Modernizing Drought Response for the Smith Mountain Project

A Low Inflow Protocol for the Water Management Plan

ABSTRACT

The 2026 drought tested the Smith Mountain Project's Water Management Plan, and its drought design fell short. The triggers lagged the decline they were meant to slow and rested on forecasts only APCo can see, the deepest conservation stage could be used in summer only through a variance, and once releases reached the fixed 400 cfs minimum, the plan had no further conservation stage to offer. The lake fell through the plan's own drought thresholds to its lowest level since 2001. This paper proposes a Low Inflow Protocol for the project, modeled on the FERC-approved Catawba-Wateree protocol (Project No. 2232) and informed by the Yadkin–Pee Dee protocol (Project Nos. 2197 and 2206). Drought stages are declared on measured conditions, flows step down by stage toward agency-defined Critical Flows, municipal water users share the conservation, and a standing drought group governs declarations and recovery. It can be adopted in two phases: LIP Phase 1 applies the new staging to the trigger flows the plan already contains, changing no agreed flow rate, and LIP Phase 2 adds agency-defined Critical Flows. An illustrative water-accounting model with placeholder parameters tests both phases against the 2026 record and a 20-year pressure test (2007–2026). In 2026, Phase 2 would have kept the lake above 792 ft from March onward, and Phase 1 would have left it about 1.8 ft higher; raising the existing trigger lines gains about 0.6 ft. Over twenty years, the weeks spent below 792 ft fall from 54 to 19 under Phase 1 and to 9 under Phase 2. Because the pumped storage cycle reuses the same water, the cost to the operator is small: mostly generation deferred, not lost. The adoption path begins with comment at the public meeting FERC has asked APCo to hold, followed by an out-of-cycle amendment of the Water Management Plan, since its scheduled five-year review was completed in 2025.

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Table of Contents

Executive Summary 3

2. What 2026 Proved About the Current Architecture 5

2.1 Six structural defects 6

2.2 A design failure, not an operating failure 7

3. The Models: Two FERC-Approved Low Inflow Protocols 7

3.1 Multi-indicator staging 7

3.2 Minimum flows as a drought variable 7

3.3 Shortage-sharing beyond the dam 8

3.4 Governance, recovery, and self-correction 8

3.5 A second precedent: the Yadkin–Pee Dee protocol 8

4. The Adaptation: A Smith Mountain Project Low Inflow Protocol 9

4.1 Definitions for this basin 10

4.2 Proposed stage structure 11

4.3 Governance: A Smith Mountain Project Drought Management Advisory Group 11

4.4 Safeguards the proposal builds in 12

4.5 A flow-neutral first step: protocol stages on the existing trigger flows 12

5. What a LIP Would — and Would Not — Have Changed in 2026 13

5.1 An illustrative water-accounting test of 2026 13

5.2 Differences a model cannot capture 16

5.3 What it would cost the operator 17

6. A 20-Year Pressure Test (2007–2026) 18

6.1 Data and resolution 19

6.2 The protocol as transplanted: what breaks 19

6.3 A calibrated protocol 19

6.4 What it would have gained 21

6.5 What it would have cost 21

6.6 How much depends on the placeholders 22

6.7 What the record says about common objections 22

6.8 A second design, a similar answer 22

6.9 LIP – Phase 1 – Existing Flow Rates over twenty years 23

6.10 The Drought Monitor indicator 23

6.11 The drought the record leaves out: 2000–2002 24

6.12 What the pressure test changes 25

7. The Path to Adoption 26

8. Anticipated Objections 27

9. Conclusion 28

Appendix A — Architecture Side-by-Side 29

Appendix B — Sources and Notes 30

Appendix C — Counterfactual Method 32

Appendix D — Pressure Test Method (Section 6) 34

Executive Summary

The 2026 drought ran a full-scale test of the Water Management Plan's drought architecture, and the plan failed it. The operator followed the plan, and the plan responded as written: Triggers 1 and 2 were declared in April and May, releases were reduced, and APCo reports that those measures conserved about two feet of lake elevation. It was not enough, and the plan had nothing more to offer. By late September the lake had spent 92 days below the plan's own 790.5 ft drought threshold and 25 days below 790.0 ft, and it had reached its lowest level since 2001. The trigger ladder trailed the decline and rested on forecasts only APCo could see, Trigger 3 could be used in summer only through a variance, and once releases reached the fixed minimum, the plan had no further conservation stage available — however low the lake fell or however long the drought lasted. The way the project responds to drought today is not working, and following the current plan more carefully would not have changed that.

This paper proposes that the Smith Mountain Project adopt a Low Inflow Protocol (LIP) built on the design FERC has approved for two neighboring Southeastern river systems: Duke Energy's Catawba-Wateree Project (FERC No. 2232), and the Yadkin–Pee Dee system, where one protocol binds two licensees (FERC Nos. 2197 and 2206). Both are staged, multi-indicator, shortage-sharing drought protocols, negotiated in relicensing settlements in 2006 and 2007 and carried into the licenses that followed; the Catawba-Wateree protocol was developed with roughly seventy stakeholder parties and was exercised in real time during the same 2026 drought that exposed the Smith Mountain Project plan's limits. Under both, minimum flows are not a fixed floor but a drought variable that steps down by stage toward agency-defined Critical Flows; reservoir levels are tied to the stages; municipal and industrial water users accept escalating conservation obligations; and a standing multi-party drought group governs declarations and periodically revises the protocol itself. The two differ in useful ways. Catawba-Wateree measures storage as a share of usable storage and steps flow by fixed fractions; Yadkin–Pee Dee measures storage in feet below a normal minimum elevation, will not declare drought while its main reservoir is in its normal range, ends a declaration when that reservoir refills, and seats lake associations in its drought group. This proposal takes from each what best fits the Smith Mountain Project. The ask is simple: when the next drought comes — and it will — the Smith Mountain Project should meet it with a plan built to respond, governed by everyone it affects, and honest about how the shortage is shared. The first step need not change a single agreed flow rate.

The 2026 drought also offered an informative natural comparison. Two Southeastern FERC licensees faced the same regional drought, under different local hydrology and different drought-management architectures. One declared LIP Stage 2 on May 1 and reduced its flow requirements by 95% of the difference between normal flows and Critical Flows while its municipal partners imposed mandatory restrictions. The other stepped down its Brookneal targets but held a 400 cfs release floor immovable while natural inflow fell to roughly 330 cfs, so storage kept falling, and needed a variance to deploy its own deepest trigger in summer at all. The Yadkin–Pee Dee protocol, one basin over, shows the other half of the design at work: on September 1 it held its system at normal despite drought conditions across the basin, because its main reservoir remained above its normal minimum elevation. A well-built protocol acts early when storage is falling and stays quiet when it is not.

