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2.0 ENVIRONMENTAL RISKS AND NUISANCE ASSOCIATED WITH LIVESTOCK PRODUCTION

2.1 Air Quality

The three primary sources of odour and air contaminants from dairy production are barns, manure storages and land application of manure. Dust and fumes from increased traffic associated with livestock production can also reduce air quality. The presence of contaminants does not equate to an environment or health risk unless minimum threshold values are exceeded. Air contaminants released from these sources may include: gases, particulate matter (dust), micro-organisms and endotoxins. Gases

include ammonia, hydrogen sulphide, methane, sulphur and nitrogen compounds.

Gases and particulate matter are of the greatest concern to people working directly with livestock because they are exposed to the highest concentrations of contaminated air. In general, neighbours are at minimal risk from air contaminants because the contaminants are well diluted and dispersed in the air after travelling very short distances from their source.

2.2 Odour

The primary complaint about livestock operations is odour. Though odour is generally considered more of a nuisance than a health risk to neighbours, because of the degree of dilution and dispersion that occurs within short distances from the odour source, odour's impact on health is uncertain due to the high number of compounds that may be present at extremely low concentrations.

There is a difference between the psychological and physiological health effects related to odour exposure. Psychological effects such as irritation, can result from exposure to odour and often occur at levels well below those that can harm human health. Physiological effects can occur from exposure to specific compounds that make up odour, for example, asphyxiation from exposure to hydrogen sulphide (H₂S) in a confined space.

It is difficult to evaluate odour and its health effects for the following reasons:

- Psychological and physical health effects are not necessarily independent.

- Odour from livestock is made up of about 160 compounds. Humans have many and varied responses to these compounds.
- The proportion and characteristics of odour contributed by each of the primary sources (barns, storages and land application) are not well understood. Research is underway to characterize odours released from each of these sources.
- Odour intensity and offensiveness vary between individuals.
- Combining different odour compounds can have positive and negative effects on odour's intensity and offensiveness. These effects are not easily predicted. Eliminating all odour from livestock operations is not feasible. However, there are management practices that can control odour within reasonable limits. Odour mitigation practices should strive to reduce the nuisance to neighbours, by minimizing the frequency, intensity, duration and offensiveness of odours.

2.3 Dust

Dust is composed of fine aerosol particles in suspension. These particles are various shapes and sizes and are both inorganic and organic. In animal housing, 70 to 90 percent of the dust is organic. Organic dust includes: dandruff, dried manure and urine, feed, mold, fungi, bacteria and endotoxins (produced by bacteria and viruses). Organic dust is biologically active and may react with the defence system of the respiratory tract. Inorganic dust is composed of numerous aerosols from building materials and the environment (concrete, insulation, soil).

Air quality in livestock facilities can affect the health of humans and animals if they are

exposed to high concentrations of dust. Exposure to fine particles (less than 10 microns) of dust can cause eye and throat irritation and can potentially contribute to respiratory conditions such as asthma or chronic bronchitis. In barns with a high concentration of dust, workers should wear dust masks.

Dust and particulate matter exhausted from livestock facilities may not represent a direct health risk to neighbours because the survival rates of airborne micro-organisms are considered very low and the dilution factor of the air high. However, airborne particulate matter can contribute to odour.

2.4 Gases

Gases emitted from livestock operations may have an impact on global warming, acid rain and water quality. These gases can be generated in the barn, during manure storage and land application. Odour release from manure depends on the type of storage (liquid or solid), agitation frequency and manure spreading. Typical gases include ammonia, hydrogen sulphide, methane, sulphur, nitrogen compounds and several trace gases associated with odour. The properties and effects of these gases are shown in Figure 2.1.

Global warming refers to the increase in the earth's atmospheric temperature, which many scientists believe is a result of an increase in the concentration of "greenhouse gases." Water vapour, carbon dioxide (CO₂), methane

(CH₄), halocarbons (used in refrigerants) and nitrous oxide (N₂O) are the main greenhouse gases in the atmosphere. Increases in all of these gases, except water vapour, are believed to be responsible for global warming.

