



EFFECTIVE RISK-BASED DECONTAMINATION STRATEGIES USING ENZYMATIC INDICATORS

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ACDP – AUSTRALIA'S NATIONAL BIOCONTAINMENT FACILITY
www.csiro.au





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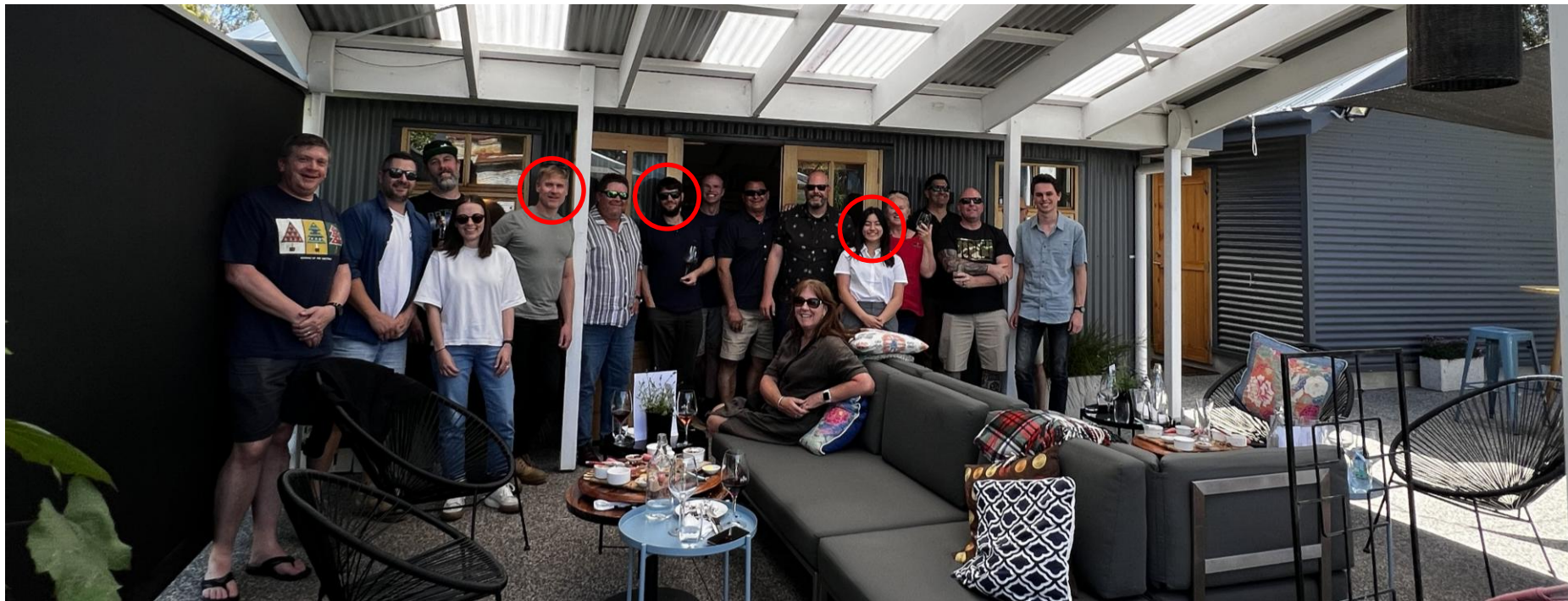
The Australian Centre for Disease Preparedness respectfully acknowledges the Wadawurrung people of the Kulin Nation, the Traditional Owners of the land on which ACDP sits. We pay our respects to their Elders past and present.

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ACDP's Biorisk Management Group



