The Board of Education of
School District No. 83 (North Okanagan-Shuswap)
341 Shuswap Street SW, Box 129, Salmon Arm, BC, V1E 4N2
Phone: (250) 832 2157 Fax: (250) 832 9428

Summary of Findings and Recommendations for Parkview Elementary School

Apex EHS Services - Mould Air Sampling Results

Sample collection – September 11, 2019

Report presented to SD 83 – September 12, 2019

The results of air sampling for mould require careful interpretation. There are no accepted numerical criteria for indoor fungal spore concentrations. The accepted practice among leading authorities is comparison of samples in areas of concern with outdoor and/or indoor control samples. An acceptable condition is indicated when concentrations of airborne fungal particles are not significantly elevated when compared to concentrations in the control samples, and the types of fungal particulate do not differ significantly from those present in the control samples.

Mould air samples collected within the West corridor, Main Office, Northwest Foyer and Central Corridor were quantitatively lower and qualitatively similar to outdoor reference samples.

Sample results indicate that mould growth was not impacting on air quality at the time of sampling.

VanDriel OHS Consulting – Preliminary Indoor Air Quality Investigation

Sample 1 collection – September 19, 2019

Report presented to SD 83 – October 2, 2019

Culture mould report presented to SD 83 – October 7, 2019

Temperature and Relative Humidity
The temperature and relative humidity were within a comfortable range for most occupants. Room 19 had a lower temperature (and higher relative humidity) because the doors leading to the outside from Room 19 (to the south) were opened during recess with no one inside, and outdoor temperature was lower than the indoor temperature, causing a fall in temperature (and a subsequent increase in relative humidity).

Ventilation
The ventilation appears to be effective. This is based on the increase in CO2, which reached up to 780 ppm in one classroom. When the occupants of the room left, the CO2 concentration decreased rapidly, returning to an equilibrium within minutes (See Appendix B for time-series plot of CO2 over time).

Carbon Monoxide
No CO was detected above the detectable limit of 0.1 ppm in all five rooms where the Q-Trak was placed. CO is not likely the cause of the odour complaint or the source of the symptoms experienced by the occupants of the building.

Mould
Results from the samples collected in the office area, east wing corridor and west wing corridor showed lower fungal concentration than the outdoor samples. This suggest that the ventilation system on the roof is functioning adequately to remove dust particles from the outdoors. The samples collected from the crawlspace showed greater fungal concentration, about three times, than the outdoor samples. This suggests that the crawlspace is a likely source of fungal growth at the school.

The samples from the office area, east wing corridor and the west wing corridor had a similar ratio of *Cladosporium* sp. and *Penicillium* sp. as the outside samples. However, the crawlspace had a different ratio of the two fungi genus than the outside samples. This suggests that the fungal community inside the crawlspace differs from that of the outside. The crawlspace also only grew one species of *Cladosporium* sp. unlike the other indoor spaces. This suggests that the dominant community in the crawlspace differ from those outside.

Recommendations
The crawlspace must be kept dry to prevent further odour complaints due to the crawlspace becoming wet. Currently, there is a system of heaters and fans that dry out the crawlspace, which may not be sufficient when there is a heavy rainfall. A long-term recommendation is to finish the crawlspace floor surface with concrete removing the potential for soil/sand from harvesting mould growth.

Sample 2 collection - October 2, 2019

Report presented to SD 83 – October 10, 2019

Cultured mould report presented to SD 83 – October 28, 2019

Gaseous Contaminants
NO2 was detected between 0.1 to 0.3 ppm inside the school, while the outdoor concentration was 0.2 to 0.4 ppm. As NO2 reacts slowly with water to form nitric acid (HNO3), the amount of NO2 eventually decreases from the environment. Therefore, the source of the NO2 within the school does not come from a source inside the school.
NO, CO, H2S and SO2 were not detected at any time throughout sampling above 0.5 ppm, 9.0 ppm, 0.5 ppm, and 0.05 ppm respectively. O2 was around 20.9%. The VOC sensor did not detect anything above 0.5 ppm, or 1800 µg/m3 as toluene equivalent VOCs at 25 °C and 101.325 kPa. The LEL sensor did not detect any explosive material reaching above 0.5% of the LEL. Therefore, there was no significant source of these gaseous contaminants in the school.

Volatile Organic Compounds
On October 2, 2019, similar VOCs were detected at similar concentrations at the four other locations, suggesting that the products containing VOCs at the school were releasing these as vapors. The supply closet sample contained a few other unknown hydrocarbons, which are expected to be in the cleaning agents in the room. As the VOC amounts are all less than 300 µg/m_3, the exposure to these VOCs are not expected to contribute to the indoor air quality issue at the school.

