ODOUR SURVEY ANALYSIS
Cobble Hill, BC

Prepared for:

Cowichan Valley Regional District
Recycling & Waste Management
Engineering Services Department
175 Ingram Street
Duncan, BC V9L 1N8

Prepared by:

SENES Consultants
AN ARCADIS COMPANY

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

List of Acronyms	
BACT	Best Available Control Technology
CASA	Clean Air Strategic Alliance (Alberta)
CofA	Certificate of Approval
CLS	Central Landscaping Supplies
CVRD	Cowichan Valley Regional District
EAB	Environmental Appeal Board
FIDOL	Frequency, Intensity, Duration, Offensiveness and Location
FPB	Farm Practices Board
FRR	Fisher Road Recycling
FRH	Fisher Road Holdings Limited
GG	Gamboa Greenhouses
GVRD	Greater Vancouver Regional District
MAFF	Ministry of Agriculture, Farms and Fisheries
MOE	Ministry of Environment
OH	Odour hour
POI	Point of Impingement
PSCAA	Puget Sound Clean Air Agency, Washington, USA
WHO	World Health Organization
WWTP	Wastewater treatment plant
Contaminants	
DMS	Dimethyl sulphide
DMDS	Dimethyl disulphide
H_2S	Hydrogen sulphide
NH_3	Ammonia
TRS	Total reduced sulphur
Symbols, Measurements, and Abbreviations	
DDO	Dynamic dilution olfactometry
D/T	Dilutions to threshold
OU	Odour units
OU/m^3	Odour units per cubic metre
OU/s	Odour units per second
$\mu g/m^3$	Micrograms per metre cubed

EXECUTIVE SUMMARY

SENES Consultants (SENES) was retained by the Cowichan Valley Regional District (CVRD) to assist in designing an odour survey and to conduct an analysis of odour monitoring survey conducted in July and August 2014 collected by the CVRD in the community of Cobble Hill, British Columbia. This type of odour survey is intended to be used in identifying the magnitude of a community odour problem by systematically collecting and recording information on important odour variables such as the frequency, intensity, duration, offensiveness and location at which the odours occur.

The CVRD conducted the odour sampling survey in the community of Cobble Hill from July 2nd to August 27th, 2014. Odours were detected for the majority of sampling observations during the survey period, and at most of the sampling stations, regardless of whether the odours were pleasant or unpleasant. For a vast majority of the observations (i.e., 98-100%), the predominant odours detected were reported to be either pleasant, barely noticeable or noticeable but not offensive. The only exception was the location near a wastewater treatment plant where predominantly offensive odours were noted on almost 3% of the observations. However, short-term peak offensive odours (i.e., the highest intensity odours recorded during a survey observation period) were recorded more frequently at the survey sites. The overall conclusion of the odour survey is that offensive odours are present in the community of Cobble Hill. Most of the offensive odours during the survey were of short duration (on the order of 30 seconds), and were frequently, though not exclusively, composed of odours from more than one source. The survey identified several sources of offensive odours, namely:

1. Maple Hill WWTP
2. Twin Cedars WWTP
3. Fisher Road Recycling (FRR)
4. Central Landscaping Supplies (CLS)
5. Gamboa Greenhouses (GG)

The odour survey results related to each of these sources are discussed below.

Maple Hill WWTP

The highest frequency of both predominant and short-term peak odour intensities was associated with this WWTP during the odour survey. Predominant offensive odours were noted 2.9% of the time near this WWTP, while short-term peak offensive odours were noted to be present during 64% of the survey observations. Nevertheless, there were no odour complaints lodged from residents living near this facility during the odour survey period.

Twin Cedars WWTP

There were no observations of predominant offensive odours in relation to this WWTP; however short-term peak offensive odours were noted to be present during 25% of the odour survey observations. There were only two odour complaints lodged with the CVRD about odours in the general vicinity of this plant during the odour survey period, and odours from the GG or some other unidentified source in the area could have been responsible for one or both of those complaints.

Fisher Road Recycling

There were no observations of predominantly offensive odours on the east side of the FRR facility, but odours were present during 87-90% observations on the north, west and south sides of the facility during the odour survey. Most of the on-site odours on the north side of the FRR facility were attributed to the neighbouring CLS facility, as were some of the odours noted on-site on the west side of the FRR facility. Predominantly offensive odours were present at the FRR property lines indicating that the FRR facility is almost certainly a source of off-site odours. The dilution and dispersion with the transport of the odours downwind appears to diminish the intensity of these odours the further they travel from the facility, as would normally be expected to occur.

Central Landscaping Supplies

The observations made during the odour survey near the boundary between the FRR and CLS facilities indicated that the CLS facility was the predominant source of odours at this location when winds were blowing from the direction of the CLS facility towards FRR, despite the proximity of sources of odour within the FRR site itself. Therefore, odour emissions from the CLS operations have the potential to migrate off-site at concentrations that could be considered to be offensive. However, as with the FRR facility, the concentration of those odours is diminished with transport distance away from the CLS site. A primary conclusion of the odour survey is that the survey observations frequently noted the difficulty in distinguishing between odours from the FRR and/or CLS operations at off-site locations because the odours were so weak.

Gamboa Greenhouses

The GG were identified as a source of offensive odour near the junction of Fisher Road and Fairfield Road. This facility was also identified as a possible source of barely noticeable-to-noticeable odours at four other off-site locations.

There were 63 odour complaints lodged with the CVRD on 36 of the 57 days of the odour survey period. Odour complaints were most frequently received from an area southwest of the FRR/CLS facilities along Holland Avenue, Galliers Road, Regent Crescent and Soren Place. The odour surveyors were able to follow up on 27 of the odour complaints. In 23 of the 27

follow-ups, the surveyors reported the odours as being barely noticeable, with 10 observations also noting short-term peak odour intensities as noticeable during a portion of the follow-up period. The surveyors noted that the FRR and/or CLS facilities could have been the source of the odours in 15 of the 27 follow-ups. However, it should be noted that 35% of the odour complaints during the two-month period were made at times when the FRR facility was either closed or there were no operations being conducted at the time of the complaint (excluding ongoing continuous emissions from the FRR compost curing piles and biofilters, as well as the CLS yard and garden waste piles). In particular, the FRR facility was closed on the two occasions when complainants described the odours as unbearable. Similarly, survey follow-ups to odour complaints indicated that there was no particular activity at the CLS facility 47% of the time when an odour complaint was reported.

In the absence of a definition of what constitutes a nuisance odour within the context of the CVRD bylaws, or in the Province of British Columbia as a whole, it is necessary to consider how nuisance is defined in other jurisdictions. As one alternative, nuisance odour can be based on the World Health Organization (WHO) definition of a nuisance threshold as being that concentration at which less than 5% of the population experiences annoyance more than 2% of the time. The difficulty in applying this definition to the odours from the five likely sources of odour in the Cobble Hill community is that the population in Cobble Hill is widely dispersed. Furthermore, the WHO has not specified whether the 2% frequency criterion is to be applied to the predominant odour intensity that is experienced by an observer, or to the short-term peak odour intensity that may come and go over a 5-10 minute period of observation.

For the predominant odours in the Cobble Hill community, the only location where the frequency of offensive odours exceeded the 2% criterion defined by the WHO for nuisance odours was in the immediate vicinity of the Maple Hill WWTP. Whether this location would also meet the WHO criterion for 5% of the community population is unclear. Although the other sources of odour such as the FRR, CLS, GG and the Twin Cedars WWTP all emit offensive odours at times, the odour survey did not identify persistent, predominant odours that were intense enough and frequent enough to meet this WHO criterion for nuisance odour impacts within the community.

If the same WHO 2% criterion is applied to the peak intensity odours (i.e., those that were present for approximately 30 seconds at least once during an observation period), then the highest impacted area would be in the vicinity of the Maple Hill WWTP where over 37% of the peak odours would have been considered to be offensive. The second location with the most frequent peak offensive odours would be on Galliers Road at the FRR facility property line where peak offensive odours were note with a frequency of 19%, and these would be related to emissions from the FRR and/or CLS operations. A close third in ranking would be on Hutchison Road beside the Twin Cedars WWTP with 15% frequency of short-term peak offensive odours.

The location with the next most frequent occurrence of offensive odours was at the junction of Fairfield Road and Fisher Road which had a mixture of odours from FRR, CLS and the GG at various times, collectively combining for a frequency of offensive odours at 8% of total survey observations. The remaining stations where short-term peak offensive odours exceeded the WHO 2% criterion were near the junction of the Trans-Canada Highway and Fisher Road and at the junction of Fisher Road and Ball Road. In the area where odour complaints were lodged most frequently during the odour survey, the frequency of peak offensive odour intensity observations was just 1.4% at the junction of Princess Avenue and Regent Crescent (Station 13) and zero along Holland Avenue between Fisher Road and Galliers Road (Stations 11 and 12). Therefore, the WHO criterion for nuisance odours was not met for either predominant or short-term peak odours in the area where odour complaints were most frequently recorded.

Despite an intensive survey completed by the CVRD during which two surveyors completed from 68 to 102 odour observations at 20 individual locations throughout the Cobble Hill area, the survey results were unable to corroborate the community odour complaint data logged during the survey period. Survey locations that were identified as having the most frequent offensive odour levels near WWTP had few if any odour complaints attributable to these plants. On the other hand, the odours identified in the locations from which the majority of odour complaints were received were judged by the surveyors to be barely noticeable, or noticeable but not offensive. This is not meant to imply that the complaints made by the residents in these areas were not valid. It simply means that the odour survey was not able to measure comparable odour intensities that would classify these odours as being offensive.

The results suggest that objectionable odours are infrequent enough that they do not meet the definition of a nuisance impact within the WHO definition for nuisance odours at most off-site locations in the odour survey. If the WHO nuisance odour guideline is considered in the context of short-term intermittent odours that were determined to be high enough in intensity to be offensive, then the emissions from the FRR, CLS and GG facilities collectively could be having a nuisance impact at the following four locations:

- the eastern end of Galliers Road;
- the junction of Fisher Road and Fairfield Road;
- the junction of Fisher Road and Ball Road;
- the junction of Fisher Road and the Trans-Canada Highway.

These locations are approximately 350-400 m from the boundary between the FRR and CLS facilities. The location on the eastern end of Galliers Road is 150 m from the north-western corner of the FRR facility, while the location at the junction of Fisher Road and Fairfield Road is approximately 250 m from the south-western corner of the FRR facility, and only about 50 m from the GG facility. The location at the junction of Fisher Road and the Trans-Canada

Highway is approximately 330 m east of the CLS facility. All of these locations fall within the separation distance of 400 m suggested by the B.C. Ministry of the Environment for composting facilities.

Because these odours are infrequent and, based on the odour survey, intermittent when they do occur, it is unlikely that any future odour monitoring program based on collecting ambient odours for laboratory analysis would be successful in determining odour concentrations either in terms of odour units for the aggregate of odour compounds in a sample or concentrations of individual odorous compounds based on gas chromatography/mass spectrometry analysis. The alternative would be to consider odour dispersion modelling based on either measured odour emission rates from the FRR, CLS and GG facilities, or emission factors derived from published literature at other facilities. Odour dispersion modelling has been successfully applied in many situations where odour issues arise, but may not always resolve differences between modelling results and community perceptions of offensive odours. Such modelling may help to identify those specific sources which are most likely to contribute to offensive odours in the community and the spatial extent over which those odours are likely to occur. This may provide some direction to the CVRD and the operators of the FRR, CLS and GG facilities in guiding future efforts to reduce or eliminate odour emissions from their facilities.

1.0 INTRODUCTION

SENES Consultants (SENES) was retained by the Cowichan Valley Regional District (CVRD) to assist in designing an odour survey similar to surveys that were completed near a composting facility in Central Saanich by the Capital Regional District in 2013 and another in Chemainus in May and June 2014 for the CVRD. The odour monitoring survey in Cobble Hill was conducted in July and August 2014. This type of odour survey is intended to be used in identifying the magnitude of a community odour problem.

There are a number of monitoring methods that can be used by a regulator to address and tackle odour issues from an existing site. Reactive methods are used as a means of characterising the odour emissions from operations carried out on site and assessing the odour impact on local receptors. An odour survey such as the one completed for the CVRD (i.e., a sniff test) is one of the main tools used by regulators to assess odour impact. Sniff tests are designed for assessing the odour impact by recording some important variables such as the frequency, intensity, duration, offensiveness and location at which odours occur. They can be used to determine compliance with a facility's odour management plan, or to improve the quality of information available to the regulator about a community odour issue.

This study was funded by Fisher Road Holding Ltd. (FRH) and the CVRD and stemmed from a condition set out in FRH's waste stream management licence under CVRD Bylaw No. 2570-*Waste Stream Management Licencing Bylaw, 2004*, and was initiated as a result of odour complaints lodged against the operation of the Fisher Road Recycling (FRR) facility located at 1355 Fisher Road in Cobble Hill by members of the general public. Prior to the survey, odour complaints from the general public originated primarily from residential properties within one kilometre radius of the facility, and the majority of the complaints came from residents located south and west of the facility.

A second recycling facility, Central Landscape Supplies Ltd. (CLS) located at 1345 Fisher Road, accepts yard and garden waste for composting was also considered to be a potential source of odour, and there are three small community wastewater treatment plants operated by CVRD located within 1-1.5 km of the FRR facility. Therefore, the odour survey was designed to include those areas where complaints were being lodged. However, in order to rule out any potential for other sources of odour being confused with odours from the FRR facility, the odour survey was expanded to include locations in and around the community of Cobble Hill.

The purpose of the odour survey was to fulfill the requirements of FRR's operating licence, and to:

1. Determine the characteristics of the odours emanating from the FRR facility, as well as other odour sources in the area, including their intensity, frequency, and likely source;

2. Determine the relationship between the odours detected in the area and weather conditions and specific activities at the facility, as well as the activities of other potential odour producing facilities in the area;
3. Determine to what degree, if possible, FRR is responsible for any of the odours detected, what activities at FRR these odours are related to, and if these result in odour complaints;
4. Determine to what degree, if possible, odour sources other than FRR are responsible for odours, what activities these odours are related to, and if they result in odour complaints;
5. Prepare recommendations for the abatement of odours identified as emanating from the facility; and
6. Based on the survey results, define steps towards further mitigating odours in the community where possible.

The scope of the analysis of the odour survey data included the following items:

1. pre-survey and briefing on potential odour issues for the 20 locations used for the odour survey;
2. site visit to the FRR and CLS facilities by SENES completed on June 27th;
3. review of proposed locations for odour sampling survey and procedures to be followed in conducting the survey;
4. analysis of the odour monitoring data and the community odour complaint data collected by CVRD in July & August 2014 during the period of the survey;
5. an assessment whether public complaints of alleged odours from the FRR facility are a result of composting, or other recycling activities, based on correlation of existing odour survey data; and
6. preparation of a report on the information obtained in the tasks listed above and discussion of any odour impacts from the operation of the FRR facility.

2.0 REGULATION OF ODOURS

The regulation of odours has been, and continues to be, one of the most challenging elements of air quality to address. The primary reason for this is that these nuisances are subjective in nature, and are often based on the personal feelings, perceptions and memories of the observer (McGinley et al. 2000). Also, people have differing sensitivities to different odours. An odour that is highly objectionable or noxious to one person may be barely noticeable by another. As a result, there is no universal threshold of exposure to odours that can be considered to be acceptable to all members of the population.

Another problem is that odours are typically viewed as a "nuisance", since exposure to them is disruptive to ones sense of personal well-being, but generally do not cause health effects (although many individuals experience health-based symptoms such as nausea, vomiting, headache, etc. due to exposure to odours). Therefore, nuisance odours tend to be treated differently in regulation than are other air contaminants.

As environmental legislation has evolved over the past several decades, many jurisdictions have developed different approaches to regulating odours. The B.C. Ministry of Environment (MOE) commissioned a comprehensive review of odour management policies and practices in anticipation of adopting some of the measures in this province (RWDI 2005). In that report, it was noted that bylaws which stipulate that sources must avoid causing a nuisance are the most common and oldest approach to managing odours. Such 'avoidance of nuisance' bylaws are based on either a vaguely defined concept of not creating a "nuisance" or on avoiding adversely affecting the "quality of life" of others in the community. The RWDI report notes that: *"The exact wording varies from jurisdiction to jurisdiction but essentially requires that odour from a facility will not result in a nuisance or cause pollution."* Other approaches to managing nuisance odours include:

- Setting ambient concentration objectives or standards for individual chemicals or groups of chemicals. For example, objectives are commonly defined for sulphur-bearing compounds such as hydrogen sulphide (H_2S), dimethyl sulphide (DMS), dimethyl disulphide (DMDS) and mercaptans which collectively are referred to as total reduced sulphur compounds (TRS). British Columbia has defined a TRS objective to control odorous emissions from pulp and paper mills as well as other sources of such compounds such as wastewater treatment plants. Several provinces have also defined objectives for ammonia. However, there are no defined objectives or standards for the many types of compounds (see Rosenfeld et al. 2007) likely to be emitted from composting operations.
- Ambient concentration limits for odours. At present, the Province of Ontario is the only jurisdiction in Canada that uses a numerical odour criterion (i.e., 1 odour unit per cubic metre as a 10-minute average) for managing odorous emissions, but even that criterion is

not an official limit (see discussion in Section 2.3). An attempt by Metro Vancouver to enforce such a criterion against a rendering plant in Vancouver failed after an appeal by the rendering plant operators before the Environmental Appeal Board.

