Document 3

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Block C Performance & Condition Report

Hutt Valley High School
Woburn Road
Lower Hutt

CoveKinloch
BUILDING CONSULTANTS & ASSET MANAGERS

Document 3

Block C Performance & Condition Report

Block C

WLG771-17/4

PREPARED FOR:

Hutt Valley High School
84-114 Woburn Road
LOWER HUTT 5010

Email: craig.braun@hvhs.school.co.nz

8/04/2021

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Document 3

Table of Contents | Page

Document 3

Section 1.0 General Information

1.1 Introduction

This Performance & Condition Report for block C has been prepared by Stuart Jeffs Registered Building Surveyor of CoveKinloch New Zealand Ltd on behalf of Hutt Valley High School as per the signed offer of service dated 31/3/2021.

General particulars of this report are as follows:

Commissioned by:	Hutt Valley High School.
Site Address:	84 – 114 Woburn Road, Lower Hutt.
Inspection Date:	29 – 31/3/2021
Inspection by:	Stuart Jeffs & Stefan Baines
Other persons present:	School was Operational.
Weather:	29/3/2021 – Overcast with mist and light rain
	30/3/2021 – Rain on and off Light winds
	31/3/2021 – Southerly with rain in the afternoon.

1.2 Extent of Instructions

Scope of service

It is our understanding you would like investigations carried out to establish how the building is preforming, condition of internal spaces, identification of active external moisture ingress and resulting damage from longstanding roof leaks.

The purpose of the investigations is to identify how the building is preforming and if longstanding moisture issues has impacted on the internal teaching spaces.

- Undertake site visits to inspect internal and external spaces of Block C to identify resulting damage from longstanding water ingress issues and determine if the internal environment has been impacted.

- Where timber decay is observed or suspected, remove a sample of timber and have it analysed to confirm the species of timber, decay morphology and timber treatment levels.

- Provide a report with photographs and laboratory analysis of timber samples identifying the overall condition of the investigated structural framing timbers.

- An electronic copy of the report will be provided by email in pdf format only.

Considerations

- Additional site visits maybe required where samples have been removed and confirmed to contain the presence of fungal decay or toxigenic mould.

- Timber decay analysis at the laboratory averages $195.00 per sample. We will test timbers to identify timber species, decay morphology and any timber treatment to determine the extent of remediation or replacement requirements. Depending on laboratory results additional site visits and timber samples may be required.

- We have not been made aware of any asbestos containing material (ACM) present in locations requiring investigations. If ACM is suspected, we will notify you before proceeding to agree the best approach and associated costs.
- Architectural or Structural Engineering drawings or Specifications of any recommended repairs is excluded and requires specialists' separate input for any identified remediation requirements.

1.3 Documents Provided

The following documents provided by the school or previously investigated assisting this report:

- Biodet Services Report 21/43015 dated 19/03/2021.
- Block C Floor Plan.

1.4 Documents Referenced

The following documents are referenced in this report as they are applicable to the standards of construction at the time or building performance expectations:

- BRANZ Psychrometric & Sorption Charts for concrete and timber.
- BRANZ Indoor Air Quality in New Zealand Homes and Schools - 01/2017
- World Health Organisation – Europe WHO guidelines for indoor air quality: dampness and mould – 2009.
- Ministry of Education Catalogue of Standard School Buildings – 08/2013.
- CoveKinloch HVHS Roof Condition Report – 07/2019.
- New Zealand Building Code – 2004.

1.5 Formal Dialogue

Formal dialogue has been undertaken between CoveKinloch New Zealand Ltd and the following parties in connection with this report:

- Denise Johnson – Principal HVHS.
- Craig Braun – Business Manager HVHS.
- Simon Kydd – Property Manager HVHS.

1.6 Methodology

The site survey of Block C has been undertaken using visual aids assisted by moisture meters, air sampling equipment and selected invasive and destructive testing. The northwest quarter of Block C closed to further school use due to unfavourable indoor air quality.

Photographs were taken during the survey, copies of which are included the body of the report.

A moisture meter was used to detect moisture content of the indoor environment, relative humidity, air temperatures, surface temperatures and wood and concrete moisture contents. It is not possible however to guarantee that all areas of water penetration have been covered due to possible leaks from hidden pipework, blocked drains etc which are not readily evident during the survey.

The report has been compiled from the evidence gathered from site, describing the construction of Block C, condition and current performance of the building.

1.7 Reporting Conditions

This report has been prepared under the following conditions of engagement:

a. This is a report on the condition and current performance of Block C generally based on the northwest quarter of Block C which has been closed to further use due to unfavourable internal air quality.
b. As the purpose of the investigation was to assess the general condition of Block C with minimal disturbance to the operating areas of the Block, based on the inspection described in (a) this report may not identify all past, present or future defects. Any area or component of the building or any item or system not specifically identified in this report as having been inspected was excluded from the scope of the inspection.
c. The survey does not cover any temporary fixtures, fittings or chattels on or at the property.
d. This report is provided for the use of Hutt Valley High School and their legal representatives only. CoveKinloch New Zealand Ltd accepts no liability to third parties who may act on the contents of this report.

1.8 Moisture Content & Relative Humidity Analysis

A Protimeter MMS moisture meter with current calibration to August 2021 was used for the recording of moisture content in the timber and concrete relative humidity, air temperatures and surface temperatures. No attempt has been made to correct for species of timber, timber treatment or minor variations possible in moisture content readings displayed which are included in this report.

Moisture content and the potential for decay in the timber framing and adjacent substrates should be considered according to the following criteria:

Normal: Moisture content below 18%. Decay is considerably reduced with the exception of the dry rot fungus Serpula lacrymans.

Concern: Moisture content between 18 and 30%. Decay is uncertain. Initiation of decay requires higher moisture levels than for maintenance. Establishment probably requires levels closer to 30% (24 – 30%), whereas on-going decay occurs at 22 – 25%.

Severe: Moisture contents over 30%. Decay is almost certain. This is close to the moisture saturation point of wood. To get above fibre saturation levels liquid water must be present.

1.9 Comments & Exclusions

- Additional site visits maybe required where samples have been removed and confirmed to contain presence of fungal decay or toxigenic mold.
- Detailed drawings of any recommended solutions.
- Detailed seasonal analysis of Building Performance. The investigations have allowed a snap-shot review of current performance reflecting on past performance with consideration of future performance, a holistic review of Block C.

1.10 Areas Not Accessed

The balance of the school property other than Block C for the investigations.

1.11 Building Orientation

All orientations are described using compass North and as viewing the element being described.

1.12 Building History

Block C is of S68 Generic Block design used between 1968 and 1974. Constructed 1971-1972 Block C is 50-years old, in original format with no changes to the structure of the School Block.

Interior alterations have changed the floor plan slightly over the years to address teacher and learning spaces as required.

S68 design definition from the MOE catalogue produced for the Canterbury region schools following the earthquakes of 2010 and 2011.

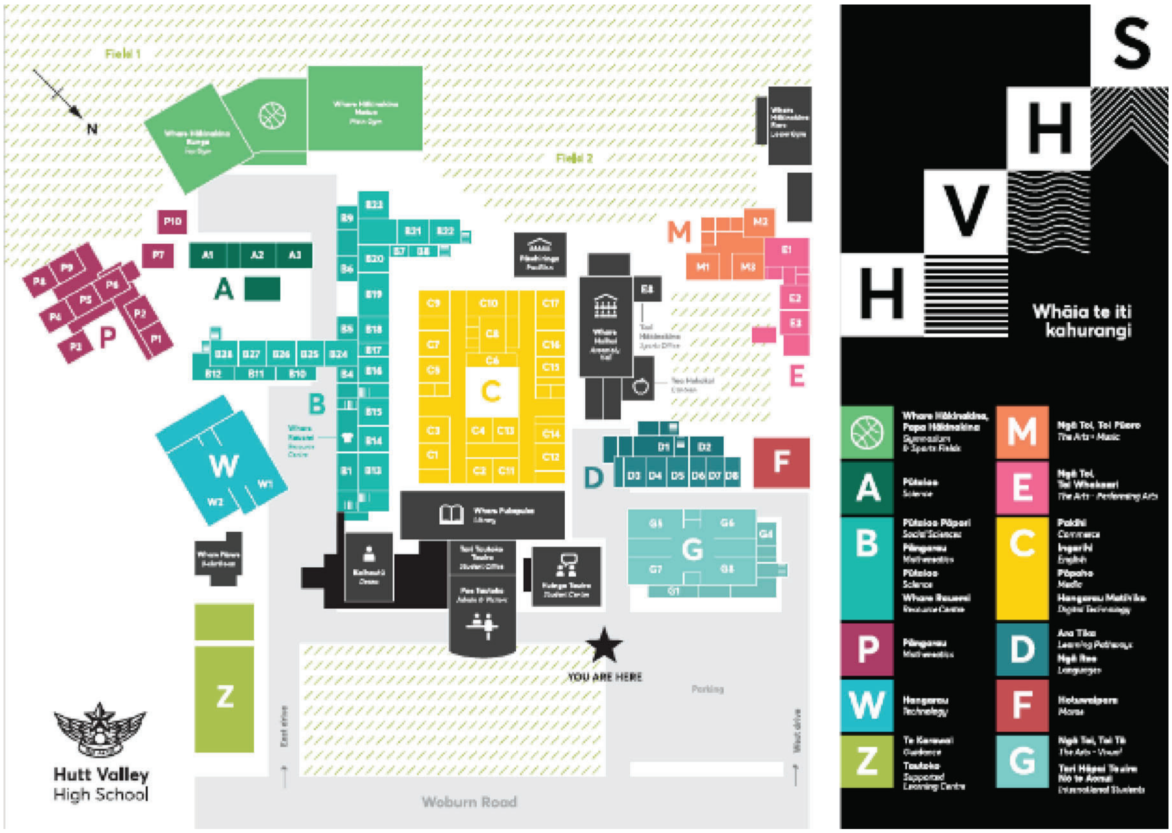
Document 3

Building description		Variants within standard design
Roof	Flat roof – Originally trough section roofing but most schools reroofed with butynol. Laminated timber rafters with timber ceiling.	Timber rafters may be replaced with steel trusses.
Walls and cladding	Double single masonry block with block or brick veneer and reinforced concrete block structure.	Brick veneer in lieu of Block.
Floor and foundations	Concrete slab floor	Unknown
Constructed	From 1968 to 1974	*(approximate date range only)*
Key identifying features	Flat roofs with exposed rafter windows between block piers. Buildings in groups with long corridors between classrooms and central court yards in middle of blocks.	Blocks vary between Arts and Craft block with large hall, technology blocks with longer classroom spaces, science block and teaching block with large room with dividing wall. Other specialist S68 buildings noted elsewhere include the boiler house, library, gym and admin blocks.
Looks similar to the following		
General description Building plan typically 'H' shape with corridors opening into large courtyards. Various blocks with arts and craft, science, and technology classrooms. Some blocks have large hall in lieu of classrooms at one end. Other S68 standard buildings include the Admin block, Library building, Gymnasium and boiler house (refer photos below).		
MLE Compliance Construction limits flexibility but redevelopment at Porirua College demonstrates how these buildings can be converted to MLE. Generally poor acoustics due to timber ceilings. Excellent cross ventilation and natural ventilation intake around panel heaters below windows. Excellent solar control. Minimum insulation. South facing clerestory glazing provide excellent natural lighting but difficult to blackout.		

The definition in the table referring to "excellent cross flow ventilation and natural ventilation should be limited to the common corridor areas only.

Document 3

Block C - single level structure positioned amongst the other multi-story school buildings with minimal 10 meters separation between the buildings.



Section 2.0 Performance & Condition Report

2.1 General Description of Construction

Block C generally fits into the generic description of S68 design with trough section metal roofing with rafter clerestory roof windows, windows on the external wall of each classroom, concrete block external and partition walls and concrete slab on ground.

Block C is single level construction positioned with multi story buildings alongside all elevations and overlapping the air space of Block C along the eastern elevation. The surrounding structures appear to be suffocating Block C by restricting suitable cross flow ventilation.

The adjacent two-story buildings shield Block C from prevailing weather patterns create a microenvironment around the Block obstructing air flow and the amount of direct sunshine hitting the external wall lines of Block C.

The roof structure is standing rib or similar metal roofing direct fixed to treated 65mm tongue & groove Pine sarking timbers direct fixed to the large (untreated?) Pine rafters spanning across each classroom space.

There are no purlins or roof voids within the main roof areas above the classrooms for the inclusion of insulation. Roof voids above the common corridors and covered walkways within the central courtyard house the plumbing, electrical and data services for Block C.

Concrete block masonry forms the main structure of the Block supported by the concrete slab on the ground. Timber framing is used for the roof structure, rafter clerestory windows and for non-structural internal partition walls. Fibre cement sheet claddings are used above roof level which may contain asbestos as the binder within the sheet cladding.

Window joinery is a mix of fixed timber frame for the clerestory roof windows, timer frame and sash and timber frame with metal frame and sash installed. Opening windows are generally provided at roof level on opposing sides of the classroom spaces.

Additional ventilation to the classrooms is provided through openings beneath the external wall windows associated with the original radiator heater network for Block C. It is unclear if the radiator network is still in operation with electrical heaters hung from the ceilings in each learning space.

2.2 Performance Dynamics Block C.

Air Quality Testing (AQT) undertaken in Block C during March 2021 highlighted unfavourable internal air quality within teaching and resource spaces that had experienced leaking issues.

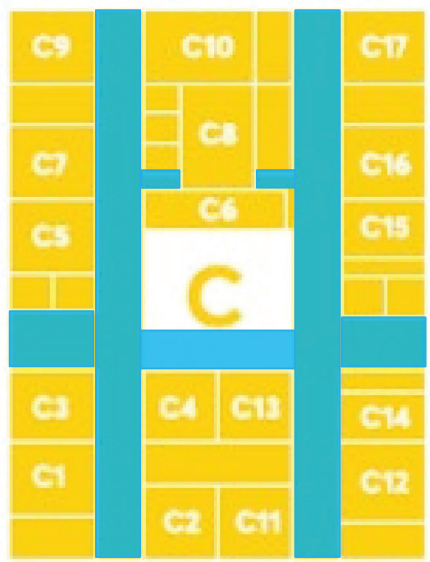
We have been advised by school staff that Block C had a long history of leaking issues and the building was very cold in the winter months and extremely hot in the summer months.

