Calendar Integrity and Watershed Water Accounting

Scientific and Engineering Release Notes for `wepp_261021`, artifact revision 2

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Binary scope: Reissued artifact revision 2 of `wepp_261021` and `wepp_261021_hill`, from the University of Idaho's WEPP Forest fork. This is not a release note for an upstream USDA release.

Abstract

The 261021 reissue combines Gregorian calendar and input-stream integrity repairs with bounded corrections to soil-water allocation, hillslope groundwater initialization, channel-source construction, outlet publication, and retained Muskingum–Cunge state. A watershed audit traced deep percolation, evapotranspiration, lateral flow and surface runoff from individual hillslope segments through PASS transfer files and channel routing. That audit exposed both concrete implementation errors and a separate, unresolved question about signed soil/channel exchange. This report explains the defects, revised methods, controlled evidence and their consequences, including a complete Cedar Creek comparison with 261010. The release preserves Muskingum–Cunge dynamics and its numerical storage authority. It does not claim complete physical channel water-budget closure, field calibration, or resolution of every negative-rate clipping case.

AI authoring disclosure: OpenAI Codex assisted with investigation, analysis scripts, report drafting, equations, figures and document validation. Separate AI-agent review checked numerical implementation, source coverage and scientific interpretation. These checks are not independent human peer review. The named author retains responsibility for publication approval.

The operator authorized replacing the earlier, undeployed 261021 binary pair. Its source identity and hashes remain in the release history. Binary reissue, report publication and production deployment are separate decisions. This approved edition contains independently written descriptions, equations and figures; it does not reproduce restricted legacy source or mixed-origin patch listings. No NSERL endorsement or independent human peer-review certification is implied.

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1 Release scope and the questions the audit addressed

The practical objective is to make the model's water transfers intelligible from a hillslope soil calculation to watershed outlet discharge. An apparently balanced printed table is insufficient if the routed rate series describes a different volume. Conversely, a difference between an algebraic routing-storage coordinate and a Manning-derived physical channel volume is not by itself proof that the routing recurrence creates or loses water. The investigation therefore separates physical process accounting, transfer representation, numerical continuity and output publication.

An overland-flow element (OFE) is a modeled segment within a hillslope. D_p denotes deep percolation below the modeled soil profile. ET includes plant transpiration and soil/residue evaporation. Lateral flow transfers water out of a soil profile; some of it is internal runon to the next OFE rather than an additional watershed export. `Q` and `QOFE` describe runoff with specific length/area normalizations. PASS files carry hillslope transfers into the watershed. Confusing a local-depth normalization with an aggregate volume, or counting an internal transfer twice, can produce an erroneous budget even when individual model calculations are consistent.

The audit was prompted by questions about these terms in single-OFE and multiple-OFE cases, including a 60/40 length split, and about daily versus hourly soil-water balance. An investigator's workbook was available but its original input decks and executable identity were not. The team therefore treated the workbook as a hypothesis and accounting example, and generated controlled cases with retained inputs and binary identities. It did not claim to reproduce the missing original experiment. A separate long-climate investigation began after a 200-year watershed execution failed and a one-day alignment discrepancy was reported in an event-output comparison.

1.1 Three identities that must not be conflated

The source-change baseline is native source `7471bb5`, corresponding to `wepp_261010`. The reviewed replacement source is `d354e3c998f81955f9d9e5ca7d01ca56e1a9f04b` on the canonical release branch. The first, undeployed 261021 pair came from `a87925df9`; it contained the calendar repairs but not the subsequent physical-water corrections. Artifact revision 2 replaces that pair at the operator's request. The same filename is not sufficient to distinguish them: source identity and SHA-256 are required.

The behavioral reference for the new Cedar Creek study is the actual 261010 binary pair, with fresh same-build hillslope PASS files in both lanes. The previous published scientific report is the 261010 report, revision 2. Its hourly surface-return peak estimator, component-v3 PASS representation and CHRQIN first-sample normalization correction are inherited behavior, not new 261021 inventions. Their presence in a changed source routine does not make them a new correction in this report.

1.2 Reader-facing change map

Area	Defect or boundary	Revised behavior and release claim
Calendar	Gregorian century years disagreed with four-year execution scheduling; EOF could retain a stale climate record.	Use the shared Gregorian year length, reject invalid dates and incomplete climate streams, and validate daily ASCII PASS keys.
Groundwater	Initial hillslope storage was converted using terminal OFE area.	Use full hillslope area for an aggregate groundwater inventory; preserve local soil flux bases.

Area	Defect or boundary	Revised behavior and release claim
Hourly allocation	A terminal infiltration-allocation remainder could be discarded.	Allocate each hourly request through the soil layers, retaining the positive final-layer remainder and bounding signed withdrawals; do not invent a new water source.
Flat sources	A short flat hydrograph omitted part of its continuous support.	Use the supplied volume/duration rate and interval overlap, including the partial final cell, so sampled quadrature delivers the assigned volume.
Channel inputs	Local net water and deferred groundwater were not represented consistently in routed rates.	Assemble eligible local water and admitted groundwater once; retain the positive-side-impoundment boundary.
Publication	Balance-derived daily outlet volume could differ from accepted routed discharge.	Publish the accepted MC trapezoidal outlet integral, including the initial endpoint, and include that endpoint in the peak.
Retained state	Boundary-only eligibility/reference estimates could ignore live interior channel state.	Keep live state eligible; retain the last valid MC4 reference only at the reviewed degenerate boundary.
Execution	Exact finite-precision fixed points caused redundant time-step work in a long regression.	Copy only bitwise-identical full states under bitwise-constant remaining forcing; no magnitude cutoff.
Working fluxes	A prior channel's element output could occupy the next channel's plane scratch slot.	Initialize current-plane runoff and local runoff before the next channel's own producers execute.
Open exchange	Soil credits and signed routing withdrawals lack a complete accepted-exchange contract.	Disclose the remaining clipping and coupling gap; no new physical storage authority or silent loss cap.

The internal change register maps these accounts to every source change and retained test/evidence record. Related HBP schema-2 work is discussed as investigation context only: this binary pair still uses ASCII PASS component version 3 and does not enable the HBP family. CLIGEN source was inspected for calendar behavior; no CLIGEN executable change is included in this reissue.

1.3 Highest supported claim

The evidence supports a bounded implementation repair with reproducible native regressions, matched-build watershed execution and a clearer outlet-publication contract. It does not support replacing Muskingum–Cunge storage by an inferred geometric volume, or declaring all channel exchanges physically closed. Negative raw discharge is still clipped in some controlled cases, including some cases without an imposed signed sink. Changes in outlet volume cannot all be assigned to a single defect without matched ablations.

The source-level hydrologic repairs can affect erosion, sediment and nutrient calculations through changed water quantities or timing. This reissue does not introduce a new erosion or nutrient formula. The new detailed Cedar comparison focuses on water discharge and peaks; it is not a new comprehensive sediment or nutrient validation. Prior 261010 studies remain evidence for their stated builds and scopes, not automatic proof for every consequence of the reissue.

2 Water quantities, control volumes and shipped repairs

An overland-flow element (OFE) is a segment of a hillslope with its own soil, slope and management. Several OFEs can pass surface and subsurface water downslope before the hillslope delivers water to a channel. A depth printed for one OFE is therefore not automatically an independent contribution to the watershed outlet. The audit first established the spatial basis, time interval and producer of each quantity, then compared the quantities at successive interfaces. The process terminology follows the WEPP hydrology and water-balance documentation; the corrections below are implementation decisions of this fork, rather than new results attributed to that documentation [1, 2].

Let $A_i = w_i \ell_i$ be local OFE area in m^2, and let $A_H = \sum_i A_i$ be hillslope area. For a local daily depth d_i in mm,

$$V_d = 10^{-3} \sum_i A_i d_i, \qquad \overline{d}_H = \frac{\sum_i A_i d_i}{A_H}. \tag{1}$$

This is the correct spatial reduction for precipitation, local soil-water stocks, evapotranspiration components, and deep percolation. An annual flux sums daily volumes; a stock is an endpoint or time average with an explicitly stated meaning, not a sum of daily storage depths. Actual areas are required: rounded descriptions such as "60/40" cannot replace the areas in the model.

Daily evapotranspiration is the sum of plant transpiration, soil evaporation and residue evaporation, $ET_i = E_{p,i} + E_{s,i} + E_{r,i}$. Deep percolation Dp_i leaves the soil column. Where the groundwater option is active, that same volume enters the modeled groundwater reservoir. It must not be counted both as a loss from the combined soil–groundwater domain and again as its later baseflow. Deep seepage from groundwater is a separate external export.

For ordinary constant-width, serial OFEs in this native source, the water-balance writer reports surface runoff using two different denominators:

$$Q_i = 1000\, r_i \frac{L_{\mathrm{eff},i}}{L_{\mathrm{cum},i}}, \qquad QOFE_i = 1000\, r_i \frac{L_{\mathrm{eff},i}}{\ell_i}. \tag{2}$$

Here r_i is the native runoff depth in m and each length is in m. Thus $10^{-3} Q_i A_{\mathrm{cum},i} = 10^{-3} QOFE_i A_i$ for this geometry. These are two representations of the flux crossing the same OFE boundary. Summing either representation over all OFE boundaries double-counts water that continues downslope. The terminal boundary supplies the hillslope export. General contour/variable-width layouts and other executable lineages require their own producer check; column names alone cannot establish this identity.

