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Project Number 20488.000.001

Bromley Black Staining and Mould Investigation

Bromley and New Brighton, Christchurch,

Submitted to:
Christchurch City Council
53 Hereford Street
Christchurch 8013

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1 Introduction

ENGEO Ltd was requested by Christchurch City Council (CCC) to undertake an assessment of the black staining observed on residential dwellings in the Aranui, Linwood and South New Brighton areas of Christchurch. The black staining was first reported after the Christchurch Wastewater Treatment Plant caught fire in November 2021. ENGEO were contracted to assess residential properties with black staining for the presence of elevated concentrations of fungi, in particular mould, on building surfaces. The work also included an assessment of the outdoor air, and the potential risk to human health. Additionally, surfaces where black staining was noted were assessed for the presence of lead-based paint and its exposure to potentially elevated concentrations of Hydrogen sulphide gas (H_2S).

This work has been carried out in accordance with our signed agreement (ENGEO, 2022.05.31 – CCC Bromley Mould and Odour).

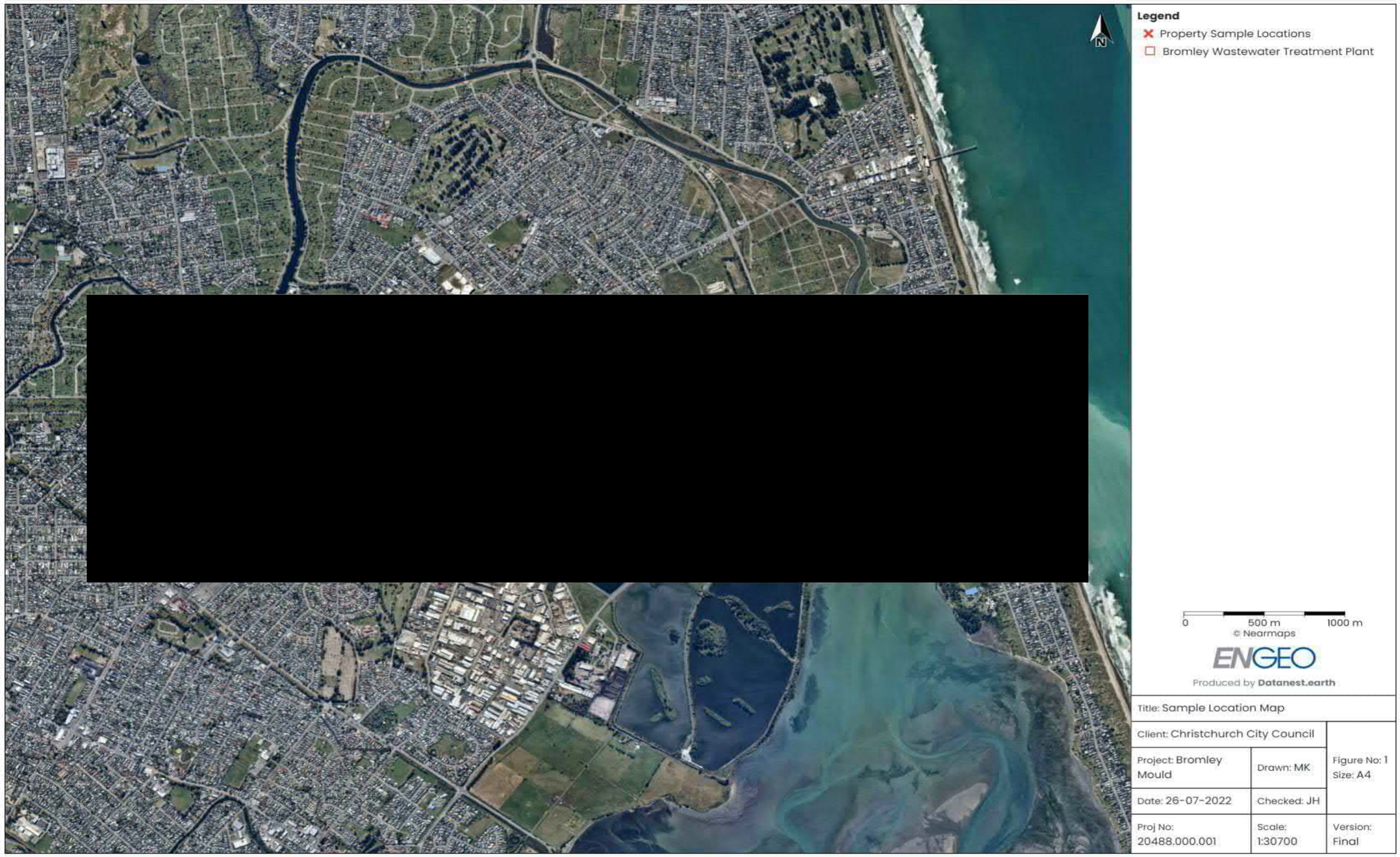
2 Site Description

Christchurch City Council received several reports of black staining on the exteriors of residential dwellings in the Bromley, Linwood, and South New Brighton areas of Christchurch. A shortlist of eleven properties displaying evidence of black staining on painted exterior timber and cement-based cladding, soffits, and trim was provided to ENGEO for investigation see Table 1, Figure 1.

Table 1: Investigation Locations

Site	Legal Description
[redacted]	

Figure 1: Investigation Locations



3 Site Investigation

3.1 June 2022

ENGEO completed an initial round of testing on the 2 June 2022 at four locations provided by CCC. [redacted] in Aranui and adjacent to the Wastewater Treatment Plant, and [redacted]n South New Brighton, east of the CCC wastewater settlement ponds. This initial investigation was completed to determine if the black staining was the result of fungi accumulating on building exteriors, and if fungi was present in outdoor air in concentrations which present a potential risk to human health.

As part of this initial investigation, the following was completed at each of the four residential addresses provided by CCC:

- Cello-tape swab samples of surfaces observed to have black staining to assess for the presence of fungi;
- Collection of paint samples from areas where black staining is observed to identify the presence of lead;
- A representative spore trap sample of outdoor air collected with a Buck bioslide sampler;
- Cello-tape swab samples were submitted to Biodet Laboratories to undergo macroscopic and microscopic analysis for the presence of fungi;
- Paint samples were submitted to Hills Laboratories and analysed for the presence of lead; and
- Spore trap samples were sent to Biodet Laboratories and analysed for airborne concentrations of fungi.

3.2 July 2022

On 1 July, 2022, ENGEO was engaged to complete further testing at eight residential properties provided by CCC. The purpose of this investigation was to determine if the black staining reported was the likely result of lead-based painted surfaces reacting with potentially elevated concentrations of hydrogen sulphide (H_2S) gas. The study *Hydrogen Sulphide Darkening of Exterior Paint* (1966), Appendix 1, demonstrated that the presence of a lead-based paint and H_2S chemical reaction can be tested for utilising a hydrogen peroxide (H_2O_2) solution. When swabbed with H_2O_2, lead-painted surfaces stained black by H_2S exposure will immediately restore back to their original colour, however organic / fungal staining is generally unaffected. Alternatively, surfaces with organic / fungal staining can be swabbed with a sodium hypochlorite (NaClO) solution to restore colour while generally unaffecting areas where lead-paint and H_2S chemical reactions have occurred. ENGEO adopted this methodology and applied it as part of their field investigation.

The following was completed on each of the eight residential properties provided by CCC:

- Portable X-ray fluorescence (XRF) analysis of painted surfaces observed to be impacted by black staining for the presence / concentrations of lead;
- Swab of black stained surfaces with H_2O_2 to screen for presence of a lead and H_2S chemical reaction; and

- Swab of black stained surfaces with sodium hypochlorite (NaClO) solution to test for the presence of organics including fungi.

4 Results

4.1 Field Observations

Grey / black staining was observed at all test locations in varying concentrations. Surfaces impacted included exterior walls, trim materials around doors and windows, and soffits on the underside of rooflines. Building materials impacted consisted predominantly of painted timber and cement-based weatherboards, see photos 1-8.

Figure 2: Black Staining

Anecdotal observations provided by current occupants included the following:

- Black staining temporarily improving when exposed to direct sunlight;
- Surfaces where black staining has been painted over becomes stained again within days / weeks; and
- Areas cleaned / washed down with soap and detergents become stained again within days / weeks.

