MORRISON HERSHFIELD

FINAL REPORT

BEST ODOUR MANAGEMENT PRACTICES AT COMPOSTING FACILITIES

Metro Vancouver

Prepared for:
Terry Fulton
Metro Vancouver
4330 Kingsway
Burnaby, BC V5H 4G8

Submitted by:
Konrad Fichtner
Morrison Hershfield Ltd.
310-4321 Still Creek Drive
Burnaby, BC V5C 6S7

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Glossary of Abbreviations

ASTM	American Society for Testing Materials
BAT	Best achievable technology
BOD	Biological oxygen demand
C:N	Carbon and nitrogen
EMA	BC Environmental Management Act
MoE	BC Ministry of Environment
OMRR	BC Organic Matter Recycling Regulation
OU	Odour unit
VOC	Volatile organic compounds
WWTP	Wastewater treatment plant

EXECUTIVE SUMMARY

PURPOSE AND BACKGROUND

Morrison Hershfield was commissioned by Metro Vancouver to provide an overview of composting best practices with special emphasis on odour control.

Metro Vancouver has implemented an organics disposal ban at all regional disposal facilities. Composting is currently the most common method of managing source-separated organics in the Metro Vancouver region. In the course of the rapid development of this technology, some compost facilities in the region and other jurisdictions have experienced challenges with managing odorous emissions and leachate.

This report comprises a description of odorous substances from organics management facilities, a summary of best practices for odour management (prevention and treatment) and how odour management is dealt with by provincial, regional and municipal regulations. In this report, options for integration of best practices into Metro Vancouver regulations are also included.

BEST MANAGEMENT PRACTICES TO AVOID GENERATION OF ODOROUS EMISSIONS

The best way to manage odours is to avoid them in the first place. The report provides best practice guidance in accordance with the following odour management hierarchy:

1. Odour avoidance during planning (e.g. siting considerations and odour dispersion analysis).
2. Odour avoidance by considering the food waste hierarchy (i.e. finding the most suitable management option for various organic waste types).
3. Odour avoidance via optimized facility operations (by using best management practices).
4. Odour abatement (biological/chemical/thermal neutralization, etc.).

Odour Avoidance During Planning

To avoid odorous emissions, two approaches can be considered for siting a composting facility.

- The site can be selected based on availability, cost and other considerations (such as access to transportation, utilities, etc.). In this case, sensitive human receptors (e.g., residences, schools, hotels, restaurants, churches, public parks, or any commercial and industrial occupancies) may be within a range where odours from a composting operation could reach them. In this case, the technology must be selected and the facility designed in such a way that potential odours are captured and treated at the facility.
- The site can be selected as far away from receptors as possible, reducing the need for odour capture and treatment, provided the odorous substances are diluted to the point of non-detection by the time they reach sensitive human receptors.

A remote facility that relies on dilution of odorous substances through atmospheric dispersion will generally have lower costs than a facility that must capture and treat odours on site.

Odour Avoidance by Considering the Food Waste Hierarchy

Applying the food waste hierarchy can play a substantial role in avoiding odours from composting facilities, since many types of food waste can be particularly odorous during the composting process.

The food waste hierarchy prioritizes actions that organizations can take to prevent and divert wasted food. Each tier of the food waste hierarchy focuses on different management strategies for wasted food.

The top levels of the hierarchy are considered the best ways to prevent and divert wasted food because they create the most benefits for the environment, society and the economy. The hierarchy is shown in the following Figure ES 1.

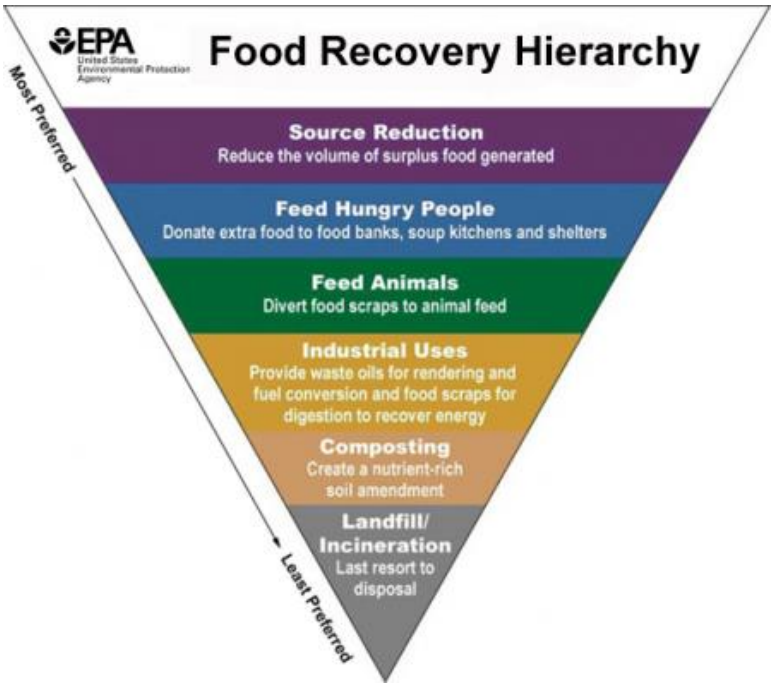

Figure ES 1: EPA's Food Recovery Hierarchy[1]

This report presents various strategies and technologies that apply to the different aspects of the food waste hierarchy that can help to minimize odours at composting facilities through diversion and better use of food waste.

Odour Avoidance via Optimized Facility Operations

Optimal composting facility operations mean that operators must maintain operations within well accepted and documented guidelines (these are described in detail in the Environment Canada

[1] From URL: https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy

Technical Document on Municipal Solid Waste Organics Processing[2]). This means ensuring proper management of:

- The correct C:N ratio.
- Moisture and oxygen content.
- pH.
- Porosity of mix.
- Processing temperature.
- Maintaining aerobic conditions.

However, in addition to the process itself, there are practices that can reduce the generation of odorous substances before and after the main composting process is completed. These practices will vary slightly depending on volumes, types of feedstock and location and are presented in this report for the following composting steps:

- Waste material transport and storage.
- Mixing and loading.
- Compost processing.
- Post processing.

Odour prevention and effective odour management are also dependant on plant capacity and operational flexibility, adequate staff training, appropriate management of process by-products, leachate management, odour monitoring, complaints management and the employment of suitable treatment technologies.

Waste Material Transport and Storage

Odour generation can begin well before the feedstock arrives at the composting facility. Food waste has often been stored for several days before it is collected. In the summer it may have begun decomposition during storage and transportation and thus arrive in an odorous state. Best practice for odour control during waste material transport and storage is presented in the Table ES 1 below. This applies mainly to materials that can cause odours, such as food waste, biosolids, or digestate from an anaerobic digestion (AD) facility.

[2] Environment Canada, Technical Document on Municipal Solid Waste Organics Processing, 2013, accessible via URL: https://www.ec.gc.ca/gdd-mw/3E8CF6C7-F214-4BA2-A1A3-163978EE9D6E/13-047-ID-458-PDF_accessible_ANG_R2-reduced%20size.pdf

Table ES 1: Best Practice for Waste Material Transport and Storage

Category	Best Practice
Collection at source	Use water and air sealed containers.
Transportation	Covered collection vehicle with leachate catchment for feedstock containing food waste or biosolids.
Drop-off at processing facility	Determine destination (in-door or out-door drop off) and immediate management methods depending on the nature of the feedstock material and its odour generation potential. Tipping floor receiving sludge / biosolids, food waste and digestate should be indoors in air controlled environment; whilst tipping areas for yard and garden materials can be outdoors.
Air control at drop-off areas	Enclosed drop off areas should be outfitted with rapidly closing doors. Consider air-lock system with double doors for entry and exit.
Storage of material	Yard and garden materials can be stored outside if covered with a 20 cm layer of compost to act as a biofilter. Food waste, digestate and biosolids should be stored in an enclosed area with air control and exhaust air treatment (e.g. biofilter).
Housekeeping	Remove spilled organic feedstock from site roads and other areas daily; clean delivery vehicle wheels and loading area before leaving a site.

Mixing and loading

Typically composting facilities must mix feedstock with amendment to achieve suitable conditions for composting such as mixing food waste with shredded yard and garden waste. Biosolids and digestate require careful mixing with amendment (often wood chips) to achieve optimal porosity and moisture content for composting.

Best practices for odour control during mixing and loading is shown in Table ES 2.

Table ES 2: Best Practices for Mixing and Loading

Category	Best Practice
Mixing / preparation of food waste, biosolids, and other putrescible and odorous materials	Mixing of food waste and putrescible organics should take place indoors with air control; priority should be given to mixing odorous waste materials.
Loading	Immediately after mixing, place material into processing area (vessel or aerated piles).
Housekeeping	Clean mixing equipment regularly; avoid contaminating outdoor areas with organics from indoor mixing area.

Compost Processing

Numerous proprietary technologies exist for compost processing. These are described in detail in the Environment Canada 2013 Document. The categories range from simple open windrows and static piles for yard and garden waste only, to a variety of enclosed systems for food waste and other putrescible materials including covered aerated static pile, enclosed aerated static pile (tunnel), static container, channel, agitated bed and rotating drum. Common to all of the enclosed systems is that they maintain full control of the process air, which is often odorous and must be treated to reduce odours before being released to the atmosphere.

Best practice for odour control during compost processing is summarized in Table ES 3 below.

Table ES 3: Best Practice for Odour Control during Compost Processing

Category	Best Practice
Enclosed composting	Maintain optimal C:N ratio, provide adequate aeration, keep moisture in the best range for composting organisms. Maintain separation between process area and ambient air. Monitor temperature and oxygen and adjust air supply as required to maintain optimum conditions.
Air controlled enclosure	Process area must always remain enclosed; maintain negative air pressure if process in a building or enclosure.
Open composting	Only yard and garden waste is suitable for processing in open air composting facilities using technologies such as open windrows and static piles.

Post Processing

Once the active phase of composting is complete, the compost will undergo post processing. This involves one or more curing steps to make the compost mature and depends on the chosen process. Curing is followed by screening to remove oversized amendment materials, such as wood chips (which can then be recycled back into the process) and to reduce the volume of finished product that needs to be stored.

With some technologies, initial curing is still undertaken in an enclosed environment; with others, the process is moved outdoors. Initially, some aeration is still required; during later curing stages the compost is often left without additional aeration.

The screening process is also a potential source of odours and is ideally undertaken in an enclosure, but in practice is often undertaken outdoors.

Best practice for odour control during post processing is shown in Table ES 4.

Table ES 4: Best Practice for Odour Control during Post Processing

Category	Best Practice
Open air Composting	Place 15 cm cover of mature compost over the post processing piles to act as a biofilter. Conduct screening when weather conditions are such that odorous emissions are unlikely to reach potential receptors.
Enclosed composting	Conduct initial phases of curing in an enclosed environment with air control, or some form of negative aeration to capture remaining odorous emissions. Screen compost when measured odour concentration levels are below levels specified by regulatory criteria and/or site specific assessment, or screen within a controlled environment.

Leachate Management

When water, either from rainfall, snowmelt or intentional addition, comes into contact with organic waste materials (e.g., feedstocks) it becomes contaminated and is considered leachate. The best way to manage leachate is to avoid its generation in the first place. Inadequate management of leachate can generate odorous substances.

At a composting facility, best practice involves clear separation of areas where leachate is generated and areas where stormwater is collected and drained. Stormwater is all water that drains from structures, covered areas, roads (that are kept clean) and site areas that are not used for waste processing or storage.

A program of preventative maintenance should ensure the functionality of the leachate collection and management system to minimize odour release.

Plant Capacity and Operational Flexibility

It is important to determine the maximum capacity of a composting facility in order to ensure that waste received can be processed promptly and effectively. Proponents of new composting facilities should provide calculations of the maximum capacity of their site which is typically included as a condition of their permit. The calculations should address plans for dealing with seasonal variability, downtime for maintenance and the removal of finished compost from the site.

Once a facility is built, operations need to be kept within the designed facility capacity. Prudent operators will operate their facilities at or slightly below practical capacity to allow for variations in feedstock and process conditions.

Odour Emission Monitoring

Odour emission monitoring is essential for the successful operation of an organics management facility. In addition to regular odour sampling and monitoring, staff must be trained to recognize odorous conditions when they occur during operations and to immediately undertake corrective measures.

Different monitoring methods are needed for various odour sources depending on whether the owner / operator wishes to measure odorous substances from point sources (e.g., stacks, vents), area

sources (e.g., open piles / windrows, open tanks, biofilters), or fugitive sources (e.g., windrows during turning, open doors, trucks waiting to unload or load).

The trend in odour emission monitoring in Europe and Ontario appears to favour the monitoring of substances in odour units (OU, as described in more detail in section 3.2.9) instead of chemical substances, such as specific volatile organic compounds. This is because OU more accurately reflect the full scope and magnitude of odorous emissions perceived by sensitive receptors.

Other Best Practices to Avoid Odour Generation

Facility operators will need to have adequate systems in place for staff training, management of process by-products and complaints management. Table ES 5 summarizes these best practises to avoid odour generation.

Table ES 5: Other Important Best Practices for Odour Avoidance

Category	Best Practice
Staff training	All operators at organics management facilities should receive operator certification training. This training teaches the basic principles of composting and the management of odorous substances and leachate. In addition, and since each technology is different, operators must also receive training on the particular technology that they are working with. Operators must be able to recognize early what can lead to upset conditions that could cause the emission of odorous substances and proactively mitigate these conditions. Annual training updates are strongly recommended.
Management of process by-products	By-products from the composting process are typically reused onsite where possible to minimize costs. By products referred to as “overs” represents a substantial portion of the feedstock after screening (typically 30%). Depending on the point in the composting process where the screening takes place, the overs may be more or less odorous. The overs piles may also give off some odorous substances when they are stored outdoors or re-used as part of an outdoor process. The magnitude of the odour concentration needs to be measured to determine which odour control measures are required, if any.
Complaints management	Operators should have procedures in place for odour complaint recording and management. For larger facilities and/or facilities located in urban areas, electronic sensors can be used for real-time calculation of estimated odour concentration and enable immediate corrective measures to the operation of the process. Odour monitoring data should be correlated with odour complaints received. Odour complaints may be received by the regulator, the facility operator, or both. Coordinated responses may be required.

ODOUR MANAGEMENT REGULATIONS

1.1.1 British Columbia

The BC Ministry of Environment (MoE) administers and regulates air quality issues, including odour issues, under the authority of the *Environmental Management Act* (EMA). The *Organic Matter Recycling Regulation* (OMRR) under the EMA governs production, quality and land application of certain types of organic matter. The EMA and the OMRR are the two primary regulatory documents that govern odour management related to processing organics waste in BC as administered by the MoE.

Currently OMRR requires an environmental impact study (EIS) to be completed prior to approval and operation of a composting facility. The EIS details the nature and scale of the facility, how the project will impact the physical, chemical and biological environment and its receptors, and the measures that can be taken to reduce, alleviate and monitor these impacts. Proposed amendments to the OMRR intend to consolidate requirements for the EIS, OMP, operating plan, and leachate management plan into one plan called a "facility environmental management plan." An intentions paper on the proposed amendments is expected in summer 2017.

The EMA provides Metro Vancouver the authority to regulate air quality and solid waste management through bylaws. Metro Vancouver has two such bylaws: one relating to solid waste management facility licensing and the other to air quality management.

The Metro Vancouver Solid Waste Regulatory Bylaw No. 181 requires that all privately operated compost facilities have and comply with a valid licence. The goal of the regulatory system is to ensure proper management of privately operated facilities.

Metro Vancouver's Air Quality Management Bylaw No. 1082 applies to the discharge of air contaminants from composting facilities whether or not they are prescribed under the EMA or its regulations. The bylaw prohibits the discharge of air contaminants unless the discharge is conducted in accordance with the terms and conditions of a Metro Vancouver emission regulation or a valid permit or approval. Metro Vancouver may issue a permit to allow the discharge of an air contaminant subject to requirements considered advisable for the protection of the environment. The permit can place limits and restrictions on the quantity, frequency and nature of an air contaminant permitted to be discharged and the term for which such discharge may occur. It can also specify monitoring requirements.

The report refers to bylaws implemented by other regional districts and local governments aimed at controlling odour or nuisance related to odours. The report also presents odour management provisions in contracts between facility operators and the regional district / local governments.

1.1.2 Odour Regulations in Other Jurisdictions

Canadian federal legislation does not contain any regulations pertaining to the emissions of odours from industrial or agricultural facilities. Instead, individual provinces and territories have a responsibility for odour emissions. There are currently different approaches taken across Canada. The report provides examples of regulatory approaches by Ontario, Saskatchewan and Quebec, where there are clear definitions for either odours or odours as an air contaminant. These three provinces have regulations that are more prescriptive than the BC regulation.

The report also refers to odour management regulation in the United Kingdom (UK). In the UK, there is a desire to set OU maximum emission rates at the source of the emissions, however, in practice this is not being applied.

OPTIONS FOR INTEGRATION OF BEST PRACTICES INTO METRO VANCOUVER REGULATIONS

The following conclusions can be made on the options for integration of best practices in odour management into Metro Vancouver regulations and contract management.

Metro Vancouver's Solid Waste Regulatory Bylaw 181

Metro Vancouver is considering changes to Solid Waste Bylaw No. 181, which governs the management of municipal solid waste and recyclable materials at privately operated facilities.