The terminal lateral depth is expressed on the terminal local area and may already contain upstream lateral water. Multiply it by that area once, then divide by whole-hillslope area only if a whole-hillslope depth is desired. The native PASS writer already performs the depth-to-volume conversion. Within an OFE balance, however, incoming surface water and lateral inflow remain necessary terms. Their cancellation occurs only when adjoining OFE control volumes are combined (Figure 1).

A complete external balance also needs changes in soil liquid, frozen water, snow, interception, groundwater and channel states, plus applicable irrigation, drainage and impoundment terms. Unknown initial stocks were not set to zero. PASS contains selected delivered volumes; event-selection omissions must be measured separately from transfer errors. Daily printed WAT rows do not identify the internal soil timestep: both daily and hourly calculations produce daily rows. The empty `wepp_ui.txt` marker selects the hourly implementation. The audit exercised both implementations, with single, equal, unequal and three-OFE layouts [5, 6].

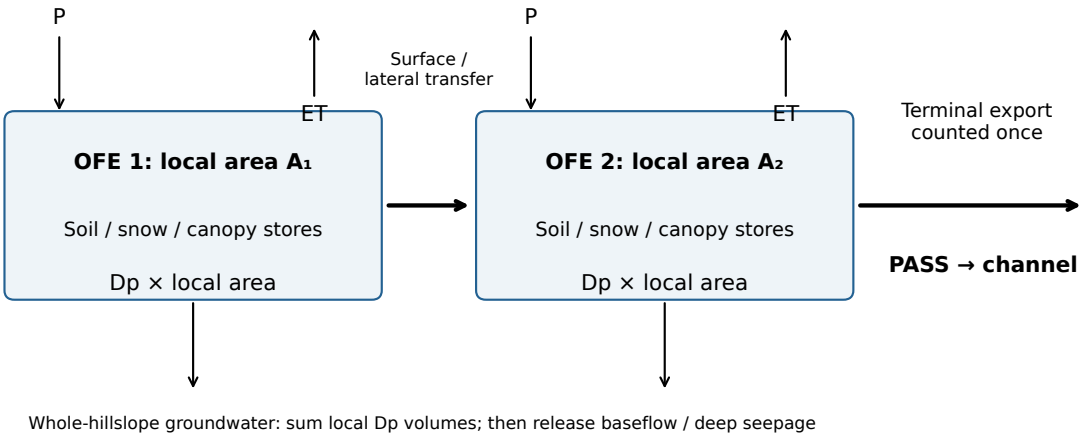


Figure 1: Original accounting diagram. ET and deep percolation use local area; surface and lateral transfers between OFEs are internal to the hillslope. Only the terminal export enters the downstream boundary once. Dp becomes internal recharge when the soil and groundwater are audited together.

2.1 One Gregorian calendar and validated daily streams

RN-261021-01–03. Continuous hillslope execution, master-PASS assembly and watershed execution now use one proleptic Gregorian calendar, including synthetic climate years beginning at 1:

$$\mathrm{leap}(y) = (4 \mid y) \ \wedge \left[(100 \nmid y) \ \vee \ (400 \mid y)\right]. \tag{3}$$

The previous execution loops explicitly added a day at common-century years 100, 200 and 300 even though the climate calendar did not. The extra model iteration consumed the following weather record and could assign subsequent fluxes to the wrong date. Year 400 correctly retains February 29. For years 1–400, the correct count is 146,097 days, rather than 146,100 iterations under the former schedule. Figure 2 shows the deterministic schedule difference; it is not a measured one-day hydraulic travel time.

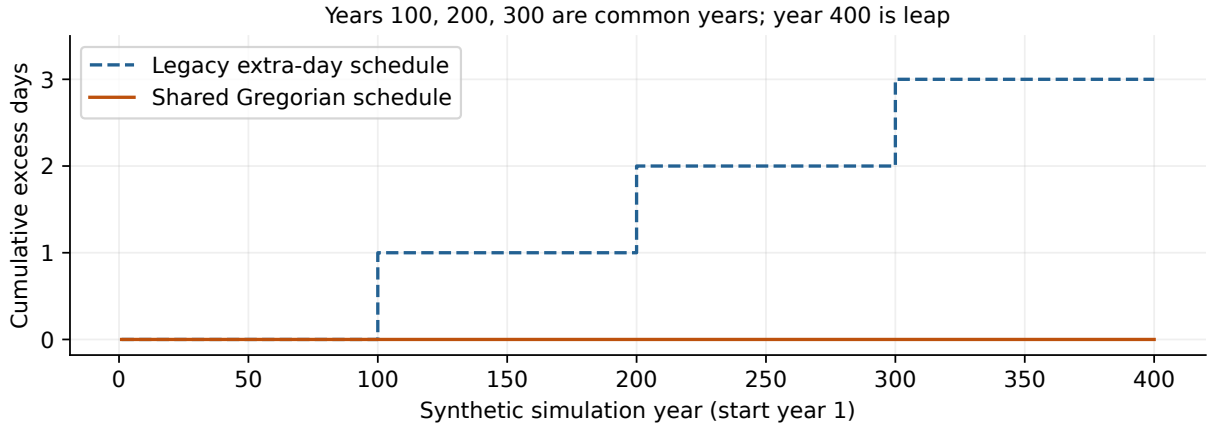


Figure 2: Analytical calendar consequence of the old and revised rules for synthetic years 1–400. The native validation independently completes all 146,097 Gregorian days with matching date keys. The revised line represents zero extra scheduled days; it does not quantify a hydrologic flux difference.

The climate reader still buffers up to ten daily records, but now records how many complete lines were actually read. End-of-file cannot make untouched buffer slots into valid weather. Every requested

continuous day must match the expected year and day. Duplicate, reordered, invalid or incomplete records fail explicitly instead of silently advancing. Blank trailing lines are not weather. CLIGEN-style records must contain complete whitespace-separated numeric fields; Fortran list-directed null, repetition, slash termination and comment syntax are rejected because they can leave fields unassigned despite a successful read. Breakpoint climate headers receive corresponding completeness/date checks.

Both hillslope-to-master and master-to-watershed ASCII PASS headers are checked, including `EVENT`, `SUBEVENT` and `NO EVENT`. Checking only runoff days would leave dry-day misalignment undetected. Single-storm calendar behavior is unchanged. The CLIGEN source was inspected and its Gregorian output checked; CLIGEN was not modified. The separate HBP schema-2 fixed-slot reader investigation is not part of these ASCII component-v3 binaries (RN-261021-16–17).

2.2 Whole-hillslope groundwater initialization

RN-261021-04. Initial groundwater depth g_0 in mm is a hillslope quantity. The revised initial volume is $G_0 = 10^{-3} g_0 A_H$ in m^3. Previously it was overwritten while visiting the OFEs and ultimately used the last OFE's area. With nonzero initial groundwater, merely splitting an otherwise equivalent hillslope changed the reservoir inventory.

Initialization now occurs once, at the first OFE on the first simulated day, before recharge accumulation. Prior baseflow/deep-seepage withdrawals and the recharge accumulator are reset there. The established daily recurrence is preserved:

$$R_d = \sum_i A_i Dp_{i,d}^{(\mathrm{m})}, \tag{4}$$

$$G_d = G_{d-1} + R_d - B_{d-1} - D_{d-1}, \tag{5}$$

$$B_d = k_b G_d, \qquad D_d = k_s G_d. \tag{6}$$

G_d is the daily pre-withdrawal reservoir coordinate, R_d recharge, B_d baseflow and D_d deep seepage, all in m^3; k_b, k_s are the configured fractions per daily update. The prior-day withdrawal convention has not been replaced by a same-day recurrence. An ordinary new calendar year does not reinitialize the reservoir.

For 10,000 m^2, $g_0 = 100$ mm, $k_b = 0.04$ and zero first-day recharge, the correct first baseflow is 40 m^3 for every partition. Native legacy probes returned 16 m^3 for a 60/40 split and 20 m^3 for a 20/30/50 split (Figure 3). Zero-initial-storage controls and unchanged soil WAT outputs isolate this initialization correction from a change to percolation physics.

2.3 Bounded allocation of signed hourly infiltration

RN-261021-05. An hourly signed input f in m must be assigned to actual layer liquid stores before existing percolation. The old traversal stopped when the remaining magnitude fell below 10^{-5} m. For a three-layer 0.3 m tilled profile, an input of 10^{-6} m assigned only about $3.33333332 \times 10^{-7}$ m to storage. Repeating that decision over hours loses the remainder independently of the later ET or Dp equations.