The livestock industry in Alberta contributes approximately one percent of Canada's total greenhouse gas emissions. The bulk of agriculture emissions are nitrous oxide and methane. The majority of emissions from dairy production come from manure. Although the intensity and offensiveness of an odour may be high, it is not necessarily an indication of the presence of greenhouse gases. Research is required to establish the relationship between greenhouse gases and odours.

Figure 2.1

Properties and Effects of Gases Emitted from Dairy Production

Gas	Source	Properties	Health Effect		Environmental Effect
			Concentration	Symptom	
Ammonia (NH ₃)	<ul style="list-style-type: none"> manure decomposition, composting, commercial fertilizer and manure handling, storage application 	<ul style="list-style-type: none"> sharp, pungent odour (like glass cleaner) lighter than air 	<p>25 ppm.....</p> <p>2 - 6 ppm.....</p> <p>20 - 30 ppm.....</p> <p>40 - 200 ppm.....</p> <p>3,000 ppm.....</p> <p>5,000 ppm.....</p>	<ul style="list-style-type: none"> Acceptable TLV* detectable but not considered a risk to public health burning eyes headaches, nausea, respiratory irritation asphyxiating could be fatal 	<ul style="list-style-type: none"> contributes to the formation of airborne particulates may react with other compounds, potentially leading to acid rain and ozone depletion soil and water acidification contributes to odour
Hydrogen sulphide (H ₂ S)	<ul style="list-style-type: none"> bacterial decomposition in manure without oxygen (anaerobic) 	<ul style="list-style-type: none"> heavier than air accumulates near the floor in enclosed buildings initially a rotten egg smell, but lethal concentrations paralyze sense of smell 	<p>10 ppm.....</p> <p>2 ppm.....</p> <p>20 ppm.....</p> <p>50 ppm.....</p> <p>>500 ppm.....</p>	<ul style="list-style-type: none"> Acceptable TLV detectable paralyzes sense of smell dizziness, nausea, headache, respiratory irritation death from respiratory paralysis in seconds 	<ul style="list-style-type: none"> may react with other compounds, potentially leading to acid rain
Methane (CH ₄)	<ul style="list-style-type: none"> decomposition of manure without oxygen (anaerobic) 	<ul style="list-style-type: none"> no smell lighter than air 	<p>50,000 ppm.....</p> <p>500,000 ppm.....</p>	<ul style="list-style-type: none"> explosive when mixed with air can cause headaches and eventually asphyxiation when oxygen is displaced 	<ul style="list-style-type: none"> a greenhouse gas that may contribute to global warming
Carbon dioxide (CO ₂)	<ul style="list-style-type: none"> anaerobic and aerobic decomposition of organic materials plant and animal respiration combustion of fossil fuels 	<ul style="list-style-type: none"> no smell heavier than air 	<p>5,000 ppm.....</p> <p>30,000 ppm.....</p> <p>40,000 ppm.....</p> <p>100,000 ppm.....</p> <p>300,000 ppm.....</p>	<ul style="list-style-type: none"> Acceptable TLV increased rate of breathing drowsiness, headache dizziness, unconsciousness could be fatal in 30 minutes 	<ul style="list-style-type: none"> a greenhouse gas that may contribute to global warming removed from the air by photosynthesis stored in soil and oceans
Nitrogen oxides** (NO _x)	<ul style="list-style-type: none"> NO_x naturally generated by bacterial processes, decomposition and fires humans contribute primarily through burning fossil fuels 	<ul style="list-style-type: none"> NO and N₂O are colourless, NO₂ is reddish brown NO₂ is the most common of NO_x and is one of the main components of smog 		<ul style="list-style-type: none"> NO_x not very soluble so symptoms may be delayed. Effects include respiratory irritation, coughing, fever and, in extreme situations, respiratory failure. 	<ul style="list-style-type: none"> potentially toxic to plants, leading to reduced growth NO_x are the most potent greenhouse gases emitted by agriculture may deplete ozone
Trace gases associated with odour	<ul style="list-style-type: none"> anaerobic decomposition of manure 	<ul style="list-style-type: none"> often have distinct smells 	<ul style="list-style-type: none"> in low quantities, these compounds are not considered a serious threat to human health 	<ul style="list-style-type: none"> contributes to odour may form airborne particulates 	

* Threshold Limit Values (TLV) are exposure limits that serve as guidelines to control health hazards in work environments. Alberta Occupational Health and Safety Association establishes these values.