The following industry best practices may be considered for Solid Waste Licences:

- For all facilities handling putrescible waste, key areas should be enclosed (including areas for waste receipt, pre-processing/mixing and composting area), and odorous air from these enclosures should be treated by a biofilter or other odour treatment systems.

- Define types and quantities of organic materials that the facility can receive. Consider not authorizing slaughterhouse waste and similar meat products going to compost facilities due to their ability to cause excessive odours and due to their higher use at rendering plant. Based on the food waste hierarchy, rendering is a higher use than both AD and composting for the purposes of managing food waste. Rendering would result in value added products and remove animal wastes from AD and composting.

- Prevent leachate generation by separating stormwater from leachate generating areas where rain comes into contact with organic materials (waste or compost). Recommend that leachate generated by rainfall that comes into contact with organic materials is collected from these areas and treated. All surface areas on which organic materials are stored or processed must have a hard and impermeable surface. Roads at the compost site should be paved.

- Develop and submit for approval an OMP, which aligns with any OMP developed as part of meeting permit requirements of Metro Vancouver's Air Quality Management Bylaw No. 1082.

Metro Vancouver's Air Quality Management Bylaw No. 1082

Metro Vancouver is considering enhancements to its Air Quality Management Bylaw No. 1082 (Bylaw 1082), which governs the management of air quality in the region. This report identifies various regulatory options available to Metro Vancouver for managing odours at compost facilities. Examples of approaches to odour management and regulation used in other jurisdictions have been provided, including odour definitions, design standards, regulatory performance standards and ambient air quality metrics (for individual substances and odour concentration), odour monitoring and odour management plan development.

1. BACKGROUND AND DOCUMENT STRUCTURE

1.2 BACKGROUND AND CONTEXT

Morrison Hershfield was commissioned by Metro Vancouver to provide an overview of composting best practices with special emphasis on odour control.

Metro Vancouver has implemented an organics disposal ban at all regional disposal facilities. Composting is currently the most common method of managing source-separated organics in the Metro Vancouver region. In the course of the rapid development of this technology, some compost facilities in the region and other jurisdictions have experienced challenges with managing odorous emissions and leachate.

Composting facilities sometimes receive complaints about objectionable odours to surrounding receptors and this can result in the need to substantially change operations and equipment to address the odour issues. The most cost effective way to manage odours is to avoid generating them in the first place.

This report comprises a description of odorous substances from composting facilities, a summary of best practices for odour management, and how odour management is dealt with by provincial, regional and municipal regulations.

1.3 DOCUMENT STRUCTURE AND OVERVIEW

This report summarizes the findings of Morrison Hershfield, which have been reported to Metro Vancouver in three technical memos. The report describes odours from composting facilities and how it can be measured (section 2), composting best practices to prevent and manage odours (section 3) and regulations for odour management (sections 4 and 5). Section 6 of the report provides best practices options for odour management and odour regulation that could be applied in Metro Vancouver regulations.

2 ODOURS FROM ORGANICS PROCESSING FACILITIES

2.1 ODOURS AND ODOUR MEASUREMENT

Odour is the perception of specific chemicals within the olfactory area of the sinuses. To be perceived as an odour:

1. The chemical must be released to the air.
2. It must dissolve in the olfactory mucus (consisting mainly of water).
3. There must be a receptor nerve cell available that can detect it.

The olfactory sinus area contains over three hundred types of receptor cells. An odorous substance may only trigger one or two receptor cells at low concentrations. The perceived pleasantness or unpleasantness of an odour is referred to as the hedonic tone. Hedonic tone tables provide numerical scores: the higher the score the more pleasant the odour. Examples are coffee, with a score of 2.33, and dead animal, with a score of -3.75.

In the brain, odours are processed by the limbic system which is responsible for emotion and formation of memories. For this reason, odours, both pleasant and unpleasant, can create strong emotional responses in the perceiving individual.

Adaptation to odorous substances occurs when people are exposed to the odorous substances on an on-going basis. People working around an odour will become less aware of the odour over time. People who are exposed to changing concentrations, for example due to dispersion patterns in the air, will not adapt to the odour and will be sensitive to the odour each time it is perceived.

When a composting facility is operated according to best practice there should be minimal emissions of odorous substances. When operating conditions are compromised increased odorous substances may be produced. There are many operational steps in the composting processes that can be potentially odorous. Table 1 presents a list of typical odour sources in composting facilities.

Table 1: Common Odour Sources in Compost Facilities

Odour Source	Example of Source
Waste material transport	• Trucks (on route or parked on-site) • Tipping operations • Open conveyors • Spillage from trucks or tipping operations
Pre-processing and storage	• Emissions from loading or mixing • Untreated emissions from pre-processing or storage • Spillage from mixers or around storage facilities • Residue on equipment • Digestate from AD facility
Compost loading (pile building or feeding of process area)	• Emissions from material handling (if outdoors) • Spillage (if outdoors) • Residue on equipment

Odour Source	Example of Source
Processing (main process)	• Fugitive emissions from treatment vessels and aeration systems • Emissions from active composting piles (if not fully enclosed) • Emissions from odour treatment systems • Leakage and ponding of condensate, leachate and digestate
Post-processing and storage	• Screening activities • Curing piles that are still active

Receptors

Sensitive receptors are generally defined as persons or facilities that may come into contact with odorous substances and become impacted by these if their concentration is above a certain threshold. Typical sensitive receptor sites include residences, schools, hotels, health care facilities, restaurants, churches, public parks, or any commercial and industrial occupancies.

Odorous Substances from Composting Facilities

When a composting facility is well operated under optimum process conditions, the odorous substances produced will be minimal. When operating conditions are compromised, for example composting piles become anaerobic, odorous substances can be produced. Odorous substances that can be emitted at composting facilities include:

- Reduced sulphur compounds, such as hydrogen sulphide resulting from anaerobic decomposition, smell like rotten eggs or rotting cabbage.
- Volatile fatty acids, often present in the initial phase of composting, smell like vinegar or rancid food.
- Nitrogen compounds (often ammonia), which occur under low pH and low carbon to nitrogen (C:N) ratio conditions and with certain feedstocks (e.g., food waste, green grass and biosolids), have a fishy smell.
- Indoles and skatoles, naturally occurring in feces, beets and coal-tar, smell sewer-like.
- Ketones are volatile organic compounds created from carbohydrates, fatty acids and amino acids, which are difficult to detect, smell like nail polish remover.
- Aldehydes are volatile organic compounds created in aerobic conditions from the oxidation of alcohols and they have a sharp, unpleasant odour.

Hydrogen sulfide is produced by the biological reduction of sulfate (SO_3). The bacteria that are responsible for reducing sulfate to sulfide are strict anaerobes and cannot exist in the presence of oxygen. Typically, compost facilities aerobically digest the green and food waste. Oxygen, moisture and temperature are monitored so that anaerobic conditions do not occur. Thus, odorous substances emitted from a compost facility are more likely to be terpenes and volatile fatty acids formed from the oxidation of biological compounds (Martin, Y., Odotech, personal communication, March 29, 2017).

Odorous substances can vary greatly in type and intensity and are also perceived differently by individuals (i.e., one individual may perceive the intensity or unpleasantness of an odour differently than another).

3 BEST PRACTICES FOR ODOUR MANAGEMENT

The best way to manage odours is to avoid them in the first place. The following odour treatment hierarchy provides a logical sequence of priorities:

- **Odour avoidance through siting**
    - Siting considerations
    - Odour dispersion analysis
- **Odour avoidance by applying the food waste hierarchy**
- **Odour avoidance via optimized facility operations**
    - Waste material transportation, acceptance and streaming
    - Feedstock pre-processing and storage
    - Composting process (main process)
    - Post processing (curing, screening, storage)
    - Leachate management
    - Facility capacity and operational flexibility
    - Staff training
    - By-products (overs, contaminants)
    - Odour emissions monitoring and complaint procedures
- **Odour abatement**
    - Biological neutralization (e.g., active and passive biofilter).
    - Chemical neutralization (e.g., wet scrubber).
    - Thermal neutralization (e.g., regenerative thermal oxidation).
    - Odour dilution.
    - Membrane covers.

Odours can be managed at two main levels. The first and priority level is to avoid the generation of odours in the first place. Once all measures of avoidance through siting, odour dispersion analysis and system design and optimization have been achieved, the next level is to contain and treat/neutralize odours.

3.1 SITING CONSIDERATIONS FOR COMPOST FACILITIES

3.1.1 Siting Considerations

For composting facilities, there is a need to consider many factors, such as transportation needs, utilities, available space, topography and distance from human and environmental receptors. The Environment Canada Technical Document on Municipal Solid Waste Organics Processing (Environment Canada, 2013) dedicates two chapters to the subject of siting. For the purpose of this study, only siting considerations related to odour will be discussed.

From the perspective of odours, there are two approaches:

- The site can be selected based on logistical and financial considerations, and the technology is designed to manage odours within the constraints of the site and its location, i.e. odour emissions must be reduced and treated at the site so that they do not impact receptors.
- A technology is selected for cost or other reasons, and an appropriate site with adequate distance to receptors is then found, i.e. odour emissions are diluted through atmospheric dispersion over large distances so that they do not impact receptors.

Some general guidelines for minimum buffer distances between compost facilities and sensitive receptors are presented in the Environment Canada 2013 document. For example, the minimum distance between a compost facility and any kind of sensitive receptor is 300 metres. In practice, this has been shown to be inadequate, and either the buffer must be greater, or the technology and operations improved to reduce the emission of odours. Under certain climatic conditions, odorous substances can travel several kilometres.

3.1.2 Odour Dispersion Analysis

A common method of determining in advance how odorous substances might affect surrounding receptor areas is conducting an air dispersion analysis. This well-known process uses prognostic meteorological models and surface meteorological measurements from local data sources such as those measured by Metro Vancouver (ambient monitoring stations), the BC Ministry of Environment (obtained from the BC ENV archive website[3]) or Environment Canada in the absence of other data. If necessary, other local data sources can be used to provide the most accurate prediction of wind direction, speed, and frequency of change of these parameters. In Metro Vancouver, air dispersion analysis must use quality-controlled data measured by Metro Vancouver and be conducted according to an approved dispersion modelling plan.

The dispersion model simulates odour emissions by taking into account source emission characteristics such as the volume of exhaust air, exit temperature of emissions, height of emission release and the concentration of odorous substances in the exhaust from the compost facility. The dispersion model uses the meteorological data and source emission characteristics to determine the spatial distribution of odour concentrations at specific receptor locations within the area of interest. CALPUFF is a recommended model under the Guidelines for Dispersion Modelling in BC (Ministry of Environment, 2015) and can be used to model the dispersion of odorous emissions (OUs or concentration of odorous substances) that have been measured at the source.

With the information from the dispersion model, the compost odour abatement technology can be selected to reduce odour emissions to a level that is acceptable to receptors and regulators. In addition, regulators can ask for a dispersion model to be conducted during the permitting process to set maximum permissible odour levels. Examples of these are provided in the section 5 on Odour Management and Regulations in Other Jurisdictions.

[3] BC Air Data Archive Website, accessible via http://envistaweb.env.gov.bc.ca/

For newly planned facilities, estimates for predicted odour emissions must come from similar existing installations, ideally where odour concentrations have been measured in the past. Many suppliers of composting technologies can provide this kind of data.

3.2 Odour Avoidance by Consideration of The Food Waste Hierarchy

This section introduces the food waste hierarchy and provides a discussion on its role to reduce odours from composting facilities.

Technologies that co-process food waste with biosolids are not discussed. The use of macerators at the source (home) for food waste with subsequent co-digestion at the waste water treatment plant is rejected as not being economical or environmentally friendly in some jurisdictions (in England) and hailed as an environmentally sound and effective approach based on a multi-year case study in Sweden. Evaluating this conflicting evidence is beyond the scope of this report.

3.2.1 What is the Food Waste Hierarchy?

A food waste hierarchy has been developed in the USA and in the UK. As defined by the US Environmental Protection Agency (EPA), the food waste hierarchy prioritizes actions that organizations can take to prevent and divert wasted food. Each tier of the food waste hierarchy focuses on different management strategies for wasted food.

The top levels of the hierarchy are considered the best ways to prevent and divert wasted food because they create the most benefits for the environment, society and the economy. The hierarchy is shown in the following Figure 1.

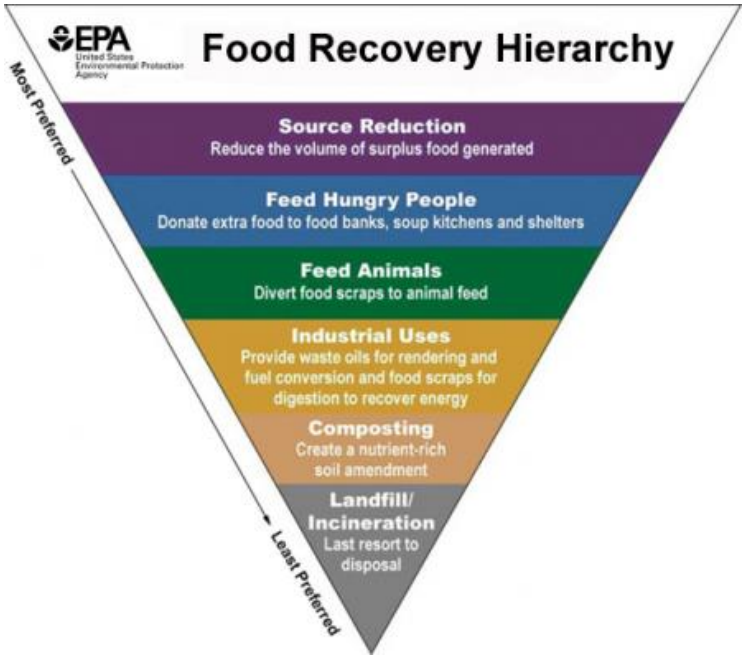

Figure 1: US EPA's Food Recovery Hierarchy[4]

In early 2011, the UK launched Vision 2020 with the goal of eliminating food waste going to landfills by the year 2020. The food waste hierarchy was a model adopted by Vision 2020 to achieve the goal of eliminating food waste to landfills. It draws a distinction between surplus food, which can be used to feed humans or animals and food waste that can be further processed to create compost, extract energy and generate heat. The Vision 2020 hierarchy varies slightly from the EPA pyramid as it specifies AD on the same level as industrial uses.

Implementing the food waste hierarchy requires involvement from food producers, retailers, restaurants and households. Each step requires the parties involved take full advantage of food waste's potential uses through re-use, recycling and energy recovery.

3.2.2 Where Has the Food Waste Hierarchy Been Implemented?

The Vision 2020 goal in the UK has been implemented for 6 years and case studies of successful implementation of the food waste hierarchy are presented on their website. A few examples are presented below.

Waitrose, a large supermarket chain in the UK, achieved its goal of not sending food waste to the landfill by 2012. Their environmental strategy involved a review of its operations and supply chain in order to identify each individual factor contributing to food waste. The solutions identified by Waitrose included donating surplus food to food banks, animal charities and zoos. Any remaining food waste is sent to an AD facility.

[4] *From https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy*

The South Oxfordshire and Vale of Whitehorse District Councils (equivalent to regional districts in BC) are the top two recycling counties in England with recycling rates of 68% and 69% respectively. Through promoting food waste reduction, the counties have diverted more than 9,000 tonnes of food waste per year, an average of 1.7 kg per household per week, which is sent to an AD facility for treatment.

The US EPA has a Food Recovery Challenge on their website where any business or organization can join as a participant or endorse. The participants and endorsers include grocers, educational institutions, restaurants, faith organizations, sports and entertainment venues and hospitality businesses. In order to sign up, participants are requested to provide 12 months of food waste baseline data and select from three food diversion categories: food waste prevention, donation and/or recycling (e.g. composting, AD). The participants are then requested to set a goal and track their progress.

Annual awards are provided to the Food Recovery Challenge participants and endorsers. There are two categories of awards, data-driven and narrative. The data-driven awards are based on the organizations tracking their progress through the online data system. Awards are given out to each type of participant (e.g. grocers, sports and entertainment venues). Narrative awards are given out through application to those organizations who demonstrate characteristics such as leadership, innovation and education.

The BC Ministry of Environment has a Residential Food Waste Prevention Toolkit (2015). This Toolkit focuses on food waste prevention, which is the top tier of the food waste hierarchy.

3.2.3 Solutions for Surplus Food

Recognizing that some surplus food is currently unavoidable, Vision 2020 provides solutions to manage surplus food in order of priority. Vision 2020 provides a framework for managing food waste based on nine categories of food waste characteristics. The characteristics include edibility, state, origin, complexity, animal product presence, stage of supply chain, treatment, packaging and biodegradability. These characteristics are used to determine the appropriate management approach (Garcia-Garcia et al., 2015).

As presented on the US EPA website, Kroger, a US grocer, donated 56 million pounds (25,000 tonnes) of fresh food to local food banks. This was done through its Perishable Donations Partnership program.

Following food waste prevention on the hierarchy, food re-distribution involves re-distributing surplus edible food to people in need. In Metro Vancouver, organizations like Quest Food Exchange and the Food Bank are currently providing this service.

Certain materials are suitable for feeding to livestock and poultry directly, which is a more economically viable solution than rendering, composting, landfilling or incineration. In the UK, the animal feed industry comprises 25 re-processors which handle over 550,000 tonnes of surplus food from the manufacturing, retail and distribution sectors (Vision 2020).