Ethanol, acetone, isopropyl alcohol, and ethyl acetate are found as either solvents for products such as cleaning agents, personal care products, nail polish remover, some perfume/cologne. Chloromethane may off-gas from rubber and silicone products and may also be included as a refrigerant. Benzaldehyde is a preservative in some food products, cosmetics and degradable building materials, such as caulking. Based on TVOC readings, these are not likely to have caused any irritating symptoms.

Freon 12, 1,1-dichloro-1-fluoroethane, and 1,1-difluoroethane are used as refrigerant or heat exchange fluid but do not have observable adverse effect to human health at the identified concentration. It is not associated with respiratory irritation. Toluene and xylene are used as a solvent in building materials, such as paints, paint thinner, adhesives. Pentane, propane, and butane are added as a solvent in some building materials, adhesives, and aerosolized personal care products (e.g.: shaving cream spray). Cyclohexanes are used in the production of or used in industrial processes for making lacquers, resins and synthetic rubber. Decane, undecane, and nonane are found in heavier fuels, such as diesel and jet fuel. These are associated with headache and nausea symptoms.

A surface conditioner for the self-adhesive membranes used for the new roof installation includes IKO self-adhering membrane adhesive. The components include hydrotreated light naphtha, acetone toluene, and solvent-refined heavy paraffinic petroleum distillate. This accounts for the observed presence of acetone, propane, butane, pentane, cyclohexanes,
nonanes, decanes, undecane, toluene, and xylene.

Tape Lift Mould Samples

The ceiling tape sample from the central section of the school identified spores from outdoor fungi, such as ascomycetes, basidiomycetes, and myxomycetes.
There were also some Cladosporium spores as well, indicating that the area received air from outdoors. In the crawlspace, the wet area by the sump tank pipe in the west wing and the drier area by the exposed plywood of the building envelope detected a large number of hyphal fragments, which is indicative of constant mould growth in the area. No spores were detected in high concentration on surfaces, though various outdoor fungi (Stachybotrys, Cladosporium, Chaetomium, Aspergillus, Penicillium, Memnoniella) were detected. When areas with nutrients for fungi (such as wood) do not dry up quick enough, it can become a suitable environment for mould growth. It is likely that the crawlspace is conducive to mould growth whenever the crawlspace becomes wet or damp.

Non-viable Airborne Mould Samples

The fungal spore concentration within indoor spaces is below the concentrations outside. The ratio of outdoor fungi spores and other spores are also similar, with ascospores and basidiospores (groups of fungi that can only grow in outdoor environments) comprising most of the spores. The exception is the supply closet in the east wing, which has a higher concentration of fungi spore than the outdoor samples. This is likely due to a lack of cleaning and an inward flow of materials from the hallway and entrance towards the closet.

Mould Air Samples
Results from the air samples collected in Room 20, from the ceiling spaces the two supply closets showed lower fungal concentration than the outdoor samples. The sample collected from the crawlspace showed almost equal concentration of fungal CFU, double the concentration of Penicillium and four times the concentration of Cladosporium as ccompared to the outdoor samples. This suggests that the crawlspace is a likely source of fungal growth at the school. The chi-squared test shows a trend that the crawlspace may have a different community of fungi that can grow there than the outdoor environment. This trend is not statistically significant, which is likely due to the low CFU detected. When the conditions in the crawlspace allow more spores to be generated (such as the period after a rainfall), there may be a trend showing that there is a difference between the community in the crawlspace and the outdoor environment. Due to the lack of recent rainfall, other locations may also show positive result due to the low counts, which may not have captured all the possible fungi community that exists in the space, thus skewing the results.

Results from the west supply closet showed Aureobasidium sp., indicating that there had been damp soil in the area. The source of the damp soil is most likely from the floor drain, where there may be damp soil that have collected in the drain.

Aureobasidium sp. was also detected in the swab sample of dirt collected in the crawlspace in the west wing during the investigation. This suggest that the crawlspace area was recently wet. The swabs in the west and east supply closet drains found Fusarium sp. (Table 3), which grows abundantly in soils and near plants. It suggests that there is a lot of dirt that may have ended up in the drains. This is typical of a space meant for collecting the wastewater from cleaning the school's interior. However, some drains collected more dust than others, thus increasing the fungal spores that were collected on the swab.

Recommendations
The crawlspace must be kept dry to prevent further odour complaints due to the crawlspace becoming wet. A long-term recommendation is to finish the crawlspace floor surface with concrete removing the potential for soil/sand from harvesting mould growth and preventing water penetration into the crawl space.

