

# Print/Scan Survival of PaperBack Data Pages

## A fine-grain sweep of dot density, dot size, and scan factor

*How well does a paper backup survive printing and scanning?*

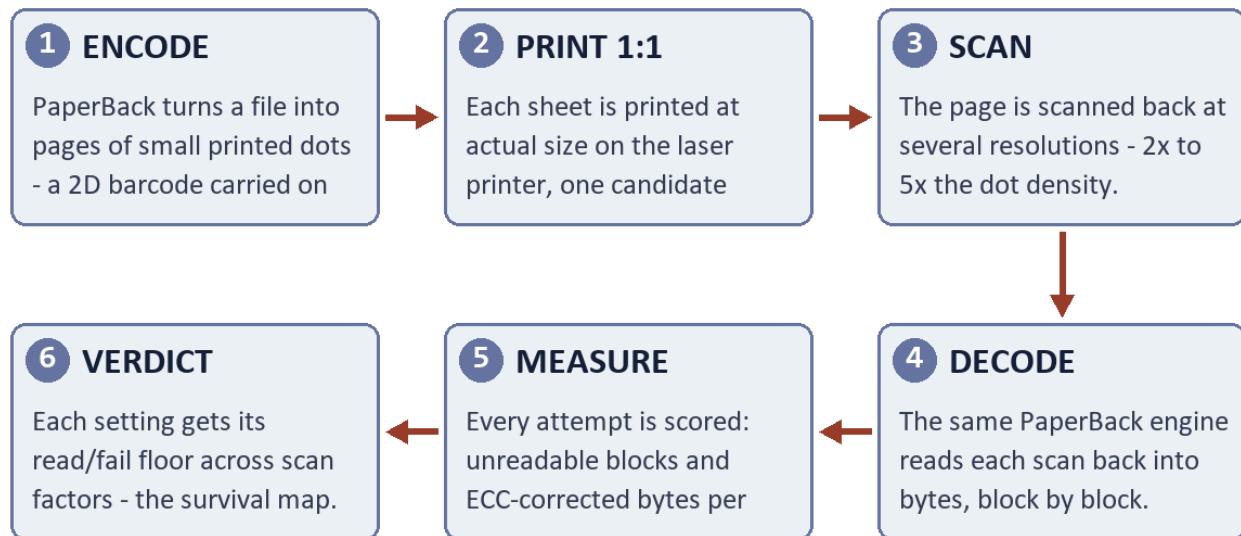
### REVISED EDITION v4 - corrected tables (standalone re-audit)

This edition re-derives the section 3 and 5 tables and figures from the 2026-10-02 standalone re-decode of all 600 Canon trials, which fixed a decode-slot accumulation error in the original pipeline. One verdict changed (candidate 17: FAIL -> CLEAN). All published picks stand. An HP LaserJet 4350dtn sweep-1 section is new in this edition.

**Data:** Sep 28 - Oct 2, 2026 (re-audit)  
**Station:** SCANNER01 - tech-center workstation  
**Chain:** PaperBack 1.10 - rebuilt from source, automation-enabled  
**Print/Scan:** Canon iR-ADV DX CS840i / HP LaserJet 4350dtn + Epson V700  
**Editions:** v3 9/30 (superseded) -> v4 10/9 (this PDF)

## 1 | Start here: what was tested and how to read this report

PaperBack encodes a computer file into a two-dimensional matrix of small printed dots - a 2D barcode carried on paper. To retrieve the file, the page is scanned and decoded again. The catch: real printers and scanners are imperfect - fine dots print faint, scans blur, paper moves. This project measured which dot settings survive the whole chain, on two printers (Canon primary, HP added in October).



The workflow: a file is encoded into dot pages, printed 1:1, scanned at multiple resolutions, and decoded programmatically for measurement. Flow runs left-to-right across the top row, then drops into the bottom row and returns right-to-left (reverse-S).

Every knob and metric definition is unchanged from the previous edition; see section 2 for the constants (redundancy 1:5, maximal compression, 309-byte shared test payload) and the sweep chronology.