4.2 Lead Paint Results

4.2.1 Laboratory Paint Analysis

All paint samples submitted to Hills laboratories contained concentrations of lead ranging from 1,320 – 45,000 mg/kg, see Table 2. Full laboratory report in appendix 2.

Table 2: Hills Laboratory Lead Paint Results from June sampling

Sample	[redacted]				
Paint colour	White	White	Beige	White	Beige
Lead mg/kg	2,700	2,400	42,000	1,320	45,000

Paint is generally considered “lead-based” when concentrations of lead are >1,000 mg/kg (ppm).

4.2.2 XRF Paint Analysis

The XRF analysis and observations can be summarised as follows:

- All painted surfaces exhibiting black staining scanned positive for the presence of lead-based paint with concentrations ranging from 128 – 68,000 mg/kg.
- Both properties at [redacted] were observed to have surfaces with no visual black staining that tested negative for the presence of lead.
- Both properties at [redacted] were observed to have recently painted surfaces with no black staining that tested positive for concentrations lead of 3,670 and 5,909 mg/kg respectively.

Table 3: XRF Lead Paint Results from July sampling

Location	Paint Colour	Lead Concentration (mg/kg)
[redacted]	Beige	23,800
	White	56,000
	White	27,100
	White	6,962
	White	4,924
	White	43,700
	Blue	67,400
	White	13,600

4.2.3 Fungi

Cello-Tape Swab Samples

Laboratory results indicated the absence of moulds in all swab samples collected. A small amount of miscellaneous fungal spores is noted with minor active fungal growth detected from the [redacted] swab, see Table 4. Biodet Laboratory states the fungal growth is likely due to a build-up of dust / debris in response to condensed moisture on a surface. See Appendix 2 for full laboratory results.

Spore Trap Results

Laboratory results indicated concentrations of fungi within laboratory averages for outdoor air from all test locations and are considered typical of an outdoor environment.

Table 4: Mould and Fungi Results

[redacted]	Location	
Exterior	Soffits	
Site Observations		
Black staining was observed on underside of soffits.		

Surface Tape Samples Laboratory Analysis					
Sample ID	Location	Mould Detected	Potential Toxic Mould	Potential Allergen	Active Growth
46021/2	Exterior Soffit	None Detected	None identified	Unlikely	None

Outdoor Air Spore Trap Sample Laboratory Analysis														
Slide Sample ID	Cladosporium	Penicillium / aspergillus type	Stachybotrys	Chaetomium	Alternaria / Ulocladium	Pithomyces	Drechslera / Bipolaris	Epicoccum	Curvularia	Fusarium	Basidiomycete	Hyphal Fragments	Other Spore Types	Spore Total / m^3
46021/1	53	27	0	0	0	0	0	0	0	40	700	27	5367	6214

[redacted]	Location
Exterior	Soffits

Site Observations
Black staining was observed on underside of soffits and trim around windows.

Surface Tape Samples Laboratory Analysis

Sample ID	Location	Mould Detected	Potential Toxic Mould	Potential Allergen	Active Growth
46022/2	Exterior Soffit	None Detected	None identified	Unlikely	None

Outdoor Air Spore Trap Sample Laboratory Analysis

Slide Sample ID	Cladosporium	Penicillium / aspergillus type	Stachybotrys	Chaetomium	Alternaria / Ulocladium	Pithomyces	Drechslera / Bipolaris	Epicoccum	Curvularia	Fusarium	Basidiomycete	Hyphal Fragments	Other Spore Types	Spore Total / m^3
46022/1	387	33	0	0	0	0	0	7	0	53	447	27	2867	3821

[redacted]	Location
Exterior	Walls and Cladding
Site Observations	
Black staining was observed on exterior walls / cladding and trim around windows.	

Surface Tape Samples Laboratory Analysis

Sample ID	Location	Mould Detected	Potential Toxic Mould	Potential Allergen	Active Growth
46023/2	Walls and Cladding	None Detected	None identified	Unlikely	None

Outdoor Air Spore Trap Sample Laboratory Analysis

Slide Sample ID	Cladosporium	Penicillium / aspergillus type	Stachybotrys	Chaetomium	Alternaria / Ulocladium	Pithomyces	Drechslera / Bipolaris	Epicoccum	Curvularia	Fusarium	Basidiomycete	Hyphal Fragments	Other Spore Types	Spore Total / m^3
46023/1	780	0	0	0	0	0	0	0	0	60	220	13	2700	3773

[redacted]	Location
Exterior	Walls and Cladding
Site Observations	
Black staining was observed on exterior walls / cladding and trim around windows.	

Surface Tape Samples Laboratory Analysis

Sample ID	Location	Mould Detected	Potential Toxic Mould	Potential Allergen	Active Growth
46024/2	Exterior Soffit	None Detected	None identified	Unlikely	None

Outdoor Air Spore Trap Sample Laboratory Analysis

Slide Sample ID	Cladosporium	Penicillium / aspergillus type	Stachybotrys	Chaetomium	Alternaria / Ulocladium	Pithomyces	Drechslera / Bipolaris	Epicoccum	Curvularia	Fusarium	Basidiomycete	Hyphal Fragments	Other Spore Types	Spore Total / m^3
46024/1	373	0	0	0	0	13	0	0	0	60	233	20	4200	4899

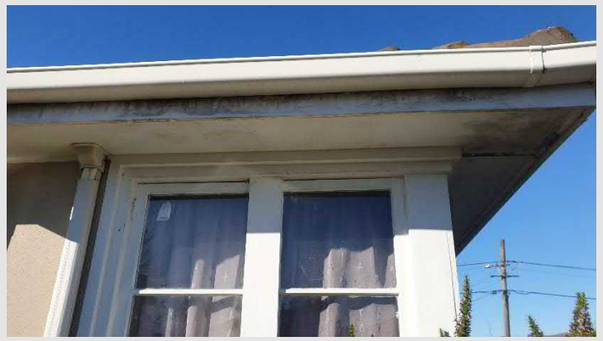
4.2.4 Lead-based Paint with H_2S Reaction - Test Results

Eight properties were assessed for the presence of a chemical reaction between lead-based paint and H_2S. The test results can be summarised as follows, see Table 5.

- All areas of black staining swabbed with the NaClO solution reacted suggesting the presence of organic based dust build-up;
- [redacted] had black stained surfaces that reacted quickly when swabbed with H_2O_2 suggesting a presence of a lead-based paint and likely H_2S chemical reaction;
- [redacted] had black stained surfaces that had a reduced reaction when swabbed with H_2O_2 suggesting some lead-based paint and H_2S chemical reaction may be occurring; and
- [redacted] had black stained surfaces where no reaction occurred when swabbed with H_2O_2 indicating a lead-based paint and H_2S chemical reaction is unlikely occurring. Black staining reacted immediately when swabbed with NaClO indicating the presence of organic dust.

Table 5: Lead-based Paint with H2S Reaction - Test Results

Property: Surface and Paint	Surface Staining Pre-Test	Hydrogen Peroxide Test	Bleach Test	Results
[redacted] Grey paint to walls				Staining removed under both tests; ring outline noted under Hydrogen Peroxide test.
[redacted] White paint to soffits				Staining is clearly removed during bleach test, and only partially removed under Hydrogen Peroxide test.
[redacted] White paint to soffits				Staining is clearly removed during bleach test, but no observable change during Hydrogen Peroxide test.

Property: Surface and Paint	Surface Staining Pre-Test	Hydrogen Peroxide Test	Bleach Test	Results
[redacted] White paint to walls				Staining is clearly removed during bleach test, and only partially removed under Hydrogen Peroxide test.
[redacted] White paint to gable ends				Staining is clearly removed during bleach test, but no observable change during Hydrogen Peroxide test.
[redacted] White paint to soffits				Staining is clearly removed during bleach test, and partially removed under Hydrogen Peroxide test.

Property: Surface and Paint	Surface Staining Pre-Test	Hydrogen Peroxide Test	Bleach Test	Results
[redacted] Blue paint to walls				Staining is clearly and immediately removed under both bleach and Hydrogen Peroxide tests.
[redacted] White paint to walls				Staining is clearly removed during bleach test, but no observable change during Hydrogen Peroxide test.

