



Lettuce

5.0 Lettuce Food Safety Risk Assessment

**Food Inspection Branch
Food Industry Division
Ontario Ministry of Agriculture and Food**

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Pre-Production</p> <p>Site Selection and Preparation</p> <p>Including tillage and application of any soil amendments (manure, biosolids, chemical fertilizer etc.) prior to planting.</p>	<p>Biological</p> <p>Concern that pathogens existing in soil, water, and applied amendments will contaminate the future crop (2, 7, 8, 9, 10, 11, 12, and 13). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayatanensis</i>, and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.</p>	<p>Nglg-Low</p> <p>Microbial and environmental degradation of pathogens prior to production reduces the likelihood of contamination (15, and 17). Manure and biosolids are not generally applied to organic soils although they may be applied to mineral soils where lettuce crops are also grown. There is some potential for contamination where animal agriculture is in close proximity or where water could flow from these farms to lettuce fields or into water sources used for lettuce production. Research suggests that <i>E. coli</i> can be transmitted through the roots and contaminate the leaves (145).</p>	<p>Nglg-Low</p> <p>If contamination of the crop occurs, the probability that pathogens would survive through to consumption is low. Pathogens are reduced by microbial and environmental degradation during the growing season, and through removal of wrapper leaves (head lettuce) and washing prior to consumption (8, 17, 18, and 19). Once lettuce is contaminated with <i>E. coli</i> there is some potential for infiltration and survival of these pathogens (7, 55, and 145). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24).</p>	<p>Low</p> <p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High	Low-Med	Nglg	Low-Med	Nglg-Low	<p>To reduce risk: Determine previous land use, especially where land has been recently purchased or is rented. Consider the potential for adjacent land to contaminate fields via water or windblown sources of pathogens. Use Good Agricultural Practices (GAPs) (29, 30, 31, 32, and 33). Apply and incorporate manure in the fall. When off-farm biosolids are used, a certificate of approval for land application from the Ministry of Environment (MOE) is required and an analysis of the nutrients applied should be available from the applicator. In addition, sewage biosolids may not be applied to organic soils and must be applied at least 12 months prior to planting on mineral soils to be used for vegetable crops (34).</p>
<p>If infection occurs, the impact is variable depending on the pathogen and the individual. The young, elderly and immune-compromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traceable to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although some research has been initiated (145), little is currently known relating to contamination from pre-production activities. Knowledge of plant growth, the agricultural industry, and limited traceable cases provides some information for this assessment.</p>	<p>The probability of contamination and exposure at this stage of production are mainly quite low. The impacts of contamination and exposure are variable, but mainly low. While there is some uncertainty, the overall risk is expected to be negligible to low.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Pre-Production</p> <p>Site Selection and Preparation</p> <p>Including tillage and application of any soil amendments (manure, biosolids, chemical fertilizer etc.) prior to planting.</p>	<p>Chemical</p> <p>Concern that applied chemicals or chemicals in the environment at or near the production site will contaminate the future lettuce crop. While the level of chemicals in food is quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Low</p> <p>No specific issues have been identified at this stage of lettuce production. Through normal plant growth, plants utilize chemicals such as fertilizer. Similarly, as lettuce grows, it utilizes chemicals from the air, water and soil environment (37). Agricultural chemicals registered for use may be applied at this stage of production (158, and 159). Crop contamination may occur where errors are made in application or by not following product label information. Chemicals used in agricultural production tend to breakdown in the environment, reducing the potential for contamination.</p>	<p>Nglg-Low</p> <p>Those applying agricultural pesticides in Ontario are trained and certified. When pesticides are applied according to label instructions, residues are unlikely to exceed allowable Maximum Residue Limits (MRLs), as set by Health Canada. During the growing season, microbial and environmental degradation reduces the likelihood of chemical contamination, and subsequent exposure. Washing and removal of wrapper leaves (head lettuce) prior to consumption also reduces the probability of chemical exposure (38). The short time period needed to grow lettuce increases the potential for exposure if lettuce is contaminated.</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

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Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
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<p>Nglg-Med</p> <p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long-term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, and 42).</p>	<p>Low</p> <p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traceable to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>Nglg</p> <p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>Low-Med</p> <p>While there are no specific data on the uptake or impact of environmental chemicals found in lettuce, studies indicate that chemicals can accumulate in produce (35, and 36). Specific data on how the levels found in produce would affect human health over the long-term are not known.</p>	<p>Nglg-Low</p> <p>Although the impact is variable, it is reasonably certain that the overall chemical risk at this stage of production is negligible to low, due to the low probabilities of contamination and exposure.</p>	<p>To reduce risk:</p> <p>Determine history of land. Consider potential pesticide residues from past crops or soil contamination from previous application of amendments such as biosolids. Test soil where the possibility of contamination exists. Apply pesticides according to the product label and ensure only those properly trained and certified prepare and apply pesticides. Prevent contamination of farm water supplies through proper storage of pesticides, proper rinsing of containers, careful mixing, and use of an anti-back flow device to prevent back siphoning. Where off-farm biosolids are used, a certificate of approval for land application from the Ministry of Environment (MOE) is required, and an analysis of the nutrients applied should be available from the applicator. Application of sewage biosolids must meet the metal content criteria set out in Table 1 and 2, OMAF fact sheet 95-069 (34). In addition, sewage biosolids may not be applied to organic soils and must be applied at least 12 months prior to planting on mineral soils.</p>

