Staff report

DATE: November 4, 2015

FILE: 5340-20

TO: Chair and Members
Comox Valley Sewage Commission

FROM: Debra Oakman, CPA, CMA
Chief Administrative Officer

RE: Odour control systems evaluation report - Comox Valley water pollution control centre

Purpose
To present the Comox Valley water pollution control centre (CVWPCC) odour control system evaluation report.

Policy analysis
By supplementary letters patent dated January 11, 1979 and amended January 14, 1982 the regional district was empowered to provide sewer interception, treatment and disposal of sewage primarily for the benefit of the City of Courtenay, the Town of Comox and on a contract basis to the Department of National Defence (DND), and the K'ómoks First Nation (KFN) Indian Reserve No. 1.

Bylaw No. 2541, being the "Comox Valley Sewerage Service Establishment Bylaw No. 2451, 2003" was adopted to convert the function to a service as defined in the bylaw.

Policy 5340-00 being the "Expenditure of funds for odour control – Comox Valley Water Pollution Control Centre" policy (2006)", establishes how the regional district will consider the expenditure of additional funds to control odours at the CVWPCC or the biosolids composing site.

On November 26, 2013 the board approved the following recommendations:

> *THAT the Comox Valley Regional District complete an evaluation of the existing odour control equipment and practices at the CVWPCC including performance testing of the odour control system, an odour audit of operational and maintenance practices, a review of odour control technologies or enhancements to current technology and the development of a monitoring system to ensure odour control performance;*
>
> *AND FURTHER THAT a complaint tracking system be designed and implemented that addresses odour complaints in a consistent manner and provides statistical information related odour complaint frequency.*
>
> *AND FINALLY THAT funding for the above evaluation, in the amount of $50,000 be included in the 2014-2018 Comox Valley sewerage service financial plan.*

Executive summary
In 1997 the regional district installed a wet chemical scrubber odour control system at the CVWPCC. This system draws odourous air from enclosed process vessels, chemically treats the air and then discharges the treated air through a vent stack to atmosphere. When originally commissioned, the system was found to be 99.3 per cent efficient at removing hydrogen sulphide compounds from the treated air. The system has now been operational for 18 years and in November 2013 the board passed a motion requiring that the regional district complete an evaluation of the existing odour control equipment and practices at the CVWPCC including performance testing, a review of

operational and maintenance practices, a review of odour control technologies and the development of a complaint tracking system that addresses odour complaints in a consistent manner and provides statistical information related to odour complaints.

In 2014 the odour complaint tracking system was developed consisting of a centralized database which records name, address, date of complaint, nature of issue and duration of issue. This updated system has been implemented for all properties located in the CVWPCC vicinity and is shown on Appendix B. At the same time, the CVRD drafted a terms of reference to evaluate the existing odour control system and a request for proposal (RFP) was subsequently prepared, issued and awarded to RWDI Consultants through a competitive evaluation process.

In January 2015, RWDI Air Inc (RWDI) began their work to review the wet-chemical scrubber's performance, auditing the facilities operational practices, developing a monitoring system to ensure odour performance, reviewing new odour control technologies and providing cost estimates for any recommended improvements.

Upon the consultant's review of the facility, their opinion is that the original process technology and design is appropriate for the plant and has the necessary capacity to treat the odours. The plant is in good shape, all major components of the plant are operating properly and staff have taken several innovative steps to reduce odour from the facility such as:

1. Dampening at the drop of the primary clarifiers to reduce the amount of odour released;
2. Installing flow diverters at the secondary tank to eliminate dead end flow zones;
3. Installing spray bars to break up the formation of bacterial foam in the summer.

In a waste water treatment plant the compound of greatest concern with regards to treating odours is hydrogen sulfide. The CVWPCC uses a traditional process of a wet chemical scrubber to primarily treat the odours. The scrubber was evaluated and tested under normal working conditions as it is important to evaluate the scrubber under normal loads since removal efficiency for wet scrubbers is often lower with low inlet concentrations. As the inlet concentrations of hydrogen sulfide are very low at the CVWPCC, the removal efficiency for odour was measured at 42%, however the best case removal efficiency with these low inlet concentrations was 60%. Originally it was proposed that artificially induced concentrations of hydrogen sulfide be examined to best evaluate the scrubber's efficiency, but based on the availability of the gas, transportation and safety concerns, the consultant determined it was more appropriate to test the scrubber under actual conditions. The consultant recommends that if accurately measuring the scrubbers efficiency compared to its original efficiency is required, then testing the scrubber using artificially induced concentrations of hydrogen sulfide will be necessary.

The odour collection system was determined to be in good working order and all components were under sufficient negative pressure to ensure adequate collection. There were several large leak points identified that should be either sealed or reduced, but the majority of these have already been addressed by staff. During the period of testing in January 2015, the consultant noted that these were the "worst atmospheric conditions possible to test in", and still the odours in the surrounding community were intermittent and barely perceptible. Measurements of hydrogen sulfide were zero at all points on the perimeter of the facility and in almost all outdoor locations on the property even those adjacent to tanks and vessels.

RWDI has further recommended that in order to determine whether the stack and scrubber are providing sufficient odour control in the surrounding community that dispersion modelling of the exhaust stack be completed.

Dispersion modelling will better determine if further controls on the exhaust stack would make a significant difference or whether it would be better to expand the odour collection system to include other sources such as the primary tanks. In the proposed 2016-2020 financial plan, funding has been included that would allow the CVRD to complete the consultants recommended testing including dispersion modelling and scrubber performance testing using a higher concentration of hydrogen sulfide gas.

Recommendation from the chief administrative officer:
For information only.

Respectfully:

D. Oakman

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Chief Administrative Officer

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Attachments: Appendix A - "Odour Control System Evaluation report"
Appendix B - "Map of subject properties"

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Comox Valley Water Pollution Control Centre

FINAL REPORT

Revision 1

Odour Control System Evaluation

RWDI # 1500239
October 30, 2015

SUBMITTED TO

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TABLE OF CONTENTS

Figures

Appendices

INTRODUCTION

The Comox Valley water pollution control centre (CVWPCC) is a secondary level wastewater treatment plant that provides improved wastewater treatment to the City of Courtenay and the Town of Comox. The plant is located east of the Town of Comox in a rural area adjacent to the Strait of Georgia (Figure 1 Site Map).

Soon after start-up in 1984 the Comox Valley Regional District (CVRD) began to receive odour complaints related to plant operation. These complaints tended to be from residents along Curtis Road where odours are more frequent, especially on evenings in the late summer or early fall when certain weather conditions (off-shore wind) prevail.

Current situation

RWDI AIR Inc. (RWDI) has completed a review and evaluation of the ongoing performance of the wet chemical scrubber system installed at the CVWPCC. The overall odour control practices at the plant were also reviewed.

Figure 1: Site Map (CVRD RFQ September 2014)

RWDI presents this document to provide a report consisting of the following:

1. Review of the existing wet-chemical scrubber odour control system performance that establishes the current performance relative to initial start-up performance.
2. An odour audit of operational and maintenance practices.
3. Develop a monitoring system to ensure odour control performance.
4. Review the current state of the art with respect to wastewater treatment plant odour control and if warranted, make recommendations on alternate technologies for CVWPCC odour control.
5. Provide cost estimates for any recommended improvements.

METHODOLOGY

Phase 1 - Pre-Study

Prior to beginning the site work RWDI reviewed the CVRDs background information related to the original selection and installation of the wet chemical scrubber system. This involved a review of design flow rates, concentrations and removal efficiencies on which the design was based, plant flow at time of design, etc.

A cursory review of the scrubber operation was made at this time and included flow measurements within the system, chemical usage rates, scrubber solution renewal rates, water make-up and overall physical condition.

RWDI met with CVRD staff to determine the best way to interact with area residents near the CVWPCC to better understand their concerns with respect to existing odour issues.

RWDI audited the operational and maintenance odour potential of the existing plant. This included process rates, standard maintenance practices and general physical condition of the plant equipment.

Phase 2 – Evaluation of wet chemical scrubber system

In order to evaluate the control efficiency of the scrubber unit RWDI tested the scrubber under normal working conditions. Originally it was proposed that artificially induced concentrations of hydrogen sulfide be examined. Based on the availability of pure hydrogen sulfide gas, difficulties with transporting the gas and safety concerns around using the pure gas, it was decided that it was more appropriate to test the scrubber under the actual working conditions. The other scenarios are not truly relevant to the normal control efficiency of the scrubber.

It is very important to evaluate scrubber efficiency at normal load since removal efficiency for wet scrubbers is often lower with low inlet concentrations.

Velocity, Temperature and Volumetric Flow Rate Determination

Source velocity and flow rates were determined by U.S. EPA Methods 1 and 2. Velocity measurements were taken with a pre-calibrated S-type Pitot tube in conjunction with an incline manometer. Temperature measurements were made simultaneously with the velocity measurements, using a chromel-alumel type "k" thermocouple in conjunction with a digital temperature indicator. The volumetric flow rate was determined by following the equal area method as outlined in Method 2.

With reference to stack gas composition, the dry molecular weight (Md) was determined by following calculations outlined in Method 3. Stack gas composition was determined through the employment of a Nova Combustion Analyser. The analyser measures the CO_2 concentration of the stack gas by means of a non-dispersive infrared (NDIR) detector. The O_2 concentration is measured by the analyser through the use of an electrochemical cell. Moisture determination was conducted by following Method 4.

Hydrogen Sulfide Sampling

Sampling for H_2S was performed in accordance with U.S. EPA Methods CEMS 5 using a continuous emission monitor (CEM). The method provides real-time measurement for total reduced sulfur. The exhaust gas sample was withdrawn from a point at the center of the duct using a stainless steel probe. The sample proceeded to a heated filter, where particulate matter was removed, and then transferred via a heated Teflon® line to a sample conditioner. The Teflon® line was heated above the condensation temperature of the exhaust gas stream. The sample conditioner eliminated any condensation in the exhaust. The sample was then routed to the CEM for measurement. Reference method measurements were taken at both the inlet of the scrubber and at the outlet of the scrubber. Measurements were alternated between the two locations.

The scrubber removal efficiency was calculated by comparing inlet and outlet concentrations. The chemical efficiency was calculated from the mass of H_2S removed in the scrubber. The theoretical chemical usage can be calculated from the chemical equations for H_2S removal. This value was compared to the chemical feed rate into the scrubber.

Odour Sampling

In addition to the H_2S sampling, it was felt that it would be prudent to collect odour samples in Tedlar bags and have them submitted for odour panel analysis. Hydrogen sulfide is a major component of the odour from waste water treatment plants but is not the only component. It is possible that local odour issues are not related solely to H_2S impacts. This allowed RWDI to evaluate the scrubber efficiency in terms of odour removal as well as H_2S removal.

The field dilution odour sampling system operates by delivering nitrogen gas to an eductor at a constant rate to provide the necessary suction to draw sample gas into the Tedlar gas sample bag. The odourless nitrogen gas also acts to dilute the sample gas as it is extracted from the source. The sample gas is drawn through a calibrated capillary tube from the sample probe. The low sample flow rate is measured by a Magnehelic differential pressure gauge which measures the pressure drop across the capillary tube. Sample bags are purged with diluted stack gas prior to being filled. This sampling method complies with OSTC ON-6 (Ontario Source Testing Code). The purpose of performing the field dilutions is to eliminate condensation in the sample bags.

Once the samples have been collected in Tedlar bags, they are covered to avoid exposing the sample to light and to minimize potential photochemical reactions.

The samples were then submitted for subsequent analysis by an odour panel. The panel was tested prior to odour analysis and the members are considered to be in the normal odour sensitivity range as determined through an accepted odour panelist screening process. The samples were transferred by airfreight to the Pinchin odour lab in Mississauga, Ontario for analysis within 24-hours of sampling.

The odour evaluation uses an olfactometer with a multi-port system to deliver the odour samples to the panel members. The sample bag is pressurized and an electronic mass flow controller meters the sample flow rate. A three way valve is operated to permit the sample to flow into either one of the two ports. The analysis begins with a high dilution sample, diluted at a controlled flow rate with odourless air. The test is then repeated at decreasing levels of dilution until the odour panelists can detect the odour. For each dilution of the sample, the panelist identifies from which port the odour is detected. A data acquisition system records the panelists' responses and performs a regression analysis to calculate the odour threshold value. The odour threshold value, also called the ED50 (effective dilution to 50% response), is a statistical measure which identifies the dilution at which 50% of the panel can just detect the odour.

The odour samples were shipped to a lab and analysed within 24-hours of sampling.

Vacuum Checks

RWDI completed vacuum measurements throughout the odour collection ductwork in all accessible locations. The measurements were taken using a calibrated digital manometer. RWDI has itemized leak points in the system. At most points there were also flow rate measurements taken using a hotwire anemometer. The flows and pressures were compared to the initial air balance done during commissioning of the system.

Review of Scrubber Operations

RWDI examined the ongoing maintenance and operational procedures of the scrubber. This included but was not limited to: examining the service schedule and records, the measurement and feedback system for adjusting chemicals and water levels in the scrubber.

Additional Equipment

RWDI also completed a complete survey of the site including those areas and pieces of equipment that are not currently captured by the scrubbing system. These pieces of equipment and areas were examined using a Jerome 621 hand held H_2S detector. Hydrogen sulfide concentrations near to these pieces were measured and where the values were significant, the pieces of equipment or specific areas were considered for inclusion in the scrubber gas collection.

OBSERVATIONS

Phase 1 - Observations

RWDI staff was at the plant from January 19 to January 22, 2015. The site visit involved touring of the facility and the neighboring community, collecting information from plant staff and making various measurements and observations related to the operation of the plant generally and the odour collection system specifically.

Overall Operation of the CVWPCC

The overall impression of the facility at the time of the visit was that it was well operated and that the staff had taken several innovative steps to reduce odour from the facility. These steps include:

- selective damming at the drop of the primary clarifiers to reduce the drop height of the water and the amount of odour released at that point;
- the installation of flow diverters at the end of the secondary tank to eliminate dead flow zones and stagnation in the collection trough and;
- the installation of spray bars on the secondary tanks to break up the formation of bacterial foam which occurs occasionally in the Summer.

The plant was commissioned in 1984 but seems to be in good shape based on cursory observations. All major components of the plant were operating properly at the time of the visit and the general level of “housekeeping” was excellent for this type of facility.

Review of Initial Odour Control Design

The original complaints at the facility stemmed from the operation of a bio-solids composting facility on the site which was moved at about the same time the odour control system was installed in 1996/97. Generally the compound of greatest concern with regard to odours from waste water treatment plants is hydrogen sulfide (H_2S). The selection of a packed column wet scrubber with a caustic/hypochlorite feed is a traditional and effective way to control H_2S emissions from this type of source.

The collection system has focused on the most odorous components of the treatment plant and has for the most part sealed those components and put them under negative pressure. The original design of the system indicated that the overall flow was to be approximately 27,000 cubic feet per minute (cfm). The review of the mechanical specifications showed a 40 horsepower centrifugal fan which seemed to indicate a maximum flow rate of approximately 20,000 cfm. In either case, the design of the system was adequate to supply sufficient flow and vacuum to keep the odourous components of the system under negative pressure.

The stack design from the scrubber is also sufficiently tall to be removed from building wake effects and will supply dilution without experiencing a building downwash effect during poor dispersion meteorology.

Review of Scrubber Operation

The packed column scrubber is a standard design with a counter flow system using a caustic/hypochlorite scrubbing solution. The solution is monitored with pH and chlorine sensors and fresh chemicals are added as required based on the input from the sensors. The source testing program showed an inlet loading of between 14.5 and 4.4 mg/s. These cases were with the aerator operating/not operating. As an estimate of typical loading we would assume a value of about 7.3 mg/s. This translates to roughly 230 kg of total reduced sulfur compounds (as H_2S) per year or 6.7 kMol. Based on discussions with staff, there were three 550 litre totes of 25% sodium hydroxide used in 2014 and 36,000 litres of 12% sodium hypochlorite used. This translates to 413 kg of sodium hydroxide or 10.3 kMol and 4320 kg of sodium hypochlorite or 58 kMol. The hydrogen sulfide and the solution react as per the formulas below:

$$H_2S+4NaClO \rightarrow Na2SO_4 + 4NaCl$$
$$H_2S+2NaOH \rightarrow Na2S+2H_2O$$

Based on the above, if only hypochlorite was used to neutralize the reduced sulfur compounds 13.4 kMol would be required. Similarly, 13.4 kMol of sodium hydroxide would be required if only sodium hydroxide was used. The hypochlorite also will neutralize many other compounds, it will also act as a disinfectant to neutralize biological agents and it serves to act as a masking agent for the stack odour.

The feed rate of chemicals is adequate to neutralize the reduced sulfur compounds. There is some excess of hypochlorite but this does perform the functions discussed above. The chemical feed system appears to be dosing at an appropriate rate based on the observations made.

There was initially a hydrogen sulfide sensor installed in the duct after the scrubber. This sensor has been inoperable for some time and we do not recommend that it be replaced. These types of sensors will not provide meaningful measurements in the required range.

Community Observations

On the morning of January 20, 2015, the weather conditions were overcast, with light fog, winds were light and variable blowing generally from the plant towards the sea. These conditions should have provided near worst-case dispersion for experiencing odours in the community. There are a series of observations listed below

- 10:30 - Walter Road – some areas where very faint mercaptan odours were detected – very faint
- 10:35 - Andrew Road – very faint mercaptan odour, intermittent – more like pulp and paper
- 10:40 - 396 Curtis Road – downwind of stack – very faint intermittent odour – would probably not be noticed if not trying to smell the plant
- 10:45 to 10:50 - 413 to 453 Curtis Road faint to mild odour but intermittent

The observations were made during worst case atmospheric conditions and odours were intermittent and barely perceptible.

Flows and Loading

The odour system was designed and built in 1996/97 and since that time the population in the area has increased a comparison was made between earlier years of operation and 2014. Table 1 below shows the flows in 1997 and 2014. The table also shows influent Biological Oxygen Demand (BOD) loading for 2014 and also average BOD loading for 2004.