5 Conclusions

Concerns have been raised by Christchurch residents that elevated concentrations of fungi and gases are being released into the community after the November 2021 fires at the wastewater treatment facility. To investigate this a total of eleven properties across suburbs Aranui, Linwood, and South New Brighton were assessed for the presence of fungi on exterior residential building surfaces and in outdoor air. Additionally, an assessment for a potential chemical reaction between lead-based paints and hydrogen sulphide gas was completed. Spore trap and cello-tape swab samples were taken from a representative number of houses and analysed for fungi species including mould. Painted surfaces were also either sampled and sent to a laboratory for analysis or scanned with an X-ray fluorescence machine for concentrations of lead. These surfaces were then swabbed with both H_2O_2 and NaClO for the presence of a hydrogen sulphide chemical reaction or the presence of organic matter.

Laboratory fungi analysis indicate outdoor air concentrations are within the likely laboratory averages and are considered seasonably normal for mould. Concentrations of hazardous moulds were not detected in cello-tape swab samples with minor concentrations of fungal spores present. Minor active growth was noted at [redacted]. Biodet Laboratory states that fungal growth is likely due to a build-up of dust / debris in response to condensed moisture on a surface. Concentrations of fungi including mould are considered unlikely to be a risk to human health and the observed black staining is unlikely to be the result of hazardous mould growth.

Laboratory and XRF paint analysis reported all surfaces with black staining to be coated in lead-based paint. Concentrations of lead in the paints ranged from 128 to 68,000 mg/kg. Five properties tested positive and three tested negative for the likely presence of a chemical reaction between lead-based paints and hydrogen sulphide gas exposure.

6 Recommendations

Field testing results indicate lead-based paints are / were likely exposed to hydrogen sulphide gas and is potentially the cause of some black staining being observed. Ongoing monitoring should be completed to ensure hydrogen sulphide levels are below concentrations that would be a risk to human health.

The three residential dwellings of [redacted] were observed to have black staining however tested negative for the presence of a lead-based paint and hydrogen sulphide reaction. These dwellings were not assessed for the presence of mould on their surfaces. They are in proximity to locations where outdoor air samples were collected and laboratory results of the outdoor air indicate that mould is not likely present in concentrations that would pose risk to human health. Cello-tape swab samples of black staining at these properties would confirm the presence / absence of hazardous mould.

There is limited information on black staining resulting from the chemical reaction between lead-based paints and hydrogen sulphide gas. *Hydrogen Sulphide Darkening of Exterior Paint* (1966) notes that areas of black staining may fade back to normal conditions over time once the chemical reaction and hydrogen sulphide exposure has ceased. The washing of black stained surfaces with exterior cleaners may assist in the reinstatement rate of the effected surfaces, however several rounds of washing may be required. Anecdotal evidence indicates that staining reappears after surfaces have been cleaned. It may be advantageous to randomly select a small sample of impacted dwellings to be professionally cleaned and observe the effectiveness over time.

All surfaces impacted with black staining which were tested are coated with lead-based paints of varying concentrations. Although considered unlikely to be necessary if the lead-based paints are to be disturbed, controls in line with best practice should be put in place to ensure the risk from the lead based paint to the site owners, workers and surrounding environment are managed.

7 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Christchurch City Council, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the Engineering NZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on [redacted] if you require any further information.

Report prepared by

[redacted]

Environmental Scientist

Report reviewed by

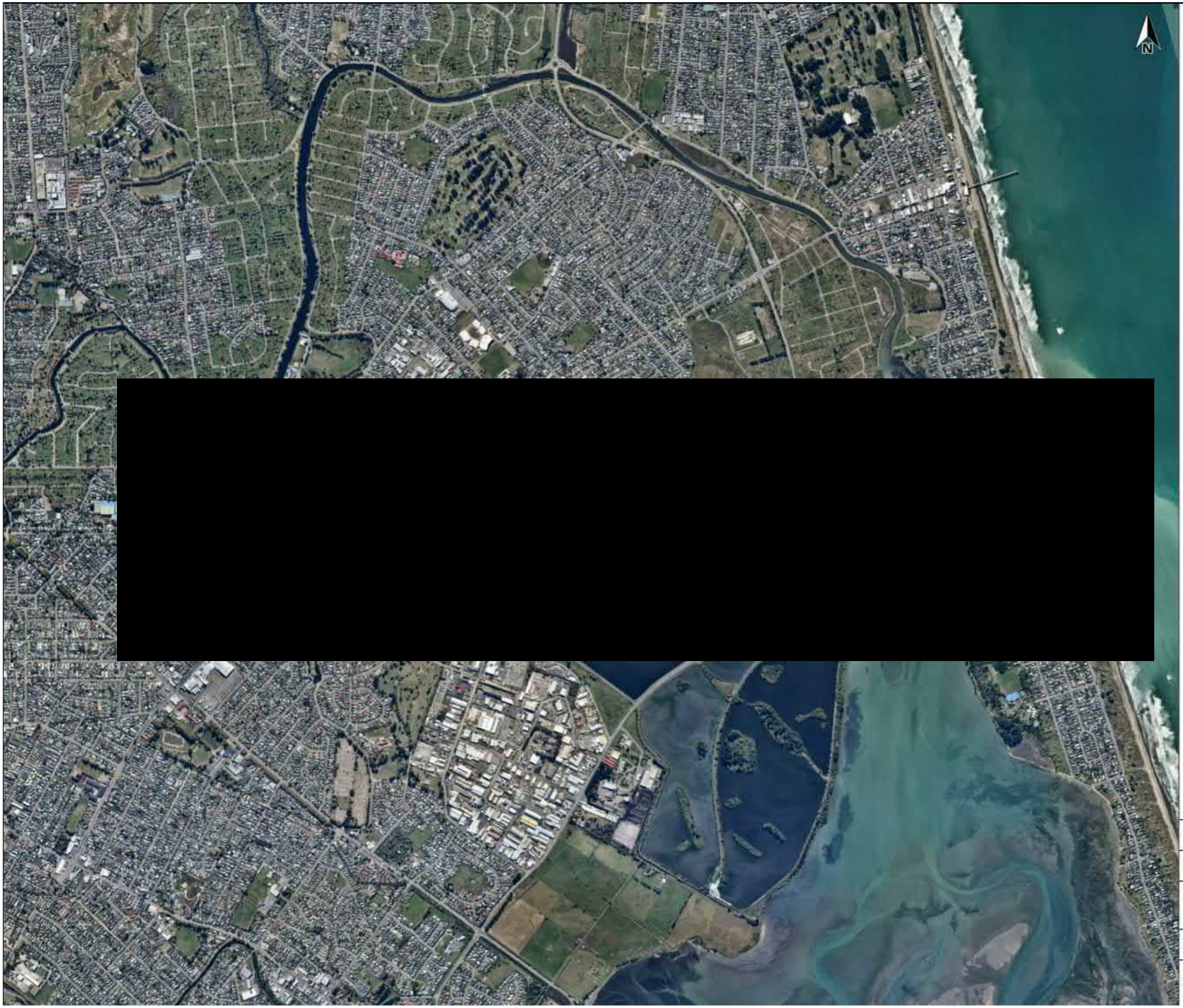
[redacted]

Principal Environmental Consultant

8 References

Feldstein, M. & Wohlers, H.C. (1966). Hydrogen Sulfide Darkening of Exterior Paint. Bay Area Pollution Control District, San Francisco, California.

FIGURES



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Title: Sample Location Map		
Client: Christchurch City Council		Figure No: 1 Size: A4
Project: Bromley Mould	Drawn: MK	
Date: 26-07-2022	Checked: JH	
Proj No: 20488.000.001	Scale: 1:30700	Version: Final

APPENDIX 1:

Hydrogen Sulfide Darkening of Exterior Paint (1966)

Hydrogen Sulfide Darkening of Exterior Paint

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Bay Area Air Pollution Control District, San Francisco, California

Hydrogen sulfide reacts with heavy metal salts in exterior paints to form a precipitate which discolors the paint. Variables of this reaction include: type and concentration of heavy metal in the paint, age and condition of the paint surface, concentration and time of hydrogen sulfide exposure as well as the temperature and relative humidity of the ambient atmosphere. Variables of this reaction will be reviewed in terms of literature references and field results in the San Francisco Bay Area.