** Nitrogen oxides (NO_x) include nitric oxide (NO), nitrogen dioxide (NO₂) and nitrous oxide (N₂O) (laughing gas).



2.5 Pesticides

Pesticides include insecticides, herbicides, fungicides and rodenticides. Pesticides can be a risk to non-target organisms, applicators and workers, if these products are not handled and applied properly. During pesticide application, spray droplets, mists or vapours may form. These airborne particles can drift and contaminate adjoining properties and water. Soil pollution can occur when pesticides are applied using improper application methods or rates, when disposal protocols are not followed and during spills. Storing large amounts of pesticides increases the potential for a significant pesticide spill to occur.

Pesticide mismanagement can eliminate beneficial insects, inhibit crop growth and

reduce viable crop varieties. Depending on toxicity and dose of the pesticide, domestic animals and wildlife may be harmed by eating crops or soils that have had a pesticide application. Some pesticides may accumulate in plant and animal tissue and may make food unfit for human consumption. Pesticides, when misused, have great potential to pollute both surface and groundwater. Water pollution from pesticides can be the result of drift, runoff, leaching, erosion of contaminated soil, spills and direct introduction. The severity of pesticide contamination depends on the pesticide toxicity, dose applied and how the risk is managed.

2.6 Pharmaceuticals

A range of pharmaceutical products, including antibiotics, dewormers and reproductive hormones are used in the dairy industry. Most of these products are completely broken down in the animal's body and do not present a risk to the environment. However, concern has surfaced that some of these products could find their way from livestock manure into the environment and have a negative impact on the ecosystem. Two specific areas of concern are:

- Reproductive hormones that can act as endocrine disruptors. Endocrine disruptors are chemicals that affect the function of the body's endocrine system. They may cause health problems, reproductive failure and developmental abnormalities in both humans and wildlife. There are many sources of endocrine disruptors in the environment, including phytoestrogens (from plants), mycotoxins (from molds) and man-made chemicals that imitate certain hormones.
- Antimicrobials, such as sulfamethazine, that are excreted into the environment in an

active form. This could potentially alter the population of bacteria in the environment or select for the development of drug-resistant bacteria.

There is little evidence to confirm that reproductive hormones and antimicrobials are significant issues at this time. The risk to the environment from pharmaceuticals is low. Drug residues are excreted at very low levels, and are then diluted with water and manure from other untreated animals. It is further diluted when the manure is spread on the land. Because the amount of drug present is extremely small, the concentrations in manure may not be high enough to have any effect on animals that come in contact with it. Thus far, there has been no evidence that residues from pharmaceuticals used in dairy production have created problems with the health of humans, wildlife or the environment. Research is ongoing to evaluate the potential environmental risk associated with certain antimicrobials and reproductive hormones.

2.7 Pathogens

Currently in Alberta, dairy cattle manure is not considered a major source of infectious disease for humans or livestock. There are three main reasons for this. First, many infectious diseases that occur in the rest of the world are not found here. Second, modern production practices and drinking water supply systems prevent many diseases from being transmitted. Third, the density of dairy cows in the province is relatively low.

Dairy manure contains a wide range of micro-organisms, including bacteria, viruses and parasites. Under certain conditions, some of these can cause disease in humans or livestock. Many of these organisms are also

present in the feces of other livestock, pets, wildlife and in human sewage.

In recent years, many large outbreaks of waterborne disease have occurred in humans in North America. The increase in intensive livestock production has often been blamed. While it is not yet known how much of the problem can be attributed to agriculture, two things are certain – poorly handled manure can result in waterborne disease in humans, and other sources of contamination, such as human sewage, are also responsible. It is critical that manure be handled appropriately to minimize the risk of disease to both livestock and humans.