Table 1: 1997 and 2014 Flows and BOD Loading

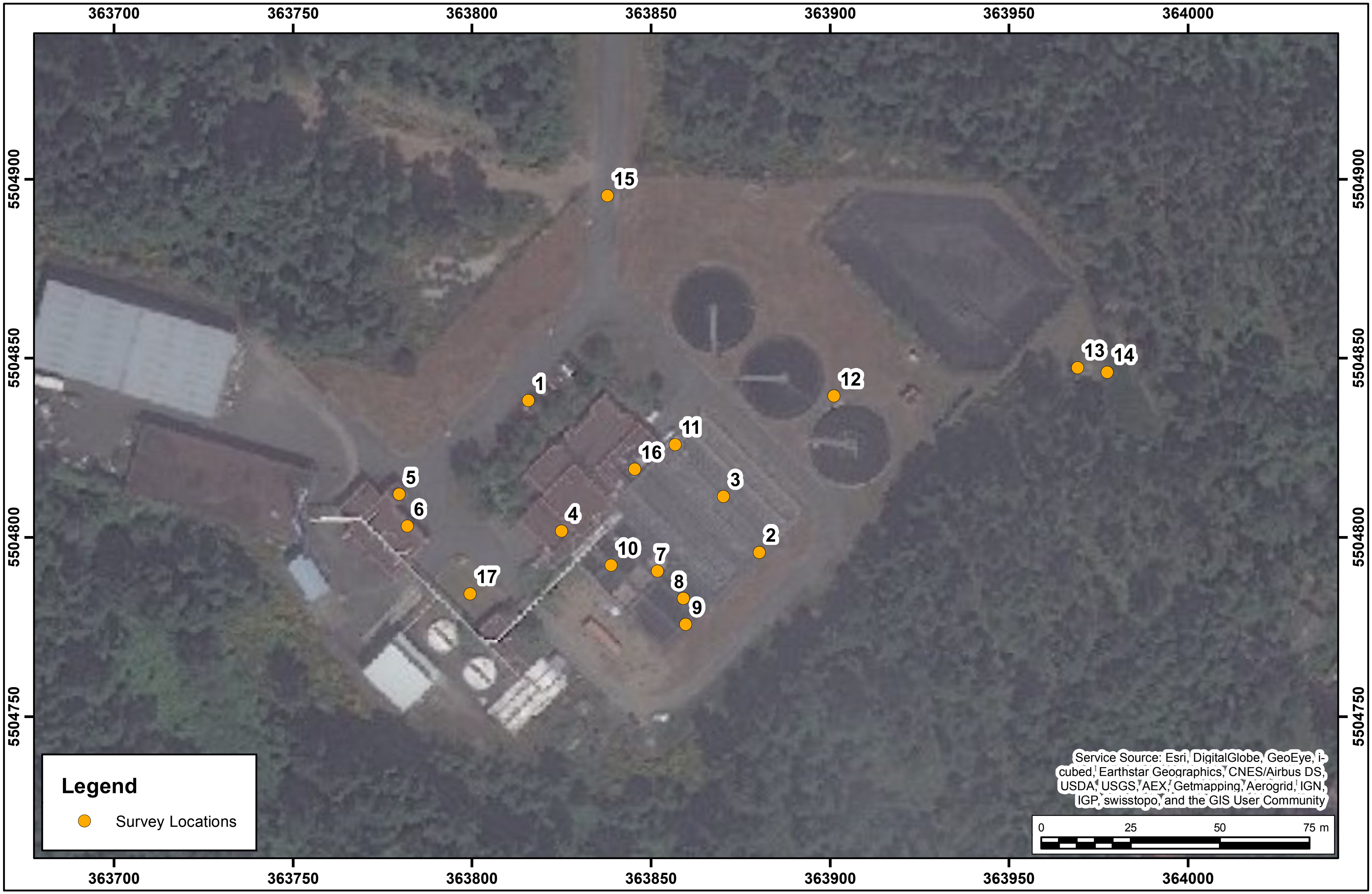
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1997	TOTAL BOD
MAX (m^3)	26329	50336	64298	38823	41801	41459		38540	40143	39453	22927	24743	64298	(tonnes)
MIN (m^3)	11948	11372	11086	10550	12758	12277		12733	12216	12779	11626	12906	10550	
AVG (m^3)	15509	21146	22878	16957	18928	18704		14782	16896	17585	15173	15569	17648	
BOD* (g/m^3)													239	1540
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**2014**	**TOTAL BOD**
MAX (m^3)	22623	24911	21137	14850	15581	12916	13459	13656	13874	28977	19974	38462	38462	(tonnes)
MIN (m^3)	11899	11123	13083	12366	11682	10982	11400	11241	10965	11570	12306	12931	10965	
AVG (m^3)	13574	15523	15993	13244	13047	11954	12258	12255	12335	15918	15154	19338	14216	
BOD (g/m^3)	351	244	212	232	317	429	355	280	315	188	234		287	1489

Notes: ** Please note that BOD numbers for 1997 were not easily available so values for 2004 were used since those values were the earliest available in electronic format.*

Despite the growth in population, the overall flows have dropped slightly since 1997. This is due to low-flow initiatives that the region has implemented. There is no control for differences in precipitation in these statistics. While flows have decreased, the total amount of BOD loading has increased leaving the overall BOD loading very similar. Anecdotally, the staff have related that BODs have been steadily increasing over the years. This increase in BOD concentrations may cause an increase in odours at some times but the overall statistics would indicate that loading is similar to earlier years. This indicates that the design parameters for the odour control system are still valid.

Hydrogen Sulfide Survey

A handheld Jerome 621 Gold Film analyzer for hydrogen sulfide was used at various locations around the facility. The locations of these measurements are shown in Figure 2. The results are shown in Table 2



Comox Valley Water Pollution Control Centre Hydrogen Sulfide Survey

January 21, 2015

Map Projection: NAD 1983 UTM Zone 10N.

Comox Valley Water Pollution Control Centre - Comox Valley, BC

True North

Project #1500239

Drawn by: NBN	Figure: 2
Approx. Scale:	1:1,500
Date Revised:	Mar. 18, 2015

RWDI

Table 2: H_2S Sampling Results

Sample Point	H_2S (ppb)	Sample Location
1	0	parking lot in front of main door to control bldg
2	0	back end of bioreactors
3	0	6 feet above bioreactor in the middle
4	0	bar screen room
5	66	solids loading bay
6	19	centrifuge room
7	2	2 feet above primary surface
8	5	2 feet above primary tank adjacent to bubbling gas
9	5	above water drop at end of primary
10	0	2 feet above primary tank at top end
11	0	beneath walkway at the end of the bioreactors
12	0	edge of clarifier
13	1	on edge of pressure chamber
14	0	about 18" below goose neck vent from discharge well chamber
15	0	front gate
16	1	blower room
17	2	DAF building

Notes: Survey was taken on January 21 between 1:30 and 3:00.
The measurements were taken with a Jerome 621 H_2S handheld. analyzer
The winds were light and variable during testing but samples were all taken at the point with the greatest odour near the source.

Phase 2 - Observations

Review of Odour Collection System

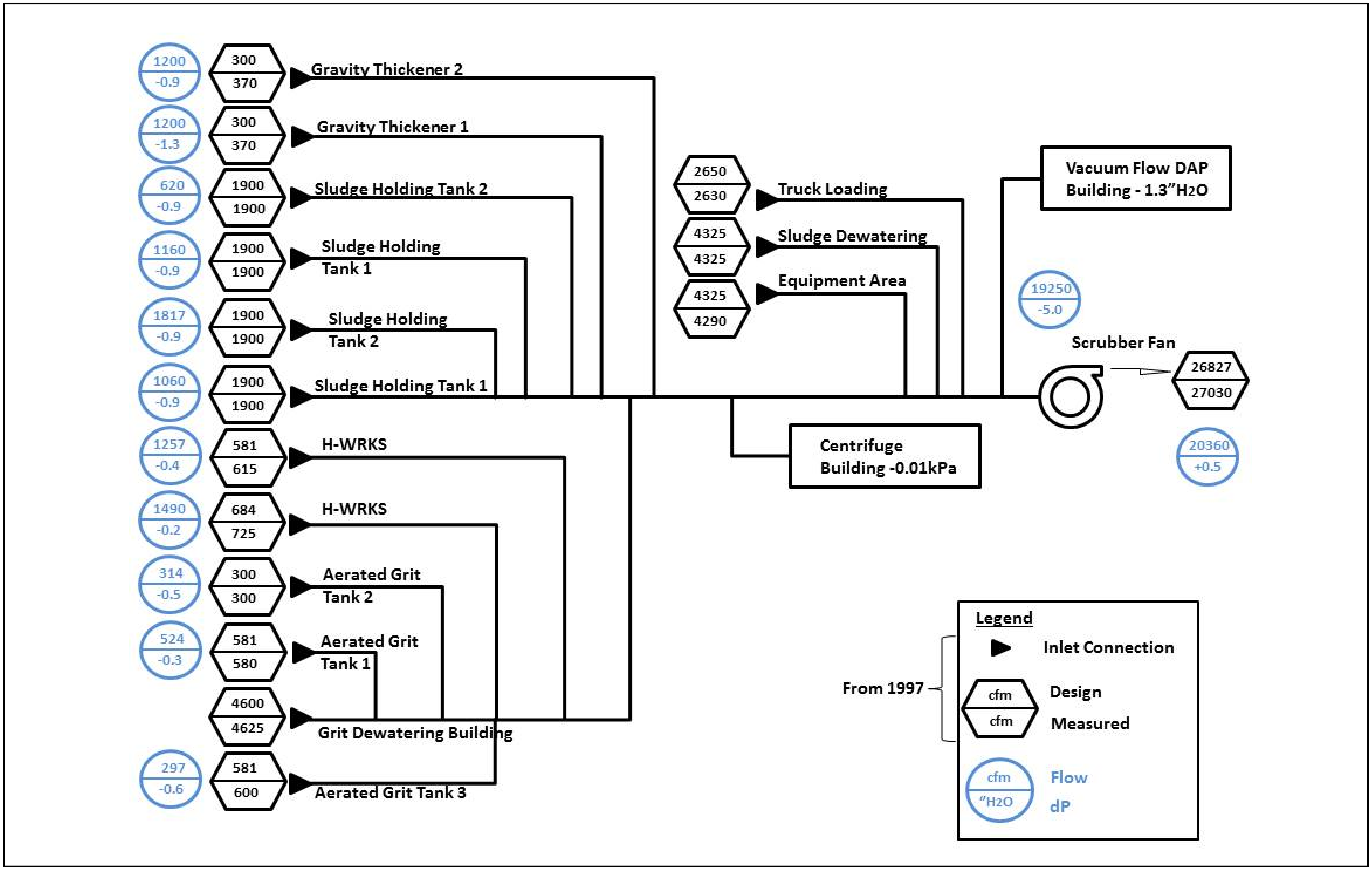
The odour collection system was examined during the site visits and it was determined that the system is in good working order and all components were under sufficient negative pressure to ensure adequate collection. Figure 3 shows a schematic of the odour collection system and the flows and pressures measured during the site visit. It was not possible to measure flows from all components but pressure measurements were made at all locations. The figure also shows the original design flows as well as the initial flow measurements of the system.

The system does have several large leak points which should be sealed or at least reduced. The openings on top of the sludge thickeners are much larger than they need to be. These openings could be reduced in sized and the remaining area could be covered with neoprene flaps. This would still leave ample access for maintenance and decrease the amount of vacuum leakage. Similarly, the opening above the headworks inlet chamber could be partially closed off with the same technique. There is also an opening in the back wall of the centrifuge building where the conveyer enters the building that represents a large vacuum leak.

There is an additional fan in the centrifuge building that previously was operated with an automated switch. This has been recently overridden and is on at all times now; we would recommend that this continues.

One of the odour sources on-site occurs from the unloading of vacuum trucks. Anecdotally, two drivers had mentioned that the unloading process would be accelerated if there was some additional head pressure in the hose that drains the trucks. This would seemingly decrease the amount of time for unloading and therefore the odour impact. Material transfers of this type are not RWDI’s expertise but it would seem to be fairly easily accomplished by raising the ramp/pad for the vacuum trucks another half to quarter metre. We would suggest that the matter be examined to see if it is a feasible improvement.

There are likely other smaller leaks around sealed cover plates and other small sources. We would recommend that an ongoing check of vacuum at various points in the system to identify areas where leaks have developed. As stated earlier, the system is operating effectively but the system could probably be expanded to include more sources without additional fan power if the leaks were addressed.



Flow Balance Diagram Comox Valley Water Pollution Control Centre

True North

Drawn by: NBN	Figure: 3
Approx. Scale:	N/A
Date Revised:	Mar. 18, 2015

RWDI

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

Stack/Scrubber Testing

The testing program was completed on January 21 and 22, 2015 using the techniques described in the methodology section. The flow and TRS measurements were taken on January 21.

The TRS testing was initially done on the scrubber inlet during normal conditions. After an hour an aerator was turned on to increase loading on the system. The scrubber inlet was monitored for a period while the aerator was on. The exhaust stack was then monitored for approximately one hour while the aerator was on. The scrubber inlet was then monitored again to see if there was a decrease in TRS levels. Tables of all the testing results are included in Appendix A and the summary Table 3 below.

Table 3: Summary of TRS Sampling

			Avg TRS	Avg TRS	Emission Rate*
	Start Time	End Time	(ppm)	(µg/m^3)	(mg/s)
Inlet to scrubber	12:30	13:30	0.3	439.2	4.4
Inlet to scrubber (aerator on)	13:45	14:00	1.0	1464	14.5
Exhaust Stack	14:35	15:35	0.4	585.6	5.8
Inlet to scrubber	15:50	16:10	0.5	732	7.3
Dry reference flow rate (m^3/s)	9.92				

The odour sampling was completed on January 22, 2015 and samples were shipped to the odour lab for analysis on January 23, 2015. The odour lab results are shown in Appendix B and are also summarized in Table 4 below.

Table 4: Laboratory Analysis Sample Results

Location	Odour	Sample	Net Odour	Odour Emission Rate
	Threshold	Dilution	(OU/m^3)	(OU/s)
Inlet 1	1114	5.2:1	5792.8	57465
Inlet 2	1020	5.2:1	5304	52616
Inlet 3	1324	5.2:1	6884.8	68297
Inlet Average				**59459**
Exhaust 1	721	4.5:1	3244.5	32185
Exhaust 2	663	4.5:1	2983.5	29596
Exhaust 3	935	4.5:1	4207.5	41738
Exhaust Avg				**34507**
Dry reference flow rate (m^3/s)				9.92

Notes: *Odour units (OU) are based on the required dilution for 50 % of the population to be able perceive an odour. This does assume that the population all have a normal range of sensitivity to odour.

Scrubber Efficiency

The inlet concentration of reduced sulfur is very low and did not get much over 1 part per million during the testing. The nature of scrubber solutions is that there will always be some gas coming out of solution as well as being absorbed into the solution. Even with perfectly fresh solution the exhaust concentration would probably be a few hundred parts per billion. The scrubber would probably show a much higher efficiency if the inlet concentration was higher but it is not relevant to the plant's operation parameters. The best case removal efficiency for reduced sulfur was 60%. The removal efficiency for odour was 42%.

Community Consultation

As part of the community consultation process the Comox Valley Regional District conducted a mail survey regarding odours from the Comox Valley Water Pollution Control Centre. The purpose of the survey was twofold. Firstly it was an assessment of odour impacts from the facility in terms of frequency, seasonality, intensity etc. Secondly it was to gauge the level of concern in the area surrounding the plant.

There were a total of 85 surveys mailed out to residents who live near the plant. A total of 27 surveys were filled out and returned. The detailed results are included Appendix D of this report.

The results of the survey indicated that roughly half the respondents experienced the plant odours frequently. Only about a quarter of the people that experienced odours deemed them strong and objectionable. The survey responses indicated that the Region should allocate some resources to informing the public of the new complaint process. Based on public response, there was a perception that odour impacts were more frequent in the Summer but this is a small enough bias that it is probably more related to increased resident time outdoors rather than any operational change. Similarly, there was a perception that there were more odour impacts in the evening than other times of day. This may have been related to meteorology or again, the increased likelihood of residents being outside.

There was a wide range of responses in the written comments but the most common note was a desire to know what was going on with regard to odours from the plant.

DISCUSSION

Based on our observations we would make the following conclusions:

- The plant is operated well with regard to odour control activities.
- The interaction with the public will be achieved by means of a mail out survey which has been supplied to the Region for comment at this point.
- The odour impact in the community was very faint and intermittent in a limited area during the RWDI visit.
- Ambient measurements of hydrogen sulfide were zero at all points on the perimeter of the facility and in almost all outdoor locations on the property.

- The odour collection system is operating well but several leak points should be addressed particularly if the collection system is expanded.
- The height of the ramp/pad for the vacuum trucks should be reviewed. However based on discussions with the Region this may not be productive.
- The scrubber is not working very efficiently but the overall emission rate from the stack is not that high in terms of reduced sulfur compounds – including hydrogen sulfide.
- The scrubber is removing 42% of the odour emission in the exhaust.
- The stack is a good design and is providing good dispersion of the exhaust odours.
- There are some odours in the community but the impacts seem to be restricted to the area fairly near the plant and are similar to what we have observed elsewhere at similar facilities in other jurisdictions. Including jurisdictions with odour regulations.
- The Region may want to include some information update process linked to the website so residents can be aware of upgrades, upsets, plans or construction at the plant.

Phase 3 – Evaluation of alternate technologies

Upgrades to the vacuum collection system to include more sources

Upon review of the collection system it was determined that there was probably some excess capacity in the system that could allow for some expansion. Based on the survey, the two most odourous sources that are not currently captured by the vacuum collection system are the primary tanks and the secondary bioreactors. It is likely that the primary tanks are the more dominant source of odour and it could be enclosed in a cover building that would be vented to the vacuum system/scrubber.

The budget cost for an enclosure to cover the primary bioreactors would be approximately $600,000 based on current rough building cost guidelines for BC for warehouse type buildings. This is probably a conservative estimate since the structure will not have a floor or foundation. A mechanical balance will have to be completed to determine if the structure can be ventilated properly with only the existing vacuum system. The safest rate of ventilation would be 12 air changes per hour but as little as 4 air changes could be used. If the building was ventilated separately from the current vacuum system we would estimate the required fan and ducting would have a budget price of $40,000.