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<p>Pre-Production</p> <p>Site Selection and Preparation</p> <p>Including tillage and application of any soil amendments (manure, biosolids, chemical fertilizer etc.) prior to planting.</p>	<p>Physical</p> <p>Concern that extraneous physical material such as metal, wood, rocks, glass, plastic, etc., could contaminate the future lettuce crop. Physical hazards in food are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards and potential injury.</p>	<p>Nglg</p> <p>No specific issues have been identified other than windblown and water-splashed soil particles and debris which are not considered significant food safety hazards. The probability of any physical material contaminating the edible product at the pre-production stage is negligible. Lettuce plants are not likely to incorporate extraneous material into their structure as they grow from seed to maturity.</p>	<p>Nglg</p> <p>If contamination occurs, the probability of consumer exposure is very low. With some lettuce varieties, wrapper leaves are removed at harvest prior to packing. In addition, lettuce is generally washed and additional wrapper leaves (head lettuce) are removed prior to consumption, reducing potential exposure. Consumers may occasionally be exposed to soil particles and small grit. Larger extraneous material may also be visible or felt by the consumer, and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

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Nglg-Med	Nglg	Nglg	Nglg-Low	Nglg	<p>To reduce risk: Be aware of physical material hazards and provide information to employees on potential physical material hazards. Wash lettuce where soil has contaminated the lettuce. Use Good Agricultural Practices (GAPs) (30, and 31).</p>
<p>If contamination occurs, the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).</p>	<p>Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occur and are traceable to a specific company or industry, the economic impact to the company or industry may be greater.</p>	<p>Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered negligible.</p>	<p>No previous issues have been identified with lettuce from this stage of production. Experience and knowledge of lettuce plant growth and production provide reasonable certainty of the assessment.</p>	<p>Although the impact is variable and specific data are not known due to the negligible probability of contamination and exposure, it is reasonably certain that the overall risk is negligible.</p>	

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Production Growing the Crop Including seeding, transplanting, and application of fertilizer, crop protection materials and other soil or crop amendments during the growing season.	Biological Concern that pathogens in manure and applied amendments may contaminate lettuce directly, or through contaminated workers, birds, rodents or other pests (2, 7, 8, 9, 10, 11, 50, 51, 52, 53, 54 and 55). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i> , Hepatitis A, <i>Shigella sonnei</i> , <i>Cyclospora cayetanensis</i> , and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.	Low-Med If contaminated products are applied or workers are contaminated the lettuce plants, can become contaminated. Pathogens such as <i>E. coli</i> 0157:H7, <i>Salmonella</i> and <i>Campylobacter</i> may be present in manure and live in soil for three months (11). Research suggests that <i>E. coli</i> can be transmitted through the roots and contaminate the leaves (145). Manure and biosolids are not generally applied to organic soils, although they may be applied to mineral soils where lettuce is also grown.	Low Although the probability of consumer exposure is expected to be mainly low, once lettuce is contaminated with <i>E. coli</i> there is some potential for infiltration and survival (7, 55, 145, and 153). Lettuce has a pH of 5.8-6.0, which supports the growth of pathogenic microorganisms (56, and 57). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). Pathogens are reduced by microbial and environmental degradation during the growing season, and through physical removal of the wrapper leaves (head lettuce) during harvest and packing (8, 17, 15, 18, and 19). In addition, removal of leaves and washing prior to consumption reduce the potential of consumer exposure.	Low Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.

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on human health	economic	environment			
Low-High	Low-Med	Nglg	Low-Med	Low-Med	<p>To reduce risk: Apply and incorporate manure in the fall. In the year of harvest use only fully composted manure or chemical fertilizer. Use Good Agricultural Practices (GAPs) (29, 30, 31, 32, and 33). When off-farm biosolids are used, a certificate of approval for land application from the Ministry of Environment (MOE) is required. An analysis of the nutrients applied should be available from the applicator. In addition, sewage biosolids may not be applied to organic soils and must be applied at least 12 months prior to planting on mineral soils to be used for vegetable crops (34). Control pests and pets to reduce contact with the lettuce crop (53). Provide sanitary hygiene facilities. All workers should follow sanitary practices including proper hand washing and be provided with information and training in proper hygiene practices (50, 58, 59, and 60).</p>
<p>If infection occurs, the impact is variable depending on the pathogen and the individual. The young, elderly and immunocompromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traceable to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although limited information is available on contamination during crop production, previous biological contamination of lettuce has been documented (14, 15, and 16). While some knowledge of plant growth, potential pathogens, and the agricultural industry is known, there is some uncertainty.</p>	<p>The probability of contamination and exposure are mainly low. The impacts of contamination and exposure are variable, but mainly low. While there is some uncertainty, the overall risk relating to this stage of production is expected to be low to medium, but mainly low.</p>	