Positive input retains the existing tilled-layer weights. Traversal is bounded by the number of soil layers, and the last eligible layer receives the complete remainder before percolation. There is no new runoff conversion or evaporation correction. For negative input, the demand $W = -f$ is compared with original available liquid:

$$A_\ell = \sum_{j=1}^{N_\ell} \max(S_j, 0), \qquad W \le A_\ell. \tag{7}$$

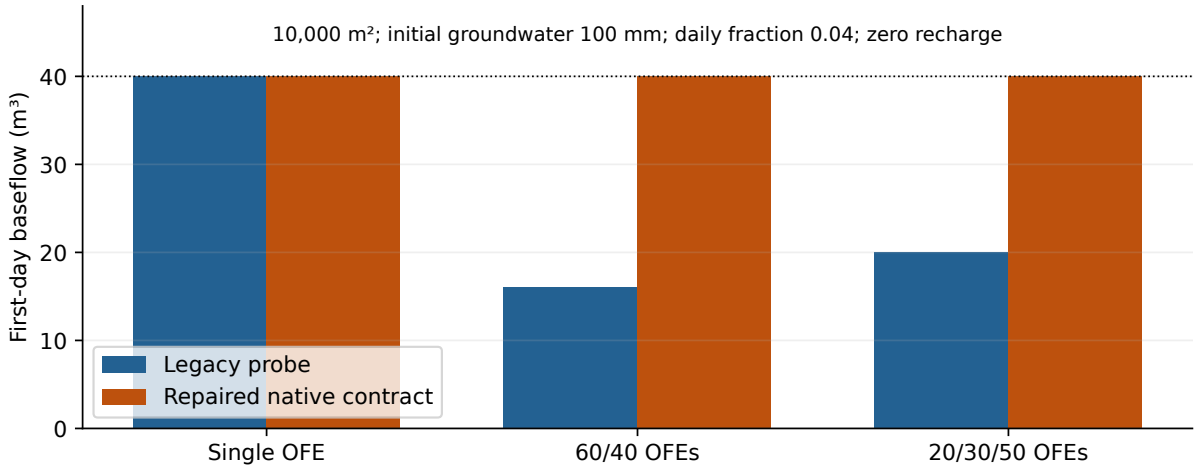


Figure 3: Native groundwater initialization controls. Legacy first-day baseflow depends on terminal-OFE area. The revised native tests recover the same 40 m^3 for all three layouts, with the same total area, initial depth, release fraction and zero recharge. Bars are rounded to the displayed precision.

S_j is the native liquid store in layer j, expressed as an equivalent depth in m; frozen water is not made available by this calculation. Each weighted withdrawal is bounded by the remaining liquid in that layer. A second bounded top-down pass uses liquid left in earlier layers if the first pass could not place the full demand. A single proportional pass was rejected because it can leave feasible demand unassigned while earlier layers remain wet.

The original binary32 stores and demand are promoted to binary64 for inventory comparison and working allocation, then final stores are cast once. Exact inventory exhaustion empties the eligible stores explicitly. This prevents a binary32 subtraction remainder, such as -4.66×10^{-10} m after removing 0.03 m from three 0.01 m layers, from being interpreted as a genuine shortage. No tolerance fitted to that example is used. An actually excessive withdrawal or nonzero final unallocated remainder fails with day/OFE/hour context. This failure is an explicit unsupported state, not an instruction to reduce the upstream physical flux silently.

Final conversion still has ordinary finite-precision error. The independent stress audit bounded it by final-store half-ULPs and a conservative binary64 operation-count bound. All 3,473 feasible heterogeneous profiles completed with nonnegative stores and zero unallocated remainder; the largest storage change residual was 3.8932×10^{-9} m. These allocation results do not establish that a later channel can supply every daily soil-derived sink.

2.4 Flat hydrograph cells conserve the selected source volume

RN-261021-06; inherited normalization RN-261021-18. CHRQIN reconstructs hillslope surface delivery from selected volume V in m^3, supplied peak q_p in $m^3\ s^{-1}$ and duration T in s. The flat branch is selected when the volume reaches or exceeds the supplied peak–duration product, subject to the existing branch comparison. The old rule added q_p only at endpoints inside T. It both lost fractional final cells and failed when $V \neq q_p T$.

The revised flat source preserves V and supplied support $[0, T]$:

$$q_f = V/T, \qquad \bar{q}_n = \frac{q_f}{\Delta t} \max[0, \min(n\Delta t, T) - (n-1)\Delta t], \quad n \geq 1. \tag{8}$$

Thus $\Delta t \sum_{n=1}^{N} \bar{q}_n = V$ apart from representation rounding, even if $T < \Delta t$. The recalculated flat rate

can exceed the supplied peak: that is the stated resolution of an inconsistent flat volume/peak/duration triple, not a newly calculated hydrologic peak. Extending duration would instead alter the supplied temporal support and was not chosen. Rate and overlap endpoints use binary64, with one cast when each cell mean is added. Forming each endpoint independently avoids repeated binary32 subtraction error on non-divisor grids.

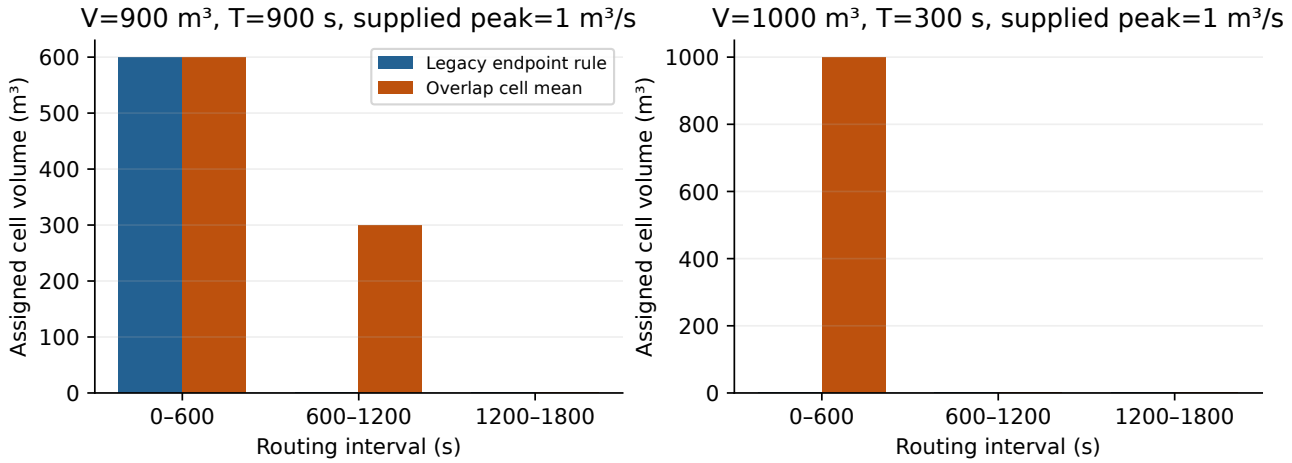


Figure 4: Analytical illustrations of the source-cell repair at 600 s resolution, using configurations covered by native regression controls. A 900 s event loses its final half-cell under endpoint selection. A 300 s event lies entirely inside the first routing cell and previously supplies no positive-time sample. The overlap rule preserves each declared volume. These bars are source-cell volumes, not a claim about the downstream MC point-value quadrature.

Reconstructed source volume above the existing negligible-volume threshold requires finite $0 < T \leq 86{,}400$ s; invalid duration fails before division. The physical day, rather than a rounded $N\Delta t$, defines the upper limit. Index zero supplies an initial boundary value and does not add a source-cell volume. Continuing days preserve their established endpoint carry. Separate return-flow support and the existing exponential reconstruction remain unchanged. The earlier 261010 exponential sample normalization is the baseline, not a new change in this reissue.

2.5 Local water and deferred baseflow enter the intended channel

RN-261021-08–09. A channel's lateral source combines side-hillslope surface delivery, lateral subsurface delivery, admitted baseflow and local channel exchange. With the convention that positive transmission T_c removes channel water into the soil, its daily net local term is $V_{\text{local}} - T_c$. Negative transmission can represent water released by the channel soil process; its sign is not, by itself, an input error.

The old positive-source branch could depend on a side-hillslope surface hydrograph even when no such hydrograph existed. Positive local water was then absent from the rate array. The correction extends the existing uniform non-surface representation to that case, provided neither side impoundment supplies positive volume. A daily net amount V_L is represented by $V_L/86{,}400$ m^3 s^{-1} before division by channel length. The latter division changes the lateral-rate units to m^2 s^{-1} for spatial routing. Positive side-surface reconstruction is retained, so mixed local water can still inherit side-hillslope timing. Positive impoundment release timing is explicitly excluded from this new eligibility condition.

WSHCQI already defers groundwater below the configured contributing-area threshold and admits it at the first qualifying channel. WSHCHR now adds exactly that admitted deferred volume to the top

rate array as a uniform daily rate. It does not add all upstream baseflow again: groundwater already present in routed upstream discharge is not a new source. The former separate initial-outlet addition was removed because the same volume is now present in the initial inlet. Native first-day 100 m^3 baseflow controls and 100→0→200 m^3 sequences verify initialization and endpoint carry; three-channel threshold controls verify admission once. These source fixes apply to the existing KW3 and MC4/5 assembly paths without replacing their routing equations.

2.6 Live interior state and a usable MC4 recession reference

RN-261021-07. A dry inlet and dry previous outlet do not imply an empty channel. The former MC execution guard could skip a step while interior nodal discharge remained nonzero, leaving the next profile at initialized zero. The revised guard also checks the complete retained interior. It runs the unchanged recurrence for nonzero state, including negative or subnormal values; it introduces no small-state deletion threshold.

RN-261021-11–12. MC4 normally selects a reference discharge before restoring the previous interior profile. When the boundary-derived reference falls into the existing $q_{\mathrm{ref}} \le 10^{-8}$ m^3 s^{-1} branch, the selected $K = X = 0$ gives recurrence coefficients $(1, 1, -1)$. With zero forcing, spatial induction gives $q_j^n = -q_j^{n-1}$: an even number of daily steps restores the same profile indefinitely rather than transporting it.

Only MC4 now reuses its last valid positive reference when the ordinary reference is degenerate *and* retained interior state is live. The cache is per channel, reset at simulation initialization, and is not overwritten by a degenerate reference. A read-only state query occurs before grid selection. Ordinary positive-reference selection, no-history cases, MC5 and KW3 are unchanged. Deriving a new reference from interior amplitude was rejected as a broader, unnecessary coordinate change in the controlled recession.