### How to read the numbers

- Unreadable blocks (count) - data blocks the decoder could NOT recover. 0 = page decoded completely. A block holds about 90 bytes.
- ECC corrections (bytes) - bytes needing error-correction inside blocks that DID decode, per page. Lower = more margin.
- "Reads from x3.0" - smallest scan factor where the raw scan decoded with 0 unreadable blocks.
- This edition: every verdict/floor/ECC figure comes from standalone re-decodes (the decode slot is discarded before every trial), so no number is inflated by accumulation across scans.

## 2 | Equipment, constants, and the sweeps

Print chain (Canon sweeps): 1:1 prints through the BW-8.5x11 EnvisionWare queue to a Canon imageRUNNER ADVANCE DX CS840i. Scan: Epson Perfection V700 Photo, 8-bit grayscale, no sharpening. Decode: PaperBack 1.10 rebuilt from source with a control interface (see appendix). The HP section (new) used an HP LaserJet 4350dtn through the same queue.

|               |               |            |                                   |
|---------------|---------------|------------|-----------------------------------|
| Compression   | Maximal (2/2) | Redundancy | 1:5                               |
| Encryption    | off           | Payload    | 309-byte test file (Canon sweeps) |
| Header/border | on            | Factors    | x2.0 x2.5 x3.0 x3.5 x4.0 x5.0     |

### Erratum - the decode-slot accumulation error, and the fix

**What changed between v3 and v4**

During HP-sweep work (2026-10-02) we found that PaperBack's files`[],{goodblocks,badblocks,restoredbytes,complete}` accumulate across decodes of the same payload into the same decode slot. Stale slot state could even report `complete=true` for a decode that still had unreadable blocks.

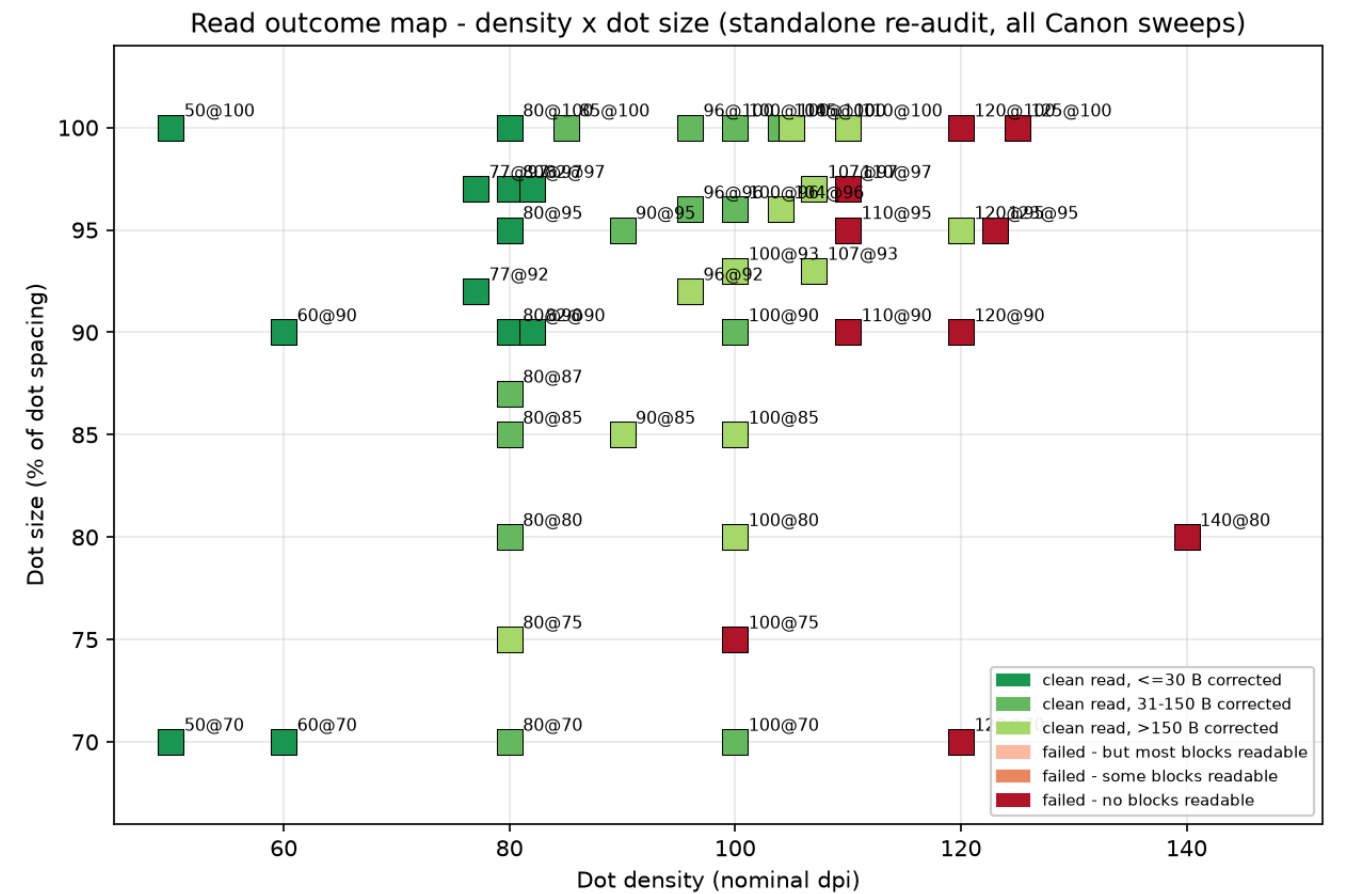
The per-page unreadable/ECC tables published on 9/30 were page-level and were never contaminated. But verdicts and floors in sections 3-5 were partly derived from accumulated state, so all 600 Canon trials were re-decoded standalone (slot discarded before every trial; page-level stats only) on 2026-10-02.