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<p>Production</p> <p>Growing the Crop</p> <p>Use of Water</p> <p>Water is used for application of crop protection materials and for irrigation. Surface water sources including canals or ponds are commonly used for irrigation. When rainfall is insufficient, overhead irrigation is commonly used to provide water to lettuce in Ontario.</p>	<p>Biological</p> <p>Concern that water used for irrigation and application of crop protection materials may contain harmful pathogens that may contaminate the crop (2, 7, 8, 9, 10, 11, and 61). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayatanensis</i>, and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for a list of foodborne pathogens that may be transmitted through contaminated water sources.</p>	<p>Nglg-Med</p> <p>Use of contaminated water for irrigation or application of pesticides can contaminate the lettuce crop. Recent information indicates that some pesticides may actually increase the growth of pathogens in spray tanks (61). <i>E. coli</i> and <i>Cryptosporidium</i>, which could contaminate lettuce, are often found in surface water in Ontario (12). Research suggests that <i>E. coli</i> can be transmitted through the roots and contaminate the leaves (145).</p>	<p>Low</p> <p>Although the probability of consumer exposure is expected to be mainly low, once lettuce is contaminated with <i>E. coli</i> there is some potential for infiltration and survival (7, 55, 145, and 153). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). Pathogens are reduced by microbial and environmental degradation during the growing season and through physical removal of the wrapper leaves (head lettuce) at harvest and washing prior to consumption (8 17, 15, 18, and 19). Lettuce has a pH of 5.8-6.0, which may support the growth of pathogenic microorganisms (56, and 57).</p>	<p>Low</p> <p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.</p>

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Low-High	Low-Med	Nglg	Low	Low-Med	<p>To reduce risk: Use Good Agricultural Practices (GAPs) (29, 30, 31, 32, and 33). Surface-fed water sources are more likely to be contaminated than spring-fed water sources. Use the best quality of water available, preferably potable water (62). Take precautions to reduce the opportunity for contamination of water sources (access to animals, buffer zones etc.). Where water of questionable quality is used, periodically test water to ensure that it meets as a minimum, the Canadian Water Quality Guidelines for the protection of agricultural water used for irrigation (maximum total coliforms 1000/100ml and maximum fecal coliforms 100/100 ml) (63). Do not use water of poor quality near the time of harvest.</p>
<p>If infection occurs, the impact is variable depending on the pathogen and the individual. The young, elderly and immune-compromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traceable to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Data does indicate that contaminated water can potentially contaminate lettuce. Previous biological contamination of lettuce has been documented (14, 15, and 16). While some knowledge of plant growth, potential pathogens, and the agricultural industry is known, there is some uncertainty.</p>	<p>The probability of contamination and exposure at this stage of production are variable, but mainly low. The impacts of contamination and exposure are also variable ranging from negligible to medium. The overall risk relating to this stage of production is expected to be low to medium, but mainly low.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Production</p> <p>Growing the Crop</p> <p>Including application of fertilizer, crop protection materials and other soil or crop amendments during the growing season.</p>	<p>Chemical</p> <p>Concern that lettuce may become contaminated with chemicals during crop production. While the level of chemicals in food is usually quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Med-High</p> <p>Agricultural chemicals registered for use are routinely applied at this stage of production (158). Additional contamination may occur where errors are made in application, by not following product label information, or where chemicals not registered for use are used. Health Canada regulates chemicals used in the production of food (46, and 64). It is unlikely that water used for irrigation or application of pesticides is itself chemically contaminated. Those applying pesticides in Ontario are trained and certified.</p>	<p>Nglg-Low</p> <p>During the growing season, microbial and environmental degradation reduces the likelihood of chemical contamination at harvest and subsequent exposure. When applied according to label instructions, pesticide residues are designed not to exceed allowable Maximum Residue Limits (MRLs), at harvest as set by Health Canada. Washing and removal of wrapper leaves (head lettuce) prior to consumption also reduce the probability of exposure (38). Residue monitoring of harvested lettuce in Ontario indicates that chemical contamination exceeding the allowable Maximum Residue Limits (MRLs) is unlikely, but can occur (45).</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

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on human health	economic	environment			
<p>Nglg-Med</p> <p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long-term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, and 42).</p>	<p>Low</p> <p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traceable to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>Nglg</p> <p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>Low</p> <p>While chemical residue data covering a broad range of chemicals are not known, results from the Ontario Food Safety Monitoring Program indicate a low incidence of chemical residues exceeding the allowable Maximum Residue Limits (MRLs), as set by Health Canada (36, 45, and 46).</p>	<p>Low</p> <p>The impacts of chemical exposure are variable but mainly quite low. There is some uncertainty of data. While the probability of lettuce becoming contaminated is medium to high, the overall risk from this stage of production is mostly low, mainly due to the low probability of exposure.</p>	<p>To reduce risk:</p> <p>Apply pesticides according to the product label and in accordance with Regulation 914 of the Pesticides Act. Note in particular the days to harvest interval. Prevent contamination of farm water supplies through proper storage of pesticides, proper rinsing of containers, careful mixing, and use of an anti-back flow device to prevent back siphoning. Ensure only those properly trained and certified, apply pesticides. In Ontario, agriculturists applying pesticides to agricultural products must be certified. Use Good Agricultural Practices (GAPs) (30, 31, 32, and 34). If applying crop protection materials through an irrigation system, ensure that chemical injection systems are functioning properly. Use the best quality of water available.</p>