Exterior paints containing heavy metal salts react with atmospheric hydrogen sulfide to darken or discolor the surface. Lead, mercury, cobalt, iron, and tin salts cause a gray or black discoloration; cadmium salts cause a yellowish-orange discoloration. Despite the advent of fume proof paints which contain negligible quantities of heavy metal salts (and hence will not discolor in the presence of hydrogen sulfide), the problem of hydrogen sulfide discoloration of exterior paint still exists in those areas where lead base paints are used.

This paper will present information on three phases of the problem of hydrogen sulfide darkening of exterior paint:

(*1*) The detection of the hydrogen sulfide effect on paint by both visual and chemical procedures, as well as methods for the sampling and analysis of hydrogen sulfide.
(*2*) A review of available references on the discoloration of paint by hydrogen sulfide based upon literature search.
(*3*) The experimental results of a number of field investigations in which many hundreds of homes were darkened by atmospheric hydrogen sulfide.

Detection of Hydrogen Sulfide Darkening of Paint and Methods of Sampling and Analysis for Atmospheric Concentrations of Hydrogen Sulfide

Visual Description of Hydrogen Sulfide Darkening of Paint

The darkening of a light tint paint can vary both in extent and severity.

From a distance of about 20 feet, a home severely discolored by hydrogen sulfide appears as if the color had been changed overnight from the original color to various tones of "battleship gray;" in some cases, the color change is to "jet black." In these cases, there is an almost uniform gray-to-black discoloration over most of the surface.

In mild cases, the gray-black discoloration may be noted only in specific areas of the surface such as under the eaves, around windows or doors and other areas which, because of location, tend to remain damp or are otherwise susceptible to the action of hydrogen sulfide.

From a distance, exterior surfaces discolored by fungus *Pullularia pullulans* appear similar to surfaces exposed to hydrogen sulfide. The two types of discoloration may be differentiated, using specialized techniques.

Variables involved in the darkening of surfaces by hydrogen sulfide include:

(*a*) the percent of heavy metal salts in the paint,
(*b*) the temperature and the presence of moisture,
(*c*) the presence of hydrogen sulfide in the air at concentrations of 50 parts per billion or higher for even short periods of time,
(*d*) the age and/or condition of the painted surface, and
(*e*) the presence or absence of other contaminants (such as sulfur dioxide which could bleach the darkened area, etc.).

The discoloration by hydrogen sulfide is not permanent. Chalking of the paint, washing of the surface by rain or bleaching by the sun will bring the original color back in time periods ranging from days to three to six months.

Chemical Identification of Hydrogen Sulfide Darkening of Paint

Simple chemical and physical tests are available to assist the investigator in a problem of paint darkening by hydrogen sulfide.

The presence of a heavy metal salt in the paint is confirmed by placing a drop of five percent sodium sulfide solution on the surface. If the drop turns black, a heavy metal salt is present in the paint. If the drop remains clear, no heavy metal salts are present (fume proof paint) and the paint will not turn black in the presence of hydrogen sulfide. If the drop turns a light brown color, two factors may be involved:

(*a*) the "second" coat may contain a small amount of a heavy metal salt either as a drier or fungicide, or
(*b*) the "second" coat may contain no heavy metal salt but the primer or underneath coat may contain lead which reacted with the sodium sulfide.

In both these cases, the painted surface may discolor in the presence of hydrogen sulfide.

The darkened area may be wiped with a cotton swab dipped in a solution of three percent hydrogen peroxide. If the original color is immediately restored, the darkening was caused by hydrogen sulfide. In the case of a mild discoloration by hydrogen sulfide, wiping with water may reduce the intensity of the discoloration.

The filamentous growth of bacteria can be identified readily with a low power hand lens. A drop of a five percent sodium hypochlorite solution will remove the mildew but will not readily remove hydrogen sulfide discoloration.

A painted surface uniformly soiled by dirt can be easily cleaned with a small amount of water.

Air Sampling and Analysis of Hydrogen Sulfide

Lead acetate saturated filter papers or tiles exposed in the area may be used to determine the source of the emitted hydrogen sulfide and to indicate the area of concern.

For both the paper or tile method, it is necessary to provide a simple shelter for protection against rain and/or bleaching by sunlight. For this purpose, an inverted, one-quart freezer container has been used. The freezer container is secured on a support using masking tape. The lead acetate strip (about twice as long as the width of the opening of the container) is stapled on opposite sides of the open bottom forming a loop inside the container. The tile, which should be shorter than the length of the freezer container, has a hole bored through one end and is suspended on a hook fastened to the solid, inverted top of the container.

Lead Acetate Paper

Hydrogen sulfide reacts with lead acetate saturated filter paper to form a dark stain of lead sulfide.[1-9] Such papers, exposed in a grid-like pattern, may be used to track down a suspected source of hydrogen sulfide emissions.

The lead acetate paper (strip) is most conveniently obtained from specialty companies.[10] Papers may also be prepared in the laboratory by a one-minute immersion in a solution of 10 grams lead acetate, 90 milliliters distilled water, five milliliters glacial acetic acid, and 10 milliliters glycerol. The superfluous liquid on the paper is allowed to drain off and the paper dried at room temperature. After drying, the top and bottom inch of the strip should be discarded.

Papers so prepared and stored should be replaced every two weeks. Commercially obtained papers are much more stable.

The grid-work of exposed papers should be examined and replaced at such times that there is a gradation of darkening on many of the papers; obviously, if the exposed papers are all jet black after exposure, the exposure time must be shortened.

The intensity of the darkened paper may be measured either visually or with a spot sampler for reading percent transmission through the tape.[10]

When the darkened paper is judged visually, the papers should be coded according to a rating such as described below:

0—No visible darkening
1—Slight darkening
2—Moderate darkening
3—Severe darkening

When a spot sampler is used to estimate the darkening of the paper, an "equivalent concentration" can be calculated based on the measured optical density and the use of the chart prepared by Sensenbaugh and Hemeon[3] relating optical density and parts per million hydrogen sulfide.

Unglazed Tiles

Unglazed tiles may be used in a manner similar to that described for lead acetate paper for studies involving paint darkening by hydrogen sulfide.[11-12] We have found that the lead acetate tiles are more sensitive to low concentrations of hydrogen sulfide and hence require more frequent replacement and evaluation. It is often difficult to obtain the required size tile and the cost per tile is much greater than the readily available paper strips.

Except for specialized problems, it is suggested that hydrogen sulfide studies use paper strips.

Automatic Samplers

Specialty houses[10] provide instrumentation to continuously monitor the atmosphere for hydrogen sulfide in concentrations below and above those which will darken paint (parts per billion range).

The hydrogen sulfide sampler utilizes lead acetate impregnated tape. Air is drawn through the tape for predetermined times (from minutes to hours) leaving a darkened area when hydrogen sulfide is present in the air. The measured optical density of the spot is proportional to the amount of hydrogen sulfide in the air sample.

A major disadvantage of this instrument is that the concentration of hydrogen sulfide is averaged over the sample time period. Thus, a final two-hour integrated sample may show a hydrogen sulfide concentration of 30 parts per billion; included in this concentration may be a 10-minute peak concentration of the order of 200 parts per billion.

Recent improvements in this type equipment include an instantaneous readout of hydrogen sulfide levels. In this manner, peak concentrations are recorded. Instrumentation is now available which will ring an alarm at preset air concentrations of hydrogen sulfide.

Whenever such equipment is used in a hydrogen sulfide survey, the equipment should be calibrated prior to field use.

Bubblers—Hydrogen Sulfide Analysis

Bubblers containing specific reagents[4, 13-16] may be used to sample for atmospheric hydrogen sulfide. Sequential bubbler samplers may be programmed to obtain samples over a 24 hour period.[10]

Air is bubbled through an alkaline solution of cadmium hydroxide. The concentration of the absorbed hydrogen sulfide is estimated by the methylene blue method.[13, 15, 16]

Literature References on the Effect of Hydrogen Sulfide on Paint

The precise air concentrations of hydrogen sulfide necessary to darken paint is not known. Our best estimate, based upon an evaluation of literature and field experimental tests, is that darkening of paint containing heavy metal salts can occur under favorable conditions at hydrogen sulfide levels of 50 parts per billion and higher.