The construction materials should either be coated with thick polymer or be constructed from plastic or FRP type materials. As an alternative, the possibility of only enclosing the only effluent weirs could be examined

If both the secondary bioreactors and primary tanks were enclosed we would estimate that the enclosure cost would be roughly $1,000,000 but again, this is probably a conservative estimate. There would be a requirement for additional fan power if both the primaries and bioreactors were enclosed and we would estimate a budget price of $60,000 for fan and ducting

To determine whether enclosing either the primary tanks or bioreactors would be beneficial, we would recommend that an odour emission rate estimate be completed from measurements of similar sources. We would further recommend that these odour emissions be modelled using a numerical dispersion model such as CALPUFF or AERMOD to determine what the odour impact of these emissions is on surrounding residences.

Optimization of the current wet scrubbing system

As part of our investigations we evaluated the current scrubber efficiency and capacity. The removal efficiency of the scrubber for odour in general and for reduced sulfur compounds in particular is not as high as manufacturer's claims but this is due to the relatively low inlet concentration. Basically the chemical balance indicates that an appropriate amount of chemicals are being used. There could be some gains made by increasing the amount of makeup water but this will require the use of additional chemicals. It is unlikely that the gains would be significant in terms of overall impacts.

Expanding the wet scrubbing system

At present there would seem to be little point in expanding the wet scrubbing system. The air through the scrubber has sufficient residence time and the loading on the scrubber is very light. If it were determined that enclosing the primary and/or secondary bioreactors would be beneficial, it may be necessary to expand the scrubber system but that would need to be determined after any additions were made.

Adding a Bio-filter system

Bio-filtration is a traditional control for these types of sources since many of the components in the exhaust stream are effectively treated by bio-filters. A combination of a wet scrubber and a bio-filter will usually achieve 80% or better odour removal efficiency. Typically the operating costs are fairly low with these types of systems but it can vary based on several factors. The downfall of this type of treatment is that it does require a fairly large footprint. The other downfall is that bio-filters rarely achieve better than 90% odour removal.

The capital cost for these types of systems (U.S. EPA) is between $3 and $21 per cfm of exhaust. In the current configuration, this would give a budgetary price of roughly $600,000 dollars of capital cost. If the collection system was expanded the price would increase if the flow increased.

There is no way to tell if the addition of a bio-filter would provide a significant benefit at present. We would recommend that the odour emissions from the current stack be modelled using a numerical dispersion model such as CALPUFF or AERMOD to determine what the odour impact of these emissions is on surrounding residences. The source could then be remodeled to determine the benefit from the addition of a biofilter

Adding a Thermal Destruction System

Thermal destruction has a very high efficiency in terms of odour removal, generally greater than 95%, but there are several disadvantages for this type of system.

First it is very costly, with a capital cost in the $140 per cfm (U.S. EPA) range which would translate to a budgetary price of roughly $3,000,000 for capital costs. The operating costs would be in the range of $300,000 per year.

Secondly, there is an increase in emissions of oxides of nitrogen, carbon monoxide, sulfur dioxide and greenhouse gases. It is possible that there may be a compliance issue with one of these emissions.

Finally, most thermal destruction units have a relatively short lifespan and need to be replaced after ten to twenty years.

We would not recommend a thermal destruction unit unless further analysis showed that an odour destruction efficiency of greater than 95% was required.

Adding Other Control Technologies

There are several other technologies that would possible be beneficial. One of these technologies is non-thermal plasma destruction. This technology does not have a long, proven track record but it does have some advantages that may be worth examining. The odour removal efficiency is quoted at 90% which is very good and we would estimate the budgetary capital cost at about $300,000. The operating costs would include additional electricity use which would be less than $10,000 per year. The systems are modular and can be expanded fairly easily if required. We have been in contact with a British Columbia supplier that could also supply a pilot unit to examine the control efficiency on the facility's exhaust.

However, this is a control technology that does not have widespread acceptance and the one similar unit that RWDI has any working knowledge of, is not currently working.

We would not recommend any further examinations of this technology until it is determined if additional control is required on the exhaust stack.

SUMMARY RECOMMENDATIONS

It is not possible to say at this point whether the stack and scrubber are providing sufficient odour control in the surrounding community. We would recommend that dispersion modeling of the exhaust stack as well the other sources of odour at the plant. Modeling would determine if further controls on the exhaust stack would make a significant difference or whether it would be better to expand the odour collection system to include other sources such as the primary tanks. Modelling would also allow the site to be evaluated against odour standards from other jurisdictions until such time as BC gets their own odour standard. If the plant achieves the standard it would go a long way in limiting any possible civil liability.

A community odour monitoring plan has been developed in consultation with the Region and is included in the attached Appendix C. We would recommend that these surveys begin as soon as possible so that there can be a baseline established to determine community odour impacts. This will be important in establishing whether any improvements made at the facility have a significant effect.

The results of the public odour consultation should be evaluated to see the degree of the perceived odour problem in the area. This will allow the Region to gauge the urgency of any improvements to odour control at the site.

APPENDIX A

TEST RESULT TABLES

TRS SAMPLING DATA

year	day	time	TRS (ppm)
2015	21	1231	0.014525
2015	21	1232	-0.0111
2015	21	1233	-0.03813
2015	21	1234	-0.03235
2015	21	1235	-0.06918
2015	21	1236	-0.0878
2015	21	1237	-0.02263
2015	21	1238	-0.03265
2015	21	1239	0.002725
2015	21	1240	0.1359
2015	21	1241	0.174275
2015	21	1242	0.09345
2015	21	1243	0.075025
2015	21	1244	0.0438
2015	21	1245	0.009775
2015	21	1246	0.01535
2015	21	1247	0.062125
2015	21	1248	0.1431
2015	21	1249	0.191275
2015	21	1250	0.18285
2015	21	1251	0.219825
2015	21	1252	0.288
2015	21	1253	0.195775
2015	21	1254	0.20715
2015	21	1255	0.232525
2015	21	1256	0.2395
2015	21	1257	0.174275
2015	21	1258	0.22105
2015	21	1259	0.201225
2015	21	1300	0.2126
2015	21	1301	0.158775
2015	21	1302	0.18415
2015	21	1303	0.230925
2015	21	1304	0.2847
2015	21	1305	0.294675
2015	21	1306	0.31585
2015	21	1307	0.307425
2015	21	1308	0.2804
2015	21	1309	0.249175
2015	21	1310	0.23775
2015	21	1311	0.230725
2015	21	1312	0.2747
2015	21	1313	0.298875

year	day	time	TRS (ppm)	
2015	21	1314	0.29325	
2015	21	1315	0.304625	
2015	21	1316	0.3542	
2015	21	1317	0.378175	
2015	21	1318	0.37535	
2015	21	1319	0.396525	
2015	21	1320	0.3355	
2015	21	1321	0.345475	
2015	21	1322	0.29585	
2015	21	1323	0.307025	
2015	21	1324	0.2702	
2015	21	1325	0.342575	
2015	21	1326	0.32835	
2015	21	1327	0.359525	
2015	21	1328	0.3795	
2015	21	1329	0.363875	
2015	21	1330		
2015	21	1331	0.299691	30 min avg
2015	21	1332		
2015	21	1333		
2015	21	1334		
2015	21	1335		
2015	21	1336		
2015	21	1337		
2015	21	1338		
2015	21	1339		
2015	21	1340		
2015	21	1341		
2015	21	1342		
2015	21	1343	0.0896	
2015	21	1344	0.1928	
2015	21	1345	0.2518	
2015	21	1346	0.405	
2015	21	1347	0.5852	
2015	21	1348	0.6604	
2015	21	1349	0.6746	
2015	21	1350	0.771	
2015	21	1351	0.8518	
2015	21	1352	0.9312	
2015	21	1353	0.9596	
2015	21	1354	1.0192	
2015	21	1355	1.008	
2015	21	1356	1.0094	
2015	21	1357	1.0264	
2015	21	1358	1.0888	
2015	21	1359	1.0576	

year	day	time	TRS (ppm)	
2015	21	1400		
2015	21	1401	1.0349	inlet sampling with ae
2015	21	1402		5 min avg after ramp u
2015	21	1403		
2015	21	1404		
2015	21	1405		
2015	21	1406		
2015	21	1407		
2015	21	1408		
2015	21	1409		
2015	21	1410		
2015	21	1411		
2015	21	1412		
2015	21	1413		
2015	21	1414		
2015	21	1415		
2015	21	1416		
2015	21	1417		
2015	21	1418		
2015	21	1419		
2015	21	1420		
2015	21	1421		
2015	21	1422		
2015	21	1423		
2015	21	1424		
2015	21	1425		
2015	21	1426		
2015	21	1427		
2015	21	1428		
2015	21	1429		
2015	21	1430		
2015	21	1431		
2015	21	1432		
2015	21	1433		
2015	21	1434		
2015	21	1435		
2015	21	1436	0.385333	
2015	21	1437	0.424867	
2015	21	1438	0.3564	
2015	21	1439	0.327733	
2015	21	1440	0.331667	
2015	21	1441	0.3	
2015	21	1442	0.257133	
2015	21	1443	0.283667	
2015	21	1444	0.2862	
2015	21	1445	0.302933	

year	day	time	TRS (ppm)
2015	21	1446	0.355267
2015	21	1447	0.3506
2015	21	1448	0.336133
2015	21	1449	0.325867
2015	21	1450	0.2914
2015	21	1451	0.251333
2015	21	1452	0.270867
2015	21	1453	0.265
2015	21	1454	0.291533
2015	21	1455	0.340867
2015	21	1456	0.3986
2015	21	1457	0.408333
2015	21	1458	0.399467
2015	21	1459	0.3766
2015	21	1500	0.370733
2015	21	1501	0.318067
2015	21	1502	0.3064
2015	21	1503	0.338733
2015	21	1504	0.291467
2015	21	1505	0.2528
2015	21	1506	0.242533
2015	21	1507	0.303067
2015	21	1508	0.3012
2015	21	1509	0.387533
2015	21	1510	0.411267
2015	21	1511	0.506
2015	21	1512	0.497333
2015	21	1513	0.492867
2015	21	1514	0.4712
2015	21	1515	0.476533
2015	21	1516	0.429267
2015	21	1517	0.4104
2015	21	1518	0.428533
2015	21	1519	0.415467
2015	21	1520	0.3954
2015	21	1521	0.375333
2015	21	1522	0.358067
2015	21	1523	0.3322
2015	21	1524	0.375933
2015	21	1525	0.447867
2015	21	1526	0.4816
2015	21	1527	0.499733
2015	21	1528	0.544867
2015	21	1529	0.5488
2015	21	1530	0.474733
2015	21	1531	0.491467

year	day	time	TRS (ppm)	
2015	21	1532	0.5166	
2015	21	1533	0.416933	
2015	21	1534	0.284667	
2015	21	1535		
2015	21	1536		
2015	21	1537		
2015	21	1538	0.374803	scrubber exhaust
2015	21	1539		1hour avg
2015	21	1540		
2015	21	1541		
2015	21	1542		
2015	21	1543		
2015	21	1544		
2015	21	1545		
2015	21	1546		
2015	21	1547		
2015	21	1548		
2015	21	1549		
2015	21	1550	0.35	
2015	21	1551	0.45	
2015	21	1552	0.439	
2015	21	1553	0.55	
2015	21	1554	0.5438	
2015	21	1555	0.558	
2015	21	1556	0.5154	
2015	21	1557	0.4642	
2015	21	1558	0.4996	
2015	21	1559	0.4854	
2015	21	1600	0.4996	
2015	21	1601	0.5264	
2015	21	1602	0.569	
2015	21	1603	0.5406	
2015	21	1604	0.5292	
2015	21	1605	0.5136	
2015	21	1606	0.4994	
2015	21	1607	0.5264	
2015	21	1608	0.515	
2015	21	1609	0.542	
2015	21	1610	0.5662	
2015	21	1611		
2015	21	1612	0.508705	inlet sampling
2015	21	1613		20 min avg

Stack Gas Velocity and Volumetric Flow Rate

Client:	Comox WWTP
Project #:	
Locations:	Main Stack
Date:	21-Jan-15
Time:	
stack diameter (inches):	30
Stack Area, (ft2):	4.9
Barometric Press, Pb (" Hg):	29.80
Stack Pressure, Ps (" Hg):	29.84

Pitot Coefficient, Cp:	0.79
Molar Weight Stack Gas:	29.06
Moisture, Bws (%):	1.3%
Static Pressure, Pg (" H2O):	0.5

		Traverse 1				Traverse 2			
Point	**Position** (in)	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle
1	2	1.90	52	71.4	0	1.78	52	69.1	0
2	4	1.90	52	71.4	0				
3	6	1.90	52	71.4	0				
4	8	2.00	52	73.3	0				
5	10	1.90	52	71.4	0				
6	12	2.00	52	73.3	0				
7	14	1.80	52	69.5	0				
8	16	1.80	52	69.5	0				
9	18	1.80	52	69.5	0				
10	20	1.90	52	71.4	0				
	22	1.80	52	69.5	0				
	24	1.60	52	65.5	0				
	26	1.5	52	63.5	0				
	28	1.2	52	56.8	0				
Average		**1.79**	**52**	**69.1**		**1.78**	**52**	**69.1**	

Average velocity	(ft/s)	69.1
	(m/s)	21.1
Flow Rate, Qs (actual)	(cfm)	20,357
	(m3/min)	576.4
	(m3/sec)	9.61
Flow Rate, Qs (ref,dry)	(cf/sec)	350
	(m3/sec)	**9.92**

Dry Ref Flow - Actual O2	25oC	9.9	(8.5%O2)
Dry Ref Flow - 11% O2	25oC	-0.9	
	20oC	-0.9	
	0oC	-0.8	

Dry Molecular Weight

O_2	21.8	%
CO_2	1.4	%
CO	0	ppm
N_2	75.9	%
Ar	0.9	%
Md	**29.20**	

Stack Gas Moisture Content

Impinger	Final	Initial	Gain
1			23.6
2			9.9
3			4.1
4			8.5
Total	(g)		**46.1**

Volume of gas sampled

Dry Gas Meter Reading	1,000.00	ft^3
Dry gas meter temp	49	^oF
Orifice Pressure	0.5	" H_2O
Dry gas meter pressure	29.84	
Dgm correction	0.9593	
Total Volume(dry.ref)	**1,009.38**	ft^3

BWS

Volume water vapour	2.2128	ft^3
Moisture (B_{ws})	**0.013**	<assumes 100%RH at 49F

Stack Gas Velocity and Volumetric Flow Rate

Client:	Comox WWTP
Project #:	
Locations:	Blower Inlet
Date:	21-Jan-15
Time:	
stack diameter (inches):	30
Stack Area, (ft2):	4.9
Barometric Press, Pb (" Hg):	29.80
Stack Pressure, Ps (" Hg):	29.43

Pitot Coefficient, Cp:	0.79
Molar Weight Stack Gas:	29.07
Moisture, Bws (%):	1.2%
Static Pressure, Pg (" H2O):	-5

Dry Molecular Weight		
O_2	21.8	%
CO_2	1.4	%
CO	0	ppm
N_2	75.9	%
Ar	0.9	%
Md	**29.20**	

		Traverse 1				Traverse 2			
Point	**Position** (in)	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle
1	2	1.50	49	63.7	0	2.00	49	73.5	0
2	4	1.70	49	67.8	0	2.00	49	73.5	0
3	6	1.70	49	67.8	0	1.80	49	69.8	0
4	8	1.60	49	65.8	0	1.80	49	69.8	0
5	10	1.50	49	63.7	0	1.80	49	69.8	0
6	12	1.50	49	63.7	0	1.70	49	67.8	0
7	14	1.50	49	63.7	0	1.70	49	67.8	0
8	16	1.60	49	65.8	0	1.70	49	67.8	0
9	18	1.60	49	65.8	0	1.70	49	67.8	0
10	20	1.40	49	61.5	0	1.70	49	67.8	0
	22	1.20	49	57.0	0	1.70	49	67.8	0
	24	1.10	49	54.5	0	1.70	49	67.8	0
	26	1	49	52.0	0	1.7	49	67.8	0
	28	1.1	49	54.5	0	1.5	49	63.7	0
Average		**1.43**	**49**	**62.0**		**1.75**	**49**	**68.8**	

Average velocity	(ft/s)	65.4
	(m/s)	19.9
Flow Rate, Qs (actual)	(cfm)	19,248
	(m3/min)	545.1
	(m3/sec)	9.08
Flow Rate, Qs (ref,dry)	(cf/sec)	329
	(m3/sec)	**9.32**

Stack Gas Moisture Content			
Impinger	Final	Initial	Gain
1			23.6
2			9.9
3			4.1
4			8.5
Total	(g)		**46.1**

Volume of gas sampled		
Dry Gas Meter Reading	1,000.00	ft^3
Dry gas meter temp	49	^oF
Orifice Pressure	0.5	" H_2O
Dry gas meter pressure	29.84	
Dgm correction	0.9593	
Total Volume(dry.ref)	**1,009.38**	ft^3

BWS		
Volume water vapour	2.2128	ft^3
Moisture (B_{ws})	**0.012**	

<assumes 100%RH at 49F

APPENDIX B
ODOUR EVALUATION REPORT

FINAL

Odour Evaluation Report

2470 Milltower Court
Mississauga, ON
L5N 7W5

Prepared for:

John DeYoe
RWDI
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February 3, 2015

Pinchin File: 23026-012315

MEMBER OF
THE PINCHIN GROUP

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Issued on: February 3, 2015
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TABLE OF CONTENTS

APPENDICES

1.0 EVALUATION SAMPLE & TIMING SUMMARY

Pinchin Ltd. (Pinchin) was contracted to determine the detection threshold (DT), recognition threshold (RT), hedonic tone (HT) and character of air samples submitted to Pinchin's Odour Laboratory located in Mississauga, Ontario. The particulars of the odour panel were as follows:

Client Name:	RWDI
No. of Samples Delivered:	6
Date Samples Received:	January 23, 2015
Condition of the Sample Bags on Arrival:	No leaks or condensation detected.
No. of Samples Analyzed:	6
Date of Odour Panel Analysis:	January 23, 2015
Time of Odour Panel Analysis:	9:37 – 11:44 AM

2.0 METHODOLOGY

2.1 Laboratory Methodology

All samples were evaluated in accordance with the Ministry of the Environment "Ontario Source Testing Code" (OSTC), Version #3, June 2010 (Part G, Method ON-6), using an AC'SCENT International triangular forced-choice, ascending concentration, dynamic dilution Olfactometer. A listing of Standard Practices to which the evaluations conform is provided in Appendix IV.