Sample 3 collection – November 15, 2019

Report presented to SD 83 – December 10, 2019

Non-Viable Airborne Mould Spore Samples
The two locations that had fungal spore concentrations higher than outdoor samples were the storage room and the office vents. The storage room sample contained mostly basidiospores, which can be found outdoors. During the previous two site visits, the items in the storage room were removed. The odour in the storage room now indicates that there may be some dirt carried from the items in the storage room.

The sample collected in the office vents in the floor had a higher concentration than the outdoor samples. In addition, most of the spores found were either *Aspergillus* sp. or *Pencillium* sp. This is typical of the environment in the crawlspace, as determined in previous reports. A sample was collected from the office vents when it was discovered that vents on the floor supplied air into the front office and the councilor's room. These vents were found to run through but not into the crawlspace.

In the other rooms (classrooms, kindergarten room, and front office), the concentration of fungal spores are below the concentration of outdoor samples. All of the spores found in these rooms can be attributed to the outdoor environment. The amount of fibrous materials, skin fragments, and background dust is consistent with the locations of the samples.

Volatile Organic Compounds

The main sources of TVOCs in a school building can include off-gassing from plastic objects (plastic balls, gym surface coating), body odour, and certain food items. At locations where there is higher human occupancy (such as the west section of the building), it is expected that there is a higher TVOC concentration. Examples include the gym (after students completed physical education activities), the west corridor, and the classrooms in the west section (Rooms 12 to 20).

The rooms that have an atypical concentration include the front office and the councilor room. An examination of several vents in the front office revealed that these have a higher concentration of TVOC than the rest of the office area and the copy room. This suggests that there is a source of TVOC in the vents leading into the office area, though the actual substance cannot be characterized.

The councilor room had a higher TVOC concentration than the classrooms and corridors. As the air handling unit that supplies the front office also supplies the councilor room, it is likely that the room may have accumulated more of the unknown substance through the supply vents as well. The higher concentration of TVOC suggest that more ventilation may be required.

Temperature, Relative Humidity, Carbon Dioxide and Carbon Monoxide

The temperature and RH range are within comfortable range indoors within the three classrooms and the front office. CO was detected up to 0.4 ppm in those rooms as well. The concentration of CO2 increased with human occupancy. At certain times, the concentration rose slightly above the threshold of 700 ppm above ambient concentration (i.e. 1082 ppm). This can occur earlier in the day if there are more classroom activities that involves more physical movement compared to sitting at a desk. As the samples were not collected from breathing zones of the occupants, air does not mix efficiently in a room, the CO2 concentration may be higher than expected. Since there was no plateau concentration of CO2 observed during sampling with up to 30 minutes of occupancy (Figure 3), it is expected that extended human occupancy and/or more vigorous human activity in a classroom would reach above the threshold limit, leading to some IAQ complaints.

Ventilation Effectiveness

The larger classrooms (Room 18 and 19) had approximately 0.03 air changes per hour, while the smaller classroom (Room 15) had approximately 0.017 air changes per hour. Based on the approximate volume of the larger classrooms (115 m3) and smaller classroom (90 m3), this corresponds to roughly 1 L/s and 0.4 L/s respectively. This is well below the ASHRAE standard's recommended airflow for an acceptable indoor environment in these classrooms.

Recommendations

Communicate the findings of this investigation to the occupants and joint health and safety committee. Clean the duct system responsible for supplying air to the office. Particularly, focus on the ducts that run through the crawlspace. Inspect the ducts to ensure there are no penetrations that allow

crawlspace air to enter the ducts. Increase the ventilation rate for the classrooms. Examine the ventilation rate in classrooms after the increase to ensure that it meets the minimal airflow as recommended by *ASHRAE Standard 62 Ventilation for Acceptable Indoor Air*. Consider retaining a ventilation engineer to confirm that the ventilation rate is sufficient.

Limitations

- The TVOC measurement only indicates the sources and concentration of VOC and does not characterize them.
- A strong limitation of using CO_2 as the tracer gas in this analysis is that humans and other organisms can produce it, leading to underestimated air change rates as measured. Despite that, there is approximately a hundred-fold difference between the measured air change rate and the ASHRAE standard recommended ventilation rate.
- This report was intended only for the sole use of School District 83 and not for other third parties, no other warrantee, expressed or implied was made. VOHS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.
- The information and conclusions provided in this report was based on the scope of work agreed upon. Nothing in this report is intended to express any legal opinion or whether conditions conform to regulatory requirements.
- The report has been prepared in accordance with best occupational health and safety and industrial hygiene practices and professional expertise of those who were involved and signed.
- Changes to the properties use, condition, circumstances or environment could impact and alter the conclusions of this report.
- VOHS Group is not responsible for any damages resulting from carrying out the defined scope of work. VOHS Group is only responsible for damages resulting from negligence of VOHS Group.