In winter months the concrete block walls are said to run with moisture and water drips from the pitched rafter clerestory windows and ceiling.

CoveKinloch completed a roof condition report for the whole school in July 2019, Block C was highlighted as having a mix of old and newer metal roofing generally requiring full roof replacement including suggested redesign of the rafter clerestory windows and consideration of a simpler overall roof design for Block C.

Wet weather during these investigations highlighted the leaking issues across Block C. Water leaks are a common theme through the corridors and covered walkways which house all the electrical and plumbing services.

The roof service void of the corridors and covered walkways is open plan across Block C and sits lower than the main roof areas above the classrooms creating a linked tunnel at lower roof height throughout Block C.



Blue boxes display the roof service void across Block C linking all four quadrants of the Block.

Radiator water feeds, plumbing water feeds, electrical cabling and data cabling all housed within the roof service void.

Water damage was widespread across the corridors and covered walkways affecting the roof framing timbers, metal brackets, cable trays and service pipes.

The particleboard ceiling linings swollen and disintegrating from the effects of ongoing moisture entry.

Water leaks into corridor form service void roofing drip onto the floor. There was light mist rain most of the day 29/3/2021.

Water leaks from corridor roof drip onto alarm services, ceiling linings swollen and sagging.

Water leaks corroding anchor bolts, saturating structural timber framing eventually end up at floor level. The leaks increase the moisture loading of the roof cavity leach timber treatments and encourage fungal decay. Foil roof underlay is non-breathable or vapour permeable.

Repeated water damage in the service void ceiling.

Corroded cable tray, electrical cables sitting in water. Decaying ceiling linings to walkway ceiling.

Multiple leaks across the service void roofing from end to end of Block C increase the moisture loading of the service roof ceiling cavity. The elevated moisture corroding the steel service pipes, steel hangers and cable trays, provides the right moisture rich environment for supporting fungal growth.

The air leaky roof structure allows easy distribution of fungal spores throughout the service void roofing following any regular wind patterns that affect the building. The wind distribution around the building affected by the adjacent multi-story buildings will create lee areas of no air movement outside and inside of Block C as well as areas of increased air movement.

AQT results from samples taken within the service void roof indicate elevated spore counts and unfavourable air quality toward the north eastern quadrant suggesting wind patterns mainly effect the northern side of the building within the service void roof.

Sample Number	Slide Number	Location	Cladosporium	Penicillium/ Aspergillus type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Hyphal Fragments	Other Spore Types	Fungal Structures TOTAL/m³	[illegible]	Pollen
4521712	02152990	14 - Male Staff Toilet	267	2767	0	0	0	0	0	13	0	33	27	20	5502	7520	140	7
4521713	[illegible]	15 - Room [illegible]	[illegible]	[illegible]	0	0	0	713	0	40	0	17	[illegible]	[illegible]	[illegible]	[illegible]	7	7
4521714	[illegible]	16 - Female Toilet [illegible]	[illegible]	[illegible]	0	1	0	7	0	1	0	11	[illegible]	11	[illegible]	[illegible]	[illegible]	1
4521715	02156536	17 - NW Corridor Ceiling Space	1597	453	7	7	0	80	0	20	0	0	473	160	6067	9354	127	47
4521716	[illegible]	18 - N/E Corridor Ceiling Space	[illegible]	[illegible]	0	0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
4521717	02151726	20 - S/E Corridor Ceiling Space	327	3040	0	340	0	13	0	0	7	30	287	60	33532	38100	420	13
4521718	[illegible]	21 - S/W Corridor Ceiling Space	[illegible]	[illegible]	0	0	0	0	0	0	0	30	[illegible]	18	[illegible]	[illegible]	[illegible]	0
4521719	02152094	23 - Counsellor's Room (Hall)	803	34200	7	7	13	80	0	7	0	20	133	300	15347	51134	[illegible]	7

Section from Biodet Services Report Appendix A, service void roof/corridor ceilings highlighted in red.

Stale air from the leaking service void ceiling able to bleed from the roof cavity into the corridors and through service pipe penetrations and holes into other areas Block C.

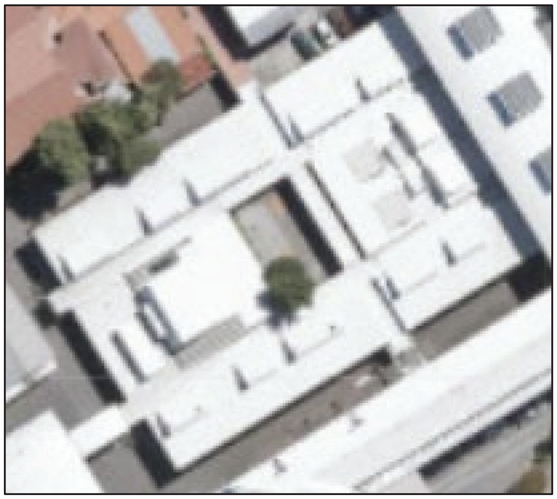
The roof of Block C is the largest area influencing the internal environment of the classrooms. Roof slope is formed in the large untreated Pine timber rafters that span across the classrooms with 65mm thick tongue and groove treated Pine sarking timbers direct fixed to the rafters supporting the foil roof underlay and metal tray roofing.   The roof mass is approximately 100mm deep, insulation and thermal resistance = Zero.

With no allowance for insulation within the roof structure the internal building temperature is influenced by the outside temperatures acting on the roof surface.

Insulation alone will not stop this issue with the roof design, it will only lesson its effect.

Solar gain on the roofing during summer months would beat heat into the learning spaces and cold days in the winter would be worsened by night sky radiation of clear frosty nights. Metal roofing surface temperature can be 10° colder than the surrounding air due the effects of night sky radiation.

Just as sun beats down during the day the freezing temperatures of space radiate down at night. Fact – It is always coldest just before dawn a couple of hours before school starts!



Roof area Block C, the largest area to have direct influence on the internal environment.

Roof areas of the classrooms with elevated rafter clerestory roof windows and lower pitched flat roof areas, roof mass only 100mm deep in general.

The second largest influence on the internal environment of the classroom is the external block walls and internal partition block walls. There is a large mass of concrete block forming the main structure of Block C.

The external walls are double thickness 15 Series concrete blocks with the inner course filled with concrete and the outer course hollow and a 50mm gap between the two rows of blocks – overall wall thickness approximately 330mm.

The outer course of blocks is vented top and bottom through open perpends which extend through to the 50mm cavity between the two rows of blocks. The external walls of Block C are generally shaded from solar gain during the day by the taller adjacent structures.

Outside air temperatures directly influence the thermal mass of the concrete block walls, warmer mid-summer and colder mid-winter. The insulation value of the exterior walls with an open vented cavity to the outer layer is reduced to the value of a filled 15 Series concrete block without insulation = R 0.63 or similar.

The insulation value of the internal block walls spanning the length of the corridors influenced by external air temperature is the same as the exterior walls.

Uninsulated roof and uninsulated walls result in fluctuating internal temperatures driven seasonally by the weathers influence on the exterior temperatures of the block walls and metal roofing.

Heating of the classroom is supplied from electric roof mounted radiant heaters and potentially what is left of the original radiator heating system. The efficiency of these heaters was not tested as part of this investigation.

The relative humidity of an unoccupied classroom was measured over the three days displaying similar results to atmospheric conditions. This was anticipated in an uninsulated non-airconditioned environment.

Measurements taken Between 11.00am & 1.00pm each day.	Relative Humidity	Air Temperature	Dew Point
29/3/2021	71%	22.5°	17°
30/3/2021	80%	18.4°	15°
31/3/2021	76%	20°	15.5°

The uninsulated concrete block walls and direct fixed metal roof have surface temperatures that fluctuate with the seasons and often in winter the surface temperature or thermal mass of the concrete walls would sit well below the heated internal air temperature of the classroom.

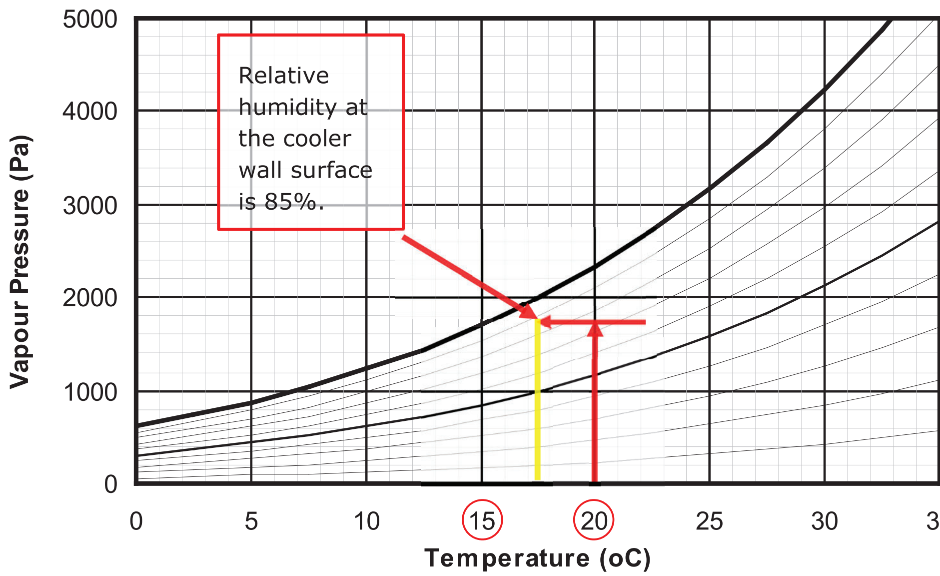
Introduce to Block C classrooms roughly 2000 pupils a day and a moisture rich environment is formed. Heat the air and it holds more moisture as moisture vapour. Moisture vapour is lighter than air and moves freely to the top of the rafter clerestory windows cools quickly near the surface of the windows and roof drops down external walls where the temperature falls below dew point and moisture forms on the internal surfaces.

Initially this moisture is invisible however on very cold days the walls and windows would run with condensation.

Hygroscopic materials within the classroom absorb and release surplus moisture vapour, a continuous process with these materials trying to reach equilibrium with the surrounding moisture in the internal environment.

Consequently, cooler wall, floor and roof surfaces with relative humidity's above 80% encourage the growth of fungi and dust mites. This can be displayed by the following Psychrometric chart.

Psychrometric Chart



31/3/2021 - Inside Relative Humidity (Rh) 76%, Inside Air temperature 20° wall surface temperature 17.5°. – Rh at the wall surface is 85%, this level of moisture will support fungal growth.

In general Fungi require moisture levels above 80% Rh to establish and ongoing moisture levels above 70% Rh to remain active in the material. Once established degenerative fungi can sit dormant waiting for the right conditions to become active again.

As Block C cools at night and during the winter months moisture rich internal environments within the building fabric encourage the growth and release of fungal spores into the internal spaces.

Un-insulated concrete floor with cool ground temperatures and the fluctuating water table of the Hutt Valley influences the temperature of the concrete floor. Carpet softens the floor however supports raised relative humidity within the carpet matrix encouraging dust mites.

Relative humidity's within hygroscopic materials like carpets, curtains, Autex fabrics and other soft furnishings are impossible to get below 70% in a non-air-conditioned environment, encouraging dust mites.

Raised RH above 80% encourage bacterial and fungal microenvironments to thrive with 2000 students supplying a large portion of food in the form of skin particles as dust to the internal environment each day.

Block C has been repeating this seasonal cycle of hot and cold wet and dry since constructed due to the simple fact there is no insulation to assist in the thermal performance of the structure.

Leaking issues with aged roofing have exacerbated the poor insulation issues with the air leaky original design of Block C. Cross flow ventilation through the common corridors was considered with the original design however is impractical during colder winter weather and impeded by larger adjacent structures.

The corridor wall and ceiling surface temperatures are directly affected by the outside air temperature. Heated damp air from the raised relative humidity of the classrooms would exit through the single access door into the common corridor.

As the warm damp air meets the cooler ceiling and wall surfaces of the corridor and classroom the relative humidity at the wall and ceiling increases above 80% and fungal growth establishes on the surface. A repeated cycle of air movement occurring at regular intervals with each classroom period during the day.

Fungal spotting on the curtain fabrics which absorb and release water vapour in the classrooms.

Sample ID	Macroscopic features	Microscopic features and comments
43117/24 2 – C13; Back of curtains, upper windows	***Sample:*** Sellotape® swab ***Appearance***: Areas of grey-black discolouration on the tape.	*Stachybotrys* was not detected. A high level of an unidentified dematiaceous fungus. Growth active. ***Conclusion***: Likely to be well-established fungal growth.

Section from Biodet Services Report Appendix A.

Fungal growth on the higher windowpanes not regularly cleaned due to difficulty with access.

43117/25 3 – C13; Window, top of wall	***Sample:*** Sellotape® swab ***Appearance***: Black speckled discolouration across the tape.	*Stachybotrys* was not detected. A moderate to high level of an unidentified dematiaceous fungus. Growth active. ***Conclusion***: Likely to be well-established fungal growth.

43117/27 5 – English Help; Clearstory windows	***Sample:*** Sellotape® swab ***Appearance***: Bands of speckled black discolouration across the tape.	*Stachybotrys* was not detected. A moderate level of *Cladosporium*. Growth active. ***Conclusion***: Likely superficial fungal growth in response to condensed moisture on a surface.

Sections from Biodet Services Report Appendix A.