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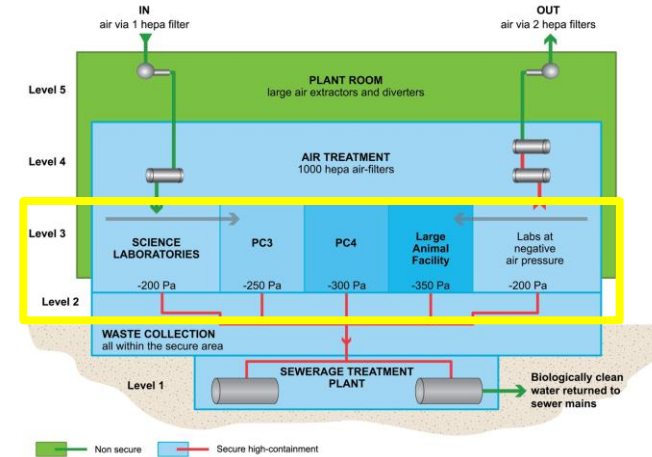
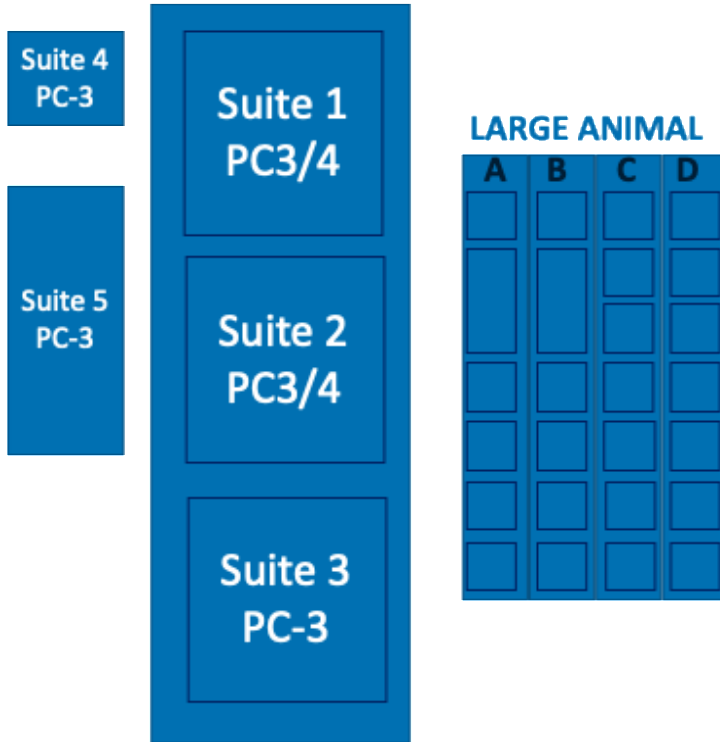
ACDP – A CSIRO National Facility

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- Opened 1985
- 100-year life span
- Lab Facilities
 - PC-2= 2600m²
 - PC-3= 2900m²
 - PC-4= 400m²
- Animal Facilities
 - PC3- 955m²
 - PC4= 127m²
- Insectary
 - PC-3= 250m²
- Mixed hazard environment

ACDP – Decontamination Considerations

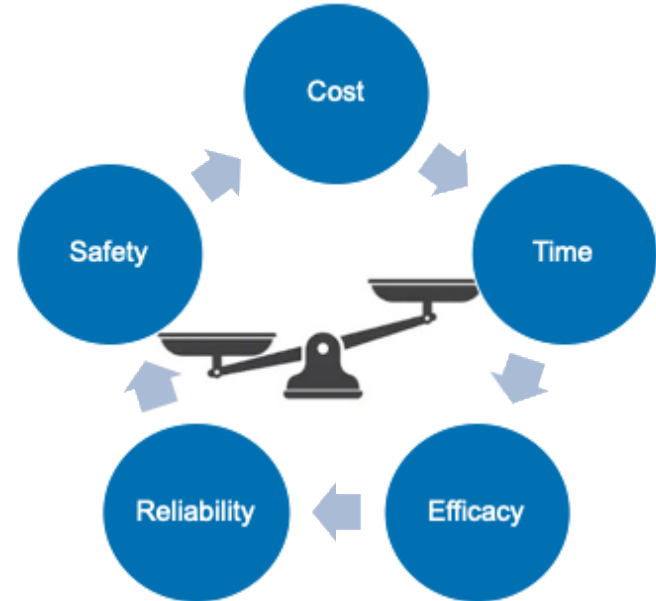


- PC3 and 4 Laboratories and animal rooms
- 3 contained floors of supporting infrastructure
- Decontamination activities differ between laboratory, animal rooms, and critical infrastructure

Risk-Based Considerations for Biorisk Management

Decontamination

- Choice of method is evidence-based and risk informed
- Driven by agent characteristics, bio-load, requirements of the decontaminant, material compatibility, safety considerations, environmental impact and feasibility
- Operationally implemented with good practice, incident response, equipment maintenance and facility design
- Methods must be validated