The AC'SCENT Olfactometer was calibrated according to the manufacturer's guidelines on the day of sample evaluation. The CHEMFLUOR® PTFE tubing through which the odour sample is presented to the panellists was replaced prior to the assessment session. All sample delivery lines were purged continuously with odour free air between sample presentations.

A panel of eight trained assessors was employed in the evaluation of the odour samples. Each panel is screened for accuracy and repeatability following the procedures outlined in British Standard, BS EN 13725:2003, "Air quality – Determination of odour concentration by dynamic olfactometry", utilizing 50 ppm n-butanol calibration gas prior to sample evaluation. The geometric mean of the individual threshold estimates for 50 ppm n-butanol was determined to be between 20 and 80 ppb/v.

The odour samples were presented to the panellists using the "triangular forced-choice" method, described by ASTM E679-04, "Standard Practice for Determination of Odour and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits". Each panellist evaluated the odour by "sniffing" the diluted odour samples presented by the Olfactometer. At each dilution level, the panellist "sniffed" three sample presentations, two of which were blank, odour free samples and one that contained the odorous air. The panellist was then asked to identify which of the three presentations was different from the other two by recording a "guess", "detect" or "recognize" response as defined by ASTM E679-04.

A "guess" response was recorded when the assessor could not distinguish between any of the presentations. A "detect" response was recorded when the assessor could differentiate the odorous sample from the two blanks, and "recognize" was recorded when the assessor could identify and describe the odorous sample.

As per BS EN 13725:2003, each sample assessment began with the Olfactometer diluting the odorous sample to sub-detection levels. The odour sample and two blanks were then presented to one panellist, who "sniffed" the three presentations and recorded their response. The concentration of odorous gas was then doubled and re-presented to the same assessor with two blanks. Again, the assessor "sniffed" the three presentations and recorded their response. The process continued with the concentration of odorous gas increasing until the panellist had correctly detected the odour in at least two consecutive presentations as described by BS EN 13725:2003. The process was repeated for each panellist until all samples were evaluated.

Sample analysis was conducted "blind"; neither the panellist nor the test administrator knew which port would deliver the odour sample. Panellist's results were recorded and analyzed using AC'SCENT DataSense Olfactometry software integrated with the Olfactometer. The software incorporates an Access database program designed specifically for olfactometry laboratories and is compatible with international olfactometry standards including BS EN 13725:2003 and ASTM E679-04.

As part of laboratory Quality Assurance and Quality Control (QAQC), test results were retrospectively screened in accordance with BS EN 13725:2003. As the standard requires, each assessor's individual threshold estimate (Z_{ITE}) was compared to the panel's average threshold, with the ratio between the individual threshold estimate and the panel average threshold represented as ΔZ. Assessors having a ΔZ greater than 5.0 or lower than -5.0, were eliminated from the results. The purpose was to exclude panel members that showed deviant responses due to health factors or specific hyperosmia or anosmia for the odour of the analyzed sample. Where screening was required, both the screened and unscreened results were provided.

2.2 Odour Evaluation Parameters

2.2.1 Odour Threshold Values – Detection Threshold (DT)

The detection threshold (DT) is the dilution ratio at which 50% of the panellists correctly detected the odour. DT, as defined by ASTM E679-04, is synonymous with the MOE definition of an odour threshold value (ED_{50}) and the BS EN 13725:2003 definition of odour concentration (C_{OD}). That is, the DT represents the amount of dilution required for the odour to be just detectable. Since DT values are dimensionless, pseudo-dimensions of odour units per unit volume (i.e. odour units per cubic metre (ou/m^3)) are often used for reporting purposes.

In accordance with BS EN 13725:2003, individual threshold estimates (Z_{ITE}) were calculated as the geometric mean of the lowest dilution ratio where the odour could not be detected and the dilution ratio at which the panellist correctly detected the odour. Where a detection response could not be established at the Olfactometer's dilution limit, it was assumed that the panellist would have detected the odour at a dilution ratio half that of the limit, and the Z_{ITE} was calculated. The sample odour concentration (C_{OD}) was then calculated as the geometric mean of the Z_{ITE} values.

2.2.2 *Odour Threshold Values – Recognition Threshold (RT)*

The recognition threshold (RT), as defined by ASTM E679-04 is the dilution ratio at which the assessor first detects the odour's character (i.e. the odour "smells like…") or the dilution level at which 50% of the panellists correctly recognized the odour.

RT was evaluated following the same procedure as outlined for DT except once the assessor correctly detected the odour, the process continued with the concentration of odorous gas increasing until the panellist had correctly recognized the odour in at least two consecutive presentations. The process was repeated for each panellist until all samples were evaluated.

Calculations for RT were based on the BS EN 13725:2003 procedures for the determination of odour concentration (C_{OD}) where the individual recognition threshold estimates were calculated as the geometric mean of the lowest dilution ratio where the odour could not be recognized and the dilution ratio at which the panellist correctly recognized the odour. Where a recognition response could not be established at the Olfactometer's dilution limit, it was assumed that the panellist would have recognized the odour at a dilution ratio half that of the limit, and the individual recognition threshold estimate was calculated. The sample RT was then calculated as the geometric mean of the individual recognition threshold estimates.

2.2.3 *Hedonic Tone (HT)*

Hedonic tone (HT) is a measure of the pleasantness or unpleasantness of an odour sample and is independent of its character. Odours are commonly ranked by hedonic tone using the following 21 point scale:

+10	Most Pleasant
0	Neutral
-10	Least Pleasant

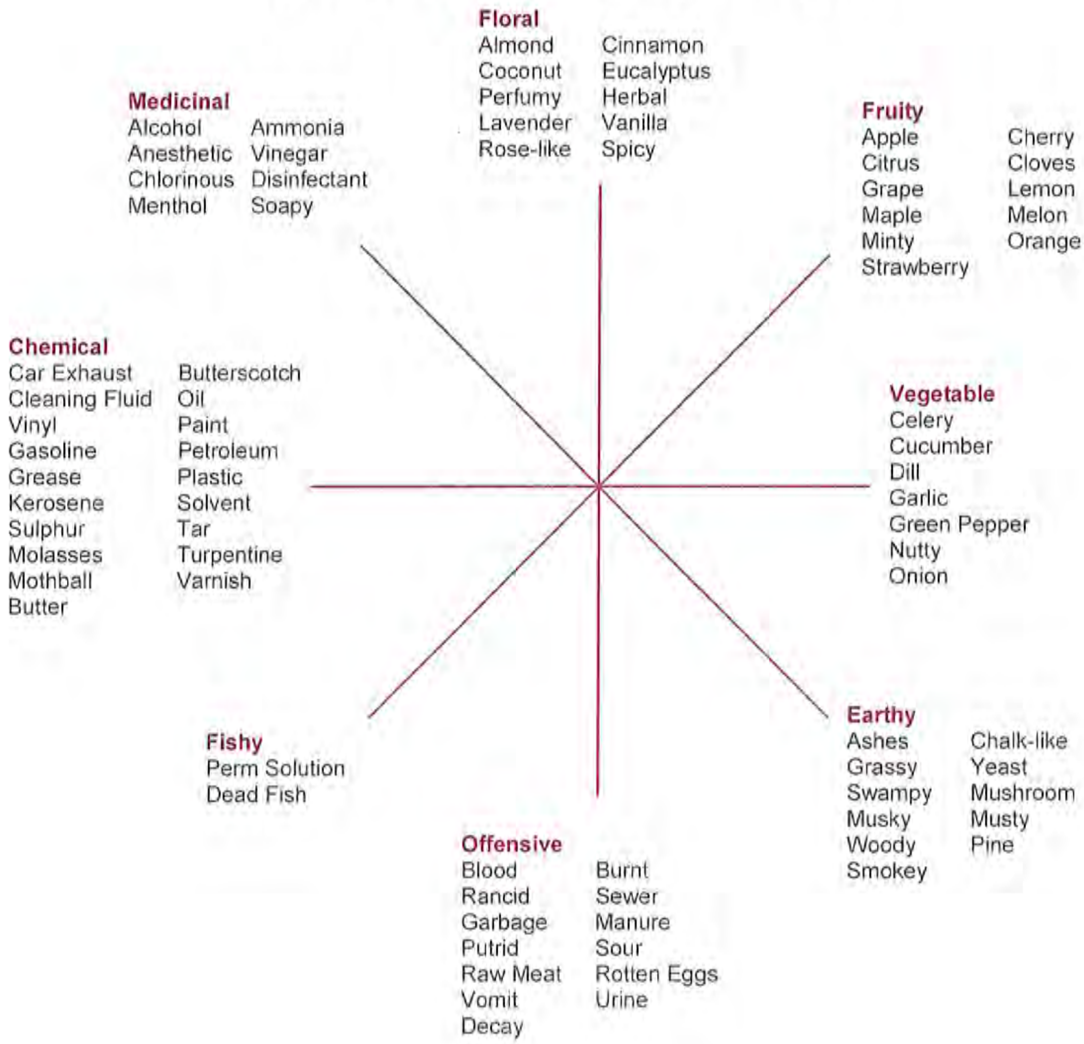
Prior to evaluating a sample for HT, each panellist was provided with a copy of an odour descriptor data collection form. For each sample requiring HT, the recognition threshold (RT) was determined by following the procedures outlined above. Once the panellist had correctly recognized the odour in two consecutive responses, the panellist was asked to mark the box corresponding to the point on the 21 point scale which best described the "pleasantness" of the odour. HT evaluation is done independently by each panellist without the consultation of the other panel members or the test administrator.

The average of the individual HT values was reported as the HT for the sample. If the panellist was unable to recognize the odour at the Olfactometer's dilution limit, that panellist was eliminated from the calculation of the sample HT.

2.2.4 Odour Character

There are numerous odour wheels available for use as a referencing vocabulary when describing an odour's character. The eight recognized odour categories include "Vegetable", "Fruity", "Floral", "Medicinal", "Chemical", "Fishy", "Offensive" and "Earthy". Each of the eight odour categories includes a list of specific descriptors to be used for further odour character analysis. The odour wheel currently used as Pinchin is shown in the figure below (Figure 1).

Figure 1: Odour Character Reference Vocabulary Wheel



Prior to evaluating a sample for odour character, each panellist was provided with a copy of an odour descriptor data collection form. For each sample requiring characterization, the recognition threshold (RT) was determined by following the procedures outlined above. If a panellist was unable to recognize the odour at the Olfactometer's dilution limit, that panellist was eliminated from odour character evaluations. Once the panellist had correctly recognized the odour in two consecutive responses, the panellist was asked to indicate which of the eight general odour categories best described the odour. In addition, the assessor was asked to mark the box corresponding to the strength of the odour within that general category. The odour strength is referred to as the relative odour intensity.

The relative odour intensity was determined using a 5 point scale. The number "1" corresponds to a mild odour and "5" corresponds to a strong odour. Assessors were given the option to choose as many general categories as required to describe the odour. The eight general odour categories were presented on a spider graph with each extension representing a scale of 0 to 5, referencing relative intensity (mild to strong). The intensity is the average of the individual intensity scores reported for that category. General odour categories showing a "0" were not used by the panellists in the odour's general character description.

Once the general odour character section was complete, the assessors were asked to indicate specific odour descriptors. Assessors were given the option to choose as many specific descriptors as required to describe the odour and to add their own descriptions as required. A histogram was used to present the percentage of assessors that assigned specific descriptors to the odour sample.

All odour character evaluation is done independently by each panellist without the consultation of the remainder of the panel or the test administrator.

3.0 RESULTS

3.1 Odour Threshold Values – Detection Threshold (DT) & Recognition Threshold (RT)

The odour threshold value results for detection threshold (DT) and recognition threshold (RT) are presented in Table 1. Where appropriate, the DT and RT values have been adjusted for field pre-dilution reported by the client. The adjusted DT and RT values are recorded as DT_{NET} and RT_{NET}, respectively. Datasheets are provided in Appendix I.

Table 1 – Odour Threshold Value Results

Odour Evaluation Results

Client: RWDI
Pinchin Project No.: 23026
Client Project No.:

Test Reference No.: 23026-012315
Evaluation Date: 23-Jan-15

Lab No.	Field Number/ Description	Dilution Factor	Evaluation Time	Detection		Recognition		Comments
				DT	DT_{NET}	RT	RT_{NET}	
PO15-23026-J1395	OUT1	4.5 :1	9:37 - 9:57 AM	721	3245	279	1256	
PO15-23026-J1396	OUT2	4.5 :1	9:58 - 10:18 AM	663	2984	332	1494	
PO15-23026-J1397	OUT3	4.5 :1	10:19 - 10:34 AM	935	4208	430	1935	
PO15-23026-J1398	IN1	5.2 :1	10:36 - 10:58 AM	1114	5793	511	2657	
PO15-23026-J1399	IN2	5.2 :1	11:01 - 11:21 AM	1020	5304	468	2434	
PO15-23026-J1400	IN3	5.2 :1	11:24 - 11:44 AM	1324	6885	468	2434	

DT_{NET} - Results have been adjusted for field dilution
RT_{NET} - Results have been adjusted for field dilution
Presentation Flow Rate = 20 litres per minute

Odour Evaluation Report Nomenclature

DT Detection Threshold
RT Recognition Threshold
DT_{NET} Detection Threshold adjusted for field dilution
RT_{NET} Recognition Threshold adjusted for field dilution

3.2 Hedonic Tone (HT) & Odour Character

The hedonic tone (HT) values are presented in Table 2. The relative odour intensities and corresponding general odour character for each sample are represented in the spider graphs attached as Appendix II.

Specific descriptors were the second part of the odour character evaluation. The histograms found in Appendix III present the percentage of assessors that assigned specific descriptors to the odour sample. The results summary is provided in Table 2.

Table 2 – Hedonic Tone & Odour Character Results

Odour Characterization Results

Client:	**RWDI**	**Test Reference No.:**	**23026-012315**
Pinchin Project No.:	23026	**Evaluation Date:**	**23-Jan-15**
Client Project No.:		**Evaluation Time:**	**9:37 - 11:44 AM**

Lab No.	Field No. Description	Average HT	Range HT	Primary Descriptor	Specific Descriptors[1]
PO15-23026-J1395	OUT1	-2	-8 to 3	Offensive	Car exhaust, earthy, **garbage**, kerosene, **offensive**, putrid, sewer, smoky, swampy.
PO15-23026-J1396	OUT2	-3	-7 to 2	Offensive	Burnt, earthy, **garbage**, offensive, rancid, sewer, swampy.
PO15-23026-J1397	OUT3	-3	-10 to 3	Offensive	Earthy, garbage, **offensive**, rancid, raw meat, sewer, swampy, vomit.
PO15-23026-J1398	IN1	-3	-10 to 4	Offensive	Earthy, **garbage**, offensive, onion, rancid, **sewer**, smoky, sour, swampy, vomit.
PO15-23026-J1399	IN2	-2	-8 to 3	Offensive	Apple, earthy, fruity, **garbage**, musky, musty, offensive, onion, rancid, sewer, swampy, vegetable.
PO15-23026-J1400	IN3	-2	-6 to 4	Offensive	Earthy, fruity, **garbage**, manure, melon, mushroom, musty, offensive, rancid, **sewer**, sour.

Odour Evaluation Report Nomenclature

HT Hedonic Tone

Note 1 – The most commonly selected specific descriptor(s) for a sample are presented in **Bold**.

23026-012315 RWDI Odour Lab Report

Template: 14852 – Report Template for Recognition Threshold & Characterization - September 19, 2014

APPENDIX I

Odour Evaluation Data Sheets

Pinchin File: 23026-012315

(6 Pages)

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1395 **Field No. :** OUT1

Description : 4.5:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : Unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1						2	1	1	1	6	8	8			2.26	2.26	1.96
00001	1						1	1	6	6	8	8				2.86	2.86	2.26
14853-668	1						1	1	6	8	8					2.86	2.86	2.56
14853-917	1						2	1	6	6	8	8				2.86	2.86	2.26
14853-671	1						1	6	8	8						3.16	3.16	2.86
14853-719	1						1	6	8	8						3.16	3.16	2.86
000100	1						1	2	6	8	8					3.16	2.86	2.56
14853-787	1						2	1	6	6	8	8				2.86	2.86	2.26

Sample Comments :

Specific Chemical Concentration Data

Chemical : n/a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	2.90	2.86	2.45
Std. Dev.	0.30	0.28	0.32
Threshold	787	721	279

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1396 **Field No. :** OUT2

Description : 4.5:1

Sampling Date : 1/22/2015
Sampling Time :
Sample Collector : RWDI
Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14		Calibration Date :	
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2		1/23/2015	
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150		THRESHOLDS	
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0		G = Guess	
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3		D = Detection	
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05		R = Recognition	
Assessor/Round															**Log G**	**Log D**	**Log R**
14853-665 1						2	5	5	5	6	8	8			2.26	2.26	1.96
00001 1						2	6	8	8						3.46	3.16	2.86
14853-668 1						1	8	8							3.16	3.16	3.16
14853-917 1						2	2	6	8	8					3.46	2.86	2.56
14853-671 1						2	5	6	8	8					2.86	2.86	2.56
14853-719 1						2	1	6	8	8					2.86	2.86	2.56
000100 1						1	2	1	1	6	8	8			2.26	2.26	1.96
14853-787 1						1	6	6	8	8					3.16	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	2.93	2.82	2.52
Std. Dev.	0.47	0.37	0.41
Threshold	860	663	332

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1397 **Field No. :** OUT3

Description : 4.5:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : unknown

Dilution Level		1	2	3	4	5	6	7	8	9	10	11	12	13	14			
Sample Volume		0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2	Calibration Date : 1/23/2015		
Total Volume		20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	THRESHOLDS		
Dilution Ratio		65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0	G = Guess		
Geometric Mean		91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3	D = Detection		
Log (Geo. Mean)		4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05	R = Recognition		
Assessor/Round																Log G	Log D	Log R
14853-665	1						2	2	6	8	8					3.46	2.86	2.56
00001	1						1	6	8	8						3.16	3.16	2.86
14853-668	1						1	6	8	8						3.16	3.16	2.86
14853-917	1						1	2	6	8	8					3.16	2.86	2.56
14853-671	1						1	6	8	8						3.16	3.16	2.86
14853-719	1						1	2	6	8	8					3.16	2.86	2.56
000100	1						1	1	1	6	8	8				2.56	2.56	2.26
14853-787	1						2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.16	2.97	2.63
Std. Dev.	0.28	0.22	0.21
Threshold	1,445	935	430