Result: 417/420 archived page metrics matched exactly. ONE verdict changed: candidate 17 (100 dpi @ 70% dot size) went FAIL -> CLEAN, reading from x2.5 with 51 B corrected (conv). The build improvement (20260929b -> 20260930f) also lifted its norm variant to a x3.5 floor with 10 B.

Every pick stands: 44 (reliability), 45/58 (capacity), 62 (density), 65 (fallback). All tables and figures in sections 3-5 of this edition are re-derived from the standalone set.

### 3 | The big picture: which settings read, which fail (corrected)

Each marker is one candidate: horizontal = dot density, vertical = dot size. Greens are clean reads (darker = fewer corrected bytes); reds are failures (lighter = more blocks still readable). Verdicts are from the standalone re-audit; the one changed candidate (17: 100 dpi @ 70%) now sits on the clean side of the frontier at x2.5.



The frontier still slopes up to the right - finer dot grids need larger dots - and the density ceiling near 120 dpi is unchanged. The corrected Excel-style table mirroring this figure is delivered alongside this PDF (paperback-outcome-map-corrected-20261009.xlsx), with a changed\_vs\_0930 column flagging every corrected cell.

## 4 | Master results - every candidate that reads cleanly (corrected)

### How to read this table

Capacity (blocks) = usable data-block cells in the candidate band as printed (one border column excluded; ~90 payload bytes per block before 1:5 redundancy).

Reads-from = smallest scan factor with a standalone clean raw decode (0 unreadable). Best ECC = fewest corrected bytes at any clean factor.