The 2026 record also allows the central claim to be tested rather than asserted. In an illustrative water-accounting re-run of the year against AEP's daily data (Section 5.1), raising the existing Trigger 1 and 2 elevations by two feet would have left the lake about 0.6 ft higher today — a modest gain, which shows that where the trigger lines sit matters less than how the response is built. Making the deepest stage available whenever conditions warranted, rather than only after September 30, would have left it about

2.0 ft higher and above 791 ft all year. Running the year through the Low Inflow Protocol framework itself, with placeholder parameters, holds a single drought declaration all year and keeps the lake above 792 ft from March onward — about 2.6 ft above where it stands today — at a cost in reduced winter and spring releases that the agencies would have to weigh. The lever is the architecture of the response, not where the trigger lines are drawn — which is precisely what a Low Inflow Protocol changes.

Comparing the options. Figure ES-1 compares 2026 as it actually unfolded with four alternatives, each estimated with the same water-accounting model. Two keep today's plan and adjust its trigger rules. WMP – Higher Trigger Levels raises the Trigger 1 and 2 lines by two feet; WMP – Year-Round Trigger 3 also lets Trigger 3 engage in any season. Two are the phases of a Low Inflow Protocol. LIP – Phase 1 – Existing Flow Rates uses the protocol's staged, observable triggers and recovery rules but applies only the Brookneal flow targets the Water Management Plan already contains, with the license's 400 cfs minimum release unchanged; it requires no change to any existing, agreed-upon flow rate. In the 2026 run shown, it would have kept the lake roughly 1.8 ft higher than it was by late September; over the 20-year record it captures roughly two-thirds of the full protocol's gain in drought lows. LIP – Phase 2 – Critical Flow Rates, the full protocol, adds agency-set Critical Flows and a minimum release that steps down by stage, and does better still, because only a movable floor helps once inflow falls below 400 cfs (Sections 4.5, 5.1, and 6.9). Neither LIP phase is costly for the operator: because the pumped storage cycle reuses the same water, the protocol defers generation rather than forfeiting it, and priced at 2026 market rates its net effect on the plant's energy value is within about ±$0.4 million, 1–2 percent of the plant's net energy margin for January through September (Section 5.3).

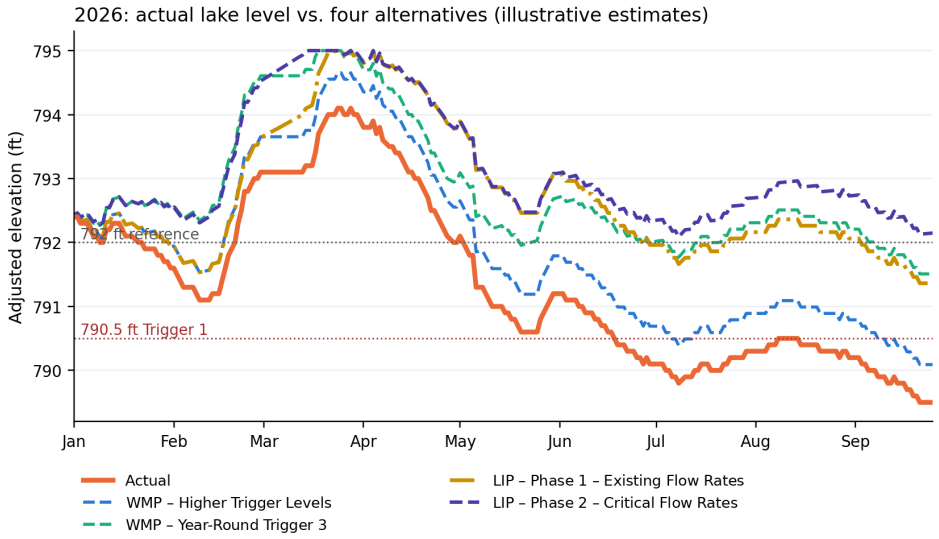


Figure ES-1. Actual 2026 adjusted elevation against four illustrative alternatives: WMP – Higher Trigger Levels and WMP – Year-Round Trigger 3 raise the existing trigger elevations by two feet, the second also making Trigger 3 available in any season; LIP – Phase 1 – Existing Flow Rates applies Low Inflow Protocol staging to the plan's existing trigger flows, with no change to any agreed flow rate; LIP – Phase 2 – Critical Flow Rates is the full protocol with placeholder thresholds and Critical Flow. Estimates from the water-accounting model in Section 5.1; lines show the midpoint of the surface-area range. Figure 1 shows the full version with ranges.

A single year is not a test of a protocol, so Section 6 runs a 20-year pressure test, January 2007 to September 2026. Merely adopting the Catawba-Wateree thresholds unchanged fails: the protocol declares drought ten times, six of them while the lake stayed above 793 ft, and stays declared through full-reservoir springs. Two calibrations — a refill exit and a slightly less sensitive first stage — fix most of that. The calibrated protocol declares eight episodes, six of them in the droughts of 2007, 2008, 2012–13, 2017–18, and 2025–26, and raises each modeled drought low by 0.8 to 2.2 ft, at a quantified cost in

reduced summer, fall, and winter releases; an evenly spaced, Yadkin–Pee Dee-style set of stages gives the same result. The test misses the deepest drought of the period, 2000–2002, when six-month inflow fell to 24 percent of normal and the lake to 788.5 ft, so how the protocol performs in a multi-year drought of that kind has not yet been tested (Section 6.11). On the same record, LIP – Phase 1 – Existing Flow Rates cuts the weeks below 792 ft from 54 to 19, against 9 for LIP – Phase 2 – Critical Flow Rates, without changing any agreed flow rate (Section 6.9). Adding the U.S. Drought Monitor as a third indicator, as both precedent protocols do, changes no result: on this basin it signals drought months after streamflow does (Section 6.10).

What this paper does and does not propose. This paper does not propose reducing releases to 350 cfs, or adopting any other specific flow or elevation. The values used in its analysis — a 350 cfs Critical Flow release, stage thresholds between about 794 and 789 ft, a 792 ft reference elevation — are analytical placeholders, not proposed operating limits, and its results come from an illustrative water-accounting model, not an operations model. It proposes that the agencies determine whether a scientifically defensible drought Critical Flow exists below the current normal-condition minimum and, if so, incorporate it into staged drought operations; and that APCo test the architecture in its own hydrologic and operational model, before any parameter is set. It also identifies a flow-neutral first step that changes no agreed flow rate (Section 4.5).

The central proposition. The 2026 drought demonstrated that the existing plan does not work in a drought of this kind: it reaches a point at which reservoir storage keeps declining while no additional conservation stage is available without a variance or license action. Other FERC-approved drought protocols manage that problem with observable multi-indicator staging, predefined recovery rules, staged conservation by water users, and agency-established Critical Flows. The Smith Mountain Project should determine, through agency study and APCo's operational models, whether a basin-specific version of that architecture would improve drought resilience while continuing to protect downstream resources. That determination can begin with a version that changes no agreed flow rate (Section 4.5).

