monitor environmental conditions accordingly.
- Amount of rainfall in relation to time: Heavy or unusual rain may present a higher risk than lighter precipitation and increase potential opportunities for crop infection by plant or human pathogens.
- Wind speed and duration: Higher than normal wind speeds may pose a greater food safety risk than lower wind speeds. Consider the wind directional changes to assess the level of risk. Check with your local weather experts to determine what is higher than normal.
- Content of the air: Higher than normal particulates in the air may pose a food safety risk. Check with your local weather experts to determine what is higher than normal.
- Time to harvest: Adverse weather conditions associated with rainfall, wind, and temperature that occur closer to harvest may present higher risk than earlier in the growing season. The time of harvest in relation to the stage of the crop may increase plant stress and impact susceptibility to infection by pathogens.
- Extent of crop damage: Crop damage includes, but is not limited to rips, tears, holes, shriveling, browning, blistering, thickening, thinning, and tissue discoloration. The greater the amount of tissue damage and/or crop production area affected by adverse environmental conditions, the greater the risk to food safety.
- Equipment exposure: If equipment is exposed to adverse environmental conditions clean and sanitize the equipment as soon as possible after the adverse weather conditions.
- Water sources: Water quality may be impacted by severe weather conditions and events. Evaluate all water sources to minimize contamination, visually inspect for runoff and excessive turbidity. Consider turbidity (observed or measured) and/or microbial levels as an indicator of water quality

Table 1 was developed as result of work done under the Leafy Green Food Safety Task Force established in May 2018. This table contains more detailed information regarding key risk factors and suggested actions in response to changes in weather conditions.

Table 1. Risk Factors and Suggested Actions in Response to Changes in Weather Conditions

(Note: Any combined weather events should be assessed for increased hazards / synergistic risk)

Weather Condition	Considerations for Risk Analysis	Potential Actions in Response to Risks
Rain	Extent of rain – Light, medium, or heavy	<p>Monitor rain to determine if it is light, medium, or heavy using local weather data, such as AZMET (https://cals.arizona.edu/azmet/) or rain gauge in the field.</p> <ul style="list-style-type: none"> • Normal risk: Rainfall is light – continue normal surveillance. • Higher than normal risk: Rainfall is medium to heavy – increased surveillance i.e., focus visual inspection on amount of in-field debris, excess mud on plants, other potential sources of contamination. • Very high risk: Do not harvest if you experience monsoon rain (heavy rain that accompany seasonal reversing wind).
	Time in growth cycle/ Proximity to harvest in combination with medium or heavy rains	<ul style="list-style-type: none"> • Normal risk: There are weeks or months before harvest – implement buffers, if necessary, and harvest stays on schedule. • Higher than normal risk: There are only a few days before harvest – implement buffers, testing, other preventative controls and/or decide if it's okay to harvest based on food safety assessment.
	Runoff from adjacent land uses into fields and irrigation sources: CAFO, hobby farm, manure or livestock compost facility	<ul style="list-style-type: none"> • Normal risk: Adjacent land uses are managing runoff – continue normal surveillance of fields and irrigation sources. • Higher than normal risk: Runoff is present – decide if buffers need to be implemented in fields; if using affected irrigation water source, decide if it should be treated, should/ should not be used, and depending on the type of source, if time delays before use are necessary to allow particulates to settle and decrease in turbidity. • Very high risk: Runoff is present and excessive – implement buffers in fields, and either treat irrigation water source or do not use it until observed (e.g., water is visibly clear) or measured turbidity is normal and generic <i>E. coli</i> levels are below the acceptable criteria; if flooding occurs, refer to <i>13. Issue: Flooding</i> section in metrics for additional guidance.
	Extent of damage to crops	<ul style="list-style-type: none"> • Normal risk: No damage to crops – continue normal surveillance. • Higher than normal risk: Some crop damage (as indicated by rips, tears, holes, shriveling, browning, blistering, thickening, thinning, tissue discoloration, etc. and determined by % and/or type of damage) – implement buffers and decide if it's okay to harvest. • Very high risk: Extensive damage to crops – do not harvest • Other factors to consider: What is the general health of the crop? Are there additional stress factors impacting crop health (i.e. are there plant pathogens, insects damaging crop, etc.)?
	Exposure of tools and equipment	<ul style="list-style-type: none"> • Assess damage to tools and equipment; make necessary repairs. • Re-clean and re-sanitize tools and equipment exposed to mud; re-sanitize tools and equipment exposed to rain. • Assess traffic patterns as part of the overall food safety assessment. For example, runoff from a CAFO may not have occurred in the farm of concern, but if the farming equipment passes through a nearby focal point where contaminated standing water is present, this should be considered a food safety risk. Find an alternative entry point or some other means of avoiding tracking the contamination into the unaffected field.