ACDP – Spatial Decontamination Methods

Formaldehyde



Chlorine Dioxide

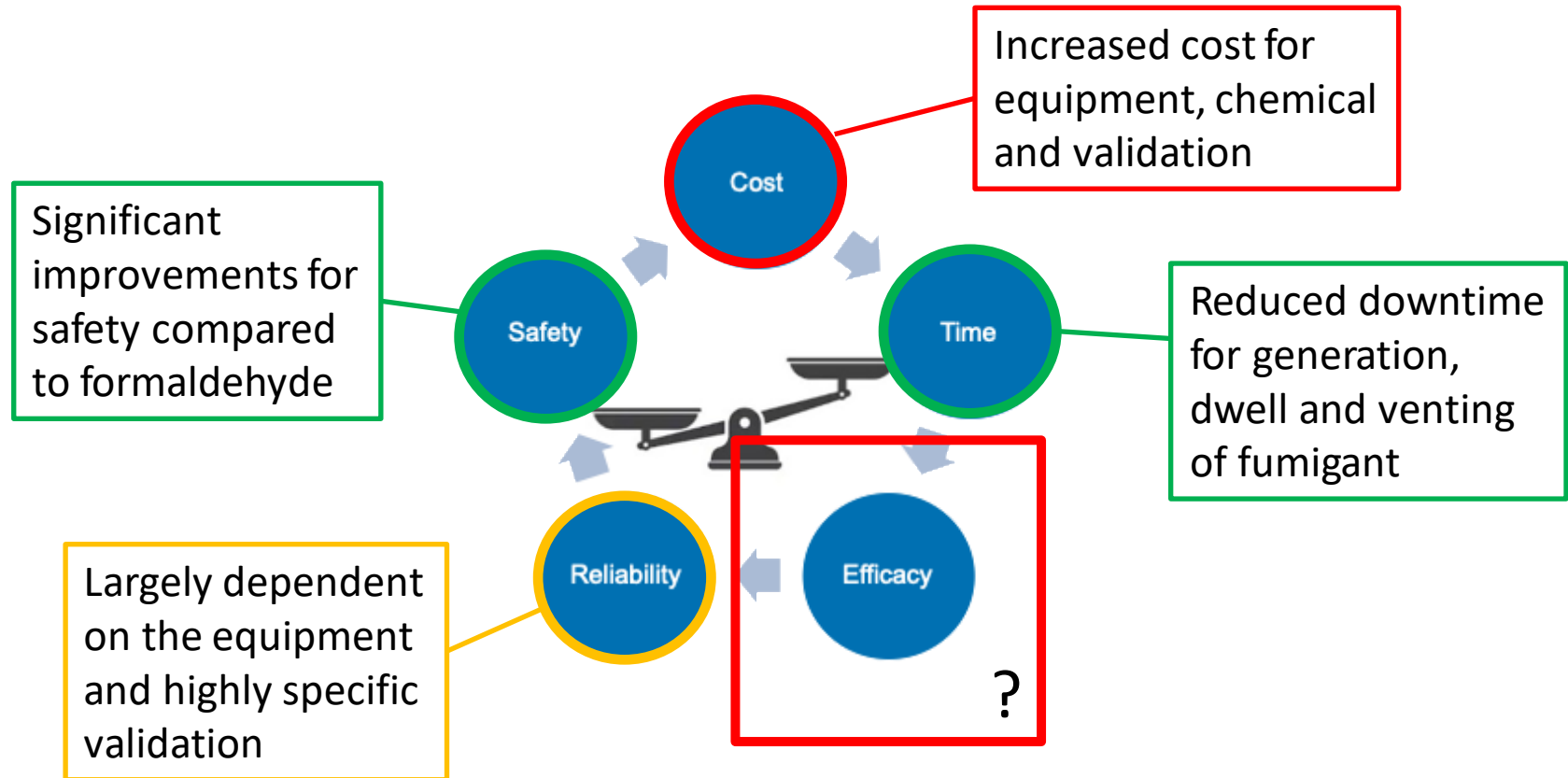


Hydrogen Peroxide





ACDP's Switch to Hydrogen Peroxide- Risk Analysis



Validation; reproducible, predictable efficacy determinations

Biological Indicators (BI)