- Odour episode duration-frequency criteria. This type of approach is used in Germany and in the State of Texas and relies on defined limits for frequency and persistent of odours in a community, based on observations made by duly appointed regulatory officers.
- Minimum separation distances. Many jurisdictions have defined buffer zones around sources of odour in order to avoid creating a nuisance odour problem in communities. The Organic Matter Recycling Regulation (OMRR) guidance suggests that permitting authorities consider a 100 metres distance sufficient for separation between a composting facility and a farm, and a minimum separation distance to residential properties of between 400 to 1000 metres. Many other jurisdictions in Canada and internationally have established similar minimum separation distance requirements for composting facilities, ranging from 250 m to 1600 m.
- Odour intensity scales. RWDI (2005) noted that several jurisdictions such as the Puget Sound Clean Air Agency (PSCAA) in Washington State, the State of Western Australia and Germany have used this approach. The PSCAA in Appendix A (Section A.1).
- Odour Index Scale. As noted by RWDI (2005), "*the 'Odour Index' is used in Japan to quantify the intensity of odours. The odour index is equal to ten times the log of the odour concentration. It differs from an odour intensity scale because it is a calculated value."* No other jurisdictions have been identified that use this approach.
- Odour complaint criteria. Some jurisdictions have defined the minimum number of public complaints that need to be registered before an investigation is launched to determine if a source is creating a nuisance odour issue. These jurisdictions have also defined how complaints are verified and justified as valid.
- Quantitative emission criteria for odours or specified chemical compounds. Some jurisdictions have defined the amount of odour (in terms of odour units per second) or chemical compound (in terms of grams or kilograms per second) that a source can emit in its operations. This approach assumes that the emission rate can be quantified which, in the case of an odour emission rate, assumes the use of dynamic dilution olfactometry. In addition, the allowable emission rate may be determined based on odour dispersion modelling to ensure that off-site odours meet some pre-defined acceptable ambient odour concentration.
- Technology criteria. RWDI (2005) notes that many jurisdictions specify odour treatment controls and best management practices for specific industries or processes to ensure that odour emissions are kept to a minimum. This might include, for example, the use of properly designed aeration of compost piles and the collection and venting of air from compost facilities through a biofilter.

Appendix A provides more discussion of the different approaches that have been developed, how they are used to prevent, control and mitigate nuisance odours.

2.1 AMBIENT ODOUR MANAGEMENT PRACTICES IN CANADA

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).

The provinces of New Brunswick, Newfoundland and Labrador, Prince Edward Island, the Yukon and the Northwest Territories have no odour standards or policies, although Newfoundland and Labrador and New Brunswick have ambient air quality objectives or standards for odorous compounds such as hydrogen sulphide (H_2S) and/or ammonia (NH_3). Alberta also has ambient air quality objectives for H_2S and has initiated a review of odour management policies for possible future adoption (see Section 2.6 below). Nova Scotia, Manitoba, Saskatchewan and British Columbia also have no odour standards, but odour may be considered a contaminant in these four provinces. Manitoba tried to adopt numerical standards but ultimately revised its odour policy to use more qualitative approaches (see Section 2.8.2 below). British Columbia commissioned a review of odour management policies in 2005, but has not developed a formal policy since then. Similar to some of the other provinces, B.C. also has adopted ambient air quality objectives for Total Reduced Sulphur (TRS) compounds (expressed as H_2S), but Metro Vancouver is the only jurisdiction in B.C. that has tried to address odour in a formal manner.

2.2 BRITISH COLUMBIA

The Ministry of Environment (MOE) in British Columbia administers and regulates air quality issues, including odour issues, under the authority of the Environmental Management Act (EMA). In 2004, the MOE developed guidelines for the siting and operation of composting in support of the Organic Matter Recycling Regulation (OMRR). The guidelines (Forgie, Sasser and Neger . 2004) were issued in 2004 *"to assist waste generators, the general public, qualified professionals ("QP"s), compost producers and/or facility owners ("dischargers" under the definitions of the OMRR) and Ministry staff in understanding and/or complying with the conditions established in Part 5 - Composting Facility Requirements of the OMRR."* The EMA and the OMRR are the two primary regulatory documents that govern odour management in B.C. as administered by the MOE.

In addition, the Ministry of Agriculture, Food and Fisheries (MAFF) is responsible for resolving odour issues related to farming under the Farm Practices Protection (Right to Farm) Act. Under the Right to Farm) Act, persons who are aggrieved by any odour, noise, dust, or other

disturbance resulting from a farm operation conducted as part of a farm business, may apply to the Farm Practices Board (FPB) for a determination as to whether the disturbance results from a normal farm practice. A complaint under the Right to Farm Act involves first determining whether or not the complainants are aggrieved by the actions of the farm or farmer, and secondly whether the grievance is the result of normal farm practices or not. If, after a hearing, the FPB is of the opinion that the odour, noise, dust, or other disturbance results from a normal farm practice, the complaint would be dismissed. If the practice is found to not be a normal farm practice, the FPB has authority to order the farmer to cease or modify that practice.

In 1972, the Provincial Government delegated authority for air quality management to the Greater Vancouver Regional District (GVRD). In 1993, the Greater Vancouver Regional District (GVRD; Metro Vancouver) prepared a working paper on odour management as part of its comprehensive planning process for air quality management in the region and in the Lower Fraser Valley as a whole (GVRD 1993). The report identified a number of management options, including:

1. Continuation of the existing policies of stipulating that there be *"no odour past the plant boundary such that the Air Quality Director determines that air pollution has occurred."* Suspected non-compliances would be investigated based on complaints received or at the discretion of the District staff.
2. Getting specific concentration limits for known odorous compounds from point source discharges.
3. Using a combination of odour sampling, olfactometry and dispersion modelling to determine whether odour concentrations emitted by a source constitute air pollution at or beyond the plant boundary.
4. Placing limits on permitted odour concentration emissions from point sources.
5. Setting quantitative odour concentration objectives or standards based on olfactometry.
6. Mandating Best Available Control Technology (BACT) or BACT-derived criteria for odorous emissions.
7. Using a combination of approaches.

In the end, the GVRD settled on using general regulatory language that prohibits off-site nuisance or annoyance conditions as determined by field inspectors for odour management within its jurisdiction. Subsequently, there were three specific cases which have helped to define odour regulation policy in the GVRD and the Lower Fraser Valley: 1) the Money's Mushroom case in 1997, 2) the Vane duck barn case in the Township of Langley in 2002, and 3) the West Coast reduction case in 2010. These cases are discussed below.

In 1997, the GVRD successfully prosecuted the operators of Money's Mushrooms, a large composting facility used to produce mushroom growing media, in Provincial Court in response

to numerous odour complaints from the community. The prosecution was launched under the authority of GVRD Bylaw No. 725 which stated that an 'air contaminant' meant any substance, including an odorous substance, which caused or was capable of causing material discomfort to a person. As reported by RWDI (2005), the judge in this case defined "material discomfort" to mean more than merely unpleasantness, but had to include material physiological consequences (e.g., nausea, gagging, coughing, eyes watering, headaches, aggravation of existing asthma, etc.) or substantially altered or impaired the usefulness of the air. In determining whether or not the odorous emissions from Money's Mushrooms had caused material discomfort, the judge in the case considered the number of persons affected, the neighbourhood, the degree of physiological effect, length of time that the odour was present, consistency of the characteristics of the odour, the methodology for collection of odour incident records, and any bias in the collection of data. Furthermore, with respect to a challenge from Money's Mushrooms that odour was not a "substance," the court ruled that "*The presence of a substance in the environment can be established by odour*." Therefore, odour can be considered a substance with the same standing as any other emission (RWDI 2005).

In 2002, the Westcreek Citizens Society launched a case under the Right to Farm Act against a hobby farm operator in the Township of Langley. The farmer had established an intensive duck rearing operation and had plans to expand the operation. The decision of the FPB rendered in 2003 determined that the complainants were aggrieved by the odour emanating from the Vane duck farm. Furthermore, the FPB determined that the duck barn was a source of continuous odour of high intensity. The odor was of a sufficiently high intensity to adversely impact residents living within five km of the site. Furthermore, the FPB determined that the manure storage at the duck barn did not meet the definition of normal farm practice. Although the FPB agreed with the duck barn operator that it was consistent with normal farm practices to site a duck farm or a similar livestock operation on a small acreage. However, the FPB stated that duck farm or livestock operation must be of an appropriate size and must employ proper manure management practices. However, *"Where the duck farm or livestock operation is located on a small acreage, with neighbours in close proximity, practices producing intense odours which are proper and accepted on a larger acreage located in an area where other livestock operations are present are not appropriate or reasonable. In fact the combination of a small site and close neighbours leads to the conclusion that manure management practices should meet if not exceed the practises seen on larger operations sited on larger properties."*

In 2005, the British Columbia Ministry of Environment (formerly the Ministry of Water, Lands and Air Protection) commissioned a general review of odour management policies in other jurisdictions. The Steering Committee for the review included representatives from the MOE, MAFF, GVRD and Environment Canada. The objective of the report was to provide the Ministry, the GVRD and the other members of the Steering Committee with recommendations for odour management approaches that would be effective in British Columbia (RWDI 2005).

The review noted that, at the time, the GVRD had recently published a draft Odour Management Strategy that consisted of a comprehensive, six-level approach to resolve odour issues in that jurisdiction. The nature, severity, frequency and duration of specific odour problems, as indicated by the number of complaints and information gathered via inspection, determine the level of enforcement action. One of the recommendations of the review was that the province could adopt ambient odour criteria for design purposes and provide guidelines for odour impact assessments as a proactive measure to prevent new odour problems.

In response to hundreds of odour complaints from residents of the Grandview-Woodlands area of Vancouver in the period 2004-2007 in relation to emissions from a rendering plant operated by West Coast Reduction Ltd., Metro Vancouver began the process of developing a quantitative ambient odour objective (Robb 2007; Trask 2008). The operators of the rendering plant challenged permit amendments issued by Metro Vancouver (Metro Vancouver 2008) which would have required the facility to conduct periodic monitoring of their emissions in 'odour units' and to use dispersion modelling to evaluate the impact of those odour unit emissions on the surrounding community. In addition, the draft permit amendment would have required the facility to ensure that there were 'odour-free' periods of time on weekends and statutory holidays from the beginning of May to the end of September.

The proposed amendments to the plant's operating permit were challenged by West Coast Reduction Ltd. before the Environmental Appeal Board (EAB) of British Columbia. The decision of the EAB (EAB 2010) stated that:

- The Metro Vancouver District Director had no jurisdiction under the *Air Quality Management Bylaw* to amend the permit in the manner that he did. It was stated that the amendments were more likely an attempt to appease a relatively small number of individuals in the community who frequently complained about the odour.
- Although odour is capable of causing air pollution and may be subject to monitoring requirements, odour itself is not a "substance", and therefore does not fall within the definition of "air contaminant" in the *Bylaw* and the *Environmental Management Act*, and no legislation in the province has placed any specific numerical limits on odours.
- The District Director's imposition of odour limits, as measured in "odour units", as an enforcement tool was unreasonable and inappropriate because odour units are a subjective and imprecise measurement tool that have been developed based on data and assumptions that are not readily applicable to environmental odours, especially for the purposes of enforcement.

On that basis, the EAB rescinded the permit amendments issued for the plant. In 2013, West Coast Reduction Limited submitted an application for a permit amendment to the GVRD to

authorize upgrades to emission control measures and procedures that would reduce odour emissions.

In 2011, Metro Vancouver adopted the Air Quality and Greenhouse Gas Management Plan which included the development and implementation of an odour management program, including an odour management regulation that would address key sources of odorous emissions, effective complaint management and communication processes. Under the proposed regulation, which was adopted as GVRD Air Quality Management Bylaw No. 1083 in 2013, Metro Vancouver charges a fee of $50 per billion odour units emitted.

In 2012, prior to adopting Bylaw 1083, Metro Vancouver proposed implementing specific rules based on how much odour was emitted, how many people would potentially be affected, and how offensive the odours could be. As part of the proposed odour regulation, composting facilities that process yard and other types of waste would have been regulated based on three categories, namely:

- **Low Risk Facilities:** Processing moderate quantities of non-putrescible yard waste (i.e., less than 10,000 cubic metres) would be classified as having a low potential for odorous emissions and would be authorised to emit air contaminants with minimal requirements.
- **Moderate Risk Facilities:** Processing more than 10,000 cubic metres of yard waste and/or less than 10,000 cubic metres of organic wastes would be classified as having a moderate odour emission potential and would be authorized provided that Best Management Practices were employed and substantial odour impacts were avoided. Such facilities would have been required to have a separation distance from urban areas (as defined by population density) greater than 500 metres but less than 1.5 km.
- **High Risk Facilities:** Facilities with a high potential for odour impacts, including rendering plants, animal feed plants, mushroom media composting facilities, intensive agricultural feedlot activities, anaerobic digesters processing non-agricultural waste and large composting facilities having more than 10,000 cubic metres bulk volume of compostable materials other than yard waste would have been required to obtain permits and pay fees based on the potential impacts of odorous emissions.

Facilities with a high risk potential for odour impacts would also have been required to estimate or measure their odorous emissions in accordance with the European Standard EN13725 and methods approved by the GVRD district director. High risk facilities would also be required to undertake dispersion modelling and population analysis in accordance with procedures approved by the district director to estimate odour impacts upon the community. In addition, Metro Vancouver proposed that high risk facilities would be required to pay an annual fee of $5/year for every person that was estimated to experience 11 odour units or more (30-second average, 99.9%) of odour from the facility as determined by approved dispersion modelling analysis. A

multiplier value of 11 would be specified in order to convert results predicted on a 1-hour average to a 30-second average, which better reflects the time scale on which odour impacts are experienced in the community (see discussion of odour dispersion modelling in Appendix A, Section A.6).

However, these provisions for low, moderate and high odour emitters were subsequently withdrawn by Metro Vancouver and not incorporated into Bylaw 1083. Consequently, the only stipulation in this bylaw is that odour emitters must pay a fee of $50 per billion odour units, this fee covering the cost for Metro Vancouver to deal with odour issues in the district.

2.3 ONTARIO

Ontario does not have a formal Odour Policy. Instead, potentially odorous facilities are addressed on a case-by-case basis, typically through the use of a maximum 1 OU (10-minute average) ambient performance limit in Certificates of Approval (CofA). This is applied on an *ad hoc* basis. Some CofA (air) for odorous facilities have no ambient odour performance limits, while others have limits greater than 1 OU on a 10-minute basis. The use of a 10-minute average was based on an informal survey completed by the MOE, which determined that people will tolerate an offensive odour for approximately 10 minutes before complaining. On this basis, the MOE made it an offence to exceed a 10-minute odour-based standard. With the exception of one municipality in Quebec (see Section 2.8.2) Ontario is the only province in Canada that uses such a numerical performance limit value based on odour units.

In 2005, the Ontario Ministry of Environment (MOE) announced that it would be developing an Odour Policy Framework, which would clarify requirements when industry applies to obtain a Certificate of Approval (air) and ensure the selection of appropriate odour abatement options. This would also potentially deal with odour complaints. The MOE released two position papers (March 2005, June 2006). The first outlined the proposed basis of the future Odour Policy, which was to include both odour-based contaminant Point of Impingement (POI) standards for compounds such as H_2S, TRS, etc., and ambient olfactometric-based criteria (i.e., in odour units). The second position paper discussed the application of FIDOL (Frequency, Intensity, Duration, Offensiveness and Location of the odour impact) factors in the proposed regulatory framework for odours. However, the regulated community had significant concerns about the subjective nature of this approach. As a result, the proposed Odour Policy Framework was not carried forward at that time. The odour-based POI standards, however, were included in a subsequent amendment to O.Reg. 419/05.

The MOE is still developing the policy, but it is likely to be based on some of the requirements of O.Reg. 419/05, which does currently have odour-based standards for individual contaminants. In these cases, the standards are typically based on a 10-minute averaging period, and apply

"where human activities regularly occur at a time when those activities occur" at a frequency of 99.5% of the time. In order to provide consistency, it is likely that these requirements would be applied to any ambient olfactometric-based criteria developed as part of the broader Odour Policy Framework.

At present, there is relatively little consistency in the abatement approach used by the MOE to address odour issues at existing facilities. Abatement issues are the responsibility of the individual MOE District (local) Offices that govern specific geographical areas in Ontario. The approach taken depends greatly on the direct experience of the MOE Environmental Officer and the District Office in general. As a result, differing abatement requirements and time frames for compliance are often placed on facilities across the province, which is perceived by many to be inequitable treatment.

2.4 MANITOBA

The Manitoba Environment Act contains a provision to allow an odour nuisance clause to be included in environmental permits. The odour nuisance clause makes the proponent responsible for taking the necessary action to resolve odour nuisance complaints. It also enables enforcement action to be taken against them if the measures taken fail to resolve an ongoing odour nuisance problem. In particular, action can be taken if five or more complaints are received within a 90-day period from five different individuals who do not live in the same household.

Manitoba Conservation's (MC) "Odour Nuisance Management Strategy" states that "*members of the community affected by the odour nuisance should be the ones to decide what constitutes an unacceptable ambient odour level in their community."* The community is considered to include those people who live, work or are present as members of the public in an area that is affected by the odour nuisance, excluding the property of the proponent (Manitoba Conservation, 1998).

Although Manitoba tried to implement a maximum acceptable odour guideline value of 2 OU in residential areas and 7 OU in industrial areas, the application of these guideline values proved to be unworkable, and the Odour Nuisance Management Strategy was revised in 2008. MC found it difficult to handle odour nuisances in a way which appropriately responded to the needs and concerns of stakeholders, including both citizens with odour complaints and developments undergoing environmental licensing (MC 2008). The subjective nature of odours made it difficult to measure ambient odours and to apply quantitative limits for control purposes.

In particular, the following problems were noted:

- the administration of the existing odour limits had proven difficult;

- the odour limits were questioned in several high profile situations as to whether or not they provided adequate protection;
- it became increasingly difficult to technically defend the odour limit criteria; and
- portable ambient monitoring equipment was not readily available for field use.

As a result, the previous strategy was revised, and includes community complaint criteria, rather than odour levels/measurement criteria as the measure of an odour nuisance. The ambient criteria are no longer used.

2.5 QUEBEC

The Province of Quebec has no formal odour management policy or program. However, in 2008, the Town of Boucherville (Town of Boucherville 2008), Quebec passed a by-law limiting odour impacts to:

10 OU/m^3 (4-minute average, 100^{th} percentile)
5 OU/m^3 (4-minute average, 98^{th} percentile)

The by-law also stipulates that any odour emission sampling analysis be conducted using the European EN13725 standard for DDO analysis of odour samples and that use of the AERMOD model is mandatory for any odour dispersion modelling analyses.