The darkening of paint by hydrogen sulfide is the result of the color of the precipitated sulfide according to the reaction:

$$M^{++} + H_2S = MS + 2H^+$$

where M is a heavy metal salt. The subsequent oxidation or bleaching of the dark stain may be considered to be the reaction to form either a metal oxide or sulfate. Before the metal sulfide is precipitated, the solubility product of the sulfide salt must be exceeded.

Based upon the solubility product, Hoffman[17] calculated that lead sulfide would start to precipitate at a partial pressure of 1.4×10^{-7} mm mercury, corresponding to a hydrogen sulfide content of 0.001 micrograms/liter or about one part per billion. Corresponding values at pH 5 mercury, cobalt and iron sulfides were reported as 1.2×10^{-27}, 3.6×10^{2}, and 2.2×10^{3} partial pressures of hydrogen sulfide (mm mercury).

Although the calculated concentration of hydrogen sulfide to cause darkening (precipitation of lead sulfide) of paint may not be precise, the indication is that low levels of the order of parts per billion hydrogen sulfide can cause such a problem. Holbrow[18] agrees with this concept.

Sensenbaugh and Hemeon[3] report that concentrations of 100 parts per billion (ppb) hydrogen sulfide may be necessary to darken paint. Sullivan,[6] on the other hand, reported that paint darkening occurred at hydrogen sulfide concentrations of 50 ppb.

It can generally be concluded that paint darkening "always" occurs when hydrogen sulfide can be smelled. This would bring the critical concentration of hydrogen sulfide down to approximately 50 to 100 ppb.

Other references refer to paint darkening at relatively high concentrations of hydrogen sulfide—ranging from a H_2S saturated water solution down to 2000–5000 ppb.[19-21]

Field Studies of Paint Darkening

A field investigation was made of exterior paint darkening within the Bay Area Air Pollution Control District over a period of one and a half years. During this time period, there were seven separate episodes in which paint darkening occurred. One of the episodes occurred in the summertime while the remainder happened during wintertime conditions of higher humidity. The maximum two-hour average air concentration measured during the summertime in the affected area was

0.21 ppm H_2S. The maximum two-hour average concentration measured during the wintertime episodes was 0.11 ppm H_2S.

Early in the investigation about 50 specially prepared six by nine inch paint panels were exposed in the area of concern and in control areas. Lead and fume proof paints were used in six different combinations of prime and top coat. The panels were exposed during one summertime and two wintertime exposures. No blackening was observed on the paint panels during the period, even though homes were blackened. Hence, "new" lead base paint is insensitive to hydrogen sulfide exposure for at least 10 months at the air concentrations noted above. "Sensitized" or older surface coatings darkened overnight during this period.

Because of repeated hydrogen sulfide episodes, it was not possible to determine the precise time necessary for the blackened paint to revert back to the initial color. For the relatively mild summer fumigation, the color is restored by air oxidation in several days to a month. The more severe wintertime episodes, required six months after the last fumigation; however, some "jet-black" surfaces were not completely clean in this six month period.

It must be emphasized that a two-hour average air concentration for hydrogen sulfide can be misleading. Included within the two-hour average air concentration can be peak concentrations for short periods of time, 10 times the average air concentration. For field work, it is mandatory to use either short sampling periods of the order of 10 minutes or an integrating analyzer if two-hour sampling periods are used.

Hydrogen Sulfide Dosage

The attempt was made to fix the time-concentration relationship (dosage) for non-health air pollution effects of hydrogen sulfide. Using the California Standard of Ambient Air Quality for hydrogen sulfide (0.1 ppm for one hour) as a "cornerstone," Fig. 1 was prepared; this graph was based upon the formula:

$$C = \frac{0.099}{t} + 0\ 001$$

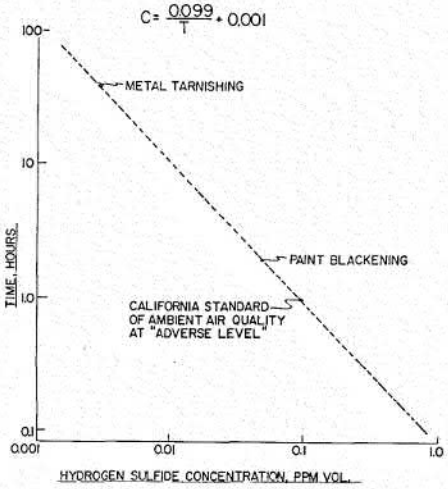
where:

C = H_2S concentration, ppm vol
t = time, hours.

Despite the myriad of variables, the use of Fig. 1 permits interesting projections hydrogen sulfide:

(*a*) levels above 0.1 ppm for one hour are annoying to the general public,
(*b*) levels above 0.05 ppm for several hours darken paint under optimum conditions, and
(*c*) levels above 0.003 ppm for about 40 hours blacken sensitive metals such as silver or copper.

Fig. 1. Time vs. concentration for hydrogen sulfide effects.



For hydrogen sulfide concentrations other than those noted in (*a*), (*b*), and (*c*), the time-concentration relationship shown in Fig. 1 may be used to determine the time factor.

Summary

(*1*) Chemical and visual tests are described to determine the presence of hydrogen sulfide darkening of exterior paint.

(*2*) Instrumentation is described to detect air concentrations of hydrogen sulfide.

(*3*) Literature references on hydrogen sulfide darkening of paint are reviewed.

(*4*) Results of paint darkening episodes in the Bay Area are described.

(*5*) The time-concentration relationship (dosage) for non-health air pollution effects of hydrogen sulfide is presented.

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APPENDIX 2:

Laboratory Results

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Engeo Limited	**Lab No:**	3006919 SPv1
Contact:	[redacted]	**Date Received:**	03-Jun-2022
	C/- Engeo Limited	**Date Reported:**	09-Jun-2022
	PO Box 373	**Quote No:**	82742
	Christchurch 8140	**Order No:**	
		Client Reference:	20488.000.001
		Submitted By:	[redacted]

Sample Type: Dried Paint

Sample Name:		[redacted] White	[redacted] White	[redacted] Beige	[redacted] White	[redacted] Beige
Lab Number:		3006919.1	3006919.2	3006919.3	3006919.4	3006919.5
Lead in paint						
Total Recoverable Lead	mg/kg dry wt	2,700	2,400	42,000	1,320	45,000
Total Recoverable Lead	% w/w	0.27	0.24	4.2	0.132	4.5
Paint classification		Lead Paint	Lead Paint	Lead Paint	Lead Paint	Lead Paint

Analyst's Comments

Samples 1-5 Comment:
The accuracy of the paint classification may be affected by the sampling strategy and procedure employed. Please ensure that the sampling strategy and procedure outlined in section A4 and section A3.2.2, respectively of AS/NZS 4361.2:2017 have been followed before interpreting these results. The classification of the paint has been determined using a decision rule that treats all values as fixed, with no consideration of the Uncertainty of Measurement (UoM) of the analysis performed. A paint that contains greater than 0.1% lead by mass in the dry film is defined as 'Lead Paint'.

Appendix No.1 - Chain of Custody

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Dried Paint

Test	Method Description	Default Detection Limit	Sample No
Lead in paint			
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-5
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-5
Total Recoverable Lead	Calculation: Total Recoverable Lead (mg/kg dry wt.) / 10,000 to convert to units of % by weight of dry paint.	0.00004 % w/w	1-5
Paint classification	Paint classification as per the following standard. AS/NZS 4361.2:2017 Guide to hazardous paint management Part 2: Lead paint in residential, public and commercial buildings.	-	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 08-Jun-2022 and 09-Jun-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

[redacted]
Client Services Manager - Environmental

Job No: 300 6919 Date Recv: 03-Jun-22 13:53

ENVIRONMENTAL Analysis Request Form

Hill Laboratori

R J Hill Laboratories Limited — accredited b
Accreditation NZ
1 Clyde Street, Telephone: +6
Private Bag 3205, Facsimile: +6

Received by: Kate Evans

3130069198

CLIENT

Name ENGEO Ltd. [160117]

PO Box 373

Christchurch 8140

Phone: 03 328 9012 Fax:

Client Reference: 20488.000.001 (Project Code)

Quote Number: Order No: (Cost Centre)

Hill Laboratories office use only:

Date In Job # No. of Samples

Submitted By [redacted]

Charge To: ENGEO. [160117]

RESULTS TO

☐ Mail Client ☐ Mail Submitter

☐ Fax Results

X Email Results

✠ C.O.C & coversheet to be scanned and emailed back

Additional Information

Chain of Custody Record

Delivered to Hill Laboratories (Depatched by)	Date & Time: 3/6/22 Name: [redacted] Signature: [redacted]
Received at Hill Laboratories	Date & Time: Name: Signature:
Condition	☐ Ambient Temp ☐ Chilled ____ °C

PRIORITY ☐ **Normal** (up to 10 days) ✠ **High** (approx 5 days) ☐ **Urgent** (MUST be pre-arranged)

Results required by: .....