The paper makes three contributions: it states the case (Section 2) by documenting six architectural defects the 2026 drought exposed; it describes the two models (Section 3) with their actual trigger and stage mechanics; and it drafts the adaptation (Sections 4–7) — a Smith Mountain Project LIP framework, an honest account — including a quantified re-run of the 2026 record — of what it would and would not have changed, and a concrete procedural path — comment at the FERC-requested public meeting, agency consultation, and an out-of-cycle FERC filing. The paper is written to the same standard as its predecessor: every criticism is aimed at plan design and the approving framework, not at operator compliance, and every proposed number is labeled as a placeholder for agency negotiation rather than asserted as settled. It also offers a flow-neutral first step (Section 4.5) that uses only the flows the plan already contains, so the trigger reforms can proceed while the Critical Flow studies are done.

2. What 2026 Proved About the Current Architecture

The current plan failed the test that 2026 set for it. By late September the lake had spent 92 days below the plan's own 790.5 ft drought threshold and 25 days below 790.0 ft, and APCo's published annual lows show it had reached its lowest level since November 2001. The six defects below explain why. The evidentiary record is set out in detail in the companion white paper (The 2026 Smith Mountain Lake Drawdown) and in the project's public data. This section restates only the findings that bear on drought-plan architecture, because the argument for a LIP rests on them.

2.1 Six structural defects

1. At the floor, the plan runs out of tools. The license sets an absolute minimum Leesville release of 400 cfs (March–October; 375 cfs November–February). By July 2026, estimated natural inflow had fallen to roughly 330 cfs — below the floor. From that point, every day of compliant operation was a day of mandated storage loss: the deepest possible conservation still released more water than the watershed delivered. Drawing on storage in a drought is what a reservoir is for; the failure is that the plan could not stop drawing on it. Once inflow fell below the fixed minimum release, the plan had no remaining mechanism for conserving storage, regardless of how low the lake fell or how long the drought lasted. A drought plan that runs out of tools while the drought is still getting worse is not working.

2. The trigger ladder chases the lake down. Each stage authorizes deeper conservation only after the decline that warrants it is established. Trigger 1 was declared April 27, 2026, with the adjusted elevation at 792.1 ft and falling; Trigger 2 followed May 11 at 791.0 ft. The adjusted elevation crossed 790.5 ft on June 18 and 790.0 ft on July 4 — the staged reductions were consistently outrun by the decline they were reacting to.

3. The trigger conditions are not well ordered. Trigger 2's condition (a 2% probability of the adjusted level falling below 790.0 ft within 10 weeks) is logically weaker than Trigger 1's (a 20% probability of falling below 790.5 ft within 16 weeks) on any sustained decline. It is difficult to construct an honest forecast that satisfies Trigger 1 without simultaneously satisfying Trigger 2 — yet the declarations came fourteen days apart. A stage ladder whose stages collapse into one another under the conditions they were designed for is not doing staged work.

4. The triggers run on forecasts no one else can see. Triggers 1 and 2 are defined as probabilities that APCo computes with its OASIS operations model, and APCo does not publish those runs. Outside the operator, no one — not the lake community, not downstream users, not the public — can see a declaration coming, check whether one arrived on time, or test whether the thresholds are set where they should be; the fourteen-day gap between two conditions that should have been met together (No. 3) cannot be explained from the outside. The early warning was not hidden: the streamflow indicator tested in Section 6.10 reached its Stage 1 level on September 1, 2025, nearly eight months before Trigger 1 was declared. What only APCo could see was whether the plan would act. A drought trigger that only its operator can compute leaves everyone it affects watching the gauge.

5. The deepest stage answers to the calendar, not the drought. Trigger 3, the plan's strongest conservation tool, is confined by rule to the fall and winter windows. In 2026 it became available in summer only through a Section 2.F variance effective July 22 — after the adjusted elevation had already crossed both lower thresholds. When a plan's emergency stage requires an improvised exception to function during an actual emergency, the defect is in the plan.

6. One party absorbs the entire shortage. Under the current plan, downstream flows are protected by hard numbers, municipal and other withdrawals carry no drought obligations at all, and lake storage — with the recreation economy, property values, and tax base standing on it — absorbs whatever the drought delivers. During drought the fixed floor even delivers above-natural flows: an unregulated river in July 2026 would have carried roughly 330 cfs, yet the project released at least 400, with lake storage making up the difference. This is the inverse of every modern drought protocol's first principle: shortage is shared.

2.2 A design failure, not an operating failure

None of this is a compliance critique. The operator met or exceeded downstream targets in every month of 2026 except one narrow trigger-transition month, the elevated April releases were mandated spawning flows, and the variance was pursued through the proper channel. APCo reports that the plan's measures conserved about two feet of lake elevation by mid-July. That strengthens the case rather than weakening it: the plan was followed, its tools were used, and the lake still fell to its lowest level in a quarter-century. The 2026 outcome is what the plan produces when it is followed. The remedy is therefore not enforcement but redesign — and redesign has FERC-approved precedents.

3. The Models: Two FERC-Approved Low Inflow Protocols

FERC has approved Low Inflow Protocols on two neighboring Southeastern river systems, and both inform this proposal. Sections 3.1 through 3.4 describe the Catawba-Wateree protocol, the more fully documented of the two and the one exercised in the 2026 drought. Section 3.5 describes the Yadkin–Pee Dee protocol, which shares the same architecture but differs in ways that matter for a pumped storage project like the Smith Mountain Project. Table A1 in Appendix A compares both protocols with the current plan side by side.

The Catawba-Wateree Project (FERC No. 2232) comprises eleven reservoirs on the Catawba River across North and South Carolina, including Lake Norman. Its Low Inflow Protocol emerged from the 2006 Comprehensive Relicensing Agreement, an approximately seventy-party settlement, was implemented voluntarily ahead of licensing, and was incorporated into the new 40-year license FERC issued on November 25, 2015. The standing drought group has revised it since (the current version was approved in January 2019). Its stated purpose is that "all parties with interests in water quantity will share the responsibility to establish priorities and to conserve the limited water supply." Four design elements matter for the Smith Mountain Project.

3.1 Multi-indicator staging

The LIP defines five stages, from Stage 0 (Low Inflow Watch) through Stage 4 (Emergency). Staging is driven by three independent indicators: a Storage Index (remaining usable storage between each reservoir's critical elevation and full pond, as a percentage of the seasonal target); the U.S. Drought Monitor's three-month numeric average over the basin; and rolling six-month streamflow at four named USGS gauges as a percentage of the period-of-record average. Stage 0 requires any two of the three; each deeper stage requires the storage condition plus at least one of the other two. No single sensor — and no single probabilistic forecast — can whipsaw the system in either direction.