In the US, Rutgers University currently collects and processes their dining hall food waste (and paper napkins) into a pulp, which is then refrigerated and stored. The pulp is then transported to a nearby farm where the pulverized food scraps are feed to pigs and cattle. On average, one tonne of food waste is diverted from landfill daily for a cost of approximately $30 per tonne (US EPA, 2009).

Pet food is produced by using animal by-products such as organ meats and bone. In 2011, in the UK, 1.26 million tonnes of pet foods were generated with a value of £2.14 billion ($3.22 billion CDN).

Rendering produces products used in pet foods such as tallow, processed animal protein, and meat and bone meal. In the UK, rendering produces about 2.25 million tonnes of rendered products and is estimated to reduce GHG emissions by approximately 70,000 tonnes per annum. In Metro Vancouver, West Coast Reduction Ltd. (WCRL) is a rendering facility that processes pre-consumer meat by-products into value added commodities such as protein meals and animal fats. The facility offers pickup and disposal services in three provinces (British Columbia, Alberta, Saskatchewan) and has a storage capacity of 83,000 tonnes. Annually, the facility recycles more than 450,000 tonnes of raw material and collects and recycles 28,000 tonnes of used cooking oil. WCRL estimates that rendering these materials has the same effect on GHG emissions as eliminating 150,000 cars from the road annually (WCRL, 2017).

The next management method on the hierarchy is AD. Food waste, particularly oils, fats and greases, enhance the generation of biogas, which is GHG neutral and helps to offset the use of fossil fuels. The residue from AD is called digestate and is usually composted to bring it to an odour free state. Pure composting of food waste is possible, but much less desirable than AD or rendering, since much of the food and energy value of the material is not recovered. The least preferable management options involve thermal treatments and landfilling.

3.2.4 Food Waste Processing Technologies

Food waste is a resource that contains nutrients and energy, therefore process solutions for management should maximize its resource potential. Furthermore, food waste is a potential cause of odours if it is not processed in the best possible way. Therefore implementing higher levels of re-using or processing food waste can have beneficial effects on downstream composting systems, for example by removing meat and dairy products from the compost feedstock.

This section gives a summary of the technologies mentioned previously plus other technologies that might be considered. The odour considerations for each technology are also included.

3.2.4.1 Rendering

Rendering was described briefly in the previous section where it can be used to produce pet food. However, rendering can also be used to process high risk animal by-products that have a limited end-market. The resulting tallow can be used in the production of biodiesel and the meat or bone meal can be used as a biofuel. The environmental benefits are related to the reduction of GHG emissions as described in the previous section. The economic benefits of rendering include job creation with the processing and the production of a valuable end-product.

Rendering releases odorous gases and facilities are required to implement odour treatment systems. WCRL, as described in the previous section, has had odour complaints in the past, most notably during the warmer months when the wind blows from the northwest (Vancouver Sun, 2016).

3.2.4.2 Anaerobic Digestion

AD is a proven technology that has been widely used in the waste water treatment industry. It is also considered the highest value use for food waste (after re-use and rendering) as it produces biogas. The main AD process outputs are gas and digestate, which is composted. The main purpose of AD is to generate gas, since it has the most environmental (GHG offsets) and financial (available energy markets) benefits. For example, an efficient AD technology can produce 150 to 250 kWh of net electricity for every tonne of organics put through the process.

Digestate is the solid portion of the AD process and requires composting or bio-drying to produce a valuable end-product. Digestate is typically more odorous than the feedstock, therefore best practices for composting digestate is to utilize an in-vessel system to produce the end-product.

3.2.4.3 Composting

From the perspective of the food waste hierarchy, composting ensures that nutrients and organic matter return to the soil. However composting is not a source of biogas. For any food waste to be composted, best practices dictate that composting should be done in an enclosed environment to prevent odours from spreading and becoming a nuisance to surrounding human receptors.

3.2.4.4 Bio-drying

The thermal recovery of energy from organics is lower on the hierarchy than AD or composting. However, the creation of a biofuel from organic feedstock has become a common technology in Germany and other European countries. It is generally applied when the economics of making and selling a biofuel are better than for composting.

A common method of converting waste organics, including food waste into biofuel is through bio-drying. This process involves using the heat generated through microbial action (similar to composting) to dry organic waste to increase the calorific value of the organic waste for use as a fuel. The fuel is then used in applications such as cement kilns or industrial boilers where it offsets the use of fossil fuels, thus providing a substantial environmental benefit. Use of the biofuel results in some gas emissions and residual ash that require management. However, biofuel derived from organics is GHG neutral and a form of energy recovery.

Feedstock requirements for bio-drying are similar to those for composting, but they are much less strict. Contamination from plastics can be accommodated, since the product will be used as fuel, although a large plastic component would make the fuel less biogenic.

Bio-drying is essentially the same process as composting, therefore the same risks for odour emissions exist as for composting operations. Best practices for odour management at compost facilities must also be applied to bio-drying facilities.

Bio-drying has recently become popular in Europe as a replacement for composting, since operators and owners were having trouble selling product. Several compost system suppliers now offer their technology for either composting or bio-drying.

The Resort Municipality of Whistler (RMOW) in BC, which operates two agitated container composters (Wright Technology), is considering the conversion from composting to the production of bio-fuel. The RMOW is currently reviewing the cost of conversion, and the value of the bio-fuel for use in cement kilns in the Vancouver area. This review is being driven by a high cost for composting and low market value for the finished compost product in the Whistler area, as well as a growing requirement for non-fossil fuels within the cement manufacturing sector.

3.3 FACILITY OPERATION

The following is a brief description of the key steps in a composting process, typical methods employed, and comments on best practices. It provides examples of operational practices of several large composting operations in the Pacific Northwest with highlights of identified best practices.

The key composting steps are:

1. Waste material transportation, acceptance and streaming
2. Feedstock pre-processing and storage
3. Composting process (main process)
4. Post processing (curing, screening, storage)

In the last sub-sections of best management practices for facility operation, the following aspects are covered:

- Operations related issues
    - Leachate management
    - Facility capacity and operational flexibility
    - Staff training
    - By-products (overs, contaminants)
- Odour emissions monitoring and complaint procedures

3.3.1 Waste Material Transportation, Acceptance and Streaming

Odour generation can begin well before the feedstock arrives at the organics managing facility. Food waste has often been stored for several days before it is collected, and in the summer it can be partially digested and anaerobic, which can cause significant emissions of odorous substances. Putrescible feedstock should be transported using covered collection vehicles with leachate catchment for feedstock containing food waste or biosolids.

Upon feedstock receipt, records should be kept of each load of material (waste and bulking agents) received at the site. The records should include information such as a description of the material, the date the material was received, the source of the material and the weight or volume of the load. Depending on the nature of the feedstock material and its odour generation potential, the destination (in-door or out-door drop off) and immediate management methods are determined by the operator.

Generally, feedstock should be incorporated into the composting or digestion process as soon as possible. Highly putrescible wastes, including food waste, biosolids, sewage sludge and manures, should only be accepted at the site if they can be incorporated into the process promptly and processed by the system without the release of odorous substances. Food waste, biosolids and sewage sludge often have excess liquids (leachate) which must be contained since leachate also emits odorous substances. For biosolids and sludge, which are odorous on their own, even after dewatering they often contain below 25% solids. Any volume of sludge/biosolids (or digestate from internal operations) should be unloaded and managed indoors. Food waste is ideally also managed in a receiving building with air control. Depending on the nature and concentration of food waste when mixed with yard and garden waste, outdoor processing can be considered if there is no excessive impact due to odorous substances at the location of human receptors.

Based on interviews with four large composting facilities in the Pacific North West (refer to Appendix A), the practise to have food waste unloaded and mixed or pre-processed in an air-controlled building, appears to be common and accepted best practice.

Records should also be kept of any rejected loads including the source of the material and the reason for rejecting the load.

Best practice is to only accept the type of organic waste that the facility is designed to handle and process without generating excessive odour emissions.

Best practice for odour control during waste material transport and storage is presented in Table 2 below. This applies mainly to materials that can cause odours, such as food waste, biosolids, or digestate from an AD facility.

Table 2: Best Practice for Waste Material Transport and Storage

Category	Best Practice	Comments
Collection at source	Use water and air sealed containers.	Applies to potentially odorous materials.
Transportation	Covered collection vehicle with leachate catchment for feedstock containing food waste or biosolids.	Applies to potentially odorous materials.
Drop-off at compost facility	Determine destination (in-door or out-door drop off) and immediate management methods depending on the nature of the feedstock material and its odour generation potential. Tipping floor receiving sludge / biosolids, food waste and digestate should be indoors in air controlled environment; whilst tipping areas for yard and garden materials can be outdoors.	Odour measurements must show no excessive odour emissions leaving the site. Adequate distance to sensitive receptors must be present. Larger, remotely located sites might also be able to receive food waste mixed with yard and garden materials outdoors. Any volume of sludge/biosolids (or digestate from internal operations) should be dropped off and managed indoors due to their concentrated odorous emissions.
Air control at drop-off areas	Enclosed drop off areas should be outfitted with rapidly closing doors. Consider air-lock system with double doors for entry and exit.	
Storage of material	Yard and garden materials can be stored outside if covered with a 20 cm layer of compost to act as a biofilter. Food waste, digestate and biosolids should be stored under cover with air control and exhaust air treatment (e.g. biofilter).	
Housekeeping	Remove spilled organic feedstock from site roads and other areas daily; clean delivery vehicle wheels and loading area before leaving a site.	

3.3.2 Feedstock Pre-processing and Storage

Feedstock preparation, or pre-processing, can include activities such as debagging and removal of contaminants, size reduction by grinding or shredding, and mixing with a bulking agent (if needed) to achieve optimal feedstock conditions and reduce the risk of odour generation. Feedstock preparation influences the rate of degradation, the generation of process by-products, such as leachate and odour, and the quality of the resulting compost.

Odour control requirements for composting facilities in receiving and pre-processing areas are dictated by closeness and sensitivity of receptors and the distance that odorous substances may be transported in ambient air. In cases with receptors in close proximity or where atmospheric and topographic conditions are such that odorous substances could be transported a sufficient distance to reach receptors, food waste and other highly putrescible wastes should be unloaded and processed in a building with air control. Access doors should be of the rapidly opening and closing type to reduce the time that odorous air can escape the building. Building air must be treated before being vented, usually through a well-maintained biofilter.

Digestate, which is generated if there is an AD facility on site, is considered a highly odorous feedstock. It should be treated and pre-processed indoors under controlled air conditions.

Remotely located sites with adequate buffers to human receptors may be able to mix some putrescible wastes outdoors, but must do so within hours of receiving it, or cover it in a way that odorous substances do not escape. The operator must limit outdoor mixing activities to periods of favourable wind conditions where there is little risk of odorous substances being carried to human receptors.

Yard and garden waste can generally be mixed and stored outdoors. When food waste is mixed in with the yard and garden waste, then the blended mixture becomes an attractant to rodents, birds and insects. The odour generation of mixed yard and garden waste with food waste will depend on the type and level of food waste, but it is best practice to receive and process food waste in an air controlled building.

Odour generation from truck spills and carry over from the tipping floor and pre-processing areas can be mitigated by frequent cleaning of roadways and surfaces. Vehicle wheels and the loading area should be cleaned before leaving the site. Mixing equipment should be cleaned regularly and the operator should not contaminate outdoor areas with organics from the indoor mixing area.

Best practice for odour control during preprocessing and storage is presented in Table 3 below.

Table 3: Best Practices for Pre-processing and Storage

Category	Best Practice	Comments
Mixing / preparation of food waste, biosolids, and other putrescible and odorous materials	Mixing of food waste and putrescible organics should take place indoors with air control; priority should be given to mixing older waste materials. Any volume of biosolids (or digestate from internal operations) should be mixed indoors.	Larger, remotely located sites might also be able to receive food waste mixed with yard and garden materials outdoors. Odour concentration measurements must show no excessive odour emissions leaving the site. Adequate distance to sensitive receptors must be present.
Loading	Immediately after mixing, place material into processing area (vessel or aerated piles).	
Housekeeping	Clean mixing equipment regularly; avoid contaminating outdoor areas with organics from indoor mixing area.	

3.3.3 Technology Options for Composting Process

Numerous proprietary technologies exist for compost processing. The categories range from simple open windrows and static piles (for yard and garden waste only), to a variety of enclosed systems for food waste and biosolids/sludges including enclosed aerated static pile (tunnel), static container, channel, agitated bed and rotating drum. These are described in detail in the Environment Canada Technical Document on Municipal Solid Waste Organics Processing (Environment Canada, 2013). Common to all of the enclosed systems is that they maintain full control of the process air, which is often odorous and must be treated to reduce odours before being released to the atmosphere. An enclosed system helps to control aeration, keep moisture in the best range for composting organisms and maintain separation between process area and ambient air and climatic conditions.

In theory, and if the compost process is kept fully aerobic, the generation of odorous substances should be minimized. In practice, there are always some unpleasant odours due to pockets of feedstock that are not adequately aerated, thus harbouring anaerobic bacteria which create odorous substances, or from the formation of ammonia. The purpose of an odour containment system is to capture all odorous off-gases in order to treat them before release to the atmosphere.

Generally, buildings or custom structures and containers are used as enclosures for odour containment. They are designed by the technology provider to achieve the necessary processing capacity, and may include a loading area and mixing area. The design usually includes an air handling system that vents through a biofilter.

A simpler method of odour containment is with the use of membrane covers. Pioneered by GORE™, these covers with polytetrafluorethylene/Teflon membranes allow some of the aeration air to escape while retaining the odorous substances under the cover. In addition they provide protection from precipitation and vectors/birds. These types of compost systems require separate buildings for organic waste receipt and mixing.

An alternate odour containment process utilizes negative air that is extracted from open compost piles through the use of fans. This method is practiced at some facilities accepting food waste comingled with yard and garden waste. In this system there are large blowers that extract enough air from the bottom of the composting piles (negative aeration) such that few or no emissions of odorous substances from the process can escape from the surface of the piles. This process system needs to be designed for adequate air suction to ensure process air does not escape from the top of the piles. In addition, it is common to place 15 cm or more of biofilter material or a layer of mature compost on top of piles to treat any odorous substances inadvertently not being caught by the suction system.

These negatively aerated static piles are more sensitive to odour release than fully contained systems, since the system requires proper sizing of blowers, unhindered circulation of air from the piles to the blowers, and good mixing and pile building to the capture of all odorous air. Due to large air volumes, they require large biofilters and emit large volumes of filtered air that may still contain some residual odorous substances released from the bio-filter. Because the piles are open to the atmosphere, it can be challenging to maintain proper moisture content for optimal composting. In addition, the piles are open to the atmosphere while they are being built, moved, or mixed, potentially releasing odorous substances.

Generally, it is best practice for organic processing facilities in urban settings that handle food waste, sludge or biosolids to be fully enclosed to control the release of odorous substances and to keep out vectors (e.g., insects, vermin or birds). The entire process, from waste receipt through end of active composting process, should be maintained in an enclosed environment with air control and treatment. Waste receipt and processing can be located in separate enclosures. Enclosures are also beneficial in cold climates for better process control and for preventing leachate generation in high precipitation areas.

Based on interviews with four large composting facilities in the Pacific North West (refer to Appendix A), the actual composting process at all of the interviewed facilities is either conducted in a building with biofilter odour treatment, or in aerated static piles under a membrane cover.

Best practice for odour control during compost processing is summarized in Table 4.

Table 4: Best Practice for Odour Control During Compost Processing

Category	Best Practice	Comments
Open air composting	Only yard and garden waste is acceptable for processing in open air composting facilities using technologies such as open windrows and static piles.	
Enclosed composting	Maintain optimal C:N ratio, provide adequate aeration, keep moisture in the best range for composting organisms. Maintain separation between process area and ambient air. Monitor temperature and oxygen and adjust air supply as required to maintain optimum conditions.	Good control of composting parameters enables the composting process to achieve the same level of performance using different composting technologies.
Enclosure air control	Process area must always remain enclosed; maintain negative air pressure if process in a building or enclosure.	

3.3.4 Post Processing (Curing, Screening, Storage)

Once compost has achieved pathogen destruction by meeting time and temperature requirements, it is subjected to a post processing or maturation step. At this point, the microbes in the compost are usually still active, and the degree of odour generation depends on the operational procedures used by the operator for the chosen technology. With some technologies, initial post processing is still undertaken in an enclosed environment whereas with others, the process is moved outdoors. Initially, some aeration may still be required to manage odorous substances (either through blowers or by turning the piles). When the curing piles produce very little heat, the curing process is often completed without additional aeration.

The determination of whether outdoor curing piles are a source of odorous emissions that need to be treated depends on the level of maturity achieved in the active composting process. This will vary from technology to technology and actual odour measurements of curing product will be required to determine if additional odour control measures (such as containment or negative aeration) are required. Odour emissions are usually measured in odour units, as described later in this report.

Post processing also includes the screening of the compost to remove oversized amendment materials, such as wood chips (which can then be recycled back into the process) and to reduce the volume of finished product that needs to be stored.

Screening itself will cause some dust, and because the piles are disturbed, some emissions of odorous substances. Screening is typically conducted outdoors and best practice is to screen only when weather conditions are unlikely to carry odorous substances to off-site receptors. In sensitive urban locations, indoor screening with air control may be required.

Adequate space must be allocated (on- or off-site) to allow sufficient compost curing to maturity levels required for product sales.