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1398 **Field No. :** IN1 **Sampling Date :** 1/22/2015

Sampling Time :

Description : 5.2:1 **Sample Collector :** RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1					2	1	6	8	8						3.16	3.16	2.86
00001	1					2	2	1	6	8	8					2.86	2.86	2.56
14853-668	1					1	6	8	8							3.46	3.46	3.16
14853-917	1					2	2	6	8	8						3.76	3.16	2.86
14853-671	1					2	6	8	8							3.76	3.46	3.16
14853-719	1					2	6	5	1	8	8					2.56	2.56	2.56
000100	1					1	1	2	2	6	6	8	8			3.16	2.56	1.96
14853-787	1					1	2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.27	3.05	2.71
Std. Dev.	0.42	0.36	0.39
Threshold	1,869	1,114	511

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1399 **Field No. :** IN2

Description : 5.2:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1					1	1	2	6	8	8					3.16	2.86	2.56
00001	1					1	1	6	8	8						3.16	3.16	2.86
14853-668	1					1	1	6	8	8						3.16	3.16	2.86
14853-917	1					1	2	6	8	8						3.46	3.16	2.86
14853-671	1					1	6	5	8	8						2.86	2.86	2.86
14853-719	1					1	2	6	8	8						3.46	3.16	2.86
000100	1					1	2	2	2	6	8	8				3.46	2.56	2.26
14853-787	1					1	2	6	6	6	8	8				3.46	3.16	2.26

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.27	3.01	2.67
Std. Dev.	0.22	0.23	0.27
Threshold	1,872	1,020	468

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1400 **Field No. :** IN3 **Sampling Date :** 1/22/2015

Sampling Time :

Description : 5.2:1

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Calibration Date : 1/23/2015		
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2			
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	THRESHOLDS		
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0	G = Guess		
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3	D = Detection		
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05	R = Recognition		
Assessor/Round															**Log G**	**Log D**	**Log R**
14853-665 1					2	1	2	6	8	8					3.16	2.86	2.56
00001 1					1	6	6	8	8						3.46	3.46	2.86
14853-668 1					1	1	6	8	8						3.16	3.16	2.86
14853-917 1					2	1	6	8	8						3.16	3.16	2.86
14853-671 1					1	6	6	8	8						3.46	3.46	2.86
14853-719 1					2	1	6	8	8						3.16	3.16	2.86
000100 1					2	1	1	1	6	6	8	8			2.56	2.56	1.96
14853-787 1					1	2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.20	3.12	2.67
Std. Dev.	0.30	0.30	0.32
Threshold	1,575	1,324	468

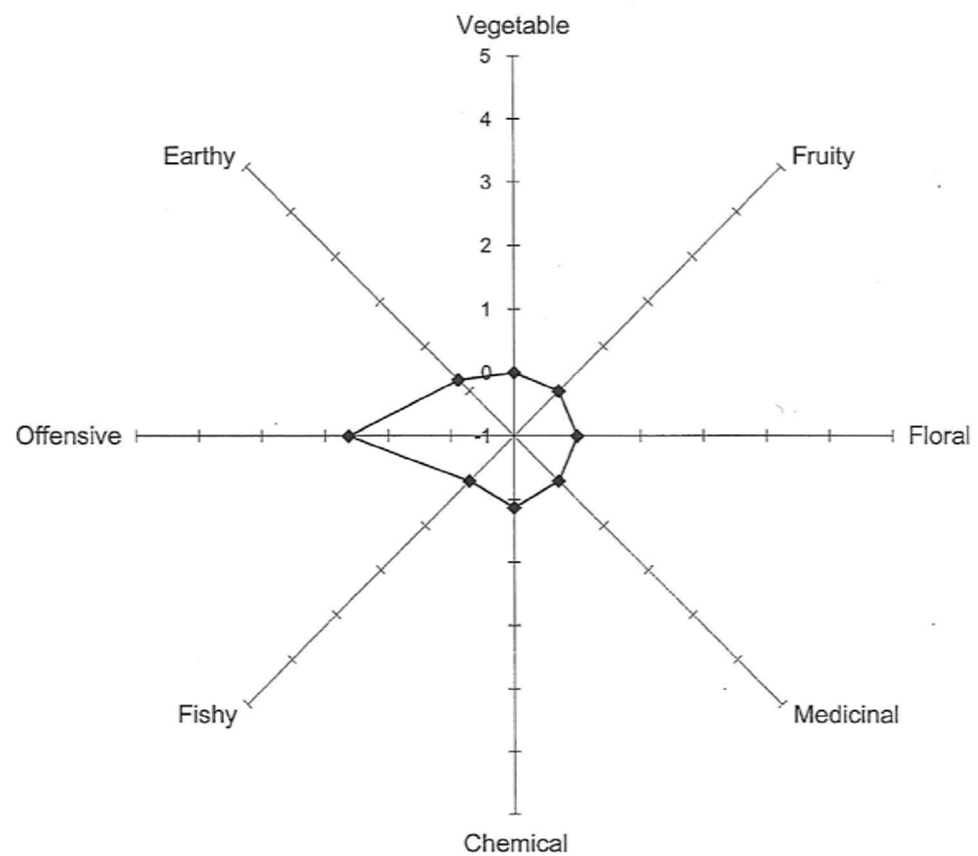
APPENDIX II

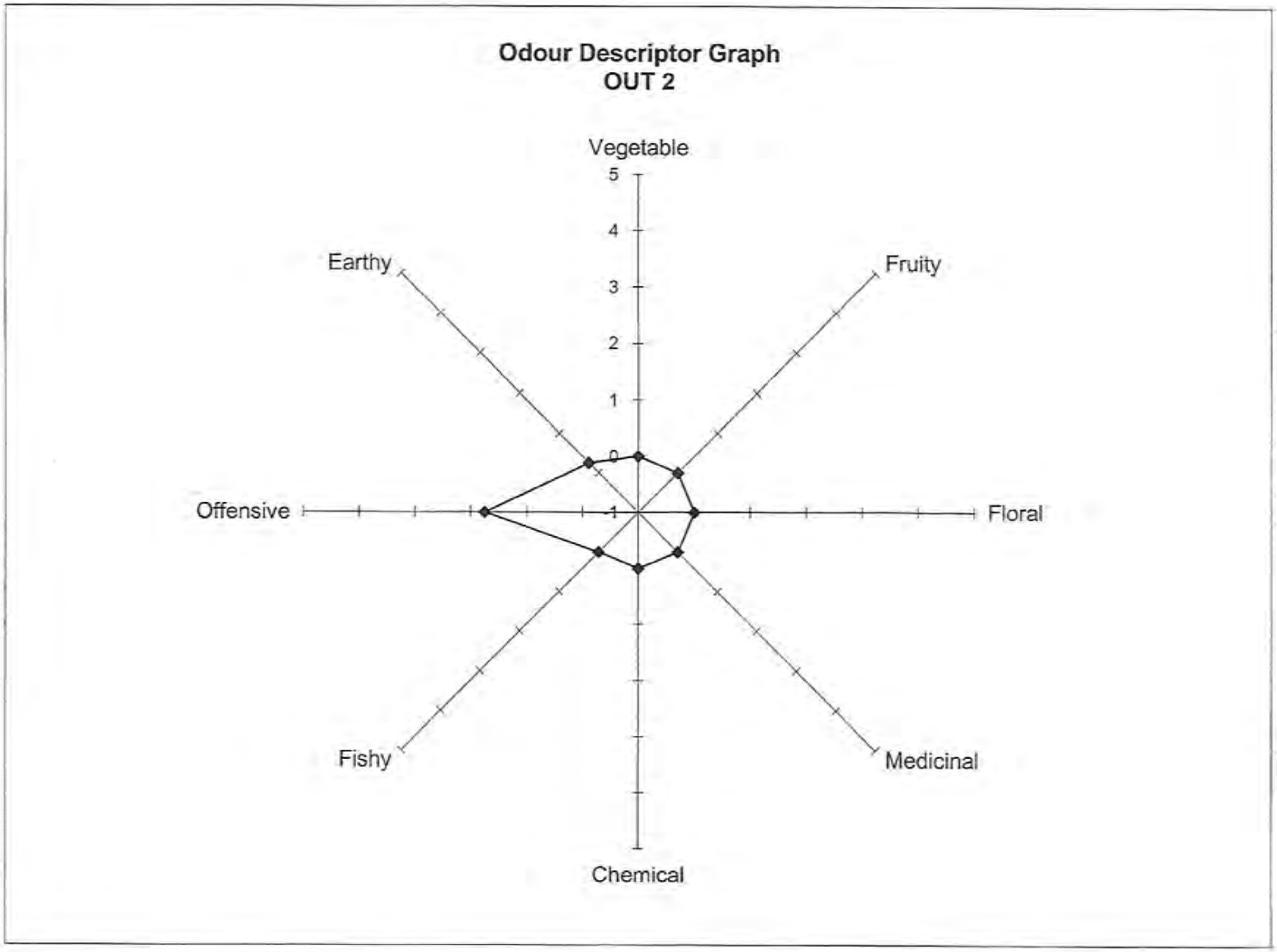
Relative Odour Intensity Spider Graphs

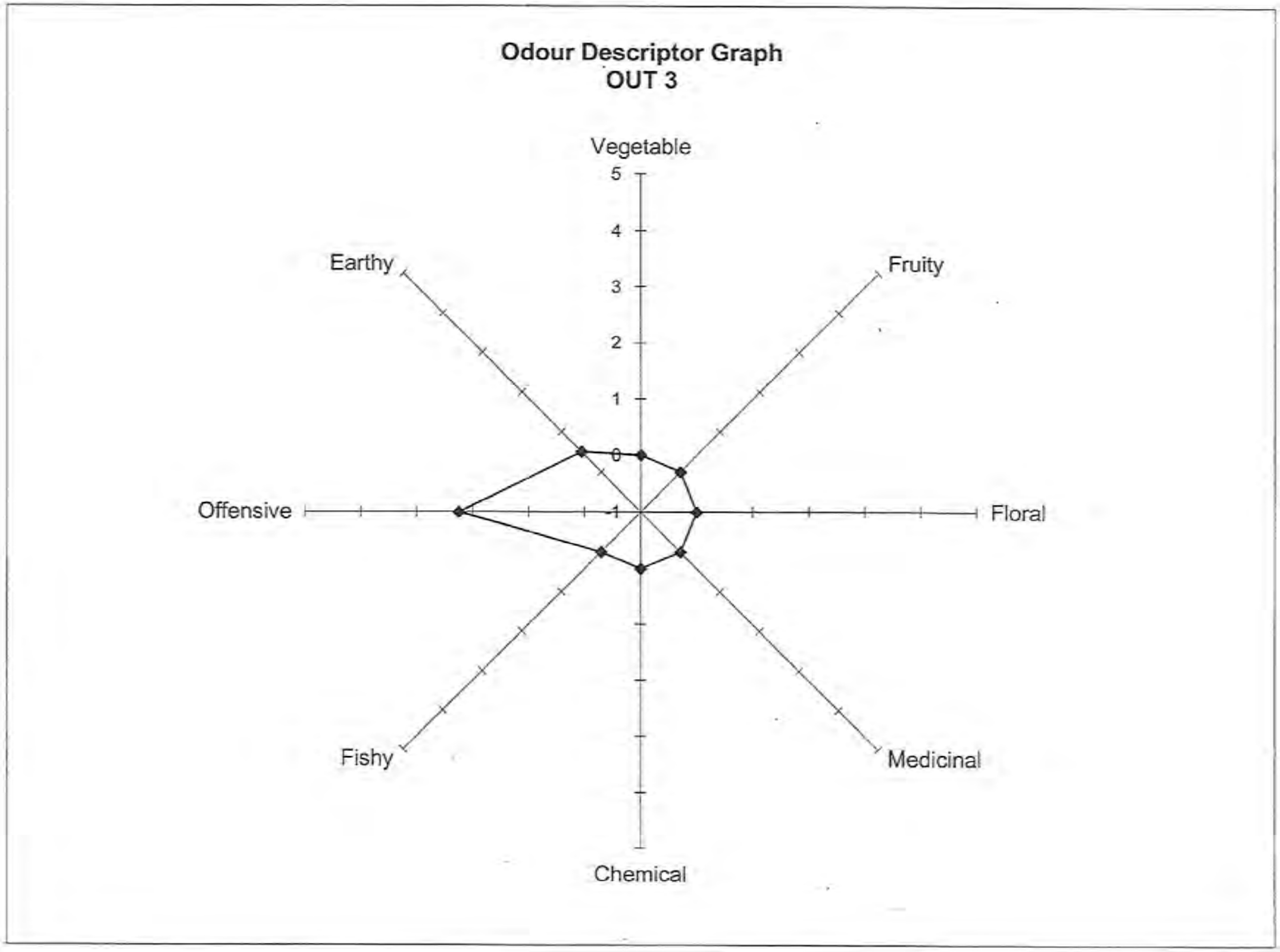
Pinchin File: 23026-012315

(6 Pages)

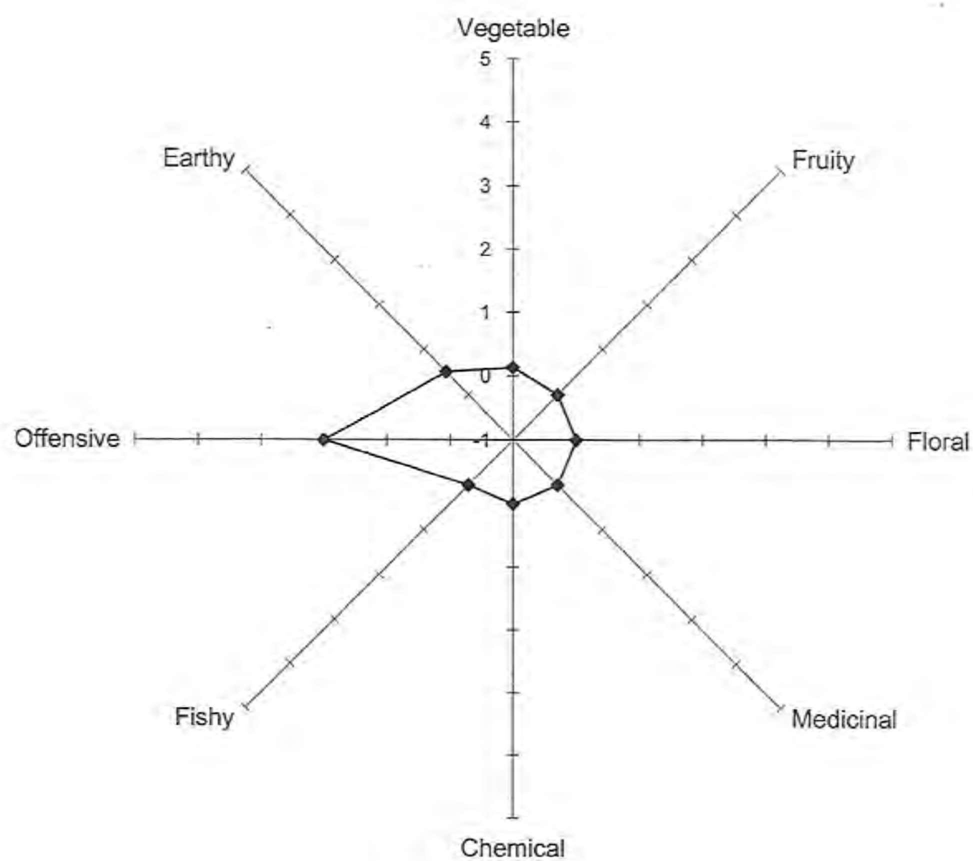
Odour Descriptor Graph
Out 1

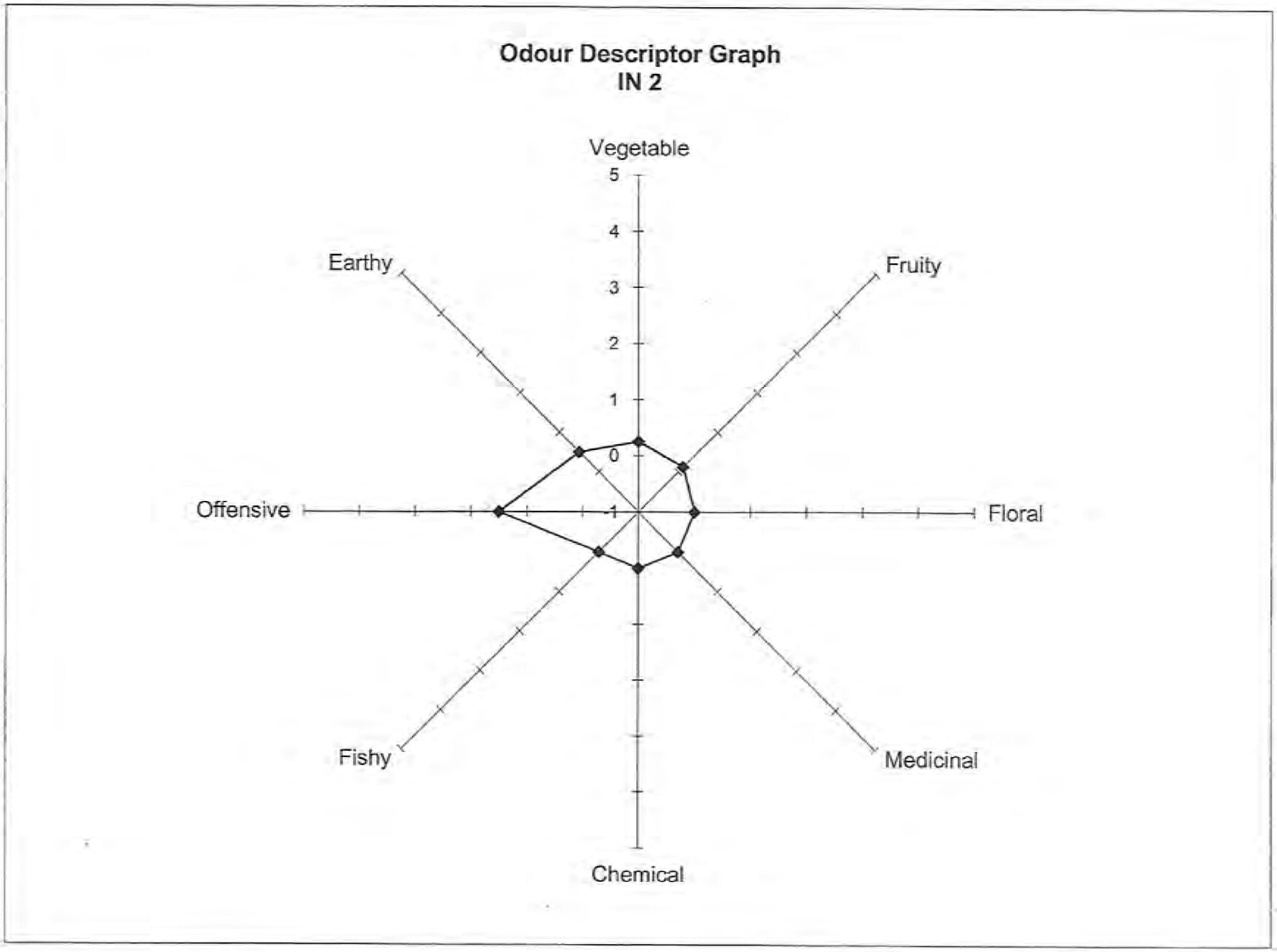



Odour Descriptor Graph
OUT 2
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy

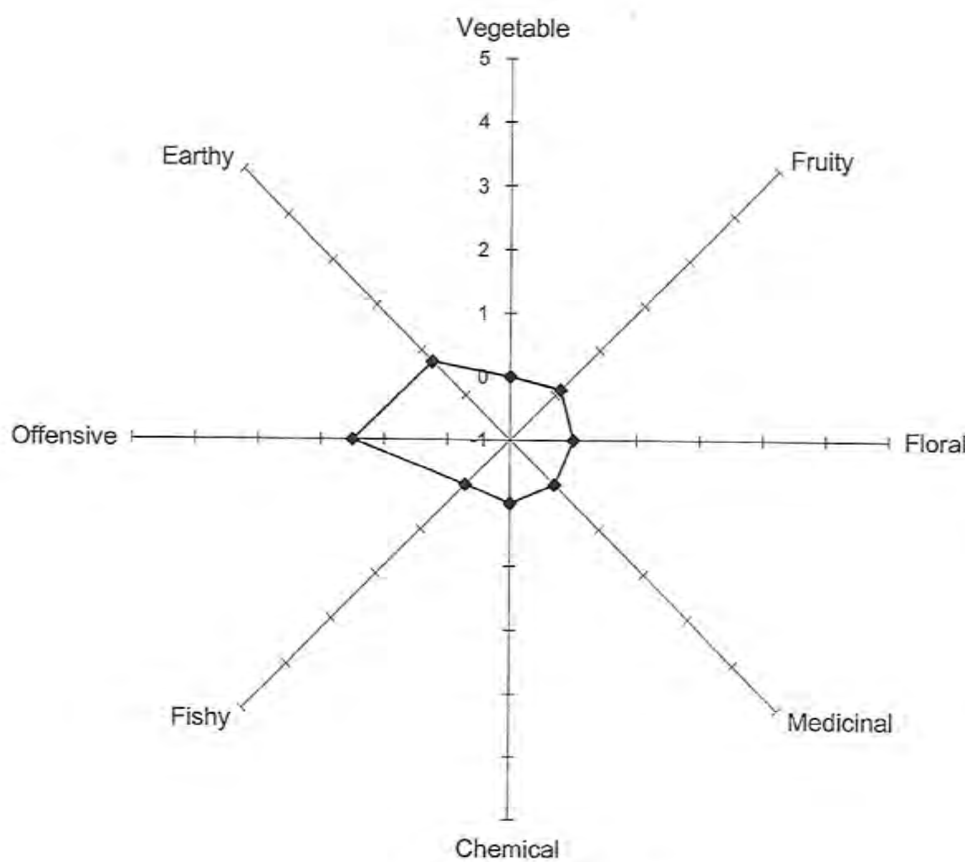

Odour Descriptor Graph
OUT 3
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy

Odour Descriptor Graph
IN 1




Odour Descriptor Graph
IN 2
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy

Odour Descriptor Graph
IN 3



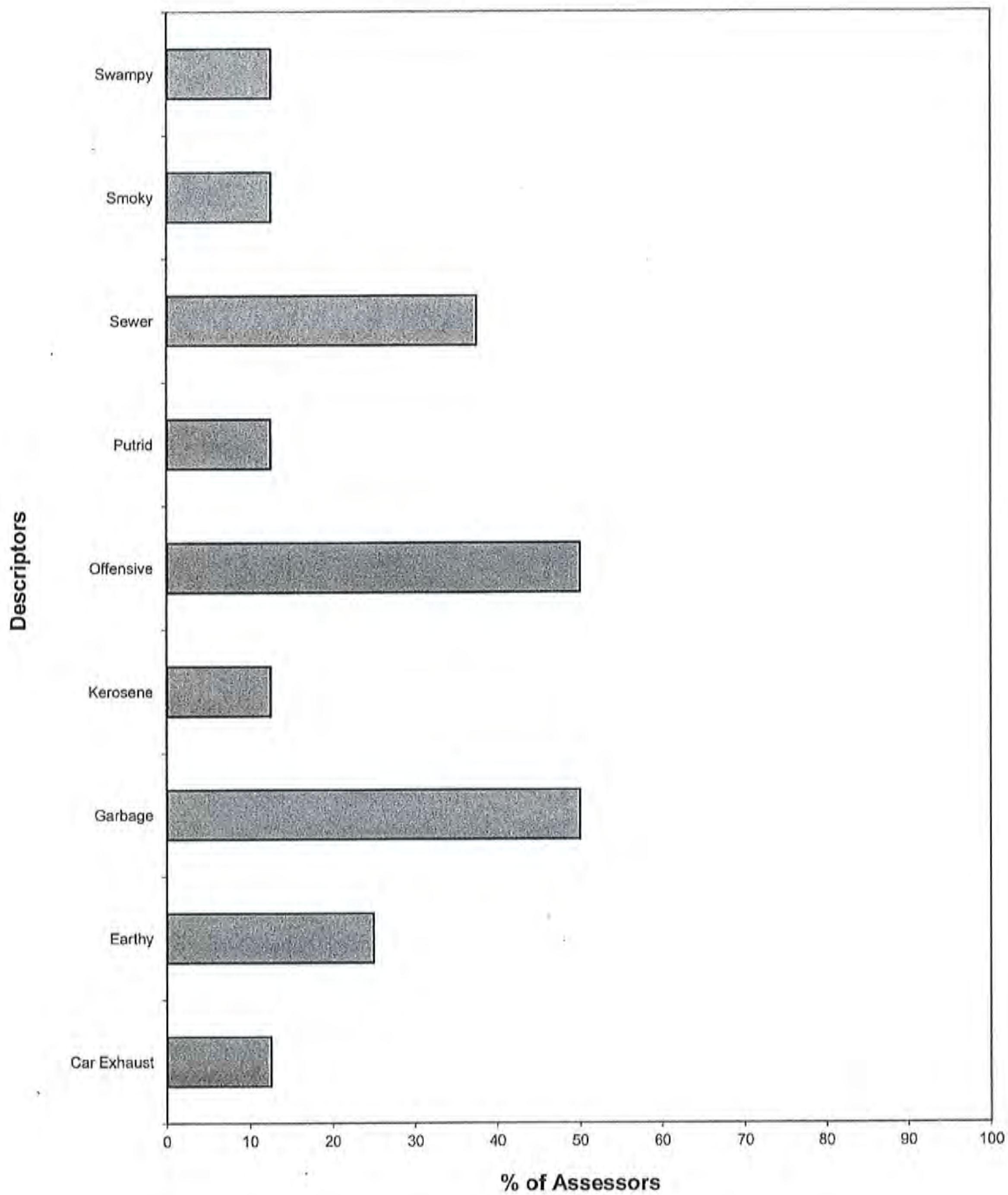
APPENDIX III

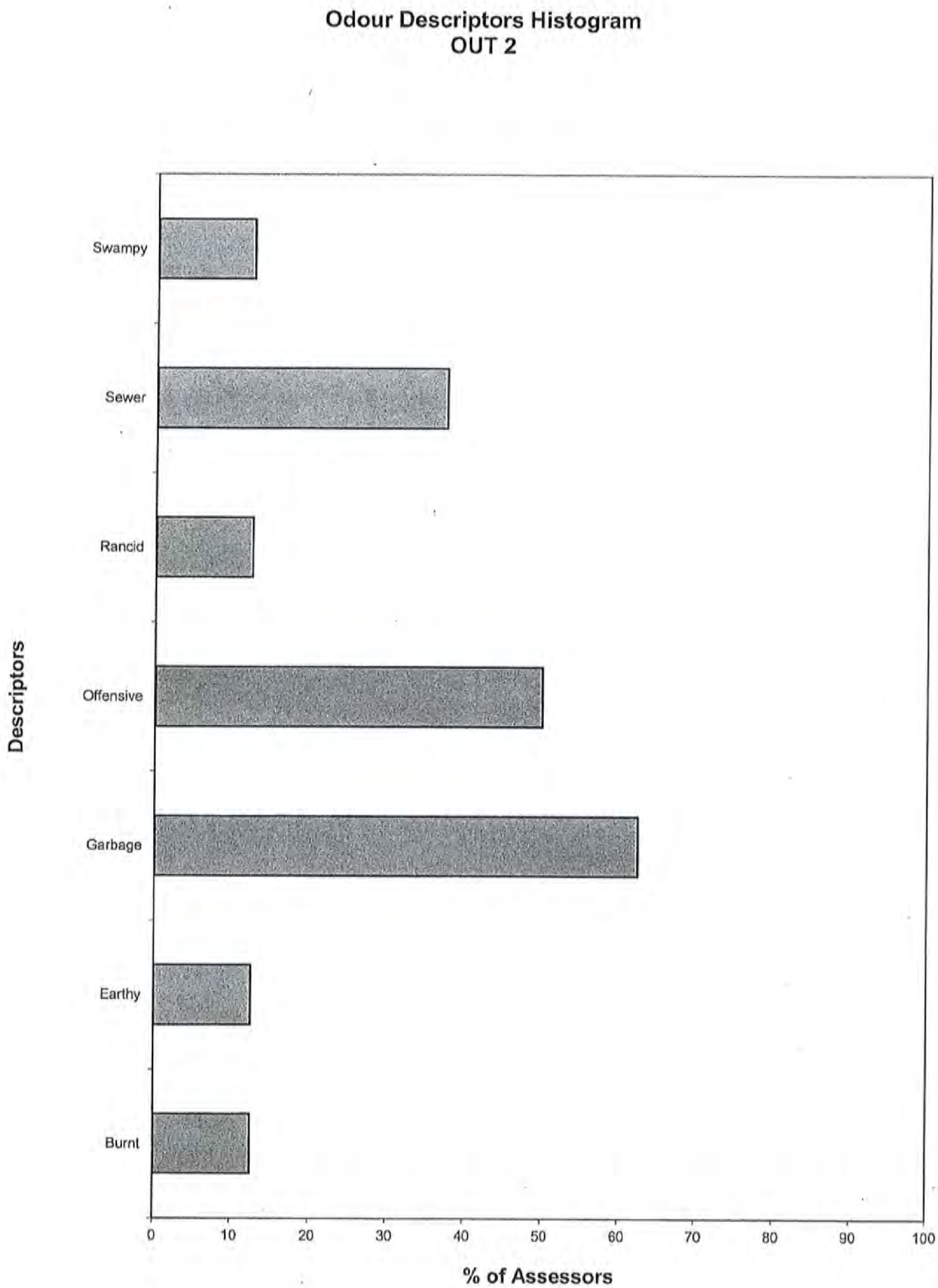
Specific Descriptor Histograms

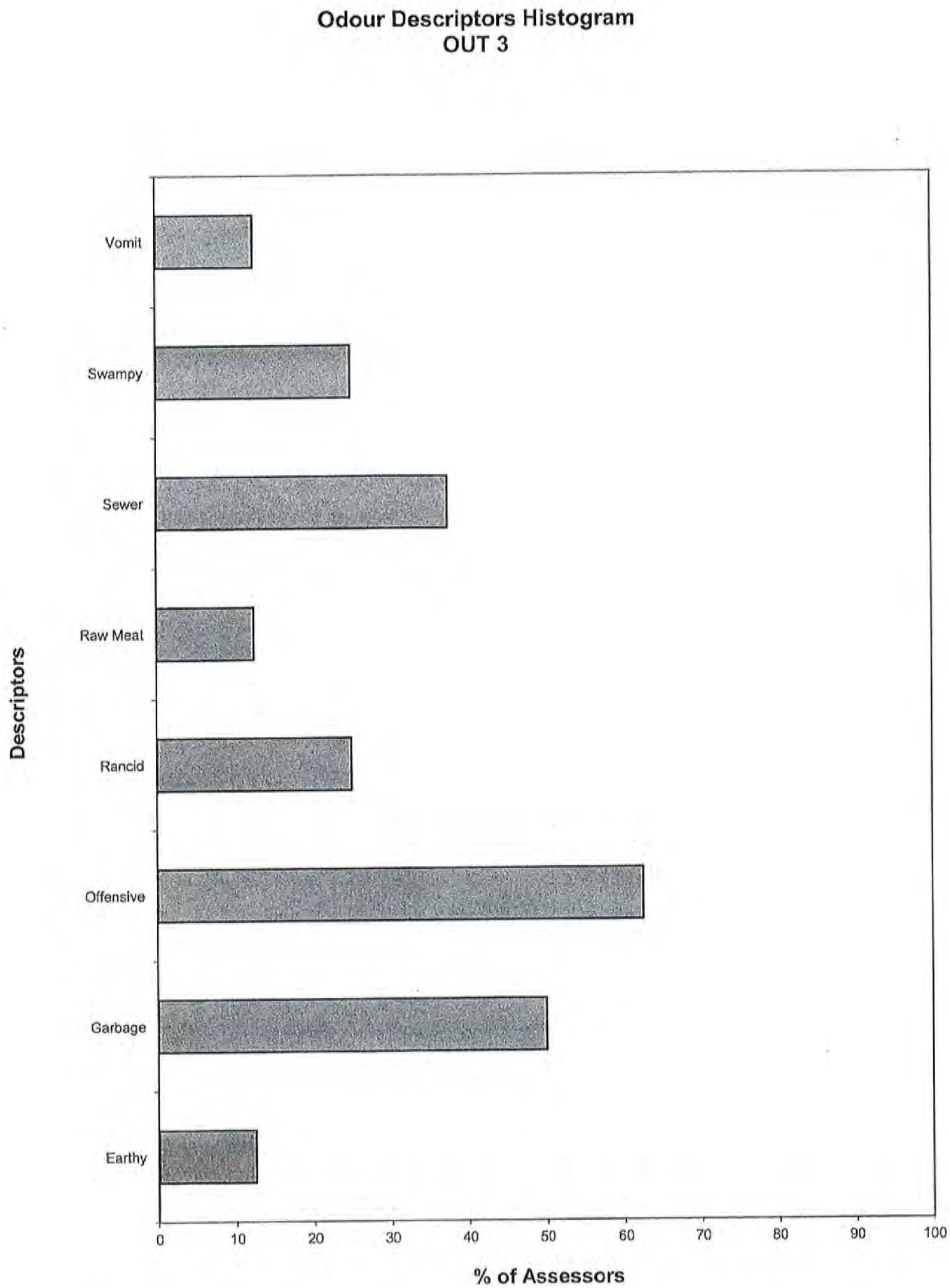
Pinchin File: 23026-012315

(6 Pages)

Odour Descriptors Histogram
Out 1

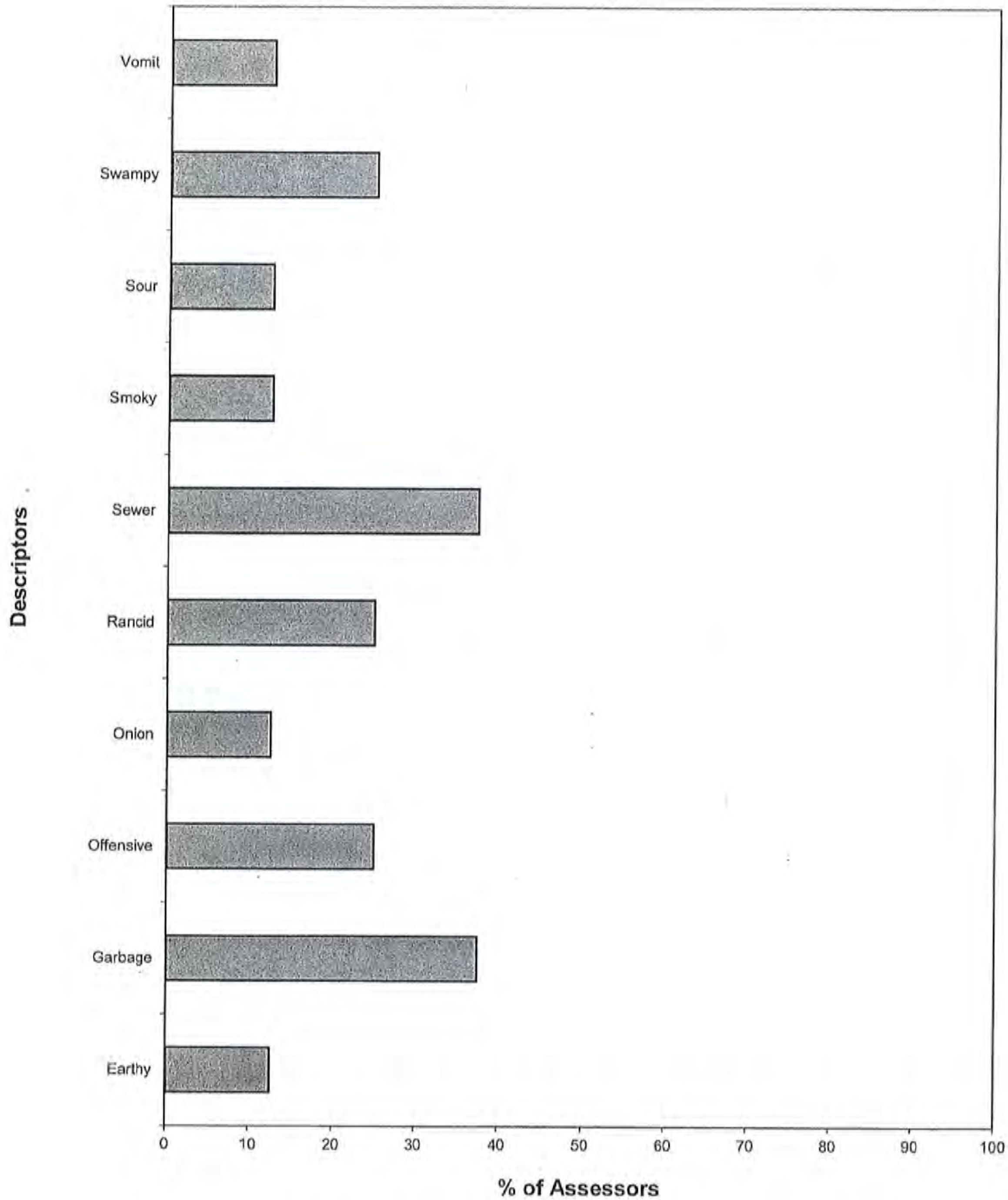



Odour Descriptors Histogram
OUT 2
Swampy
Sewer
Rancid
Offensive
Garbage
Earthy
Burnt
Descriptors
0
10
20
30
40
50
60
70
80
90
100
% of Assessors