Sample types

GW	Bore/well	**TW**	Trade waste	**S**	Saline water	**ES**	Soil/Solid	**Pl**	Plant
SW	Surface water	**E**	Effluent	**O**	Oil	**Sed**	Sediment	**BM**	Fish/shellfish/Biota
P	Potable/DI	**L**	Leachate	**Sl**	Sludge	**BS**	Biosolid	**M**	Misc (Specify)

Site ID	Sample type	Tests required	Comments
[redacted] White	Paint	Lead	Please table/Name
White	"	Lead	Samples as
Beige	"	Lead	per CoC
White	"	Lead	
Beige	"	Lead	
[redacted]			

Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

17 June 2022

Biodet Ref: 22/46021
Client Ref: [redacted]

ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Dear Jonathan

Re: **SPORE TRAP AND SELLOTAPE® SAMPLES FOR MICROBIOLOGICAL EXAMINATION**

Building/Ref: [redacted]
Samples taken: 2 June 2022
Samples received: 8 June 2022
Samples analysed: 15 June 2022

Laboratory Number	Sample Type	Location
46021/1	Spore Trap	Outside dwelling
46021/2	Sellotape® swab	Outside cladding

METHODS:

The spore trapping sample (Non-culturable Method) was taken using a Buck BioSlide sampler and was analysed by ASTM D 7391 -20 'Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy'.

The Sellotape® swab was analysed by ASTM D7658-17 (Reapproved 2021) Standard Test Method for 'Direct Microscopy of Fungal Structures from Tape'.

RESULTS:

Non-Culturable Air Spore Trapping Results:

See attached spore trapping report.

Macroscopic and Microscopic Examination of the Sellotape® swab:

Sample ID	Macroscopic features	Microscopic features and comments
46021/2	***Sample:*** Sellotape® swab ***Appearance***: Dark discolouration noted across the tape.	*Stachybotrys* were not detected. A high level of amorphous particulate with areas of a low-level *Cladosporium*-like fungus. Growth active. A low level of *Epicoccum* spores was also observed. ***Conclusion***: Likely superficial fungal growth within a buildup of dust/ debris in response to condensed moisture on a surface.

Note: Active fungal growth can be determined by the presence of distinct fungal hyphae and structures that readily take up stain.

DISCUSSION

The presence of fungi always indicates that moisture is or has been present.

Stachybotrys was not detected suggesting that conditions were not suitable for the growth of this fungus.

Cladosporium species are common air-borne contaminants particularly in outdoor air. They are commonly found on outdoor claddings, particularly timber and will also grow on surfaces that have a moisture level between 15 and 20%, often in response to slightly elevated moisture levels such as condensation. The main effect of the fungus is disfigurement of the surface that the fungus is growing on.

OVERALL CONCLUSIONS:

- The spore levels and types in the outdoor air were typical of an outdoor environment and were comparable to the Biodet averages for an outdoor air.
- The tape sample exhibited a high level of amorphous particulate with a low level of a *Cladosporium*-like fungus. This fungus is commonly found growing on outdoor claddings in response to slightly raised moisture levels.

RECOMMENDATIONS:

- The black discolouration on hard surfaces can be cleaned off by washing with warm soapy water.

I hope this information is of help to you. If you have any queries please do not hesitate to contact me.

Yours faithfully

[redacted]

The samples were tested as received.

Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

NON-CULTURABLE AIR SAMPLING REPORT

DATE OF REPORT 17 June 2022
BUILDING: [redacted]
DATE SAMPLE TAKEN: 2 June 2022
DATE SAMPLE RECEIVED: 8 June 2022
DATE SAMPLE ANALYSED: 15 June 2022
BIODET REF NO: 22/46021

CLIENT: ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Method : ASTM D 7391 -20 Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy
Air Volume sampled: 150 litres of air. (Sampled using a Buck Bioslide sampler)
The final result is expressed as fungal structures per meter cubed (/m^3). Limit of detection is 7 fungal structures per m^3 (0 = <7)

Sample Number	Slide Number	Location	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces*	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	Fungal Structures TOTAL /m^3	Spore Clusters	Pollen
46021/1	02344607	Outdoor	53	27	0	0	0	0	0	0	0	40	700	27	5367	**6214**	13	220

Particle Analysis - Extraneous Material

Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
46021/1	02344607	Outdoor	0	+	+	+	+	+

Particle Level Key

Abundant	+++++
High	++++
Moderate	+++
Light	++
Sporadic	+
Not present	**0**

CONCLUSIONS:

The spore levels and types observed were typical of an outdoor environment, and were comparable to the Biodet averages for an outdoor air.

Yours faithfully

[redacted]

[redacted]

The sample was tested as received.
This report must not be reproduced except in full.

AIHA PROFICIENCY ANALYTICAL TESTING PROGRAMS
Fungal Direct Examination Test
Biodet Services Ltd status: **Proficient**

Biodet Services Ltd
Consulting Industrial Microbiologists

BIODET OUTDOOR SPORE TRAP DATABASE (Average counts taken from indoor sources throughout New Zealand between 2017 and 2020)

	Cladosporium	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m^3**	Spore Clusters	Pollen Grains
Spring (Taken 1 September to 30 November)	787	54	0	0	2	1	0	4	0	25	151	19	3871	**4914**	83	156
Summer (Taken 1 December to 28/29 February)	2160	129	0	0	21	8	7	33	9	51	504	46	8969	**11937**	216	55
Autumn (Taken 1 March to 31 May)	1013	122	0	0	16	0	1	20	2	50	676	24	9418	**11342**	122	28
Winter (Taken 1 June to 31 August)	172	77	0	0	1	0	1	1	0	39	254	14	6479	**7038**	47	66

* This category was separated out from *Alternaria*/*Ulocladium* in 2020

INTERPRETATION OF RESULTS

Unless stated all sample traces are 100% examined at 1000x magnification which is higher than recommended in the methodology. This is to ensure the minute differences between fungal spores are more easily identified allowing them to be accurately catergorised.

Due to the numerous variations observed with sporetrapping it is important that a microbiologist with experience interpret the results.

Biodet staff take part in the AIHA Proficiency Analytical Testing Program for Fungal Direct Examination. This is an international interlaboratory comparison program comprising of laboratories across the world. Results may be supplied upon request.

Biodet staff interpret the results based on the information given by the client, previous results (if known) and our experience gained from analysing spore trap samples and assisting with air quality investigations since 2003.

Many fungal types found in outdoor air can also be the types that grow indoors in response to moisture. This is why it is recommended to take an outdoor sample with each job to show what current 'normal' levels and types are for each geographical location. This allows Biodet staff to compare the indoor fungal species and levels with the outdoor fungal species and levels, as well as with our database, to determine whether there are any indications of moisture issues.

In areas where there are no moisture issues it is typical to find that fungal spore counts taken from non-air-conditioned indoor areas are similar to or lower than the outdoor air, where as fungal spore counts taken from well maintained HVAC air-conditioned areas are typically significantly lower than the outdoor air.

The presence of some fungal spores in an indoor environment even in low levels, such as *Stachybotrys* and *Chaetomium*, can be an indication that there are moisture issues. For other fungal types such as *Cladosporium* or Basidiomycete spores a 10-fold increase may indicate a site of fungal amplification. These subtle variations show why it is important that a microbiologist with experience interprets the results.