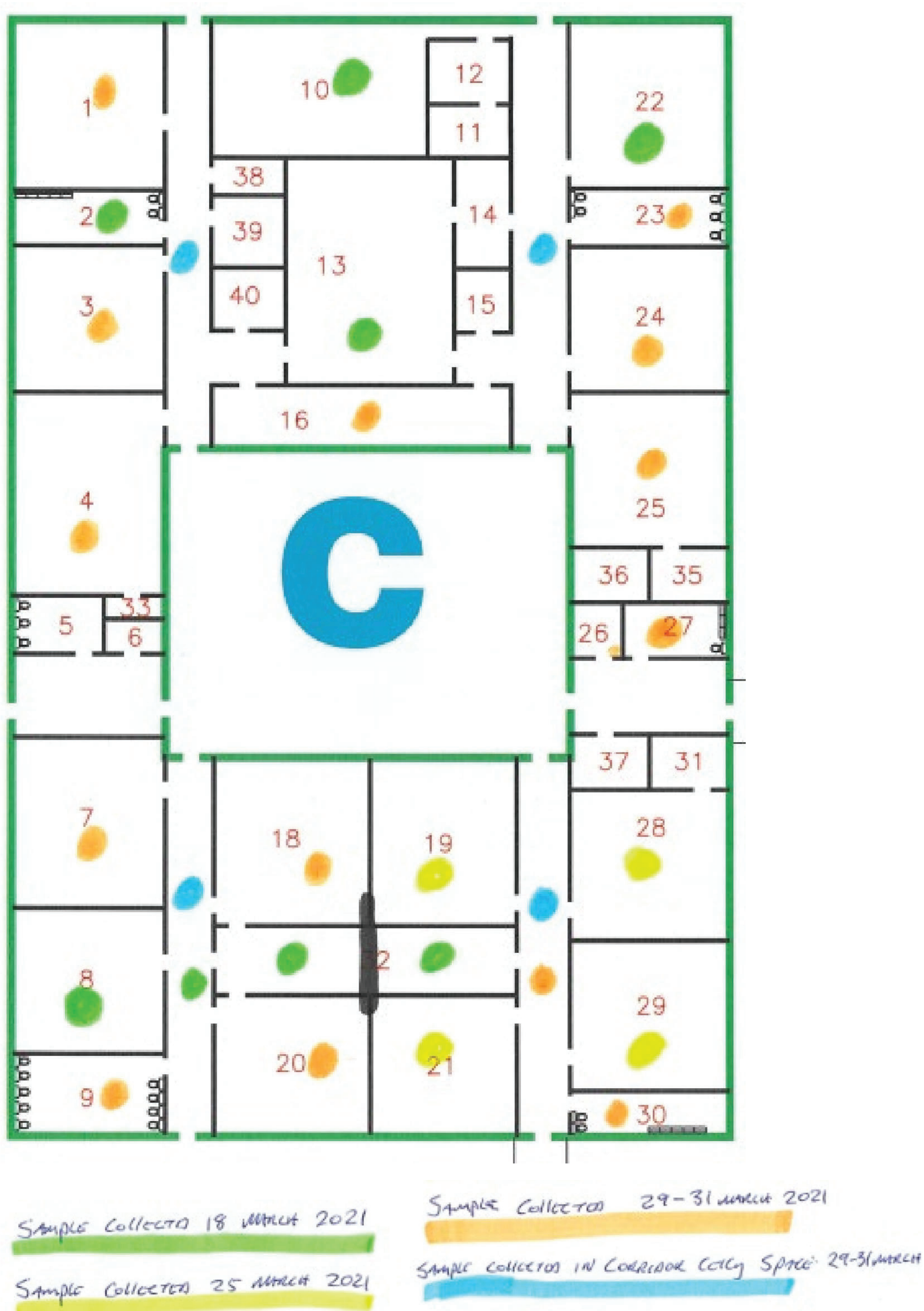
The corridor ceilings displayed a mist of fungal growth on the ceiling surface in alignment with the classroom doors. Warmed damp air exiting the classrooms contacting the cooler surfaces of the corridor service void ceiling raising the relative humidity at the ceiling surface encouraging fungal growth. Difficult to photograph however a swab of the growth revealed fungi had become established.

43117/26 4 – C14; Corridor ceiling	***Sample:*** Sellotape® swab ***Appearance***: Pale brown discolouration across the tape.	*Stachybotrys* was not detected. Conglomerations of amorphous particulates and skin cells with areas of low-level *Cladosporium* growth. ***Conclusion***: Likely an accumulation of dust and debris in which fungal growth had become established.

Section from Biodet Services Report Appendix A.

2.3 Indoor Air Quality

AQT has been undertaken across Block C to obtain a snap-shot review of the internal air quality at the time of testing. Refer to Appendix A for Biodet Services full report.



Air Quality Samples Taken 18 March 2021						
Sample Number	Room Sample Taken From	Location	Sample Type	Test	Date Sample Taken	Time Sample Taken
1	Control Northeast Corner	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	8.00-8.10am
2	Room C1	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	8.14-8.24am
3	North East corridor	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	8.36-8.46am
4	English Help Room	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	8.53-9.03am
5	Room C17	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	9.06-9.16am
6	Room C10	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	9.02-9.30am
7	Boys Toilet S/E	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	9.36-9.46am
8	Room C8	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	9.53-10.03am
9	Staff Resource N/ CorridorE	900mm from Ground	Glass Slide	Mould Spore Analysis	18-Mar	10.08-10.18am

Air Quality Samples Taken 18 March 2021						
Sample Number	Room Sample Taken From	Location	Sample Type	Test	Date Sample Taken	Time Sample Taken
1	Control West Elevation	900mm from Ground	Glass Slide	Mould Spore Analysis	25-Mar	12.30-12.40pm
2	Room C13	900mm from Ground	Glass Slide	Mould Spore Analysis	25-Mar	12.46-12.56pm
3	Room C11	900mm from Ground	Glass Slide	Mould Spore Analysis	25-Mar	1.02-1.12pm
4	Room C12	900mm from Ground	Glass Slide	Mould Spore Analysis	25-Mar	1.18-1.28pm
5	Room C14	900mm from Ground	Glass Slide	Mould Spore Analysis	25-Mar	1.36-1.46pm

Air Quality Samples Taken Between 29-31 March 2021						
Sample Number	Room Sample Taken From	Location	Sample Type	Test	Date Sample Taken	Time Sample Taken
1	Control Northeast Corner	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	1.16-1.26pm
2	Northeast Corridor	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	1.38-1.48pm
3	Boys Toilet N/W	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	1.49-1.59pm
4	Room C2	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	2.04-2.14pm
5	Room C4	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	2.20-2.30pm
6	Room C3	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	3.23-3.33pm
7	Girls Toilet N/E	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	3.36-3.46pm
8	Room C5	900mm from Ground	Glass Slide	Mould Spore Analysis	29-Mar	9.04-9.14am
9	Control Northeast Corner	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	9.20-9.30am
10	Room C7	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	10.00-10.10am
11	Room C9	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	10.16-10.26am
12	Commerece HOD	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	11.48-11.58am
13	Room C15	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	12.04-12.14pm
14	Male Staff Toilet	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	12.18-12.28pm
15	Room C16	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	12.32-12.42pm
16	Female Toilet S/W	900mm from Ground	Glass Slide	Mould Spore Analysis	30-Mar	3.45-3.55pm
17	N/W Corridor Celing Space	In Ceiling	Glass Slide	Mould Spore Analysis	30-Mar	4.03-4.13pm
18	Control Northeast Corner	900mm from Ground	Glass Slide	Mould Spore Analysis	31-Mar	10.47-10.57am
19	N/E Corridore Ceiling Space	In Ceiling	Glass Slide	Mould Spore Analysis	31-Mar	11.01-11.11am
20	S/E Corridore Ceiling Space	In Ceiling	Glass Slide	Mould Spoor analysis	31-Mar	11.20-11.30am
21	S/W Corridore Ceiling Space	In Ceiling	Glass Slide	Mould Spoor analysis	31-Mar	11.37-11.47am
22	Counsellors Room (Hall)	900mm from Ground	Glass Slide	Mould Spoor analysis	31-Mar	12.26-12.36pm

Material Samples Taken Between 29-31 March 2021						
Sample Number	Room Sample Taken From	Location	Sample Type	Material	Date Sample Taken	Time Collected
1	Room C13	Curtians Clearstory Windows	Mould Type Identification	Tape Sample	31-Mar	N/A
2	Room C13	Curtians Clearstory Windows	Mould Type Identification	Tape Sample	31-Mar	N/A
3	Room C13	Clearstory Window Frame	Mould Type Identification	Tape Sample	31-Mar	N/A
4	N/W Corridore (C14)	Ceiling Tile	Mould Type Identification	Tape Sample	31-Mar	N/A
5	English Help	Clearstory Window Frame	Mould Type Identification	Tape Sample	31-Mar	N/A
6	Central Courtyard N/E	Service Duct Ceiling Tile	Mould Type Identification	Material Sample	31-Mar	N/A

Timber Samples Taken Between 29-31 March 2021						
Sample Number	Room Sample Taken From	Location	Sample Type	Material	Date Sample Taken	Time Collected
1	West Elevation	Rafter	Timber Species, Treatment Level, Decay Fungi	Timber	29-Mar	N/A
2	South West Elevation	Sarking	Timber Species, Treatment Level, Decay Fungi	Timber	30-Mar	N/A
3	North East Corridore	Skirting	Timber Species, Treatment Level, Decay Fungi	Timber	31-Mar	N/A
4	Central Corridor	Rafter	Timber Species, Treatment Level, Decay Fungi	Timber	29-Mar	N/A
5	South East Elevation	Sarking	Timber Species, Treatment Level, Decay Fungi	Timber	30-Mar	N/A
6	East elevation	Rafter	Timber Species, Treatment Level, Decay Fungi	Timber	29-Mar	N/A

Sample list sent of AQT samples, Sellotape Swap samples and Timber samples.

Stale internal air with elevated fungal spore counts is a familiar theme across Block C corridors in their current condition with leaking roofs. Air pressure differentials and wind movement allow distribution of the stale air across Block C transported within the service void roofing.

The service void roof is a fungal reservoir and delivery system for stale air due to the air leaky open plan design of the service filled roof. Multiple leak points result in multiple areas of fungal growth across the corridor roof network.

Decayed wet ceiling linings have mushroom type spores present.

43117/28 6 – Central Courtyard N/E; Service duct ceiling tile	***Sample:*** Chipboard (Compressed fibre board) ***Sample size:*** 140mm x 110mm ***Appearance***: Damp. Black discolouration on one side. ***Loss of strength:*** A moderate loss of strength noted.	*Stachybotrys* was not detected. Abundant blue-staining fungal hyphae within wood cells. A high level of Basidiomycete spores also noted. ***Conclusion***: Advanced soft rot. Any adjacent timber requires investigation for possible decay.

2.4 Building Code Requirements

Block C was constructed well before the guidelines introduced by the New Zealand Building Code on how buildings should perform and function.

The current objectives, functionality and performance requirements of the New Zealand Building Code as they would apply to Block C regarding:

Clause E2 - External Moisture.

- Objective:
  E2.1 - The objective of this provision is to safeguard people from illness or injury that could result from external moisture entering the building.
- Functional Requirements:
  E2.2 - Buildings must be constructed to provide adequate resistance to penetration by, and the accumulation of, moisture from the outside.
- Performance:
  E2.3.1 - Roofs must shed precipitated moisture. In locations subject to snowfalls, roofs must also shed melted show.
  E2.3.2 - Roofs and exterior walls must prevent the penetration of water that could cause undue dampness, damage to building elements, or both.
  E2.3.5 - Concealed spaces and cavities in buildings must be constructed in a way that prevents external moisture being accumulated or transferred and causing condensation, fungal growth, or the degradation of building elements.

Clause E3 – Internal Moisture.

- Objective:
  E3.1 - The objective of this provision is to (a) Safeguard people against illness, injury, or loss of amenity that could result from the accumulation of internal moisture.
- Functional Requirements:
  E3.2 - Buildings must be constructed to avoid the likelihood of
  (a) Fungal growth or the accumulation of contaminants on linings and other building elements; and
  (b) Free water overflow penetrating to an adjoining household unit; and
  (c) Damage to building elements being caused by the presence of moisture.
- Performance:
  E3.3.1 - An adequate combination of thermal resistance, ventilation, and space temperature must be provided to all habitable spaces, bathrooms, laundries, and other spaces where moisture may be generated or may accumulate.

Clause G4 – Ventilation.

- Objective:
  G4.1 - The objective of this provision is to safeguard people from illness or loss of amenity due to lack of fresh air.
- Functional Requirements:
  G4.2 - Spaces within buildings shall be provided with adequate ventilation consistent with their maximum occupancy and their intended use.

- Performance:
  G4.3.1 - Spaces within buildings shall have means of ventilation with outdoor air that will provide an adequate number of air changes to maintain air purity.
  G4.3.3 - Buildings shall have a means of collecting or otherwise removing the following products from the spaces in which they are generated:
  (g) Airborne particles,
  (h) Bacteria, viruses or other pathogens.
  G4.3.4 - Contaminated air shall be disposed of in a way which avoids creating a nuisance or hazard to people and other property.

Clause H – Energy Efficiency.

- Objective:
  H1.1 - The objective of this provision is to facilitate efficient use of energy.
- Functional Requirements:
  H1.2 - Buildings must be constructed to achieve an adequate degree of energy efficiency when that energy is used for-
  (a) modifying temperature, modifying humidity, providing ventilation, or doing all or any of those things; or
  (b) providing hot water to sanitary fixtures or sanitary appliances, or both.
- Performance:
  H1.3.1 - The building envelope enclosing spaces where the temperature or humidity (or both) are modified must be constructed to-
  (a) provide adequate thermal resistance; and
  (b) limit uncontrollable airflow.
  H1.3.3 - Account must be taken of physical conditions likely to affect energy performance of buildings, including-
  (a) the thermal mass of building elements; and
  (b) the building orientation and shape; and
  (c) the airtightness of the building envelope; and
  (d) the heat gains from services, processes and occupants; and
  (e) the local climate; and
  (f) heat gains from solar radiation.

Block C fails to achieve the minimal performance requirements of the New Zealand Building Code when measured against the expected performance requirements of today's buildings.

Issues detrimental to a healthy building also affect occupant comfort and wellbeing with raised indoor relative humidity's encouraging poor indoor air quality, fungal growth and dust mites.

The inability to appropriately insulate the thermal mass of the existing structure and provide appropriate ventilation to control the internal relative humidity places Block C in the "not fit for purpose" category measured against todays building code requirements for building performance.

