

An evidence review // Critical environments

The dirty cause of downtime

How contamination takes data centres offline, what it costs, and how to measure your exposure.

\$9,000

per minute. The median cost of enterprise downtime.

ITIC Hourly Cost of Downtime Survey, 2025

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Key findings

This report reviews published research on airborne contamination in data centres and server rooms: what it costs when it reaches hardware, the failure mechanisms behind it, and the measured standards that define an acceptable environment. The figures below anchor everything that follows.

\$9,000 per minute

Median cost of downtime for enterprises with more than 1,000 employees, roughly \$540,000 per hour. 97% of large enterprises put a single hour above \$100,000, and 41% put it between \$1 million and \$5 million.

ITIC Hourly Cost of Downtime Survey, 2025 [1]

53 minutes

Median duration of a significant data centre outage. 57% of operators say their most recent major outage cost more than \$100,000 from failure to full recovery.

Uptime Institute, 2025 [2, 3]

0.5 microns

The particle size at which airborne contamination can damage servers, storage and network equipment. ASHRAE's cleanliness benchmark for data centres, ISO 14644-1 Class 8, corresponds to less than 15 micrograms of particulate per cubic metre of air.

ASHRAE TC 9.9; industry field reporting [4, 8]

142 power failures

Recorded at a single facility and traced to conductive metal particulate. Contamination failures routinely present as unexplained faults with no software cause, which is why they stay off root-cause reports.

Industry field reporting; NASA whisker research [8, 9]

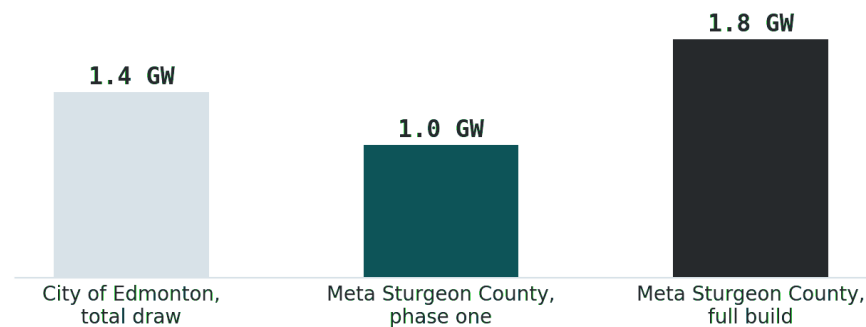
None of these numbers require a catastrophic event. They accumulate through ordinary operations: construction dust that never left the plenum, particulate drawn in through intake air, conductive filaments shed by the raised floor itself. The sections that follow trace the chain from contamination to outage, and end with a worksheet for putting numbers to your own facility.

01 A construction boom is a contamination event

Alberta is now the centre of Canadian data centre construction. In July 2026, Meta broke ground on its Sturgeon County campus, a 1 gigawatt facility scalable to 1.8 gigawatts, representing an investment of more than \$13 billion and the company's largest data centre outside the United States.⁵ Roughly 3,000 construction workers will be on site at peak.⁵ The provincial government reports up to \$200 billion in prospective data centre investment drawn to Alberta, with several other gigawatt-scale proposals in development.⁶

Every one of those facilities passes through the highest-risk period of its operating life before a single workload runs. Fit-out generates concrete dust, drywall particulate, metal shavings and packaging debris, and it settles into subfloor plenums, cable trays and equipment enclosures. ASHRAE's contamination guidance notes specifically that localised construction activities such as drilling and drywall work push particle levels above acceptable limits, and that residual particles must be removed before they enter equipment cooling airstreams.⁴ Once commissioning starts the cooling system becomes a distribution network, moving whatever construction left behind through the same airflow that keeps servers alive.