Best practice is to contain or neutralize odorous substances during curing if the compost piles still have odorous emissions. Screening should only be conducted when weather conditions do not carry odorous substances and dust to off-site receptors.

Best practice for odour control during post processing is shown in Table 5.

Table 5: Best Practice for Odour Control during Post Processing

Category	Best Practice	Comments
Open air Composting	Place 15 cm cover of mature compost over the post processing piles to act as biofilter; conduct screening when weather conditions are favourable.	Allocate adequate space (on- or off-site) to allow sufficient compost curing to maturity levels required for product sales.
Enclosed composting	Conduct initial phases of curing in an enclosed environment with air control, or some form of negative aeration to capture remaining odorous emissions. Screen compost when odour concentration levels are low enough not to cause a nuisance, or screen within a controlled environment.	Allocate adequate space (on- or off-site) to allow sufficient compost curing to maturity levels required for product sales.

3.3.5 Leachate Management

When water, either from rainfall, snowmelt or intentional addition, comes into contact with organic waste materials (e.g., feedstocks) it becomes contaminated and is considered leachate. The inherent water in the organic material and in waste itself can also produce leachate. Typically, leachate drains from composting areas including feedstock piles, active composting and curing piles and residual piles. Where leachate is generated it has to be controlled and collected to prevent leakage and ponding. Poorly managed leachate can generate odorous substances and have environmental impacts. The basics for site drainage are described in Section 4.3 of the Guide for Composting Facilities (MoE 2004).

The same management approach exists for leachate as for odorous substances from other aspects of the composting process; the best way to manage leachate is to avoid its generation in the first place. This is best achieved by separating stormwater from areas where leachate is generated. Only precipitation that comes into contact with waste is considered leachate and needs to be treated for contaminants and odorous substances.

At an organics management facility best practice involves clear separation of areas where leachate is generated and areas where stormwater is collected and drained. Stormwater is all water that drains from structures, covered areas, roads (that are kept clean) and site areas that are not used for waste processing or storage.

Leachate is generated where waste is unloaded, pre-processed, composted/digested, and possibly cured. Finished compost does not typically generate leachate. These areas should ideally be enclosed or at least covered in regions where there are high rainfall events so that the leachate generated is not unnecessarily increased and diluted by precipitation. Leachate needs to be collected and ideally re-used in the process of digestion and/or composting. Whatever cannot be re-used internally needs to be treated. This is often handled by an existing waste water treatment plant, either through a sewer

connection (if access is available) or by trucking the leachate to the plant (if the volumes are low enough).

It is already common for many large composting facilities in the Pacific North West (refer to Appendix A) to cover the actual composting process. Given that most of the odour-sensitive compost processing is conducted indoors, these facilities have little issue with heavy rainfall events. One of the interviewed facilities (Cedar Grove in Washington State) sometimes covers stored piles of finished compost with a tarpaulin.

Facilities with large amounts of excess leachate may require on-site leachate treatment technologies such as passive/ mechanical biological treatment processes, and/or chemical treatment.

Best practice for leachate management with respect to odour control is shown in Table 6.

Table 6: Best Practice for Leachate Management with respect to Odour Control

Category	Best Practice	Comments
Building requirements	Store feedstocks prone to leaching (e.g., food waste) on a covered impervious surface where leachate is collected.	Open air compost systems should not be used for food waste, where excessive leachate volumes can be produced.
Stormwater control infrastructure	Establish diversion ditches, channels, berms, or interceptor drains in order to divert stormwater from entering the site and into composting and storage area. Provide impermeable surfaces with edge berms and curbs to prevent the release of leachate. Pave uncovered waste receipt area with berms to catch leachate and keep separate from storm water.	All containment infrastructure should be designed to capture stormwater run-off during a 1-in-25-year, 24-hour storm event.
Leachate containment infrastructure	Store leachate in underground or above ground tanks. Install appropriate filters in tank vents to reduce odours. Mitigation measures (e.g., secondary containment, aeration) for subsurface pipe work and tanks must be included.	Open-air detention ponds are not suitable for leachate collection and storage. A program of preventative maintenance should ensure the functionality of seals, pumps and other potential odour release points within a leak test regime. A vent filter needs to be replaced regularly.
Stormwater containment infrastructure	Direct stormwater to retention pond and natural capture system.	Aeration or a form of algae treatment may be required to prevent water from turning anaerobic and produce odorous substances.

3.3.6 Facility Capacity and Operational Flexibility

It is important to determine the maximum capacity of a composting facility in order to ensure that waste received can be processed promptly and effectively. The Ontario Composting Guidelines (Ontario Ministry of the Environment , 2012) request that proponents provide calculations of the maximum

capacity of their site which is typically included as a condition of their permit. The calculations should address plans for dealing with seasonal variability, downtime for maintenance and the removal of finished compost from the site.

Site capacity for outdoor facilities depends on the size of the concrete pad(s) for the composting process, windrow spacing and height as well as the time it takes to complete the process. At an enclosed site, the size required for enclosed facilities depends on the vessel size and retention time, as well as time and space needed for curing and truck traffic.

Facilities should be designed with sufficient capacity to allow for routine maintenance of equipment, equipment breakdowns and any major operational issues. The conditions during these events should not compromise any of the process conditions, environmental controls or the quality of compost.

Maintaining operations within the designed plant capacity is important from an odour management perspective. An experienced operator will know not only the theoretical amount of organics that the facility can handle well, but also the practical amount, depending on season and material variability, that the facility's technology can handle without generating excessive odorous substances. This is often determined based on trial and error. A facility that accepts more feedstock than it can practically process will almost certainly produce excessive odorous substances.

Prudent operators will operate their facilities at or slightly below practical capacity to allow for variations in feedstock and process conditions.

3.3.7 Staff Training

Since odour avoidance through proper facility operations is a key odour management component, operator training is an important factor in minimizing the risk of emitting odorous substances at composting facilities.

Item 25.1.2b in the OMRR states that a copy of the personnel training program plan that addresses specific training needed to operate the facility to be in compliance with the OMRR must be submitted as part of the notification of operation. The Solid Waste Association of North America (SWANA) offers a three day course in BC which covers all topics in the OMRR compost facility requirement guidelines. The exam at the end of the course can also be taken as part of the Compost Council of Canada National Compost Operator Certification Program[5]. This program was prepared to promote environmentally responsible and compliant operations and is directed at facility operators and supervisors.

Alberta has a requirement that all non-agricultural composting facilities be supervised by a certified operator during the hours of operation. The key operational personnel should have a "basic certification" (e.g. from SWANA or CCC) which include individuals who are designated as on-site supervision responsible for the operations of the facility.

[5] Information on Compost Council of Canada National Compost Operator Certification Program is accessible via www.compost.org

The certifications required by Alberta for compost facility supervisors are administered by the Compost Council of Canada and the overall program is governed by the Alberta Landfill and Compost Facility Operator Certification Guidelines. The Solid Waste Certification Advisory Committee, which is chaired by Alberta Environment, oversees the program by making recommendations on program requirements, updating exams and auditing certifying partner programs. Furthermore, this certification requires that operators continue to update their knowledge through Continuing Education Units (CEUs). The requirements and training opportunities to meet the CEU requirements are provided by Alberta Environment[6].

All operators at organics management facilities should receive operator certification training. This training teaches the basic principles of composting and the management of odorous substances and leachate. In addition, and since each technology is different, operators must also receive training on the particular technology that they are working with. Training must be structured in such a way that operators can recognize early what can lead to upset conditions that could cause the emission of odorous substances and proactively mitigate these conditions before increased odorous substances are produced and released. Training must include preventative maintenance of all odour management equipment and procedures. Annual training updates are strongly recommended.

There should always be at least one staff with the daily responsibility to note odorous situations in a site log, and the causes analyzed to prevent repeat occurrences. It is important to note that on-site staff that are regularly exposed to odours can become de-sensitized over-time.

3.3.8 By-Products (Overs, Contaminants)

The composting process creates by-products which are typically reused onsite where possible to minimize costs. The “overs” component represents a substantial portion of the feedstock after screening. The proportion of overs depends on the type of amendment material used and the size of the compost screen. Typically about 30% overs are produced, but this can vary substantially. Depending on the point in the composting process where the screening takes place, the overs may be more or less odorous. For facilities where the screening occurs late in the process, e.g. after curing, the overs will emit a lower level of odours than if the screening takes place before or during curing.

The overs piles may also give off some odorous substances when they are stored outdoors or re-used as part of an outdoor process. The magnitude of the odour concentration needs to be measured to determine which odour treatment measures are required, if any.

Other contaminants are also removed from the compost during screening, most notably plastics, stones and glass. These are generally not odorous.

[6] Information on requirements is accessible via: http://www.compost.org/English/PDF/CEU-Policy.pdf

3.3.9 Odour Emissions Monitoring

Odour emissions monitoring is essential for the successful operation of an organics management facility. In addition to regular odour sampling and monitoring, staff must be trained to recognize odorous conditions when they occur during operations and to immediately undertake corrective measures.

Different monitoring methods are needed for various odour sources depending on whether the owner / operator wishes to measure odorous substances from point sources (e.g., stacks, vents), area sources (e.g., open piles / windrows, open tanks, biofilters), or fugitive sources (e.g., windows during turning, open doors, trucks waiting to unload or load).

Chemical quantification can be used to measure specific odorous substance causing chemicals (e.g., ammonia, hydrogen sulphide) to demonstrate compliance with air quality limits established for source monitoring or ambient monitoring. Recognized monitoring techniques are readily available for use in these situations (e.g., the use of gas chromatography or open-path fourier transform infrared spectroscopy). However, the use of chemical quantification may not provide the odour concentration of the full spectrum of odorous substances since they only measure one indicator. Odours are usually made up of numerous individual odorous substances and many of these are present at very low concentrations, sometimes below detection limits. Some substances can still be odorous at very low concentrations.

There is also a sensory technique for monitoring odorous substances using dynamic olfactometry. It provides a direct link between the odour and human perception. The technique involves collecting an odorous gas stream into a Tedlar bag and presenting it to a human odour panel. Typical odour panels are composed of six to twelve selected panel members. The general concept is to dilute air samples with known amounts of odour-free air. The most diluted samples are presented to the odour panel first. Less dilute samples are gradually presented to the panel until 50% of the panel can detect an odour. This is defined as the odour detection threshold. By definition, the odour concentration at the detection threshold is one odour unit (OU) per cubic metre of gas at standard conditions (OU/m^3), or simply one OU. Higher odour concentrations are expressed in terms of multiples of the detection threshold. For example, if an odour sample must be diluted with 10 equivalent volumes of odour-free air then the odour concentration is 10 OU.

As air quality regulation has evolved, two primary standards have developed for the sensory measurement of odours. The first is published by the American Society for Testing Materials (ASTM) as the International E679-04: Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits (ASTM E679-04). The second standard is the unified European Union Standard EN13725:2003: Air Quality – Determination of Odour Concentration by Dynamic Olfactometry. The European Union Standard EN13725:2003 has been adopted by the EU with the standard being approved and published in 2003 after a number of years of testing in nineteen different laboratories (RWDI, 2015). The European Standard EN13725:2003 and the Australian/New Zealand standards (AS4323.3-2001 and NZ4323.3-2001) require that panelists repeatedly and accurately detect n-butanol as a standard odorous substance.

The EU standard is more stringent than the ASTM standard, with additional requirements of EN13725 improving repeatability, reproducibility and accuracy of odour analysis performed in the laboratory, and has also been adopted by Australia and New Zealand, which refer to their respective standards. In a study conducted in 2001, laboratories working in compliance with the EN13725 standard have achieved

a significantly better repeatability and were closer to acceptable thresholds than other laboratories (RWDI, 2015).

There are advantages and disadvantages of monitoring odours as individual odorous substances or in OU. Table 7 highlights the key points for both of these.

Table 7: Advantages and Disadvantages of Measuring Odours as Individual Odorous Substances or in Odour Concentration

Chemical Measurement of Individual Substances	Sensory Measurement in Odour Units
Advantages: • Suitable for operators where only one odorous compound is released and/or can easily be identified. • Relatively easy to set and monitor emissions at the source or under ambient conditions.	**Advantages:** • More comprehensive way to measure odour concentrations, since this covers a broad spectrum of odorous substances. • Subjectivity of human measurement has been reduced due to established standards.
Disadvantages: • Costly if a large number of substances need to be measured. • May require sampling methods with very low detection limits since some substances can be odorous at very low concentrations. • Cannot accurately capture an odour based on individual chemicals if a large number of substances potentially involved in causing the odour (e.g. composting).	**Disadvantages:** • The measurement may be considered subjective, since the odour threshold must be determined by a human odour panel. • There are few laboratories with the analytical capability in Canada (in Montreal and Toronto only) and in the USA estimated fewer than 15 laboratories exist (Yves Martin, Odotech, 2017). • Costly as the method is labour intensive. • Shipping times to laboratories may potentially degrade the odour samples.

The trend in odour emissions monitoring in Europe and Ontario appears to favour the monitoring of OU instead of chemical substances, such as specific volatile organic compounds. This is because OU more accurately reflect the odorous emissions perceived by sensitive receptors. Sometimes, certain chemicals are also monitored and used as a proxy for odours, since individual chemicals are more easily measured.

One example of equipment, which can continuously measure odour concentrations every four minutes at strategically chosen site locations is the electronic nose (eNose). Odotech is one of the suppliers of this technology. The eNose enables facility operators to quantify and monitor odour concentrations from the facility. It helps to identify operational conditions that are likely to lead to odour complaints for nearby receptors. The measurement is based on patented algorithms that transform measurements from 16 different sensors for odorous substances based on calibration done on a specific source that involves olfactory analysis (human panel). The monitoring equipment is customized to each site and to each odour source from which the odour concentration is measured. Each odour monitoring system is customized depending on the number of odour sources. The cost for a facility that uses eNoses can range from $5,000 to $1 million, but is usually between $50,000 - $125,000 for one site. This depends on the type and quantity of sensors required for a site.

At existing composting facilities, odour concentrations can be measured and used in a dispersion model (refer to Section 3.1.2). For example, odour concentration data collected by the eNose can be integrated

with meteorological data received from permanent weather stations on site. The combined information can be used to generate the atmospheric dispersion of odours, which displays the odour dispersion plume. The system generates a site areal map that is colour-coded according to the odour concentration (in OU) to show if there are likely to be any odour impacts at the site boundary and beyond.

The facilities interviewed and reviewed for this study did not use eNoses to demonstrate compliance with regulatory requirements. Other sensors, such as the SulfNose (a hydrogen sulphide sensor) can be used to demonstrate regulatory compliance. There are examples of landfill facilities using the SulfNose for fenceline monitoring. For a compost facility, the eNose can only be used to demonstrate regulatory compliance if there is an odour concentration criteria set for a source emission (e.g., at the outlet of a stack from the biofilter). The data from eNoses at known applications is aimed to inform daily operational activities to prevent off-site odour impacts.

According to Odotech, there are approximately half a dozen facilities using eNoses in BC. These include a biosolids composting facility in Kelowna, Orgaworld in Surrey (operational in 2017) and one WWTP. The Cedar Grove compost facility in Everett, Washington State, U.S., is also using the Odotech odour monitoring system. The electronic odour monitoring system can recognize odour emission excursions in real time, enabling operators to quickly respond to upset conditions, both from an operational and from a public information perspective.

3.3.10 Odour Complaints Management

To maintain good relations with the local community, the operator should have odour response procedures in place to immediately respond to odour complaints. Odour monitoring data should be correlated with odour complaints received. The complaint evaluation should include the recording of the time and location of the complaint recorded and an analysis of if the composting facility could potentially be the cause of the odour complaint based on site conditions and data plus weather conditions.

Best practice for odour monitoring and odour complaints management is shown in Table 8. These best practices are based on a summary of what is being practiced or recommended in BC, in Canada and in the UK.

Table 8: Best Practice for Odour Complaints Management

Category	Best Practice	Comments
Odour complaint recording	Record the complaint for follow-up and assess if composting facility is likely source. Recording and evaluation can be conducted by facility staff, a third party or the regulator, depending on permit conditions.	Odour monitoring data should be correlated with odour complaints received. Odour complaints may be received by the regulator, the facility operator, or both. Coordinated responses may be required.
Odour complaint response	Implement remedial measures when the facility is deemed to cause the odour; and respond to the complaint that the situation is being resolved.	

4 REGULATIONS FOR ODOUR MANAGEMENT IN BC

4.1 ENVIRONMENTAL MANAGEMENT ACT

The BC Ministry of Environment (MoE) administers and regulates air quality issues, including odour issues, under the authority of the *Environmental Management Act* (EMA). The *Organic Matter Recycling Regulation* (OMRR) under the EMA governs production, quality and land application of certain types of organic matter. The EMA and the OMRR are the two primary regulatory documents that govern odour management in BC as administered by the MoE.

The EMA does not explicitly define odour, but does define “air contaminants” in such a manner that odour could be construed as an air contaminant. Additional pertinent definitions are “waste” and the phrase “introduced into the environment”.

"Air contaminant" means a substance that is introduced into the air and that:

a) Injures or is capable of injuring the health or safety of a person,

b) Injures or is capable of injuring property or any life form,

c) Interferes with or is capable of interfering with visibility,

d) Interferes with or is capable of interfering with the normal conduct of business,

e) Causes or is capable of causing material physical discomfort to a person, or

f) Damages or is capable of damaging the environment.

"Waste" includes:

a) Air contaminants.