A new insulated roof system will not solve the internal environmental issues however, should address the roof leaks.

Insulation to the external block walls will not solve the internal environmental issues however, will assist in preventing the walls becoming a condensation plane.

Thermal Double-glazed windows will not improve the internal environment but should stop the windows becoming a condensation plane.

Improved ventilation will assist the internal environment however is difficult to implement in a non-air condition building while considering the comfort of the occupants.

A combination of improved insulation to the entirety of the building fabric, including the floor, new thermally broken double-glazed windows along with appropriate ventilation allowing a minimum of 4 air changes per hour without affecting heat loss would transform Block C.

To implement measures to upgrade Block C at 50-years old, to align with the minimum insulation, thermal resistance and energy use requirements expected of today's buildings is like flogging a dead horse.

It is highly likely Block C will require structural strengthening to meet todays standards for seismic strength.

2.5 Condition of Block C

The bulk of the building fabric for Block C is 15 & 20 series concrete blocks supporting a paint finish. Concrete block construction is robust and durable with high fire resistance ratings however has poor thermal resistance to restrict the influence of the surrounding environment.

The roof is the largest area of Block C having influence on the performance of internal environment. The poor roof condition of Block C is known from condition reports commissioned in 2019. The roof structure remains in the same poor condition today.

Block C at 50-years displays signs of aged infrastructure with:

- Decaying roof structure with untreated rafters identified with advanced soft rot decay present.
- Decaying timber substructure in the roof driven by roof leaks. Corroding anchor bolts and metal cleats to timber framing.
- Decaying internal linings and fungal growth driven by roof leaks and raised relative humidity's.
- Corroding steel frame windows. The windows are generally protected from the weather however form a condensation plane for elevated internal moisture.
- Decaying wooden frame windows and external doors. Rotten mullions allow water ingress beneath the window frame into the wall structure beneath.
- Localised areas of spalling concrete where reinforcing steel has insufficient concrete cover.
- Corroding cable service trays, corroding service pipes and metal supporting structure within the service void ceiling, driven by roof leaks and elevated internal moisture.

- Redundant radiator heating system. Part of the system may still be operational but highly likely inefficient.
- Mould growth on ceiling, wall and window surfaces driven by raised internal relative humidity's and poor ventilation. Difficult to access and clean.
- Localised insect infestation to the timber trims driven roof leaks increasing the moisture loading leaching timber treatments softening the timber encouraging insect attack.
- Evidence of rodent and bird habitants within the service void ceiling.
- Efflorescence bleed from concrete blocks at floor level display the longevity of the roof leaks affecting both sides of the filled concrete blocks.
- Un-insulated concrete floor and the fluctuating water table of the Hutt Valley. Carpet softens the floor however supports a raised relative humidity when bonded in place against a cooler surface.

The main framing timbers of the roof structure are likely untreated Pine timber for the large spanning rafters with no retentions of copper or tin identified within the timber samples taken. Potentially the exposed sections of rafter timbres may have had all the timber treatment leached from the timber however it is likely the rafters are untreated Pine as all three samples gave the same indications. The large rafters potentially too big for pressure treatment operations of the day spanning nearly 10.000meers. Additional testing from sections of rafter mid-section, not exposed to the weather would further confirm treatment levels.

The sarking timbers above the rafters gave indications of copper in the treatment suggesting the sarking timbers are treated to H3.2 levels suitable for above ground exterior exposure.

No	Location	Description	Decay & Fungal Analysis	Preliminary Replacement Guide*	Treatment#	Toxigenic Mould$
1	West Elevation	Rafter	Radiata pine. Pockets of advanced brown rot and soft rot across the depth.	Yes	None detected (LOSP?)	None detected
2	South West Elevation	Sarking	**Radiata pine. Superficial soft rot and bacterial decay in the outer 1 mm. No established decay micromorphology was detected in deeper wood.** Dense fungal growths predominantly typical of mould fungi, yeasts, sapstain and/or soft rot fungi. Fungal growths present across the entire depth. Moulds: *Torula, Cladosporium, etc.*	No†	Copper = CCA, e.g., H3.2	None detected
3	North East Corridor	Skirting	Radiata pine. Pockets of advanced brown rot and soft rot across the depth. Low numbers of spores of *Stachybotrys*	Yes	None detected (LOSP?)	Trace
4	Central Corridor	Rafter	Radiata pine. Pockets of advanced soft rot across the depth.	Yes	None detected (LOSP?)	None detected
5	South East Elevation	Sarking	Suspected incipient brown rot	Probably††	Copper = CCA, e.g., H3.2	None detected
6	East elevation	Rafter	Radiata pine. Pockets of advanced soft rot across the depth.	Yes	None detected (LOSP?)	None detected
7	East elevation	Rafter	Radiata pine. Pockets of advanced soft rot throughout.	Yes	None detected (LOSP?)	None detected

Part section of report, Refer to full Beagle Consultancy Report Appendix B.

The overall condition of the roof structure has not been assessed. Selected roof members were tested to define timber species and any detectable timber treatment levels.

From appearance the exposed sections of rafters with paint protection and sarking timbers with a varnish protection appear solid. Laboratory testing identified the rafter timbers to have advanced soft rot decay in the structural roof members and replacement is recommended.

The sarking timbers displayed incipient brown and superficial soft decay. With the history of roof leaks across Block C it is highly likely sarking timber treatments have been leached and localised pockets of decay have taken hold within the matrix of the timber sarking.

Metal roofing in contact with damp sarking timbers treated to H3.2 would result in accelerated corrosion of the metal roofing. Trapped moisture allows the softer copper metals in the timber treatments to start electrolysis reactions with the zinc protection of the metal roofing resulting in accelerated corrosion.

The 50-year minimum durability requirement of the building consent process drives the obligation to amend the current roof design to encapsulate the exposed untreated rafter timbers. Decay in the rafters is a failure in durability and structural integrity which requires replacement of any affected timbers.

Any major upgrade to Block C must consider the existing age of the building at 50-years and the conditions of the building consent documentation. All building consents require a minimum 50-year durability for new and existing structure.

Surface corrosion to service pipes forming a condensation plane. Service pipes at pelmet level within the classrooms sit in the zone of moisture rich damp internal air.

Lower face of same pipe showing water stain trails and drip point from the service pipe.

Corroding steel window frame. Slightly open allows saturated internal air to bleed to the exterior keeping the steel frame in a moist environment encouraging corrosion.

Saturated core to lower course of concrete blocks, corridor internal wall. Results of longstanding roof leaks.

Localised spalling of concrete through sections of the bond beam due to insufficient concrete cover allowing moisture entry and resulting corrosion.

Windowsill of rafter clerestory windows, peeling paint, dust debris including supporting fungal spores, a condensation plane. These areas are too high for standard cleaning operations and require specialist access equipment.

Fungal spotting to surface in roof area with passing moist air in the bathrooms.

Document 3

Ceiling / roof forming condensation plane in bathrooms. Discolouration is fungal growth on the ceiling surface.

Efflorescence bleed from saturated concrete blocks, results of longstanding roof leaks.

Corroding cable trays and steel hangers, corroding bolt fixings to framing, saturated framing timbers, 50 years of dust debris in service ceiling cavity.

Foil roof underlay non-breathable traps moisture vapour, moisture damage to roof framing, active leak zone.

Document 3

Section 3.0 Summary & Signatures

3.1 Report Overview

Old and cold is no exaggeration of how Block C performs having direct bearing on the health of the building and the wellbeing of the occupants. Driven seasonally by the weather hot in the summer and cold in winter Block C structure amplifies the outside temperature variations through the thermal mass of the building.

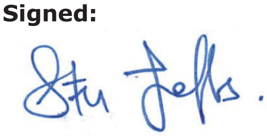
The inability to insulate effectively and regulate the relative humidity of the internal environment Block C is inefficient to heat. Raising internal temperatures exacerbates the poor indoor air quality by warm air being able to support more moisture increasing internal relative humidity's which encourage fungal growth on cooler surfaces where condensation dew points form, a repeating cycle.

Block C fails to meet the minimum insulation and thermal performance requirements expected from today's buildings. Insulating the thermal mass of the Block C including the floor and replacing the roof will at best only achieve building code minimums for aged infrastructure to perform a further 50 years.

Block C is not the fit for purpose building it was once considered to be when constructed in 1971-1972.

3.2 Signatures

Signed:



Stuart Jeffs *MNZIBS LBP*
Registered Building Surveyor

Peer Review:

Stefan Baines
Building Surveyor

Registered BUILDING SURVEYOR

For and on behalf of CoveKinloch New Zealand Ltd

Document 3

Appendix A Biodet Services Report

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

8 April 2021

Biodet Ref: 21/43117
Client Ref:

CoveKinloch Ltd
PO Box 44065
LOWER HUTT 5040

Attn: Stefan Baines

Dear Stefan

Re: **SPORE TRAP, SELLOTAPE® SWAB AND BUILDING MATERIAL SAMPLES FOR MICROBIOLOGICAL EXAMINATION**

Building/Ref: Hutt Valley High School
Samples taken: 29-31 March 2021
Samples received: 6 April 2021
Samples analysed: 6-8 April 2021

Laboratory Number	Sample Type	Location
43117/1	Spore Trap	2 – Northeast Corridor
43117/2	Spore Trap	3 – Boys Toilet N/W
43117/3	Spore Trap	4 – Room C2
43117/4	Spore Trap	5 – Room C4
43117/5	Spore Trap	6 – Room C3
43117/6	Spore Trap	7 – Girls Toilet N/E
43117/7	Spore Trap	8 – Room C5
43117/8	Spore Trap	10 – Room C7
43117/9	Spore Trap	11 – Room C9
43117/10	Spore Trap	12 – Commerce HOD
43117/11	Spore Trap	13 – Room C15
43117/12	Spore Trap	14 – Male Staff Toilet
43117/13	Spore Trap	15 – Room C16
43117/14	Spore Trap	16 – Female Toilet S/W
43117/15	Spore Trap	17 – N/W Corridor Ceiling Space
43117/16	Spore Trap	19 – N/E Corridor Ceiling Space
43117/17	Spore Trap	20 – S/E Corridor Ceiling Space
43117/18	Spore Trap	21 – S/W Corridor Ceiling Space

Laboratory Number	Sample Type	Location
43117/19	Spore Trap	22 – Counsellor's Room (Hall)
43117/20	Spore Trap	1 – Control Northeast Corner (Taken 29/03/21)
43117/21	Spore Trap	9 – Control Northeast Corner Taken (30/03/21)
43117/22	Spore Trap	18 – Control Northeast Corner (Taken 31/03/21)
43117/23	Curtain	1 – Room C13; Curtains Clearstory Windows
43117/24	Sellotape® swab	2 – Room C13; Back of curtains, upper windows
43117/25	Sellotape® swab	3 – Room C13; Window, top of wall
43117/26	Sellotape® swab	4 – N/W Corridor (C14); Ceiling Tile
43117/27	Sellotape® swab	5 – English Help; Clearstory Window Frame
43117/28	Chipboard (Compressed fibre board)	6 – Central Courtyard N/E; Service Duct Ceiling Tile

METHODS:

The spore trapping samples (Non-culturable Method) were taken using a Buck BioSlide and were analysed by ASTM D 7391 -09 'Categorisation and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy'.

The Sellotape® swabs and building material samples were analysed by ASTM D7658-17 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® swabs and Building Materials:

The samples were examined both macroscopically and microscopically.

Sample ID	Macroscopic features	Microscopic features and comments
43117/23 1 – C13; Clearstory Windows	***Sample:*** Curtain ***Sample size:*** 85mm x 75mm ***Appearance***: Brown discolouration on one side. Band of dense black discolouration on other side. ***Loss of strength***: No loss of strength noted.	*Stachybotrys* was not detected. The black discolouration was observed to be a high level of soot-like particulates. The brown discolouration was observed to be a moderate level of amorphous particulates, skin cells and miscellaneous spores. ***Conclusion***: Likely an accumulation of dust and debris in which superficial fungal spores were present. No obvious evidence of active fungal growth.

Sample ID	Macroscopic features	Microscopic features and comments
43117/24 2 – C13; Back of curtains, upper windows	***Sample:*** Sellotape® swab ***Appearance***: Areas of grey-black discolouration on the tape.	*Stachybotrys* was not detected. A high level of an unidentified dematiaceous fungus. Growth active. ***Conclusion***: Likely to be well-established fungal growth.
43117/25 3 – C13; Window, top of wall	***Sample:*** Sellotape® swab ***Appearance***: Black speckled discolouration across the tape.	*Stachybotrys* was not detected. A moderate to high level of an unidentified dematiaceous fungus. Growth active. ***Conclusion***: Likely to be well-established fungal growth.
43117/26 4 – C14; Corridor ceiling	***Sample:*** Sellotape® swab ***Appearance***: Pale brown discolouration across the tape.	*Stachybotrys* was not detected. Conglomerations of amorphous particulates and skin cells with areas of low-level *Cladosporium* growth. ***Conclusion***: Likely an accumulation of dust and debris in which fungal growth had become established.
43117/27 5 – English Help; Clearstory windows	***Sample:*** Sellotape® swab ***Appearance***: Bands of speckled black discolouration across the tape.	*Stachybotrys* was not detected. A moderate level of *Cladosporium*. Growth active. ***Conclusion***: Likely superficial fungal growth in response to condensed moisture on a surface.
43117/28 6 – Central Courtyard N/E; Service duct ceiling tile	***Sample:*** Chipboard (Compressed fibre board) ***Sample size:*** 140mm x 110mm ***Appearance***: Damp. Black discolouration on one side. ***Loss of strength:*** A moderate loss of strength noted.	*Stachybotrys* was not detected. Abundant blue-staining fungal hyphae within wood cells. A high level of Basidiomycete spores also noted. ***Conclusion***: Advanced soft rot. Any adjacent timber requires investigation for possible decay.

Note: Active fungal growth can be determined by the presence of distinct fungal hyphae and structures that readily take up stain. Some fungi produce enzymes that can cause the deterioration of building material substrates eventually resulting in loss of strength. Loss of strength has been determined by visual observation and manual manipulation.