Exhibit 3 The scale of one project: Sturgeon County against a major city



Source: Meta Platforms, July 2026; The Globe and Mail [5]

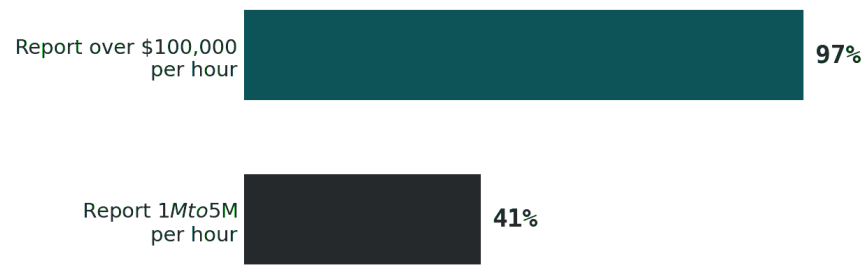
Operating facilities face the slower version of the same problem. Server rooms accumulate particulate continuously through fresh air intake, foot traffic, cardboard unboxed inside the space, and trades work done overhead. The rest of this report sets out what that accumulation costs, how it takes hardware down, and how the exposure is measured.

02 The price of an outage

Downtime is the unit of account for every operational decision in a critical facility, and the current research is consistent. ITIC's 2025 survey places the median cost of downtime at \$9,000 per minute for enterprises with more than 1,000 employees, approximately \$540,000 per hour. 97% of large enterprises report that a single hour of downtime costs over \$100,000, and 41% place it between \$1 million and \$5 million.¹

Uptime Institute's 2025 outage analysis reports that 57% of operators' most recent major outage cost more than \$100,000, measured from outage to full recovery and including direct, opportunity and reputation costs. The median significant outage lasts 53 minutes, and half of all data centres experienced at least one impactful outage in the past three years, with one in ten outages causing serious or severe disruption.^{2,3}

Exhibit 1 Share of large enterprises by hourly downtime cost

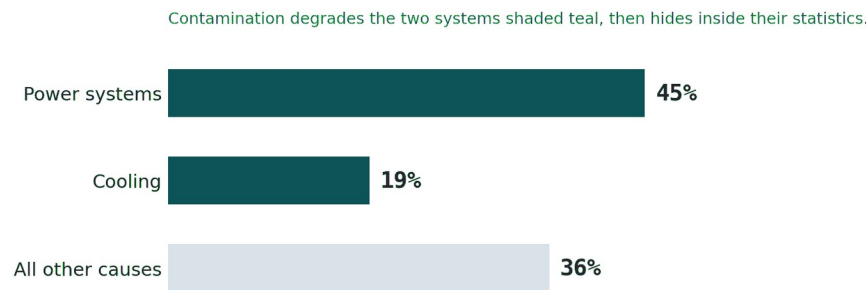


Source: ITIC Hourly Cost of Downtime Survey, 2025 [1]

Where contamination sits in the cause data

Outage statistics attribute most incidents to power systems, at 45% of impactful outages in 2025, with cooling failures second at 19%.³ Contamination rarely appears as a category of its own, and that absence is worth understanding rather than taking at face value. Particulate does not announce itself as the root cause. It presents as the cooling unit that lost capacity, the power supply that shorted, the server that overheated, the fault that cleared before anyone could diagnose it. Section 3 traces those mechanisms. The practical point is that contamination is a contributing condition that degrades the systems the outage gets attributed to, which is precisely why it goes unmanaged.

Exhibit 2 Where impactful outages are attributed, 2025



Source: Uptime Institute Global Data Center Survey, 2025 [3]

The arithmetic

A full year of quarterly certified data hall cleaning typically represents an investment in the range of \$20,000 to \$48,000 depending on facility size and scope. At the ITIC median that is roughly four minutes of enterprise downtime.¹ A single certified server room clean typically costs less than 20 seconds of downtime at the same rate. Few items in a facilities budget carry a comparable ratio of cost to risk retired.