Verdict/floor/ECC values: standalone re-decode set (2026-10-02). changed = differs from the 9/30 edition.

| ID | dens | size | cap | reads-from | best ECC | chg | note                       |
|----|------|------|-----|------------|----------|-----|----------------------------|
| 20 | 50   | 70   | 27  | x2.0       | 4        |     |                            |
| 65 | 50   | 100  | 27  | x2.0       | 0        |     | bulletproof fallback       |
| 19 | 60   | 70   | 33  | x2.0       | 18       |     | first success (classic)    |
| 27 | 60   | 90   | 33  | x2.5       | 23       |     |                            |
| 52 | 77   | 92   | 42  | x2.5       | 9        |     |                            |
| 53 | 77   | 97   | 42  | x2.5       | 12       |     |                            |
| 18 | 80   | 70   | 45  | x2.5       | 140      |     |                            |
| 33 | 80   | 75   | 45  | x2.5       | 197      |     |                            |
| 34 | 80   | 80   | 45  | x2.5       | 67       |     |                            |
| 35 | 80   | 85   | 45  | x2.5       | 76       |     |                            |
| 43 | 80   | 87   | 45  | x2.5       | 43       |     |                            |
| 25 | 80   | 90   | 45  | x2.5       | 9        |     | sweep2 champion (90%)      |
| 41 | 80   | 90   | 45  | x2.5       | 64       |     |                            |
| 36 | 80   | 95   | 45  | x2.0       | 23       |     |                            |
| 44 | 80   | 97   | 45  | x2.5       | 6        |     | record-low corrections     |
| 26 | 80   | 100  | 45  | x2.5       | 25       |     |                            |
| 50 | 82   | 90   | 45  | x2.5       | 29       |     |                            |
| 51 | 82   | 97   | 45  | x2.5       | 7        |     |                            |
| 46 | 85   | 100  | 48  | x2.5       | 40       |     |                            |
| 37 | 90   | 85   | 51  | x2.5       | 295      |     |                            |
| 38 | 90   | 95   | 51  | x3.0       | 100      |     |                            |
| 57 | 96   | 92   | 54  | x2.5       | 219      |     |                            |
| 56 | 96   | 96   | 54  | x3.0       | 114      |     |                            |
| 55 | 96   | 100  | 54  | x2.5       | 82       |     |                            |
| 17 | 100  | 70   | 57  | x2.5       | 51       |     | NEW clean (was fail in v3) |
| 29 | 100  | 80   | 57  | x3.5       | 171      |     |                            |
| 30 | 100  | 85   | 57  | x3.5       | 542      |     |                            |
| 23 | 100  | 90   | 57  | x3.5       | 120      |     |                            |
| 54 | 100  | 93   | 57  | x3.5       | 238      |     |                            |
| 45 | 100  | 96   | 57  | x2.5       | 49       |     | Zone B efficiency pick     |
| 24 | 100  | 100  | 57  | x2.5       | 61       |     |                            |
| 42 | 100  | 100  | 57  | x2.5       | 84       |     |                            |
| 59 | 104  | 96   | 60  | x3.5       | 250      |     |                            |
| 58 | 104  | 100  | 60  | x3.0       | 86       |     | Zone B capacity pick       |
| 47 | 105  | 100  | 63  | x3.0       | 256      |     |                            |
| 63 | 107  | 93   | 63  | x3.5       | 492      |     |                            |
| 62 | 107  | 97   | 63  | x3.0       | 186      |     | Zone C pick                |
| 40 | 110  | 100  | 66  | x3.5       | 450      |     |                            |
| 31 | 120  | 95   | 69  | x3.5       | 405      |     |                            |