Weather Condition	Considerations for Risk Analysis	Potential Actions in Response to Risks
Wind (includes sand storms and dust storms)	<p>Wind speed – Low, medium, high, or excessive</p> <p>Note – these indicators need to be assessed in context of the growing region history; determine background levels to assess when risk is above “normal” for your production area.</p>	<p>Monitor wind to determine if it is low, medium, high, or excessive using local weather data (such as AZMET) or wind gauge in the field.</p> <ul style="list-style-type: none"> • Normal risk: When wind speed is low for any amount of time – continue normal surveillance of fields and irrigation sources. • Higher than normal risk: Wind speed is medium or high – decide if it is okay to harvest by visually inspecting fields for debris and animals that have taken refuge in the field; if harvesting, decide if buffers need to be implemented in fields to exclude exposed crops; if irrigation water source has been affected, decide if it should be treated, can/cannot be used, and if delays are necessary to allow particulates/turbidity to settle. • Very high risk: Winds are excessive or there is a haboob – decide if it is okay to harvest; visually inspect fields for debris on crops and on the ground and for animals that have taken refuge in the field; if harvesting, implement buffers in fields to exclude affected crops; if irrigation water source has been affected, decide if it should be treated, should/should not be used, and how long to delay use to allow particulates to settle and turbidity to decrease. <p>Other considerations: Be aware of wind direction and particulates/dust sources i.e., from compost yards, CAFOs, etc.</p>
	Time in growth cycle/ Proximity to harvest in combination with medium, high, or excessive winds	<p>For higher than normal wind speeds:</p> <ul style="list-style-type: none"> • Normal risk: There are weeks or months before harvest – implement buffers, if necessary, based on the food safety assessment; harvest stays on schedule. • Higher than normal risk: There is less than a week before harvest – decide if it is okay to harvest based on visual inspection and crop/water/soil testing, as appropriate. If harvesting, implement buffers for un-harvestable crops.
	Extent of damage to crops	<ul style="list-style-type: none"> • Normal risk: There is no damage to crops – continue normal surveillance. • Higher than normal risk: There is some damage to crops – decide if it is okay to harvest; if harvesting, implement no-harvest buffers around affected crop. • Very high risk: Crop has extensive damage throughout the field, do not harvest. • Other considerations: What is the general health of the crop? Are there additional stress factors impacting crop health (i.e. are there plant pathogens, insects damaging crop, frost damage, excessive moisture, etc.)
	Exposure of tools and equipment	<ul style="list-style-type: none"> • Assess damage to tools and equipment; make necessary repairs. • Re-clean and re-sanitize tools and equipment that were exposed to or otherwise affected by the wind. • Clean and sanitize harvesting machines and packing equipment before next harvest.

Weather Condition	Considerations for Risk Analysis	Potential Actions in Response to Risks
Unusual temperatures (hot or freezing)	Duration – Minutes, hours, days	<p>Monitor weather to determine temperature using local weather data (such as AZMET).</p> <ul style="list-style-type: none"> • Normal risk: Temperature is unusually high or low for a short time (< an hour) – continue normal surveillance of fields and irrigation sources making sure to assess plants for susceptibility to contamination post- freezing. • Higher than normal risk: Temperature is unusually high or low for a long time (hours) – decide if it's okay to harvest; if harvesting, decide if no- harvest buffers need to be established around affected areas of the field. • Very high risk: Temperature is unusually high or low for a very long time (days) – decide if it's okay to harvest; if harvesting, implement no-harvest buffers around damaged crops.
	Time in growth cycle/ Proximity to harvest	<ul style="list-style-type: none"> • Normal risk: There are weeks or months before harvest – implement buffers around affected crops, if necessary, based on food safety assessment; harvest stays on schedule. • Higher than normal risk: There is less than a week before harvest – decide if it is okay to harvest; if harvesting, implement no-harvest buffers around damaged crops.
	Extent of damage to crops (burning, blistering, thickening, peeling, curling, etc.)	<p>When unharvested crop is exposed to abnormal temperatures and/or an atypical duration, blistering, thickening, peeling, curling, etc. might occur depending on the commodity and/or variety.</p> <ul style="list-style-type: none"> • Normal risk: There is no damage to crops – continue normal surveillance. • Higher than normal risk: There is some damage to crops – decide if it is okay to harvest; if harvesting, implement buffers around damaged crops. • Very high risk: There is extensive damage to crops, do not harvest. • Other considerations: What is the general health of the crop? Are there additional stress factors impacting crop health (i.e. are there plant pathogens, insects damaging crop, etc.)?
	Efficacy of chlorination or other sanitizers in irrigation water	<ul style="list-style-type: none"> • Low risk - chlorine does not work as well or dissipate in cold water so if you are treating your water, you should test the chlorine levels more frequently than routine testing.
	Post-harvest cooling	<ul style="list-style-type: none"> • Prolonged holding of harvested produce outdoors, particularly in hot weather, can have negative impacts on produce quality and potentially, its safety. Ensure efficient cooling of produce post-harvest by keeping harvested product in the shade as much as possible and moving it into the cooler, preferably within the hour of harvest.
	Worker hygiene	<ul style="list-style-type: none"> • In cold temperatures, workers may not wash their hands properly, resulting in a higher than normal risk. Monitor handwashing stations and consider providing warm water for handwashing.

Weather Condition	Considerations for Risk Analysis	Potential Actions in Response to Risks
Hail	Size and amount – Small, medium, large	<ul style="list-style-type: none"> • Higher than normal risk: Hail is small and light – decide if buffers need to be implemented in fields, and if irrigation source should be treated, can/cannot be used, and if delays are necessary to allow a decrease in turbidity. • Very high risk: Hail is medium to large and/or heavy – implement no- harvest buffers around affected crops, and decide if irrigation source should be treated, can/cannot be used, and what time delays are necessary to allow for a decrease in turbidity.
	Time in growth cycle/ Proximity to harvest	<ul style="list-style-type: none"> • Regardless of timing, there is a higher than normal risk – decide if it is okay to harvest; if harvesting, implement buffers around damaged crops.
	Extent of damage to crops	<ul style="list-style-type: none"> • Normal risk: There is no damage to crops – continue normal surveillance. • Higher than normal risk: There is some damage to crops – decide if it's okay to harvest; implement buffers around damaged crops. • Very high risk: There is extensive damage to crops, do not harvest.
	Exposure of tools and equipment	<ul style="list-style-type: none"> • Assess damage to tools and equipment; make necessary repairs. • Re-sanitize tools and equipment that were exposed to hail.