Even with a valid reference, finite-precision recurrence can reach a tiny fixed profile. At native 60 s resolution, one measured recession retained $2.8025969 \times 10^{-45}$ m^3 s^{-1} at all 101 nodes. Rather than deleting that state, an MC4-only optimization copies future states after proving an exact fixed point: all remaining inlet/lateral forcing is bitwise constant, two consecutive complete raw profiles are bitwise identical, and the accepted outlet values used by the execution guard are also bitwise identical. With fixed daily coefficients, the next deterministic step has identical inputs; induction establishes the repeated result. Signed zero and subnormals are preserved by bit comparisons, not numeric equality. MC5 is excluded because its coefficients can vary during the day. A future forcing change prevents early copying.

2.7 Publish and transfer the accepted MC outlet integral

RN-261021-10. MC routing produces raw nodal discharge and an accepted outlet series Q_n after the existing small/negative-rate clipping rule. The old daily outlet volume was separately inferred from a geometric storage balance, then the reported ending storage was adjusted to close that balance. It could disagree with the discharge series actually passed downstream.

For MC4/5, the daily volume now uses the accepted full-precision outlet array:

$$V_{\mathrm{out}} = \Delta t \left[\sum_{n=1}^{N} Q_n + \tfrac{1}{2}(Q_0 - Q_N) \right]. \tag{9}$$

The accumulation is binary64 before the final native storage conversion. This volume supplies the channel report, daily runoff volume and downstream volume transfer. The initial endpoint participates

in peak metadata as well. A case with positive Q_0 and zero subsequent rates therefore has a positive half-step integral rather than zero reported export. Unlike a source-cell sum, this trapezoid legitimately includes the initial endpoint.

The existing Manning-derived geometric storage remains independently calculated. It is not replaced by a residual-derived store, so the printed geometric balance may no longer be zero. KW3 retains its previous publication convention. Public columns and units are unchanged, but MC volumes and balance residuals have changed meaning in this precise respect. Rate/volume consistency does not certify source availability or undo clipping.

2.8 Receiving-channel working variables have local lifetimes

RN-261021-21. Channel output arrays indexed by watershed element can overlap slots subsequently used as channel-plane working arrays. A completed upstream channel could therefore leave a positive runoff value in the next channel's working slot. On a dry day the rainfall-excess routine was skipped, allowing that inherited value to alter the receiving soil's infiltration. Similarly, a wet day with no local rainfall excess could retain another channel's local-runoff value and publish a fictitious local source.

WSHDRV now initializes the receiving plane's `runoff` and `chnrun` immediately after WSHCQI has consumed preserved element transfers, and before optional WSHIRS and soil water balance. No soil store or MC state is reset. The existing wet-event and surface-return gates remain in force; final output restoration still uses its preserved element results. Real local runoff is recomputed normally. The location states the ownership boundary explicitly: WSHCQI uses preserved element-transfer arrays, not these two scratch fields, and the subsequent local runoff/soil operations own their new values. Resetting them after those operations would erase a newly calculated local result.

These corrections can alter runoff hydraulics and the water supplied to erosion and sediment transport, even though no detachment, transport-capacity or deposition formula is changed [3]. Likewise, corrected soil inputs can change later ET and Dp without changing their process equations. No blanket sediment, nutrient, snow or impoundment parity is inferred from water-only controls; quantitative evidence and limits follow below.

3 What the routing audit establishes

3.1 Discrete MC continuity is the relevant numerical identity

RN-261021-20. Muskingum–Cunge (MC) routes discharge through a discrete relation whose storage coordinate depends on its coefficients. WEPP's MC4 and MC5 implementations and their routing context are described by Wang et al. [4]; the equations below are an independent accounting derivation for the implementation audited here. A discrepancy between that coordinate and a volume inferred from Manning geometry is not, alone, evidence of water loss. The release preserves the accepted MC method rather than introducing a geometric-volume continuity solver.

For one spatial cell and one regular executed step, let I_p, I_n be previous and current upstream discharge, and O_p, O_n the corresponding downstream discharge, all in $\mathrm{m^3\ s^{-1}}$. Let K be the selected time parameter in s, X its dimensionless weighting parameter, Δx the cell length in m, Δt the timestep in s, and L the

lateral rate per unit channel length in $\mathrm{m^2\ s^{-1}}$. With the coefficients actually selected for that step,

$$D = 2K(1-X) + \Delta t, \tag{10}$$

$$a = (\Delta t - 2KX)/D, \quad b = (\Delta t + 2KX)/D, \quad c = 1 - a - b, \tag{11}$$

$$O_n = aI_n + bI_p + cO_p + 2\Delta t \Delta x L/D. \tag{12}$$

Rearrangement gives the volume identity

$$F = \frac{\Delta t}{2}(I_n + I_p - O_n - O_p) + \Delta t \Delta x L, \tag{13}$$

$$M = K\{X(I_n - I_p) + (1-X)(O_n - O_p)\}, \qquad F = M. \tag{14}$$

Shared interior discharge interfaces cancel when regular updates are summed over spatial cells. Inlet and outlet use trapezoids. Lateral point mode uses $L = (L_p + L_n)/2$, while lateral cell-average mode uses $L = L_n$. The executable evaluates coefficients and states in finite precision, so the observed residual $r = F - M$ is retained rather than assumed zero. A skipped or guarded transition is recorded separately; its discrepancy is not automatically rounding error.

For changing coefficients define $\theta = (K, X)$ and $H(\theta, q) = K[XI + (1-X)O]$ in $\mathrm{m^3}$. The same preceding state changes numerical coordinate when θ changes:

$$C_n = H(\theta_n, q_p) - H(\theta_p, q_p), \qquad M_n = H_n - H_p - C_n. \tag{15}$$

MC4 holds coefficients fixed within an ordinary day, giving $C_n = 0$ there. MC5 requires a separate coefficient pair for every cell and step. For example, $(K_p, X_p, I_p, O_p) = (2, 0.2, 1, 0.5)$ gives $H_p = 1.2\ \mathrm{m^3}$. With $(K_n, X_n, I_n, \Delta t) = (3, 0.1, 2, 1)$ and no lateral input, the recurrence gives $O_n = 0.71875\ \mathrm{m^3\ s^{-1}}$, $H_n = 2.540625\ \mathrm{m^3}$ and $C_n = 0.45\ \mathrm{m^3}$. The net flux and $\Delta H - C_n$ are both $0.890625\ \mathrm{m^3}$. Omitting C_n would create a false $0.45\ \mathrm{m^3}$ discrepancy.

The next day can have a different grid, reference and upstream boundary. CHRSTATE carries nodal discharge and interpolates when the grid changes. The observed jump $J_d = H_{\mathrm{start},d} - H_{\mathrm{end},d-1}$ records those changes; it is not a new water source. Raw outlet rates and accepted exported rates can also differ. With

$$B_d = \frac{\Delta t}{2}(\delta Q_0 + \delta Q_N) + \Delta t \sum_{n=1}^{N-1} \delta Q_n, \qquad \delta Q_n = Q_{\mathrm{accepted},n} - Q_{\mathrm{raw},n}, \tag{16}$$

the regular-update daily identity becomes

$$V_{\mathrm{in,executed}} - V_{\mathrm{out,accepted}} = H_{\mathrm{end}} - H_{\mathrm{old}} - J_d - \sum C_n + \sum r_n - B_d. \tag{17}$$

$V_{\mathrm{in,executed}}$ is the upstream boundary integral plus the signed lateral contribution represented by regular executed cells; it is not gross positive admission before losses. Any nonregular transition or requested-but-unexecuted source needs its own measured term. The initial simulation coordinate is an explicit initial condition. In particular, steady-flow initialization is not a dry start. Negative X is permitted by the retained method, so H need not be a nonnegative physical cross-sectional volume; neither H nor X is clipped to make a geometric budget pass.

Actual native full-node controls demonstrate the distinction. With a late positive pulse, adaptive MC4 grids gave day-two full-geometric residuals of about -558 and $-822\ \mathrm{m^3}$ on the two source paths, while the corresponding MC-coordinate residuals were about -0.016 and $+0.0011\ \mathrm{m^3}$. Fixed-grid, positive-coefficient controls also retained the mismatch. Replacing endpoint geometry with a complete spatial geometric integral did not remove it. Consequently, an earlier proposal to make geometric inventory the acceptance authority was rejected. This report does not reinterpret that rejected experiment as a shipped solver change [7].

3.2 Source cells, solver quadrature and publication are different checks

For a uniformly sampled rate sequence,

$$V_{\text{trap}} = V_{\text{rect}} + \tfrac{1}{2}\Delta t(q_0 - q_N), \qquad V_{\text{rect}} = \Delta t \sum_{n=1}^{N} q_n. \tag{18}$$

This identity explains why a conservative source-cell sum does not by itself prove agreement with MC point-value consumption. A half-step endpoint term may telescope across days with matching boundaries and timesteps; first-day initialization and changed grids require explicit treatment. It is not a soil or groundwater store. Already-routed upstream discharge must be transferred with its accepted integral once, without another source normalization.

Likewise, forcing a daily geometric report to balance cannot demonstrate that its published volume equals the routed rates. The new publication contract fixes that specific disagreement and its downstream volume handoff. It leaves source timing, coefficient revaluation, grid transitions, accepted-rate clipping and soil credit visible as separate audit boundaries.

4 Controlled evidence and adversarial checks

The evidence ladder combines production-block probes, actual routing routines, full generated hillslope/watershed runs, and the Cedar comparison. Synthetic states isolate mechanisms; they are not estimates of their prevalence in real watersheds. Observer-on/off byte parity establishes that a diagnostic did not alter the scientific files. It does not establish that the files are physically correct. Every full-period claim also checks dates, final records, finite values and binary/PASS provenance.