3.2 Minimum flows as a drought variable

The LIP's central mechanism is the pair of flow tiers: normal Project Flow Requirements at the top and Critical Flows at the bottom — the agency-defined minimum releases needed to prevent long-term or irreversible damage to aquatic communities, keep large water intakes operable, and maintain basic water quality. Each stage closes a defined fraction of the gap between the two (Table 1):

Stage	Flow action	Parallel actions
Stage 0 (Watch)	Recreation releases cut (e.g., 6,000 to 3,000 cfs at Wylie)	Drought group activated; monthly meetings begin
Stage 1	Flow requirements reduced by 60% of the gap to Critical Flows	Minimum reservoir elevations lowered 1–2 ft; voluntary water-use restrictions (3–5% goal)

Stage	Flow action	Parallel actions
Stage 2	Reduced by 95% of the gap; recreation releases eliminated	Elevations lowered further; mandatory restrictions with penalties (5–10% goal)
Stage 3	Flows reduced to Critical Flows	Deeper elevation allowances; stricter mandatory restrictions (10–20% goal)
Stage 4 (Emergency)	Critical Flows held "as long as possible"	Elevations to critical levels; emergency restrictions (20–30% goal); outage contingency planning

Table 1. Catawba-Wateree Low Inflow Protocol: flow and parallel actions by stage (2006 protocol text).

Two features deserve emphasis. First, the floor itself moves: by Stage 3 the release requirement is the Critical Flow, a number derived from what downstream actually needs rather than from normal-condition habitat targets. Second, the reductions are proportional and pre-agreed — there is nothing to negotiate, forecast, or improvise when drought arrives.

The Yadkin–Pee Dee protocol reaches the same result by a different route: instead of a formula, it sets seasonal flow targets for each stage at each development, stepping down to fixed Critical Flows (Section 3.5). Either form gives the drought group a pre-agreed schedule rather than a negotiation.

3.3 Shortage-sharing beyond the dam

The LIP binds more than the licensee. Every owner of a large water intake — municipal, industrial, agricultural, or power — sits on the drought group, reports withdrawals, and accepts staged conservation obligations that escalate from voluntary (Stage 1) to mandatory with penalties (Stage 2) to emergency restrictions (Stage 4). Counties in the basin have written LIP compliance into their ordinances. The lake communities, the river, the cities, and the generator all give something at every stage; no single interest is asked to absorb the drought alone.

3.4 Governance, recovery, and self-correction

Declarations and communications run through the Catawba-Wateree Drought Management Advisory Group — state resource and water-quality agencies from both states, USGS, every large intake owner, and the licensee as coordinator — which meets monthly during any watch or declared condition and annually regardless. Recovery is as disciplined as escalation: stepping down a stage requires meeting all of the lower stage's triggers, so a single storm cannot prematurely unwind conservation. And the protocol audits itself: the group re-evaluates the LIP at least every five years and modifies it by consensus, with revisions filed at FERC. The protocol was exercised through the 2007–2008 drought of record and again this year — Stage 2 was declared May 1, 2026 — so it is a tested instrument, not a paper one.

The Yadkin–Pee Dee protocol handles recovery differently and, for the Smith Mountain Project, more usefully: besides a stage-by-stage reversal, it ends a declaration outright once its main reservoir returns to its normal range. Section 6 shows why a pumped storage project needs that rule.

3.5 A second precedent: the Yadkin–Pee Dee protocol

The Catawba-Wateree protocol is not an isolated case. A second FERC-approved protocol governs the Yadkin–Pee Dee system in North Carolina and South Carolina, adopted in the February 2007 relicensing settlement. It covers two licensees at once: the upstream Yadkin Project (FERC No. 2197, now operated by Cube Yadkin Generation, with High Rock Lake as its main storage reservoir) and Duke Energy's downstream Yadkin–Pee Dee Project (FERC No. 2206, Lake Tillery and Blewett Falls), whose new license

FERC issued on April 1, 2015. Its stated goal matches Catawba's: staged action to delay the point at which reservoir storage is fully depleted, while maintaining downstream flows, to buy time for rain. Its architecture matches too — five stages from Watch to Emergency, three indicators, flows that step down to agency-defined Critical Flows, staged conservation by water users (goals of about 5, 10, and 20 percent), a standing drought group, and review at least every five years. Two neighboring FERC licenses built on the same design make this a pattern in Commission practice, not a single example.

Four of its features fit the Smith Mountain Project better than Catawba's do.

Storage is a gate, measured in feet. Each stage requires High Rock Lake to sit a set distance below its monthly normal minimum elevation — more than 1, 2, and 3 ft for Stages 1 through 3, and halfway to the critical elevation for Stage 4 — plus either the Drought Monitor or the streamflow indicator. A healthy reservoir cannot be declared in drought. On September 1, 2026, with the Drought Monitor reading 2.33 and three-month inflow at about 63 percent of the historical average, the protocol reported normal conditions because High Rock stood 1.7 ft above its normal minimum. Triggers in feet are also the language the Smith Mountain Project Water Management Plan and this community already use.

Recovery follows refill. Besides a stage-by-stage reversal, the protocol ends outright when High Rock returns to its normal minimum for two consecutive weeks, or to 2.5 ft above it. Section 6 reached the same rule independently: without a refill exit, a Catawba-style protocol stays declared through full-reservoir springs.

The downstream floor steps down by stage. Flow targets are set by season and stage at each development. At Blewett Falls, the June–January continuous target steps from 1,200 cfs to 1,080, 1,000, and a 925 cfs Critical Flow. That is the movable Leesville floor this paper proposes, already approved on another FERC license.

The lake community is written in. The High Rock Lake Association, the Badin Lake Association, and representation for Lake Tillery homeowners are members of the drought group. The licensees must publish reservoir elevations, releases, inflows, the indicator calculations, the current stage, and meeting summaries.

Other features do not carry over. The protocol is evaluated monthly and escalates at most one stage per month; its streamflow thresholds are deep (48, 41, 35, and 30 percent of the historical average); and it balances drawdown among several reservoirs owned by two companies. It was designed for reservoirs whose normal minimum and critical elevations lie 10 to 24 ft below full pond, where Smith Mountain Lake's normal operating band is about 2 ft. Section 6.8 tests what those differences mean on this lake.

4. The Adaptation: A Smith Mountain Project Low Inflow Protocol

The Smith Mountain Project is neither of these systems. It is a pumped storage project — Smith Mountain Lake is its upper reservoir and Leesville Lake its lower reservoir — rather than a chain of six or eleven conventional reservoirs; it lies in one state rather than two; and its license is mid-term rather than in relicensing. The proposal does not transplant either precedent. It identifies the architecture common to both — multi-indicator staging, Critical Flows, shortage sharing, standing governance, and defined recovery — and tests alternative implementations of those common elements against the Smith Mountain Project's record. Within that frame, the adaptation below borrows from each protocol where it fits: from Catawba-Wateree, proportional flow steps and its entry and exit tests; from Yadkin–Pee Dee, stage thresholds written in feet of lake elevation, the refill exit, the seasonal flow schedule, and lake-association seats in the drought group. Every numeric value marked is exactly that: a starting point for the

consultation process described in Section 7, not a demand. Section 4.5 describes a flow-neutral first step that keeps every existing flow rate and changes only when those flows apply.