Exhibit 4 Prevention and failure, priced in the same unit



Source: Derived from ITIC 2025 median [1] and Uptime Institute median outage duration [3]

03 How contamination takes hardware down

Particles as small as half a micron can damage servers, storage and networking equipment.⁸ The failure mechanisms are documented in ASHRAE Technical Committee 9.9's contamination guidelines and in decades of field and laboratory research. Five matter most.

Thermal failure

Dust accumulating at the leading edge of heat sinks blocks airflow through the fin channels, raising pressure drop and cutting the air volume that carries heat away. Published thermal engineering research identifies this entrance blockage, rather than the dust coating itself, as the dominant driver of heat sink performance degradation.⁷ Fans compensate by running harder, consuming more energy, and components run hotter and fail sooner. The same fouling applies to CRAC and CRAH coils, degrading room-level cooling capacity, which is how contamination ends up inside the 19% of outages attributed to cooling.³

Electrical failure

Settled dust in humid conditions absorbs moisture and becomes conductive, bridging closely spaced circuit features and causing shorts, current leakage and intermittent faults. ASHRAE recommends keeping relative humidity below 60% in part because corrosion product films become dramatically more conductive once they take on moisture.⁴

Corrosion

Urban air carries sulphur and nitrogen compounds at levels high enough to corrode electronics, and data centres in urban areas have reported UPS, server and hard disk failures caused by sulphur corrosion.⁸ The industry benchmark is ANSI/ISA 71.04 severity level G1, defined as a copper reactivity rate under 300 angstroms per month, with ASHRAE guidance adding a silver rate under 200 angstroms per month after research showed silver corrosion is the better predictor of hardware failure.^{4,10}

Zinc whiskers

Microscopic conductive filaments grow spontaneously from electroplated zinc surfaces, most commonly the underside of older raised floor tiles, pedestals and cable trays. ASHRAE identifies them as the most common electrically conductive particles found in data centres.⁴ Disturbed during tile lifts or cable pulls, they go airborne, ride cooling airflow into equipment and short circuits on contact. NASA has researched the phenomenon since the 1940s, the Colorado Department of State traced crippling data centre malfunctions to whisker contamination, and one operator recorded 142 power failures caused by metal particulate.^{8,9} Because the resulting surge often vaporises the whisker, these events present as ghost failures: random resets and shorts with no software cause and nothing left to find.

Electrostatic discharge

Contaminated and dry environments raise ESD risk, and discharge damages components at voltages far below human perception. IEC 61340-5-1 defines the grounding and handling controls required for anyone working near live electronics.¹¹

04 The cleaning paradox

The most common objection to specialised cleaning is that the building already has a cleaning contract. In a critical environment, general janitorial service does not reduce contamination risk. It adds to it.

	General janitorial	Certified critical environment cleaning
Vacuum equipment	Standard vacuums exhaust fine particulate back into room air	HEPA-filtered vacuums capture particles to 0.3 microns
Chemicals	General-purpose products damage anti-static finishes and leave residue	Anti-static, residue-free products rated for raised access floors
Zinc whisker handling	Scrubbing and sweeping tile undersides snaps whiskers loose and launches them airborne	Controlled tile handling and containment protocols
ESD protection	No grounding, no ESD-safe tools or footwear	Grounded equipment and technicians per IEC 61340-5-1
Verification	None. Clean means it looks clean	Particle counts before and after, measured against ISO 14644-1 Class 8
Documentation	None	Signed report with readings, suitable for audits and insurers
Personnel	General building access, variable vetting	Background-checked technicians trained for live critical environments

The zinc whisker case makes the point sharply. A cleaner who sees a dirty raised floor and applies a rotary scrubber or stiff broom converts a stationary risk into an airborne one. Routine cleaning done wrong is a documented cause of the contamination events it is meant to prevent.⁹

05 The standards that define clean

In a critical environment, certified means measured against a published standard by someone accountable for the result. Four standards govern contamination, and hardware manufacturers increasingly write them into operating requirements: NVIDIA installation documentation specifies ISO 14644-1 Class 8 and ISA 71.04 G1 as the operating environment target, and IBM documentation states data centres must meet ISO Class 8 for particulate.¹²