Boundary	Retained evidence	Interpretation
Calendar and input stream	Real and generated long runs, malformed/missing daily records, all PASS event kinds, and a paired 400-year run with 146,097 exact dates.	Calendar/reader integrity; no climate-generator modification.
Groundwater	Single, unequal two-OFE and three-OFE layouts; zero/100 mm initial storage; recharge, seepage, year transition and successive-hill initialization controls.	Whole-area inventory; daily recurrence retained.
Hourly allocation	3,473 feasible heterogeneous profiles plus impossible withdrawals; 2,314,224 observed hourly allocations across three 44-year layouts. All observed remainders zero.	Largest full-run allocation rounding about 3.73×10^{-9} m; soil/source acceptance remains a separate question.
Flat source	Aligned, fractional and substep durations; both approximation modes; first/continuing boundaries; invalid durations and fine non-divisor grids.	Selected source-cell volume preserved; not universal MC quadrature closure.
Source/publication	Local-only, side-surface, signed-net, deferred-baseflow, first-call and threshold cascades; MC4/5 publication and q_0-only cases.	Component admission once; accepted volume and downstream transfer agree.

Boundary	Retained evidence	Interpretation
Retained MC state	Live-interior control; late pulse/recession; positive, negative, tiny and signed-zero states; cache reset/isolation; shortcut ablation.	Changed execution eligibility/reference selection; recurrence retained.
Channel-plane lifetime	Four causal variants, 12 scenarios, both soil modes, two/three channels; 96 two-year observer-paired executions.	1,800 exact scientific-file pairs; upstream channel records unchanged.

The groundwater/soil probes exposed failed intermediate attempts, which were not shipped: a single negative-allocation pass rejected feasible demand; binary32 working subtraction rejected exact capacity; and a flat-overlap implementation repeatedly subtracting rounded endpoints failed fine-grid volume checks. The final methods address those causal failures without relaxing an acceptance bound to fit a result.

4.1 Interior state, recession and exact fixed points

An admissible fixed-eight-cell MC4 profile with one interior node at 1 $m^3\ s^{-1}$ and dry boundaries has initial MC coordinate 1,262.180542 m^3. The old execution guard performed no updates and erased it. The corrected guard performed 1,152 cell updates and exported 1,262.179855 m^3, leaving only negligible final state and a 0.000687 m^3 rounding/clipping discrepancy. This is a causal seeded-state result, not evidence that every natural recession reaches that profile.

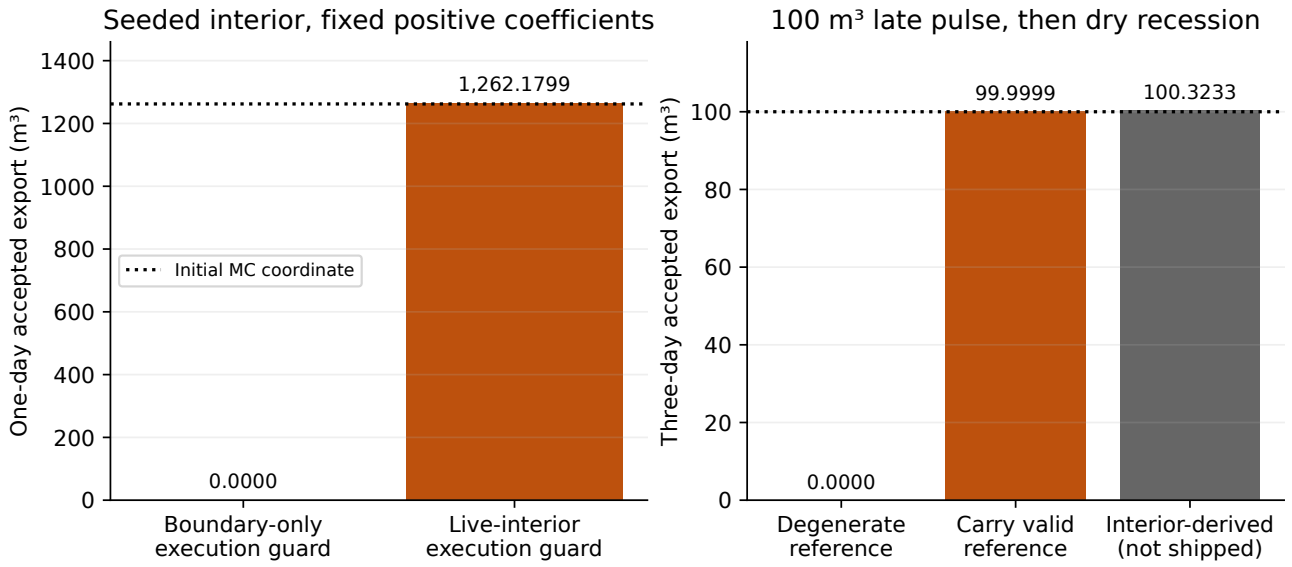


Figure 5: Two separate actual-routine experiments. Left: the live-interior guard prevents an admissible seeded profile from being discarded. Right: in a three-day 100 m^3 late-pulse test, carrying the previous valid MC4 reference allows recession; deriving a new reference from interior amplitude gives 100.3233 m^3 and was not selected. The bars compare isolated experimental policies, not three independently released binaries. MC coordinate/transition terms still govern interpretation of their exports.

The exact fixed-point optimization was checked against the same implementation with only the shortcut disabled. All raw spatial/time states, accepted outlet arrays and daily publication were compared. Numeric equality was rejected after signed-zero controls showed unequal raw bits. The final bitwise

version passed the retained 26-pair review; portable coverage expanded across both lateral modes and includes future forcing changes, 60/600 s resolution, subnormals and MC5 exclusion. In a 12-day 60 s recession, recurrence cell evaluations fell from 1,460,561 to 203,010 while the tiny final state remained unchanged. These are operation counts, not a universal runtime speedup.

The preceding interface candidate timed out on a 100-year watershed gate at 900 s. It was rejected. Retained-state reference handling and the exact fixed-point optimization were then validated against that failing case and the full gate. Final checkpoint evidence comprises 520 full-suite tests plus seven subsequently added causal tests, 29 paired replay cases, 12 watchlist cases and two host smoke checks. The artifact-specific reissue gate and binary identities are reported separately in the release validation record; the historical checkpoint count is not substituted for that gate.

4.2 The channel-plane alias has two distinct consequences

In an actual hourly dry-day receiving-channel control, inherited runoff was 0.00135309249 m, or 1.548344 m^3 over 1,144.30005 m^2. Four whole-run variants isolated neither reset, runoff reset only, local-runoff reset only, and both resets. The runoff reset changes antecedent soil history as well as the event-day working value; it is not just an instantaneous subtraction. The measured daily transmission request changes from 38.84190 to 9.04843 m^3 in that control.

A wet, higher-conductivity three-channel control exercises the other lifetime: local rainfall excess is zero, but surface return from soil activates the existing forwarding gate. An inherited `chnrun` value falsely labels 26.98620 m^3 as local runoff in the hourly case (26.90986 m^3 in daily mode). Resetting that field alone removes the false local amount while leaving the receiving soil and forwarded runoff unchanged. Genuine positive local-runoff controls retain their source. These experiments preserve the native soil formulas, event gates and MC recurrence.

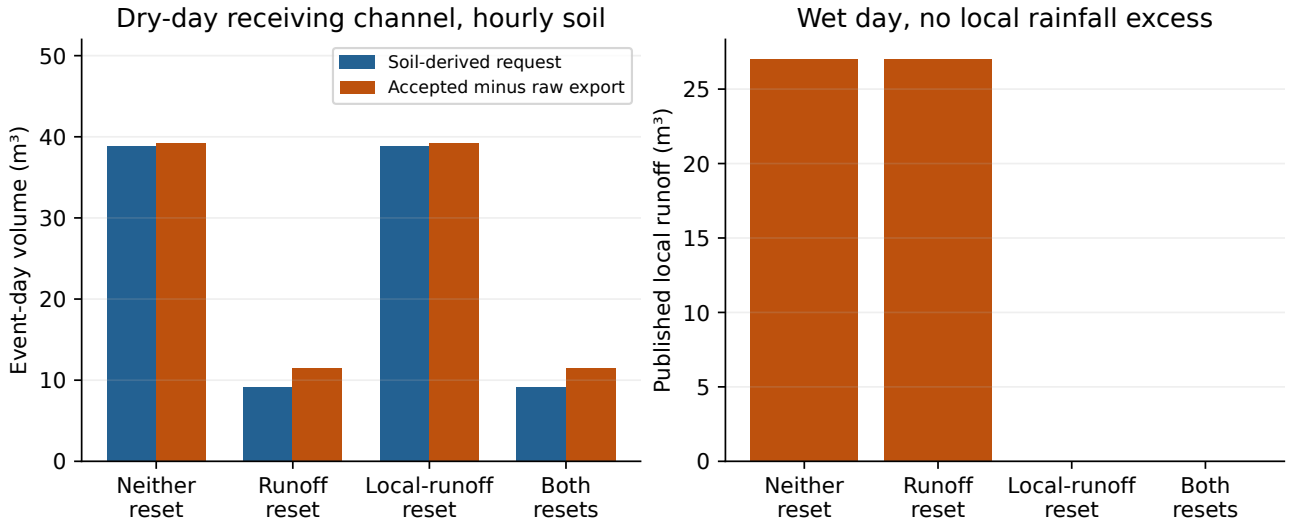


Figure 6: Actual two-year causal variants with earlier interface repairs held fixed. Left: the dry-day hourly soil request and accepted-minus-raw outlet volume both change after the runoff-slot reset, including changes to antecedent soil state. Right: the local-runoff-slot reset removes false publication on a wet day with no local rainfall excess. Nonzero clipping after both resets remains an open routing boundary; this figure does not claim its elimination.