2.6 ALBERTA

The Province of Alberta has no odour management strategy related to the use of numerical odour units. However, in July 2014, the Clean Air Strategic Alliance (CASA), a multi-stakeholder group composed of representatives from industry, government and non-government organizations that provides strategies to assess and improve air quality for Albertans using a collaborative consensus process, issued a Request for Proposals to more effectively manage odours in Alberta. The objective of the proposed work is to undertake an inventory of odour prevention and mitigation tools used in Alberta and in other jurisdictions and then to assess this inventory of tools for applicability in an Alberta context. The work is to be completed by the end of 2014.

Apart from that, Alberta has adopted odour-based ambient air quality objectives of 14 $\mu g/m^3$ (1-hour average) and 4 $\mu g/m^3$ (24-hour average) for hydrogen sulphide.

3.0 COBBLE HILL ODOUR SAMPLING SURVEY

In response to complaints about offensive odours from residents in Cobble Hill, the CVRD expended considerable effort to try to work with the operators of the FRR facility in order to understand which, if any, operations at the facility might or were likely to contribute to off-site odours. Through consultations with SENES, the CVRD determined that, since the CVRD's representatives could not be present at the FRR facility or in the community on a frequent basis, an odour survey, essentially a 'sniff test', should be instigated in order to better understand the nature and magnitude of the odour issues in the community. A similar odour survey had been conducted by the CVRD in Chemainus in May/June 2014, as well as in the Capital Regional District in 2013 in relation to a composting facility located in Central Saanich.

The objective of the odour survey was to obtain a database of systematically collected information at pre-determined locations in the community which could be used to measure the frequency with which odours are detected, their relative degree of intensity and offensiveness, and a description of the odour (i.e., what does it smell like) to see if the odours could be identified with a particular source(s) or activity, located either at the FRR facility or elsewhere in the community.

The CVRD conducted an odour sampling survey in the community of Cobble Hill from July 2nd to August 27th, 2014. The time of day varied between 6:15 am and 00:30 am, although most of the observations were made between 8:00 am and 18:00 pm because this was the time of day when odours had frequently been reported to the CVRD in the past.

The 20 pre-defined odour sampling stations used in the survey were selected to represent locations where odours had been previously been reported by residents and/or to ensure that other known and potential odours sources were captured. The sampling stations were as follows:

1) Trans-Canada Highway and Fisher Road
2) Fisher Road and Braithwaite Drive
3) Braithwaite Drive and Rolmar Crescent
4) Sitka Way and Hidden Oaks Crescent (near the Maple Hill waste water treatment plant)
5) Hutchinson Road and Dougan Drive
6) North end of Learning Way at the Cobble Hill Elementary School
7) Hutchinson Road and Verner Avenue
8) Hutchinson Road (near the Twin Cedar waste water treatment plant)
9) Fairfield Road and Fisher Road
10) Fairfield Road and Verner Avenue
11) Holland Avenue and Fisher Road
12) Holland Avenue (between Fisher Road and Galliers Road)

13) Princess Avenue and Regent Crescent (near the Cobble Hill waste water treatment plant)
14) Galliers Road near the FRR property (near the cul-de-sac)
15) Fisher Road and Ball Road
16) The FRR's property (on-site)
    a. East side of property (to the left of the entrance gate in the waste receiving area)
    b. North side of property (near the western edge of the CLS property line)
    c. West side of property (near the compost curing piles)
    d. South side of property (near the biofilters)
17) CLS's property (on-site)

In conducting the odour survey inside the FRR property line, the surveyors followed a route from 16a to 16b, 16c and 16d in sequence, noting any odours along the route as well. Within the CLS property, the surveyors made observations in the vicinity of the fresh yard and garden waste piles, the grinding area, the curing waste piles and the soil mixing area.

Figure 3.1 shows the locations of the odour survey sampling stations in relation to the FRR and CLS sites and the locations of the three wastewater treatment plants (WWTP), while Figure 3.2 provides an expanded view of Stations 1 and 6-17. Also indicated in Figures 3.1 and 3.2 is the location of the Gamboa Greenhouses (GG) which appear to be a source of odours in the community, and the location where most of the odour complaints registered with the CVRD originated during the period of the odour survey.

The odour survey was conducted following a sampling route starting at Station 1 and continuing on to follow the sampling stations sequentially in numerical order (i.e., Station 1, Station 2, Station 3, etc.). On days when time was limited (e.g., due to complaint investigations), and to supplement full survey routes done on the same day, the surveyors conducted a tighter focus route at and around the composting facilities at Stations 1, 6, 9, 10, 12, 14, 16a and 17 where odour complaints most frequently were reported and/or odours were frequently observed by the surveyors. Due to safety reasons, the surveyors did not enter onto FRR or CLS properties when they were closed; at these times survey observations were made at the property boundary instead.

The surveyor would spend a minimum of five minutes at each location, but often ten to fifteen minutes or more, depending on the degree of persistence or intermittency of the odours detected, at each station to determine whether or not any odours were detected, and if odours were noted, estimate the strength of the odour (i.e., its intensity) on a five point scale (as described in Sections 3.1 and 3.2 below), as well as try to identify the odour using ten odour descriptors (see Section 3.3). The surveyor would also take note of the wind speed and direction at the sampling location using a hand-held anemometer and survey tape and compass, as well as the ambient temperature. The second surveyor followed the same route as the first surveyor approximately one hour later or occasionally several hours later. The spacing of survey observations was done

to determine whether the same or other odours were present over time, as well as changes in odour characteristics. Sampling conducted by each surveyor at each station was treated as a single, independent sampling observation in the survey. If possible, the surveyors noted the most likely source of the odour based on its description and the wind direction at the sampling location. However, it was frequently not possible to identify a single source of odour in relation to FRR or CLS operations.

The total number of observations during the survey period ranged from 68-69 (at Stations 2, 3, 4, 5, 7, 16b, 16c, and 16d) to 102 at Stations 1.

Figure 3.1 Location of Odour Survey Stations

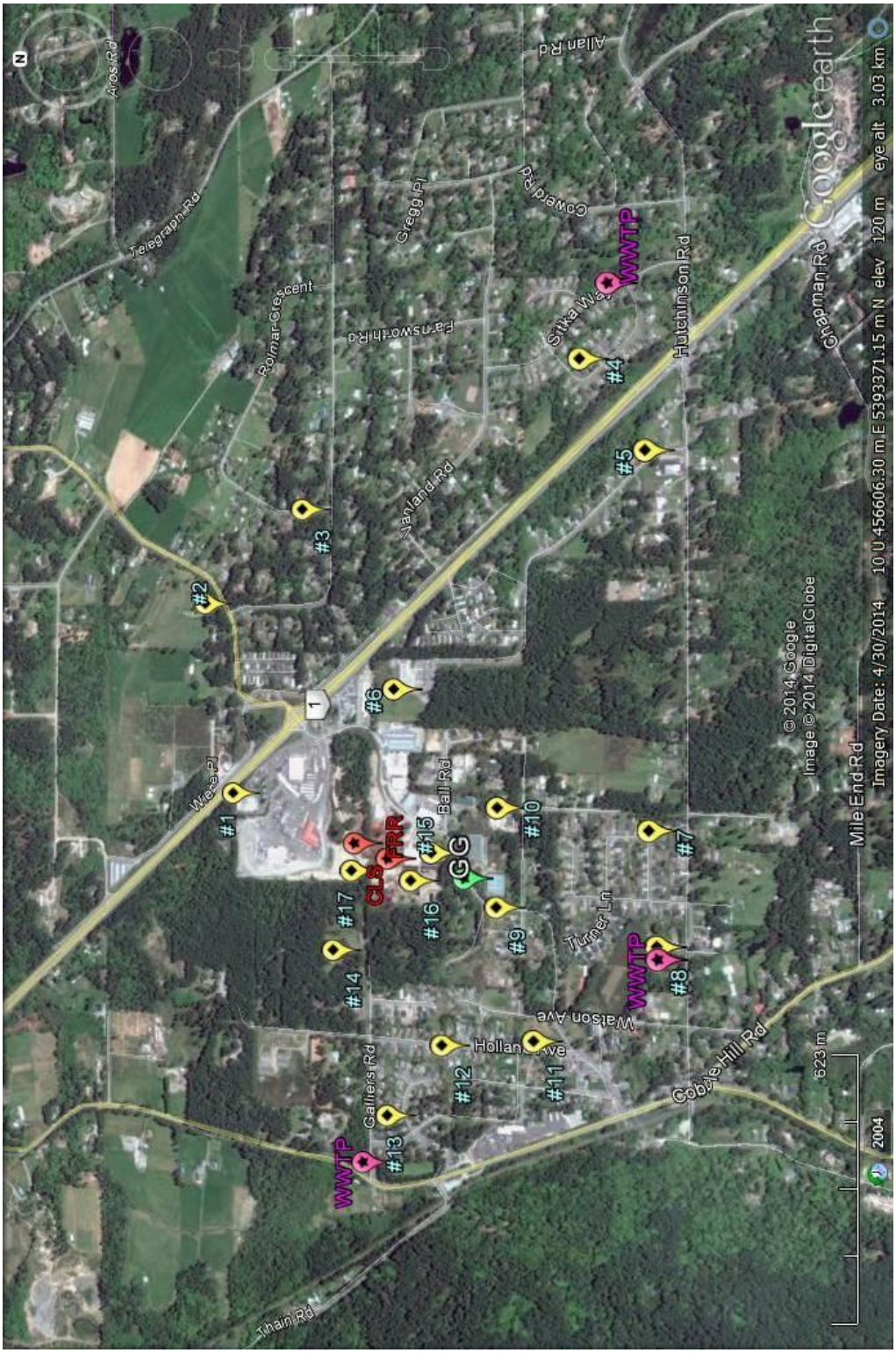
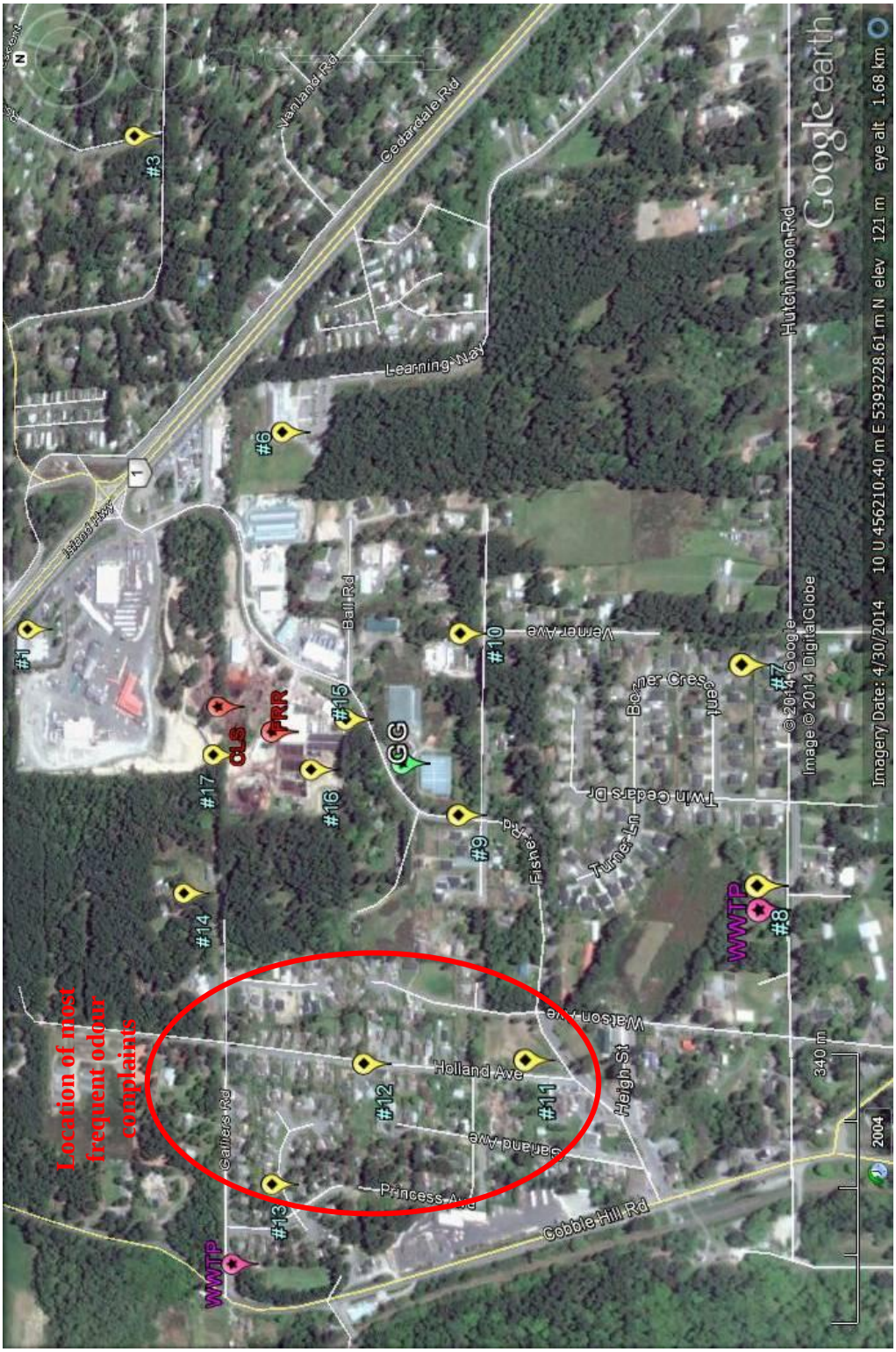


Figure 3.2 Location of Odour Survey Stations 1, 3 & 6-17



3.1 ODOUR INTENSITY

When odours were present at a station, the odour intensity was subjectively determined on a five point scale, namely:

0 Pleasant
1 Neutral/Barely noticeable
2 Noticeable
3 Strong/Offensive
4 Very strong/Offensive

The surveyors recorded the predominant odour intensity during each sampling period, and made note of short-term peak odour intensities. Based on the surveyors' observations, high intensity odours typically lasted for about an average of 30 seconds, such that the predominant odour intensity recorded during the survey was generally much lower than the peak odour intensity over short-term periods. The peak odour intensity recorded by the surveyor was highest odour intensity experienced by the surveyor during the observation period, regardless of whether the peak intensity occurred only once for up to 30 seconds or several times during the observation period.

The presence of intermittent peak intensity odours overlaying no odours or much lower intensity odours over the longer observation periods is typical of most community odour issues, as is discussed in Appendix A. Public complaints about community offensive odours are often related to short-term peak odour concentrations than to the average odour levels over several minutes. For example, in one instance during the Cobble Hill survey, a surveyor recorded an odour intensity of 1 (barely noticeable) and members of the general public nearby did not appear to be aware of any odour, but in another instance the surveyor reported a predominant odour intensity of 1, with peaks up to an intensity of 3 and a member of the general public commented to the surveyor that the odour was "just reeking" at that moment.

On the other hand, as noted in Section 2.3 with respect to an informal survey conducted by the Ministry of Environment in Ontario, people will tolerate an offensive odour for approximately 10 minutes before complaining. For the analysis of odour intensity in Cobble Hill, the predominant odour intensity over the surveyor's sampling period was used to determine the frequency of offensive odours during the survey period, and the frequency of more intense short-term odours was addressed separately.

3.1.1 Predominant Odour Intensities

Figure 3.3 indicates the frequency with which different predominant odour intensities were measured at each sampling station during the survey using the five point odour intensity scale, and summarized in Table 3.1.

The survey determined that odours were barely noticeable most of the time during the survey at all locations except on the north, west and south sections of the FRR site. The locations with the most frequent noticeable off-site odours in the community were those at Stations 4 in the vicinity of the Maple Hill WWTP, and at Station 14 northwest of the FRR and CLS sites. The occurrence of predominantly strong, offensive odours was limited to low frequencies (i.e., 1% to 2.9% of the observations) at Stations 4, 7, 9, 10 and 14. There were no observations of predominantly very strong, offensive odours at any of the off-site locations, and such odours were only observed on 6% of the observations on the north side of the FRR property.