4.1 Definitions for this basin

- **Stage elevations and the operating limit.** Each stage is defined by an adjusted elevation of Smith Mountain Lake, in feet — the form the Yadkin–Pee Dee protocol uses, and the form the current plan and this community already use. Separately, the storage study must establish the project's operating limit, or critical elevation, for the upper reservoir (Smith Mountain Lake) and lower reservoir (Leesville Lake): the level set by pump-turbine operating limits, intake operability, water quality, and infrastructure below which the project cannot operate normally. The critical elevation is a physical boundary drawn from APCo's data, not a tuning parameter, and every stage threshold must sit above it. (The Catawba-Wateree protocol instead expresses storage as a percentage of usable storage above the critical elevation. For a project whose normal operating band is only about 2 ft, a percentage scale is hard to read and depends entirely on where the critical elevation is set, so this proposal writes the thresholds in feet.) The project's existing "adjusted elevation" — the pump-back-corrected level — is the right basis, and its governing role should finally be communicated to the public clearly.
- **Streamflow indicator.** The four USGS inflow gauges already used for the project's inflow estimation (Roanoke River at Niagara, Back Creek, Blackwater River, and Pigg River) supply the rolling six-month percentage-of-normal metric with no new instrumentation.
- **Drought Monitor indicator.** The U.S. Drought Monitor three-month numeric average computed over the upper Roanoke basin above Leesville Dam. Computed weekly as the area-weighted average drought category for the Upper Roanoke watershed (no drought −1, D0 0, D1 through D4 1 through 4). Section 6.10 tests it.
- **Critical Flows for the Staunton River.** The single most important number the process must produce, and one this paper deliberately does not assert. It must be established by the resource agencies from drought-condition science: the needs of the federally endangered Roanoke logperch, the dissolved-oxygen certification requirements, intake operability at Altavista and Brookneal, and the seasonal structure the license itself already recognizes (the difference between the 400 and 375 cfs floors shows that the license already recognizes seasonally differentiated minimum releases, though it does not establish what a drought-season Critical Flow should be). The Critical Flow may differ by season; it may be higher during the spring spawning window and lower outside it.

4.2 Proposed stage structure

Stage	Entry (adjusted elevation + streamflow or Drought Monitor)	Flow action	Community action
0 — Watch	Any two of three indicators below seasonal norms [placeholder bands]	Weekend recreation releases (650 cfs) suspended	SM-DMAG activated; monthly meetings; public dashboard flag
1	Below 793.5 ft [placeholder; 794.0 ft as first translated from Catawba-Wateree — see Section 6]	Brookneal targets reduced by 60% of the gap to Critical Flows	Voluntary conservation by lake-area and downstream water users (3–5%)
2	Below 792.5 ft [placeholder]	Reduced by 95% of the gap; non-essential scheduled releases eliminated	Mandatory restrictions for participating suppliers (5–10%)
3	Below 790.7 ft [placeholder]	Releases at Critical Flows	Stricter mandatory restrictions (10–20%)
4 — Emergency	Below 789.2 ft [placeholder; must stay above the operating limit]	Critical Flows held as long as possible	Emergency restrictions (20–30%); contingency planning

Table 2. Proposed Smith Mountain Project stage structure. Values marked [placeholder] are starting points for consultation, not proposals.

The stage fractions in Table 2 (60%, 95%, Critical) are carried over from the Catawba-Wateree protocol deliberately: they arrive pre-vetted. The Yadkin–Pee Dee schedules step down on a similar path — at Blewett Falls, roughly half, three-quarters, and then all of the way to the Critical Flow — so either set of fractions sits within what FERC has already approved. The stage elevations are placeholders pending a storage study; they come from translating the Catawba-Wateree storage percentages into feet on this lake. Note what disappears: there is no calendar lock on any stage — the drought, measured three independent ways, is the only clock — and no probabilistic forecast to dispute, because every indicator is an observable.

Two ways to space the stages. The stage elevations can be spaced in two ways, and Section 6 tests both. The Catawba-derived spacing in Table 2 comes from translating that protocol's storage percentages into feet on this lake, which places the stages unevenly: 793.5, 792.5, 790.7, and 789.2 ft. The Yadkin–Pee Dee spacing sets each stage a fixed distance below a normal minimum elevation [placeholder]: with a normal minimum of 794.5 ft, Stage 1 falls below 793.5 ft, Stage 2 below 792.5 ft, and Stage 3 below 791.5 ft [placeholders]. Either way, no stage can be declared while the lake is in its normal range, and 792 ft — the reference elevation used in this analysis — falls between Stages 2 and 3. Section 6.8 shows that the two spacings produce similar modeled lake outcomes.

4.3 Governance: A Smith Mountain Project Drought Management Advisory Group

The September 11, 2026 stakeholder meeting at APCo's Roanoke offices — convened through SMLA's leadership with APCo, TLAC, the SML Regional Chamber of Commerce, the Leesville Lake Association, DWR, and DEQ at the table — is, in embryo, the drought group this proposal requires. SMLA convened it on its own initiative, outside any formal FERC review — which is exactly why it needs to be formalized. Formalize it: add the U.S. Fish and Wildlife Service, the Army Corps (Kerr coordination), USGS, the regional

water authorities with project-water intakes, and downstream-locality representation; give it the functions both protocols assign their drought groups (declaration consultation, monthly drought meetings, annual review, withdrawal reporting, public meeting summaries); seat the Smith Mountain Lake Association and the Leesville Lake Association as members, as the Yadkin–Pee Dee group seats the High Rock Lake Association, the Badin Lake Association, and Lake Tillery homeowners; and adopt the Yadkin–Pee Dee public-data obligation, under which the licensee publishes elevations, releases, inflows, indicator calculations, and stage status; and charge it with re-evaluating the protocol at least every five years by consensus, with revisions filed at FERC. The project's existing Technical Review Committee provides the scientific backbone.

4.4 Safeguards the proposal builds in

- **Endangered species.** Critical Flows are defined with the Roanoke logperch first; any protocol touching license minimum flows proceeds through ESA Section 7 consultation. The LIP mechanism is compatible — its Critical Flow definition exists precisely to name the no-irreversible-harm line.
- **Water quality.** The dissolved-oxygen obligations under Virginia's certification are honored inside the Critical Flow definition and, where necessary, as stage-independent seasonal overlays; DEQ holds the pen.
- **Spawning flows.** The striped-bass spawning window can be carved out as a seasonal flow requirement where stages reduce differently or not at all — an agency decision the framework accommodates rather than forecloses.
- **Disciplined recovery.** Stage exit requires meeting all of the lower stage's entry conditions — the LIP's rule — so a February-2026-style storm neither unwinds conservation prematurely nor whipsaws the staging. A refill exit overrides it: any stage ends when the adjusted level recovers to 794.8 ft, because a full reservoir is not in drought. The Yadkin–Pee Dee protocol uses the same rule for its main reservoir. Section 6 shows why both rules are needed.
- **Ramping and monitoring.** Flow changes follow agreed ramp rates with real-time DO and temperature monitoring downstream, and an equipment/emergency protocol analog preserves operational flexibility.
- **Annual maintenance outage.** Each fall the plant stops generating and pumping for about two weeks of turbine maintenance — late October to mid-November in 2020 through 2024, and September 26 to October 10 in 2025, in the SML+ record. Leesville Lake then carries the full minimum release from its own storage and the Pigg River, with no water coming from Smith Mountain. The storage study should test Leesville's critical elevation through that window, and the drought group should know when it falls.