5 Cedar Creek: full-period discharge and peak consequences

The retained study compares the available `wepp_261010` pair with repaired source `d354e3c99`, using the same frozen Cedar Creek inputs: 864 hillslopes, 371 channels, 10 cm initial random roughness, 1980–2003 climate, MC4 and 600 s output. Both builds independently regenerated all hillslope outputs and consumed their own PASS files. Both use hourly soil balance, confirmed by the input marker and WAT header. This is an end-to-end build comparison: the hourly allocation repair changes hillslope delivery as well as routing and publication. It is not a routing-only ablation or a comparison with measured streamflow [8].

Independent streaming readback verified all 1,262,304 finite, nonnegative outlet samples and 8,766 dates in each run, every daily and annual comparison, and all 356 descriptive event windows. The same derived-yield conversion was applied to both fresh PASS/WAT sets. The 19.25814309 km^2 contributing hillslope area is constant in that aggregation. Its runoff, lateral-flow and baseflow volumes sum to the reported hillslope streamflow, but it is not an independent ledger of all channel-admitted sources.

Quantity	261010	Repaired source	Change
Mean sampled outlet Q (m^3 s^{-1})	1.672156	1.680793	+0.51653%
Sampled outlet volume (million m^3)	1266.461660	1273.003350	+0.51653%
Published outlet volume (million m^3)	1272.337712	1273.001266	+0.05215%
Maximum reported peak (m^3 s^{-1})	46.19911	46.31255	+0.24555%
Maximum printed sampled peak (m^3 s^{-1})	46.2	46.3	+0.21645%
Hillslope streamflow (million m^3)	1267.735666	1268.205085	+0.03703%

Table 3: Complete 24-year comparison. Sampled volume is the 600 s right-endpoint sum of printed outlet rates. Published volume follows each build's daily publication rule. Reported and sampled maxima differ in precision and endpoint treatment. The two volume changes must not be substituted for one another.

All 24 annual reported maxima increase, by 0.222857–2.461208%; annual sampled volumes increase by 0.458629–0.653537%. Both builds' largest printed maximum first occurs at October 27, 1994, 04:40. The printed peak has two tied samples in the release and three in the repaired run. The available record therefore supports a common ten-minute first-maximum timestamp, not substep timing parity. Across daily printed peaks, 4,826 increase and none decrease; the remaining 3,940 are equal at the available printed precision.

The hydrograph publication check reconstructs q_0 from the preceding day's last printed sample for days 2 onward; first-day q_0 is unknown. The repaired trapezoid agrees with the daily publication within a conservative printed-rate rounding bound on all 8,765 checked days. The release fails that bound on 3,446 days. An independent, tighter bound that applies half weights directly to both endpoints gives 3,455 release exceedances and still zero repaired exceedances. The difference between those counts is the stated conservatism, not disagreement about the underlying files. Printed rates have three significant figures; exact solver closure cannot be inferred from them. These results establish publication consistency, not a physical storage budget.

The symmetric event screen uses daily local maxima from both builds (0.1 m^3 s^{-1} prominence, seven-day spacing within each screen), plus the ten largest daily peak changes. Each selected date receives a seven-day window. This descriptive selection is not a set of independent storms and some windows overlap. Three major events remain close in shape and maximum timing (Figure 8), while lower-flow departures are material in percentage terms (Figure 9).

The largest screened peak increase is 19.066%, from 0.257 to 0.306 m^3 s^{-1} in November 2–8, 1999. The largest window-volume increase is 13.552% in October 22–28, 1991. These effects would be concealed by reporting only the half-percent full-record change. The November 9–15, 1999 window has the largest

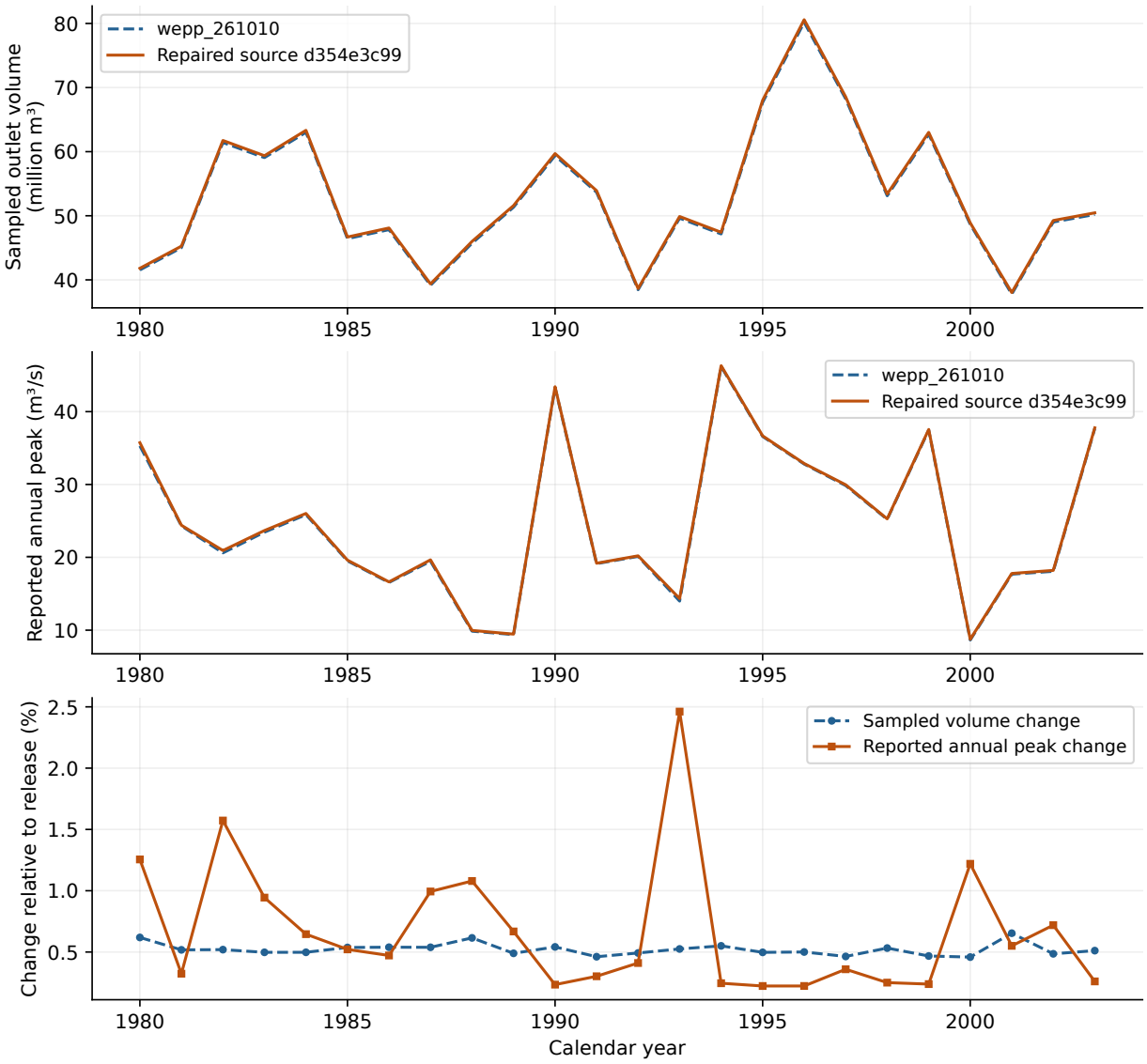


Figure 7: Cedar Creek annual sampled volume, reported annual maximum and paired percentage changes. Dashed/solid lines and markers distinguish quantities and builds independently of color. These are model-to-model comparisons under fixed forcing, not observational performance scores or fitted flood return levels.