Figure 3.3 Predominant Odour Intensity at Sampling Locations (July-August 2014)

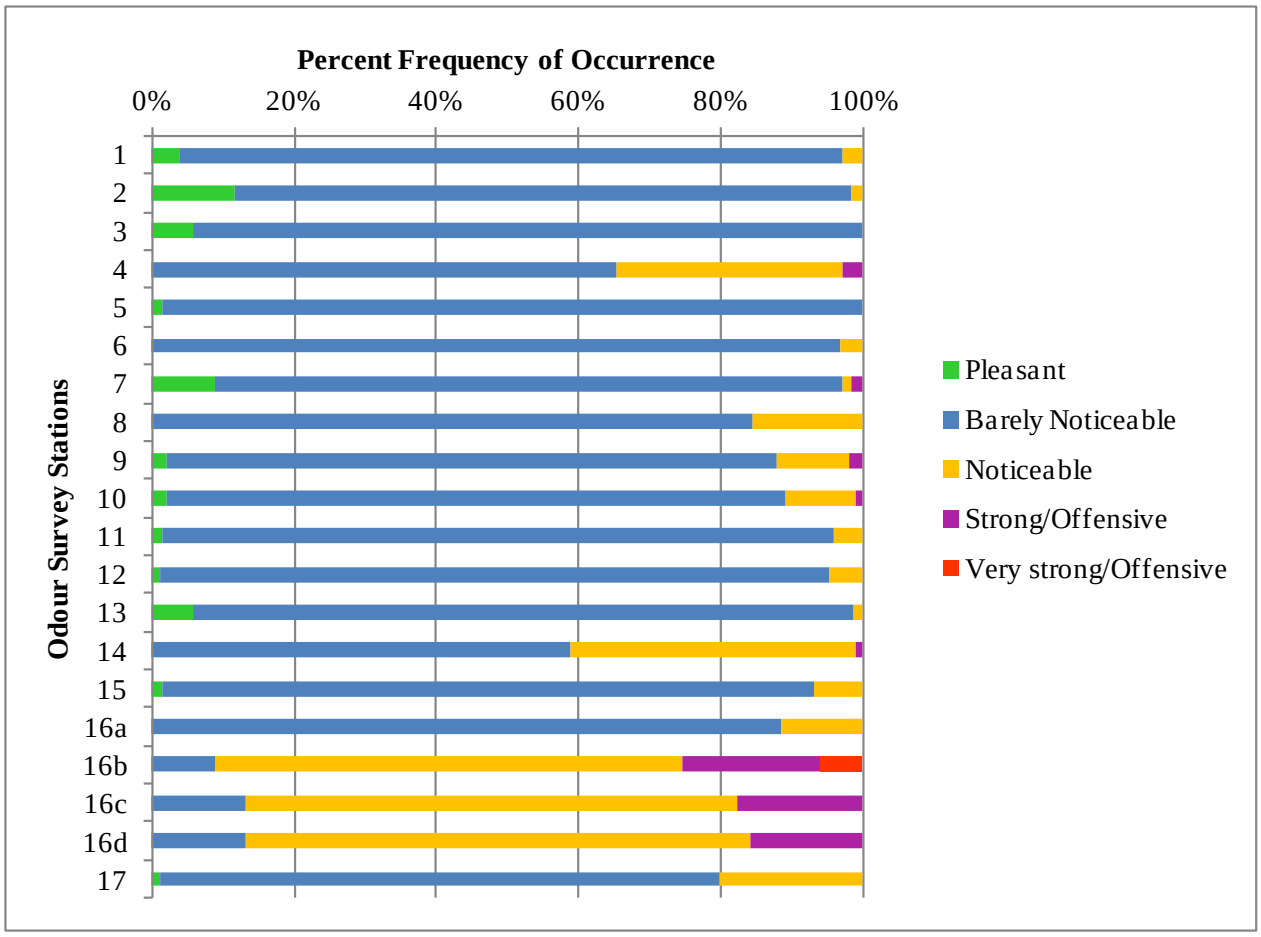


Table 3.1 Predominant Odour Intensity at Sampling Locations (July-August 2014)

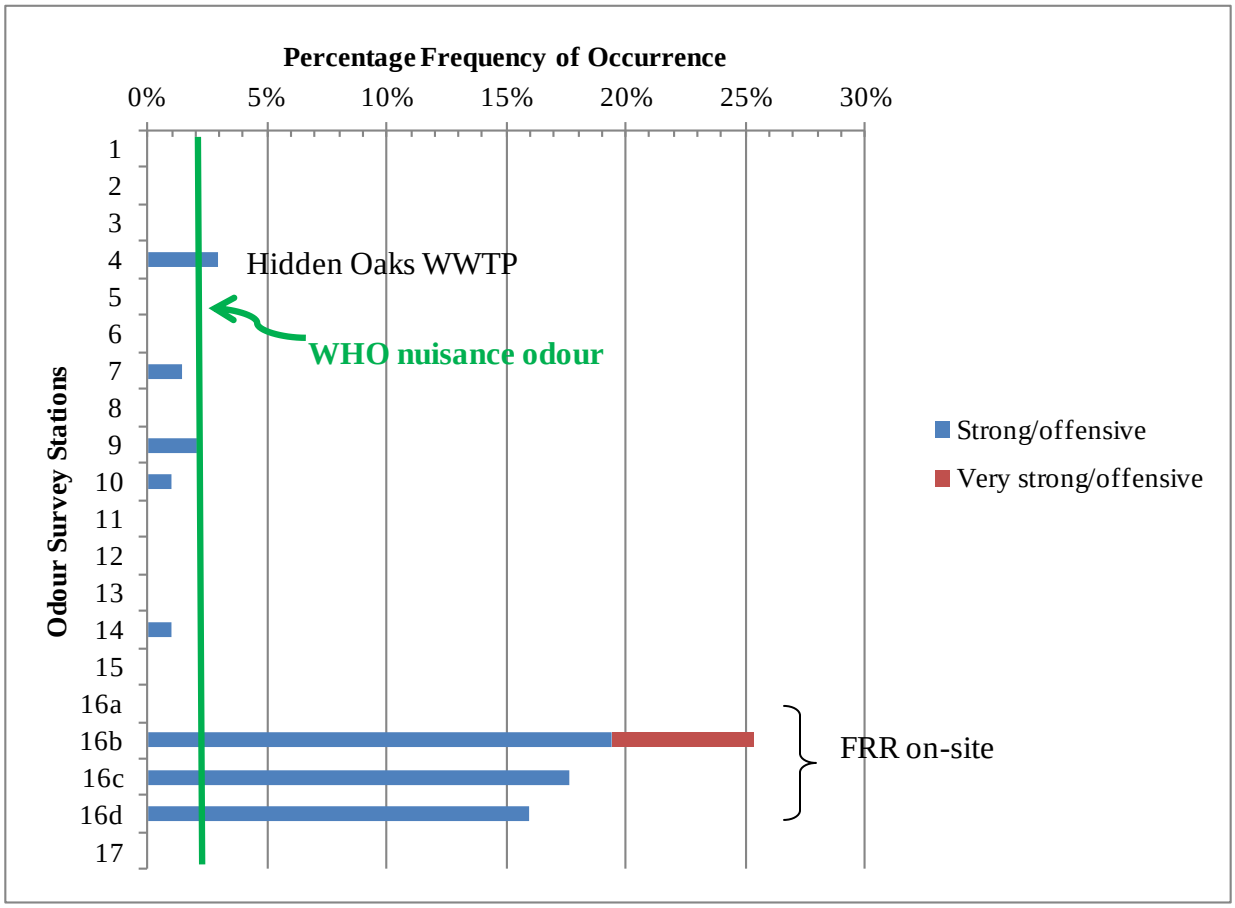
Station	Total No. of Observations	Percent Frequency of Observations				
		Pleasant	Neutral/Barely Noticeable	Noticeable	Strong/ Offensive	Very Strong/ Offensive
1	102	3.9%	93.1%	2.9%	0.0%	0.0%
2	68	11.8%	86.8%	1.5%	0.0%	0.0%
3	68	5.9%	94.1%	0.0%	0.0%	0.0%
4	69	0.0%	65.2%	31.9%	2.9%	0.0%
5	68	1.5%	98.5%	0.0%	0.0%	0.0%
6	100	0.0%	97.0%	3.0%	0.0%	0.0%
7	68	8.8%	88.2%	1.5%	1.5%	0.0%
8	71	0.0%	84.5%	15.5%	0.0%	0.0%
9	99	2.0%	85.7%	10.2%	2.0%	0.0%
10	100	2.0%	87.0%	10.0%	1.0%	0.0%
11	76	1.3%	94.7%	3.9%	0.0%	0.0%
12	84	1.2%	94.0%	4.8%	0.0%	0.0%
13	70	5.7%	92.9%	1.4%	0.0%	0.0%
14	100	0.0%	59.0%	40.0%	1.0%	0.0%
15	72	1.4%	91.7%	6.9%	0.0%	0.0%
16a	97	0.0%	88.5%	11.5%	0.0%	0.0%
16b	68	0.0%	9.0%	65.7%	19.4%	6.0%
16c	68	0.0%	13.2%	69.1%	17.6%	0.0%
16d	69	0.0%	13.0%	71.0%	15.9%	0.0%
17	90	1.1%	78.9%	20.0%	0.0%	0.0%

Table 3.1 indicates that noticeable odours were present more than 0.5% of the time at all of the locations except Station 3 and Station 5.

Figure 3.4 indicates the percentage of the survey observations at each station that were rated to be more than noticeable. Also indicated on Figure 3.4 is the World Health Organization (WHO) threshold level for nuisance odour impacts. The WHO defines a nuisance threshold as being that concentration at which not more than a small proportion of the population (less than 5%) experiences annoyance for a small part of the time (less than 2%) (WHO 2000). In the absence of an alternative definition of a nuisance odour threshold, the WHO definition can be used as one alternative in evaluating the odour survey observations. The off-site locations with the highest frequencies of offensive odours were recorded at Station 4 (2.9%) and Station 9 (2%), while the highest frequencies of on-site odour observations were on the north side of the FRR property. Although the highest frequency of noticeable odours at off-site locations was recorded at Station

14 northwest of the FRR site, predominantly strong/offensive odours were only recorded 1% of the time at this location.

Figure 3.4 Frequency of Predominant Offensive Odours (July-August 2014)



Therefore, if the WHO definition of a nuisance odour is interpreted solely on the basis of whether predominantly offensive odours occur less than 2% of the time, then locations 4 and 9 could to considered to meet that definition. However, there is insufficient information available about the number of people affected at these locations to determine whether they represent 5% of the population in Cobble Hill. All that can be said with certainty is that the frequency of predominantly strong/offensive odours at these two locations is marginally higher than at locations 7, 10 and 14.

Note that the higher frequency of odours at Stations 16a through 16d were all located on-site at the FRR facility, while survey Station 17 is located on the CLS property. It should also be noted in Table 3.1, Figure 3.4 and Figure 3.5 that the higher frequency of offensive odours at Station

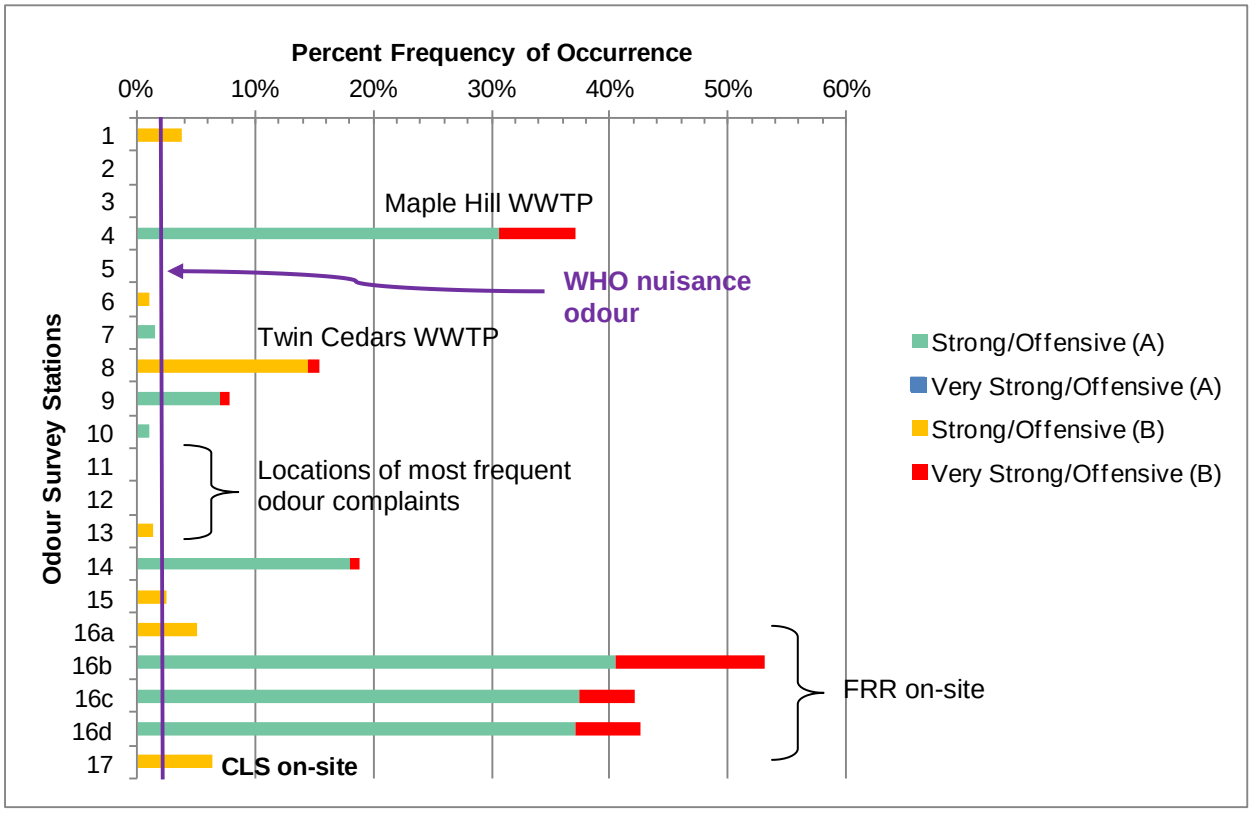
16b was mainly due to emissions from the CLS facility because the odours were recorded near the boundary between FRR and CLS, with winds generally blowing from the NE through SE, placing Station 16b downwind of the CLS facility. With winds from a generally easterly direction, the lower frequency of odours reported at Station 17 may simply reflect that observations made on site at CLS would not necessarily have been made at locations downwind of the primary odour sources at CLS.

3.1.2 Predominant & Peak Odour Intensities

Overall, the surveyors noted the intermittent nature of most odour observations. The predominant barely noticeable and noticeable odour intensities presented in Figures 3.3 and 3.4 were frequently accompanied by short-term (i.e., lasting up to 30 seconds) wafts of higher intensity odours in the offensive/strong and very strong/offensive categories. Peak odour intensity refers to the highest short-term odour intensities that were observed during the survey observations, whether those intensities occurred once or several times during the observation period. Peak odour intensities were not present for all observations. However, when present, the highest odour intensity observed was recorded in addition to the lower, predominant odour intensity. As noted in Section 3.1 above, residents in the Cobble Hill community appear to react more strongly to these peak odour intensities than to the predominant odours.

Figure 3.5 shows the frequency of observations during the survey which were recorded as offensive on the five point odour intensity scale. The frequency of odours denoted as being predominantly strong/offensive or very strong/offensive with peak odour intensities in these two categories are indicated as (A) in Figure 3.5. The frequency of peak only odour intensities greater than the highest predominant odour intensity at each station is denoted as (B) in Figure 3.5.

Figure 3.5 Frequency of Predominant & Peak Odour Intensities (July-August 2014)



Note:

(A) - denotes predominant plus peak odours

(B) - denotes peak odours only

The highest frequency of predominant and short-term peak offensive odour intensities at off-site locations was reported at Stations 4 and 14 in the vicinity of the Maple Hill WWTP and the western boundary of the FRR facility, respectively. Predominantly and peak strong/offensive odours were also noted at Station 8 near the Twin cedars WWTP and Station 9 near the intersection of Fairfield Road and Fisher Road. In respect to the odours noted at Station 9, it appears that odours from the GG may be contributing to the offensive odours in the community, as well as odours from FRR and CLS.

A relatively higher frequency of peak only offensive odours was also noted in the vicinity of the Twin Cedars WWTP at Station 8. The combination of predominant and peak offensive odours at these locations exceeded the WHO guideline of 2% frequency for nuisance odour impacts. Peak only offensive odours were also noted to occur with frequencies of 3.7% at Station 1 near the intersection of Fisher Road and the Trans-Canada Highway and 2.5% at Station 15 near the intersection of Fisher Road and Ball Road.

The high frequency of offensive peak odours at the FRR site property line at Stations 16b, 16c and 16d indicate that the FRR site is a potential source of offensive odours that can be carried off-site. The location where these odours may have their largest impact is at Station 14 which is close to the northwestern section of the FRR site.

As noted by Griffiths (2014), the same level of negative community response can be derived from a few acute exposures to high odour concentrations as from more frequent exposures to lower levels of odour intensity. Nevertheless, there was a higher frequency of both predominant and peak offensive odours at Station 4 than at Stations 11, 12 and 13, while the majority of odour complaints were received from residents in the area of the latter three stations and no submissions from the residents near Station 4.

3.2 NIGHT TIME ODOUR INTENSITIES

Anecdotal information provided to the CVRD by residents in Cobble Hill during the survey suggested that odours were more intense at night than during the day. Four of the odour survey observation periods were conducted during the evening hours (i.e., after 18:00 pm) on:

July 16th
August 14th
August 20th
August 24th

Odour complaints were received on the first three of these days, but only the complaint on July 16th coincided with the time of the survey period starting at 18:00 pm. The other two complaints were lodged earlier in the day before noon on August 14th and 20th. None of the four surveys were conducted beyond 01:00 am.

Most of the evening observations noted pleasant, barely noticeable or noticeable odours at almost all of the stations. The exceptions were as follows:

- July 16th - noticeable odours with peak very strong/offensive odours at Station 4 near the Maple Hill WWTP
- July 16th - barely noticeable odours with peak strong/offensive odours at Station 8 near the Twin Cedars WWTP
- August 20th - noticeable odours with peak strong/offensive odours at Station 1 which could have been related to yard and garden waste odours from the CLS facility
- August 20th - noticeable odours with peak strong/offensive odours at Station 4 near the Maple Hill WWTP

- August 20th - noticeable-to-strong/offensive odours at Station 10 that were attributed to the GG facility
- August 24th - barely noticeable odours at Station 1 which could have been related to the FRR facility with strong wafts of peak strong/offensive odours that could have been attributed to the yard and garden waste odours from the CLS facility
- August 24th - noticeable odours with peak very strong/offensive odours at Station 4 near the Maple Hill WWTP

Therefore, the odours identified during the evening hour surveys noted odours that may have been attributed to the FRR and/or CLS facility at Station 1 near the Junction of the Trans-Canada Highway and Fisher Road, at Station 10 near Fairfield Road and Verner Avenue that were attributed to the GG facility, and at Stations 4 and 8 that were attributed to the Maple Hill and Twin Cedars WWTP. There were an insufficient number of evening observations to conclude that odours during the evening or night time hours were more intense than during daytime hours.

3.3 ODOUR DESCRIPTORS

The odours at each sampling site were evaluated on a 10-point scale using odour descriptors. The descriptor categories used by the surveyors were similar to those defined by the 'odour wheel' for the types of odorous compounds likely to be emitted from composting facilities as provided by Rosenfeld et al. (2007). The scale used by the surveyors was as follows:

1. Fecal/sewage/manure
2. Earthy/musty
3. Pine/mint/hay/lemon/eucalyptus
4. Sweet/garbage can/nail polish/solvent
5. Soap/fruit/citrus/green
6. Chemical/rubbery/shoe polish/glue/gasoline
7. Dead animal/rancid/putrid
8. Woody
9. Fishy/urine/ammonia
10. Rotten cabbage/egg/sulphur

Given the complexity of some of the odours emanating from the FRR and CLS facilities and other odour sources such as the GG, the surveyors were not always able to limit their use of descriptors to only one category from among these 10 categories of odour descriptors, and sometimes used two or more categories to describe an odour. For example, the various FRR biofilters were described using the following categories:

Open biofilter - musty (category 2), lemony (category 3), solvent (category 4), chemical (category 6), woody (category 8)

Partially covered biofilter - musty (category 2), solvent (category 4)

East tent biofilter - musty (category 2), sweet (category 4), woody (category 8), as well as yeasty or rancid/putrid

West tent biofilter - musty (category 2), sweet or solvent (category 4), woody (category 8), as well as yeasty and sharp

In addition, there were frequent observations wherein more than one odour was present during the sampling period at a station (e.g., odours from both FRR and CLS simultaneously present), such that several categories might be used during one observation. For example, CLS fresh yard and garden waste was frequently listed as pine/mint/hay/lemon/eucalyptus (category 3) and soap/fruit/citrus/green (category 5), but sometimes also with additional descriptors such as musty (category 2), and woody (category 8). The odours from GG were described as sweet (category 4), as well as musty (category 2) and fruity (category 5), as well as rotten. Given that no one descriptor could be said to be the dominant odour descriptor for any of the three facilities (i.e., FRR, CLS and GG), the surveyors frequently used the several descriptor categories to describe odours, especially when they perceived that more than one source was contributing to the perceived odour during an observation period.

