Frothly

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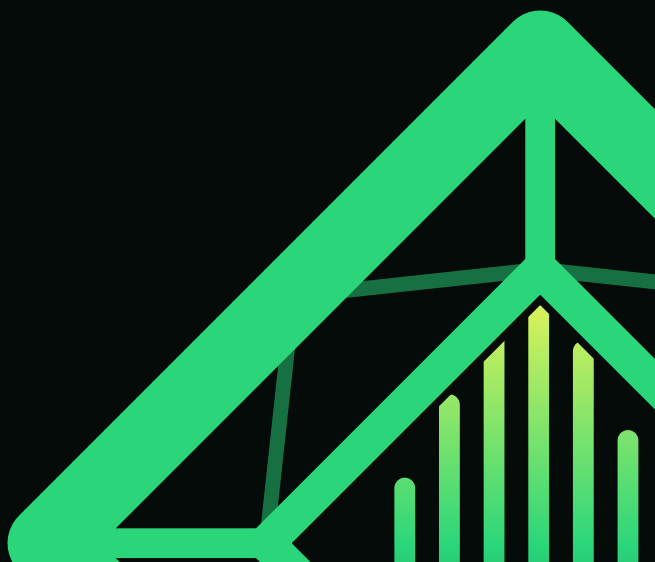
REPORT

Seepage

Failure modes in overloaded storage.

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Lazarus · Jan 2026



SUMMARY

Storage systems pushed beyond their rated capacity rarely fail all at once. They degrade: quietly at first, then in ways that spread from one record to the next. By the time the failure is noticed, the damage has often been done for years.

Drawing on 3,000 storage devices recovered by Lazarus between 2014 and 2025, this report catalogues how overloaded storage fails, shows how strongly failure rates rise with sustained utilization, and recommends thresholds for retiring media before it begins to leak.

KEY FINDINGS

01 Overloaded storage fails gradually. Silent corruption was the most common failure mode, and the hardest to detect.

02 Utilization predicts failure. Devices run above 90% of capacity for more than a year were six times as likely to show corruption as devices kept below 70%.

03 Data bleeds. In 11% of overloaded devices, fragments of one record had corrupted an adjacent one.

04 Doubling up is dangerous. Every device we examined that had been modified to exceed its rated capacity showed damage.

01

What we examined

Lazarus recovers data from failing and obsolete storage on behalf of archives, families and public institutions. Over eleven years we kept detailed records of the condition of every device we worked on: hard drives, flash media, magnetic tape, optical discs and a small number of specialized devices, including 41 medical and implanted storage units recovered with the consent of their owners or estates.

For 3,000 of these devices we were also able to establish how full they had been kept during service, using filesystem records, owner interviews and manufacturer logs. That allowed us to ask a simple question: does keeping storage full make it fail?

02

How overloaded storage fails

TABLE 1 Failure modes observed in devices run above 90% capacity

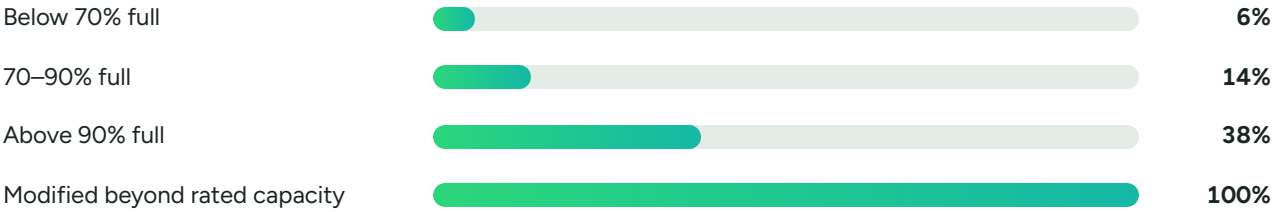
Failure mode	What happens	Share of failures
Silent corruption	Data changes without any error being reported	44%
Retrieval failure	Data is intact but cannot be located or read back	21%
Bleed	Fragments of one record overwrite or corrupt another	17%
Wear-out	Media degrades until writes begin to fail	12%
Catastrophic loss	The device fails completely	6%

Catastrophic failure, the kind that people fear, was the rarest outcome. The common failures were quieter and, for that reason, more damaging. A drive that dies is replaced. A drive that silently alters one record in a thousand can go on being trusted for years.

03

Utilization and risk

FIGURE 1 Share of devices showing corruption, by sustained utilization



3,000 devices recovered by Lazarus, 2014–2025. Utilization sustained for at least twelve months.

The relationship is strong and consistent across every type of media we examined. Full storage works harder: it rewrites more, relocates more and has less room to route around worn or damaged areas. Each of those effects is small. Over years, they compound.

Seepage

We use the term *seepage* for the most troubling failure mode we observed: data from one record leaking into its neighbors. Seepage is rare on lightly used devices and common on overloaded ones. It is particularly dangerous where a single device holds records belonging to different people, because the leak is not only a loss of data but a breach of it.

04

The doubled courier drive

One case illustrates the risks of exceeding rated capacity. A portable drive used to carry confidential files between offices had been modified, using aggressive compression and an unofficial firmware patch, to hold twice its rated capacity. When it reached us it held 320 gigabytes of data on a device designed for 160.

Most of the data was recoverable. But fragments of one client's records had seeped into another's, and the drive's owner had been experiencing intermittent failures, which he had attributed to bad luck, for more than a year. The modification had saved the cost of a second drive. The recovery cost considerably more.

A RULE OF THUMB

Never ask a storage device to carry more than it was built for, and never store anything you cannot afford to lose on a device that is nearly full.

05

Recommendations

- Retire or expand any storage that has been above 80% full for more than six months.
- Never modify archival or confidential storage to exceed its rated capacity.
- Verify checksums of archived data at least once a year, and keep a record of the results.
- Keep records belonging to different people on separate devices wherever confidentiality matters.

None of these measures is expensive. All of them are cheaper than recovery, and recovery is not always possible.

References

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Acknowledgments

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About the authors

Miranda Lawson leads Lazarus, Frothly's digital preservation program, from our Vancouver office.

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