- Live/Dead spore readout
- Traditional and widely accepted
- Varied incubation time (1-7 days)

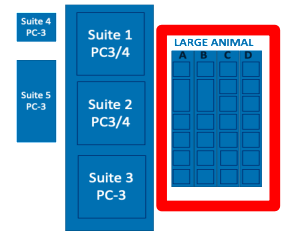


Enzymatic Indicators (EI)

- Stable enzyme (Adenylate Kinase)
- Quantitative efficacy readout (Log 10^1 - 10^9)
- Highly accurate
- Rapid readout (1 min per strip)



Replacement of Formaldehyde for spatial decontamination of animal rooms



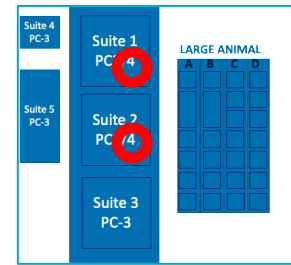
- Operational turn-over of rooms improved from 5 days to 2 days
- Further operational gains realized when transitioned from BIs to EIs (2 days to 4 hours)
- Significant enhancement to occupational safety with quick ventilation and no off-gassing issues





Validation of H₂O₂ for Decontamination of PC-4(s)

- Quantifiable variability of EI reading throughout the suite allowed for generator and fan adjustments
- Deviations between EIs and BIs were noted in select locations (BSC floor) with BIs reading negative and EIs Log 5.5-5.8
- Further operational gains realized with H₂O₂ and EIs shifting decontamination timeframes during annual shutdowns from 2 weeks to 1 day





BI versus EI evaluation

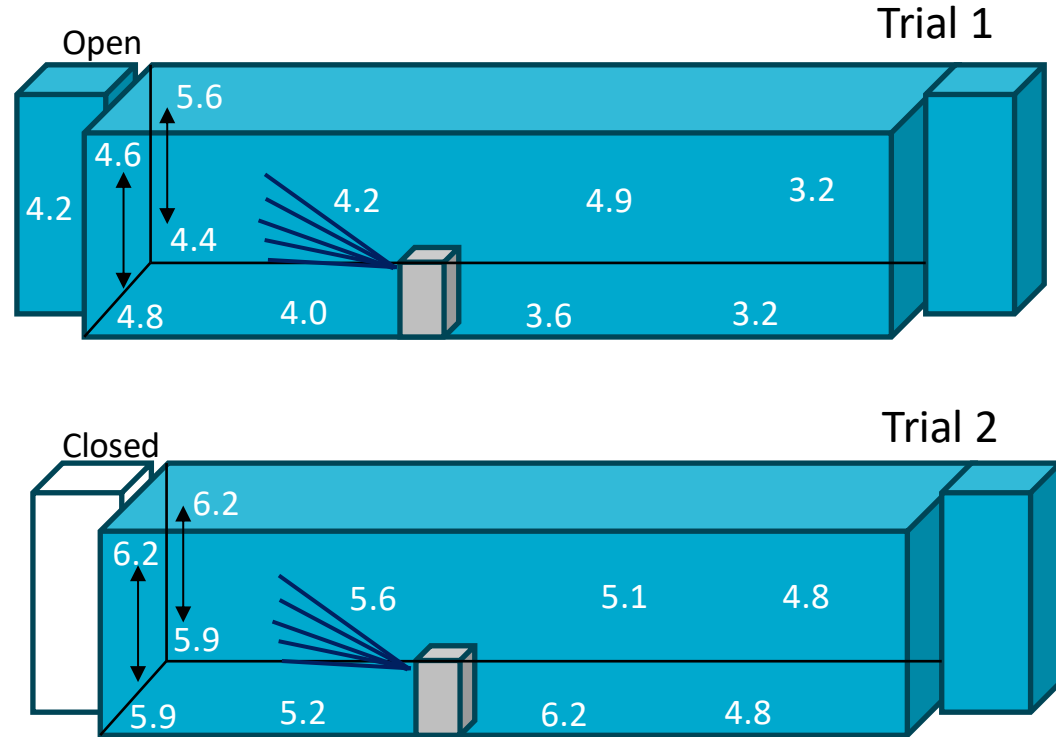
H2O2 Volume(mL)	H2O2 conc. (mL/m ³)	BI 1 Result (48 hr)	BI 2 Result	BI 3 Result	EI Result (Log reduction)	EI 2 Result	EI 3 Result
900	9	-	-	-	7.7	6.7	7.4
500	5	+	+	+	6.3	7.4	6.3
250	2.5	+	+	+	4.5	4.9	3.3