4.5 A flow-neutral first step: protocol stages on the existing trigger flows

The full protocol changes two things: when the plan acts, and how low releases can go. The second requires agency-defined Critical Flows and a license amendment. The first does not. A flow-neutral version of the protocol keeps every flow rate the project has already agreed to and changes only the rules for when those flows apply.

What stays the same. Each stage uses the Brookneal targets already in the Water Management Plan: Stage 1 applies the Trigger 1 targets, Stage 2 the Trigger 2 targets, and Stages 3 and 4 the Trigger 3 targets. The license's minimum Leesville release — 400 cfs from March through October and 375 cfs from

November through February — is unchanged and continues to govern whenever a trigger target would allow less. No Critical Flow is introduced, and no study is needed to set one.

What changes. Stages are entered on measured conditions — the adjusted lake elevation and the streamflow indicator, at the stage elevations in Table 2 — rather than on probabilistic forecasts. Every stage, including the Trigger 3 flows, can be used whenever conditions warrant, rather than only in fall and winter. Stages end under the protocol's recovery rules, including the refill exit. The governance, shared-conservation, and public-data provisions of Section 4.3 can be adopted with it.

Why it matters. Because it changes only the plan's trigger mechanics, this step could proceed as a Water Management Plan amendment without a license amendment. The agencies would still need to review it: summer use of the Trigger 3 flows was approved only by variance in 2026, and the approved reduced flows would apply earlier and more often than they do today. But every flow value it uses is one the agencies and FERC have already accepted. Its limit is equally clear. In a summer drought, when the 400 cfs floor binds, no trigger change can conserve more water; that is the gap the full protocol's Critical Flow is designed to close. Sections 5.1 and 6.9 test it.

5. What a LIP Would — and Would Not — Have Changed in 2026

Credibility requires stating the limits plainly. A LIP would not have refilled Smith Mountain Lake in 2026; the drought was hydrologic, and no protocol manufactures rain. The 2026 record does, however, allow part of the question to be tested rather than argued. Section 5.1 reports that test; Section 5.2 describes the differences a protocol makes that a water-accounting model cannot capture.

5.1 An illustrative water-accounting test of 2026

Method. This is an illustrative water-accounting counterfactual, the approach used in the companion drawdown paper — not an operations model. It does not represent APCo's forecasting, generation and pumpback scheduling, or dissolved-oxygen operations, and it converts volume to elevation with a linear surface-area approximation rather than the reservoir's elevation area storage curve. Its results are estimates to be tested in APCo's operations model, not predictions. Actual inflow, actual releases, and actual Brookneal flows from AEP's daily notices (January 1 – September 25, 2026) are held fixed. On any day an alternative rule set would have placed the project in a deeper stage than it actually was, the Leesville release is reduced by the difference between the two stages' Brookneal targets in the Water Management Plan's own table (Condition D.7), never below the license minimum and never above the actual release. Stage entry and exit are evaluated on the counterfactual elevation, so a higher lake enters drought operations later; exit requires recovering 1.0 ft above the entry threshold; and water that would carry the lake above 795.0 ft is treated as passed downstream. Results are reported across a 19,000–20,260 acre surface. Full assumptions are in Appendix C. The options are named for what they change: the WMP options keep today's plan and adjust its trigger rules, and the LIP options are the two phases of Section 7 — LIP – Phase 1 – Existing Flow Rates and LIP – Phase 2 – Critical Flow Rates, or Phase 1 and Phase 2 for short. Figure 1 and Table 3 show the results.

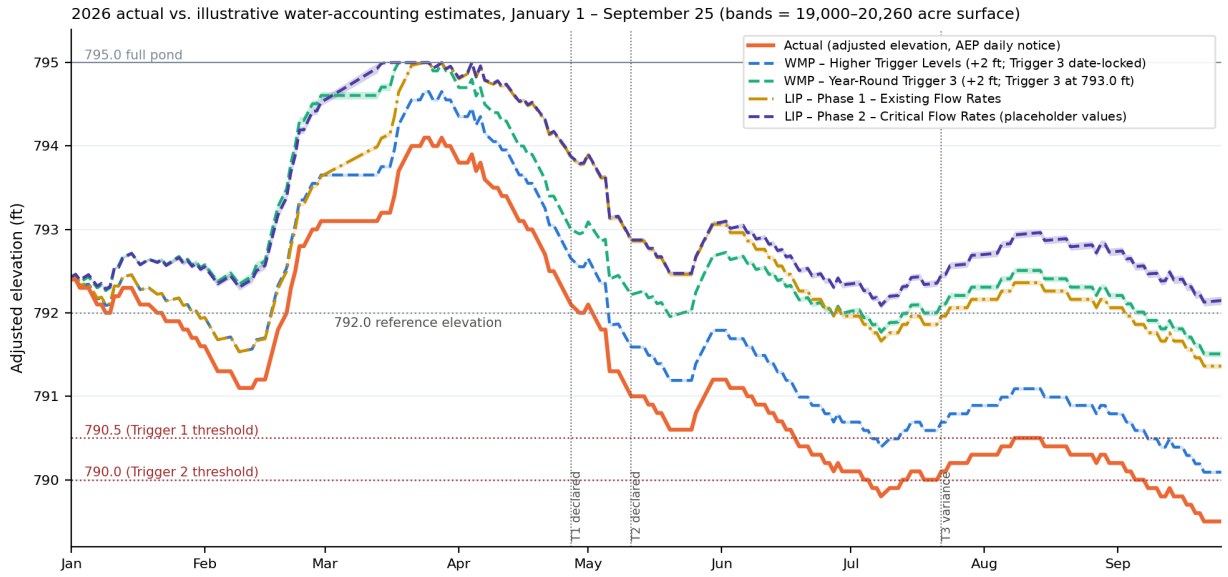


Figure 1. Actual adjusted elevation versus four counterfactuals. WMP – Year-Round Trigger 3 and LIP – Phase 2 – Critical Flow Rates reach full pond in March and pass the excess downstream. In the water-accounting estimate, LIP – Phase 2 – Critical Flow Rates holds a single Stage 2 declaration all year and stays above 792.0 ft from March onward. Bands reflect the surface-area range.