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<p>Production</p> <p>Growing the Crop</p> <p>Including seeding, transplanting and application of fertilizer, crop protection materials and other soil or crop amendments.</p>	<p>Physical</p> <p>Concern that extraneous physical materials such as metal, wood, rocks, glass, plastic, etc., may contaminate the lettuce crop. Physical hazards are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards.</p>	<p>Nglg</p> <p>No specific issues have been identified other than windblown and water-splashed soil particles and debris. Lettuce plants are not likely to incorporate extraneous material into their structure as they grow from seed to maturity. Other than surface contamination with soil particles, the probability of any physical material contaminating the edible product is negligible.</p>	<p>Nglg-Low</p> <p>If contamination occurs, the probability of consumer exposure is very low. With some lettuce varieties wrapper leaves are removed at harvest prior to packing. In addition, lettuce is generally washed and additional wrapper leaves (head lettuce) are removed prior to consumption, reducing potential exposure. Consumers may occasionally be exposed to soil particles and small grit. Larger extraneous material may also be visible or felt by the consumer, and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

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Nglg-Med	Nglg	Nglg	Low	Nglg	<p>To reduce risk: Keep all equipment guards in place and maintain equipment in good repair. Be aware of physical material hazards and provide information to employees on potential physical hazards. Consider washing lettuce where soil has contaminated the lettuce. Use Good Agricultural Practices (GAPs) (30, and 31).</p>
<p>If contamination occurs, the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).</p>	<p>Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occur and are traced back to a specific company or industry, the economic impact to the company or industry may be greater.</p>	<p>Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered to be negligible.</p>	<p>No previous issues have been identified in lettuce from this stage of production. Experience and knowledge of lettuce plant growth and production, provide reasonable certainty of the assessment.</p>	<p>Although the impact is variable and specific data are not known due to the negligible probability of contamination and very low probability of exposure, the overall risk is negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Production	Biological	Low-Med	Low-Med	Low
<p>Harvesting and Packing</p> <p>This includes cutting each plant at soil level by hand, trimming to remove any unwanted wrapper leaves and packing mainly into cardboard boxes in the field. The boxes are often placed on wooden skids, then transferred to wagons and trucks.</p>	<p>Concern that lettuce may become contaminated with foodborne pathogens during harvest from workers, harvesting equipment, containers or from soil (2, 7, 8, 9, 10, 11, 12, and 13). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayetanensis</i>, and <i>Campylobacter jejuni</i>, have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.</p>	<p>Lettuce is harvested by hand, which increases the potential for contamination over machine harvested crops. Data shows that people can contaminate produce (31, 50, and 55). A person may cause contamination even though they may feel well (65). Lettuce is not usually washed prior to packing in Ontario. When lettuce is washed and the water temperature is colder than the lettuce, pathogens in the water may be absorbed (86, and 104). There is minimal opportunity for pests to contact lettuce during the harvest process. Although most containers are new, used, and reusable containers are also used, which increase the probability of contamination.</p>	<p>Once lettuce leaves are contaminated with <i>E. coli</i> there is some potential for infiltration and survival of these pathogens (7, 55, 145, and 153). Lettuce has a pH of 5.8-6.0, which supports the growth of pathogenic microorganisms (56, and 57). Cold chain management reduces the potential for pathogen growth, and washing and trimming lettuce prior to consumption, reduces the probability of exposure (7, 19, 55, and 21). Washing cannot completely remove microorganisms in or on lettuce (19, and 69). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24).</p>	<p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can occur (9, 22, 23, and 69). Primary exposure may be broadly distributed, but secondary spread is expected to be local.</p>

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Low-High	Low-Med	Nglg	Low-Med	Low-Med	<p>To reduce risk: Use Good Agricultural Practices (GAPs) (29, 30, 31, 32, and 33). Use new boxes for packing lettuce. Minimize soil contact with boxes. Use two skids or pallets, placing boxes on the upper "clean" skid, leaving the lower skid to contact the soil. Inform workers of the possibility of contamination of lettuce with foodborne pathogens from contaminated soil, pets, and from human contact. Keep harvest equipment clean and sanitary. All workers should follow sanitary practices including proper hand washing. Provide employees with sanitary hygiene facilities and information and training in proper hygiene practices (58, 59, and 60). Employees that are ill should not be allowed to contact food.</p>
<p>If infection occurs, the impact is variable depending on the pathogen and the individual. The young, elderly and immuno-compromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although no specific harvest data are known, previous biological contamination of lettuce has been documented. While some knowledge of plant growth, potential pathogens and the agricultural industry is known, there remains some uncertainty.</p>	<p>The probabilities of contamination and exposure range from low to medium. The impacts of contamination and exposure are mostly low. Although there is some uncertainty, the over all risk is expected to be low to medium, but mainly low. Where unsafe harvesting practices allow lettuce to become contaminated, there is potential for greater risk.</p>	