The 'Other Spore Types' category are comprised of microscopically unidentifiable fungal spores, Smuts/Myxomycete/Periconia and a range of ascospores (fungal spores produced in a sac or body in response to adverse environmental conditions) and some basidiospore types. The majority of these spores are not associated with specific health issues, but exist in the natural environment, especially where there is dense vegetation or soil. Levels will vary due to seasonal variation and proximity to vegetation etc. Occasionally a spore type not represented by any of the other categories is noted in this category, and if the level of this spore type was significantly different to the outdoor air or other indoor samples, it would be specifically commented on.

Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

17 June 2022

Biodet Ref: 22/46022
Client Ref: [redacted]

[redacted]
ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Dear [redacted]

Re: **SPORE TRAP AND SELLOTAPE® SAMPLES FOR MICROBIOLOGICAL EXAMINATION**

Building/Ref: [redacted]
Samples taken: 2 June 2022
Samples received: 8 June 2022
Samples analysed: 16 June 2022

Laboratory Number	Sample Type	Location
46022/1	Spore Trap	Outside dwelling
46022/2	Sellotape® swab	Outside cladding

METHODS:

The spore trapping sample (Non-culturable Method) was taken using a Buck BioSlide sampler and was analysed by ASTM D 7391 -20 'Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy'.

The Sellotape® swab was analysed by ASTM D7658-17 (Reapproved 2021) Standard Test Method for 'Direct Microscopy of Fungal Structures from Tape'.

RESULTS:

Non-Culturable Air Spore Trapping Results:

See attached spore trapping report.

Macroscopic and Microscopic Examination of the Sellotape® swab:

Sample ID	Macroscopic features	Microscopic features and comments
46022/2	***Sample:*** Sellotape® swab ***Appearance***: Pale brown discolouration noted across the tape.	*Stachybotrys* were not detected. A high level of amorphous particulate with occasional miscellaneous fungal spores. ***Conclusion***: Likely an accumulation of dust/ debris including fungal spores. No evidence of active fungal growth.

Note: Active fungal growth can be determined by the presence of distinct fungal hyphae and structures that readily take up stain.

OVERALL CONCLUSIONS:

- The spore levels and types in the outdoor air were typical of an outdoor environment and were comparable to the Biodet averages for an outdoor air.
- The tape sample exhibited a high level of amorphous particulate.

RECOMMENDATIONS:

- The discolouration on hard surfaces can be cleaned off by washing with warm soapy water.

I hope this information is of help to you. If you have any queries please do not hesitate to contact me.

Yours faithfully

[redacted]

The samples were tested as received.
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Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

NON-CULTURABLE AIR SAMPLING REPORT

DATE OF REPORT 17 June 2022
BUILDING: [redacted]
DATE SAMPLE TAKEN: 2 June 2022
DATE SAMPLE RECEIVED: 8 June 2022
DATE SAMPLE ANALYSED: 16 June 2022
BIODET REF NO: 22/46022

CLIENT: ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Method : ASTM D 7391 -20 Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy
Air Volume sampled: 150 litres of air. (Sampled using a Buck Bioslide sampler)
The final result is expressed as fungal structures per meter cubed (/m^3). Limit of detection is 7 fungal structures per m^3 (0 = <7)

Sample Number	Slide Number	Location	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces*	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	Fungal Structures TOTAL /m^3	Spore Clusters	Pollen
46022/1	02328414	Outdoor	387	33	0	0	0	0	0	7	0	53	447	27	2867	**3821**	40	0

Particle Analysis - Extraneous Material

Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
46022/1	02328414	Outdoor	0	+	+	+	+	++

Particle Level Key

Abundant	+++++
High	++++
Moderate	+++
Light	++
Sporadic	+
Not present	**0**

CONCLUSIONS:

The spore levels and types observed were typical of an outdoor environment, and were comparable to the Biodet averages for an outdoor air.

Yours faithfully

[redacted]

[redacted]

B.Sc.

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This report must not be reproduced except in full.

AIHA PROFICIENCY ANALYTICAL TESTING PROGRAMS

Fungal Direct Examination Test

Biodet Services Ltd status: **Proficient**

Biodet Services Ltd
Consulting Industrial Microbiologists

BIODET OUTDOOR SPORE TRAP DATABASE (Average counts taken from indoor sources throughout New Zealand between 2017 and 2020)

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* This category was separated out from *Alternaria*/*Ulocladium* in 2020

INTERPRETATION OF RESULTS

Unless stated all sample traces are 100% examined at 1000x magnification which is higher than recommended in the methodology. This is to ensure the minute differences between fungal spores are more easily identified allowing them to be accurately catergorised.

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Biodet staff interpret the results based on the information given by the client, previous results (if known) and our experience gained from analysing spore trap samples and assisting with air quality investigations since 2003.

Many fungal types found in outdoor air can also be the types that grow indoors in response to moisture. This is why it is recommended to take an outdoor sample with each job to show what current 'normal' levels and types are for each geographical location. This allows Biodet staff to compare the indoor fungal species and levels with the outdoor fungal species and levels, as well as with our database, to determine whether there are any indications of moisture issues.

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The presence of some fungal spores in an indoor environment even in low levels, such as *Stachybotrys* and *Chaetomium*, can be an indication that there are moisture issues. For other fungal types such as *Cladosporium* or Basidiomycete spores a 10-fold increase may indicate a site of fungal amplification. These subtle variations show why it is important that a microbiologist with experience interprets the results.

The 'Other Spore Types' category are comprised of microscopically unidentifiable fungal spores, Smuts/Myxomycete/Periconia and a range of ascospores (fungal spores produced in a sac or body in response to adverse environmental conditions) and some basidiospore types. The majority of these spores are not associated with specific health issues, but exist in the natural environment, especially where there is dense vegetation or soil. Levels will vary due to seasonal variation and proximity to vegetation etc. Occasionally a spore type not represented by any of the other categories is noted in this category, and if the level of this spore type was significantly different to the outdoor air or other indoor samples, it would be specifically commented on.

Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

17 June 2022

Biodet Ref: 22/46023
Client Ref: [redacted]

ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Dear [redacted]

Re: **SPORE TRAP AND SELLOTAPE® SAMPLES FOR MICROBIOLOGICAL EXAMINATION**

Building/Ref: [redacted]
Samples taken: 2 June 2022
Samples received: 8 June 2022
Samples analysed: 16 June 2022

Laboratory Number	Sample Type	Location
46023/1	Spore Trap	Outside dwelling
46023/2	Sellotape® swab	Outside cladding

METHODS:

The spore trapping sample (Non-culturable Method) was taken using a Buck BioSlide sampler and was analysed by ASTM D 7391 -20 'Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy'.

The Sellotape® swab was analysed by ASTM D7658-17 (Reapproved 2021) Standard Test Method for 'Direct Microscopy of Fungal Structures from Tape'.

RESULTS:

Non-Culturable Air Spore Trapping Results:

See attached spore trapping report.

Macroscopic and Microscopic Examination of the Sellotape® swab:

Sample ID	Macroscopic features	Microscopic features and comments
46023/2	***Sample:*** Sellotape® swab ***Appearance***: Light grey and pale discolouration noted across the tape, with paint fleck adhering.	*Stachybotrys* were not detected. A high level of amorphous particulate with occasional miscellaneous fungal spores. ***Conclusion***: Likely an accumulation of dust/ debris including fungal spores. No evidence of active fungal growth.

Note: Active fungal growth can be determined by the presence of distinct fungal hyphae and structures that readily take up stain.

OVERALL CONCLUSIONS:

- The spore levels and types in the outdoor air were typical of an outdoor environment and were comparable to the Biodet averages for an outdoor air.
- The tape sample exhibited a high level of amorphous particulates.

RECOMMENDATIONS:

- The discolouration on hard surfaces can be cleaned off by washing with warm soapy water.

I hope this information is of help to you. If you have any queries please do not hesitate to contact me.

Yours faithfully

[redacted]

B.Sc.
The samples were tested as received.
This report must not be reproduced except in full.