Option	Level on Sept 25 (ft)	vs. Actual	Days below 790.5	Days below 790.0	Water retained (ac-ft)	Lost at full pond (ac-ft)
Actual	789.5	—	92	25	—	—
WMP – Higher Trigger Levels (Trigger 1/2 elevations +2 ft, 792.5 / 792.0; Trigger 3 date-locked)	790.1	+0.6	16–25	0	11,600	0
WMP – Higher Trigger Levels + 375 cfs Floor (375 cfs floor after July 22)	790.2–790.3	+0.7	11–18	0	14,800	0
WMP – Year-Round Trigger 3 (elevations +2 ft; Trigger 3 available at 793.0 ft)	791.5	+2.0	0	0	38,800–40,000	11,300–12,400
WMP – Year-Round Trigger 3 + 375 cfs Floor (375 cfs floor after July 22)	791.7	+2.2	0	0	42,700–43,800	11,300–12,400
LIP – Phase 1 – Existing Flow Rates (protocol stages on existing Trigger 1–3 flows; 400/375 cfs floor unchanged)	791.3–791.4	+1.8–1.9	0	0	35,900–37,100	4,300–5,500
LIP – Phase 2 – Critical Flow Rates (Section 4.2 framework; placeholder stage elevations, Critical Flow 350 cfs)	792.1–792.2	+2.6–2.7	0	0	51,300–52,600	23,600–25,000

Table 3. Results through September 25, 2026. Day counts run from March 1. Water retained is net of any volume passed at full pond. Ranges reflect the surface-area band. LIP – Phase 2 – Critical Flow Rates' values depend on placeholder parameters; see Table 4.

Threshold height alone is a modest lever. Raising the Trigger 1 and 2 elevations by two feet, with nothing else changed, leaves the lake about 0.6 ft higher today, keeps it above 790.0 ft all year (versus 25 days below), and cuts days below 790.5 ft from 92 to roughly 20. Real, but modest: moving the trigger lines without changing how the stages work is a weak lever. Most of the gain comes from winter, when the project would have been in drought operations from January 1 until the February storms.

Stage availability is the dominant lever. With the same thresholds and Trigger 3 able to engage whenever the lake fell to 793.0 ft, the lake stands about 2.0 ft higher today and never falls below 791.5 ft. This is the calendar lock quantified: roughly 1.4 ft of the difference comes from letting the deepest stage respond to the drought rather than the date. It also carries costs the record makes visible. About 11,000–12,000 acre-feet saved in winter is passed downstream when the March storms fill the lake to full pond — the whipsaw risk in practice, and the reason a protocol needs disciplined entry and exit rules. And WMP – Year-Round Trigger 3's return to Trigger 3 on April 27 cuts the spawning-season Brookneal target from 1,275 to 1,050 cfs, an ecological cost the agencies would have to weigh.

The floor matters once it binds. Lowering the minimum release to the license's own 375 cfs on the days after July 22 when it sat at 400 adds about 0.15–0.2 ft to either scenario. Two months at 25 cfs is small; the point is that it is the only lever that acts once inflow falls below the floor, and under a protocol the floor itself steps down by stage toward agency-defined Critical Flows.

The trajectories did not converge. In every scenario the retained water was still in the lake on September 25. A higher starting point declines along the same slope once releases reach the floor, so the difference persists until the lake refills. Earlier conservation did not merely slow the decline; in 2026 it also changed where the lake ended up.

LIP – Phase 2 – Critical Flow Rates: the protocol itself. The WMP options modify the existing plan. LIP – Phase 2 – Critical Flow Rates replaces it with the Section 4.2 framework and runs 2026 through it. Stages are evaluated weekly on two observable indicators: the adjusted lake elevation, measured against placeholder stage thresholds, and a streamflow index (rolling six-month project inflow as a share of the 2020–2025 average from the same AEP record). The Catawba-Wateree trigger values are used, with its storage percentages translated into feet on this lake (Section 6.8 runs the Yadkin–Pee Dee spacing): adjusted elevation below 794.0, 792.5, 790.7, and 789.2 ft, and streamflow at or below 78, 65, 55, and 40 percent of normal, for Stages 1 through 4. These daily 2026 runs use lake level and streamflow; adding the Drought Monitor as an alternative indicator, as the protocol allows, changes no stage over twenty years (Section 6.10). Each stage closes 60 percent, then 95 percent, then all of the gap between the plan's normal Brookneal targets and a Critical Flow schedule — here anchored to the plan's own Trigger 3 targets, the lowest drought flows the agencies have already approved — with April–May spawning targets held no lower than the 1,200 cfs the plan already allows under Trigger 2. The Leesville minimum steps down by the same fractions toward a placeholder Critical Flow release. Stepping down a stage requires both indicators to recover, as the protocol requires.

What it shows. Under the central placeholders, the protocol declares Stage 2 on January 1 and holds it all year: one declaration, no transitions, and a modeled lake that stays above 792.0 ft from March onward and stands at 792.1–792.2 ft today, 2.6–2.7 ft above actual. The reason it never steps down is the most useful finding in this section. The February and March storms refilled storage, but the streamflow index never rose above about 49 percent of normal all year; the protocol read the storms correctly as relief within a continuing drought, not as its end. Run with a looser exit rule, in which either indicator's recovery

allows a step down, the same framework makes seven stage changes and ends about 0.8 ft lower. The requirement that every indicator recover is what answers the whipsaw concern.

What it costs. The protocol's gains are not free, and the record shows where they come from. Releases run lower than actual in every month, by about 290 cfs in January, 250 cfs in March, and 270 cfs in April, when the spawning-season target sits at 1,200 cfs for the whole month rather than reaching it under Trigger 2 on May 11. From May onward the reductions are modest — about 120 cfs in June and 45–50 cfs from July through September, where the lower floor does the work. And roughly a third of the gross savings, 23,600–25,000 acre-feet, is passed downstream when the lake reaches full pond in March: conservation that a wet month made unnecessary. The downstream side of this ledger is the agencies' to weigh, and the Critical Flow schedule is theirs to set; this scenario only shows what the lake side of the ledger would have been.

How much depends on the placeholders. The result is sensitive to the two numbers this paper deliberately leaves to the consultation process, and Table 4 shows by how much. Across the range tested, the model estimates the lake between 791.2 and 792.4 ft today, and above 791.0 ft since March in every case.

Stage elevations tested (Stages 1–4)	Critical Flow 300 cfs	Critical Flow 350 cfs	Critical Flow 375 cfs
Lower set: 793.5 / 791.3 / 788.6 / 786.3 ft	791.3	791.2	791.2
Central set: 794.0 / 792.5 / 790.7 / 789.2 ft	792.3–792.4	792.1–792.2	791.9–792.0

Table 4. LIP – Phase 2 – Critical Flow Rates level on September 25, 2026 (ft), by placeholder stage elevations and Critical Flow release. Ranges reflect the surface-area band. The streamflow normal rests on only five years of record; a longer period of record would refine the index but, at 33–49 percent of normal through 2026, would not plausibly change the stage.