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		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Production</p> <p>Harvesting and Packing</p> <p>This includes cutting each plant at soil level by hand, trimming to remove any unwanted wrapper leaves, and packing mainly into cardboard boxes in the field. The boxes are often placed on wooden skids, then transferred to wagons and trucks.</p>	<p>Chemical</p> <p>Concern that lettuce may become contaminated with chemicals during harvest. While the level of chemicals in food is generally quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Nglg-Low</p> <p>No previous issues have been identified. Chemicals are not normally applied or used during the harvest process. Although unlikely, contamination at this stage of production could potentially occur from contact with agricultural fluids used in equipment, contaminated containers, or from contaminated water where lettuce is washed.</p>	<p>Low</p> <p>If chemicals contaminate lettuce at this stage of production exposure is possible. Removal of wrapper leaves (head lettuce) prior to packing, washing, and consumption, reduces the probability of consumer exposure. Chemicals (chlorine products) used in water for washing lettuce prior to packing dissipates and poses minimal probability for significant consumer exposure.</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med	Low	Nglg	Low	Nglg	<p>To reduce risk: Use Good Agricultural Practices (GAPs) (29, 30, and 32). Monitor and maintain equipment in good working order. Where water is used to wash lettuce, consider the potential for the water source to be chemically contaminated.</p>
<p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).</p>	<p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traced back to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>No previous issues have been identified with lettuce at this stage of production. The lack of traceable cases provides some certainty of the assessment.</p>	<p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Production</p> <p>Harvesting and Packing</p> <p>This includes cutting each plant at soil level by hand, trimming to remove any unwanted wrapper leaves and packing mainly into cardboard boxes in the field. The boxes are often placed on wooden skids, then transferred to wagons and trucks.</p>	<p>Physical</p> <p>Concern that extraneous physical materials such as metal, wood, rocks, glass, plastic, etc., may contaminate the lettuce crop. Physical hazards are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards.</p>	<p>Nglg</p> <p>No specific issues have been identified other than windblown and water-splashed soil particles and debris. Lettuce plants are not likely to incorporate extraneous material into their structure as they grow from seed to maturity. The probability of any physical material contaminating the edible product is negligible.</p>	<p>Nglg-Low</p> <p>If contamination occurs, the probability of consumer exposure is very low. With some lettuce varieties, wrapper leaves are removed at harvest prior to packing. In addition, lettuce is generally washed and additional wrapper leaves (head lettuce) removed prior to consumption, reducing potential exposure. Consumers may occasionally be exposed to soil particles and small grit. Larger extraneous material may also be visible or felt by the consumer, and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).	Nglg Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occur and are traceable to a specific company or industry, the economic impact to the company or industry may be greater.	Nglg Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered to be negligible.	Low No previous issues have been identified with lettuce from harvesting or packing. Experience and knowledge of lettuce plant growth and production practices, provide reasonable certainty of the assessment.	Nglg Although the impact is variable and specific data are not known due to the negligible probability of contamination and very low probability of exposure, the overall risk is expected to be negligible.	To reduce risk: Keep all equipment guards in place and maintain equipment in good repair. Be aware of physical material hazards and provide information to employees on potential physical hazards. Wash lettuce when soil has contaminated the lettuce. Use Good Agricultural Practices (GAPs) (30, and 31).