"Introduce into the environment", in relation to waste, includes discharge, emit, dump, abandon, spill, release and allow to escape into the environment.

Composting facilities that meet the following criteria require a permit issued pursuant to the EMA:

- Facilities that process food waste or biosolids and
- Facilities that have the design capacity to produce 5,000 tonnes or greater (dry weight) of compost per year.

This is in addition to meeting all OMRR requirements as outlined below.

Under the EMA, the MoE does not have the explicit ability to regulate odour, unless it rises to the level of “pollution” or “air contaminant” as defined in EMA. Therefore the MoE has limited ability to control odour emissions directly and encourages the adoption of best practices for the management of odour emissions.

Local governments have the ability to place strict controls on the discharge of odour emissions through contracts or bylaws.

4.2 ORGANIC MATTER RECYCLING REGULATION

The requirements for the management of odorous substances from compost facilities in BC are specified in the *Organic Matter Recycling Regulation* (OMRR). This regulation governs the production, quality and land application of certain types of organic matter[7].

At the time of publication (following initial amendments to the OMRR, which came into effect June 2016 and with further amendments to follow), the regulation requires an environmental impact study (EIS) to be completed prior to approval and operation of a facility. The EIS details the nature and scale of the composting facility, how the project will impact the physical, chemical and biological environment and its receptors, and the measures that can be taken to reduce, alleviate and monitor these impacts.

The EIS report must include information on the proposed odour management measures including buffer zones and plans to minimize the impact on adjacent lands. The requirement for an EIS applies to facilities with a design production capacity of 5,000 tonnes or greater (dry weight) of finished compost per year from biosolids or food waste, or any facility that produces greater than 20,000 tonnes of finished compost (dry weight).

Under Part 5, Division 2 of the OMRR, all compost facilities must have a qualified professional prepare plans and specifications for the construction and operation of a new composting facility (regardless of capacity) or a modification of an existing facility (with some exceptions). All compost facilities, regardless of whether an EIS is required, must have a qualified professional develop:

- An OMP which stipulates how air contaminants from the composting facility will be discharged in a manner that does not cause pollution.
- A leachate management plan which stipulates how leachate generated from any and all stages of the composting process will be minimized, managed, treated or disposed.

A guideline entitled “Compost Facility Requirements Guideline: How to Comply with Part 5 of the Organic Matter Recycling Regulation” (the Guideline) was developed (Forgie et al., 2004) to assist compost facilities with compliance with the regulation. The Guideline provides information that should be considered as part of the development of the EIS and the required plans. The Guideline focuses on considerations for siting, leachate and odour control, as well as general composting best management practices and proactive strategies that could be considered during construction and operation of composting facilities.

The MoE Director may request additional information with respect to the EIS, leachate management plans or OMPs if considered necessary for the protection of human health and the environment, and may specify particular concerns or questions that must be addressed.

[7] “Managed organic matter” is defined in OMRR a Class A biosolids, Class B biosolids or Class B compost. Organic matter (feedstock) suitable for composting under the OMRR is described in Schedule 12 and includes food waste, animal bedding, biosolids, brewery and winery wastes, domestic septic tank sludge, fish and hatchery wastes, manure, milk processing waste and whey, plant matter derived from processing plants, poultry carcasses, red-meat waste, untreated and unprocessed wood residuals, and yard waste.

In October 2016, the MoE published an intentions paper proposing amendments to the OMRR. The MoE intends to consolidate requirements for the EIS, OMP, operating plan, and leachate management plan into one plan called a "facility environmental management plan".

The following supporting documents will be required as part of the "facility environmental management plan":

- An environmental impact study (for facilities with a design production capacity of 5,000 tonnes or greater (dry weight) per year of finished compost).
- An operating plan (all facilities).
- An OMP (all facilities) including, for example:
    - Details on the various sources of odour from the facility and the potential impacts to neighbouring land uses.
    - The types of odours and conditions that may lead to odour emissions and the various practices to mitigate and reduce the odour potential.
    - Odour complaint procedures.
    - Contingency procedures in the event of ongoing odour issues.
- The OMRR currently includes setback requirements for land application of managed organic matter but does not specify mandatory buffers or setbacks for composting facility siting. However, siting considerations and requirements are set out under regional district and/or municipal zoning and related bylaws. Refer to sections below. The amendment of the OMRR will not include any setback provisions for compost facilities in the amendment of the OMRR.

Composting facilities with a total design capacity less than 5,000 tonnes per year, or that that are not processing any food wastes or biosolids will remain under the OMRR and are required to comply with it. In addition, exemptions will exist if a compost facility holds an approval as part of a regional district's solid waste management plan (SWMP) and has been issued an operational certificate by the MoE.

4.2.1 Examples of Application

Since the amendments to OMRR came into effect in June 2016, an estimated nine facilities have submitted permit applications under the amended regulation. Only one permit has been issued (Enviro-Smart Organics Ltd. in Delta) while the remaining eight applications are under review. The permit to Enviro-Smart (dated August 30, 2016) does not include any specific odour emissions monitoring requirements which will be contained in the Metro Vancouver air permit (under review at the time of publication of this report). OMRR permits for sites outside Metro Vancouver will cover air quality, but air emissions from facilities within the region are regulated by Metro Vancouver with authority delegated under EMA. The Permit issued to Enviro-Smart refers to making the EIS available on site (without specific mentioning of odours) and it includes the requirement of the submission of a Design and Operating Plan, which the permittee must have prepared by a qualified professional and submitted to the MoE director (by December 1, 2016 by Enviro-Smart). The EIS and Design and Operations Plan are not publically available and specific monitoring conditions and thresholds are unknown.

The Regional Biosolids Composting Facility in Kelowna has operated under OMRR since 2006, and it submitted an application for a permit to meet the amended OMRR (in effect June 2016) for composting facilities. The following section summarizes the proposed OMP, which was submitted as part of the

OMRR requirements. The OMP was originally developed by a consultant in 2010 and the facility has since operated under this OMP.

The Regional Biosolids Composting Facility in Kelowna composts dewatered sewage sludge using an extended aerated static pile composting system. In 2015 the facility produced 24,323 wet tonnes of compost (approximately 9,693 dry tonnes). The site is permitted under the OMRR to operate in accordance with its OMP which sets out the maximum levels of measured odorous substances and overall odour concentration. The facility is using electronic noses to measure odorous substances and odour concentrations (refer to section on Odour Emission Monitoring).

The Kelowna facility has proposed the following maximum odour concentration criteria for the site under which the facility is already operating:

- Projected odour units at the property boundary: desirable 50 OU/m^3, maximum 100 OU/m^3, based on a 2 hour rolling average.
- Hydrogen sulphide desirable 0.001 ppm, maximum 0.005 ppm. The thresholds will be based on a 2 hour rolling average.

The OMP of the Kelowna facility outlines the reporting requirements to BC MoE in case exceedances occur:

- Exceedance of the desirable levels (50 OU at the property boundary or 0.001 ppm hydrogen sulphide) for 2 hours will lead to investigation of the cause and possible action.
- Exceedance of a higher threshold (for example 75 OU or 0.003 ppm hydrogen sulphide) for a 2 hour time period results in an investigation on how the facility will mitigate through adjustments to the process.
- Exceedance of the maximum level (for example 100 OU or 0.005 ppm hydrogen sulphide) for 2 hours results in an investigation on how the facility will mitigate odours including using covers and full time negative aeration in additional zones necessary to reduce the odour levels to acceptable levels, and/ or diverting biosolids elsewhere.

There are other compost facilities that are currently operating in BC without specific limits on odour emissions. For example, the compost facilities in Nanaimo, Whistler and Abbotsford have no specific odour concentration limits in their permit requirements. Odours are dealt with when there are odour complaints. The Whistler and Abbotsford facilities have not had odour complaints. The compost facility in Nanaimo had to undertake a study including odour dispersion modeling, capital investments and operational changes to deal with odour complaints in the past.

4.3 REGIONAL BYLAWS

The EMA gives regional districts the authority to make bylaws to regulate solid waste management and air quality management.

4.3.1 Metro Vancouver's Solid Waste and Recyclable Material Regulatory Bylaw No. 181

Under Metro Vancouver's Solid Waste & Recyclable Material Regulatory Bylaw No. 181 (Bylaw 181), licenses are required for all privately operated landfills, transfer stations, material recovery facilities, storage facilities and certain brokers of municipal solid waste and recyclable material. The goal of the

regulatory system is to ensure proper management of privately operated facilities by specifying operating requirements to protect the environment and public health, to protect the region's land base in accordance with the host municipality's zoning and land use policies, to ensure that regional and municipal facilities and private facilities operate to equivalent standards, and to achieve the objectives of the Integrated Solid Waste and Resource Management Plan.

Compost facilities must have and comply with a valid license. A license application is shared with the relevant municipality in which the facility is proposed to be located. The municipality provides a report containing its comments and recommendations concerning the application and stating whether the municipality approves or does not approve of the application. The Metro Vancouver Solid Waste Manager completes the evaluation of the application and may issue a License to the applicant. A license would not be issued if the municipality does not approve of the application.

The Solid Waste Manager may issue a License to a facility, which may, for example:

- Specify which waste material can be handled at the Facility in the manner, with the frequency, in the quantity or volume and during the period of time specified by the Solid Waste Manager.
- Specify materials that are not allowed to be handled.
- Provide specified operating procedures and requirements.

Other conditions can be found on page 12 of 22 of the Bylaw 181[8].

The Solid Waste Manager, or an Officer, has the power to examine, take away and make records relating to the causing of pollution, and carry out inspections, observations, measurements, tests and monitoring to ascertain whether the terms of the License have been or are being complied with.

The Solid Waste Manager may suspend or cancel a License where the Licensee for example fails to comply with the terms, conditions or requirements of the License.

As of January 2017, there were 48 Metro Vancouver licensed solid waste and recyclable material facilities, of which six are composting facilities.

4.3.2 Metro Vancouver's Air Quality Management Bylaw No. 1082

Metro Vancouver's Air Quality Management Bylaw No. 1082 (Bylaw 1082) applies to composting facilities whether or not they are prescribed under the *Environmental Management Act* or its regulations. The bylaw prohibits, regulates, controls and prevents the discharge of air contaminants. The bylaw defines an "Air contaminant" as any substance that is emitted into the air and that:

a) Injures or is capable of injuring the health or safety of a person;
b) Injures or is capable of injuring property or any life form;
c) Interferes or is capable of interfering with visibility;
d) Interferes or is capable of interfering with the normal conduct of business;
e) Causes or is capable of causing material physical discomfort to a person; or
f) Damages or is capable of damaging the environment.

[8] Available via URL link: http://www.metrovancouver.org/boards/Bylaws1/GVSDD_Bylaw_181%20-%20Unofficial%20Consolidation.pdf

The district director may issue a permit to allow the discharge of an air contaminant subject to requirements considered advisable for the protection of the environment. The permit can place limits and restrictions on the quantity, frequency and nature of an air contaminant permitted to be discharged and the term for which such discharge may occur. It can also specify monitoring requirements.

Permits and approvals can be amended if the district director considers it necessary for the protection of the environment or if the permit or approval holder applies for an amendment. The Board or the district director may suspend the permit or approval for any period, or cancel the permit or approval.

4.3.3 Bylaws of Other Regional Districts

In 2005, the Capital Regional District (CRD) approved the Composting Facilities Regulation Bylaw (Bylaw 2736) which was authorized under the EMA. The purpose of the CRD composting bylaw is to complement existing provincial requirements. In particular the CRD bylaw:

- Specifies that restricted organic matter (e.g., food waste) requires in-vessel composting and a license under the bylaw.
- Requires leachate, nuisance odour, vector, litter and dust management plans.
- Establishes a regulatory system for enforcing the requirements.

The bylaw sets out requirements, such as no discharger shall operate a composting facility in a manner that creates or results in litter, dust (spores or other particulates), odours or vectors so as to pose a risk to public health or the environment or constitute a public nuisance. Odour means smells which are ill-smelling, disgusting, offensive, nauseous or obnoxious.

It also requires an applicant to engage a qualified professional who has experience with odour management systems, to prepare an OMP. The plan must show how the generation of odorous substances detectable beyond the boundary of the parcel on which the composting facility is located will be prevented.

There are currently no composting facilities licensed under this bylaw.

Other regional districts aim to control odour emissions from composting facilities through waste stream management licensing bylaws. For example, the Regional District of Nanaimo (RDN) passed Waste Stream Management Licensing Bylaw No. 1386 in 2004. Under this bylaw, the RDN is authorized to license all private or non-government operated municipal solid waste diversion and recycling facilities within the region. The RDN's bylaw does not specify any requirements for odour or nuisance control.

The Cowichan Valley Regional District (CVRD) passed a similar bylaw in 2004. The Waste Stream Management Licensing Bylaw No. 2570 requires that any person wanting to operate a waste management facility in the Cowichan region must apply for a license to do so from the District. Through application of CVRD's bylaw, it places operational requirements on compost facilities, including maximum quantity of feedstock allowed for processing and stockpiling on-site broken down by various feedstock categories, capacity limits and leachate management. CVRD's bylaw requires the applicant to submit an operating plan, which must include the provision for odour and vector control and prevention. Compliance with these conditions are regularly audited by an officer.

Odour monitoring requirements can be included in license conditions. In one example of license conditions in CVRD for the composting facility owned by Fisher Road Holdings at Cobble Hill, the license

required ammonia sampling to and from biofilters conducted by colorimetric gas detection tubes or portable electronic gas monitors. The license did not include any ammonia criteria. There are no requirements for odour monitoring of other odorous substances apart from ammonia. This license specified daily odour monitoring via field investigation and specific remediation procedures in case of biofilter failure or odour complaints. Biofilter failure can be detected through inspections by facility operators based on observations, for example hot and cold spots indicating channeling or growth of weeds indicating old media. The license requirement is designed to inform the daily operations of the facility and ensure self-monitoring and odour prevention. When complaints are received, the facility is notified immediately. This particular facility (Fisher Road Holdings at Cobble Hill) is regularly receiving odour complaints from sensitive receptors (there are residents within 200 metres from the facility boundary). There is no threshold specified in the license conditions for a maximum number of odour complaints accepted before remediation activities are required. On an annual basis, the facility must report on all odour complaints made regarding the facility.

4.4 LOCAL GOVERNMENT REGULATIONS

It is common to use municipal zoning to regulate land use in municipalities and electoral areas. A zoning bylaw implements the broad goals, objectives and policies within the Official Community Plan at a site-specific level. It can regulate land uses including permitted uses, accessory uses, size and placement of buildings and structures - including setbacks from the property line, and height restrictions. Zoning bylaws aim to influence the type of industry allowed and not how it operates.

Other types of local government regulations address nuisances. For example, the City of Campbell River has addressed odours via the Public Nuisance Bylaw No. 3543, 2014 (Consolidated to Bylaw 3636, 2016). The bylaw provides an odour scale:

- Level 0 – no odour detected.
- Level 1 – odour barely detected.
- Level 2 – odour is distinct and definite, any unpleasant characteristics recognizable.
- Level 3 – odour is objectionable enough or strong enough to cause attempts at avoidance.
- Level 4 – odour is so strong that a person does not want to remain present.

In accordance with the bylaw, every owner or operator of a commercial business that discharges or emits a nuisance odour at a level 2 or greater that disturbs the occupants of the neighbourhood or persons in the vicinity shall, at the request of the City, supply the City with:

- A report prepared by an independent odour control specialist recommending ventilation systems and methods that will be used to prevent nuisance odours from leaving the premises so that no nuisance odour at a level 2 or greater can be detected by a person with a normal sense of smell at the exterior of the Premises regardless of wind direction.
- A letter of certification sealed by the Independent odour control specialist confirming that the methods approved by the City of Campbell River to prevent nuisance odours from leaving the premises have been fully implemented.
- A nuisance odour is defined by the City of Campbell River bylaw as an odour in the air that is harmful, poisonous, disgusting, repulsive, very unpleasant, offensive, or interferes with the use or enjoyment of property, endangers personal health or safety, or is offensive to the senses and

causes inconvenience or annoyance to a person with a normal sense of smell, except odours related to a permitted combustion such as, but not limited to, wood stoves, vehicle emissions thereto. The bylaw does not define a "normal sense of smell".

Other municipalities using nuisance laws which include odour control are:

- City of Courtenay Bylaw No. 2804
- District of Lake Country Nuisance Bylaw No. 857, 2013
- Mission District of Mission Good Neighbour Bylaw No. 5524-2016
- West Vancouver Controlled Substance Nuisance Bylaw No. 4417, 2005
- City of Surrey Controlled Substance Property Bylaw No. 15820

District of Sechelt is also considering a nuisance odour prohibition put forward to address odour issues around composting and marijuana production.

4.5 Odour Management in Contracts

Phone interviews were conducted with operators of four large organics management facilities in BC and Washington State, USA. There are currently few facilities that are required to monitor and control odours as part of contractual requirements placed by regional districts or municipalities.

For example, neither the RDN, nor CVRD have such requirements. The contract between the compost operator and RDN simply states that if the works results in pollution or odour complaints, the regional district may direct the contractor to cease or modify the work in order to reduce the odour pollution (Gardner, L. personal communication, February 28, 2017).

In February 2017, the City of Richmond used its contractual requirements for Harvest Power to address odour issues at the Richmond facility. The City recently issued a Notice of Default to Harvest Power resulting from the odour issues. Under the existing Service Agreement, Harvest Power will have 30 days to remedy odour issues to the City's satisfaction. The City's contract with Harvest Power expires in 2019. If terminated early, the City's organic waste, which only represents approximately 10 per cent of all of Harvest Power's total feedstock, would be diverted to other regional compost facilities (City of Richmond, February 2017).