Discussion

The presence of fungi always indicates that moisture is or has been present. It is important that repair of the defect that led to water damage is attended to promptly.

Stachybotrys was not detected from the Sellotape® swab or building material samples suggesting that conditions were not suitable for the growth of this fungus on these surfaces.

The Dematiaceous Fungal Group. These are fungi that produce dark fungal spores and/or dark hyphal structures. Many of these fungi are difficult to accurately identify from a microscopic examination alone, but their presence must be considered significant, as they are frequently isolated from water damaged building materials. Many of these fungal types are known to cause deterioration of paper and paper products, plastics, textiles, timber etc. Many are also found as saprophytes (do not cause disease or damage) on plants, leaf litter, timber etc, and are commonly found growing on damp windowsills, or where condensation has accumulated. They are not generally considered a health issue.

Cladosporium species are common air-borne contaminants particularly in outdoor air. They are commonly found on outdoor claddings, particularly timber and will also grow superficially on indoor 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. Although these fungi produce visible black colonies on surfaces, they are not considered toxigenic fungi, but have been reported as being potentially allergenic.

Basidiomycete Decay fungi: A number of members of this very large class of fungi are the main agents of decay in forest products. These decay fungi can cause structural damage to building materials such as fibrecement, plasterboard and building paper. They may appear on these materials as visible white mycelium, covered in calcium oxalate crystals. Such damaged material should be considered for removal and any adjacent timber examined for possible damage.

OVERALL CONCLUSIONS:

- There were definite indications that there had likely been moisture ingress in parts of this building resulting in the fungal growth usually associated with prolonged wet environments.

- Excessive levels of *Cladosporium* and *Penicillium/ Aspergillus* and a notable level of Zygomycete spores were observed in the N/E Corridor Ceiling Space. A significant level of *Chaetomium* and elevated *Penicillium/ Aspergillus* were noted in the S/E Corridor Ceiling Space with low levels of *Chaetomium* and *Stachybotrys* detected in the N/W Corridor Ceiling Space. The results suggest that the ceiling space that there is active fungal growth in the ceiling spaces.

- An excessive level of *Penicillium/ Aspergillus* and low levels of *Stachybotrys*, *Chaetomium* and an unidentified spore type was noted in the Counsellor's Room. It is recommended that this area sampled not be used until remediation can occur. Anybody entering the rooms should wear appropriate personal protective equipment. Any hard-surfaced items being removed from the room should be wiped down with warm soapy water and dried thoroughly. Soft furnishings may be HEPA-filter vacuumed and clothing/ bedding laundered, but this does not guarantee the removal of potential toxigenic sub-micron fungal elements.

- Low levels of *Stachybotrys* and/ or *Chaetomium* were observed in the Northeast Corridor and Room C15.

- Raised levels of *Penicillium/ Aspergillus* were also detected in Room C15 and the Male Staff Toilet. Since spore cluster and/ or hyphal fragment levels were also raised in these areas, the results suggest that active growth is occurring somewhere in the vicinity of these sampling points.

- Although *Cladosporium* spore levels were also raised in rooms C5, C7 and C9, the levels were comparable to the control sample taken on the same day and would be unlikely to result in health issues.

- An unidentified dematiaceous fungus was observed in two of the Sellotape® swabs taken from Room C13. The results suggest that there is active fungal growth occurring somewhere in the vicinity of this room. Growth on hard surfaces such as window framing can be cleaned off with warm soapy water.

- Fungal growth associated with advanced soft rot was observed in the chipboard sample taken from the Central Courtyard N/E. Basidiomycete spores were also elevated and I would be recommended that surrounding timber is examined for decay.

RECOMMENDATIONS:

- Any moisture sources should be identified and remediated with all fungal reservoirs being removed.

- It is recommended that the Chancellor's Room not be used until remediation can occur. Anybody entering the rooms should wear appropriate personal protective equipment. Any hard-surfaced items being removed from the room should be wiped down with warm soapy water and dried thoroughly. Soft furnishings may be HEPA-filter vacuumed and clothing/ bedding laundered, but this does not guarantee the removal of potential toxigenic sub-micron fungal elements.

- Surrounding timber to the Central Courtyard N/E ceiling tile sample should be investigated for possible structural damage and any damaged material removed.

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

Yours faithfully

Angelina Bernal
B.Sc.

Kate Fletcher
B.Sc.

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

Document 3

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	**8 April 2021**	**CLIENT:**	**CoveKinloch Ltd**
BUILDING:	**Hutt Valley High School**		**PO Box 44065**
DATE SAMPLES TAKEN:	**29-31 March 2021**		**LOWER HUTT 5040**
DATE SAMPLES RECEIVED:	**6 April 2021**		
DATE SAMPLES ANALYSED:	**6-8 April 2021**		
CLIENT REF NO:		**Attn:**	**Stefan Baines**
BIODET REF NO:	**21/43117**		

Method : ASTM D 7391 -09 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
43117/1	02350806	2 - Northeast Corridor	220	13	**7**	**13**	0	20	0	7	0	53	13	33	4067	**4446**	**180**	47
43117/2	02356694	3 - Boys Toilet N/W	340	80	0	0	0	7	0	0	0	100	140	20	6433	**7120**	100	0
43117/3	02350622	4 - Room C2	193	13	0	0	0	7	0	0	0	53	27	27	3500	**3820**	13	7
43117/4	02351542	5 - Room C4	300	13	0	0	0	67	0	20	0	27	73	140	6200	**6840**	40	7
43117/5	02356510	6 - Room C3	447	20	0	0	0	27	0	13	0	13	27	100	3153	**3800**	7	0
43117/6	02357614	7 - Girls Toilet N/E	107	20	0	0	7	93	0	27	0	20	47	20	4167	**4508**	40	13
43117/7	02355958	8 - Room C5	**1713**	47	0	0	7	7	0	7	0	7	80	13	13000	**14881**	**247**	0
43117/8	02356142	10 - Room C7	**1920**	160	0	0	0	0	7	0	0	53	87	13	6580	**8820**	**280**	0
43117/9	02357246	11 - Room C9	**1673**	140	0	0	0	27	0	33	0	13	107	47	13633	**15673**	**200**	0
43117/10	02357062	12 - Commerce HOD	273	100	0	0	0	7	0	0	0	13	47	60	2687	**3187**	20	0
43117/11	02362772	13 - Room C15	487	**1813**	0	**7**	0	13	0	7	0	7	67	**180**	4133	**6714**	**120**	7

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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
43117/12	02350990	14 - Male Staff Toilet	387	**1707**	0	0	0	0	0	13	0	33	27	20	5633	**7820**	**140**	7
43117/13	02362588	15 - Room C16	253	40	0	0	0	**213**	0	40	0	13	33	**200**	3267	**4059**	7	7
43117/14	02362404	16 - Female Toilet S/W	127	100	0	0	0	7	0	0	0	13	53	13	4067	**4380**	40	0
43117/15	02356326	17 - N/W Corridor Ceiling Space	**1907**	**653**	**7**	**7**	0	60	0	20	0	0	473	**160**	6067	**9354**	**127**	47
43117/16	02352278	19 - N/E Corridor Ceiling Space	**21667**	**11367**	0	0	0	0	0	0	0	0	300	**233**	**29933**	**63500**	**2100**	0
43117/17	02351726	20 - S/E Corridor Ceiling Space	927	**1040**	0	**340**	0	13	0	0	7	93	987	60	35633	**39100**	**420**	13
43117/18	02355774	21 - S/W Corridor Ceiling Space	233	167	0	0	0	0	0	0	0	20	213	13	22667	**23313**	100	0
43117/19	02352094	22 - Counsellor's Room (Hall)	800	**34200**	**7**	**7**	13	80	0	7	0	20	133	**300**	**15567**	**51134**	**2633**	7
43117/20	02357982	1 - Control N/E Corner 29/03/21	193	120	0	0	0	0	0	0	0	53	167	0	5866	**6399**	53	0
43117/21	02357798	9 - Control N/E Corner 30/03/21	**2140**	**420**	0	0	0	0	100	0	7	20	813	7	26700	**30207**	**760**	0
43117/22	02356878	18 - Control N/E Corner 31/03/21	387	27	0	0	0	0	20	0	0	53	793	13	45967	**47260**	180	20

Results highlighted in red are considered to be unusual amplification.

Results highlighted in brown suggest there may be localised slight amplification.

Particle Analysis - Extraneous Material

Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
43117/1	02350806	2 - Northeast Corridor	0	+	++	+++	+	+++
43117/2	02356694	3 - Boys Toilet N/W	+	+	+	+	+	++
43117/3	02350622	4 - Room C2	0	+	+	++	+	++
43117/4	02351542	5 - Room C4	+	+	+	++	+	+++
43117/5	02356510	6 - Room C3	0	++	+++	++	+	++++
43117/6	02357614	7 - Girls Toilet N/E	0	+	+	+++	+	++
43117/7	02355958	8 - Room C5	0	+	+	+	+	++
43117/8	02356142	10 - Room C7	0	0	+	+	+	++

Particle Level Key

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

Document 3

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Sample No.	Slide Number	Location	Bacterial clusters	Siliceous	Fibres	Skin	Rust	Amorphous
43117/9	02357246	11 - Room C9	+	++	+	+	+	++
43117/10	02357062	12 - Commerce HOD	0	+	++	++	+	++
43117/11	02362772	13 - Room C15	+	++	++	++	+	+++
43117/12	02350990	14 - Male Staff Toilet	0	+	++	++	+	++
43117/13	02362588	15 - Room C16	+	+	++	+++	+	+++
43117/14	02362404	16 - Female Toilet S/W	0	+	++	++	+	++
43117/15	02356326	17 - N/W Corridor Ceiling Space	0	+++	++	++	++	++++
43117/16	02352278	19 - N/E Corridor Ceiling Space	+	++	++	+	+	++
43117/17	02351726	20 - S/E Corridor Ceiling Space	0	+	+	++	+	++
43117/18	02355774	21 - S/W Corridor Ceiling Space	0	+	+	+	+	++
43117/19	02352094	22 - Counsellor's Room (Hall)	+	++	++	++	+	+++
43117/20	02357982	1 - Control N/E Corner 29/03/21	0	+	+	+	+	++
43117/21	02357798	9 - Control N/E Corner 30/03/21	0	+	+	+	+	+
43117/22	02356878	18 - Control N/E Corner 31/03/21	0	+	+	+	+	++

CONCLUSIONS:

Stachybotrys **was detected in very low levels in the Northeast Corridor, N/W Corridor Ceiling Space and the Counsellor's Room.** ***Chaetomium*** **was noted in a significant level in the S/E Corridor Ceiling Space, and in much lower levels in the Northeast Corridor, Room C15, N/W Corridor Ceiling Space and Counsellor's Room. The presence of these fungi is always indicative of sustained raised relative humidity (99%) resulting in fibre saturation of certain building materials, which would likely occur over a period of weeks to months. Possible scenarios that could give rise to this condition include on-going leaks or a major wetting event. These fungi are considered to be toxigenic and are undesirable in indoor air.**

Penicillium/ Aspergillus **spore levels were excessive in the N/E Corridor Ceiling Space and the Counsellor's Room, and raised in the Room C15, Male Staff Toilet and S/E Corridor Ceiling Space when compared to the control samples. These fungi grow indoors in response to moisture 'dewing' out onto surfaces that can often be due to moisture ingress issues or may be an accumulation of condensation in an area lacking good ventilation that has then resulted in localised superficial fungal growth. These spore types may be allergenic to sensitive people, and some of the species may cause infections in immunocompromised individuals. A lower level was observed in the N/W Corridor Ceiling Space.**

Cladosporium **spore levels were also excessive in the N/E Corridor Ceiling Space. These fungi are typically found outside growing as saprophytes on vegetation, but will grow indoors in response to a raised relative humidity. These spore types may be allergenic to sensitive people. Lower levels were detected in rooms C5, C7 and C9 but would be unlikely to result in health issues and were in similar levels to the outdoor sample taken that day.**

Penicillium/ Aspergillus **and** ***Cladosporium*** **spore levels were slightly elevated in one of the control samples taken from the Northeast corner when compared with the day before and after. These levels can vary due to environmental factors such as wind direction as well as decomposing organic material (such as a compost heap or bark gardens in close proximity to the sampling point), or the sampler being placed in close proximity to a building being declad, or having moisture issues.**

The ***Pithomyces*** **spore level was also slightly elevated in Room C16 when compared to the control samples. This fungus grows on dead grass in pasture and is rarely found indoors in high levels. Some species can be found on rotten timber, paper, textiles, and other organic substrates (cellulose), such as water- damaged building materials.**

Zygomycete spores were found in a notable level in the N/E Corridor Ceiling Space. The presence of these fungi generally signifies a very wet environment. Some species have been associated with pulmonary, cutaneous, and gastrointestinal cases in immunocompromised individuals.

A low level of an unidentified spore type was detected in the Counsellor's Room that was not seen in the other samples suggesting a reservoir in this area.

The elevated spore cluster and hyphal fragment levels observed can be indicative of active fungal growth.

Extraneous particulate levels such as amorphous and skin cells were generally light to moderate. This is not unusual in non-air-conditioned indoor areas. Where levels were high, it may be an indication that there is little ventilation or air movement.

Yours faithfully

Kate Fletcher
B.Sc.

Neethu Arun
M.Sc.

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

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BIODET INDOOR SPORE TRAP DATABASE (Average counts taken from indoor sources throughout New Zealand between 2017 and 2019)

Classroom environments	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m³**	Spore Clusters	Pollen Grains
With elevated fungal spore levels indicating moisture issues	868	3667	46	21	10	0	1	12	3	9	220	105	5753	**10716**	267	12
Without elevated fungal spore levels	384	65	0	0	4	0	0	6	1	9	116	35	2857	**3478**	33	10

BIODET OUTDOOR SPORE TRAP DATABASE (Average counts taken from outdoor sources throughout New Zealand between 2017 and 2019)

	Cladosporium	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m³**	Spore Clusters	Pollen Grains
Spring (Taken 1 September to 30 November)	1071	58	0	0	2	0	0	5	0	16	172	22	3603	**4950**	85	228
Summer (Taken 1 December to 28/29 February)	3535	194	0	0	37	0	15	51	22	44	861	35	12543	**17338**	381	46
Autumn (Taken 1 March to 31 May)	811	104	0	0	23	0	1	15	2	41	886	25	9986	**11895**	105	35
Winter (Taken 1 June to 31 August)	155	76	0	0	1	0	0	1	0	53	264	13	6998	**7560**	49	72

* 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.