Integration of EIs into ACDP Decontamination Process

- EIs provide a quantitative look into the decontamination process to allow for risk-based review of the results
- Optimized chemical volumes to desired decontamination efficacy in LAF rooms
- Optimized dwell times using EIs with dwell times beyond 4 hours showing limited efficacy gains
- Deviation between BI and EI was clear and highlighted standard deviation typically noted for BIs
- Significant opportunity to explore risk-based decontamination strategies below the BI setpoint (Log 6)

Gradient of Decontamination Efficacy Observed with EIs

- Trials conducted in sealed, empty animal room with air handling off (325m³)
- Trials with anteroom door open and closed
- H₂O₂ Generator placed 4m from wall (Sanosil CT20)
- 4 hour cycle
- 50ml/min flow rate
- H₂O₂: 2.9ml/m³
- EIs (Protak Scientific) placed throughout the area
- Efficacy reported in log scale



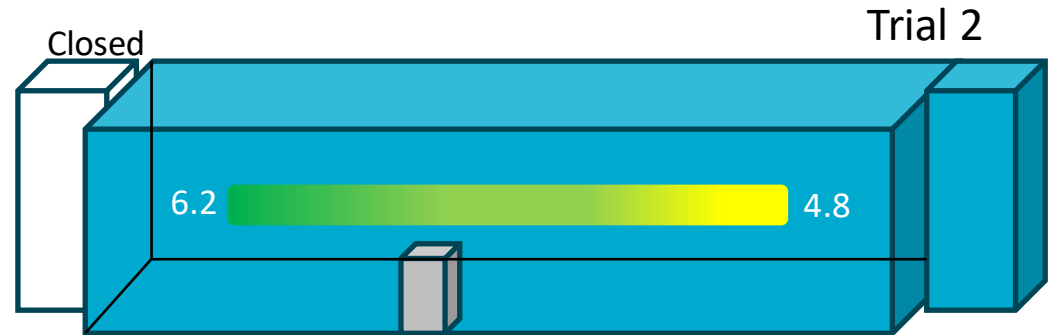
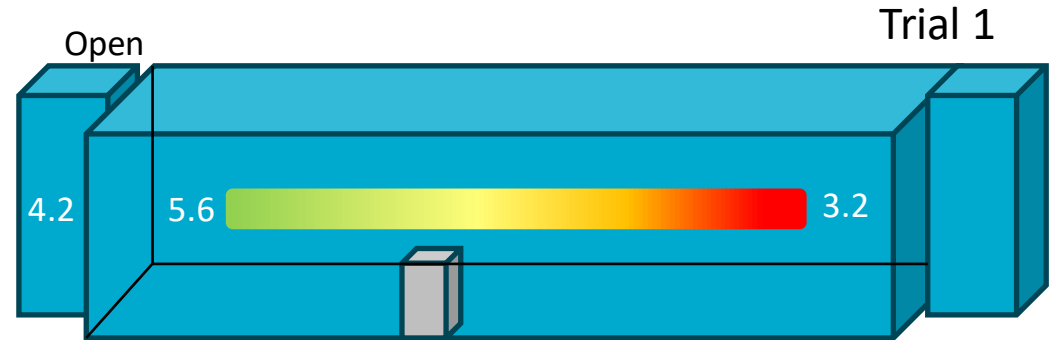


Proof of Concept Results

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Summary

- Efficacy gradient observed with enzymatic indicators (Protak Scientific) under high flow rate conditions with limited dwell time
- Gradients observed horizontally and vertically
- Dilution effect observed when open to anteroom (door open= lower efficacy/dispersal in room)
- Log 3.0 is the low limit for high flow rate testing under this circumstance
- Distance to wall impacts deflection of decontaminate back into the room
 - Low flow rate trials result in concentration the chemical on the wall with limited dispersal beyond the generator