In the contract requirements placed on Orgaworld in Surrey, the City of Surrey requires that the odour concentrations at the site boundary (within a 1.5 km^2 area surrounding the site) do not exceed the ambient odour criteria of 1 OU/m^3 based on a 10 minute average, more than 0.5% of the time. The facility is scheduled to be operational in 2017. The odour performance standard will be monitored and measured by an in-stack exhaust continuous emission monitor, which will measure concentrations of odorous substances. It is unknown which specific substances the facility is required to monitor. It is understood that odour units will also be measured using eNoses (refer to the section of Odour Emission Monitoring for more information on the eNoses). A remote notification system will give warning to the City if the maximum permissible odour emissions rate is exceeded. The City of Surrey will have remote access to all real time odour reporting, stack measurements and meteorological measurements (Oostelbos, P. personal communication March 8, 2017).

5 ODOUR MANAGEMENT AND REGULATIONS IN OTHER JURISDICTIONS

Canadian federal legislation does not contain any regulations pertaining to the emissions of odours from industrial or agricultural facilities. Instead, the individual provinces and territories have a responsibility for odour emissions (Bokowa 2010). There are currently different approaches taken across Canada. The following section focuses mainly on the Ontario regulation since it is considered more prescriptive than the BC regulation. It is followed by a summary of odour regulations in some other provinces in Canada (e.g., Saskatchewan and Quebec). Appendix A provides more examples of definitions in Canadian provincial regulations related to odour.

5.1 ONTARIO, CANADA

Numerous acts and regulations exist to help the Ontario Ministry of Environment and Climate Change protect clean and safe air, land and water and to ensure healthy communities. The most important act and regulation applied to composting facilities is the *Environmental Protection Act*, R.S.O. 1990, c. E.19 (EPA), and Regulation 347 (General – Waste Management), which regulates waste management activities, including the receiving and processing of organic waste materials by compost facilities.

The Ontario EPA is explicit with respect to prohibiting the causing of an adverse effect, although it specifically refers to water treatment and agricultural operations. Section 14 of the EPA states that a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect. A "contaminant" means any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of them resulting directly or indirectly from human activities that causes or may cause an adverse effect.

The Ontario EPA defines an "adverse effect" means one or more of the following:

a) Impairment of the quality of the natural environment for any use that can be made of it;

b) Injury or damage to property or to plant or animal life;

c) Harm or material discomfort to any person;

d) An adverse effect on the health of any person;

e) Impairment of the safety of any person;

f) Rendering any property or plant or animal life unfit for human use;

g) Loss of enjoyment of normal use of property; and

h) Interference with the normal conduct of business.

Other acts and regulations that are relevant to odour management include the *Ontario Water Resources Act*, *Nutrient Management Act, Clean Water Act, Environmental Assessment Act* and the *Environmental Bill of Rights*. These laws will not be described in any further detail in this report.

Part 5 of the EPA and Regulation 347 set out requirements for handling, storing, managing, and disposing of waste. Feedstock in a composting process is waste as defined under this legislation. Unless

otherwise exempt, a composting facility will require an environmental compliance approval (ECA) for a Waste Disposal Site (Processing) under section 27 (1) (b) of the EPA.

Control measures for odour emissions from compost facilities are regulated by subsection 14 (1) of the EPA and Ontario Regulation 419/05 Air Pollution – Local Air Quality, made under the EPA. The Regulation places limits on the concentration of contaminants in the natural environment that are caused by emissions from a facility. The concentrations in the natural environment are calculated at a nearby receptor referred to as a "point of impingement" (or POI). Demonstration of compliance with the Regulation begins with the development of an Emission Summary and Dispersion Modelling (ESDM) report, which must include a summary of total air emissions for individual contaminants from a property. Air dispersion models are then used to predict off-property concentrations of individual contaminants at nearby sensitive receptors (e.g., residences, nursing homes, health care facilities, day cares, schools) based on air emissions at the source. The Regulation requires that where a facility discharges a contaminant into the air from one or more sources, the concentration at any POI resulting from that combined discharge must be less than the standard prescribed in the Regulation.

Contaminant-specific air quality standards have been specified to protect against adverse health and environmental effects. However, the Guideline for the production of compost in Ontario has acknowledged the fact that odorous substances can cause an adverse effect even when individual contaminant standards are respected (Ontario Ministry of the Environment, 2012). As such, a composting facility should estimate the odour emission rates from all the odour sources in the composting facility. Then, these odour emission rates should be used in an air dispersion model to calculate the odour concentration levels at nearby sensitive receptors. Results of this calculation are used to assess whether adverse health and environmental effects are likely to occur.

In Ontario, compost facilities must demonstrate that they will not cause odour concentrations that are greater than 1 OU/m^3 at a sensitive receptor, based on a 10 minute average concentration. Concentrations higher than this have the potential to cause an adverse effect and can result in public complaints.

Unless otherwise exempt, composting facilities will require an environmental compliance approval (ECA) under section 9 of the EPA (Air), where there is a direct discharge of contaminants into the natural environment. ECA requirements may include source testing requirements in accordance with the Ontario Source Testing Code (OSTC) and Technology Benchmarking Reports, published by Ontario MoE. The OSTC specifies methods and procedures for the measurement of emissions of air contaminants (pollutants) from stationary sources (Method ON-6), when such emission data are required for the purpose of determining compliance with the EPA and the Ontario Regulation 419/05.

An ECA can require Source Testing to determine the rate of odour emission from the sources on-site. The testing protocol helps to estimate the maximum 10-minute average concentrations for odorous substances and odour concentrations when measured at the facility's property and at the most impacted sensitive receptor, and allows comparison with the performance limit for odour set by the ECA.

Where facilities are emitting odours from a mixture of odorous substances, the ECA can include specific terms, performance conditions and schedules. A performance condition will set a specific target in terms of allowable concentrations of odorous substances and odour concentrations that must be met at sensitive receptors. This target may also allow for some frequency of excursions above the target, but

not always. As such, there is inconsistency from one facility to another when it comes to how odour is handled (RWDI, 2015).

5.1.1 Examples of Application

The use of a maximum 1 OU (10-minute average) ambient performance limit is not an official limit and is applied ad-hoc with little consistency across the province (SENES, 2014a). The review of three ECAs concluded that the maximum 1 OU performance limit is only sometimes applied. While one example included the 1 OU performance limit, another ECA allowed a maximum of 5 OU and a third ECA did not have any ambient performance limit at all.

The ECA issued in 2014 to the Orgaworld compost facility in Ottawa contains odour management requirements that include the development of a Fugitive Odour Control Plan. The Plan is required to identify fugitive odour emission sources from the facility and outline the physical and procedural controls, such as policies and standard operating procedures, required in order to prevent odour emissions from the site.

Orgaworld's ECA contains operational requirements on the facility, such as keeping doors closed at all times, maintaining the building under negative air pressure, and immediately screening and moving odorous materials indoors upon receipt. The Source Testing requirement for Orgaworld involves determining the rates of emissions of odour concentration (in OUs), hydrogen sulphide and total mercaptans from the exhaust stack of the air pollution control equipment, every six months or within a period as directed or agreed to by the District Manager. Orgaworld must also determine, at times of Source Testing, the rate of emission of odour from the fugitive odour sources in the facility. The fugitive odour sources include the leaf and yard waste on the storage pad outside the enclosed building of the facility, and the finished compost stored outside.

If the results of dispersion calculations conducted in any report on the Source Testing or fugitive odour emission measurement indicate non-compliance with the ECA, Orgaworld is required to investigate the causes of the non-compliance and create an implementation schedule of the remedial actions identified to bring the facility back into compliance. The Company is required to repeat the Source Testing within one month after completion of remedial actions.

5.2 OTHER PROVINCES IN CANADA

The following information references RWDI (2015) from its review of odour regulations in Canada. It provides some key examples of odour regulations in other provinces in Canada.

5.2.1 Saskatchewan

The *Saskatchewan Clean Air Act* (SCAA) provides clear definitions with respect to odour, as follows:

- "Air contaminant" means a solid, liquid, gas or combination of any of them in the ambient air that contributes to air pollution.
- "Air pollution" means the presence in the ambient air of any air contaminant:
    a) In a concentration greater than the permissible concentration specified in a permit or prescribed in the regulations;
    b) In quantities that are or are likely to:
        i. Be injurious to the health, safety, comfort or well-being of the public;

ii. Be injurious or damaging to property or plant or animal life;
iii. Interfere with normal business; or
iv. That has an offensive or obnoxious odour, regardless of its concentration.

The *Saskatchewan Clean Air Regulation* sets out the detailed requirements for obtaining a permit, which includes reference to the following:

- The expected mass rate of release into the ambient air of all air contaminants on a daily basis as well as an annual basis, under normal and maximum production conditions.
- Information about the possible variations in the composition of any atmospheric emission or the release rate of any air contaminant under different production rates, during start-up, shut-down or upset conditions.
- The calculated ground level concentrations of all air contaminants that may be released under normal and maximum production conditions.

The Saskatchewan Air Quality Modelling Guideline proposes a tiered approach to modelling, with screening level dispersion models acting as the basis for the first tier. The "specialized" modelling is available only for situations in which the first two tiers are not appropriate, such as where complex terrain or land-water interfaces are a concern or areas where a large frequency of very low wind speeds can be expected.

The purpose of the Air Quality Modeling Guideline is to provide consistency in conducting air quality modelling for all approvals, environmental impact assessments and environmental protection plans. The modelling is primarily used for the development of the aforementioned items, but can also be conducted for the selection of air monitoring sites and the development of appropriate air monitoring programs. Modelling may also be used by the Saskatchewan ministry to respond to the public or to design plans for air quality management in the province.

As shown in Table 10 on Ambient Criteria for Odour Concentrations, Saskatchewan has established Odour Criteria for Modelling for four different land uses (from urban residential zones to Industrial or agricultural zones with predominantly agricultural utilization) each one with Odour Concentration Standards in OU for a 1 hour period with 99.5% compliance. This province has also established three Odour Criteria for Field Investigation). In comparison to Ontario, Saskatchewan appears to have more defined criteria for odour concentrations for new facilities.

5.2.2 Quebec

The Quebec Environment Quality Act (EQA) defines odour as a "contaminant", which means a solid, liquid or gaseous matter, microorganism, sound, vibration, rays, heat, odour, radiation, or combination of any of them likely to alter the quality of the environment in any way. Under the *Quebec Regulation Respecting the Quality of the Atmosphere*, promulgated under the EQA odour is further defined through the definition of odour level. An odour level means the volume in cubic metres occupied by a cubic metre of contaminated air when diluted at the threshold of perception. The regulation provides the relevant measurement method. Odours are determined according to the method entitled Standard Method for Measurement of Odor in Atmospheres (Dilution Method) published by ASTM under No. D 1391-57 (1967), or equivalent. The standard specified in the regulation was withdrawn in 1986 and has not been replaced (ASTM, 2017).

Under the *Quebec Regulation Respecting the Quality of the Atmosphere* odorous substances are regulated using a quantitative emission criterion, which is industry specific. According to RWDI (2015), Quebec is the only province with this approach to regulation. The benefit of this method is that enforcement can be done through mandatory source testing, which can then provide a specific pass / fail determination. In this respect, it is more effective from a regulatory point of view, and provides a clear set of requirements for facility operators. According to Odotech (Martin, Y., personal communication, March 28, 2017), the province is not actively enforcing these requirements.

5.2.3 Examples of Odour Based Standards in Different Canadian Jurisdictions

Table 9 presents the odour based standards in different Canadian jurisdictions for the measurement of hydrogen sulfide (H_2S) concentrations.

Table 9: Odour-based Standards for Hydrogen Sulfide (RWDI, 2015)

Jurisdiction	Compound	Standard	Averaging Time	Use	Comments	Date
B.C.	Total Reduced Sulphur as H_2S	28 µg/m³	1-hour	Objective	Acceptable	1977
		6 µg/m³	24-hour	Objective	Acceptable	1977
Saskatchewan	H_2S	15 µg/m³	1-hour	Standard	-	1975
		5 µg/m³	24-hour	Standard	-	1975
Ontario	Total Reduced Sulphur as H_2S	13 µg/m³	10 minutes	Ambient Air Quality Criteria	-	2013
Quebec	Total Reduced Sulphur as H_2S	6 µg/m³	4 minutes	Quebec Clean Air Regulation	-	2011

The *Quebec Clean Air Regulation* also has a set of over 116 air quality standards for specific substances, many of which could be considered odorous substances.

Table 10 compares the ambient air quality criteria established in Canada (Saskatchewan and Ontario).

Table 10: Ambient Air Quality Criteria in Odour Units (RWDI, 2015)

Jurisdiction	Offsite Standard or Guideline (OU/m³)	Averaging Time	Frequency Criteria	Use (Permit Guidance)	Comments	Date
Saskatchewan	1	1 hour	99.5 % compliance	Odour Criteria for Modelling	Urban residential zones	2012
	2	1 hour	99.5 % compliance		Urban commercial zones or mixed residential and commercial zones	2012
	4	1 hour	99.5 % compliance		Industrial or restricted business zones and rural zones with mixed utilization	2012
	6	1 hour	99.5 % compliance		Industrial or agricultural zones with predominantly agricultural utilization	2012
Saskatchewan	2 D/T[9]	2 tests not less than 15 min apart nor more than 60 min apart	99.5 % compliance	Odour Criteria for field investigation	Residential/urban residential zones	-
	4 D/T		99.5 % compliance		Mixed residential and commercial zones/ rural zone	-
	7 D/T		99.5 % compliance		Industrial or agricultural zones	-
Ontario	1	10 minutes			Proposed standard. Measured at the most impacted sensitive receptor	2013

[9] D/T means dilutions to threshold. The units OU and D/T are conceptually equivalent (i.e., 1 OU = 1 D/T); however, differences in the standard methodologies can lead to differences in the measured odour concentration (RWDI, 2015).

5.3 UNITED KINGDOM IN THE CONTEXT OF THE EUROPEAN DIRECTIVE

This section primarily relates to England. The regulatory regimes in the rest of the UK are similar (and largely stem from the same European Directives) but implementation by the regulators in Scotland, Wales and Northern Ireland is subtly different.

The overarching regulatory requirements come from the EU Waste Framework Directive, which requires all member states to take the necessary measures to ensure waste is recovered or disposed of without endangering human health or causing harm to the environment, the definition of which includes '*causing a nuisance through odours'*.

While each EU member state can define BAT, there is overarching guidance produced by the EU known as the BAT (Best Available Techniques) Reference Document (BREF).

Odour in the UK may defined as *'a characteristic property of any compound that makes it perceptible to the sense of smell, whether pleasant or unpleasant, fragrance or stench'*[10].

The UK Environment Agency report "biofilter performance & operation as related to commercial composting defines odour as *"…a stimulus of olfactory cells in the presence of specific compounds (organic or inorganic).*"

Odour Guidance for Local Authorities provided by Department for Environment, Food & Rural Affairs (DEFRA) defines the possible effects of environmental odours as:

> *"Odour is perceived by our brains in response to chemicals present in the air we breathe. Odour is the effect that those chemicals have upon us. Humans have sensitive senses of smell and they can detect odour even when chemicals are present in very low concentrations. Most odours are a mixture of many chemicals that interact to produce what we detect as an odour. Odour-free air contains no odorous chemicals whilst fresh air is usually perceived as being air that contains no chemicals or contaminants that could cause harm, or air that smells "clean". Fresh air may contain some odour, but these odours will usually be pleasant in character such as the smell of freshly mown grass or sea spray.*
>
> *Different life experiences and natural variation in the population can result in different sensations and emotional responses by individuals to the same odorous compounds. Because the response to odour is synthesised in our brains, other senses such as sight and taste, and even our upbringing, can influence our perception of odour and whether we find it acceptable, objectionable or offensive."*

Therefore, whilst it is evident that odour effects can contribute to a reduced quality of life for the individuals who are exposed to the odour, there is significant variation in how an individual perceives an odour. For that reason, Regulatory Agencies assess 'risk of annoyance', often using the FIDOL framework: Frequency, Intensity, Duration, Odour unpleasantness and Location. There is no framework as how the FIDOL factors should be used and it is left to the individual Officer to justify whether the risk of annoyance is acceptable.

[10] Environment Agency, How to comply with you permit, H4 Odour Management, March 2011.

Nuisance is typically more of a legal term and is considered to be the cumulative effect of repeated events of 'annoyance'.

In the UK, nuisance through odours is regulated through licenses or permits issued by the national regulators with differing requirements depending on scale / risk:

- Very small / low risk facilities can register for exemptions i.e. for onsite composting of park waste.
- 'Standard rules Permits' for mid-size facilities i.e. on-farm AD sites and composting if <75 tonnes per day (tpd) and relatively insensitive location.
- 'Bespoke Permits' for larger / higher risk sites i.e. >75 tpd and in proximity to sensitive receptors.

For larger biowaste treatment facilities (>75 tpd for composting and 100 tpd for AD) the requirements of the EU Industrial Emissions Directive (IED) also apply. The IED requires that the BAT are applied to minimize the environmental impact of operations.