All categories of odour descriptors observed were recorded, and the information was subsequently analyzed to identify the most dominant (i.e., frequent) categories reported at each sampling station, and summarized as follows:

Station 1: Trans-Canada Highway and Fisher Road

The surveyors reported six observations which might have been attributable to FRR and/or CLS. Four of these observations were barely noticeable, while two were noticeable odours, and there were four observations during which the peak, short-term odour intensities were reported as strong/offensive. The surveyors noted that it was at times difficult to describe the odours, but some of the time the odours were listed as being musty or smokey, and were listed as categories 2, 3 and 4 on the ten point scale of odour descriptors. These odours were considered by the surveyors to most probably be related to emissions from FRR and/or CLS operations. Other odours noted during the survey included bakery (seven times), manure (twice), gasoline or chemicals (once).

Station 2: Fisher Road and Braithwaite Drive

The surveyors reported three observations which might have been attributable to FRR and/or CLS. All three observations were reported as barely noticeable in intensity, with only one observation having noticeable peak odour intensity, but not offensive. The surveyors also noted that there were some very faint or barely noticeable odours with some stronger wafts disappearing with changes in wind direction. Manure or farm odours were noted on three occasions, but the surveyors mostly reported vegetation type odours.

Station 3: Braithwaite Drive and Rolmar Crescent

There were three observations which might have been attributable to FRR and/or CLS. All three observations were barely noticeable, with one observation having noticeable short-term noticeable peak odours. In general, any odours were very faint or barely noticeable.

Station 4: Sitka Way and Hidden Oaks Crescent (near the Maple Hill WWTP)

There were a total of 17 observations which were attributed to Maple Hill WWTP. No observations were described as being attributable either to the FRR or CLS operations. Although only two of these observations were described as having odour intensities that were considered strong enough to be offensive, eleven observations noted peak, short-term odour intensities that were either strong/offensive (seven times) or very strong/offensive (four times). The odours were generally described as ammonia and sulphur type odours mostly within 10 metres of the WWTP, and occasionally further along Sitka Way and Maple Hill Crescent. The predominant odours at this station were neutral/barely noticeable, with frequent short-term wafts of strong/offensive and very strong/offensive odours from the WWTP

Station 5: Hutchinson Road and Dougan Drive

There were only two observations which might have been related to odour from the Maple Hill WWTP as they were described as being a sulphur/fecal offensive type of odour. Both observations reported the odours as barely noticeable, with no peak offensive odours. The predominant odours at this station were neutral/barely noticeable.

Station 6: North end of Learning Way at the Cobble Hill Elementary School

Odours at this location were primarily described as neutral vegetation odours from nearby fields. A total of seven observations where described as being very faint or barely noticeable odours that may have originated from FRR and/or CLS operations. There was only one observation during which the short-term peak odour intensity was described as strong/offensive peak which might have been a mix of odours from FRR and CLS operations. This peak odour intensity was described as having a musty or sour odour.

Station 7: Hutchinson Road and Verner Avenue

Surveyors reported mostly vegetation-type odours, with occasional farm or manure-type odours. There were only two observations which might have been attributable to FRR and/or CLS, but these were only very faint, brief wafts of odour - not persistent.

Station 8: Hutchinson Road (near Twin Cedars WWTP)

Surveyors noted that the Twin Cedars WWTP was the source of odour 59 times during the survey period. By comparison, the FRR and/or CLS operations were only noted as a possible source of odour on two occasions. The surveyors reported that the possible FRR and CLS odours were experienced in waves of barely noticeable to noticeable odours on one occasion, and noticeable wafts of yard and garden type odours on the second occasion. There was only one other occasion when short wafts of a sour odour described as garbage-type odour from the FRR composting operation was noted which the surveyor associated with odours emanating from inside the composting building or the biofilter. Overall, however, 48 of 59 observations of odour were related to the nearby Twin Cedars WWTP, all of which were predominantly barely noticeable, but with occasional frequent peaks of noticeable to offensive odours described as fecal, sewage, chemical or sulphur odours. These odours were mostly confined to the immediate vicinity (up to 1-2 meters) of the WWTP.

Station 9: Fairfield Road and Fisher Road

Surveyors reported a total of 27 observations which the surveyors identified FRR or CLS operations as the source of the odour, mostly as mixture of the two sources. Twenty of these observations were barely noticeable and seven were noticeable, but with occasional short-term peak odours intense enough to be considered offensive. There were no observations of predominantly offensive odours at this location. Four of the observations listed the FRR biofilter as the possible source of odour, while another four listed the composting operation. Two observations noted a rancid, sweet garbage type of odour that the surveyors related to the FRR operation, and three observations were listed as musty odours that may have been related to the biofilters. Four observations reported yard and garden waste odours that may have been related to the CLS operations, or to a mixture of CLS and FRR operations. Therefore, both FRR and CLS were likely sources of odour at this location.

Station 10: Fairfield Road and Verner Avenue

The surveyors reported a total of ten observations at this location in which FRR & CLS operations were noted as possible sources of the odour. Only two of the observations related to FRR and/or CLS were higher than barely noticeable and none were high enough to be considered offensive. On the other hand, the GG were identified as the likely source of odour on 17 occasions, five of which had predominantly noticeable odours with short-term peak odours of strong/offensive or very strong/offensive, and one observation during which the odours were predominantly offensive which was described as “fermenting, rotten putrid, outhouse/chemical

odour, very offensive". On four occasions, the surveyors reported a yeasty type of odour in association with the GG facility. The surveyors also noted rotting cucumbers and some tomatoes in piles outside the greenhouses on several occasions. In addition to these odours, the surveyors noted barely noticeable odours of cut lumber on eight occasions that were identified as coming from the Cedar Mill sawmill.

Station 11: Holland Avenue and Fisher Road

There were a total of twelve odour observations which the surveyors noted were either related or possibly related to FRR & CLS operations, and one observation related to odours from the GG. Nine of the twelve observations related to FRR/CLS were barely noticeable, while the other three observations were noticeable but there were no short-term peak offensive odours. Odours were noted as being distinctly different from the WWTP odours around the Twin Cedars WWTP. The one observation related to the GG was rated as barely noticeable to noticeable in intensity.

Station 12: Holland Avenue (between Fisher Road and Galliers Road)

Although there were a total of 23 observations which the surveyors noted could be related to the FRR and/or CLS operations, almost all of these (21 observations) were reported as being barely noticeable, and only two observations were reported as noticeable. However, none of the observations reported either a predominant or peak odour intensity that would be high enough to be considered offensive. Therefore, while it appears likely that odours emanating from the FRR and/or CLS operations are capable of reaching this area which was the location of frequent odour complaints, none of the odours reported during the survey were considered to meet the intensity defined as offensive. The surveyors were unable to distinguish between odours from FRR or CLS in 17 of the 23 observations. For the remaining six observations, three were attributed to FRR and the remaining three to CLS. Only one observation of a noticeable odour occurred at the time of the new biofilter operation start-up at FRR. One additional observation of a noticeable odour was described as a fermenting, rotten putrid odour and was attributed to the GG, indicating that the greenhouse operations are capable of emitting odours which can travel to this location.

Station 13: Princess Avenue and Regent Crescent (near the Cobble Hill WWTP)

There were only two observations of barely noticeable odours at this location during the survey which might have been related to FRR and/or CLS. A third observation of a barely noticeable odour was noted as being related to the nearby WWTP, where peak short-term odours near the WWTP could be rated as offensive. There were no other odours identified at this station.

Station 14: Galliers Road near the FRR property (near the cul-de-sac)

The surveyors reported a total of 74 observations of odours that were related to FRR and/or CLS. Twenty-six observations were noted to be odours from FRR, and were attributed to the FRR biofilters, curing compost, screening of compost and finished compost. Six of the 74

observations were related to odours from CLS alone. The remaining 42 observations could not be distinguished between FRR or CLS and were described as being a mixture of odours from both operations. Forty of the 74 observations were rated as having a noticeable odour, and some with peak odours that were strong and offensive, but only one observation in which the odours were predominantly strong/offensive with short-term peak odours that were very strong/offensive. Some of the observations noted that the odours extended along Galliers Road west of Holland Avenue and along Soren Road. Odours from the FRR curing compost were described as musty/earthy, and sometimes odours from FRR were described as sour musty/rotten or garbage odours. Other odours from the FRR operations were described as dull manure-type odour from the finished compost. The yard and garden waste odours from the CLS operations were described as minty/piney/musty odours that got caught in the throat. The observations made during the survey at this location provide conclusive evidence that odours from both the FRR and CLS operations are capable of being transported beyond the property lines of both facilities.

Station 15: Fisher Road and Ball Road

There were a total of 19 observations at this station that could possibly have been attributable to odour emissions from the FRR and/or CLS operations. Fifteen of those observations were barely noticeable or had noticeable short-term peak intensities. Only four observations had predominantly noticeable odour intensities, with some observations reporting peak concentrations as strong/offensive. Possible sources of odour were identified as compost, biofilters, yard and garden waste, curing compost, and mixed FRR and CLS odours that were hard to distinguish. Odours that were thought to be attributable to the biofilters were reported to have a lemony, sharp and solvent-type odours, but the surveyors also noted that there were strong and distinct short-term wafts of musty odours from the yard and garden waste. Apart from the odours from FRR and CLS operations, the surveyors noted that there were five observations of barely noticeable odours from Peerless lumber, and one observation of a clearly noticeable rotten smell in the hollow along Fisher Road that the surveyors attributed to the GG.

Station 16a: The FRR Facility's east section of property

The surveyors walked the eastern section of the FRR property and noted that there was some odour present there at all times when the surveyors were standing close to the odours sources, but that the odours were barely noticeable most of the time. Noticeable intensity odours were only observed 11% of the time, and none of the observations recorded predominantly strong/offensive odours, although there were some short-term peaks in this category on occasion. For the cases where the odours were reported as predominantly noticeable, FRR was identified as the sole source of the odours for only 3 observations, and the FRR sources contributing to these odours were reported as the biofilters and the recycling drop-off area. Yard and garden waste odours from the CLS operations in combination with odours from the FRR compost,

biofilters and garbage handling accounted for about half of the predominantly noticeable odours, while short-term peak intensity odours listed as strong/offensive were attributed to the CLS yard and garden waste and the FRR biofilters. Therefore, noticeable odours at the east side of the FRR facility were not entirely related to FRR operations alone, but at least some of the odours could be attributed to the CLS operations as well.

Station 16b: The FRR Facility's north section of property, between FRR & CLS (mostly close to NW CLS boundary)

The surveyors walked the northern section of the FRR property and odours were present during all survey observations, and approximately 90% of the time the odours were of noticeable intensity, with frequent peak, short-term odours rated as either strong/offensive or very strong/offensive. The CLS yard and garden waste operations were cited as a likely source of the odours rated as offensive in all but one observation, and the CLS operations were identified as the likely source of odours rated as noticeable or offensive in 38 of the observations, accounting for 62% of all observations rated as noticeable or greater in intensity. These odours were attributed to yard and garden waste piles both before and after grinding, turning of yard and garden compost windrows and grinding of yard and garden waste. During several of the observations, the surveyors noted that the odours coming from the CLS operations had higher odour intensities than those coming from the FRR operations. Odours from the FRR operations were noted when the surveyors were close to the odour source and identified as coming from the garbage or waste bins, the finished compost and curing compost piles, and from the compost tent building when the door was open to allow machinery to enter and exit. The odours from the building when the building door was open were described as putrid/ rancid, or garbage can type odours, and having a maximum odour intensity rated as very strong/offensive. When referring to compost odours, the surveyors typically identified these odours as earthy/musty and sour.

There was a notable absence of comments about odours from the biofilters at this on-site location, in contrast with surveyors' comments about biofilter odours for observations made at off-site locations. This absence of comments about odours from biofilters may be explained by the fact that all but 11 of the observations noted wind as coming from the N through SE wind directions, and only three observations on days with winds from the SW through W directions. Therefore, the observations were made during periods when Station 16b was not downwind of the biofilters.

Yard and garden waste odours from the CLS operation were typically described as having a sweet pine/mint/hay/lemon/eucalyptus tone. In summary, the CLS operation appears to be the dominant source of odours at the north side of the FRR property, despite the proximity of FRR sources of odour.

Station 16c: The FRR Facility's west property, between curing compost and leachate ponds

The surveyors walked the western section of the FRR property and odours were present during all survey observations, and 87% of the time the odours were of noticeable intensity, with frequent peak, short-term odours rated as either strong/offensive or very strong/offensive. The primary sources of the odours were identified by the surveyors as being the FRR finished compost. When close, approximately 1-2 meters away from the material, the odour from these sources was reported as smelling as rotten manure-type odours, sometimes as slightly putrid, musty, and sweet odours. The curing compost was reported to be associated with the most intense odours rated as strong/offensive with peak very strong/offensive odours. The odours from the leachate pond were rated as barely noticeable, with short-term peaks of strong/offensive odours from the leachate holding barrel when right next to it. The curing compost odours were associated with short-term peak intensity odours rated as very strong/offensive, and were noted as having a dull or 'hollow' but very thick odour quality. In contrast, odours from the biofilters were only mentioned in seven observations, and all of these were rated as having a noticeable odour intensity with short-term peaks of strong/offensive odours. Although yard and garden waste odours from the CLS operation were cited in 11% of the observations that were rated as having a noticeable or greater intensity odour, the odour emissions from FRR operations were the dominant source of odour at this location due to the close proximity to them.

Station 16d: The FRR Facility's south section of property, near biofilters

The surveyors walked the south section of the FRR property and odours were present during all survey observations, and 87% of the time the odours were of noticeable intensity, with frequent peak, short-term odours rated as either strong/offensive or very strong/offensive. The FRR biofilters were identified by the surveyors as the dominant source of odours at this location, and were cited as the source of odour in virtually every case where the predominant odour intensity was rated as noticeable or greater. The surveyors frequently noted the covered/tented and new uncovered biofilter as the sources of the odours. The biofilter odours were described as sweet woody, or sour odours, and sometimes as chemically or acidic, musty or yeasty in tone. The odours from the uncovered biofilter were described as having a garbage or lemony/hay type of odour. At this location, the FRR curing or finished compost piles were only noted as possible sources of odour in only six observations, while the CLS operation was only noted as a source in two observations.

Station 17: CLS Property

Due machinery and limited space for the surveyors to safely access the whole site during the survey observations, the surveyors mostly walked the south and east sections of the property. A total of 78 observations at this location cited either the CLS operation or the FRR operation as being the source of the odours. Of these, 72 observations were attributed as coming solely from the CLS operation, while the remaining six observations were rated as a mix of odours from both CLS and FRR. For odours rated as coming solely from the CLS operation, 60 were rated as

barely noticeable, though with peak short-term noticeable of even strong/offensive odours. All of the peak intensity odours rated as offensive were ascribed by the surveyors to CLS yard and garden waste, grinding and making soil. The six observations that identified FRR as a possible source were described as musty odours. Apart from the CLS and FRR odours, there were three observations of paint or solvent type odours which may have come from the industrial site across Fisher Road.

In addition to the observations made at the pre-selected odour survey stations, the surveyors noted that odours in an area along Fisher Road near Station 15 that was referred to as the 'hollow' because odours seemed to linger longer at this location during the survey than at any other location. Odours were noted at this location when driving through this area. Furthermore, there were two formal complaints to the CVRD's on-line odour complaint registry made during the survey about odours in the 'hollow', as well as several informal verbal complaints made directly to surveyors from individuals in the area.

The surveyors mentioned odour in the 'hollow' on 28 occasions during the survey. Eleven of these observations were for faint or barely noticeable odours, seven for noticeable odours, and seven with either predominantly faint or noticeable odours with short-term peak strong/offensive odours. Only three odour observations noted predominantly strong/offensive or very strong/offensive odours. Four observations were reported as being related to the GG at Fairfield Road and Fisher Road, with two of the observations reporting predominantly offensive odours with peak very strong/offensive odours which were described as fermenting, rotten/ putrid odours. The biofilters were noted as a possible source of odours on five occasions, with curing compost, dull or musty odours and garbage/sour odours being noted in other observations. Therefore, at this location, there appeared to be a number of different sources of odour at FRR, CLS and the GG which altogether contributed to relatively frequent odour observations, some of which were intense enough to be considered offensive.

3.4 SUMMARY OF OFFENSIVE ODOUR OBSERVATIONS

The results of the odour survey indicate that there are a number of sources of offensive odours in Cobble Hill. While the primary focus of complaints registered with the CVRD was the FRR operation, the odour survey identified the Maple Hill and Twin Cedars WWTP as a source of odour in the immediate vicinity of these plants, as well as the CLS operation and the GG as contributing to community odours.

It is clear from the observation made at Stations 16a-d and 17 that both the FRR and CLS operations have odours on-site, and the observations at Stations 9, 14 and 15 indicate that these odours are transported beyond the property lines of both facilities. These odours were still detectable and recognizable at further distances such as at Stations 10, 11, 12 and 13 although at

much lower intensities, as would be expected for greater transport distances. For example, while there were numerous observations of odours attributed to FRR and CLS at Station 14 of which some were considered strong enough to be offensive, there were only 2 observations of barely noticeable odours further west at Station 13. Similarly, while there were quite a few observations of noticeable odours at Station 12 in the area of most frequent odour complaints, and many of these were attributed to the FRR or CLS operations based on the types of odours identified, none of these survey observations noted predominant or peak odour intensities in the range of offensive odours. One observation of noticeable (but not offensive) odour from the GG was also noted during the odour survey at Station 12.