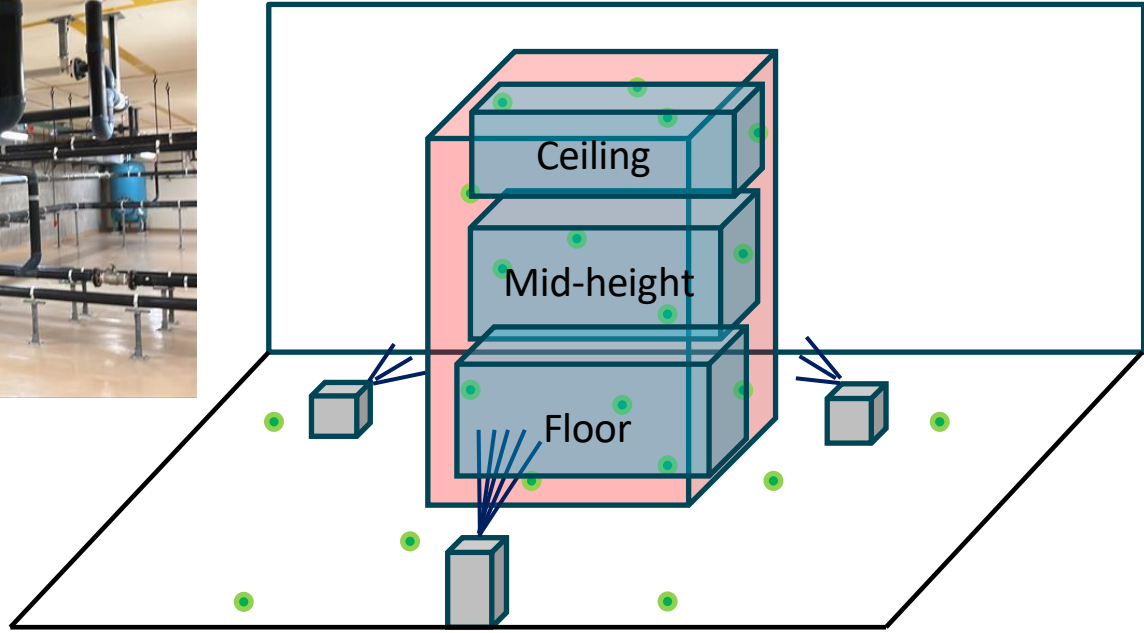


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Open Area Target Zone Decontamination Trials (HVAC On)

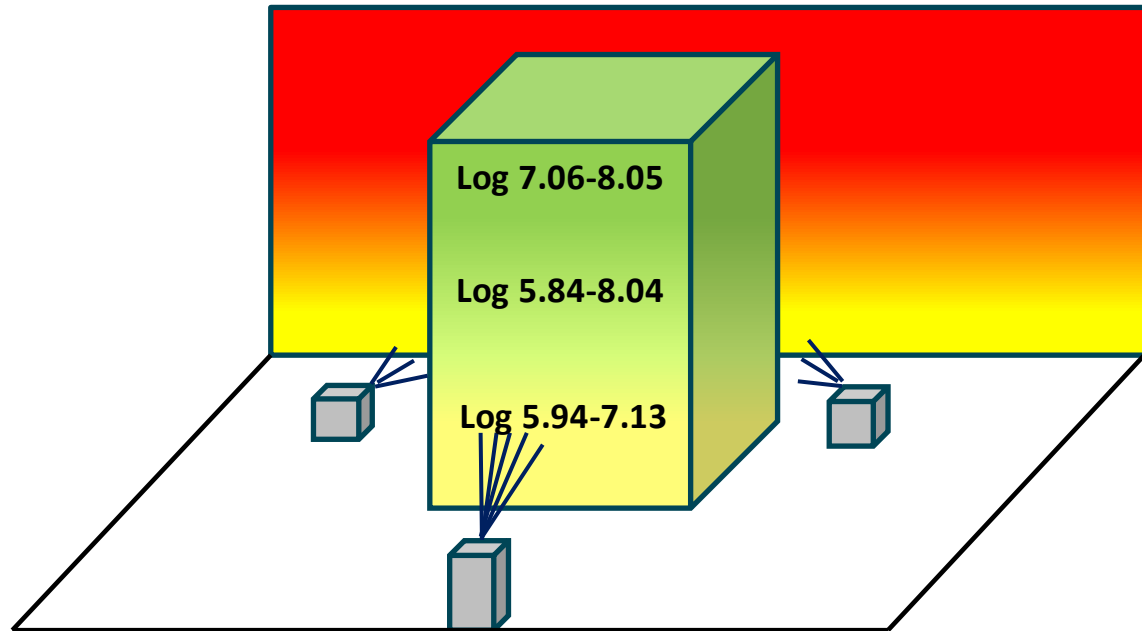


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Open Area Target Zone Decontamination Trials