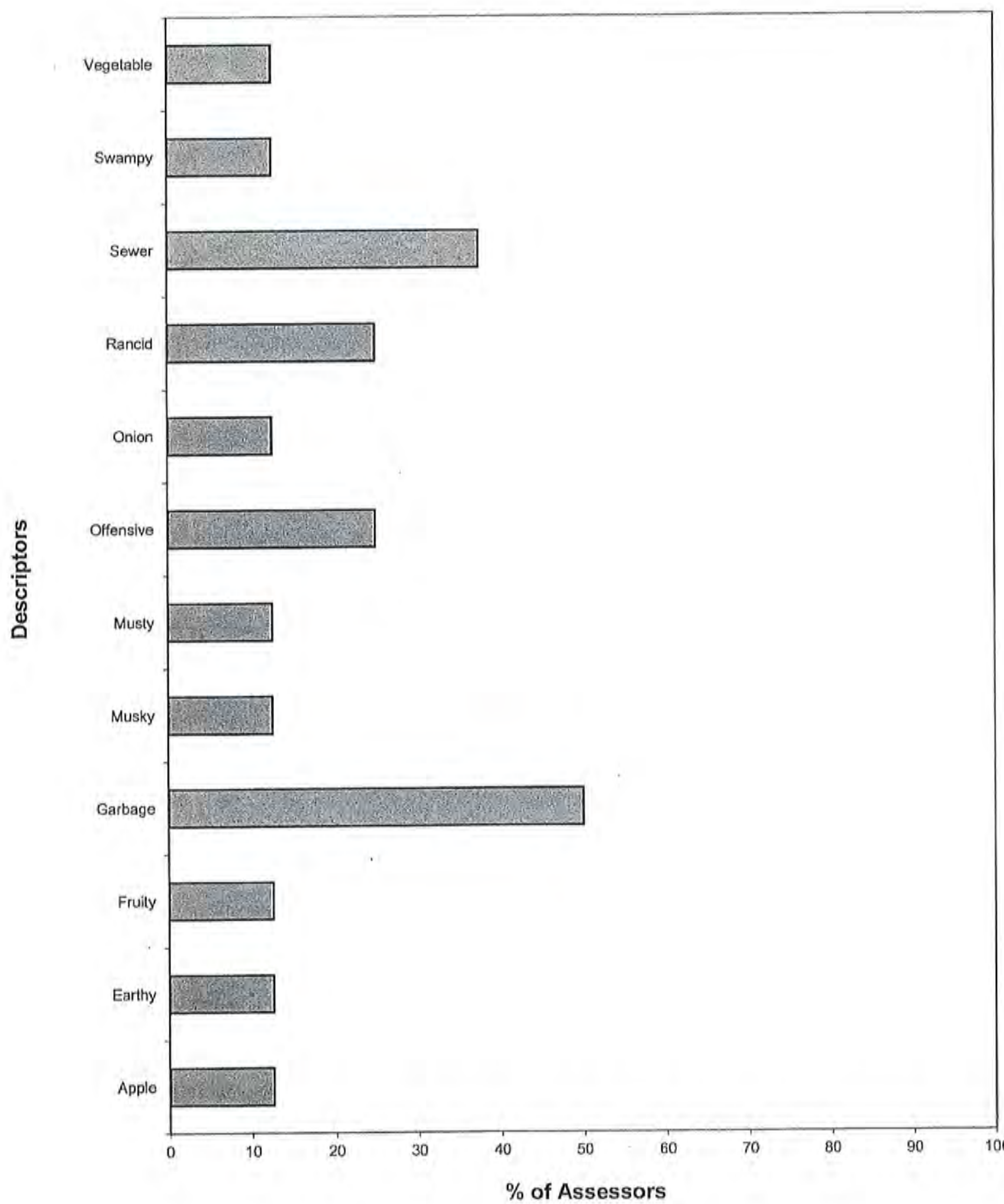


Odour Descriptors Histogram
OUT 3
Descriptors
Vomit
Swampy
Sewer
Raw Meat
Rancid
Offensive
Garbage
Earthy
0
10
20
30
40
50
60
70
80
90
100
% of Assessors

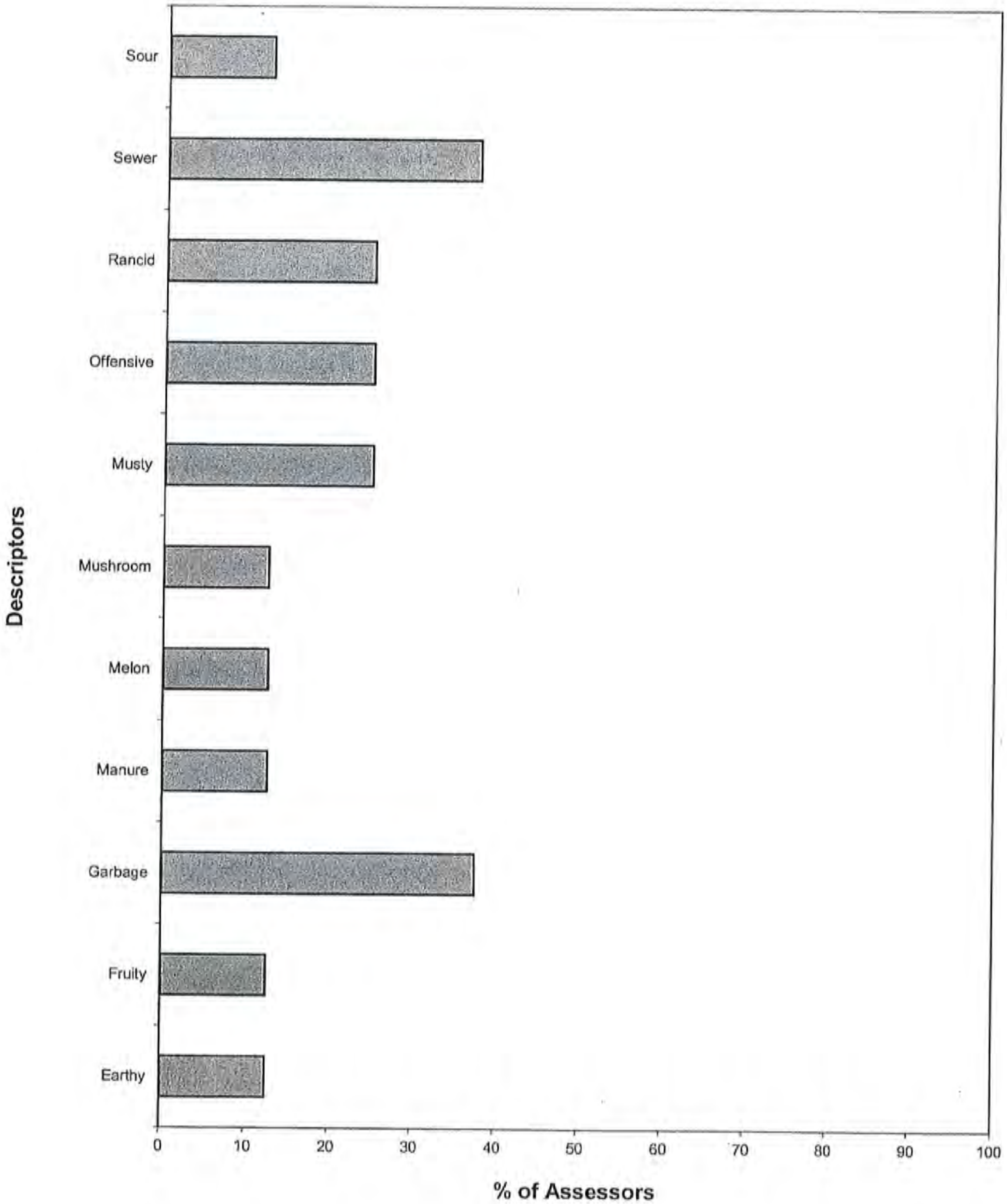
Odour Descriptors Histogram
IN 1



Odour Descriptors Histogram
IN 2



Odour Descriptors Histogram
IN 3



APPENDIX IV

Odour Evaluation Quality Assurance

Pinchin File: 23026-012315

(1 Page)

ODOUR EVALUATION QUALITY ASSURANCE

- Odour evaluations conducted at the Pinchin Odour Laboratory conform to the procedures outlined in the Ministry of the Environment "Ontario Source Testing Code" (OSTC), Version #3, June 2010 (Part G, Method ON-6) and are in accordance with ASTM (American Society for Testing and Materials) Standard Practice E679-04, Determination of Odour and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits.
- The AC'SCENT® Dynamic Dilution Forced-Choice Triangle Olfactometer complies with all aspects of the ASTM E679-04 standard as well as the operational requirements of the British Standard, BS EN 13725:2003, "Air quality – Determination of odour concentration by dynamic olfactometry".
- The detection threshold values are reported as defined by ASTM E679-04 and BS EN 13725:2003.
- Assessors are selected and trained in accordance with BS EN 13725:2003.
- The Pinchin Odour Laboratory is managed based on the requirements of the International Organization for Standardization (ISO) International Standard ISO 17025:2005, "General requirements for the competence of testing and calibration laboratories".
- Samples are consumed during the evaluation and all sample bags are destroyed 48 hours after transmittal of the Preliminary Odour Evaluation Results, unless otherwise specified.

APPENDIX C

ODOUR MONITORING PROTOCOL

ODOUR MONITORING PROTOCOL

Based on discussions with the Comox Valley Regional District (The Region), RWDI has developed a community odour monitoring protocol for the Comox Valley Water Pollution Control Centre (the facility). As part of the on-going odour improvement, an on-going method to evaluate odour impacts in the community is required.

In the interest of developing an impartial and transparent evaluation method, it is suggested that a pool of observers be compiled from members of the community liaison committee (CLC) and from Region's staff – though not individuals that actually work at the facility. Each survey will be completed by one community member and one member of the Region staff. The two observers will travel together and make observations in the same place at the same time. It is suggested that four observers from each group be selected so that there is a reasonable chance that an observer from the CLC and the Region will always be available.

Each of the proposed observers will undergo odour detection threshold testing in accordance with ASTM E679-91 using n-butanol as the odour standard. Each individual will be tested to determine the range they can detect the n-butanol sample to determine whether or not the individuals are with the acceptable normal range (detection at concentrations between 1.3 to 5.0 ppm). If the observers are not in this range then alternate observers will be selected. The certification is valid for a 1 year period.

The observations will be made once per calendar month and will be completed either between 9:00 am and 10:00 am or between 6:00 pm and 7:00 pm. The observations should be made during periods of fairly light winds, i.e. less than 10 km/h. The survey cannot be completed during heavy rain, though periods of light mist are acceptable. It is suggested that the monthly survey be scheduled for the second Monday of the month with several alternate times during that week in case of inclement weather or observer unavailability.

In addition to the regularly scheduled times, a series of three surveys should be completed when there are more complaints than usual are received in the course of a week, unless the complaints can be explained as a plant upset that has been remedied.

Observations should be made at points contained within the attached map figure. The individual surveys do not need to include every point. Only those points generally downwind from the facility on the survey day should be included. The survey should begin with the downwind points furthest away and travel towards the points closest to the facility. Each observer should take a new map for every survey and the time date and approximate wind angle on the observation day. If the wind shifts during sampling, it is acceptable to show more than one arrow.

The observations should be recorded on a copy of the attached table. Each observer should each have a fresh copy of the table whenever they complete a survey. The survey should be turned into the CVRD staff to compile the results. It may be advisable to scan and email the individual results to the CLC when the sheets are turned over.

The observers should make a note of the wind direction recorded by Environment Canada at the Comox airport just prior to the survey http://weather.gc.ca/city/pages/bc-61_metric_e.html They should begin at the point that is farthest downwind and record their observations. They should then proceed to points either side of the downwind line and record their observations and generally work their way towards the facility.

The observers should record their name, the date and general weather observations at the top of the form. At each of the observation points they should record the point number, the time of day, any relevant notes and the odour ranking number.

The odour ranking number is a scale to describe the intensity of odour, based on an odour intensity scale. This scale is described below:

0 - no odour

1 - odour just detectable

2 - distinct and definite odour

3 - strong and objectionable enough to cause a person to attempt to avoid it after a period of exposure

4 - so powerful to be offensive and repulsive and bordering on being intolerable

5 - overpowering, nauseating, intolerable odour.

Once the data is collected the CVRD personnel assembling the data should compile the data on an annual basis. In addition, the sheets should be reviewed when they come in. If unusual results are seen on any particular survey it may be prudent to investigate whether there were any upset conditions at the facility or whether it would be prudent to repeat the survey.

Appendix C Table

COMOX WPCC ODOUR SURVEY LOG

Date:___________________ **Name:**___________________________

Wind Speed and direction:______________ **Weather:**_________________________
(i.e., Cloudy, sunny, mist, fog etc.)

Location Number	Time	Odour Intensity #	Notes:

Notes: ____

____

____

Odour Intensity Numbers

0 - no odour

1 - odour just detectable

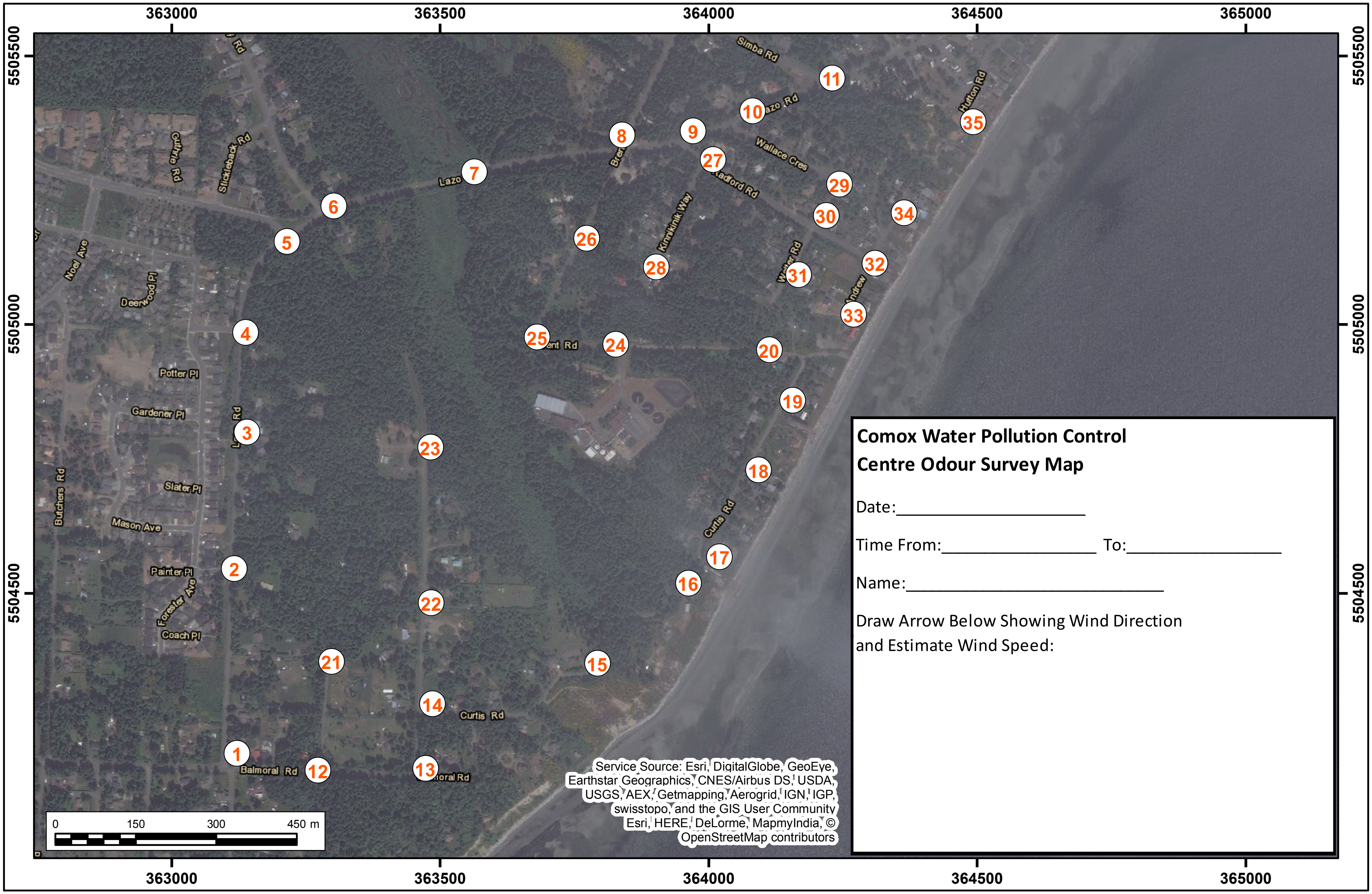
2 - distinct and definite odour

3 - strong and objectionable enough to cause a person to attempt to avoid it after a period of exposure

4 - so powerful to be offensive and repulsive and bordering on being intolerable

5 - overpowering, nauseating, intolerable odour.