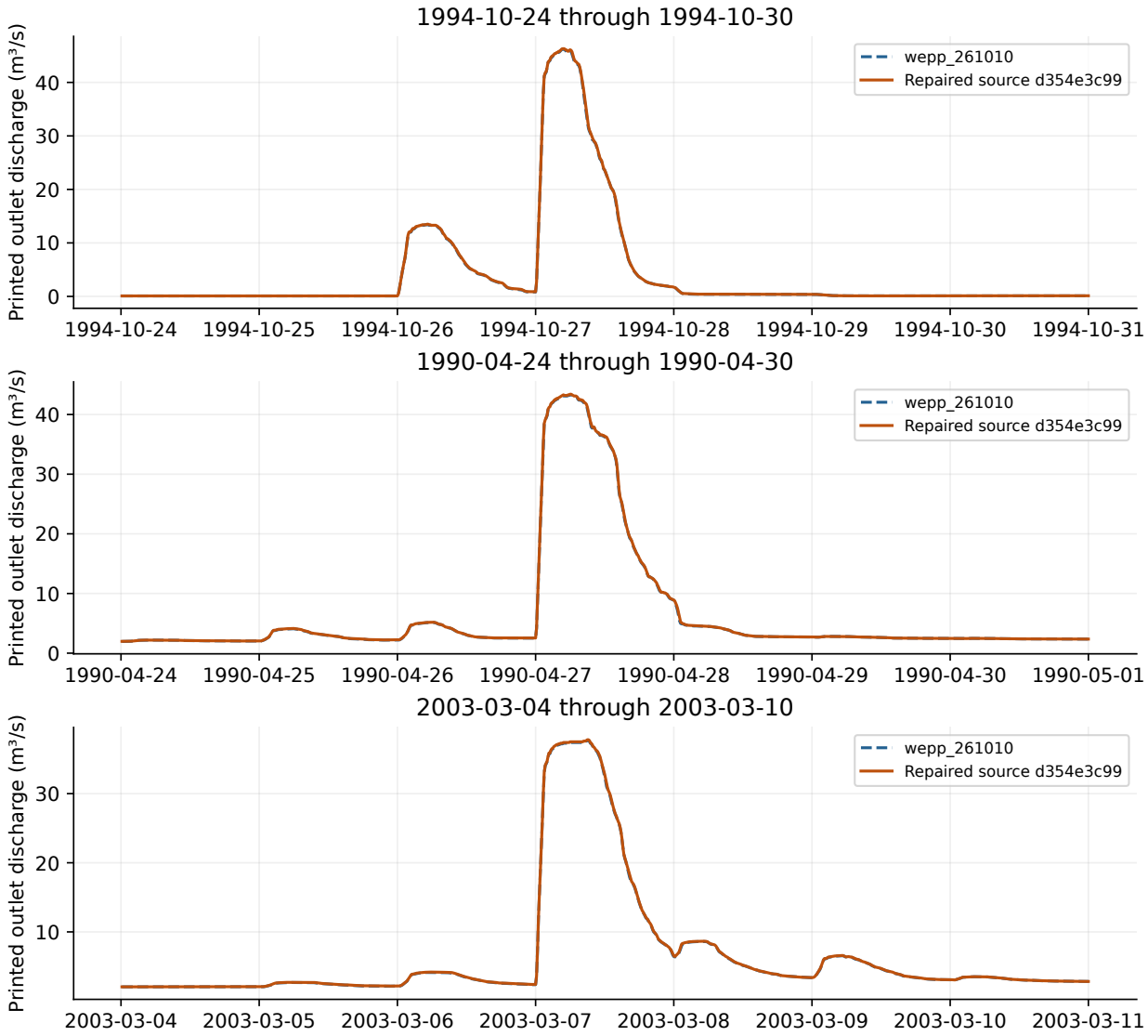


Figure 8: Three largest reference-selected Cedar event windows. Curves show the printed ten-minute outlet rate, not daily mean flow. The October 1994 maximum is unchanged in first sampled time, with reported magnitude 46.19911 versus 46.31255 $m^3\ s^{-1}$. Window volumes include all flow and are not separated storm runoff. Daily endpoint samples at 86,400 s are plotted at midnight.

negative flow-centroid shift, about 73.3 minutes. Centroids combine changes in baseflow, amplitude and window boundaries; they are not pure channel travel times.

First rounded maxima can switch between multiple pulses inside a window. Across all 356 windows, their apparent shifts span −2,680 to +4,680 minutes; the April 6–12, 1983 release window has 16 tied maximum samples. Those switches are not evidence of a multi-day calendar error. Conversely, the exact daily-date checks and shared largest-peak timestamp do not prove all hydrologic timing is correct. The 24-year period contains no non-leap century and is not the 100-year regression test.

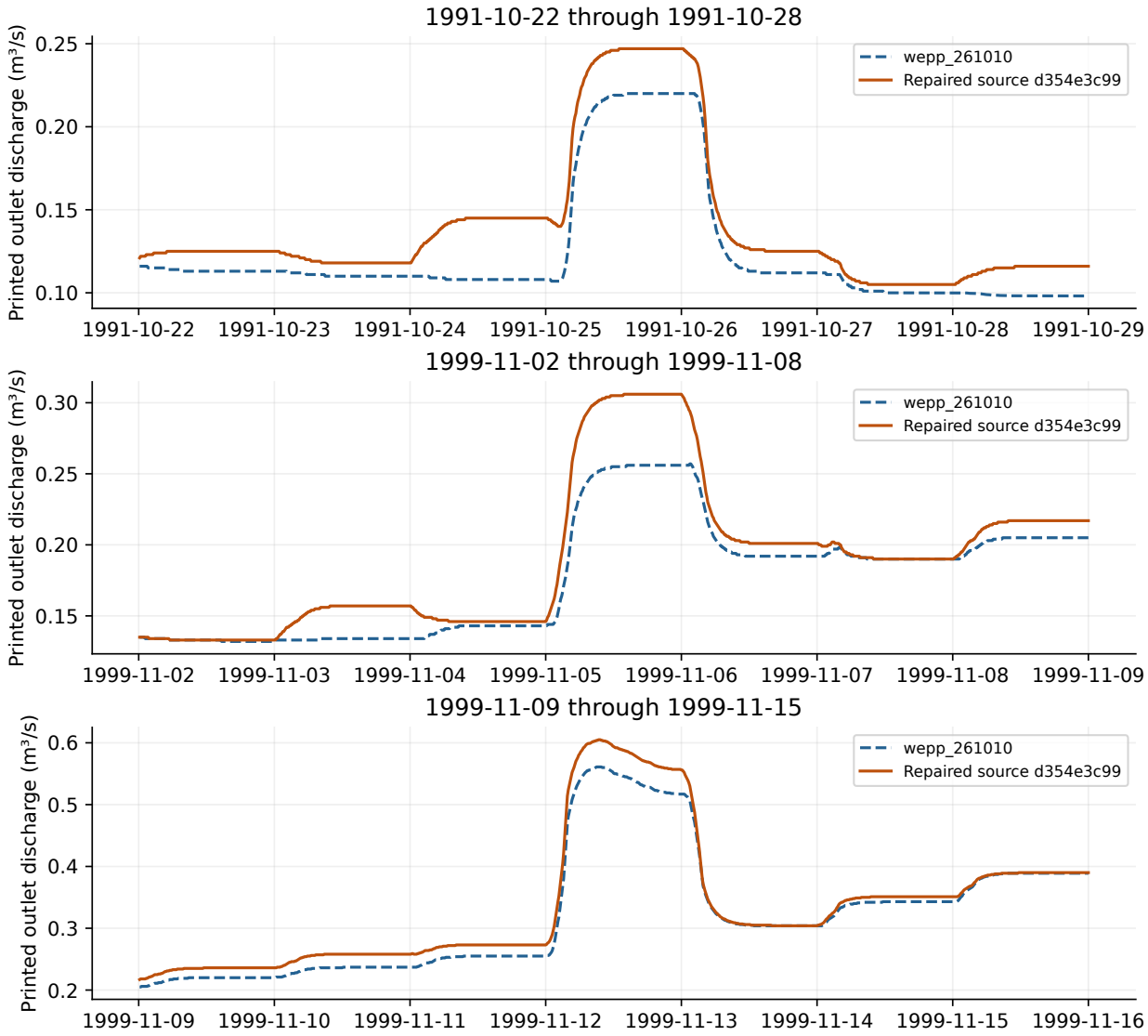


Figure 9: Adverse small-flow examples retained alongside major floods: the largest relative window-volume change, largest relative peak change and largest negative centroid shift in the symmetric screen. The release's narrow pulses and the repaired source's additional low flow should be evaluated on this scale; near-overlap of the major-event curves does not imply universal parity.

6 What remains unresolved after the released fixes

RN-261021-19. Signed channel-soil coupling remains the principal scientific acceptance gap. The soil calculation can credit a daily transmission loss before routing establishes whether water is present at the right time and position. A daily 100 m^3 inflow and 50 m^3 requested loss do not prove that an early or downstream-distributed withdrawal is available before a late inflow wave arrives. Proportionally reshaping the sink to the inlet hydrograph alone does not solve availability in every cell. Reducing the loss after soil has accepted it would leave unmatched soil water. A complete repair needs a reviewed request/acceptance/soil-commit contract, with the accepted MC dynamics and state authority preserved.

Clipping is measurable and is not always caused by a negative source. A pre-final-alias 44-year observer study found accepted-minus-raw export totals of 965.56, 36.45 and 58.89 m^3 in daily single-OFE, hourly single-OFE and hourly three-OFE cases, respectively. Their worst clipping days had positive lateral rates, separating negative-coefficient behavior from sink timing. These are diagnostic checkpoint measurements, not claimed final-release totals. More directly, the final alias-control variant still gives 11.42360 m^3 accepted-minus-raw export on the illustrated dry receiving-channel day. Wet zero-loss controls also clip; attributing the entire difference to soil loss would therefore be unsupported.

Positive side-impoundment release timing, no-history degenerate reference cases, complete initial/interception/snow inventories, every contour/variable-width layout, and untested optional consumers remain explicit coverage limits. The unavailable original workbook decks prevent attributing its specific reported discrepancy to a particular executable defect. The generated controls establish the repaired mechanisms without claiming a reproduction of those unprovided inputs. HBP schema-2 findings are a separate development-lineage investigation; the shipped ASCII component-v3 calendar and reader repair must not be described as a binary-PASS schema migration.

No new sediment accuracy, nutrient behavior, impoundment closure or field validation is inferred. Hydrology changes can propagate through erosion and transport calculations, and new generated outputs should be retained when assessing those consequences. The scoped release decision accepts the proved implementation/interface corrections while keeping these limits visible; it does not certify complete watershed physical water closure.