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Storage</p> <p>This section includes cooling and storage of lettuce. Vacuum cooling is most commonly used to remove field heat. Water is commonly added during vacuum cooling to reduce dehydration and weight loss. Lettuce is stored in refrigerated trailers, containers, or storages.</p>	<p>Biological</p> <p>Concern that lettuce contamination during storage and cooling could occur through contact with contaminated storage areas, coolers, climate control equipment, water or pests (1, 2, 3, 4, 5, 6, and 61). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayetanensis</i>, and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.</p>	<p>Nglg</p> <p>There is little opportunity for lettuce packed inside boxes to physically contact the cooling or storage facilities. Similarly, there is little opportunity for pests to contact the lettuce during cooling and storage. Where lettuce is vacuum cooled, potable water is normally added during the cooling process.</p>	<p>Low-Med</p> <p>If lettuce leaves become contaminated there is some potential for infiltration and survival of pathogens (7, 55, 145, and 153). While most pathogens do not grow well at low temperatures, <i>Listeria</i> is able to grow at storage temperatures used for produce (57). Lettuce has a pH of 5.8-6.0, which support the growth of pathogenic microorganisms (56, and 57). Where lettuce is cooled, washed, and trimmed prior to consumption, the probability of exposure is reduced (7, 55, and 21). Washing cannot completely remove microorganisms in or on lettuce (19, and 69).</p>	<p>Low</p> <p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High	Low-Med	Nglg	Low-Med	Nglg-Low	<p>To reduce risk: Control pests in locations where lettuce is stored (53). Keep storage areas closed to limit access to pests and pets. Use Good Agricultural Practices (GAPs) (29, 30, 31, 32, 33, and 50). Use only potable water during the cooling process. Monitor and clean climate control equipment regularly.</p>
<p>If infection occurs, the impact is variable depending on the pathogen and the individual. The young, elderly and immune-compromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although no specific storage data are known previous biological contamination of lettuce has been documented. While some knowledge of plant growth, potential pathogens and the agricultural industry is known, there remains some uncertainty.</p>	<p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low, and there is some uncertainty. The overall risk is expected to be quite low at this stage of production.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Storage</p> <p>This section includes cooling and storage of lettuce. Vacuum cooling is most commonly used to remove field heat. Water is commonly added during vacuum cooling to reduce dehydration and weight loss. Lettuce is stored in refrigerated trailers, containers or storages.</p>	<p>Chemical</p> <p>Concern with chemical contamination of lettuce from climate control equipment or from chemical cleaners, disinfectants, or sanitizers used in storages. While the level of chemicals in food is generally quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Nglg</p> <p>Although localized contamination is possible, widespread contamination is not likely. Chemicals are not commonly used in cold storage while product is being stored. Lettuce packed inside boxes is partially protected from chemicals that may come in contact with the exterior of the box.</p>	<p>Low</p> <p>If chemicals are present in lettuce at this stage of production, exposure may occur. Chemicals may dissipate, degrade, or may be removed through washing or removal of wrapper leaves (head lettuce) prior to consumption, reducing the potential for exposure (38).</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med	Low	Nglg	Low	Nglg	<p>To reduce risk: Monitor the use of all chemicals that could potentially contact the lettuce while in storage or being cooled. Use only products registered for use and follow label recommendations. Use potable water for hydrating lettuce during vacuum cooling.</p>
<p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long - term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, and 42).</p>	<p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traced back to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>No previous issues have been identified with lettuce from storage. The lack of traceable cases provides some certainty of the assessment.</p>	<p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Storage</p> <p>This section includes cooling and storage of lettuce. Vacuum cooling is most commonly used to remove field heat. Water is commonly added during vacuum cooling to reduce dehydration and weight loss. Lettuce is stored in refrigerated trailers, containers or storages.</p>	<p>Physical</p> <p>Concern that extraneous physical materials such as metal, wood, rocks, glass, plastic, etc., may contaminate the lettuce crop. Physical hazards are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards.</p>	<p>Nglg</p> <p>No issues have been identified at this stage of production. Lettuce is normally packed in boxes and piled on skids, which reduces the opportunity for physical contamination.</p>	<p>Nglg-Low</p> <p>If contamination occurs, the probability of consumer exposure is quite low. Lettuce is washed and wrapper leaves (head lettuce) are often removed prior to consumption, reducing potential exposure. Any large extraneous material may also be visible or felt, and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med	Nglg	Nglg	Low	Nglg	<p>To reduce risk: Protect lights and keep guards and equipment in good repair. Be aware of and provide information to employees on potential physical material hazards. Use Good Agricultural Practices (GAPs) (30, and 31).</p>
<p>If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).</p>	<p>Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occur and are traced back to an individual, company or industry, the economic impact to the company or industry may be greater.</p>	<p>Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered to be negligible.</p>	<p>No previous issues have been identified with lettuce from storage. Experience and knowledge of lettuce storage practices provide reasonable certainty of the assessment.</p>	<p>Although the impact is variable and specific data are not known due to the negligible probability of contamination and very low probability of exposure, the overall risk is expected to be negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Transportation and Distribution</p> <p>Transportation of lettuce from the grower to cooling, storage and packing facilities. Distribution of lettuce through wholesalers or grocery chain warehouses through to retail outlets.</p>	<p>Biological</p> <p>Concern that lettuce contamination could occur during transport and distribution through contact with foodborne pathogens. Contamination may occur through cross-contamination, or directly from existing foodborne pathogens (2, 7, 8, 9, 10, and 11). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayetanensis</i>, and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.</p>	<p>Nglg</p> <p>Since lettuce is packed in boxes, any contamination is likely to be quite localized and limit the potential for cross-contamination during transport. The longer the time that lettuce is transported and the warmer the temperature, the greater the potential for growth of pathogens. Pests have only a limited potential for contact with lettuce during transportation and distribution. Where open-air trucks are used, there is some potential for contamination during transport from the farm to the cooling or packing facility.</p>	<p>Low-Med</p> <p>If lettuce is contaminated with <i>E. coli</i> there is some potential for infiltration and survival (7, 55, 145, and 153). Although the probability of pathogen survival through to consumption is reduced by washing and removing wrapper leaves (head lettuce), washing cannot completely remove microorganisms in or on lettuce (19, and 69). While most pathogens do not grow well at low temperatures <i>Listeria</i> is able to grow at lettuce storage temperatures (57). Lettuce has a pH of 5.8-6.0, which supports the growth of pathogenic microorganisms (56, and 57).</p>	<p>Low</p> <p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can also occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High	Low-Med	Nglg	Low-Med	Nglg-Low	<p>To reduce risk:</p> <p>Use clean transport vehicles and boxes for lettuce. Maintain a log of previous transport vehicle uses.</p> <p>Consider the potential for foodborne pathogens on other products shipped in the same vehicle.</p> <p>Maintain temperatures below 4 °C during transport when possible and keep the length of time in transport as short as possible.</p> <p>If open-air trucks are used, consider covering product. Handle product with care. Ensure proper rotation of stock in distribution facilities.</p>
<p>If infection occurs the impact is variable depending on the pathogen and the individual. The young, elderly and immunocompromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although no specific data regarding transportation and distribution are known, previous biological contamination of lettuce has been documented. While some knowledge of plant growth, potential pathogens, and the agricultural industry is known, there remains some uncertainty.</p>	<p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be mainly negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Transportation and Distribution</p> <p>Transportation of lettuce from the grower to cooling, storage and packing facilities. Distribution of lettuce through wholesalers or grocery chain warehouses through to retail outlets.</p>	<p>Chemical</p> <p>Concern of chemical contamination from climate control equipment, chemical cleaners, disinfectants, or sanitizers during transportation and distribution. While the level of chemicals in food is generally quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Nglg</p> <p>No previous issues have been identified. Lettuce is packed in boxes, which reduces the potential for contamination during transport and distribution. Although not likely, localized contamination could potentially occur. Widespread contamination is unlikely.</p>	<p>Low</p> <p>If chemicals are present in lettuce at this stage of production, exposure may occur. Chemicals may dissipate, degrade, or may be removed through washing or removal of wrapper leaves (head lettuce) prior to consumption, reducing the potential for exposure (38).</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
<p>Nglg-Med</p> <p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long-term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).</p>	<p>Low</p> <p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traced back to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>Nglg</p> <p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>Low</p> <p>No previous issues have been identified with lettuce during transportation or distribution. Knowledge of the industry and the lack of traceable cases, provide some certainty of the assessment.</p>	<p>Nglg</p> <p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be negligible.</p>	<p>To reduce risk: Monitor the use of all chemicals that could potentially contact the lettuce during transportation and distribution. Use only products registered for cleaning and sanitizing transport vehicles. Follow label recommendations.</p>