Appendix C Figure



Comox Water Pollution Control Centre Odour Survey Map

Date:______________________

Time From:_________________ To:_________________

Name:______________________________

Draw Arrow Below Showing Wind Direction and Estimate Wind Speed:

Odour Survey Map for Observers

Map Projection: NAD 1983 UTM Zone 10N

True North

Drawn by: NBN	Figure: C-1	
Approx. Scale:	1:10,000	
Date Revised:	June 2, 2015	

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

APPENDIX D

ODOUR SURVEY RESULTS SUMMARY

Tel: 604.730.5688
Fax: 604.730.2915

RWDI AIR Inc.
830 – 999 West Broadway
Vancouver, BC, Canada
V5Z 1K5
Email: solutions@rwdi.com

CONSULTING ENGINEERS & SCIENTISTS

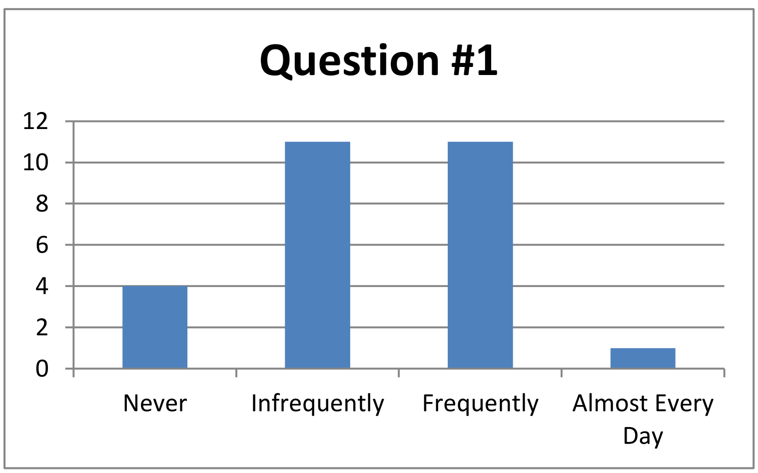
ODOUR SURVEY ATTACHMENT

As part of the community consultation process the Comox Valley Regional District conducted a mail survey regarding odours from the Comox Valley Water Pollution Control Centre. The purpose of the survey was twofold. Firstly it was an assessment of odour impacts from the facility in terms of frequency, seasonality, intensity etc. Secondly it was to gauge the level of concern in the area surrounding the plant.

There were a total of 85 surveys mailed out to residents who live near the plant. A total of 27 surveys were filled out and returned. The results are included in this attachment. Where individuals gave multiple responses to the same question the responses were weighted proportionally. Where individuals did not respond

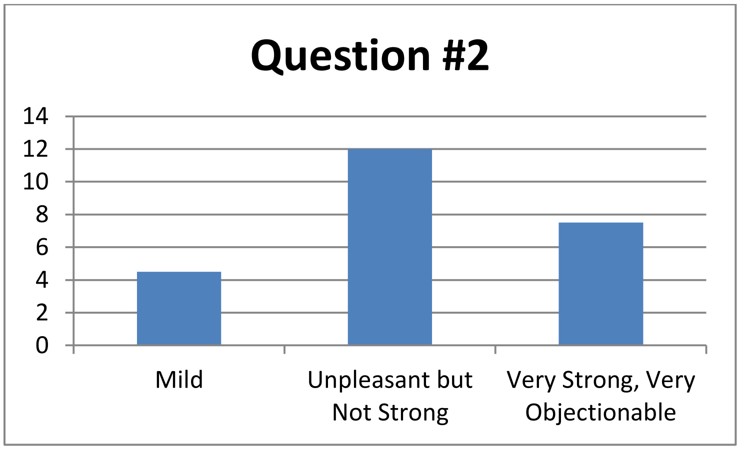
SURVEY RESULTS

1) **How often do you detect odours from the plant?**



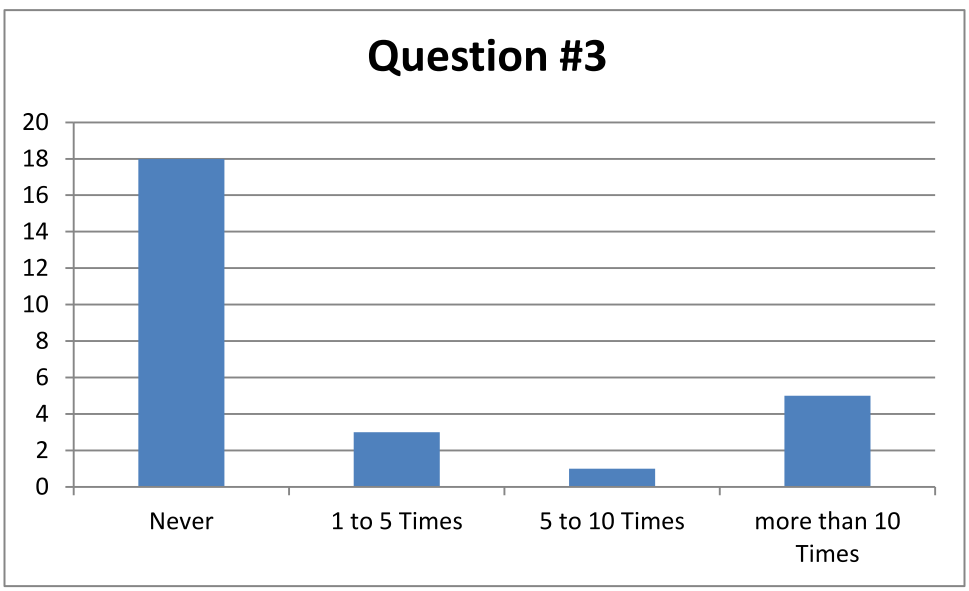
Roughly half the respondents experience odours from the facility frequently.

2) When you detect odours from the plant, how would you rate the odour?



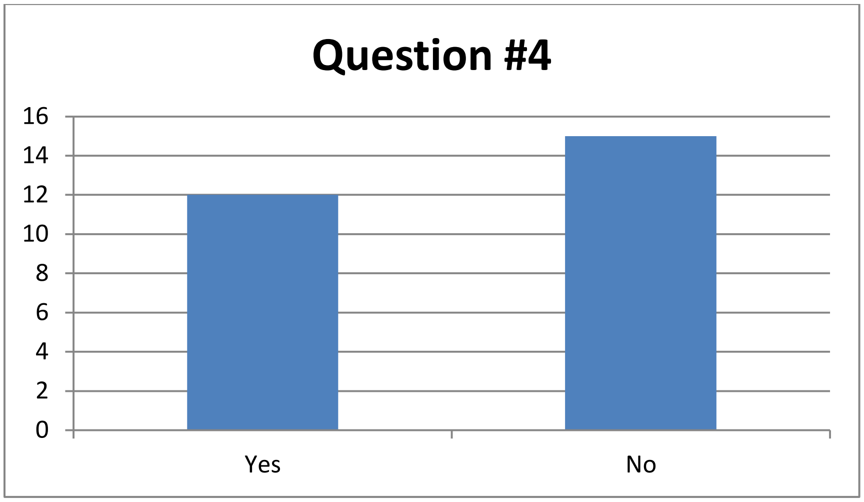
Roughly 25% of the people who detected odours found it to be strong and objectionable.

3) How often have you complained to the Regional District about the odour in the past two years?



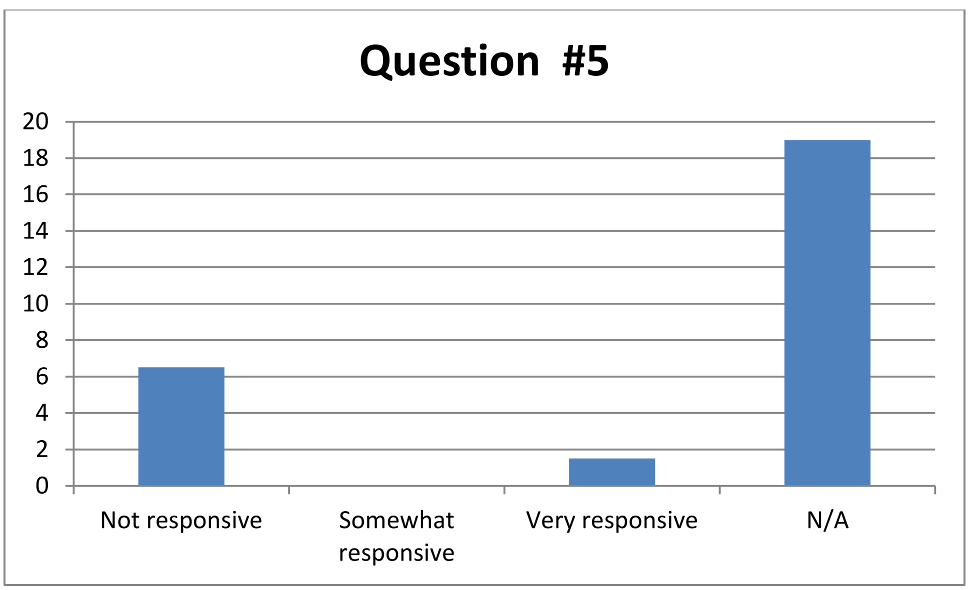
Of the 27 respondents, only nine had ever complained with regard to the odour from the facility. This certainly does not mean that only nine people ever experienced any but it does place the odour issues in the community in perspective.

4) Are you aware of the Regional District's new process for recording complaints from the plant?



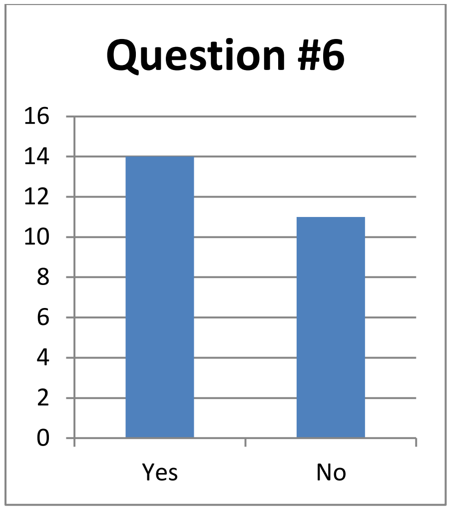
The Region should devote some resources to informing the public of the complaint process.

5) If you have used the Regional District's complaint process, did you feel that they responded to your concerns appropriately, how would you rate the from the Region's level of responsiveness to your complaint?



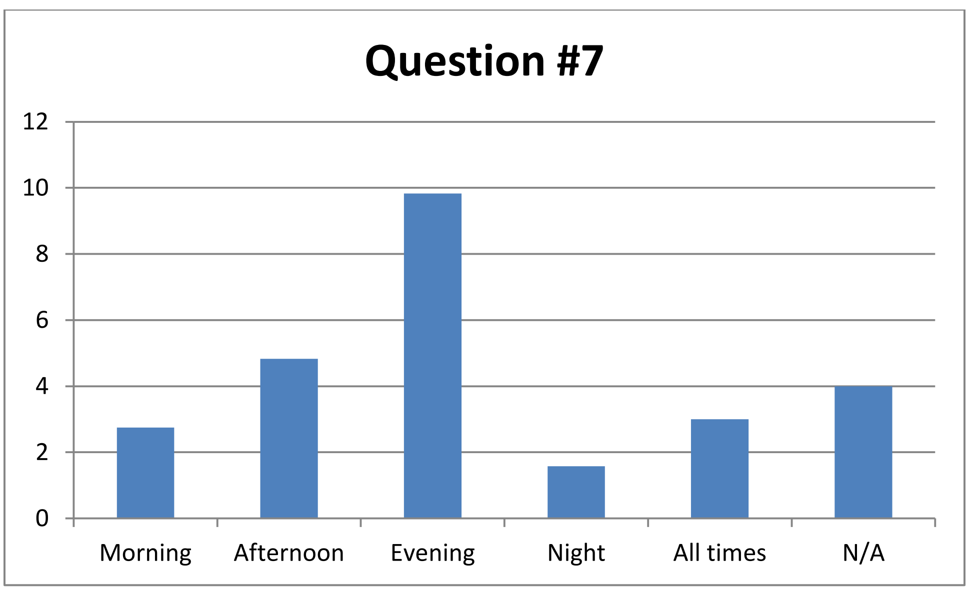
Of the people that have used the complaint system the modal response was that the Region was not very responsive to complaints but based on some notations this does seem to be improving. It is the nature of the process that meaningful responses may often take a significant amount of time.

6) Would you like to receive more information with regard to the formal complaint process?



The Region should devote some resources to informing the public of the complaint process.

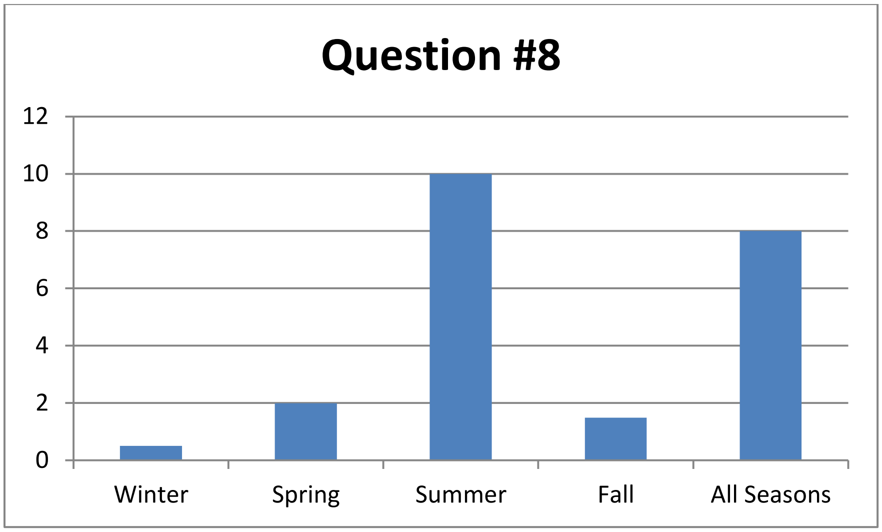
7) If you detect odours from the plant, what time of day do you tend to notice it?



Based on these responses, there does seem to be some increase in odour perception in the evening which is typical for these types of facility but the response is not overwhelming and is likely due to increased outdoor activities of the respondents.

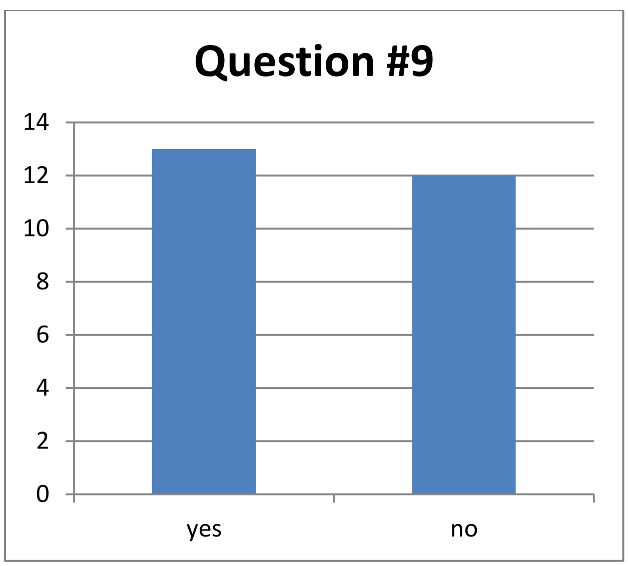
CONSULTING ENGINEERS & SCIENTISTS

8) If you detect odours from the plant, what time of year do you tend to notice it most?



The modal response to this question was summer but clearly there are enough indications that it is all seasons. The increase in the summer response may well be related to individuals being outside more and not related to any operational differences in the Summer.

9) Would you be interested in touring the facility?



There does seem to be a reasonable number of people who would like to tour the facility. Perhaps the Region could do a tour a month for a few months so that all those interested can have a chance to tour.

10) Is there anything you would like to see as part of the complaint process or as part of the overall sharing of information with residents?

Of the 27 response forms, eighteen had provided comments on this question. Of the eighteen responses, six would be classified as negative to angry, seven would be classified as neutral to negative and five would be classified as neutral. One of the recurring themes in the comments is a desire to be better informed of what is going on in terms of operations and plans to improve the odour issues.

Comox Valley Water Pollution Control Centre Odour Survey Data

Questions										
Respondent	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	b	b	a	b	d	a	c	e	a	y
2	c	b	a	b	d	a	b/c	c	a	y
3	d	c	d	a	a	a	c/d	e	b	y
4	a	a	a	a	d					
5	b	a	a	b	d	b	a/c	b/d	a	y
6	b/c	c	a	b	d	a	c	e	b	y
7	b	b	a	b	d	b	b	e	b	y
8	b	b	a	b	d	b	a	e	a	y
9	c	c	d	b	a	a	c	c	a	y
10	c	b/c	b	a	a	a	e	b/c/d	a	y
11	b/c	c	a	b	d	a	b	c	a	y
12	c	b	b	a	a	a	e	e		y
13	c	c	d	b	a	a	b/c/d	b/c/d	b	y
14	b	b	a	b	d	b	c/e	c	b	y
15	c	a	a	a	d		a/c	b/c/d	b	n
16	b	b	c	a	a/c	b	a/c	e	a	y
17	a		a	a	d	b	f	f	b	n
18	b	b	a	b	d	a	b	e	b	n
19	a		a	a	d	b	f	f	b	n
20	a		a	b	d	b	f	f	a	n
21	c	b	b	a	d	a	c	c	a	y
22	b	a/b	a	b	d	a	b	c	b	y
23	c	c	d	a	c	b	c/d	c	a	n
24	c	b	a	b	d	a	c/e	b/c	b	n
25	b	a	a	b	d	b	f	f	a	y
26	c	c	d	a	a	a	a/2\c\d/2	a/c	a	y
27	b	b	a	a	d	b	c	c	b	n
Totals										
a	4	4.5	18	12	6.5	14	2.75	0.5	13	
b	11	12	3	15	0	11	4.83	1.99	12	
c	11	7.5	1		1.5		9.83	9.99		
d	1		5		19		1.58	1.49		
e							3	8		
f							4	4		

Date Plotted: 6/23/2014