2.7.1 How disease is transmitted from manure

Disease-causing micro-organisms are referred to as pathogens. Manure pathogens are most often transmitted by the fecal-oral route (i.e. ingestion of manure or manure-contaminated feed or water). In livestock, this can occur through consumption of drinking water contaminated by manure, grazing on pasture recently spread with manure or when livestock have direct access to manure. Humans can ingest manure pathogens through consumption of contaminated drinking water, swimming in contaminated surface water or not washing hands after handling infected livestock or manure. Diseases that can be transmitted from animals to humans are referred to as zoonoses or zoonotic diseases. People most at risk of zoonotic disease are those working in barns or handling manure.

There are no diseases in Alberta that can be transmitted to humans or livestock through the air from dairy manure. The odour of dairy manure alone cannot cause infectious disease. Contamination of surface water is the main public health concern when handling manure. In order for manure pathogens to cause disease through water contamination, several steps need to occur. If any one of these steps is blocked, then transmission will not occur.

- First, the pathogen must be excreted by the cow. Not all pathogens are found in

every barn, and most can be reduced by management or medication.

- Second, the pathogen must reach a water supply either by the animal defecating directly in the water, or by manure entering surface runoff or leaching to groundwater.
- Third, the pathogen must remain alive and capable of causing infection until the time it is ingested. Heat, cold and dryness can destroy many pathogens in a short period of time.
- Fourth, the pathogen must be ingested in high enough numbers to cause infection. Some organisms, such as *Salmonella*, must be ingested in very high numbers to cause disease, whereas only a few *Escherichia coli* O157:H7 bacteria may cause disease.

Often it is difficult to determine the source of a waterborne disease outbreak. Many of the same disease-causing micro-organisms are found in wildlife, birds, pets and human sewage. Therefore, if testing finds the suspect organism in one location, it cannot be automatically assumed this was the source. Testing many sources and using new diagnostic techniques to determine the strain of the organism are usually necessary to pinpoint the source of disease. Refer to Section 10.2 for a full description of pathogens that may be present in dairy manure in Alberta.

2.8 Soil Erosion, Compaction and Salts

Soil erosion refers to the loss of soil due to wind or water. Erosion potential depends on management practices and the specific topography, climate and soil type of a region. Water erosion can be the result of surface runoff from rainfall or irrigation. Wind erosion occurs when soil is not adequately covered. Wind and water erosion can cause environmental problems if soil nutrients or fine-grained material, such as silt and clay, enter water bodies.

To avoid soil erosion when applying and incorporating manure, a balance must be achieved among incorporation techniques, tillage and timing. Incorporating manure prevents nutrient losses and mixes organic matter in manure with soil. Mixing organic matter with soil increases the binding of soil particles and can reduce the potential for erosion. However, excessive tillage leads to compaction, decreases soil porosity and

destroys soil structure and aggregate characteristics. This reduces the movement of water, air, nutrients and soil microbes through the soil. Timing manure application to avoid application on wet soil is critical to reduce soil compaction. Farm traffic, especially on headlands, can cause soil compaction, particularly when the soil is wet.

Excess salt levels, as shown by electrical conductivity measurements and sodium adsorption ratios, can increase in soils after successive manure applications. Manure can contain salts from the water used for livestock watering or from salts and minerals in feed. In many cases, salt levels are more likely to limit manure application on fields than nutrients such as nitrogen and phosphorus. Sodium, in particular, can cause problems with the soil, since it can cause structural changes in the soil and is toxic to plants at high levels.

2.9 Excess Nutrients

Spills, improper storage and over-application of fertilizers or manure may lead to excess nutrient concentrations in soil. Primary nutrients of concern are nitrogen, phosphorus and potassium. Excess nitrogen and phosphorus can cause soil and water quality problems. Excess potassium on forages can result in

reduced feed quality. An overabundance of these nutrients can result in toxicity to plants and reduce crop yields. As well, nutrients that are not used by plants can leach out of the root zone and contaminate groundwater or run off to surface water.