Document 3

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BIODET INDOOR SPORE TRAP DATABASE (Average counts taken from indoor sources throughout New Zealand between 2017 and 2019)

Cavity environments	*Cladosporium*	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m3**	Spore Clusters	Pollen Grains
With elevated fungal spore levels indicating moisture issues	2282	30454	623	8	3	0	0	3	0	20	1175	386	19487	**54442**	1449	16
Without elevated fungal spore levels	192	72	0	0	1	0	0	1	0	18	81	25	1611	**2001**	21	46

BIODET OUTDOOR SPORE TRAP DATABASE (Average counts taken from outdoor sources throughout New Zealand between 2017 and 2019)

	Cladosporium	*Penicillium/ Aspergillus* type	*Stachybotrys*	*Chaetomium*	*Alternaria/ Ulocladium*	*Pithomyces**	*Drechslera/ Bipolaris*	*Epicoccum*	*Curvularia*	*Fusarium*	Basidiomycete	Hyphal Fragments	Other Spore Types	**Fungal Structures TOTAL/m3**	Spore Clusters	Pollen Grains
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* This category was separated out from *Alternaria/Ulocladium* in 2020

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Document 3

CoveKinloch
BUILDING CONSULTANTS & ASSET MANAGERS

Appendix B Beagle Consultancy Report – Timber Morphology

Document 3

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6 April 2021

Mr Stefan Baines
Covekinloch New Zealand Ltd
Level 1
12 Victoria Street
Alicetown
Lower Hutt

Dear Stefan,

RE: Wood decay, wood species, fungal, wood preservative, diagnostics and preliminary remediation analysis for Hutt Valley High School - Block C

Objective

The Objective of the analysis covered here was to determine the extent of decay and other microbiological activity (e.g., toxigenic mould) present, the type of framing (e.g., wood species and type of preservative treatment) and diagnose its implications for successful remediation.

Executive Summary

I. The fungal morphology, its distribution and the fungal and decay types identified suggested that at least the majority of the samples examined had been exposed to moisture conditions that are inconsistent with sound building practice and/or weather-tight design, and that appropriate remediation is needed to correct this.

II. Colorimetric qualitative preservative analysis suggested that wood samples 1 and 3-7 were either untreated perishable radiata pine, or may have been LOSP-treated, e.g., low retention of tin in H3.1, or H1.2, etc., this most likely depending on the age of the building. Sample 2 was almost certainly treated with a copper chrome arsenate preservative, e.g., according to Hazard Class 3 of MP3640:1992 (same as H3.2 of NZS3640:2003.)

III. Framing samples 1, 3, 4, 6 and 7 contained advanced decay of a type that often occurs well beyond the sample and which had probably caused loss of the bulk of the original structural integrity in affected areas. Replacement is typically recommended for framing in this condition, as part of robust remediation practice, and this is likely to be required in this instance – see point 1 of the discussion.

IV. Framing sample 5 contained earlier stages of decay. Wood in this condition is somewhat marginal in terms of replacement, although as a general rule of thumb replacement is typically recommended if there is any doubt concerning the extent of affected materials – see point 1 of the discussion.

V. Framing sample 2 contained fungal growths and superficial decay but no structurally significant decay was detected. Such wood is typically found in moisture compromised wall cavities and other locations, and/or on the periphery of more seriously affected framing sometimes in need of replacement. Framing in a similar condition can typically be left in situ, provided that other provisos are applied, although global remediation practice often requires replacement of a proportion of wood in this condition – see points 2 and 3 of the discussion.

VI. Results showed that sample 2 had been exposed to conditions conducive to decay, or close to such conditions, e.g., severe decay nearby is possible, and future severe decay is likely, e.g., in the absence of suitable remediation. Presence of wood preservative had probably prevented severe decay to date, i.e., any similarly affected less-durable materials, e.g., some types of cladding, untreated wood, etc., may contain decay or other types of water-damage. This preventative effect is likely to wear off well within the life of the building. Moisture hazards often compound suddenly, e.g., the initial 5-10 years of a buildings life is often misleading as a guide to the rate of future water damage which may accelerate suddenly.

VII. The toxigenic mould *Stachybotrys* was detected – see point 15 of the appendix.

VIII. Presence of prolific fungal growths and/or decay typically has important implications for the building in general. It is important to establish the limits of fungal infection and/or decay and establish the causes and apply appropriate remediation – see main body of text. Other remediation considerations may be important depending on the local conditions.

Microscopic Analysis

Wood sections (25 – 100 micrometers thick) were cut using a microtome or razor blade, mounted in glycerol and examined under a compound light microscope using polarised light and bright field illumination. Approximately 10 - 20 sections from approximately 3 - 10 positions across the depth at each of approximately 3 – 10 lateral positions were examined for each wood sample. All sections were stained with lactophenol aniline blue dye prior to examination.

- Key observations are given in the summary table.

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Analysis Summary Table *(Wood samples were cut-outs approximately 50-150 mm long, 8-20 mm deep and 25-100 mm wide.)*

No	Location	Description	Decay & Fungal Analysis	Preliminary Replacement Guide*	Treatment#	Toxigenic Mould[$]
1	West Elevation	Rafter	Radiata pine. Pockets of advanced brown rot and soft rot across the depth.	**Yes**	**None detected (LOSP?)**	**None detected**
2	South West Elevation	Sarking	**Radiata pine. Superficial soft rot and bacterial decay in the outer 1 mm. No established decay micromorphology was detected in deeper wood.** Dense fungal growths predominantly typical of mould fungi, yeasts, sapstain and/or soft rot fungi. Fungal growths present across the entire depth. Moulds: *Torula, Cladosporium, etc.*	**No[†]**	**Copper = CCA, e.g., H3.2**	**None detected**
3	North East Corridor	Skirting	Radiata pine. Pockets of advanced brown rot and soft rot across the depth. Low numbers of spores of *Stachybotrys*	**Yes**	**None detected (LOSP?)**	**Trace**
4	Central Corridor	Rafter	Radiata pine. Pockets of advanced soft rot across the depth.	**Yes**	**None detected (LOSP?)**	**None detected**
5	South East Elevation	Sarking	Suspected incipient brown rot	**Probably[††]**	**Copper = CCA, e.g., H3.2**	**None detected**
6	East elevation	Rafter	Radiata pine. Pockets of advanced soft rot across the depth.	**Yes**	**None detected (LOSP?)**	**None detected**
7	East elevation	Rafter	Radiata pine. Pockets of advanced soft rot throughout.	**Yes**	**None detected (LOSP?)**	**None detected**

Table Key and related definitions intended to give an indication of the scale (1 - 4) of risk etc.

Replacement*: ***preliminary guide (replacement decisions require consideration of site factors and the sampling rationale applied since this may alter the preliminary guide e.g. sometimes a broad-brush replacement approach requires removal of a mixture of decayed and non-decayed wood to ensure removal of a critical mass of infected and/or decayed wood, and in other well understood situations small pockets of decay can be left in situ – see main body of report).***

1. No**:** No microbiological evidence of elevation moisture. Global remediation practice sometimes requires replacement of framing in this condition if overlapped by neighbouring repairs, e.g., to correct systemic weathertightess failures.

2. **No[†]: Lower immediate risk but potentially <u>serious moisture hazard most likely present: this is likely to compound well within the life of the building</u>.** No evidence of major structural damage and therefore **<u>replacement is probably unnecessary</u>**, provided that samples are sufficiently representative and that such wood is not interspersed with more seriously affected framing. Presence of recent fungal growth is a significant concern in general terms because it denotes occurrence of unacceptable moisture elevation that may be worse nearby i.e. there is a possibility of decay nearby and/or its imminent arrival, particularly if any untreated framing is present. This is a particular concern for untreated perishable radiata pine framing. Removal of a proportion of framing in this condition is sometimes a necessary component of the required remediation if it is amongst more seriously affected framing as is often the case and it may highlight a need for **further investigation e.g., to determine the limits of moisture affected wood if not already known – see discussion.**

3. Probably††: **Intermediate risk**. Untreated wood with incipient brown rot decay and/or early soft rot decay typically comes from framing with more serious decay very close by and therefore as a general rule of thumb replacement is typically necessary for untreated framing i.e. under New Zealand leaky building conditions incipient decay typically occurs at the periphery of wood with an advancing front of established and structurally damaging decay whereas discrete pockets of incipient decay that might arise from spore arrival is less common. **This diagnosis also often applies to small discrete decay pockets in H1 boron treated framing although typically there is more latitude to leave such wood in place (e.g., replacement or further investigation is a common recommendation in such cases).**

4. Yes: **Higher risk.** According to strict remediation practice replacement is necessary except in unusual circumstances e.g. where removal poses drastic problems beyond normal remediation challenges and where an exceptional level of detail of the situation has been established which can enable consideration of an integrated non-replacement approach e.g. where it can be unequivocally shown that decay is highly localised and poses no structural integrity loss problems or ongoing decay problems. Where there is a risk of significant structural loss due to decay it is sometimes possible to compensate without framing removal using bracing techniques with additional framing.)

#Treatment: based on colorimetric qualitative spot test analysis for boron, copper and other metals (e.g. zinc and tin) – see points vi – ix of Appendix. $***:*** refer below and point 15 of the appendix.

- Wood was tentatively identified as radiata pine. (*Perishable medium density soft wood which is the dominant structural wood species used in New Zealand. A major advantage of this species is that it is easy to treat with preservative using factory processes thereby making it highly durable. However, if not treated prior to construction then it remains highly susceptible to biodeterioration damage. The effectiveness of remedial preservative treatment varies widely and is not a reliable substitute for NZS3640 compliant framing used in accordance with NZS3602:2003. In some situations, it acts as a very valuable additional "top-up" to other more important remediation practice, when applied correctly – see points 10 and 11 of the appendix. Remedial preservative treatment is typically a robust rule of thumb but unfortunately it is sometimes used as a poorly conceived substitute for other robust remediation strategy that often includes inadequate exposure and replacement of framing and other poor treatment practice. Leaky building damage can be seriously compounded by the dangers associated with such inappropriate remedial preservative treatment*). Samples 5-12 were identified as Douglas-fir at least some of which was most likely North American grown given the growth ring density (colloquially known as Oregon pine). This wood is rated moderately durable.

- Soft rot was similar to Corbett's type 1 cavitation and type 2 erosion. Brown rot was looked for on the basis of loss of wood cell wall birefringence and characteristic bore holes and associated characteristic fungi etc. Loss of birefringence is sometimes an indication of loss of crystalline cellulose within the S2 layer of the wood cell wall, the primary provider of wood tensile strength. When used in conjunction with other observations it is a useful diagnostic tool but can be misleading if used in isolation since there is large background variation of birefringence amongst sound wood.

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- The range of conditions of hyphae was consistent with multiple growth phases over a prolonged period most likely of several years, including recent activity in most samples.

- The toxigenic mould *Stachybotrys* was detected. This mould is very common in leaky buildings – see point 15 of the appendix (presence on wood is rare but very common on paper (wood pulp) containing material like Gib, fibre cement and building wrap and therefore low incidence on wood samples can be misleading as a guide to likelihood of the scale of incidence in a building).

Wood preservative analysis

i. **Samples 1 and 3-7 gave negative colour reactions for boron, copper and other metals (e.g., zinc and tin) using colorimetric qualitative spot tests, i.e., wood was most likely untreated perishable radiata pine, or may have been LOSP-treated in some cases, e.g., low retention of tin in H3.1, or H1.2, etc., this most likely depending on the age of the building.**

ii. **Sample 2 gave a positive colour reaction for copper, i.e., wood was almost certainly treated with a copper chrome arsenate preservative, e.g., according to Hazard Class 3 of MP3640:1992 (same as H3.2 of NZS3640:2003.)**

iii. Spot tests typically do not detect the majority of the more modern light organic solvent preservatives (LOSP) e.g., the fungicide 3- iodopropynylbutylcarbamate (IPBC) and the insecticide permethrin, used in combination for H1.2 framing (since approximately late 2003 - March 2005, in accordance with NZS3640:2003 and NZS3602:2003, and slightly earlier as H1-plus (probably 2002 as a non-obligatory treatment), or substantially earlier in the case of permethrin used alone for H1 framing in accordance with MP3640:1992). The spot test used for tin is not wholly reliable for small samples or where retention is low. An H3.1 treatment based on tebuconazole, propiconazole and permethrin has been available since 2002 although it has only been used in New Zealand in substantial amounts since approximately 2006 (has largely replaced tributyl tin (naphthenate and oxide) today). Triazoles cannot be tested for using spot tests.

iv. Quantitative preservative analysis was not performed in this instance because it was not necessarily of immediate value to the diagnosis. However, in some situations of particular scrutiny it is advantageous to have quantitative analytical data, for example if compliance with the retention requirements of NZS3640:2003 is an issue or if preservatives are of a type that are undetectable using sport tests, e.g., LOSP H1.2, some LOSP H3.1, LOSP H1 (permethrin) and LOSP H1plus.

v. **See Appendix regarding background information.**

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Discussion and Conclusions

1. **Wood samples 1, 3, 4, 6 and 7 contained advanced decay that had likely caused significant loss of the original structural integrity in affected areas. Overall cross- sectional integrity of the wood may have been compromised (risk of failure nearby).** According to strict remediation practice and classical remediation empirical wisdom, as a general rule of thumb wood with well-established decay should be replaced with appropriately treated framing (NZS3640:2003 specified H1.2, H3.1 or H3.2 depending on the location). In some situations, discrete pockets of well characterised early decay, in non-critical areas, can be left in situ provided that other remediation practice is applied (see point 2). **Replacement is typically recommended for framing in this condition, as part of robust remediation practice, and this is most likely required in this instance. (See points 7 and 8 of the appendix).**

   Framing sample 5 contained earlier stages of decay. Wood in this condition is somewhat marginal in terms of replacement, this depending largely on the frequency of occurrence of wood in this condition and on local conditions e.g., building design and the nature of related faults etc. Small discrete pockets of wood in this condition can often be left in situ provided that other remediation practice is applied although it is important to establish the limits of affected framing. **Replacement, or further investigation to establish the limits of affected wood (if not already known), is recommended for untreated framing in this condition.**

2. **Wood sample 2 contained highly prolific fungal growths and superficial decay, but no structurally significant decay was detected. The bulk of fungal morphology was typical of mould fungi, sapstain fungi and/or soft rot fungi, and yeasts.** Such wood is typically found in moisture compromised wall cavities and other locations, and/or on the periphery of more seriously affected framing sometimes in need of replacement.