Standard	What it governs	Who asks about it
ISO 14644-1 Class 8	Airborne particulate concentration limits by particle size. The accepted benchmark for data centre white space, demonstrated with calibrated particle counter readings, not visual inspection.	Auditors, enterprise clients, commissioning agents
ASHRAE TC 9.9	Environmental guidelines for datacom equipment, including the particulate and gaseous contamination limits referenced in manufacturer warranty terms.	Hardware vendors, warranty reviewers, facility engineers
ANSI/ISA 71.04	Corrosive gas severity classification. Level G1 requires copper reactivity under 300 angstroms per month and silver under 200, the condition manufacturers specify.	Insurers, equipment manufacturers, commissioning agents
IEC 61340-5-1	Protection of electronics from electrostatic discharge, covering grounding, materials and handling for anyone working near live equipment.	IT operations, quality managers

A practical note on warranties and insurance. When contamination conditions appear in warranty documentation and underwriting questionnaires, documented compliance is inexpensive. Arguing about it after a claim is not.

06 When risk spikes: the contamination calendar

Contamination risk is not constant. It spikes around specific events, and a defensible program is built around those triggers rather than a flat schedule.

Trigger	Why it matters	Recommended response
Post-construction, pre-commissioning	Fit-out leaves the heaviest contamination load the facility will ever carry, sitting in plenums and trays before airflow starts	Full certified clean of white space, subfloor and overhead, with particle count sign-off before equipment install
Quarterly, live white space	Continuous accumulation from air intake, traffic and operations	Program visit covering floors, surfaces and rack exteriors, with before and after readings
Annually, subfloor plenum	The plenum is the supply air path. Contamination there is delivered directly to equipment	Controlled plenum clean with tile handling protocol
After any trades work	Drilling, cabling and ceiling work shed particulate directly into the protected space	Targeted clean of affected zones before normal operation resumes
Unexplained intermittent faults	Ghost failures, random resets and shorts with no software cause are classic signatures of conductive particulate	Contamination assessment, laboratory identification if whiskers are suspected, remediation
Facility over 15 years old with original raised floor	Electroplated tiles from earlier manufacturing eras are the primary zinc whisker source	Whisker inspection of tile undersides before any floor work

A useful self-test: when was your subfloor plenum last opened, inspected and cleaned by someone carrying a particle counter? If the answer is never, or nobody knows, that is the finding.

07 Putting numbers to your own facility

The research above describes the industry. This worksheet localises it. Filled in, it gives any organisation the current-state picture that budget and risk conversations need.

Current exposure

- Square footage of white space: _____
- Date of last certified clean with documented particle counts: _____
- Age of raised floor system: _____
- Trades work performed in or above the space, past 12 months: _____
- Unexplained hardware faults or resets, past 12 months: _____

Cost of an hour down

- Your estimated cost per hour of downtime: _____ (if unknown, the ITIC 2025 median for large enterprises is \$540,000 per hour; scale to your operation)¹
- Hardware replacement spend, past 24 months: _____
- Warranty or insurance conditions referencing environmental compliance: _____

Prevention program

- Scope (white space, plenum, racks): _____
- Frequency: _____
- Annual cost: _____
- Annual cost expressed as minutes of downtime equivalent: _____

Where it sits in the budget

Certified cleaning belongs in facilities operating expenditure as preventive maintenance, alongside HVAC servicing and fire suppression inspection. Some organisations place it in IT operations where warranty compliance is the driver. Either way it is maintenance, not janitorial, and should not be evaluated against janitorial rates.

08 Ten questions for any cleaning vendor

These ten questions separate critical environment specialists from generalists. Ask every candidate all ten and require documentary answers, not verbal assurances.