The Waste Treatment BREF was originally issued in August 2006 and an update draft was released in December 2015 but has not yet been formally adopted (there is no indication of any substantive changes to the odour management and monitoring aspects). The Waste treatment BREF applies to activities that include facilities for the disposal or recovery of organic wastes by biological methods.

5.3.1 Animal By-Products Regulations

The biological treatment of food wastes will include material covered by the Animal By-Products Regulations (ABPR), regulated in England by the Animal and Plant Health Agency (APHA), from whom a license is required.

The ABPR defines three categories of ABP; 1 for high-risk (typically material from animals with high risk diseases) to 3 for low risk (suitable for human consumption, including catering waste, etc.).

5.3.2 Land-Use Planning Requirement and Environmental Assessments

In addition to a permit or license from the Regulator, a site will also require planning permission from the relevant 'waste planning authority' (equivalent to zoning approval in Canada) and this planning application process will seek to ensure that surrounding community is not adversely affected by unacceptable levels of pollution (which includes odour).

For larger biowaste treatment sites (typically >0.5ha, or 100 tpd, although site specific) an Environmental Impact Assessment (EIA) may also be required under the EU EIA Directive, which requires that any significant adverse effects on humans or air pollution be assessed. This is equivalent to zoning in Canada.

5.3.3 Requirements for Monitoring and Modelling of Odorous Substances

The standard unit applied in the quantification of odour is the European Odour Unit (ou_E) which is determined by the human response using olfactometry in accordance with BS EN 13725:2003. This protocol has unified olfactometry standards in over 18 countries and has started to be incorporated in other legislation around the world (RWDI, 2015).

The BREF for Waste Management states:

> *"BAT 6 – BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards. Emissions can be monitored by dynamic dilution olfactometry according to EN 13725."*

For odour impact assessment of a proposed facility, atmospheric dispersion modelling is typically applied. Like air quality standards for individual pollutants, exposure to odorous emissions is assessed in terms of the average level of European Odour Units predicted in ambient air without considering rare spikes in odour concentration that may occur less than 1-2% of the time over the course of a year. These impact criteria apply only to locations where an individual's exposure is likely to occur for prolonged periods of time i.e. residential properties. Where exposure is more transient, i.e. roads, footpaths, workplaces, further consideration should be given to the sensitivity of the receptor and how the duration and frequency of exposure of the individual will influence the acceptability of the predicted impact.

Currently in the UK there are no statutory numerical standards; however EA guidance proposes indicative criteria of between $C_{98,\ 1\ hour}$<1.5 ou_E/m^3 and $C_{98,\ 1\ hour}$<6.0 ou_E/m^3 dependent upon the relative offensiveness of the source (Table 3). Generally, for biowaste sites, the $C_{98,\ 1\ hour}$ 1.5 ou_E/m^3 is requested by the EA and is the expected standard for planning, although for a purely 'green waste' composting $C_{98,\ 1\ hour}$ <3 ou_E/m^3 is more relevant due to the nature of the odour. UK ambient air quality criteria in odour units are presented in Table 11.

Table 11: United Kingdom Ambient Air Quality Criteria in Odour Units (RWDI, 2015)

Jurisdiction	Offsite Standard or Guideline (OU/m^3)	Averaging Time	Frequency Criteria	Use (Permit Guidance)	Comments	Date
United Kingdom	1.5	1 hour	98 % compliance	-	For offensive odours	2007
	3	1 hour	98 % compliance	-	For moderately offensive odours	2007
	6	1 hour	98 % compliance	-	For less offensive odours	2007

Off-site monitoring of odorous emissions is typically limited to olfactory surveys, either by Operators/Regulators to an agreed protocol, or in some EU member states to more rigid 'field survey' techniques (such as the German VDI 3940 Part 1 - Measurement of odour impact by field inspection) and a separate European Standard is being developed to standardize this approach. The German 'Guideline on Odour in Ambient Air' (GOAA) defines a rigid 'field survey' approach which is applied for Regulatory purposes and sets an acceptable limit (at 0.1 or 10% of the time for residential locations) of 'odour hours' which is defined as an odour being identified for >10% of the observation period (i.e. if odours are identified for >1 minute in a 10-minute observation period, then this equates to an odour hour). The GOAA also sets clear procedures for the field observations both in terms of area, locations, duration and the testing of the observers' acuity to odour.

Additionally 'electronic-noses' are applied in some situations for off-site continuous monitoring of odorous compounds, but there is no accepted standard for such techniques.

While there are no specific requirements to routinely monitor the emissions of odorous substances from biowaste sites, when required (either due to complaint investigation or stipulation by Regulator) emissions from biowaste sites would typically be monitored at source (where detection is more reliable and achievable) with dispersion modelling used to predict levels offsite. This could either be from a stack or from the surface of a biofilter or windrow (using a 'hood' sampling technique).

Monitoring of emissions from fugitive sources (particularly intermittent sources involving agitation of material) is extremely challenging and there are no standard methodologies. Techniques involving 'down-wind' monitoring and back modelling using micro-meteorological models have been applied for specific activities with some claimed success, but typically on a research basis and not for regulatory purposes.

For operational sites, the Regulators require a combination of a 'boundary condition' and detailed OMPs. The typical 'odour boundary condition' included in a permit or license states:

> *"Emissions from the activities shall be free from odour at levels likely to cause pollution outside the site, **as perceived by an authorized officer of the Agency**, unless the operator has used appropriate measures, including, but not limited to those specified in an approved OMP, to prevent or where that is not practicable to minimize the odour."*

The OMP is considered to be a key operational requirement. It stipulates the design parameters of any air extraction, abatement plant (e.g. the EA has specific requirements for air changes within buildings and biofilter design parameters) and monitoring of a wide range of process variables, to minimize the risk of odour generation (many of which are also required for ABP and product accreditation), as well as contingency measures for responding to plant breakdown, etc.

While abatement technologies are not stipulated and emission limits at the source are not typically set in ou_E/m^3, the 'Waste Management BREF' indicates the following:

> *"BAT 32. In order to reduce channeled emissions of odorous substances, H_2S and NH_3, BAT is to use a biofilter."*

Typically in the UK, biowaste facilities are not required to monitor emissions at source for specific odorous compounds and rely on monitoring of process parameters (e.g., temperature, oxygen, moisture, etc. within windrows, and pressure drop, pH, etc. of the biofilter) as part of an OMP and offsite olfactory observations. The specific monitoring requirements are determined on a site by site basis, but more sensitive sites may include emission (and abatement) testing according to EN:13725:2003 on an annual basis. For some sites, the periodic monitoring (weekly) of odorous compounds (such as hydrogen sulphide, ammonia or volatile organic compounds) exiting the odour treatment system is set as a permit condition, but more typically any such monitoring would be defined in the OMP.

The only odorous substances which the BREF indicates emission limits for are hydrogen sulphide and ammonia, with the BREF identifying the BAT-AELs (the associated emission level following the application of the BAT to abate emissions, i.e., a biofilter). The following emission concentrations are associated with the application of the BAT (Frederickson J. et al., 2013):

- Ammonia 0.1 – 10 mg/Nm^3
- Hydrogen sulphide 0.1 - 1 mg/Nm^3

EU Member States do not have to stipulate the requirement to monitor these odorous compounds and each member state sets its own limits and monitoring requirements that meet the overall BAT requirements of the BREF.

5.3.4 Examples of Application

In a review of five current biowaste permits from the UK, the following observations were made:

- Daily olfactory monitoring involving sniff testing may be part of an OMP.
- Process monitoring of biofilters is often specified (temperature, moisture and compaction), however in most cases, no olfactometric monitoring is required.
- One of the permits required six monthly olfactometric monitoring of biofilters as per the approved OMP.
- Regulatory performance standards for emissions of potentially odorous substances from facilities are not typically applied by regulators in the UK.

Ambient air quality performance limits are not provided. Based on the review, references to OU and dispersion modelling was made in the permits for some sites, however an actual 'odour unit' based performance limit is not defined in any of them. Odour concentration limits are generally used during plant design and the permit and planning application processes to demonstrate that impacts will not be unacceptable, but once operational they are not directly verified.

The permits themselves do not specify which actions are triggered if specific odour criteria thresholds are exceeded. These would be detailed in the OMP for the site (adherence to which is a requirement for the permit). This would include increased monitoring in response to complaints. This may result in the operator identifying that they need to cease a particular activity under certain conditions (i.e. windrow turning under certain weather conditions), cease reception of certain waste types, or modify the process.

If the regulator considered that the operators were not controlling odours acceptably, they could then force them to undertake measures to prevent this, such as cessation of accepting certain types of waste or all feedstock, curtailing certain activities such as open screening under certain climatic conditions, or process modifications such as the need to extract and treat odorous air. Suspension or revocation of the Permit is an available action and has been used on some biowaste sites in the UK due to odour, but only where all other possibilities have been exhausted or the operators refused to cooperate with the regulator.

6 OPTIONS FOR INTEGRATION OF BEST PRACTICES INTO METRO VANCOUVER REGULATIONS

The purpose of this section is to identify which odour control measures are best applied via various regulatory options available to Metro Vancouver for managing odours at compost facilities.

The findings are based on discussions between Morrison Hershfield and Metro Vancouver staff during a workshop on regulatory approaches on March 22, 2017.

6.1.1 Metro Vancouver's Solid Waste and Recyclable Material Regulatory Bylaw No. 181

Metro Vancouver is considering changes to the Solid Waste and Recyclable Material Regulatory Bylaw No. 181, as Amended (Bylaw 181), which governs the management of municipal solid waste and recyclable materials at privately operated facilities.

This section describes the proposed approach to update Bylaw 181 to improve odour management at compost facilities within the region.

The following industry best practices may be considered for Solid Waste Licences:

- For all facilities handling putrescible waste, the following areas should be enclosed, and odorous air from these enclosures should be treated by a biofilter or other odour treatment systems:
    - Waste receiving area.
    - Waste pre-processing and mixing area.
    - Waste storage area.
    - Active composting area.
    - Compost curing area (if considered an odour emission source that needs to be controlled. Other options in lieu of enclosure can be considered, such as negative aeration with biofilter).
    - Compost screening area (if considered an odour emission source that needs to be controlled. Other options in lieu of enclosure can be considered, such as screening when weather conditions are conducive to odours and dust remaining on-site).
- Define types and quantities of organic materials that the facility can receive. Consider not authorizing slaughterhouse waste and similar meat products going to compost facilities due to their ability to cause excessive odours.
- Prevent leachate generation by separating stormwater from leachate generating areas where rain comes into contact with organic materials (waste or compost). Recommend that leachate generated by rainfall that comes into contact with organic materials is collected from these areas and treated. All surface areas on which organic materials are stored or processed must have a hard and impermeable surface. Roads at the compost site should be paved.
- Develop and submit for approval an OMP, which aligns with any OMP developed as part of meeting permit requirements of Air Quality Management Bylaw No. 1082.

6.1.2 Metro Vancouver's Air Quality Management Bylaw No. 1082

Metro Vancouver is considering enhancements to its Air Quality Management Bylaw No. 1082 (Bylaw 1082), which governs the management of air quality in the region.

This section describes a potential approach to update Metro Vancouver air quality bylaws and regulations, aimed at establishing limits to odours that can be emitted from compost facilities within the region. Under Bylaw 1082, Metro Vancouver authorizes air emissions from large emitters of air contaminants through permits. Alternatively, facilities may also be authorized by an emission regulation that is specific to certain types of individual industrial, commercial or institutional sources (e.g., gasoline distribution).

Requirements for best practices for the design and operations of a facility that are directly related to air emissions, including odorous air emissions (e.g. biofilter), are addressed in air quality permits. Best practices may also be dealt with through application of Bylaw 181, and potentially through contracts with the owner/operator of a compost facility.

6.1.2.1 Definition for Odours

The current definition of an "air contaminant" in Bylaw 1082 does not explicitly mention odours or odorous substances. More clarity can be provided by adding a clear definition of odours in the bylaw. The definition could include odorous substances within the category of air contaminants, consistent with Metro Vancouver's delegated authority under the *Environmental Management Act* to "prohibit, regulate and otherwise control and prevent the discharge of air contaminants." Table 12 summarizes example definitions used in other jurisdictions which shows the inclusion of odour within the definition of a contaminant, pollutant, or air pollution in several Canadian jurisdictions. For more information on the definitions, refer to the section on Odour Management and Regulations in Other Jurisdictions and Appendix A.

Table 12: Examples of Explicit Mention of Odour in Canadian Provincial Regulations

Jurisdiction	Explicit Mention of Odour in Regulation
Ontario	Defined as part of a "contaminant"
Saskatchewan	Defined as part of "air pollution"
Quebec	Defined as part of a "contaminant"
Manitoba	Defined as part of a "pollutant"
New Brunswick	Defined as part of a "contaminant"
Prince Edward Island	Defined as part of a "contaminant"
UK	Defined as "nuisance"

6.1.2.2 Design Standards

Design standards can either specify a minimum performance standard for odour treatment at the source, as an ambient criteria, or both. During the design of a facility or facility upgrade, the maximum desirable ambient concentrations of an odorous substance can be used to calculate the maximum odorous emissions at the source using dispersion analysis. The calculated level at the source can then be used for regulatory purposes. Odorous emissions at the source are usually measured at point sources such as stacks and vents connected to the odour abatement technology.

Design standards can also specify facility best practices that an operator is required to follow when planning a new facility or an expansion to an existing facility. These have been covered as potential

requirements in Bylaw 181, as described above, and will not be described further as part of potential revisions to Bylaw 1082.

The environmental performance of an air treatment device, such as a biofilter, can be regulated and monitored through site-specific permits issued under Bylaw 1082 or a new regulation for composting facilities (similar to other MVRD air quality emissions regulations). It is possible to specify maximum output levels of specific odorous chemicals, as well as continuous measurement and recording of performance indicators, such as temperature and pressure drop.

6.1.2.3 Regulatory Performance Standards at the Source

A regulatory performance standard can be required at the source for odorous substances and/or for odour concentrations (measured in OUs). It can specify the maximum discharge rate with respect to both flow rate and concentration.

A regulatory performance standard set in OU at the source could be established through air dispersion modeling. This would provide maximum releases of odorous substances that have the potential to cause adverse impacts on the environment and to nearby sensitive receptors.

Metro Vancouver requires stack testing and dispersion modelling in some permits and emission regulations. This is consistent with regulatory requirements set out in the Ontario Air Pollution Regulation, which can require source testing through the provision of the ECA to determine the rate of odorous emissions from the sources on-site. The testing protocol helps to estimate the maximum 10-minute average concentrations for odorous substances and odour concentrations when measured at the facility's property and at the most impacted sensitive receptor, and allows comparison with the performance limit for odour set by the ECA. Source testing requirement for Orgaworld in Ottawa involves determining the rates of emissions of odour concentration (in OUs), hydrogen sulphide and total mercaptans from the exhaust stack of the air pollution control equipment every six months.

In the UK, there is a desire to set OU maximum emission rates at the source of the emissions, however, in practice this is not being applied. A UK Regulatory Agencies study indicated that biofilters typically emit 3,000 ou_E/m^3 or less.

Technologies that can be used to control and measure emission discharges include containment of the process, application of odour emission treatment technologies, odorous substance monitoring and dispersion analysis.

These technologies and methods described would typically be covered through design and operation permits (i.e. permits issued through Bylaw 1082).

6.1.2.4 Ambient Air Quality Metrics

Individual Odorous Substances

Facility operators can be required by Metro Vancouver to monitor odorous substances or odour concentrations at point sources, area sources (e.g., open piles and windrows, open tanks, open biofilters), or fugitive sources (e.g., windows during turning, open doors, trucks waiting to unload or load).

Many jurisdictions in North America have quantitative ambient concentration criteria for individual odorous substances (Table 13). The regulatory status of these criteria ranges from guidelines or objectives, to enforceable standards. According to RWDI (2015), most of the criteria for individual odorous substances are associated with an averaging period (not with a frequency criteria, such as in the UK). Many jurisdictions use the 1-hour averaging period, even though it may not be representative of how long an odour could persist (RWDI, 2015). Other jurisdictions have shorter averaging time periods (e.g., Ontario ten-minute averaging periods and Quebec four-minute averaging periods), but use 1 hour dispersion modelling results and apply a conversion factor to estimate likely maximum concentrations at the averaging period in question.

Table 13: Examples of Individual Odorous Substances with Quantitative Ambient Concentration Criteria in North American Jurisdictions

Odorous Substance	Example of Jurisdictions
Ammonia	Alberta, Manitoba, Bay Area Air Quality Management District (BAAQMD), Quebec, Missouri
Carbon disulphide	Alberta, Ontario, Quebec
Dimethyl disulphide	Ontario
Dimethyl sulphide	BAAQMD, Ontario
Hydrogen sulphide	Almost all jurisdictions
Methyl ethyl ketone	Quebec
Methyl isobutyl ketone	Ontario, Quebec
Methyl mercaptan	BAAQMD, Connecticut, Ontario, Newfoundland and Labrador

Consequences for non-compliance to set standards for individual substances are up to the regulator and will depend on the local conditions and environment. In highly populated residential or commercial areas, consequences and penalties are generally more severe to achieve rapid improvement compared to those in less populated rural environments.

Odour Concentration

Setting ambient concentration limits for individual chemicals or combinations of chemicals may work for certain applications where odours are clearly defined and represented by certain chemicals. However, because of the complex nature of odour emissions coming from compost plants (which vary depending on the feedstock mix), an odour may not be adequately characterized by individual chemicals (RWDI 2015). Therefore, measuring OU may be more representative, since the odour intensity for the mixture may be greater than a subset of individual substances.