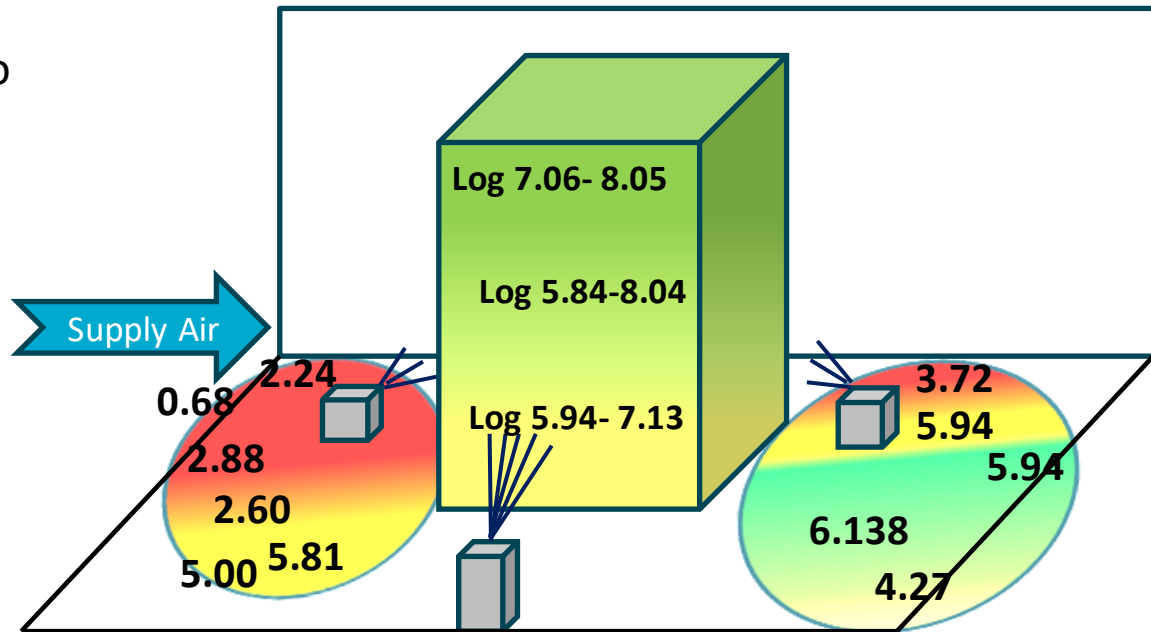
- EIs aligned with supply air duct consistently lower efficacy readings
- Supply air created an air curtain for H₂O₂ to decontaminate the back wall
- EIs placed on the face of the supply registered >Log 6.0