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Transportation and Distribution</p> <p>Transportation of lettuce from the grower to cooling, storage and packing facilities. Distribution of lettuce through wholesalers or grocery chain warehouses through to retail outlets.</p>	<p>Physical</p> <p>Concern that extraneous physical materials such as metal, wood, rocks, glass, plastic, etc., may contaminate the lettuce crop. Physical hazards are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards.</p>	<p>Nglg</p> <p>No issues have been identified at this stage of production. During transportation and distribution, lettuce is usually packed in boxes and stacked on skids, which reduces the opportunity for physical contamination.</p>	<p>Nglg-Low</p> <p>If contamination occurs the probability of consumer exposure is quite low. Lettuce is washed and wrapper leaves (head lettuce) are sometimes removed prior to consumption, reducing potential exposure. Large extraneous material may also be visible or felt by the consumer and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med	Nglg	Nglg	Low	Nglg	<p>To reduce risk: Keep transportation equipment clean and in good repair. Be aware of and provide information to employees on potential physical material hazards. Use Good Agricultural Practices (GAPs) (30, and 31).</p>
<p>If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).</p>	<p>Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occur and are traced back to an individual, company or industry, the economic impact to the company or industry may be greater.</p>	<p>Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered negligible.</p>	<p>No previous issues have been identified with lettuce during transportation or distribution. Experience and knowledge of lettuce transportation and distribution practices provide reasonable certainty of the assessment.</p>	<p>Although the impact is variable and specific data are not known due to the negligible probability of contamination and the very low probability of exposure, the overall risk is expected to be negligible.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Wholesale and Retail</p> <p>This includes storage, handling, display, and sale of lettuce at wholesale and retail outlets.</p>	<p>Biological</p> <p>Concern that lettuce could become contaminated during handling, storage, and display through poor employee or consumer health and hygiene. Lettuce may also be cross-contaminated, or contaminated directly through water, birds, rodents, flies, or insect pests (2, 8, 9, 10, 11, 50, 51, 52, 53, 54, and 55). Foodborne outbreaks of <i>E. coli</i> 0157:H7, <i>Salmonella enteritidis</i>, Hepatitis A, <i>Shigella sonnei</i>, <i>Cyclospora cayetanensis</i>, and <i>Campylobacter jejuni</i> have been previously linked to lettuce (14, 15, and 16). Low numbers of viable organisms can cause illness from some species of <i>E. coli</i> or <i>Cryptosporidium</i> (24). See Appendix A for information on previous outbreaks and Appendix B for additional pathogens known to contaminate produce.</p>	<p>Nglg-Low</p> <p>Human contact can contaminate produce (31, 50, and 55). While lettuce is sometimes wrapped in plastic or bagged for display and sale, Ontario lettuce is often displayed naked, increasing the risk of contamination by consumers and employees. A person may cause contamination although they may feel well (65). Generally, there is limited potential for pests to have contact with lettuce while in storage. Potable water is used in misting systems at retail.</p>	<p>Low-Med</p> <p>If contaminated there is potential for infiltration, survival, and growth of pathogens including <i>E. coli</i> (7, 67, 145, and 153). If lettuce is contaminated while displayed, the short time between display and consumption increases the probability of exposure. Retail environments are often humid and potentially warm which favour pathogen growth. Good cold chain management at wholesale and retail levels reduce the potential for pathogen growth. Lettuce has a pH of 5.8-6.0, which supports the growth of microorganisms (56, and 57). If contamination occurs, washing and removing wrapper leaves (head lettuce) prior to consumption reduces the probability of exposure (7, 19, 55, and 21). Washing cannot completely remove microorganisms in or on lettuce (19, and 69).</p>	<p>Low</p> <p>Some foodborne pathogens are easily transmitted directly by person-to-person, or by the fecal to oral route (9, 10, and 21). After infection occurs, secondary spread among humans can occur (9, 22, 23, and 69). While primary exposure may be broadly distributed, secondary spread is expected to be local.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High	Low-Med	Nglg	Low-Med	Low	<p>To reduce risk: Workers should follow sanitary practices including proper hand washing and be provided with information and training in proper hygiene practices (50, 58, 59, and 60). Provide sanitary hygiene facilities for staff and clients. Workers who are ill must not be allowed to contact food. Maintain pest control programs. Ensure proper rotation of stock. Maintain misting systems to ensure limited movement of free water. Maintain appropriate temperatures in storage and displays to reduce the potential for microbiological growth. Sanitize produce display areas. Using UV light to reduce surface contamination may be an alternative.</p>
<p>If infection occurs the impact is variable depending on the pathogen and the individual. The young, elderly and immune-compromised are at greater risk (21, and 40). Symptoms are variable, from mild diarrhea and upset stomach, to extreme cases where death may occur (9, 11, 24, and 25).</p>	<p>Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traceable to a specific company or industry, the economic impact for that company or industry can be significant (23, 26, 27, and 28).</p>	<p>Although no specific studies are known, the presence of biological hazards in food crops is considered to have negligible impact on the environment.</p>	<p>Although no specific data are known previous biological contamination of lettuce is documented. Although there is some knowledge of potential pathogens in the retail industry, there remains some uncertainty.</p>	<p>The probability of contamination and exposure are mainly low. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be mainly low, particularly when lettuce is wrapped or bagged prior to retail sale.</p>	