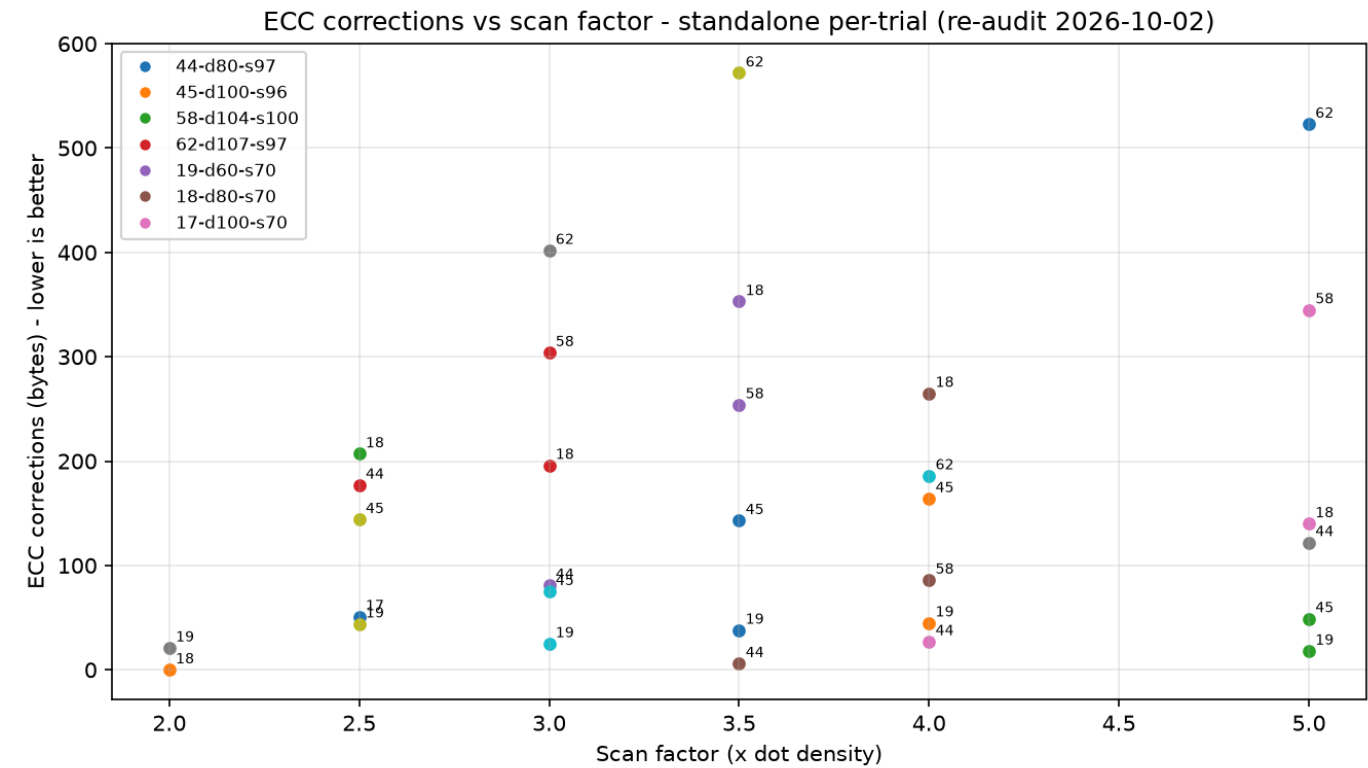
### Candidates that never decoded cleanly (standalone)

Even failed pages usually decode part of their blocks; "good-at-best" is the closest standalone attempt.

| ID | dens | size | good-at-best | closest attempt                                      |
|----|------|------|--------------|------------------------------------------------------|
| 16 | 120  | 70   | -            | x2 conv: 69/69 unreadable (Page label is not readabl |
| 21 | 160  | 70   | -            | x3 conv: 92/92 unreadable (Page label is not readabl |
| 22 | 120  | 90   | -            | x2 conv: 69/69 unreadable (Page label is not readabl |
| 28 | 100  | 75   | -            | x3.5 conv: 18/57 unreadable (Unrecoverable errors on |
| 32 | 120  | 100  | -            | x3.5 conv: 1/69 unreadable (file complete=True)      |
| 39 | 110  | 90   | -            | x3.5 conv: 57/66 unreadable (Unrecoverable errors on |
| 48 | 125  | 100  | -            | x3.5 conv: 49/72 unreadable (Unrecoverable errors on |
| 60 | 110  | 97   | -            | x3.5 conv: 1/66 unreadable (file complete=True)      |
| 61 | 110  | 95   | -            | x5 conv: 20/66 unreadable (Unrecoverable errors on p |
| 64 | 123  | 95   | -            | x4 conv: 70/72 unreadable (Unrecoverable errors on p |
| 66 | 140  | 80   | -            | x3 conv: 81/81 unreadable (Page label is not readabl |