#	Question	Pass
1	Do you take calibrated particle counter readings before and after every clean, and provide them in a signed report?	
2	What ISO 14644-1 class do you certify to, and can you show a sample certificate?	
3	Is all vacuum equipment HEPA-filtered, and what capture rating do the filters carry?	
4	Are your technicians and equipment grounded per IEC 61340-5-1 when working near live hardware?	
5	What is your protocol for handling raised floor tiles where zinc whiskers may be present?	
6	What insurance coverage and limits do you carry, and can you name our organisation as additional insured?	
7	Are all technicians background checked, and can you meet our site access and escort requirements?	
8	Do you hold current WCB clearance?	
9	What chemicals and materials do you use on anti-static flooring, and are they residue free?	
10	Can you provide references from live critical environments, not office or retail cleaning?	

A vendor operating seriously in critical environments answers all ten without hesitation. Gaps on questions 1, 2 or 5 in particular indicate a generalist, and section 4 describes what that risk looks like in practice.

09 The first step is a measurement, not a contract

Clean Vault leads every engagement with a particle assessment: calibrated readings taken across your white space and plenum, compared against ISO 14644-1 Class 8 limits, and delivered as a short written report. It gives you the current-state data for the worksheet in section 7, whether or not you engage us for the cleaning itself.

The assessment is free for Alberta facilities. It takes under two hours on site and does not disturb operations.

Book a free particle assessment

cleanvault.ca | hello@cleanvault.ca | Calgary, Alberta

Measured. Documented. Certified.

References

- [1] ITIC, Hourly Cost of Downtime Survey, 2025. Median downtime cost of \$9,000 per minute for enterprises over 1,000 employees; 97% report over \$100,000 per hour; 41% report \$1 million to \$5 million.
- [2] Uptime Institute, Annual Outage Analysis, 2025. 57% of operators' most recent major outage exceeded \$100,000, measured from outage to full recovery.
- [3] Uptime Institute, Global Data Center Survey, 2025. Median significant outage duration of 53 minutes; 50% of facilities with at least one impactful outage in three years; one in ten outages serious or severe; power at 45% and cooling at 19% of impactful outages.
- [4] ASHRAE Technical Committee 9.9, Gaseous and Particulate Contamination Guidelines for Data Centers, 2011, and Particulate and Gaseous Contamination in Datacom Environments, 2nd edition. ISO Class 8 particulate benchmark; relative humidity guidance; construction activity warnings; zinc whiskers identified as the most common conductive particles in data centres.
- [5] Meta Platforms, Breaking Ground on Meta's First Data Center in Canada, July 2026. Sturgeon County campus: over \$13 billion CAD, 1 gigawatt scalable to 1.8, approximately 3,000 construction workers at peak.
- [6] Government of Alberta statements and press coverage of the Sturgeon County announcement, July 2026, including the province's report of up to \$200 billion in prospective data centre investment.
- [7] Published thermal engineering research on heat sink fouling, including analysis identifying leading edge entrance blockage as the primary driver of thermal performance degradation in fine-pitch heat sinks.
- [8] DatacenterDynamics, industry reporting on data centre contamination, including particulate damage thresholds near 0.5 microns, urban sulphur corrosion failures, and a facility recording 142 power failures from metal particulate.
- [9] NASA Goddard whisker research program (Brusse and Sampson, 2004, and related work); publicly reported zinc whisker incidents including the Colorado Department of State data centre failures.
- [10] ANSI/ISA 71.04-2013, Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants. G1 severity: copper reactivity under 300 angstroms per month, silver under 200 following ASHRAE's silver corrosion research.
- [11] IEC 61340-5-1, Protection of Electronic Devices from Electrostatic Phenomena: General Requirements.
- [12] NVIDIA and IBM installation and site preparation documentation specifying ISO 14644-1 Class 8 and ISA 71.04 G1 operating environments.

A note on method

Figures are drawn from published industry research and public announcements current as of August 2026. Survey statistics describe the populations surveyed and should be scaled to your own operation. Where a range is given for cleaning investment, it reflects typical market pricing for certified critical environment services in Western Canada and varies with facility size and scope.