East of the FRR and CLS operations, some noticeable odours with a few short-term peak offensive odours attributed to the FRR and/or CLS operations were noted at Station 1, but these odours did not appear to affect locations east of the Trans-Canada Highway and were barely noticeable to the southeast at Station 6, consistent with the dilution of the odours through dispersion with increasing distance from the source.

For the predominant odours, the only location where the frequency of offensive odours exceeded the 2% criterion defined by the WHO for nuisance odours was in the immediate vicinity of the Maple Hill WWTP (see Figure 3.4). Whether this location would also meet the WHO criterion for 5% of the community population is unclear. Assuming that the population criterion is met, the Maple Hill WWTP could be considered as emitting odours sufficient to be considered as causing a nuisance impact in the community. Although the other sources of odour such as the FRR, CLS, GG and the Twin Cedars WWTP all emit offensive odours at times, the odour survey did not identify persistent, predominant odours that were intense enough and frequent enough to meet this WHO criterion for nuisance odour impacts.

On the other hand, it is also clear that the residents of the Cobble Hill community are more sensitive to the short-term peak odour impacts than they are to the predominant odours. If the same WHO 2% criterion is applied to the peak intensity odours presented in Figure 3.5 as offensive, then the highest impacted area would be in the vicinity of the Maple Hill WWTP where over 37% of the peak odours would have been considered to be offensive. The second location with the most frequent peak offensive odours would be Station 14 with a frequency of 19%, and these would be related to emissions from the FRR and/or CLS operations. A close third in ranking would be Station 8 beside the Twin Cedars WWTP with 15%. The location with the next most frequent occurrence of offensive odours was Station 9 which had a mixture of odours from FRR, CLS and the GG at various times, collectively combining for a frequency of offence odours at 8% of total survey observations. The remaining stations where offensive odours exceeded the WHO 2% criterion were Station 1 and Station 15 at 3.7% and 5%, respectively. In the area where odour complaints were lodged most frequently during the odour

survey, the frequency of peak offensive odour intensity observations was just 1.4% at Station 13 and zero at stations 11 and 12.

Therefore, the odour survey was not consistent with the area of most frequent odour complaints. The locations identified as having the most frequent offensive odours do not coincide with the locations where complaints were most frequently lodged with CVRD. The odour complaint data is discussed in Section 4.0.

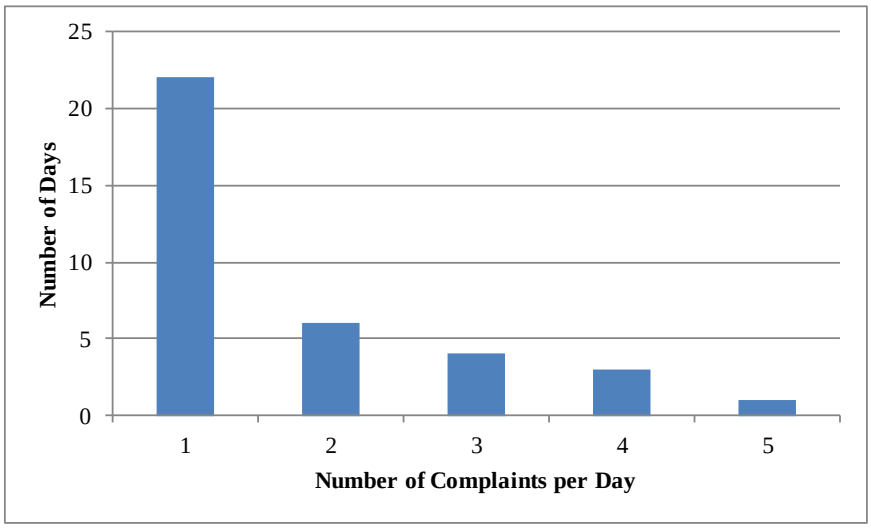
4.0 PUBLIC ODOUR COMPLAINTS/OBSERVATIONS

The CVRD mailed out a letter to residents near the composting facilities in Cobble Hill, notifying them about the odour survey and asked that any odour complaint be submitted to an on-line database so that specific information about the odours could be recorded. Some complaints were received by phone or e-mail and did not always contain the information requested in the on-line database. The following provides a summary of that information.

There were a total of 63 odour complaints received by the CVRD during the period of the odour survey, almost evenly split with 29 complaints in July and 34 complaints in August. These complaints were received from a total of 28 individual locations. Sixty-seven percent of the odour complaints were received from residents living along Holland Avenue, Garland Avenue, Soren Place, Galliers Road and Regent Place. The general location of these complainants is indicated on Figure 3.2. This area was also the location where multiple complaints were registered from the same residences, with several locations along Holland Avenue being responsible for a total of 3-4 complaints each.

Thirty-five percent of the complaints were received as a single complaint per day, while the remaining 65% of the complaints were received as two or more complaints per day, with a maximum of five complaints per day. Figure 4.1 shows the frequency of the number of complaints per day.

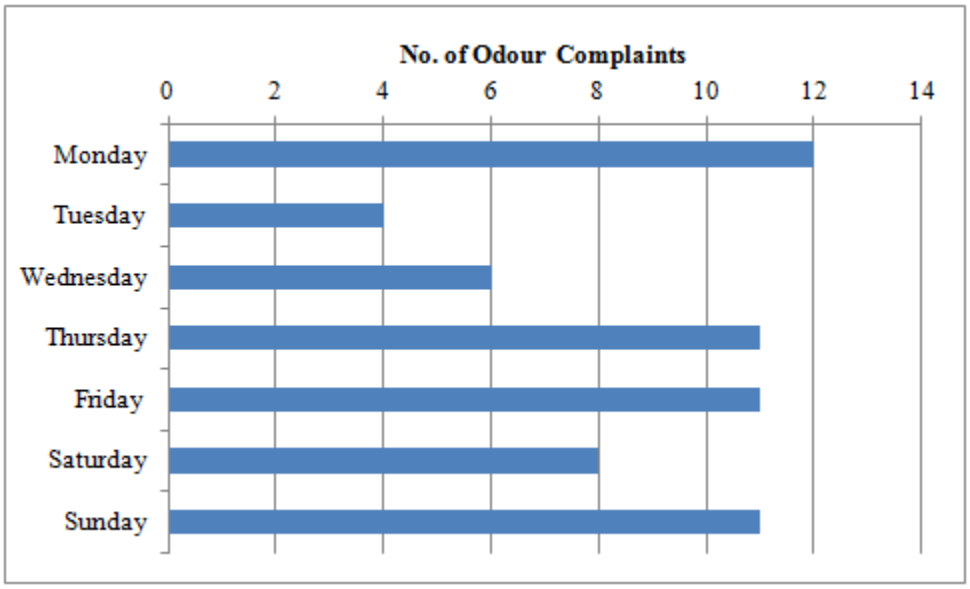
Figure 4.1 Frequency of Odour Complaints per Day (July-August 2014)



4.1 DAY OF THE WEEK

The odour complaint data were reviewed to determine whether the odours were more likely to occur during particular days in the week. The results depicted in Figure 4.2 indicate that odour complaints were more likely to be submitted on Mondays, Thursdays, Fridays and Sundays, and less likely to be made on Tuesdays and Wednesdays. Overall, however, there does not appear to be any regular pattern to complaints with respect to day of the week.

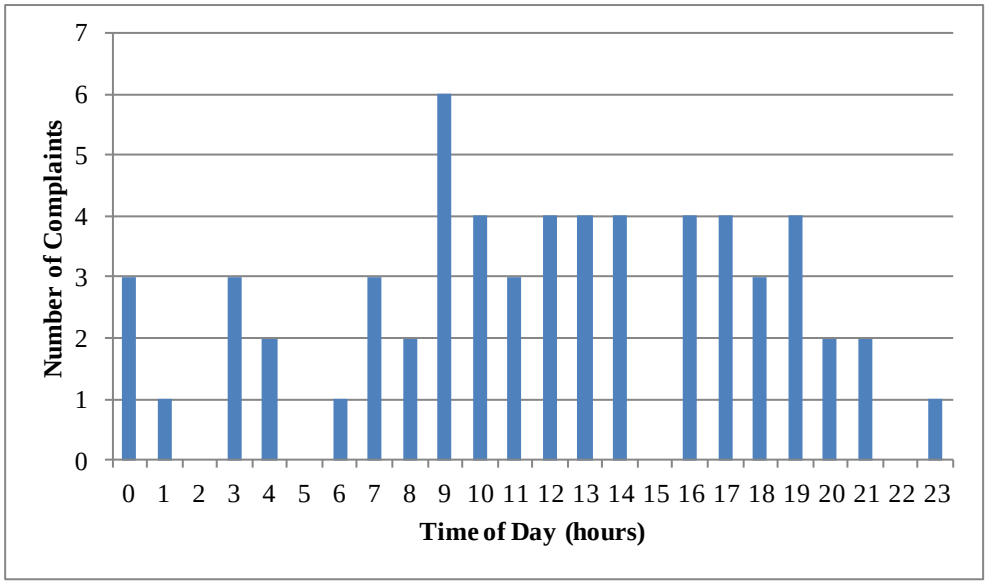
Figure 4.2 Odour Complaints by Day of the Week (July-August 2014)



4.2 TIME OF DAY

Anecdotal information received by the CVRD suggested that odours were strongest during the night time hours. However, seventy-five percent of the odour complaints were received during the July-August 2014 period reported odours to occur during the 12 hour period from 7:00 am and 19:00 pm, as indicated in Figure 4.3. Therefore, the odour complaint data is generally consistent with the time of day during which the odour survey was conducted.

Figure 4.3 Odour Complaints by Time of Day (July-August 2014)



4.3 ODOUR PERSISTENCE AND INTENSITY

In general, the complainants reported that the odour was persistent 67% of the time, and on-and-off only 33% of the time. This contradicts the observations made during the odour survey when the surveyors noted that the odours were barely noticeable most of the time, with short-term peaks of more intense odours only some of the time. Therefore, the meaning of the term "persistent" as used by the complainants in their on-line submissions may have a different meaning from what the odour surveyors identified as the predominant odours during the survey.

Only one complaint classified the odour as barely noticeable, while 21 of 63 complaints (33%) classified the odours as noticeable. Thirty-one complaints (49%) classified the odours as very unpleasant (equivalent to the odour survey category of strong/offensive), and a verbal complaint given to one of the surveyors identified the odour as offensive. Therefore, at least half of the odour complaints considered the odours to be sufficient to make a person want to take some action to avoid the odour. An additional 3 complainants reported the odour as being unbearable while another e-mail complaint referred to the odour as being a "truly sickening smell" (equivalent to the odour survey category of very strong/offensive). Five complainants did not provide a comment on the odour intensity.

In total, therefore, about 55% of the complaints would be considered as being equivalent to the odour survey categories identifying odours as offensive. The only odour survey locations which would be considered to fall into the possible range of such odour intensities were the short-term peak offensive odours near the Maple Hill and Twin Cedars WWTP, and somewhat less so at

Station14. All other observations of the odour intensities during the CVRD odour survey fall well below the levels reported by the complainants during the same two-month period.

4.4 ODOUR DESCRIPTORS

The complainants were given a selection of odour descriptors from which to choose in describing the odours that they found to be offensive. In those cases where the descriptors provided were insufficient to fully describe the odours that the residents were complaining about, the complainants could choose 'other'. Complaints submitted by e-mail and not on-line would also use other descriptors or would provide no descriptions of the odours. The frequency of specific descriptors used by the complaints as the first choice to describe the odours was as follows:

rancid/putrid (yeast, sour milk/cheese, decay)	24
earthy/musty/mouldy	12
sweet (nail polish, solvent, garbage can),	4
fecal/sewery/manure	4
nitrogen/ammonia (fishy, urine)	2
pine/lemon/grassy/terpene	1
strong and pungent	1
other	9
none listed	6

Thirty-eight of the odour complainants identified the odour as rancid/putrid or dead animal type of smell. According to the odour survey results, rancid odours were reported at Station 16b in relation to the north side of the FRR property and at Location 9 at Fairfield and Fisher Roads, but nowhere else in the survey. On the other hand, earthy/musty odours were more generally identified by the surveyors with the curing compost at Station 16c or the biofilters at Station 16d.

Three of the four odour complaints that identified fecal/sewery/manure odours were located at Regent Place, close to one of the WWTP, while the fourth was located on Braithwaite Drive in an area that the surveyors identified as having manure-type odours related to hobby farming activity. It is notable that, despite the prevalence of offensive odours identified during the odour survey in relation to the Maple Hill WWTP and Twin Cedars WWTP, there were no odour complaints of fecal/sewery type odours from residents in the vicinity of these two WWTPs.

The one odour complaint which identified the odour as pine/lemon/grassy/terpene type of odour was from a resident on Galliers Road, and so could have been related to the yard and garden odours from the CLS operations as such odours were identified as coming from there during the odour survey at Station 17.

4.5 CVRD ODOUR COMPLAINT FOLLOW-UP - JULY-AUGUST 2014

During the odour survey conducted in July and August 2014, the surveyors attempted to respond to any odour complaints received by the CVRD as they were conducting the survey. The surveyors went to the complainant's location or the corresponding odour sampling station for the survey and noted any odours present using the methodology defined for the odour survey. In addition, CVRD staff made note of which operations were being conducted at these two facilities in order to determine whether some operations were more likely to result in off-site odours leading to complaints than other operations.

The odour surveyors responded to odour complaints or were at their odour sampling stations in the vicinity where odour complaints were made on 27 days during the 2-month odour sampling survey. The surveyors spent up to 30 minutes evaluating odours on each occasion, and over an hour on some occasions when both surveyors were present in the general area where a complaint was made. In 23 of the 27 follow-ups to odour complaints, the surveyors reported the predominant odour intensity as being barely noticeable, with 10 observations also noting peak odour intensity as noticeable during some portion of the follow-up period. Only three observations noted the predominant odour intensity as being noticeable, and the peak odour intensity during one of those follow-ups was rated as strong/offensive.

In 15 of the complaint follow-ups, the surveyors noted that the FRR and/or CLS operations could have been the source of the odours. Only two of these observations noted FRR alone as the likely source, while the remainder cited both FRR and CLS as the likely sources although the surveyors were unable to distinguish between the two facilities. For the FRR operations, the curing compost was identified as the likely source on three occasions, the biofilters on three occasions and the curing compost on one occasion. The curing compost odour from FRR was described on one occasion as being rancid/putrid, but mainly musty. On another occasion, the odour smell was described as being a sweet/garbage odour, putrid/rancid/sour, some fainter musty odour, fairly persistent/lingering odour, but the sour odour was the overwhelming odour noted which the surveyor attributed to either the FRR biofilters or the curing compost. However, the GG were also associated with the same odour for one of the follow-ups, such that the source of this odour remains uncertain. On the 13 occasions when the CLS operations were cited as the possible source of the odours, grinding of the yard and garden waste at the CLS facility was noted on two occasions.

FRR and CLS operational activities that were noted to be occurring at the time of complaints were reported are listed in Table 4.1. During 22 of the 63 odour complaints (35%) received by the CVRD, the FRR cited was either closed or there were no operations being conducted at the time of the complaint. The FRR facility was closed on two of the occasions when the complainants described the odours as being unbearable, while on the third occasion when the

odours were described as unbearable the time of the odour complaint was not provided, making it impossible to relate the complaint to any specific activity at the FRR site. There was no specific activity at the CLS facility or the facility was closed for 12 of the odour complaints.

Table 4.1 FRR & CLS Activity at Times of Odour Complaints (July-August 2014)

FRR Activity	Number of times cited as occurring at time of complaint
Flipping bins/processing inside building	12
Loading cell inside building	6
Screening compost	4
Turning compost	4
Grinding wood	2
Unloading cell inside building	1
Excavator - load bins with chips	1
Excavator - working biofilter	1
Excavator - cleaning out grinder	1
Flipping piles outside on air floor	1
Flipping bunker outside	1
Processing food waste outside	1
Loading out truck with material	1
Screening stump grinds	1
Screening clean overs	1
Cleaning out screener	1
Hauling in garbage	1
CLS Activity	
Grinding yard & garden waste	6
Flipping piles or moving/making windrows	6
Material drop off	3
Moving bark mulch	1
Hauling out yard & garden waste	1
Cutting wood (not by CLS employees)	1

The data in Table 4.1 indicate that the most frequently cited FRR activity at the time of an odour complaint was turning or processing material inside the building, with screening or turning of compost being the second most frequent activity cited. Observations made during the site visit by SENES indicated that odours at Station 14 could be attributed to working the curing/finished compost piles on the west side of the FRR facility. Grinding of yard and garden waste and flipping waste piles were the two activities most frequently cited at the CLS facility at the time of odour complaints. This data should not be interpreted as meaning that these activities were the cause of the off-site odour complaints because, as discussed above, it was not possible to

distinguish between odours from FRR and CLS operations during the complaint follow-ups in all but two cases, and odours are emitted continuously from biofilters and compost curing piles.

5.0 SUMMARY AND CONCLUSIONS

An odour monitoring survey was initiated in the community of Cobble Hill and was completed by the surveyors retained by the CVRD during July and August 2014. The overall conclusion of the odour survey is that offensive odours are present in the community of Cobble Hill. Most of the offensive odours during the survey were of short duration (on the order of 30 seconds), and were frequently, though not exclusively, composed of odours from more than one source. Odours were detected during the majority of sampling observations during the survey period, and at most of the sampling stations, regardless of whether the odours were pleasant or unpleasant. For a vast majority of the observations (i.e., 98-100%), the predominant odours detected were reported to be either pleasant, barely noticeable or noticeable but not offensive. The only exception was the location near a wastewater treatment plant where predominantly offensive odours were noted on almost 3% of the observations. However, short-term peak offensive odours were recorded more frequently at the survey sites, and these were used to identify several sources of offensive odours, namely:

1. Maple Hill WWTP
2. Twin Cedars WWTP
3. Fisher Road Recycling (FRR)
4. Central Landscaping Supplies (CLS)
5. Gamboa Greenhouses (GG)

The odour survey results related to each of these sources is discussed below.