   Framing in a similar condition can typically be left in situ provided that the samples were representative of the worst case in the areas sampled, and provided that this does not interfere with any necessary global replacement strategy, and on the basis that all interior wood is dried to below 18% moisture content and ongoing moisture contents are consistent with sound building practice. Where practical, in-situ preservative treatment is typically recommended for all exposed and/or infected wood – see points 10 and 11.

3. **There is an important caveat to the diagnosis for sample 2, this being that decay is often present nearby wood in this condition. <u>Results showed that this sample had been exposed to conditions conducive to decay, e.g., more severe decay nearby, or future severe decay is not unlikely, e.g., in the absence of suitable</u>**

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remediation. Presence of wood preservative had probably prevented severe decay to date, i.e., any similarly affected less- durable materials, e.g., some types of cladding, untreated wood, etc., may contain decay or other types of water-damage. ***This preventative effect is likely to wear off well within the life of the building.*** **Moisture hazards often compound suddenly, i.e., the initial 5-10 years of the buildings life is often misleading as a guide to the rate of future water-damage which may accelerate suddenly.** It is vital to establish the limits and causes of affected wood which may require extensive removal of cladding and/or other building materials and/or iterative analysis. It is sometimes necessary to remove a proportion of sound wood along with substantially decayed wood during remediation, to ensure that a critical mass of compromised wood is removed or to achieve the most cost-effective global replacement approach.

4. Based on observations from New Zealand leaky buildings the condition of at least the majority of samples **1-4, 6 and 7** was consistent with exposure to at least 5-10 years of elevated moisture conducive to decay (moisture levels typically above 30%) although a longer period, e.g., of more highly intermittent moisture elevation, is also likely. *Decay typically develops within the first year after enclosure for many types of commonly occurring weathertightness deficiencies.* Sample **5** had been exposed to moisture elevation conducive to fungal growths and possibly also at least marginal, e.g., highly intermittent, moisture conducive to decay, but not yet deep structurally damaging decay (serious decay may be present nearby) most likely for several years. *More refined diagnosis of the duration of decay damage and its commencement is often possible with more site-specific information.*

Fungal growth can occur over the range 16 – 30% (and of course at higher moisture contents where it usually occurs with decay in perishable framing) and possibly at even lower values if humidity is very high and/or transient condensation is an issue. Fungal decay requires free moisture, as occurs at moisture contents above the fibre saturation point near 29 - 30%. However, 30% is not a reliable lower limit for decay occurrence and some decay fungi can move into wood and initiate decay at considerably lower moisture content levels.

The only reliable and indisputable facts with respect to wood moisture content effects on decay within the context of leaky building diagnostics, are that decay is inevitable above the fibre saturation point of approximately 30% and that values below this are unreliable as a guide to possible problems (partly due to the transient nature of moisture elevation and the limitations of detection techniques). However, understanding the significance of different moisture contents over the range of the lowest emc values encountered in wood in buildings (around 6% for furniture in a dry room) to the highest (about 22 – 25% such as might be found in a sauna), and for other moisture values of 25 – 30%, can be useful but is not straightforward and

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confusion often arises – see points 13 and 14 of the appendix. If in doubt, return to the rule of thumb stated here and then apply the *golden rule of thumb* referred to in point 6.

5. **The toxigenic mould *Stachybotrys* was detected and a significant biohazard health risk may be present: further investigation is recommended. This fungus is very common in leaky buildings. It may be necessary to take precautions to prevent or minimise contact with occupants and others (e.g. remediation workers) – see point 15 of the appendix.**

6. Whilst the principles of remediation science are straight forward the causes of decay in buildings are multivariate and the necessary remediation required varies significantly between sites. Diagnosis of the required remediation requires significant remediation knowledge and its on-site application. Several sampling iterations and analysis are sometimes necessary before an appropriate diagnosis and remedial response can be identified. *Always bear in mind the golden rule: keep looking until a very high degree of confidence exists that all causes of moisture elevation have been accounted for, and the limits of infection and decay have been identified and dealt with appropriately (particularly important for untreated perishable framing). Missing small areas of infection and decay is inevitable in some situations but in the great majority of cases this is not a problem provided that the golden search rule is diligently applied and provided that the attendant rules of thumb of remediation practice are not compromised along the way to final remediation.*

Appendix – Important Background Information

Wood preservative analysis

iv. The limit of detection of the boron spot test used was close to 0.02% BAE, similar to the detection limit for routinely employed quantitative analysis (0.01 – 0.04% depending on condition and size of sample). Spot tests can detect boron in wood with undetectable mean cross-sectional retentions due to the dilution steps carried out during wood preparation prior to analysis.

v. Minimum retentions needed to control decay fungi vary and typically fall within the range 0.1 – 0.5% (5 – 25 times the detection limit). The central 1/9 (11% of the wood volume) has traditionally required a minimum core retention of 0.04 for insect borer and 0.1 for decay fungi, this being a traditional check that adequate penetration was achieved it being correctly assumed that much higher retentions reside nearby in the other 89% of the wood volume. Unfortunately the core retention requirement was left out of H1.2 in 2003, a somewhat controversial omission (it is requirement for H1.1 wet frame).

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vi. Typically, buildings constructed prior to the introduction of the new H1.2 boron retention minimum requirements in 2003, contain external framing that does not meet the retention requirements of NZS3640:2003. Observations from approximately 1000 buildings (mostly aged 4 – 10 years) have shown that boron retentions of 0.05 – 0.3% w/w BAE are common although retentions as high 1.5% have been recorded. It is highly unlikely that any house built prior to 2003 contains external wall framing with a **mean** boron retention of 0.4% or above and on this basis it is reasonable to recommend that all framing exposed during remediation is treated.

vii. Rarely, depending on the age of the framing and other factors, the H1 and H1.2 alternative treatments permethrin or IPBC were used for framing. Permethrin is an insecticide only and IPBC is a fungicide only. Since NZS3640:2003 was introduced IPBC has been used with permethrin as an LOSP H1.2 treatment (blue coded framing). However, IPBC was also used in "H1-plus" framing for approximately 18 months prior to 2003 and permethrin only was used as an H1 treatment (insecticide only) according to NZS3640:1992 i.e. since 1992.

viii. There are no spot tests available for IPBC and permethrin and the quantitative analysis necessary is relatively costly, time consuming (typically a 14 day turn around) and typically unnecessary since forthcoming information usually shows that these treatments were not relevant i.e. by a process of elimination.

ix. Unlike the more commonly used H1 treatment boron, permethrin is not a fungicide and is therefore of no durability value in the context of leaky buildings and fungal decay. Boron adds resistants to decay in some low to moderate decay hazard situations found in leaky wall cavities but this effect is dependent on boron retention which varies greatly for H1 framing i.e. durability of H1 (and H1.2) boron treated framing varies greatly in leaky buildings.

Decay analysis and remediation

7. **According to strict remediation practice wood with established decay should be replaced with appropriately treated framing (NZS3640:2003 specified H1.2, H3.1 or H3.2 depending on the location).**

8. **Strict adherence to classical remediation practice is typically indicated for wood with well-established decay.** This typically involves removal of all decayed wood and sometimes an additional 1 meter of wood beyond the obviously decayed limit (***along continuous, not discontinuous framing e.g. framing broken by well defined breaks such as between parallel joists well separated by nogs or window frames, or similarly well-separated horizontal framing***). Latitude often exists for substantially less wood removal, particularly for preservative treated wood (not remedial

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treatment, including treatment applied during construction), and once the limits of decay have been well defined via suitable laboratory analysis or other appropriate methods. However, the 1 meter rule is a tried and tested approach in Europe and North America and provides a solid footing for recommendations in the first instance, or if there is doubt concerning the limits of decay. Where deviations from the rule are taken it may be important to take wood samples either side of the estimated limits of decay for further micromorphological analysis. As a general rule of thumb it is recommended that the 1 meter rule is applied unless there is a significant remediation cost-benefit in not doing so, and having established the limits of decay accurately by thorough analysis, in some cases with further concurrent micromorphological analysis.

9. Whilst 4 weeks is typically an unrealistic timeframe in which to effect remediation, 4 weeks is intended as a guide for the minimum timeframe within which wood should essentially dry out if effective drying conditions have been implemented i.e. if wood has not dried within this timeframe a different strategy is probably required. Once established, decay can advance significantly within a 4 week period if left unchecked. All untreated or poorly treated wood that cannot be dried rapidly prior to remediation or after remediation should also be replaced irrespective of its condition. Effective and rapid drying sometimes requires complete removal of cladding and/or lining and it is vital to explore all possible moisture ingress points as well as areas several meters either side of all possible vertical leakage planes since some fungi can spread long distances over essentially dry materials in some situations. Other explorative measures may be indicated depending on the nature of the construction.

10. In-situ wood preservative treatment is recommended for all exposed framing that is not treated to Hazard Class H3.2 or H3.1 and any other suspect areas i.e. areas affected by moisture elevation. Typically, buildings constructed prior to the introduction of the new H1.2 (NZS3640:2003) boron retention minimum requirements in 2003 contains external framing that does not meet the retention requirements of NZS3640:2003. Therefore, in-situ preservative treatment of framing is often a wise precaution for all buildings that have had significant leakage problems irrespective of the extent of decay. However, the decision surrounding the extent of in situ treatment required varies according the local conditions and a pragmatic approach that takes account the ongoing likelihood of recurring leaks is needed.

11. ***Two liberal applications (500 mls per 10 linear metres of 100 x 50 mm framing) of Framesaver concentrate (do not dilute) by brush or airless spray is commonly used in New Zealand (typically the default recommendation because wood is often damp) although an LOSP type preservative such as Metalex is more suitable in some situations provided wood is essentially dry. <u>However, because Framsaver has a thick consistency, much more typically gets applied during typical rapid brush</u>***

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strokes, and this is a substantial advantage because the retentions achieved are more realistic.* *It is typically vital to treat at least 3 faces of exterior framing paying particular attention to the exterior faces. However, treatment of 4 faces if at all possible is recommended. Complete removal of cladding and/or lining is often required to allow effective and rapid drying of framing and/or to facilitate discovery of all decay. Removal of cladding to expose exterior faces of external framing is typically the only effective way of allowing sufficient access to framing that is in need of preservative treatment. Typically, it is not possible to treat bottom plates effectively in situ and consequently they need to be removed in some situations. Drilling holes where multiple adjacent framing occurs such as corners improves treatment of occluded faces and deeper wood but is typically impractical as a general method of extensive application (brush and/or airless spray is the most practical application method).

- *There is occasionally a misguided view amongst those of insufficient practical experience of remediation issues in New Zealand that it is acceptable to leave large amounts of deep, well established decay in situ during remediation provided a preservative is applied. This is sometimes incorrectly justified on the basis of limited artificial laboratory studies, where preservative applied to framing with decay at optimal moisture contents for preservative diffusion are maintained, and not surprisingly this allows diffusible preservative to halt decay in mini frame experiments. These conditions rarely occur in buildings where uneven moisture distribution and uneven fungal infection and decay pockets are the norm. (Small isolated pockets of decayed wood can be left in situ in some well understood situations).*

- *However, the questionable value of laboratory data to real building conditions is not the primary danger with respect to the inherently misguided nature of leaving large amounts of decayed wood in situ. Leaving extensive deep decay in situ, in most wall cavity situations, is dangerous because it encourages a lack of exploration and lack of identification of all the causative issues. It is also contrary to classical literature and the substantial base of empirical remediation wisdom and practice on which the literature is based. Therefore, those following this practice expose themselves to potential criticism and potential legal liability. It is wise to base ones advice on a long proven robust approach based on decades of sound classical remediation practice, as opposed to more recent advice based on a narrow and limited perspective.*

- *Also, there is a risk that structurally compromised framing will be overlooked and/or left in situ. Concealed decay is not uncommon and its thorough identification and the determination of its significance typically require the* *application of classical on-site investigation techniques and supportive off-site analysis.*

- *It is sometimes argued that New Zealand conditions are significantly different from situations on which the classical remediation literature is based and that new practice can therefore be applied. Such a view is premature at best considering the track record of New Zealand building practice in recent years and the relatively recent advent of improved practice and the recent introduction of a remediation skill base.*

- *There are also methods of pressure impregnation that can be used to treat framing in-situ. Pressure impregnation has a proven track record for use in buildings and whilst there are relatively few situations in New Zealand where this approach is useful within the context of leaky building remediation, it may have application in highly specific and well understood situations. Radiata pine framing is essentially untreatable by pressure impregnation once it is part of a structure i.e. attempts to force liquid into the wood by pressure is likely to result in seepage and escape of preservative. It is typically vital to remove either the cladding or lining, and sometimes both, if wood is to be treated effectively without gross over-treatment and contamination of surrounding materials and the local area. Over-treatment may damage surrounding materials and may contaminate the living space (immediately or later if any excess dehydrated preservative becomes airborne) or the outside area and this may have health, safety and eco-toxicity issues. It is therefore essential to keep close track of where preservative goes at all times which is typically not possible if too much of the framing is concealed.*

12. In some situations it is possible to leave structural framing containing pockets of decay, in situ. This is typically not recommended, is not undertaken lightly and requires detailed knowledge of the situation. It is sometimes important to derive a method of eliminating active or potentially active decay fungus. This is difficult using surface applied preservative in many situations, the primary purpose of which is to provide future decay protection, not a sterilisation effect. Methods of sterilisation are available but their application requires specialist knowledge and equipment and is only cost effective in some situations e.g. where the cost of replacement exceeds the cost of in situ remediation. It is also vital to ensure that any structural damage left in place does not compromise the function of the affected framing or adjacent features or the overall integrity of the building.