7 Compatibility, reproduction and operational use

7.1 Paired identity and regenerated artifacts

The release names remain `wepp_261021` and `wepp_261021_hill`, but artifact revision 2 has different binary hashes from the first undeployed edition. Select and record the complete paired identity. Do not combine a reissued watershed executable with hillslope PASS files from the first 261021, 261010, a different experimental candidate, or a different PASS family. Regenerate all contributing hillslopes, integrated PASS products and watershed outputs together, then refresh interchange tables and derived reports through the normal workflow. Historical outputs should retain their original provenance. An existing filename or an unchanged user-visible release selector does not prove that an old PASS file belongs to the new pair.

This reissue preserves ASCII PASS component version 3, the existing component reader pairing, the banner, the committed capacity profiles and existing parameter/default selection. It does not turn on binary HBP files. The existing Gregorian climate validation remains active. The calendar correction does not make a malformed or prematurely truncated climate file valid; those inputs now fail explicitly instead of supplying stale records. Existing correctly dated Gregorian climate inputs should be retained

rather than relabeled to accommodate an old scheduler error.

7.2 Build and verification contract

The canonical dated-release tool builds watershed and hillslope profiles sequentially with system `/usr/bin/gfortran`, clean objects, fixed-form 72-column parsing, optimization, floating-point traps and system runtime linkage. The process preserves the committed sizing profiles. Watershed limits are 60,000 elements, 45,000 hillslopes and 15,000 OFEs/types; hillslope-profile limits are 85 elements, 45 hillslopes and 32 OFEs/types. These are not new capacity changes. Sequential builds temporarily copy profile include files; that mechanical operation is not a parameterization revision.

Each installed binary has a complete adjacent JSON sidecar recording its role, source branch/commit, hash, interface capabilities and artifact revision. The reissue sidecars retain the superseded edition's identity. ELF interpreter, compiler/runtime provenance and matching hashes are checked before and after vendoring. Both binaries must request the system ELF loader. Runtime success markers alone do not replace output/date checks.

The earlier validated source checkpoint passed 520 native tests plus seven portable integration cases added after collection. Its actual-source tests cover ordinary and degenerate MC states, reference lifecycle, bitwise fixed points, source assembly, calendar execution and the plane/element flux alias. The freshly built reissue passed all 527 native tests in 718.13 seconds, with two existing archive-extraction deprecation warnings. This includes the 100-year watershed gate within its unchanged 900-second timeout. Both native profile smokes, all 12 hillslope watchlist cases, artifact policy and runtime provenance checks passed. Exact hashes and post-vendor results are retained in the accompanying validation record and binary sidecars. Diagnostic builds used for exhaustive recurrence accounting explicitly disable the fixed-point shortcut and keep complete records; separate bitwise-parity tests establish the production relationship.

The required release resources are committed fixtures or deterministically generated cases. The original private watershed decks and Cedar Creek study are supplementary evidence, not mandatory public release prerequisites. Equivalent executable sections allow the previously validated candidate's matched-build studies to support the reissued artifact; changed executable sections would require renewed generated-output validation. Merely preserving a source filename would not establish that equivalence.

7.3 Known limits and recovery

The remaining signed-exchange problem is substantive: a desired soil infiltration/transmission allocation and a channel's numerically accepted withdrawal are not yet governed by one complete accepted/unmet exchange rule. Reducing a downstream transmission term after soil water was credited would require corresponding soil reconciliation, including subsequent percolation, lateral flow and ET. This release does not implement that reconciliation. It also does not interpret an MC numerical storage coordinate as a physical availability store or add an empirical clipping threshold to force closure.

The Cedar evidence is specific to one basin, retained inputs, 24 years, MC4 and hourly soil balance. Its annual flood changes are small, but low-flow relative changes are material and retained in the figures. The studies do not certify all impoundments, daily soil configurations, MC5 cases, climate regimes, or sediment/nutrient outcomes. The repaired century calendar has separate 200-/400-year evidence; Cedar's shorter period is not its test.

To reproduce or roll back a calculation, restore/select the entire paired binary identity and regenerate its contributing outputs. Do not silently restore one profile, mix sidecars from another build, or mix old and new PASS files. Git history and retained reissue provenance preserve the first 261021

hashes. Deployment and a default binary switch are not part of this reissue; operator selection remains unchanged.

7.4 Report status and source disclosure

This report explains implementation behavior in original prose, equations, sanitized evidence tables and generated figures. No raw legacy routine, mixed-origin patch, secret, private filesystem path or confidential input deck is a report attachment. It should remain understandable without access to restricted source. The compiled PDF is checked for text, figures, references, layout and metadata; that engineering review is not accessibility certification, independent human peer review or NSERL approval.

Public PDF distribution is a separate handoff governed by the release-note publication policy. The release owner approved this reviewed report for publication on October 21, 2026. The PDF and public manifest are paired by SHA256 before public vendoring. Previously issued 261010 PDFs remain unchanged. Report publication does not authorize production deployment.

7.5 Exact reissue identities

The release uses source commit `d354e3c998f81955f9d9e5ca7d01ca56e1a9f04b` on the canonical `wepp_260430_negmeltfix_comparator` branch, built with system GNU Fortran 13.3.0. Debug information and GNU build IDs differ from the earlier study candidate; independent comparison found identical contents and layout of all 26 allocated ELF sections after excluding only the build-ID section. Complete files also match after removing debug sections and that build ID. This establishes executable equivalence, not merely similar output statistics.

The SHA256 values below identify the complete installed files. Concatenate both lines of each displayed hash without spaces.

```
Watershed, revision 2:
e2c83b1a691fad3ffe29acf1588dadbe
cfeec9b027391df8b7fddcf4908d2971

Hillslope, revision 2:
81591bf0301604aa25002d641e3c8e5d
22e15c747b179f1613e7c329233f4965
```

The superseded calendar-only edition used source `a87925df9ffe6ebb928e126395dd159d484285fa`; its complete file hashes are retained here to make the same-name replacement auditable:

```
Watershed, original edition:
fe7a8d7b93deb2329536b9cc937b9f51a
5c747b19fd3b95584347639046fa385

Hillslope, original edition:
6e4ec397551175ffd71337eeea04f5b31
50a544f247382c863956fb50d7e59d1
```

7.6 Capability metadata is a declaration, not new physics

RN-261021-13. The release tools explicitly declare the existing multiple-OFE and single-user-defined-input support in paired sidecars. They do not introduce either capability into the solver. HBP support remains false in this release. Refreshing metadata for an older binary checks its identity and SHA256

while preserving its original source and build provenance; a metadata refresh is not a new executable build. Artifact revision 2, by contrast, has new binaries with the exact identities recorded above.

References

[1] Stone, J.J., Lane, L.J., Shirley, E.D., and Hernandez, M. (1995). Hillslope Surface Hydrology. Chapter 4 in *USDA–Water Erosion Prediction Project: Hillslope Profile and Watershed Model Documentation*, NSERL Report 10. `https://www.ars.usda.gov/ARSUserFiles/50201000/WEPP/chap4.pdf`.

[2] Savabi, M.R., and Williams, J.R. (1995). Water Balance and Percolation. Chapter 5 in *USDA–Water Erosion Prediction Project: Hillslope Profile and Watershed Model Documentation*, NSERL Report 10. Historical process documentation; not a description of every later hourly implementation or of this release's allocation repair. `https://www.ars.usda.gov/ARSUserFiles/50201000/WEPP/chap5.pdf`.

[3] Foster, G.R., Flanagan, D.C., Nearing, M.A., Lane, L.J., Risse, L.M., and Finkner, S.C. (1995). Hillslope Erosion Component. Chapter 11 in *USDA–Water Erosion Prediction Project: Hillslope Profile and Watershed Model Documentation*, NSERL Report 10. `https://www.ars.usda.gov/ARSUserFiles/50201000/WEPP/chap11.pdf`.

[4] Wang, L., Wu, J.Q., Elliot, W.J., Dun, S., Lapin, S., Fiedler, F.R., and Flanagan, D.C. (2010). Implementation of channel-routing routines in the Water Erosion Prediction Project (WEPP) model. In *Proceedings of the Society for Industrial and Applied Mathematics Conference on Mathematics for Industry: Challenges and Frontiers*, MI09, pp. 120–127. `https://research.fs.usda.gov/treesearch/40457`.

[5] WEPP Forest/WEPPpy project records (2026-10-20–21). *Consumer Audit: Local Depths, Internal Transfers and Outlet Volumes*; native writer/readback and controlled hillslope/PASS accounting. Primary implementation evidence, including version-specific Q/QOFE interpretation. The original comparison workbook lacked producing executable and input decks; it is not treated as a reproducible model validation.

[6] WEPP Forest/WEPPpy project records (2026-10-21). *Watershed Physical Water Repair*: native source audit through `d354e3c99`, allocation/source/publication regressions, paired generated replays, Gregorian date checks, and channel-plane initialization controls. The report's change register maps each repair to its primary retained evidence. These are engineering and numerical checks, not observed watershed calibration.

[7] WEPP Forest/WEPPpy project records (2026-10-21). *MC Continuity and Interface Review*; full-node geometric/algebraic controls; variable-coefficient, source, clipping and grid-transition ledgers; retained-state and fixed-point ablations. Independent mathematical derivations are reproduced in this report, without restricted legacy source listings.

[8] WEPP Forest/WEPPpy project record (2026-10-21). *Cedar Creek 261010–Physical-Water Repair Comparison.* Fresh matched 24-year simulations with 864 hillslopes and 371 channels, same-build PASS provenance, full outlet readback, independent daily/annual/event audit and aggregate-yield conversion. Sanitized numeric evidence and original figure-generation code accompany this review edition. Figures are model comparisons, not observational validation or third-party endorsements.