Maple Hill WWTP

The highest frequency of both predominant and short-term peak odour intensities was associated with this WWTP during the odour survey. Predominant offensive odours were noted 2.9% of the time near this WWTP, while short-term peak offensive odours were noted to be present during 64% of the survey observations. Nevertheless, there were no odour complaints lodged from residents living near this facility during the odour survey period.

Twin Cedars WWTP

There were no observations of predominant offensive odours in relation to this WWTP, however short-term peak offensive odours were noted to be present during 25% of the odour survey observations. There were only two odour complaints lodged with the CVRD about odours in the general vicinity of this plant during the odour survey period, one east along Hutchison Road and one east on Twin Cedars Drive. Since the latter complaint did describe the odours as having a sulphur/cabbage, rotten egg type of odour, it is at least possible that this complaint was related to the WWTP. However, the complainant also described the odour as being like the smell of pesticides from greenhouses that burned the nose and caused itchy eyes. Therefore, odours from

the GG or some other unidentified source in the area could have been responsible for this complaint.

Fisher Road Recycling

There were no observations of predominantly offensive odours on the east side of the FRR facility, but odours were present during 87-90% observations on the north, west and south sides of the facility during the odour survey. Predominantly offensive odours were present at these three sides of the facility from 16% to 25% of the observations during the site visits. Short-term peak offensive odours were present from 48% to 63% of the time. The odours on the north side of the FRR facility were generally noted to be related to emissions from the CLS facility, and odours from CLS were also present on the west side of the FRR facility, in addition to odours from FRR operations. Since these observations were made near the north, west and south sides of the property, there clearly exists a potential for odours to migrate off-site to the surrounding community from either FRR or CLS operations.

The data from the survey stations surrounding the FRR site indicate that these odours are detectable in gradually decreasing amounts with distance from the facility. For example, there were a total of 74 observations of odours at Location 14 closest to the FRR site, 26% percent of which had short-term peak odour intensities that could be considered to be offensive. By comparison, there were only 27 observations at Station 9 which were attributed by the odour surveyors to either FRR or CLS, mostly as a mixture of the two sources. However, there were no observations of predominantly offensive odours at this location, and only 7% of the observations noted short-term peak odour intensities that could be considered offensive, some of which might have also been attributable to the GG. At Station 1 north of the FRR/CLS facilities, the frequency of short-term peak odours was only 4%, while at Station 1 the frequency was reduced to 1%. At Locations 11 and 12, within the area of most frequent odour complaints, the frequency of peak offensive odours was zero. In a small number of observations, FRR (and CLS) were cited as possible sources of odour at locations east of the Trans Canada Highway at Stations 2, 3 and 6, but all of these had either barely noticeable predominant odours, or noticeable peak odours, but none that could be considered offensive.

Therefore, although the FRR facility is almost certainly a source of off-site odours, the dilution and dispersion which occur with the transport of the odours downwind appears to diminish the intensity of these odours the further they travel from the facilities, as would normally be expected to occur.

Central Landscaping Supplies

The observations made during the odour survey at Station 16b near the boundary between the FRR and CLS facilities indicated that the CLS facility was the predominant source of odours at this location when winds were blowing from the direction of the CLS facility towards FRR,

despite the proximity of sources of odour within the FRR site itself. Predominant odours high enough to be considered offensive were observed 25% of the time at Location 16b. Short-term peak offensive odours were noted to occur 63% of the time at this location, and the odours coming from the CLS operations had higher odour intensities than those coming from the FRR sources. Therefore, odour emissions from the CLS operations have the potential to migrate off-site at concentrations that could be considered to be offensive. However, as with the FRR facility, the concentration of those odours is diminished with transport distance away from the CLS site. A primary conclusion of the odour survey is that the survey observations frequently noted the difficulty in distinguishing between odours from the FRR and/or CLS operations at off-site locations because the odours were so weak.

Gamboa Greenhouses

The GG were identified as a source of offensive odour at Station 9 near the junction of Fisher Road and Fairfield Road. This facility was also identified as a possible source of barely noticeable-to-noticeable odours at Stations 10, 11, 12 and 15.

5.1 ODOUR COMPLAINTS

There were 63 odour complaints lodged with the CVRD on 36 of the 57 days of the odour survey period. Of these, 65% of the complaints consisted of 2-5 odour complaints per day, while 35% were for a single complaint in a day. Seventy-five percent of the odour complaints were lodged between 7:00 am and 19:00 pm, and there was no discernible pattern to day of the week on which the complaints were made. Two-thirds of the complaints described the odours as persistent, and 55% of the complainants described the odours as high enough to be considered offensive. The most frequent descriptors used for the odours were rancid/putrid and earthy/musty/moldy. Based on the surveyors' observations of odours on site at the FRR facility, rancid odours were most frequently associated with odours on the north side of the facility, while earthy/musty odours were more generally identified with the curing compost or biofilters. The latter two sources and yard and garden waste from the CLS facility were frequently cited by the odour surveyors at off-site locations.

The odour surveyors were able to follow up on 27 of the odour complaints. In 23 of the 27 follow-ups, the surveyors reported the odours as being barely noticeable, with 10 observations also noting short-term peak odour intensities as noticeable during a portion of the follow-up period. The surveyors noted that the FRR and/or CLS facilities could have been the source of the odours in 15 of the 27 follow-ups. The most frequently cited activities at the FRR facility at the time a complaint was made were flipping bins inside the building, and loading or processing waste in the building. However, it should be noted that 35% of the odour complaints during the two-month period were made at times when the FRR facility was either closed or there were no operations being conducted at the time of the complaint. In particular, the FRR facility was

closed on the two occasions when complainants described the odours as unbearable, while the third occasion when unbearable odours were reported the time when the odour was present was not provided and therefore could not be related to any specific activity at FRR.

5.2 DEFINING NUISANCE

In the absence of a definition of what constitutes a nuisance odour within the context of the CVRD bylaws, or in the Province of British Columbia as a whole, it is necessary to consider how nuisance is defined in other jurisdictions. As one alternative, nuisance odour can be based on the WHO definition of a nuisance threshold as being that concentration at which less than 5% of the population experiences annoyance more than 2% of the time. The difficulty in applying this definition to the odours from the five likely sources of odour in the Cobble Hill community is that the population in Cobble Hill is widely dispersed. Furthermore, the WHO has not specified whether the 2% frequency criterion is to be applied to the predominant odour intensity that is experienced by an observer, or to the short-term peak odour intensity that may come and go over a 5-10 minute period of observation.

For the predominant odours, the only location where the frequency of offensive odours exceeded the 2% criterion defined by the WHO for nuisance odours was in the immediate vicinity of the Maple Hill WWTP. Whether this location would also meet the WHO criterion for 5% of the community population is unclear. Assuming that the population criterion is met, the Maple Hill WWTP could be considered as emitting odours sufficient to be considered as causing a nuisance impact in the community. Although the other sources of odour such as the FRR, CLS, GG and the Twin Cedars WWTP all emit offensive odours at times, the odour survey did not identify persistent, predominant odours that were intense enough and frequent enough to meet this WHO criterion for nuisance odour impacts.

The odour surveyors also noted the intermittent nature of most of the odour observations, and the experience of individuals in the community who are exposed to the shorter duration peak offensive odour concentrations may not be reflected in the frequency of predominant 'offensive odours' determined during the odour survey. As discussed in Appendix A (Section A.2) of this report, the short-term peak odour levels may be more closely related to community annoyance as expressed in terms of the number of odour complaints registered by the public than the frequency of average strong and offensive odours as determined in the Cobble Hill odour survey suggests. The odour complaint information indicates that members of the community experience offensive odours far more frequently than was observed by the odour surveyors because they are reacting to the short-term peak odours rather than the average or 'predominant' odour levels.

If the same WHO 2% criterion is applied to the peak intensity odours presented in Figure 3.5 and listed in Table 3.2 as offensive, then the highest impacted area would be in the vicinity of the

Maple Hill WWTP where over 37% of the peak odours would have been considered to be offensive. The second location with the most frequent peak offensive odours would be Station 14 with a frequency of 19%, and these would be related to emissions from the FRR and/or CLS operations. A close third in ranking would be Station 8 beside the Twin Cedars WWTP with 15%. The location with the next most frequent occurrence of offensive odours was Station 9 which had a mixture of odours from FRR, CLS and the GG at various times, collectively combining for a frequency of offensive odours at 8% of total survey observations. The remaining stations where short-term peak offensive odours exceeded the WHO 2% criterion were Station 1 and Station 15 at 3.7% and 5% of total observations, respectively. In the area where odour complaints were lodged most frequently during the odour survey, the frequency of peak offensive odour intensity observations was just 1.4% at Station 13 and zero at Stations 11 and 12. Therefore, the WHO criterion for nuisance odours was not met for either predominant or short-term peak odours in the area where odour complaints were most frequently recorded.

5.3 CONCLUSIONS

The overall conclusion of the odour survey is that offensive odours are present in the community of Cobble Hill. Most of the offensive odours during the survey were of short duration (on the order of 30 seconds), and were frequently, though not exclusively, composed of odours from more than one source. However, despite an intensive survey completed by the CVRD during which two surveyors completed from 68 to 102 odour observations at 20 individual locations throughout the Cobble Hill area, the survey results were unable to corroborate the community odour complaint data logged during the survey period. Survey locations that were identified as having the most frequent offensive odour levels near WWTP had few, if any, odour complaints attributable to these plants. On the other hand, the odours identified in the locations from which the majority of odour complaints were received were determined to be barely noticeable, or noticeable but not offensive by the surveyors. This is not meant to imply that the complaints made by the residents in these areas were not valid. It simply means that the odour survey was not able to measure comparable odour intensities that would classify these odours as being offensive.

The results suggest that objectionable odours are infrequent enough that they could not be identified with a frequency sufficient to classify them a posing a nuisance impact within the WHO definition for nuisance odours at most off-site locations in the odour survey. If the WHO nuisance odour guideline is considered in the context of short-term intermittent odours that were determined to be high enough in intensity to be offensive, then the emissions from the FRR, CLS and GG facilities individually and/or collectively could be having a nuisance impact at:

- At the eastern end of Galliers Road;
- the junction of Fisher Road and Fairfield Road;

- the junction of Fisher Road and Ball Road;
- the junction of Fisher Road and the Trans-Canada Highway.

These locations are approximately 350-400 m from the boundary between the FRR and CLS facilities. The location on the eastern end of Galliers Road is 150 m from the north-western corner of the FRR facility, while the location at the junction of Fisher Road and Fairfield Road is approximately 250 m from the south-western corner of the FRR facility, and only about 50 m from the GG facility. The location at the junction of Fisher Road and the Trans-Canada Highway is approximately 330 m east of the CLS facility. All of these locations fall within the separation distance of 400 m suggested by the B.C. Ministry of the Environment for composting facilities (Forgie, Sasser and Neger 2004).

Because these odours are infrequent and, based on the odour survey, intermittent when they do occur, it is unlikely that any future odour monitoring program based on collecting ambient odours for laboratory analysis would be successful in determining odour concentrations either in terms of odour units for the aggregate of odour compounds in a sample or concentrations of individual odorous compounds based on gas chromatography/mass spectrometry analysis. The alternative would be to consider odour dispersion modelling based on either measured odour emission rates from the FRR, CLS and GG facilities, or emission factors derived from published literature at other facilities. Some of the uncertainties in odour dispersion modelling are discussed in Appendix A, particularly those related to estimating very short-term odour concentrations on the order of a few minutes, which appears to be the time frame for exposure to odours that most people are sensitive to in this case.

Odour dispersion modelling has been successfully applied in many situations where odour issues arise, but may not always resolve differences between modelling results and community perceptions of offensive odours. It may help to identify those specific sources which are most likely to contribute to offensive odours in the community and the spatial extent over which those odours are likely to occur. This may provide some direction to the CVRD and the operators of the FRR, CLS and GG facilities in guiding future efforts to reduce or eliminate odour emissions from their facilities.

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APPENDIX A: GENERAL APPROACHES TO THE REGULATION OF ODOURS

The approaches used to address odours vary widely from jurisdiction to jurisdiction. In many cases, persistent community odour issues have lead to the development of regulations or "odour laws", which typically specify different "compliance determining criteria" depending on the overall approach.

In some jurisdictions the detection of odour in the ambient air is sufficient for an offence to have occurred, whereas in others it is necessary to demonstrate that there is an adverse effect from the odour for an offence to have occurred. The type of law based on the "nuisance" or "quality of life" grounds is the most common and oldest way to manage odour. In some jurisdictions there are complaint criteria for launching an investigation about odours and their nuisance (Bokowa 2010).

Many jurisdictions have quantitative ambient concentration criteria for individual contaminants that are odorous. For example, in Canada several provinces have standards for H_2S, ammonia and other compounds.

The general approaches used to manage odours are as follows (McGinley et al., 2000):

1. Annoyance criteria (subjective categories);
2. Complaint criteria (number of complaints);
3. Ambient odour detection threshold criteria;
4. Ambient odour intensity criteria;
5. Ambient odorant criteria (mass concentration);
6. Episode-duration-frequency criteria (odour hours);
7. Source emission criteria (threshold or mass concentration);
8. Best available control technology criteria.

The various approaches are not mutually exclusive and are sometimes combined. The following sections provide a discussion of these odour management methods.

A.1 ANNOYANCE AND COMPLAINT CRITERIA

Information derived from public complaints about odours can provide some information about the frequency, timing and total number of odour complaints in relation to the operations of a particular facility or operation which may indicate to a regulatory agency that there exists a potential community nuisance odour issue (Gibson and Collings 2009). Records about the time

of day when complaints occur can help to identify specific causes of the alleged nuisance. In addition, records of complaints can be used to provide evidence of an offensive odour or nuisance in subsequent legal proceedings in the event that a plant operator appeals a regulatory action taken against a facility, or a regulatory agency is required to defend itself for taking such actions.

The use of public annoyance and/or complaint criteria are generally based on the number of complaints that are made when odour episodes occur, and subjective descriptions by the complainants on the nature of the odour to establish a nuisance. However, experience has shown that the public tends not to register odour complaints until the odours reach a certain level in terms of strength and frequency of occurrence.

Annoyance criteria in regulations typically contain statements that define the conditions that constitute a nuisance. For example, Ontario uses the concept of adverse effect to define a nuisance.

An "adverse effect" is defined in the Ontario Environmental Protection Act (EPA), subsection 1(1) to mean any one or more of the following:

- Impairment of the quality of the natural environment for any use that can be made of it;
- Injury or damage to property or to plant or animal life;
- Harm or material discomfort to any person;
- An adverse effect on the health of any person;
- Impairment of the safety of any person;
- Rendering any property or plant or animal life unfit for human use;
- Loss of enjoyment of normal use of property;
- Interference with the normal conduct of business.

However, the experience in Ontario has been that it is often challenging to prove that any of the above conditions have occurred as a result of odorous emissions from a facility. This often leads to delayed enforcement actions, a lack of abatement actions and prolonged odour issues with surrounding communities.

Complaint criteria are typically based on a threshold of a minimum number of community complaints. In order to determine that a community annoyance or nuisance exists, the regulation or odour guideline generally contains specific criteria for complaints. In addition to the number of complaints, criteria for determining nuisance can be expressed in terms of the number of different households from which the complaints originate, and a timeframe within which the complaints must be received. Also, a minimum number of complaints may have to be verified

by the Regulatory Authority to be considered valid (McGinley et al. 2000). For example, the City of Des Moines, Iowa issues an 'odour alert' for an identified source or sources of odour if it receives (McGinley 2009):

- 10 independent odour complaints in a single 24-hour period;
- 5 odour complaints from independent 'households';
- 5 'verified' complaints against an identified source.

Such provisions are considered necessary because studies of community odour problems have revealed that complaints do not always correlate with odour intensities, and other factors such as the socio-economic status of a neighbourhood, the presence or absence of an active civic association, the degree of news media attention being given to the problem, and a sense of futility on the part of citizens (i.e., they give up and quit complaining) all contribute to the frequency of complaints. In a sensitized community where citizens have been exposed to an offensive odorant over a long period of time, a considerable emotional burden may contribute to the frequency of complaints from specific individuals such that a small number of complainants may account for a large proportion of the total number of complaints registered.

Hedonic tone is a description of the pleasantness or unpleasantness of an odour, and is sometimes used to determine or demonstrate that an odour is objectionable, and thus is perceived as a "nuisance". Table 2.1 list the types of odour emission sources based on odour tone as defined by the Texas Commission of Environmental Quality (TCEQ 2007).

Table A.1 Examples of Odour Source Characterization Guidance

(Source: TCEQ 2007)

Odour Source Characteristics			
Highly Offensive	**Offensive**	**Unpleasant**	**Not Unpleasant**
Blood drying operations	Landfill garbage/waste	Well-digested or chemically-treated sludge	Ketones, esters, alcohols
Sewage treatment primary sludge	Cattle lagoon cleanout	Cattle operation under best management practices	Fresh-cut grass or hay
Putrefying animals/fish	Confined hog/poultry operations under best management practices	Waste-activated sludge processes	Normal coffee roasting
Hide processing	Decaying silage/composting	Water-based painting	Normal food preparation
Rancid grease	Unprocessed rendering plant material and wastewater	Gasoline, diesel fuel	Bakery
Hydrogen sulphide (H2S) gas from landfills, sewers, leachate, pulp and paper mills, etc.	Typical grease trap odour	Diesel exhaust	Perfume
Mercaptans (e.g., natural gas additive odorant)	Waste burning (rubber, plastic, tires, other wood materials)	Asphalt odours	Spice packaging
	Failing or improperly operated septic systems	Burned coffee/food	Winery
	Organic products such as auto body paint[1] and styrene (fibreglass, cultured marble manufacturing)	Brush/wood burning	
		Ammonia	
		Chlorine	

Note:

[1]At low concentrations, organic products such as auto body paint and styrene used in fibreglass and cultured marble operations would not normally be considered to have offensive odors. However, because of a person's potential physical response to these products at higher concentrations (where most complaints concerning these products occur), TCEQ generally consider them to have offensive characteristics.

The TCEQ also uses a series of charts to define the frequency, intensity, duration and offensiveness (referred to as the FIDO system) of ambient odours tied to the offensiveness rankings to determine whether or not a nuisance odour violation has occurred.