Watterson Geoscience Inc. – Technical Memo – Draft

Site visit – September 30, 2019

Report presented to SD 83 – October 31, 2019

Although shallow groundwater elevations commonly vary during the seasons, available background soils and groundwater information for the area suggest the water table is sufficiently deep beneath the School property to not affect shallow soil conditions. This information is supported by WGI's field assessment although the test pits were excavated during the season when groundwater elevations are their lowest, no evidence of permanent shallow groundwater, such as wet soil or gleying, caused by permanent saturation and oxygen-poor conditions, was observed. The available information and observations suggest that under normal conditions the soil beneath the School is seasonally wet, but groundwater is sufficiently deep to not affect soil characteristics beneath the school.

However, it is possible but unlikely the abundant short-term surface runoff during the rain events may have temporarily increased shallow groundwater elevation beneath the building and thereby saturated soil that was historically unsaturated. This possibility is supported by the inability of the local storm system and dry wells to accept the excess runoff causing abundant shallow water throughout the School

area. The odors may have resulted from this temporary saturation.

In addition, inadequate sealing between the building structure and underlying concrete foundation walls appears to periodically allow surface-sourced water into the crawl space. The excessive surface water present during the two flooding events may have caused much more than “normal” amounts of surface flow into the crawl space with resulting increased saturation of soil in the crawl space.

Finally, no evidence of the OTDS was observed during WGI’s site visit and the odors apparently did not smell of “septic”. Given the old infiltration area’s distance from the School it is unlikely the historic drain field, even if affected by the excess surface water and possible temporary shallow groundwater, it is unlikely saturation of this area could have caused the odors.

Falcon Engineering - Odour Assessment Report

Site visit – October 1, 2019
Report presented to SD 83 – October 4, 2019

The odours that were described to us were very strong and musty. The odours could be considered acute, as they were described to develop over a relatively short period of time. That evidence would usually lead directly to the source, but not in this case.

This office has been involved with investigating several odour problems. Most of the problems were chronic, long term odours and one was acute. Once the source of the odour was found, the solutions became very clear. In this case, we do not believe that we directly found the source of the odour. That may due to the crawlspace being dry now and significant odour mitigation efforts having been made.

The one project where the odours developed into an intolerable level in a very short period, involved composting. In that case, meat had entered the systems undetected and the whole batch had to be removed and the composting room thoroughly cleaned before the odours abated. We do not know if that was the problem here, but we saw a few composting stations throughout the facility. Without much other evidence, this could be something to consider.

The next item to consider, from a good design practice for mechanical systems, is to look for systems that were poorly configured, poorly maintained, or simply missing. The mechanical systems are well configured and well maintained, when compared to similar buildings that don’t have this odour problem.

As we could not identify the source of the odour, there are a few custodial rooms and crawlspaces that could use an exhaust upgrade to mitigate future events. But even if these spaces were ventilated, it would not account for the intensity of the odours being experienced.

Recommendations:

- An exhaust system should be added to the east and west custodial rooms.
- Reconfigure the gym return air path and provide dedicated exhaust system for the gym crawlspace.
- An exhaust system serving each crawlspace, to keep that space under negative pressure in relation to the occupied space, during occupied hours.

Conclusion:

To date the source of the odour in Parkview Elementary School appears to be the soil-based crawlspace becoming wet due to water events such as abundant rainfall. Sicamous experienced significant rainfall from September 7-9, 2019 when the odour appeared with the schools HVAC system and crawlspace ventilation turned off do to a DDC upgrade. The crawlspace produces odour from a specific *Cladosporium* sp. mould spore present only in the crawlspace and higher then normal levels of *Penicillium* sp. and *Cladosporium* sp. then present in the normal indoor samples.

School District 83 proposes the following to satisfy the concerns of Interior Health on a short- and long-term basis for Parkview Elementary School:

- **Use existing ventilation fan to vent crawlspace in office gym area that was once used for laminator in book storage room. Completed**
- **Install ventilation in custodial rooms Completed**
- **(interim) water proof exterior of crawlspace in suspect areas around perimeter of school. Completed**
- **Develop and secure funding for capital upgrades to crawlspace – slurry coat the soil floor and proper duct work for Gym return air system In development**