Open Area Target Zone Decontamination Trials

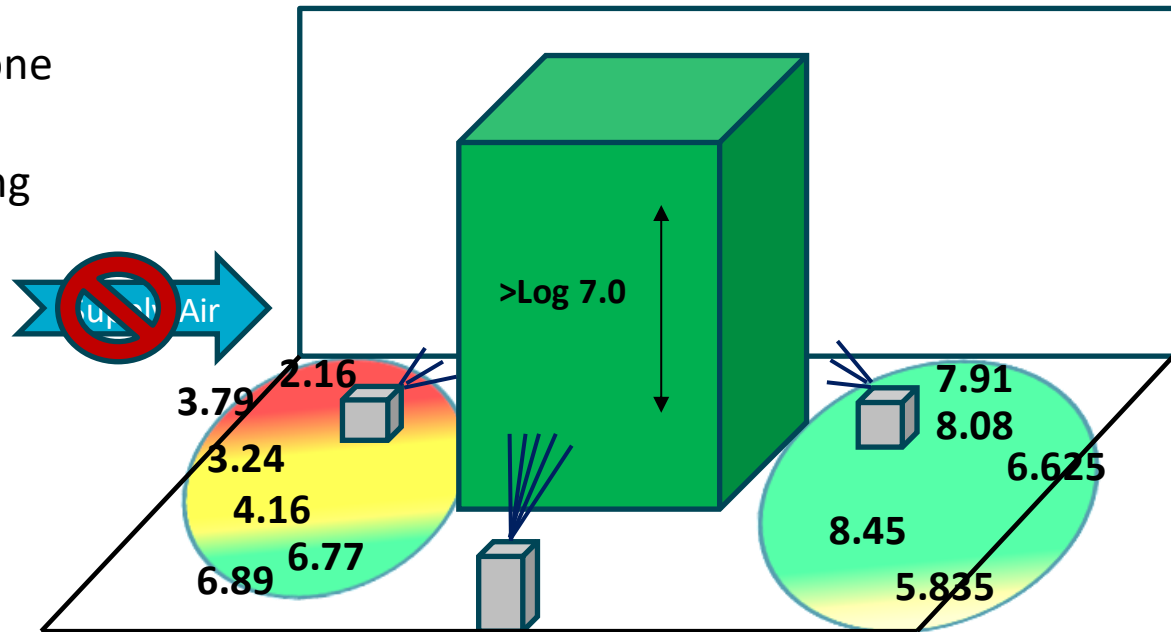
- Approximately Log 2.0 reduction in efficacy per meter outside of the target zone
- Target zone efficacy skewed to the right, aligned with air sweep from left to right





Open Area Target Zone Decontamination Trials

- Taping of left supply register resulted in more uniformity in the target zone and greater safety margin outside of the target zone
- Note, taped supply register results pending triplicate testing



Real-World Scenario

Decontamination In The Effluent Treatment Plant

- Level 1 of ACDP's biosecure areas contains the sewerage treatment plant (STP)
- Large and architecturally complex space with multiple services and high ceilings ($\sim 10,000\text{m}^3$)
- Mixed high-hazard waste from the containment facility moves, via gravity to a series of collection, holding and treatment vessels
- Predicted failure points pre-treatment, currently treated with chemical disinfection



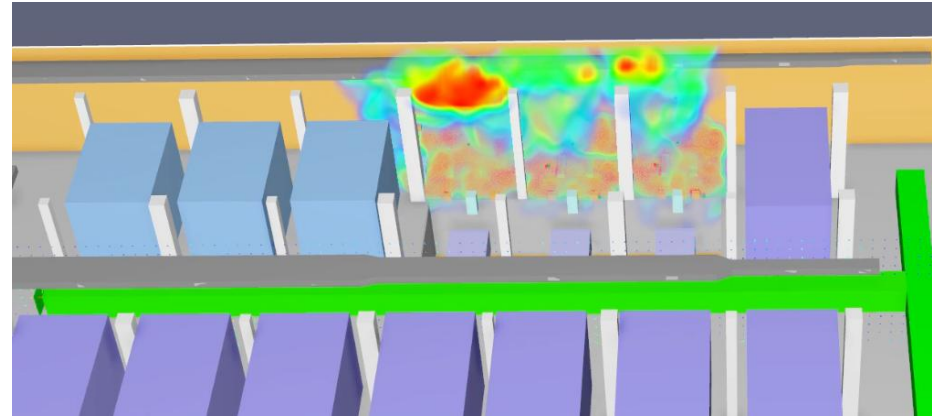
Future Development of Targeted-Zonal Decontamination Procedures For High-Risk Infrastructure

Current Operations

- Trials currently underway in ACDP's Effluent Treatment Plant
- Leverage particle dispersal modelling and proof of concept lessons learned from LAF and L2 trials

ACDP's Challenges

- Large, open non-sealable areas
- Complex architecture
- Aggressive airflow



CAD Model of the Level 1 STP particle heat map of zone 1 failure (pump)



Conclusions and Further Direction

- Significant operational gains can be made with H_2O_2 spatial decontamination procedures
 - Facility down time improvements
 - Occupational health improvements
- Integration of EI technology into decontamination processes has increased efficiencies, improved visibility of decontamination efficacy and allowed for risk-based methodologies to be developed
- Combination of aerosolized H_2O_2 and EIs technology has enabled decontamination validation in non-laboratory infrastructure environments
- ACDP has achieved an open-area decontamination with H_2O_2 in HVAC under normal operations (validation currently underway)