However, assigning a Hedonic Tone to a perceived odour by an observer is subjective, as it relies on the personal feelings and perceptions of the observer. Other jurisdictions use a standard categorical scale of odour descriptions (called an Odour Character) to describe the nature of an odour, which can be used to more definitively determine the "objectionableness" of the odour. This is a more objective approach since it relies on a standard set of descriptors that is applied by the observer (McGinley et al. 2000). It is however, still based on the demonstration of a nuisance.

One such example is the recently defined Odor Complaint and Response Enforcement Process adopted by the Puget Sound Clean Air Agency (PSCAA 2010) in Washington State. According to the PSCAA, it is *"unlawful for any person to cause or allow the emission of any air contaminant in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property."* If a Control Officer or duly authorized representative of the PSCAA is required to assess an odour from any facility, the assessment is based on an evaluation using a five-point scale, namely:

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

The PSCAA may take enforcement action if:

- a Control Officer or duly authorized representative of the PSCAA determines that an odour is at or exceeds Level 2 on this scale;
- the PSCAA receives an affidavit from a person making a complaint that demonstrates that they have experienced air contaminant emissions in sufficient quantities and of such characteristics and duration so as to unreasonably interfere with their enjoyment of life and property; and
- the source of the odour has been identified and documented.

Many jurisdictions use such nuisance-based approaches rather than concentration-based limits to regulate/control/abate odours. However, the explicit conditions that establish whether or not a nuisance exists are not easily defined. Many of the terms used to define a nuisance are subjective and open to interpretation. Also, because of the transient nature of odours, it is often difficult for Regulatory Authorities to verify or validate them. This can result in problems for both members of the public and/or owners and operators of facilities.

Since this approach is typically applied after objectionable odours occur, rather than as a preventative measure, nuisance approaches generally only provide a last resort for impacted individuals or communities to restore enjoyment of their property. Target limits (as offered by the other approaches) provide industries with a basis to design facilities with the aim to minimize impact. This also shifts part of the focus from odour abatement to odour prevention.

A.2 AMBIENT ODOUR DETECTION, INTENSITY AND ODORANT CRITERIA

Quantitative odour impact criteria are not ambient air quality standards. Instead, such criteria provide a scientifically-derived benchmark for making informed decisions in the planning, design, environmental management and regulation of sources of odour emission. These criteria are generally based on measurements or samples collected in the field or at the source (for subsequent use in dispersion modelling) to provide a direct indication of ambient odour levels at specific locations, or ambient concentrations predicted using source emission information and air dispersion models.

Ambient odour detection criteria are based on dynamic dilution olfactometry (DDO), which uses the human nose as a sensor by comparing an odour sample at various levels of dilution with odour free air. The diluted sample is presented to a panel of assessors (called an odour panel) using an olfactometer in an odour-free room or laboratory, through ports from which the assessors must sniff. The dilution level at which 50% of the odour assessors can just detect the odour is set as the odour detection threshold for the sample. The number of dilutions required to reach this level determines the odour concentration (in OU or OU/m^3) in the original sample. For example, if nine volumes of odour free air are added to one volume of sample, the odour concentration in the sample is 10 OU.

A study conducted for the California Air Resources Board concluded that for unpleasant odours the threshold of annoyance is at approximately 5 times the threshold of detection (D/T), which would be interpreted as 5 odour units (OU). California's South Coast Air Quality Management District states that at 5 D/T people become consciously aware of the presence of an odour, and that at 5-to-10 D/T odours are strong enough to evoke registered complaints (Mahin 2003). Therefore, 5 OU is generally referred to as the complaint threshold (numerically equivalent to 5 OU/m^3).

Use of this type of approach means that the detection threshold of 1 OU/m^3 can only be perceived in an odour-free environment, such as in a laboratory. Therefore, a perceived odour concentration in the field must be higher than 1 OU/m^3 to be distinguished against the background concentration. This must be considered when collecting field measurements because background ambient air is not odour free. Nicell (1994) assumes an odour concentration of

3 OU/m^3 to allow for discrimination, and one of 5 OU/m^3 for unmistakable perception (Schauberger et al. 2006).

Direct odour measurements can also be collected in the field using scentometers, or field olfactometers such as a Nasal Ranger®. However, any odour law that specifies an ambient odour threshold (D/T, Z, DT, RT, odour units, etc.) must also specify acceptable measurement methods that can be used to demonstrate compliance (i.e., field olfactometer, scentometer, or laboratory olfactometer) (McGinley et al. 2000). However, all of these methods ultimately rely on subjective human sensory assessment (i.e., the human nose). In the United States, some state regulatory agencies allow use of such measurement methods while others prohibit their use for enforcement purposes.

Some jurisdictions use odour intensity criteria instead of ambient odour concentrations to assess odour impacts. Odour intensity can be measured objectively using an Odour Intensity Referencing Scale (OIRS), which compares the intensity of the odour in the ambient air to the odour intensity in a series of concentrations of a reference odorant (McGinley et al. 2000). N-butanol is commonly used as a reference odorant. A series of a number of descending liquid reference standards of n-butanol are prepared using the serial dilution technique, and are numbered from in increasing concentration. The number of different concentrations in the reference scale ranges from 5 to 12, depending on the type of scale used. The liquid concentration in each sample can be related to the air or odour concentration by a power law relationship (Steven's Law). Hedonic tone is also sometimes used in conjunction with odour intensity measurements to determine whether a potential odour impact has occurred.

Standard methods for performing odour intensity testing are outlined in ASTM E544 "Standard Practice for Referencing Suprathreshold Odour Intensity". A number of different scales can be used, each having a different number of points, and a different progression of odour concentration. As a result, it is extremely important for odour intensity-based standards and guidelines to reference either the equivalent n-butanol concentration or report the acceptable OIRS number along with the scale range and starting point (McGinley et al. 2000).

Many jurisdictions also set ambient threshold levels of individual odorants or odorous compounds such as H_2S, ammonia, and many others, to prevent odour issues from occurring. However, this approach is only generally successful where the odorous emissions are largely the result of the single compound in question. In most cases, odours are commonly the result of a release of several odorous compounds in combination. Use of a single indicator compound in odour assessments can result in a significant underestimation of the total odour concentration, resulting in annoyance and complaints (Drew et al. 2007).

There is evidence in the published scientific literature of the additivity of odours, especially at low odour concentrations. A recent study on this subject by Kim and Park (2008) shows that the best correlations between quantitative measurements of odorant concentrations and direct odour measurement through olfactometry are for the sum of the odour quotients (i.e., summing the ratios of odorant concentration to threshold for each compound in the mixture) and the sum of the odour intensities based on suprathreshold olfactometry. Therefore, it should be possible to estimate the odour concentration for a mixture of odorous compounds by sampling the concentration of individual compounds using a gas chromatograph. However, some odorous compounds such as mercaptans, dimethyl sulphide, and dimethyl disulphide are more difficult to quantify, making it problematic to apply this methodology in practice.

Selection of the ambient odour concentration, intensity or odorant criteria to apply is typically a balance between reducing annoyance due to odours to an acceptable level at an acceptable cost. Odour emissions are typically episodic in nature, and are characterized by periods of high emission rates interspersed with periods of low emissions. It has frequently been noted that it is the short-term high concentration peaks that result in annoyance in the surrounding population. Therefore, selection of an appropriate averaging time upon which to apply ambient criteria is extremely important. Experience indicates that modelling emissions over shorter averaging periods (i.e., less than 1 hour) better matches the pattern of observed odour incidents, likely as a result of capturing peak concentrations (Drew et al. 2007). Experience has also shown that it is frequently the fluctuations from the mean concentration and not the actual mean itself that determine how odour is perceived (Best et al. 2001). While a single peak may not result in annoyance, repeated high peaks at times of high exposure could be missed by using longer term (i.e., 1 hour) averages. Also, it is unlikely that an odour will be a nuisance until it is detectable for certain periods of time, typically longer than three minutes (Simms et al. 1999). The use of short term averaging times is therefore of greater value in predicting the likely nuisance impact of an odour source and in framing appropriate regulatory controls.

A.3 EPISODE-DURATION-FREQUENCY CRITERIA

A limited number of jurisdictions use this approach to manage odours. Germany, in particular has a well-developed system that uses this approach and is purported to be successful. The approach is based on limiting a combination of the number of times, length and sometimes maximum concentration that may occur in a given year. Since odour can be intermittent and occur on a short-term basis (e.g., 5 minutes), and dispersion models typically use hourly meteorology to predict 1-hour average concentrations, dispersion modelling may not accurately predict the length and related severity of an odour episode. A person's sense of smell has the ability to detect short periods of odour, such as one minute or less. A number of short periods (one-minute to three-minute periods) of perceived odour may constitute an odour episode to an observer. Therefore, the actual duration of odour episodes should be considered in regulation or

management approaches in addition to the number of odour episodes that may occur in a specified time period. However, this must be based on record keeping by observers, such as citizen complaint calls, citizen notes or logbooks, or air pollution inspector observations and data collection (McGinley et al. 2000).

This approach generally uses the concept of Odour Hours (OH) to establish acceptability criteria. These include definitions of Odour Hour (i.e., three 10-minute periods of excess odour in one hour, or one 15-minute period of excess odour in one hour) and set limits on the number of Odour Hours that may occur within specified time periods (i.e., maximum 2 OHs per day, maximum 8 per week, maximum 36 per month). Community input in the development of such approaches is integral to the program's success.

A.4 SOURCE EMISSION AND BEST AVAILABLE CONTROL TECHNOLOGY CRITERIA

The remaining odour management approaches place limits on the odour emission rates from certain sources or specify specific control measures to be installed on certain sources. These approaches are essentially the same as those used for standard air pollutants, with the exception that odour emission rates are measured using source samples that are analyzed by dynamic dilution olfactometry. Odour emission rate information can subsequently be used with air dispersion models to predict potential ambient odour concentration levels and potential impacts in the community.

A.5 ODOUR DISPERSION MODELLING

The use of an odour dispersion model is almost a mandatory requirement for odour assessments for facility emissions. The reasons for this are that it is extremely difficult to anticipate when and where odours will occur in order to conduct an odour sampling program in a community adjacent to an odour source. Because odours from most sources occur infrequently and are intermittent when present, a lot of time, effort and cost can be expended on such a sampling program without having much to show for the expenditure unless the odour impacts are present all the time. Moreover, nuisance odours can result in complaints from the general public at concentrations below 10 D/T and most regulatory odour standards, guidelines or benchmarks are set at levels of 1 D/T to 10 D/T. However, odour panels used to evaluate odour samples cannot accurately determine odour concentrations <10 D/T. Therefore, it is necessary to use dispersion models to calculate predicted odour concentrations below this level.

Inevitably, the question arises as to which dispersion models are best suited to predicting odour concentrations. Unfortunately, unless the dispersion model has been developed specifically for modelling odours, it is unlikely to accurately predict the concentrations experienced by the community. None of the available regulatory dispersion models are particularly well-suited to

odour modelling because they have generally been developed for other purposes. The most fundamental problem stems from the fact that regulatory dispersion models are designed to use mass emissions rates (e.g., grams per second) to calculate mass concentrations (e.g., micrograms per cubic metre) downwind from the source. The use of odour emission rates in terms of odour units per second is treated as being analogous to a mass emission rate. **However, the odour unit is actually a measure of the perception of the odour, not of the mass of the odorant present, especially when dealing with odour mixtures of many compounds.**

For example, the addition of a relatively small amount of mercaptan to a larger amount of H_2S can completely change the perception of the strength of the odour mixture out of proportion to the mass concentration of each of the two compounds. Because some compounds in an odour mixture may be highly reactive, the very character of the odour plume may change as the plume is transported downwind, a process that is not replicated in any dispersion modelling analysis. Therefore, although air dispersion models treat odour emission rates (OU/s) as being analogous to mass emission rates (g/s), and predicted odour concentrations (OU/m^3) as analogous to mass concentrations ($\mu g/m^3$), the simulation of odour dispersion is not really the same thing as the simulation of mass dispersion of a contaminant.

One of the other primary issues related to odour dispersion modelling versus modelling of other air pollutants is the question of averaging time. Contaminant concentrations downwind of an emission source decrease with sampling time due to increased meander of the emission plume as it is transported downwind. Most regulatory dispersion models have been developed to predict air contaminant concentrations over averaging periods of 1 hour and regulatory criteria are based on 1 hour, or multiples of hourly averages (e.g., 3 hours, 8 hours, or 24 hours). Since a person's reaction to an offensive odour occurs within 30 seconds, and since most regulatory criteria for odour concentrations are based on averaging periods of 3-to-10 minutes, 1-hour average odour concentrations predicted by dispersion models must be converted to shorter averaging periods in order to determine their degree of potential offensiveness and/or compliance with regulatory limits for odour impacts.

Instantaneous sensing of odour means that plume meander will result in odour impacts, especially during periods of very light winds when such meandering may be quite pronounced. It has been reported that various experiments have demonstrated that the perceived odour response is not linearly related to the concentrations of the odorous compound (Best et al. 2001). Instead: *"Odour response may be more related to the general characteristics of fluctuations of concentrations away from the mean value, rather than just the value of the peak concentration".*

According to Turner (1994), studies completed in 1958 and 1959 reported that the decrease in concentration follows a one-fifth power law with sampling time for sampling periods from 3 seconds to about half an hour. Therefore, the scaling factor *(f)* that is most frequently used to

convert predicted 1-hour average odour concentrations to shorter time periods is the one-fifth power law equation:

$$f(t,t_0) = (t_0/t)^{0.2}$$

where (t) is the averaging time of interest (in minutes), and
(t_0) is the averaging time consistent with the dispersion rates used to obtain the mean 1-hour odour concentration from the dispersion model

The value of 0.2 in the exponent of the equation only applies to neutral atmospheric stability (Pasquill-Gifford Stability Classes C and D), and must be adjusted for unstable and stable conditions. Not all odour modelling studies make that adjustment, which may explain some of the differences reported between predicted and observed odour concentrations. For example, the Ministry of Environment in Ontario uses an exponent value of 0.28 for peak-to-mean conversions of 1-hour to 10-minute average odour concentrations, while the Town of Boucherville in Quebec mandates the use of 0.25 for conversions to 4-minute average concentrations.

This scaling factor has been applied to all types of odour emission sources even though the relationship was first determined for elevated sources (i.e., stacks) at the height of release, and may not be applicable to emissions from ground-level area sources (e.g., primary sedimentation tanks, secondary clarifiers, etc.). Turner noted that other studies have reported that the ratios of peak-to-mean concentrations are much higher than those given by the above power law equation where observations are made at heights considerably different from the height of release from an elevated stack, or at distances further from the axis of the plume. Furthermore, at considerable distances from the source, the peak-to-mean ratios may approach the value of 1, and can vary considerably depending on the stability of the atmosphere and the type of terrain that the plume is passing over. For example, barriers in the path of the plume (e.g., walls, vegetation breaks) may alter the turbulence of the plume and change the peak-to-mean ratios compared to those that would exist in unobstructed flow over the same distance.

Despite the many limitations in the use of dispersion models, various regulatory dispersion models are used for estimating odour concentrations around sources because, as noted above, ambient odour sampling programs are difficult to implement and cannot provide data at the low concentrations needed for comparison to regulatory odour impact criteria. Regardless of which model is used, it is important to keep in mind that the results from any model are only as good as the information used as input to the model (e.g., emission rates, meteorology, land use data, etc.). **In the end, no amount of modelling is sufficient if the members of the affected community still complain about an odour nuisance, even though the modelling analysis indicates that the established ambient standards, guidelines or objective levels are being attained.**

A.6 COMMUNITY ANNOYANCE THRESHOLDS

Based on the experience of most regulatory jurisdictions, the magnitude of any numerical ambient odour criterion should be set based on an annoyance threshold or annoyance criteria. However, this threshold is not necessarily easy to define. According to Nicell (2009), a 1 OU concentration represents a condition where there is a balance between those that may be impacted to some degree and those that are not. By definition this is the level at which 50% of the population can just detect the odour. Thus, the odour concentration at this level is above the personal threshold of the other 50% population, which means that half of the population is impacted to some degree. Also, odour response curves from typical compounds such as n-butanol, n-butyl acetate, octane, etc. show that 10% of the population have personal thresholds that are 5 times lower than the overall population threshold. Therefore, at the 1 OU level, 10% of the population experiences the odour at a level that is at least 5 times their personal thresholds, which corresponds to the "complaint threshold" for these individuals. Thus, Nicell contends that even at 1 odour unit, 10% of the population could be considered to be in a state of annoyance.

Many jurisdictions use an annoyance criterion or an odour complaint threshold of 5 OU, which is 5 times the odour detection threshold of 1 OU. The value of 5 OU has been in common practice for over 25 years. There is some justification for this value from a community odour survey of livestock odours in The Netherlands, cited by the Environment Agency (2007) and reproduced in Figure A.1. The data indicates that approximately 5% of the general population living in areas without livestock operations (i.e., non-concentration areas) would be annoyed at a level of 5 OU (1-hour average, 98^{th} percentile). The results for pig rearing odours in The Netherlands is consistent with research conducted in the United Kingdom on odours from wastewater treatment plants in which odour complaints were correlated with modelled odour impacts from nine plants. In the latter study, only 3% of the odour complaints were recorded in areas where odour concentrations were at levels $\leq$5 OU (1-hour average, 98^{th} percentile). On that basis, the use of an annoyance level of 5 OU would also be consistent with the World Health Organization's definition of a nuisance threshold as being that concentration at which not more than a small proportion of the population (less than 5%) experiences annoyance for a small part of the time (less than 2%) (WHO 2000).

A series of experiments conducted by Stowell et al. (2008) in the vicinity of an intensive swine rearing operation in Nebraska using a mask scentometer to measure instantaneous odour levels also indicated that while the threshold for any degree of annoyance appears to be between 2 and 15 OU, the threshold for consequential annoyance (i.e., that level of annoyance which is likely to cause a change in behaviour or activity level, and instilling some memory of the odour event) falls between 7 and 31 OU. On this basis, Stowell et al. concluded that candidate thresholds for odour annoyance and consequential odour annoyance could be set at 2 OU and 7 OU, respectively.

Figure A.1 Dose-Response Relationship for Livestock Odours in The Netherlands
(reproduced from Environment Agency 2007)