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Wholesale and Retail</p> <p>This includes storage, handling, display, and sale of lettuce at wholesale and retail outlets.</p>	<p>Chemical</p> <p>Concern of chemical contamination from climate control equipment, chemical cleaners, disinfectants, or sanitizers during wholesale or retail sale. While the level of chemicals in food is generally quite low, it has been suggested that foods are a vehicle of exposure to chemicals (35, and 36).</p>	<p>Nglg</p> <p>No previous issues have been identified. Prior to display at retail, lettuce is normally packed inside boxes, which reduces the potential for contamination. Where lettuce is displayed naked, the potential for contamination is greater. Although not likely, localized contamination could occur. Widespread contamination is unlikely.</p>	<p>Low-Med</p> <p>If chemicals contaminate lettuce at this stage, exposure may occur. Chemicals may dissipate, degrade, or be removed through washing or removal of wrapper leaves (head lettuce) prior to consumption, reducing the potential for exposure (38).</p>	<p>Nglg</p> <p>Chemicals are not conducive to secondary spread among humans.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
<p>Nglg-Med</p> <p>Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, and 42).</p>	<p>Low</p> <p>Direct healthcare costs vary with the level and extent of exposure. If the contaminant is traceable to a specific company or industry, the economic impact to that company or industry may be significant (43).</p>	<p>Nglg</p> <p>At the levels at which chemicals are found in food, the impact of contaminated food on the environment would be negligible.</p>	<p>Low</p> <p>No previous issues have been identified with lettuce at the wholesale or retail stage. Knowledge of the industry and the lack of traceable cases provide some certainty of the assessment.</p>	<p>Nglg</p> <p>Although exposure could occur if lettuce becomes contaminated, the probability of contamination at this stage of production is negligible. The impacts of contamination and exposure are mostly low. While there is some uncertainty, the overall risk is expected to be negligible.</p>	<p>To reduce the risk:</p> <p>Monitor the use of chemicals that could potentially contact the lettuce while in the retail environment. For cleaning and sanitizing, use only products registered for use and follow label recommendations. Maintain cooling equipment in good order.</p>

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
<p>Post Harvest</p> <p>Wholesale and Retail</p> <p>This includes storage, handling, display, and sale of lettuce at wholesale and retail outlets.</p>	<p>Physical</p> <p>Concern that extraneous physical materials such as metal, wood, rocks, glass, plastic, etc., may contaminate the lettuce crop. Physical hazards are known to cause injury (47, 48, and 49). See Appendix C for a list of physical material hazards.</p>	<p>Nglg-Low</p> <p>Although some potential exists, no issues have been identified. Prior to display, lettuce inside a box is not likely to incorporate extraneous material. There is potential for workers and customers to contaminate naked lettuce on display at retail.</p>	<p>Nglg-Low</p> <p>If contamination occurs the probability of consumer exposure is quite low. Lettuce is washed and sometimes wrapper leaves are removed (head lettuce) prior to consumption, reducing potential exposure. Large extraneous material may also be visible or felt by the consumer and subsequently removed prior to consumption.</p>	<p>Nglg</p> <p>Physical hazards are not conducive to secondary spread.</p>

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med	Nglg	Nglg	Low	Nglg	<p>To reduce risk: Maintain all equipment in good repair. Keep the display area and produce counter clean and free of debris. Keep lights protected from breakage. Be aware of and provide information to employees on potential physical material hazards. Wrapping or bagging lettuce prior to display at retail will reduce potential contamination.</p>
<p>If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, and 49).</p>	<p>Direct healthcare costs are expected to be mainly negligible. If contamination and exposure occurs and is traceable to a specific company or industry, the economic impact to the company or industry may be greater.</p>	<p>Although no specific studies are known, the impact of physical hazards in any food crop on the environment is considered negligible.</p>	<p>No previous issues have been identified on lettuce. Knowledge of the wholesale and retail trade provide reasonable certainty of the assessment.</p>	<p>Although the impact is variable and specific data are not known, due to the negligible probability of contamination and the very low probability of exposure the overall risk is negligible.</p>	