Ambient odour concentrations are often modelled using dispersion analysis. This information is then used to select and size, or modify, operations of the odour treatment technology used to manage odour emissions. In actual operations, electronic instruments (e.g. eNoses) can be used to identify odour emission exceedances in real time at the facility and to enable the operator to immediately reduce the source of the odours.

For all monitoring of ambient air quality, it will be necessary to provide guidance or criteria for how odorous emissions will be quantified. For the measurement of ambient odour concentration, the

European Standard EN13725:2003 has been established in many jurisdictions, including Metro Vancouver. It is considered more stringent than the ASTM E679-04 for measuring odour concentration (see section 3.1.10).

Monitoring ambient OU at the receptor is theoretically possible, but is not commonly practiced due to the contentious issue of determining the source of the odours. If OU are regulated, the most practiced approach is to regulate OU at the source (generally point sources only for practical reasons). The source emission levels are then set using a dispersion analysis to determine what the maximum source emission rates can be that result in acceptable ambient odour concentrations.

Odour Concentration Monitoring

Metro Vancouver can specify that a facility operator must conduct ongoing monitoring of odour emissions from various process components at a compost facility. The requirements can specify the method for monitoring. This monitoring information can be used to inform the immediate modification to the compost operations, and in case of odour complaints, the information can be used in combination with data from a local meteorological station to estimate the dispersion of odorous emissions.

6.1.2.5 Odour Management Plans

Some composting facilities in Metro Vancouver and BC already have OMPs and the level of detail within the plans can vary. Metro Vancouver refers to OMPs as Progressive Odour Management Plans (POMPs).

An odour management plan should be developed by a qualified professional and include specific details on:

- Application details of how odour treatment technologies are applied to the following process steps and expected effectiveness of each technology:
    - Waste receipt.
    - Shredding and mixing.
    - Feedstock storage.
    - Loading of compost.
    - Main composting processing.
    - Curing.
    - Screening and blending.
    - Final product storage.
- Performance measurements and monitoring of odour treatment technologies.
- Odour monitoring at source.
- Staff training for early odour recognition and corrective measures to operations.
- Odour complaint response protocols.
- Housekeeping and operational best practices.

A composting facility should implement an odour monitoring system with reporting in accordance with an approved OMP.

Complaints Response Protocols

Metro Vancouver could consider setting an acceptable number of odour complaints within a predetermined timeframe. If this number is exceeded, then the facility operator can be required to immediately implement remediation measures to stop the odorous emissions. Should odour complaints persist, a range of fines and even facility shut-down can be set as a consequence. In the UK, the permits often include increased monitoring in response to complaints.

The permit issued by CVRD to the Fisher Road Holdings composting facility in Cobble Hill requires the facility to provide a report in response to all odour complaints made regarding the facility. However, there is no threshold specified in the license conditions for a maximum number of odour complaints accepted before remediation activities are required.

Complaint response protocols are typically required as part of an OMP. In the OMP implemented by the Regional Biosolids Composting Facility in Kelowna, it provides specific procedures that follows an odour complaint. It involves an evaluation of the on-site odour monitoring system, meteorological data and whether any unusual on-site activity may have created higher than usual odour concentrations. The OMP describes an evaluation of whether or not a Stage 1, Stage 2 or Stage 3 exceedance was taking place and the associated threshold actions. The OMP was originally developed by a consultant in 2010 and the facility has since operated under this OMP. The OMP was also submitted as part of the amended OMRR requirements, which came into effect June 2016. The facility has not yet received a permit.

Odour complaint management procedures should be part of a facility's OMP. An OMP, including documented and demonstrated odour response protocols, are required by OMRR (refer to section 4.2). The protocol should record complaint management, which typically involves recording the complaint for follow-up and evaluation. The type of information collected could include time and location of the complaint recorded, examination of whether the facility could potentially be the cause of the odour complaint (based on site conditions and data plus weather conditions), implementation of remedial measures when the facility is deemed to cause the odour, and response to the complainant that the situation can and is being resolved.

Communication plans are generally covered as part of a facility's OMP and would be expected to be covered through the permit issued under Bylaw 1082. The plan should include a long-term outreach and communication strategy to include all potentially affected receptors of odorous substances.

6.1.3 Odour Management in Contracts

Contracts are generally set up between the owner/operator of a compost facility and the supplier of organic feedstock for the facility. If the facility is privately owned and accepts materials from numerous sources, then each contract will be negotiated separately. This provides very little leverage for Metro Vancouver to require special measures for odour management beyond stipulations included in an existing air quality permit, except for any materials originating from a Metro Vancouver transfer facility. In this case, practices such as those provided in Section 6.1.1 for Solid Waste Licenses could be required, with contractual consequences if the requirements are breached.

In general, contracts can require the owner/operator of a compost facility to include a wide range of services and equipment. However, these requirements will be reflected in the cost to accept the organic feedstock.

6.1.3.1 Applying the Food Waste Hierarchy to Manage Odours

Any enforcement of the food waste hierarchy through the use of regulations, contracts and local bylaws needs to carefully consider all potential odour impacts from each step of the hierarchy.

6.1.3.2 Food Waste Reduction

Some aspects of the food waste hierarchy are already in place in Metro Vancouver, however none in a regulatory context. There are organizations that re-distribute food to people in need. As described in the Food Waste Prevention Toolkit (BC MoE, 2015) reduction is the highest goal for food waste prevention, which requires involvement from the producers and consumers of food. The Metro Vancouver campaign of Love Food Hate Waste was modeled after the UK's initiative and currently has collaboration with local organizations like Safeway and FarmFolk CityFolk (Metro Vancouver, 2015).

6.1.3.3 Rendering

West Coast Reduction Ltd. (WCRL) has owned and operated a rendering facility in Vancouver since 1964. WCRL submitted a letter to Metro Vancouver in November 2016 indicating that since the Metro Vancouver Organics Disposal Ban was implemented on January 1, 2015, some pre-consumer meat by-products that historically went to rendering are being diverted to composting. WCRL stated that meat by-products have been mixed with other organic waste out of convenience and may have contributed to odour issues at Metro Vancouver compost facilities.

Based on the food waste hierarchy, rendering is a higher use than both AD and composting for the purposes of managing food waste. Metro Vancouver may want to define types and quantities of organic materials that each organics processing facility can receive through the provisions of its Solid Waste Regulatory Bylaw 181. In particular, Metro Vancouver may want to consider not authorizing slaughterhouse waste and similar meat products going to compost facilities due to their higher use at rendering plant and their ability to cause excessive odours at composting facilities. Rendering would result in value added products and remove animal wastes from AD and composting.

6.1.3.4 Anaerobic Digestion

AD is the next priority level of food waste hierarchy. Currently the AD facilities in Metro Vancouver are not operational. The new Surrey facility, which will comprise of both AD and composting, is planned to begin accepting feedstock (including food waste) in mid-2017. The AD facility at Harvest Power has been temporarily shut down due to odour issues assumed to be related to managing the digestate.

It should be noted that AD can process food waste and animal by-products provided the entire process, including subsequent composting, is fully enclosed (as is being done at the Surrey AD facility).

6.1.3.5 Bio-Drying

If the economics are favourable or if there are inadequate markets for compost, the making of biofuel from organic waste could be considered using bio-drying.

6.1.3.6 Composting

There are several privately owned composting facilities operating in and around Metro Vancouver to manage organics, including food waste. There are composting facilities that are permitted to accept

meat by-products. As highlighted previously under Rendering (section 6.1.2.2), Metro Vancouver may want to consider not authorizing slaughterhouse waste and meat by-products going to compost facilities due to their higher use at rendering plant and their ability to cause excessive odours at composting facilities.

Apart from bylaw provisions restricting certain waste materials as feedstock at composting plants, there are limited options for Metro Vancouver to enforce the food waste hierarchy.

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APPENDIX A: Feedback from Interviews with Existing Operators of Large Composting Facilities

FEEDBACK FROM INTERVIEWS WITH EXISTING OPERATORS OF LARGE COMPOSTING FACILITIES

Phone interviews were conducted with operators of large organics management facilities in BC and Washington State. The purpose of the interviews was to understand practical odour management practices being employed at operating facilities.

The facilities that were interviewed, together with their size, type of wastes accepted and length of operation are provided in Table A-1 below. These facilities are considered large as they all produce more than 5,000 tonnes of material annually. It should be noted that the Surrey facility is under construction and not yet operational.

The operators were asked about their operations including what parts of their operations are enclosed vs. open, and whether there are any special procedures for accepting odorous feedstock. Specific questions also included topics such as leachate and stormwater management, complaint frequency and response protocols.

Enviro-Smart Organics declined to be interviewed.

Table A-1: Facilities Interviewed and Site Information

Facility/ Operator	Waste Accepted	Tonnage	Operated Since	Type of Facility
Nanaimo Organics Now	Food, yard and garden	Permitted: 20,000 tonnes Operating: 15,000 tonnes	2005	Composting
Orgaworld, City of Surrey	Food, yard and garden	Capacity: 115,000 tonnes	April, 2017 (ribbon cutting June, 2017)	Anaerobic Digester (dry), Composting
Net Zero Waste Abbotsford	Food, yard and garden, agricultural	Operating: 20,000 tonnes Expanding: 30,000 tonnes	2011	Composting
Cedar Grove, Everett, U.S.	Food, yard and garden	Maple Valley: 37,000 tonnes food waste. Additional yard and garden waste composted separately from food waste Everett: 130,000 to 230,000 tonnes of food and yard and garden waste	2003	Composting

A summary table of the general operations of the facilities is provided in Table A-2 and

Table A-3 below.

Table A-2: General Operations at Interviewed Facilities

Facility/ Operator	Pre-Processing/ Screening	Composting Technology Used	Stormwater Management	Leachate Management
Nanaimo Organics Now	Yard and garden waste is stored outside, food waste is unloaded indoors on tipping floor	In-vessel drums, aerated piles, outdoor curing	Separate collection system, impermeable surfaces and controlled drains in place	Leachate is hauled to the WWTP
Orgaworld, City of Surrey	Some yard and garden waste will bypass the AD facility and go directly to composting	Dry anaerobic digester, composting of digestate. All operations, including curing indoors	Everything is in a building – stormwater is managed externally separate from process	Nothing leaves the facility, leachate is recirculated in composting process
Net Zero Waste Abbotsford	Storage until material is available to build a pile. Stored waste covered with mature compost to manage odours	Gore membrane system inside a building for first composting phase = double enclosed system. Curing outdoors	No separation in outdoor portion, outdoor areas are impermeable with controlled drains to a holding pond	Concentrated leachate from composting piles and unloading building is reused in the process. Outdoor leachate mixed with stormwater is treated in aerated ponds
Cedar Grove, Everett, U.S.	Mixing and grinding in building, then placed in aerated static piles	Gore membrane system for food waste mixed with yard and garden waste. Negatively aerated static piles for yard and garden waste only. Curing outdoors	Impermeable hard surface with separate drains, runoff from pile covers considered stormwater. All outdoor water collected in ponds and tested (treated if necessary) before release	Gore aeration trenches collect leachate, which is re-used in the process

Table A-3: Odour Management and Monitoring at Interviewed Facilities

Facility/ Operator	Indoor/ Outdoor Operations	Odour Origin and Management	Emission Limits and Monitoring	Complaints Response and Frequency
Nanaimo Organics Now	Outside: Storage of overs, incoming yard and garden waste, secondary aerated piles (protected from precipitation), then open curing. Inside: food waste receipt, first stage composting in drums, initial aerated piles	Majority of odours originate inside the building Mitigation: biofilter for building air, misting around doorways, perimeter misting of outdoor aerated piles	No specific limits, must meet general criteria that no odours leave the property, not measured unless there's a complaint	Complaints sent directly to Regional District, less than 5 received annually
Orgaworld, City of Surrey	All facilities and operations are indoors	Rapidly closing doors, negative pressure in building, ammonia scrubber, biofilter and 70 m high stack	1 OU unit at property line	When operational, there is a short time line to respond to a complaint and if not resolved facility is shut down
Net Zero Waste Abbotsford	Phase 3, curing outdoors (with aeration)	Biofilter for air from building. Composting process odour control through membrane covers	No known limits to meet	No odour complaints
Cedar Grove, Everett, U.S.	Receipt in enclosed tipping building with biofilter. Mixing and storage in building. Covered conveyors to aerated static pile area Active composting of food waste for 4 weeks under membrane cover, then 2 weeks with aeration but without cover. Followed by outdoor screening and storage/final curing	Biofilter for receiving and processing building Membrane covers on piles that receive food waste	At Everett, installed Odotech automated system with e-nose. Calibrated to different odour sources on the site (tipping building, piles, curing area, screening, storage). Do real-time monitoring of odours using calibrated e-nose and predict direction and intensity of plume based on actual meteorological data. Proactive communication with receptors	20 charges related to odours by Puget Sound Clean Air Agency prior to 2013

All of the interviewed facilities accept both food and yard and garden wastes and produce a compost product. Only the Orgaworld biofuel facility in Surrey also includes an AD component. All of the facilities receive the food and comingled wastes inside a building. Yard and garden waste is accepted and stored outside (with the exception of the Surrey and Cedar Grove facilities). The first phase of the composting process (the most odorous) is completed inside a building or with membrane covers (GORE™).

The siting of the facilities varies, both the Nanaimo and Surrey facilities are located in industrial zoned areas. The Abbotsford facility is located in an agricultural area. Zoning of the Cedar Grove facilities is unknown, but the Everett facility appears to be in an industrial area.

The biofilter is the most common odour treatment technology and is used by all facilities. The Nanaimo facility also uses misting around the building doors and on the outside compost piles for odour suppression. The Abbotsford facility and both Cedar Grove facilities use membrane covers for the composting process and biofilters only for the air from the receiving and mixing buildings. The Surrey facility will have the highest form of odour treatment of the facilities interviewed and in addition to a biofilter, it will employ a scrubber for ammonia removal and a stack for better dispersion.

Stormwater is managed separately from leachate for the facilities with an outdoor area (Nanaimo, Abbotsford and Cedar Grove). This is done by using impermeable (paved) areas and separate drains. Leachate from within the buildings and under the composting piles is either recirculated in the composting process or in the case of the Nanaimo facility, taken to a WWTP.

APPENDIX B: Examples of Definitions Relating to Odours in Canadian Regulation

Examples of Definitions Relating to Odours in Canadian Regulation

British Columbia

The *Oil and Gas Waste Regulation* (OGWR) authorizes waste discharges to the environment from upstream oil and gas facilities. The OGWR grants authorization to discharge specific wastes to the environment from specified oil and gas operations. If discharge of a particular waste is not specifically authorized by OGWR, another form of discharge authorization is required. Other forms of authorization include permits or approvals issued under EMA, regulations under EMA, or compliance with a Code of Practice of another regulation under EMA.

In the OGWR "objectionable odour" means a substance that is introduced into the air and that causes or is capable of causing material physical discomfort to a person;

Saskatchewan

a) "Air pollution" means the presence in the ambient air of any air contaminant:
   i. In a concentration greater than the permissible concentration specified in a permit or prescribed in the regulations;
   ii. In quantities that are or are likely to:
      (a) Be injurious to the health, safety, comfort or well-being of the public;
      (b) Be injurious or damaging to property or plant or animal life; or
      (c) Interfere with normal business; or
   iii. That has an offensive or obnoxious odour, regardless of its concentration;

The following examples are quoted from the RWDI report (2015):

Manitoba

Releases of odour emissions in Manitoba are covered under the *Environment Act*. It defines a pollutant as "any solid, liquid, gas, smoke, waste, odour, heat, sound, vibration, radiation, or a combination of any of them that is foreign to or in excess of the natural constituents of the environment, and

a) Affects the natural, physical, chemical, or biological quality of the environment, or
b) Or is likely to be injurious to the health or safety of persons, or injurious or damaging to property or to plant or animal life, or
c) Interferes with or is likely to interfere with the comfort, well-being, livelihood or enjoyment of life by a person (« pollutant »).

New Brunswick

The *New Brunswick Clean Air Act* defines odour as a potential contaminant. A *"contaminant" means*

a) Any solid, liquid, gas, micro-organism, odour, heat, cold, sound, vibration, radiation or combination of any of them, present in the environment,
   i. That is foreign to or in excess of the natural constituents of the environment,
   ii. That affects the natural, physical, chemical or biological quality or constitution of the environment, or
   iii. That endangers the health of human, plant or animal life or the safety or comfort of a human, that causes damage to property or plant or animal life or

renders them unfit for use by persons or that interferes with visibility, the normal conduct of transport or business or the normal enjoyment of life or use or enjoyment of property,

b) Any pesticide or waste, or

c) Anything that is designated by the Minister as a contaminant under s. 7;

Prince Edward Island

The *Prince Edward Island Environmental Protection Act* mentions odour under the definition of a contaminant. A "contaminant" means any solid, liquid, gas, waste, odour, vibration, radiation, sound, or a combination of them:

a) Which is foreign to or in excess of the natural constituents of the environment into which it is being introduced,
b) Which will or may adversely affect, either directly or indirectly, the natural, physical, chemical, or biological quality of the environment,
c) Which is or may be injurious to the health or safety of a person or be damaging to property or to plant or animal life,
d) Which interferes with or is likely to interfere with the comfort, well-being, livelihood, or enjoyment of life of a person, or
e) Which is declared by regulation to be a contaminant.