## 5 | Closer look: margins and failure modes (corrected)

ECC corrections vs scan factor, now plotted from standalone per-trial decodes (each point = one trial, slot discarded beforehand). The reliable picks sit low and flat; the density-edge candidates carry more corrections and more scan-to-scan variation. Candidate 17 - previously published as a failure - now appears as a clean x2.5 reader, which tightens the 100-dpi fill frontier down to 70%.



## 5.5 | The HP LaserJet 4350dtn sweep (2026-10-02, new in v4)

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A 24-band intensity-designed sheet (job B223386) mapped the same survival question on the library's HP LaserJet 4350dtn, scanning every band at six factors with the same standalone decode protocol. Headline results:

- Fill is the master lever at coarse pitch:  $\geq 80\%$  fill reads clean even at  $\times 2.0$ ;  $\geq 60\%$  at  $\times 2.5$ ; 50% is marginal.
- Pitch ceiling: P24 (100 dpi) works broadly; P20 (120 dpi) needs  $\geq 85\%$  fill +  $\times 3.0$ ; P17 (140 dpi) needs 100% fill +  $\times 5.0$ .
- Full saturation hurts at low factor (dot bleed at 100% fill /  $\times 2.0$ ); the 79-96% fill band is the sweet spot.
- Alias pothole: exactly-integer  $\times 3.0$  (300 dpi) sampling on P24 deterministically fails grid detection - scan at  $\times 2.5/\times 3.5$  instead.
- HP vs Canon: HP renders fine pitch slightly softer (P20 needs  $\times 4.0$  vs Canon 120 dpi @ 95% at  $\times 3.5$ ), but equals or beats Canon floors at P24-P30.

HP picks (this printer):

|             |                                                                |                                                                           |
|-------------|----------------------------------------------------------------|---------------------------------------------------------------------------|
| Reliability | 30/27 @ 80 dpi (90% fill)                                      | clean at every factor incl $\times 2.0$ , ECC $< 100$ B                   |
| Capacity    | 24/19 @ 100 dpi (79% fill)                                     | clean at $\times 2.0$ , 57 blocks; or 24/23 (95.8%) avoiding $\times 3.0$ |
| Max density | 20/20 @ 120 dpi (100%)                                         | $\times 4.0+$ , 69 blocks                                                 |
| Avoid       | P20 $\leq 65\%$ fill, P24 $\leq 54\%$ fill, P17 $< 100\%$ fill |                                                                           |

Sweep-2 (full-data bands, per-family payloads sized to eliminate the crosshair-only filler area) is designed and staged for the next print run; its manifest ships with this revision.

## 6 | Appendix - corrections, data & files

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Correction provenance: canon-reaudit-20261002\ (FINAL-standalone-floors.csv = 100 candidate-variant rows; redecode\ = 600 standalone trials; CANON-REAUDIT-20261002.md = protocol). This edition's compiled tables: paperback-outcome-map-corrected-20261009.xlsx + corrected-\*.csv in the delivery folder. HP sweep data: hp-sweep1-20261002\ (decode CSVs, manifests, STANDALONE-VERIFICATION.md).

PaperBack patches: decoder rebuilt from source with an automation control surface (named-pipe JSON interface, raw-value settings, quality-map export, GCC portability fixes). Patch kit + build guide: E:\Documents\PaperBack Build\ (PAPERBACK-BUILD-GUIDE.md).

Method notes: verdicts in this edition come from 600 standalone decode responses. Scan factors were verified by reading the scanner's configured resolution back after each scan. HP sweep: 114/114 scans at exact requested dpi.

Compiled 2026-10-09 17:58 | generator: make\_report\_v4.py (lineage: make\_report.py v2 -> make\_report\_v3.py -> this)