2.9.1 Excess nutrients and water

Surface water. Elevated nutrients in watercourses can be caused by manure or fertilizer entering a watercourse directly, by runoff from fertilized fields or by nutrient-rich soil eroding from croplands. Nutrients, primarily phosphorus and nitrogen, accelerate eutrophication of water bodies. Eutrophication is the nutrient enrichment of surface waters. The most visible effects of eutrophication are massive blooms of algae and other aquatic plants. When algae and aquatic plants die, oxygen can be depleted, reducing fish survivability. Blue-green algae can be toxic to

domestic animals and humans when ingested and can deplete oxygen levels in surface waters.

Nitrates in drinking water. Nitrate is formed through the nitrification process from the mineralization of organic nitrogen to ammonium and from ammonium to nitrate. Nitrate is a form of inorganic nitrogen that is soluble in water and is readily used by plants. Nitrate is very soluble in water and tends to quickly move down through the soil profile. Consequently, nitrate can concentrate in shallow groundwater.

Sources of nitrate in water include natural sources (e.g. peat bogs), commercial fertilizers (e.g. anhydrous ammonia), domestic sewage systems and manure. Studies in Alberta have shown that high levels of nitrate from livestock and land application of fertilizer or manure can be transported in surface runoff.

The established drinking water quality, Maximum Acceptable Concentration (MAC), for nitrate is 45 mg/L measured as nitrate (10 mg/L measured as nitrate-nitrogen). Nitrate levels below 45 mg/L do not appear to cause health problems. Above this level, however, there may be health concerns, particularly for pregnant women and for infants less than one year old, although this has rarely been reported.

Groundwater. Groundwater is the water that occurs in the pore spaces of soil and rocks. Aquifers are water-bearing layers that hold water in usable amounts. Typical aquifers are overlain by deposits of clay or shale. Unconfined aquifers occur when the groundwater is directly exposed to the atmosphere through openings in the soil. As a result, the risk of contamination to unconfined aquifers is great. Over-application

of nutrients can result in nutrient leaching directly into the groundwater.

A confined aquifer is trapped below an upper confining layer of rock, clay or shale. The risk of contamination for confined aquifers is through direct movement of contaminants into the well from the wellhead or improperly maintained well casing. Manure seepage and chemical spills or seepage into the well should be prevented.

Seepage from improperly constructed or maintained manure storage structures and the associated risk of groundwater contamination is a serious concern in some areas, particularly where the subsoil underlying the storage consists of sand, gravel or fractured bedrock that allows movement of contaminants through the soil profile to shallow groundwater.

Over-application of manure on cropland or forage land can also present a risk of elevated nitrate levels in shallow groundwater. Studies in Alberta have shown that continuous over-application of manure can increase nitrate levels in shallow groundwater.

2.10 Other Water Concerns

Metals. Metals of concern include nickel, manganese, lead, chromium, zinc, copper, iron and mercury. Trace quantities of some metals are necessary for the growth of living things. However, even low metal concentrations can interfere with how the water is used. Elevated metal levels are toxic to most life forms. Metals are found in manure, waste oil and hydraulic fluids. Elevated metal concentrations can kill fish or accumulate in their tissues, making them unfit for human consumption.

Petroleum products. Gasoline, antifreeze, paints, solvents, hydraulic fluids and other

oil-based substances can have direct and indirect harmful effects to groundwater and surface water. Direct adverse effects include the immediate toxic contamination of aquatic organisms that ingest petroleum products and interference with respiration in fish. Indirect negative effects include the destruction of fish food such as algae and other plankton, devastation of spawning areas, a reduction in the rate of photosynthesis by aquatic plants and poor stream aeration. Also, petroleum products can taint the flavour of fish, affecting its quality for human consumption.

2.11 Nuisance

Odour, noise, and traffic related to agriculture production are potential nuisances to the surrounding community if not managed property. Noise and traffic are inevitable, but

beneficial management practices discussed throughout the following chapters may minimize the irritation to neighbours.