13. Rules of thumb regarding the wood moisture content and decay.

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For inspection purposes

i. When investigating an unknown situation it is important not to rely on MC readings in isolation i.e. never take a low value at face value because moisture elevation is often transitory (MC is only one tool in the repertoire).

ii. Always take any value above the expected equilibrium moisture content (emc) value as a warning i.e. including values below 18% (if possible it is useful to obtain a few points of reference from areas that are "known" to be unaffected by poor design/faults etc. to establish the actual emc range). (Preservatives, wood extractives, moulds and sapstain fungi, wood species ect. can have substantial effects on emc.). Active fungal infection, including decay fungi, is very common in wood recorded at moisture values below 18% as measured in leaky buildings in New Zealand.

For remediation and beyond

iii. Moisture must never go above 17% (exceptions arise from extenuating circumstances but these must be well defined).

Caveat rule of thumb

iv. An important qualification is that all moisture content measures and cardinal values used or referred to during investigation and remediation are indicative not absolute (including 18%). ***Once decay is established there is a significant probability that ongoing decay will occur at and close to 18% MC but for uninfected wood the MC conditions required for decay are closer to the fibre saturation point, probably 24 – 30%.*** (Fungi produce metabolic water during decomposition of wood and this local moisture may be undetectable with available detectors which pick up the macro-moisture % not the micro-moisture %. Furthermore, moisture conditions in the outer 1 – 5 mm are sometimes different (higher) than in deeper wood in situations that are marginal for decay e.g. where condensation occurs. Whilst references for decay at 18% are rare it nevertheless serves as the lower limit of reported activity (decay at 16% has also been reported but is probably not relevant in the context discussed here). For dry rot which can grow over and through wood that "was" below 18% (i.e. it translocates moisture as it advances) this typically requires RH values above 85% and optimally close to 100%. Moving air and RH values around 75% and below usually retard dry rot growth at low wood MC.)

14. Additional Critical Moisture Value Rules of thumb for leaky building investigation

- *8 -14%: approximate emc range for framing in wall cavities*

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- *16%: (maximum MC quoted for wall cavity enclosure during construction and minimum moisture quoted in the literature at which fungal (e.g. mould) growth can occur but at which wood decay does not become established)*
- *20%: widely accepted minimum threshold below which decay is prevented (allows a comfortable safety margin below the fsp above which decay establishment is inevitable)*
- *20 - 30%: range over which it is difficult to be certain what is occurring partly because of the limitations of detection devices but also because of other factors*
    - *<fsp (approx. 30%) decay establishment unlikely because no free moisture is available but there is significant margin for error in interpretation of MC values between emc and fsp and therefore 30% is substantially too high a lower limit for reliable risk assessment*
    - *16 - 30%: fungal growth often occurs but active wood decay unlikely although it may be imminent or very close by*
    - *>fsp (approx. 30%): decay inevitable*
- *40 - 70%: common MC range for aggressive decay*
- *80%: maximum MC sometimes quoted for brown rot*
- *30 - 400%: range for decay (120 - 400%: at or close to the wood saturation point at which decay stops or proceeds at greatly reduced rates due to shortage or lack of oxygen)*

Toxigenic mould (and related hazards): putting possible risks into perspective

15. Consideration of the possible health implications of *Stachybotrys* and related hazards that are sometimes more important, is not a simple exercise and in the current context can only be addressed with significant qualification and limitation, e.g., no single statement should be relied on in isolation and over reliance on limited air spore analysis and markers of hazards such as *Stachybotrys* is often an issue. **It is important to consider *Stachybotrys* not just in its own right but as an indicator of a much larger group of potential air quality hazards the implications of which are not well understood.** In general terms it is reasonable to consider *Stachybotrys* as a marker of such potential health hazards although there are many common situations were air spore analysis fails to detect *Stachybotrys* where it is prolific, e.g., in wall cavities, and where other moisture-related hazards are present. There are also common occurrences of *Stachybotrys* in buildings were it does not pose a significant health hazard. There are many damp building situations were other hazards collectively are far more important than *Stachybotrys*.

16. **Probably the best readily available summary of many of the issues are covered in the World Health Organisation (WHO) report "*guidelines for indoor air quality, dampness and mould*", a 2007 publication. However, guidelines based on empirical wisdom and available information that reasonably apply to the**

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majority of people in the majority of known situations do not necessarily apply to everyone's health (some people are more sensitive) such that advice from a personal health care practitioner is essential if there are concerns in this regard.

17. Modern building designs, HVAC systems, and other issues that reduce dilution of internal air with clean and/or fresh air can increase the risk from moulds and other biohazards. In cities with high levels of pollution there is a probably trade-off although this is less of an issue in New Zealand. There is a significant amount of poor information available within this field and discerning investigation and consultation is therefore important.

18. *Stachybotrys* is typically the not the most important health risk issue in moisture compromised buildings.

19. *Stachybotrys* is often described as a toxigenic mould which means it contains substances that are known to have mammalian toxicity in some situations and which have been implicated as a cause of serious human illness, in some situations. There is significant controversy concerning the validity of a causal relationship between *Stachybotrys* exposure and illness, and no safe limits are available. Exposure to low doses of *Stachybotrys* is very common and there is no compelling evidence of a significant health risk to most people most of the time. On the other hand there are situations were exposure to even low doses of *Stachybotrys* and other species of fungi by some sensitive individuals, would be deemed inappropriate and risky for their health and wellbeing.

20. **Unlike some other types of biohazard and related hazards, *Stachybotrys* is commonly found in very high concentrations in wall cavities and other confined spaces in buildings that have undetectable amounts of *Stachybotrys* in the air. In fact this is an order of magnitude more common than other situations such as where *Stachybotrys* is detected at levels that truly reflect the total spore count within concealed areas, or where *Stachybotrys* is not detected in the air but is present in very high concentration in concealed spaces. This means that air spore analysis is typically an unreliable method of detection *per se*, particularly if not done regularly for a sufficient length of time. Air spore analysis is nonetheless a valuable tool that should be used in many common situations of building investigation, particularly during remediation and any other activity that disturbs building materials. It is important to monitor mould for a sufficient period after remediation because as materials settle and dry and go through multiple diurnal temperature and relative humidity cycles, air spore counts can change markedly. The possibility that other hazards, including volatiles and particulates that are not routinely looked for, may be significant should be given careful attention. Unfortunately the normal amount of airspore**

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analysis routinely applied is inadequate and in the absence of other equally important types of analysis and prognostic qualification, the potential for problems is significant.

21. ***Stachybotrys* is also a relatively common soft rot decay fungus that has an extremely high propensity for growth on (and degradation of) any building material containing wood pulp (paper, Gibralter board linings, fibre cement cladding, etc.) which gets wet for periods in excess of a few days (usually several months, or more). As such it is commonly encountered by many people.** Because there are significant unknowns concerning the health risks of *Stachybotrys* and related contaminants, it is important to err on the side of caution which, in part means that it should, at the least be removed wherever possible to the point that it becomes undetectable within the living space, e.g., via use of air-spore analysis although this method has severe limitations for detecting health hazards related to moisture compromised buildings. It is nonetheless a valuable tool if used correctly. On the other hand it is commonly used poorly, the results are commonly misunderstood, and there is a significant risk of missing important issues and misrepresenting others.

22. Exposure of healthy individuals to small quantities of *Stachybotrys* is unlikely to pose a serious health threat in most cases, most of the time. However, it is wise to handle the mould (and other moulds) with caution, avoiding direct contact and inhalation of disturbed material. It is known that otherwise healthy individuals, who are regularly exposed to toxigenic moulds found on wood products, can suffer significant health problems. Some sensitive individuals are likely to be significantly affected by much lower doses. If mould is dry upon discovery airborne spores are more likely to be inhaled. **If mould is wiped with cleaning products this can increase the risk of inhalation.** Mouldy material in living spaces should be removed, taking care not to introduce airborne material. Mouldy wall cavity materials also pose a potential threat to occupants since spores can migrate into the living space however the most serious threat occurs when the material is disturbed and therefore removal should be carefully planned and executed.

    Trichothecence mycotoxins produced by *Stachybotrys* are lipophilic (fat soluble) and can potentially be absorbed through the skin. Therefore gloves, protective disposable clothing and approved breathing apparatus are recommended whenever significant quantities of mouldy material are handled.

    The majority of other moulds that occur in buildings are not generally considered to pose as serious a health hazard compared to *Stachybotrys,* although this may not necessarily be correct and therefore the presence of any mould in dwellings can pose a health hazard, especially to those predisposed to pulmonary dysfunction

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(e.g. asthma sufferers) or those with a lowered immune response (e.g. the very young and very old). Other toxigenic moulds have been isolated from moisture compromised buildings although the bulk of information refers to mould that arises through poor management of ***internal*** moisture as described in the New Zealand building code. *Stachybotrys* can also arise in buildings as a result of poor internal moisture management (e.g. moisture from living activities such as hot water washing, cooking and breathing etc.) but in New Zealand it is almost certainly more commonly associated with ***external*** moisture, i.e., moisture that enters during leakage.

This could be related to the preference of *Stachybotrys* for very high moisture contents as are common in leaky wall cavities, as opposed to dew points associated with condensation planes that tend to result in more transient elevated moisture conditions.

Other health hazards related to microbial degradation of damp building materials are possible e.g. release of volatile toxins, either directly from microorganisms, or from decomposing building materials. Other microorganisms including actinomycetes, bacteria and yeasts may also pose a health hazard in moisture compromised buildings in some situations.

Other information about assessing mould risks in buildings

23. Any generalisation on health issues carries a degree of risk for some people but in general terms the mainstream medical fraternity (or its representatives in Government departments) typically considers that health problems from mould in buildings beyond pulmonary function issues, e.g., asthma, particularly in the young, are not well substantiated, or are poorly substantiated, at least to the required standard of scientific rigor expected within scientific circles (not necessarily legal disputes). A small minority of medical experts profess strong links between exposure to mould in houses and a raft of illnesses, neurological disease in particular. Some scientific publications support some aspects of these links, at least indirectly, or anecdotally, but such risks are sometimes over-stated.

As a point of reference, mycotoxins are well understood to cause serious, sometimes life threatening health problems, e.g., in poorly stored peanuts and mycotoxins are tested for routinely to protect health in this situation (e.g., peanuts, and some other foods). In buildings, the issue is far less clear cut, although in general terms within the field of toxicology it is well understood that some toxic substances, possibly including mycotoxins, are especially toxic when inhaled. Advocates who argue that occupants were/are adversely affected by mycotoxins in buildings often use logic that is poorly founded most of the time but that does not

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necessarily mean that they are wrong all the time, or that what they suggest is a remote possibility. For example, tremorgenic mycotoxins from *Aspergillus fumigatus* are reasonably well-established as a contributing factor for causing serious illness in sawmill workers in Sweden, as covered in respected peer reviewed scientific journals. However, high doses, usually over a prolonged period were necessary to cause symptoms in most individuals. However, sensitisation is a possibility and some individuals will start off being much more sensitive than the majority but are not necessarily taken seriously, sometimes for the wrong reasons.

One of the problems is a lack of commercial and Government funding in research on the effects of mould in poor housing. Furthermore, some of the issues are defined by complex, multifactorial parameters that are inherently difficult to investigate.

This situation means that the mould remediation industry is vulnerable to scaremongering and a lack of scientific robustness, and a lack of the most appropriate intervention to help people. The mould remediation industry regularly quotes the dire health consequences of exposure to mould where it is either inappropriate, or out of context, or at best is premature, or where a more measured approach would suffice. This is a particular problem in North America and some other countries. However, there is no question that damp buildings are bad for health in general terms (hence the WHO report) but not just because of mould and the often overly simplistic information given by mould remediation companies and laboratories attached to them, or used by them. There are other biohazards involved and chemical hazards, etc., and these are often not mentioned, or are overlooked. ***There is an over-reliance on, or poor deployment of, air spore analysis. An over-reliance on specific markers such as Stachybotrys. Links made between specific moulds and the level of health hazard tend to be too arbitrary, or are too generic.*** *For example, t*ypically, air spore testing is not carried out over a long enough period, or is carried out and interpreted poorly, e.g., in a way that is unrepresentative of the specifics of each building and/or the type of people who occupy them. Risks for different groups of people and different individuals varies greatly, as do the differences between buildings. Unfortunately there is often a lack of in-depth scientific now how at a suitably high level that is brought to bear and too often generic testing methods and overly simplistic interpretation are applied to highly variable buildings without taking account of the relative risks faced by different individuals.

Sometimes when advice is sought by those with mould in houses, rather than giving the initial problem perspective and balance, the fires of worry are often stoked upon learning the exaggerated, or misplaced risks of mould exposure. Given that it is well-established that the placebo effect and the suggestive effect are very

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powerful, this is likely to have a significant effect on people's health issues in relation to mould in buildings, **particularly where information and advice is poor.** On the other hand there are situations where the health effects of mould carry an elevated risk, e.g., those who are immunocompromised, those undergoing surgery, the very young and the very old, etc. **However, generalisations can be misleading and ultimately each person is unique and should follow the advice of appropriate health professionals and people should consider seeking second and third opinions on serious issues.**

A glance at the literature within the field of mould-investigations of buildings suggests that poor forensic analysis of the causation is the norm rather than the exception, particularly in North America. The depth of objective science appears to be rather shallow in many cases. In part, this possibly relates to a shift away from the more traditional training routes for entering this field such as mould issues attached to the wood product based sciences and industries, towards a situation where more people are coming from environmental sciences, etc., that do not appear to go into great depth with respect to the underlying science, particularly material science and microbial ecology. Possibly there are other reasons related to the huge growth in air quality related investigations and the emotive and often highly charged health issue arguments sometimes pushed by people working in this industry, although this less of a problem in New Zealand. **On the other hand New Zealand has an unprecedented incidence of leaky buildings and has other serious housing problems so this high incidence will elevate some of the risks in general terms.**

Yours Sincerely

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