Biodet Services Ltd
Consulting Industrial Microbiologists

Unit K, 383 Khyber Pass Road, PO Box 99010, Newmarket, Auckland 1149. Phone: 09-529-1563, E-mail: office@biodet.co.nz, www.biodet.co.nz

NON-CULTURABLE AIR SAMPLING REPORT

DATE OF REPORT 17 June 2022
BUILDING: [redacted]
DATE SAMPLE TAKEN: 2 June 2022
DATE SAMPLE RECEIVED: 8 June 2022
DATE SAMPLE ANALYSED: 16 June 2022
BIODET REF NO: 22/46023

CLIENT: ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Method : ASTM D 7391 -20 Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy
Air Volume sampled: 150 litres of air. (Sampled using a Buck Bioslide sampler)
The final result is expressed as fungal structures per meter cubed (/m^3). Limit of detection is 7 fungal structures per m^3 (0 = <7)

Sample Number	Slide Number	Location	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces*	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	Fungal Structures TOTAL /m^3	Spore Clusters	Pollen
46023/1	02341663	Outdoor	780	0	0	0	0	0	0	0	0	60	220	13	2700	**3773**	67	0

Particle Analysis - Extraneous Material

Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
46023/1	02341663	Outdoor	+	+	+	+	++	+++

Particle Level Key

Abundant	+++++
High	++++
Moderate	+++
Light	++
Sporadic	+
Not present	**0**

CONCLUSIONS:

The spore levels and types observed were typical of an outdoor environment, and were comparable to the Biodet averages for an outdoor air.

Yours faithfully

[redacted]

The sample was tested as received.
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AIHA PROFICIENCY ANALYTICAL TESTING PROGRAMS
Fungal Direct Examination Test
Biodet Services Ltd status: **Proficient**

Biodet Services Ltd
Consulting Industrial Microbiologists

BIODET OUTDOOR SPORE TRAP DATABASE (Average counts taken from indoor sources throughout New Zealand between 2017 and 2020)

	Cladosporium	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m^3**	Spore Clusters	Pollen Grains
Spring (Taken 1 September to 30 November)	787	54	0	0	2	1	0	4	0	25	151	19	3871	**4914**	83	156
Summer (Taken 1 December to 28/29 February)	2160	129	0	0	21	8	7	33	9	51	504	46	8969	**11937**	216	55
Autumn (Taken 1 March to 31 May)	1013	122	0	0	16	0	1	20	2	50	676	24	9418	**11342**	122	28
Winter (Taken 1 June to 31 August)	172	77	0	0	1	0	1	1	0	39	254	14	6479	**7038**	47	66

* This category was separated out from *Alternaria*/*Ulocladium* in 2020

INTERPRETATION OF RESULTS

Unless stated all sample traces are 100% examined at 1000x magnification which is higher than recommended in the methodology. This is to ensure the minute differences between fungal spores are more easily identified allowing them to be accurately catergorised.

Due to the numerous variations observed with sporetrapping it is important that a microbiologist with experience interpret the results.

Biodet staff take part in the AIHA Proficiency Analytical Testing Program for Fungal Direct Examination. This is an international interlaboratory comparison program comprising of laboratories across the world. Results may be supplied upon request.

Biodet staff interpret the results based on the information given by the client, previous results (if known) and our experience gained from analysing spore trap samples and assisting with air quality investigations since 2003.

Many fungal types found in outdoor air can also be the types that grow indoors in response to moisture. This is why it is recommended to take an outdoor sample with each job to show what current 'normal' levels and types are for each geographical location. This allows Biodet staff to compare the indoor fungal species and levels with the outdoor fungal species and levels, as well as with our database, to determine whether there are any indications of moisture issues.

In areas where there are no moisture issues it is typical to find that fungal spore counts taken from non-air-conditioned indoor areas are similar to or lower than the outdoor air, where as fungal spore counts taken from well maintained HVAC air-conditioned areas are typically significantly lower than the outdoor air.

The presence of some fungal spores in an indoor environment even in low levels, such as *Stachybotrys* and *Chaetomium*, can be an indication that there are moisture issues. For other fungal types such as *Cladosporium* or Basidiomycete spores a 10-fold increase may indicate a site of fungal amplification. These subtle variations show why it is important that a microbiologist with experience interprets the results.

The 'Other Spore Types' category are comprised of microscopically unidentifiable fungal spores, Smuts/Myxomycete/Periconia and a range of ascospores (fungal spores produced in a sac or body in response to adverse environmental conditions) and some basidiospore types. The majority of these spores are not associated with specific health issues, but exist in the natural environment, especially where there is dense vegetation or soil. Levels will vary due to seasonal variation and proximity to vegetation etc. Occasionally a spore type not represented by any of the other categories is noted in this category, and if the level of this spore type was significantly different to the outdoor air or other indoor samples, it would be specifically commented on.

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17 June 2022

Biodet Ref: 22/46024
Client Ref: [redacted]

ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Dear [redacted]

Re: **SPORE TRAP AND SELLOTAPE® SAMPLES FOR MICROBIOLOGICAL EXAMINATION**

Building/Ref: [redacted]
Samples taken: 2 June 2022
Samples received: 8 June 2022
Samples analysed: 16 June 2022

Laboratory Number	Sample Type	Location
46024/1	Spore Trap	Outside dwelling
46024/2	Sellotape® swab	Outside cladding

METHODS:

The spore trapping sample (Non-culturable Method) was taken using a Buck BioSlide sampler and was analysed by ASTM D 7391 -20 'Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy'.

The Sellotape® swab was analysed by ASTM D7658-17 (Reapproved 2021) Standard Test Method for 'Direct Microscopy of Fungal Structures from Tape'.

RESULTS:

Non-Culturable Air Spore Trapping Results:

See attached spore trapping report.

Macroscopic and Microscopic Examination of the Sellotape® swab:

Sample ID	Macroscopic features	Microscopic features and comments
46024/2	***Sample:*** Sellotape® swab ***Appearance***: Brown discolouration noted across the tape.	*Stachybotrys* were not detected. A high level of amorphous particulate with occasional miscellaneous fungal spores. ***Conclusion***: Likely an accumulation of dust/ debris including fungal spores. No evidence of active fungal growth.

Note: Active fungal growth can be determined by the presence of distinct fungal hyphae and structures that readily take up stain.

OVERALL CONCLUSIONS:

- The spore levels and types in the outdoor air were typical of an outdoor environment and were comparable to the Biodet averages for an outdoor air.
- The amorphous particulate level was higher than usual in the air sample. This may reflect a dusty environment, or construction/building or road works in the vicinity.
- The tape sample exhibited a high level of amorphous particulate.

RECOMMENDATIONS:

- The discolouration on hard surfaces can be cleaned off by washing with warm soapy water.

I hope this information is of help to you. If you have any queries please do not hesitate to contact me.

Yours faithfully

[redacted]

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NON-CULTURABLE AIR SAMPLING REPORT

DATE OF REPORT 17 June 2022
BUILDING: [redacted]
DATE SAMPLE TAKEN: 2 June 2022
DATE SAMPLE RECEIVED: 8 June 2022
DATE SAMPLE ANALYSED: 16 June 2022
BIODET REF NO: 22/46024

CLIENT: ENGEO Ltd
124 Montreal Street
Sydenham
CHRISTCHURCH 8023

Attn: [redacted]

Method : ASTM D 7391 -20 Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy
Air Volume sampled: 150 litres of air. (Sampled using a Buck Bioslide sampler)
The final result is expressed as fungal structures per meter cubed (/m^3). Limit of detection is 7 fungal structures per m^3 (0 = <7)

Sample Number	Slide Number	Location	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces*	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	Fungal Structures TOTAL /m^3	Spore Clusters	Pollen
46024/1	02343576	Outdoor	373	0	0	0	0	13	0	0	0	60	233	20	4200	**4899**	40	7

Particle Analysis - Extraneous Material

Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
46024/1	02343576	Outdoor	0	+	+	+	++	++++

Results highlighted in red are considered to be unusual amplification.

Particle Level Key

Abundant	+++++
High	++++
Moderate	+++
Light	++
Sporadic	+
Not present	**0**

CONCLUSIONS:

The spore levels and types observed were typical of an outdoor environment, and were comparable to the Biodet averages for an outdoor air.

It is unusual to observed a high level of amorphous particulates outdoors. The finding may indicate a dusty or disturbed environment.

Yours faithfully

[redacted]

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AIHA PROFICIENCY ANALYTICAL TESTING PROGRAMS
Fungal Direct Examination Test
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