LIP – Phase 1 – Existing Flow Rates: the same stages on the existing flows. Phase 1 runs Phase 2's stages and exit rules but applies only the Water Management Plan's existing Trigger 1, 2, and 3 Brookneal targets, with the license minimum release unchanged (Section 4.5). It too would have declared Stage 2 on January 1 and held it all year, and the model estimates the lake at 791.3–791.4 ft on September 25, about 1.8–1.9 ft above actual, without falling below either trigger threshold. Most of the difference from Phase 2 comes in winter and summer: in winter, the Critical Flow schedule allows deeper cuts than the Trigger 2 targets, and in summer the fixed 400 cfs floor stops Phase 1 from conserving more.

What the test does and does not show. Together, the options separate the pieces of the argument. WMP – Higher Trigger Levels isolates threshold height, WMP – Year-Round Trigger 3 isolates the calendar lock, the two + 375 cfs Floor variants isolate the floor, LIP – Phase 1 – Existing Flow Rates isolates the trigger reforms on existing flows, and LIP – Phase 2 – Critical Flow Rates runs the protocol's multi-indicator entry, all-indicator exit, fractional flow steps, and movable floor together. Section 6 extends the test to twenty years, which the single-year scenarios cannot do. What none of them tests is equally important: agency-defined Critical Flows, for which placeholders stand in; conservation by water users; and APCo's own forecasting and dissolved-oxygen operations. These results are a water-accounting estimate from public data, not a hydrologic model. Running these scenarios in operational models with APCo and agency staff is how they become results all parties accept.

5.2 Differences a model cannot capture

Three further differences follow from the protocol's design rather than its water arithmetic, and the third matters most.

Earlier, observable staging. April–July inflow ran roughly 45% of normal — a level that the streamflow indicator registers directly and the Drought Monitor corroborated through the spring. LIP – Phase 2 – Critical Flow Rates bears this out: the storage and streamflow indicators alone place the project in a declared drought stage from January 1, on the strength of measured conditions, without any dispute about forecast models, and with the community formally inside the process from the first declaration.

A floor that could reach balance. With July inflow near 330 cfs against a 400 cfs fixed floor, the current plan imposed a net storage loss of roughly 70 cfs even at its deepest conservation stage. Under a LIP at Stage 3, releases fall to the Critical Flow; whether that number lands at, above, or below prevailing inflow is for the agencies, but the mandated-decline arithmetic — a floor the drought itself cannot move — is eliminated by design. The savings are bounded — each 100 cfs retained is roughly 0.3 ft of lake elevation per month — and Section 5.1 puts a number on the 2026 case: aligning the floor with the license's own 375 cfs added about 0.15–0.2 ft over the two months it would have applied. The larger claim is architectural: a floor that can move is the only tool that works once inflow falls below it. It is also the limit of LIP – Phase 1 – Existing Flow Rates (Section 4.5), which changes when the plan acts but not the floor; in summer droughts, that difference is most of the gap between Phase 1 and Phase 2. Evaporation does not change that arithmetic. Estimated from lake-surface temperature, humidity, and wind, it took about 94 cfs from June through September 2026, but rain falling on the lake returned most of it, for a net loss of roughly 17 cfs.

A shared, legitimate burden. In 2026 the lake community's only formal role was to watch the gauge. Under a LIP it would have held seats in the drought group, received staged conservation obligations of its own, and seen downstream and municipal users step down alongside the reservoir — with recovery criteria published in advance. The difference between a community that absorbs a drought and one that participates in managing it is the difference 2026 exposed.

5.3 What it would cost the operator

Because the Smith Mountain Project is a pumped storage project, a drought protocol touches less of its generation than its flow numbers suggest. The pump-and-generate cycle moves the same water between the two reservoirs and does not depend on the Leesville release; only water that leaves through Leesville Dam carries energy out of the project, first through Smith Mountain's turbines and then through Leesville's. Every scenario in Section 5.1 changes only that release. And most of the water it holds back is not lost to generation: on September 25 it was still in Smith Mountain Lake, to be generated later, and the water passed downstream at full pond in March still ran through the turbines, only earlier.

Method. To put a number on it, the Phase 1 and Phase 2 releases were rebuilt from the Appendix C rules, and every acre-foot they hold back was priced at the hourly PJM day-ahead price for the AEP zone. Smith Mountain's share uses its measured head and an 82 percent machine efficiency — the value at which SML+'s monthly estimates of generation and pumping best match the net generation APCo reports to the U.S. Energy Information Administration on Form 923 for 2020–2026, within about 3–5 percent in a typical month — and is priced at the hours the plant actually generated. Leesville's share uses an efficiency of 60–76 percent, calibrated the same way to Leesville's 2023–2024 reports, and is priced at all hours. The rebuild reproduces Phase 1's Table 3 results closely and ends Phase 2 about 0.25 ft lower, so Phase 2's figures are slightly conservative. Table 5 shows the results; Appendix C gives the method.

January 1 – September 25, 2026	LIP – Phase 1 – Existing Flow Rates	LIP – Phase 2 – Critical Flow Rates
Energy withheld by lower releases	8,770 MWh · $823,000	13,670 MWh · $1,478,000
Returned when the lake reached full pond (March)	1,170 MWh · $92,000	3,870 MWh · $306,000
Head gain on the pump-and-generate cycle	+$170,000	+$192,000
Still in the lake on September 25	36,800 ac-ft ≈ 7,350 MWh	47,500 ac-ft ≈ 9,500 MWh
Break-even price for the stored water	about $76/MWh	about $103/MWh
Net if stored water later earns $60 / $90 / $120 per MWh	−$121,000 / +$100,000 / +$321,000	−$410,000 / −$125,000 / +$160,000

Table 5. Market value of the two LIP phases, January 1 – September 25, 2026, at PJM AEP-zone day-ahead prices, over a 19,630-acre surface. Scenario releases are rebuilt from the Appendix C rules; the Phase 2 rebuild ends about 0.25 ft below Table 3, so its figures are slightly conservative. Market value, not APCo revenue.

A timing shift, not a loss. Most of the withheld energy is still in the lake and earns its value when it is generated. It becomes a cost only to the extent that it later earns less than the break-even price in Table 5 — about $76 per MWh for Phase 1 and $103 for Phase 2. Smith Mountain's generating hours averaged roughly $85 to $215 per MWh by month in 2026.

A higher lake pays some of it back. Keeping the lake up to about two feet higher raises the head on every pump-and-generate cycle. Over the period that is worth about $170,000 to $190,000, about 1 percent of the cycle's value.

Small against the plant's value. At the same prices, the plant's generation from January through September 2026 was worth about $36 million and its pumping cost about $15 million, a net energy margin of about $21 million. The protocol's effect is within about ±$0.4 million — roughly 0.5 to 2 percent of that margin — and probably less, because pricing withheld water at the average generating-hour price assumes the operator would give up average hours; with less water to release, it would trim its least valuable ones. Winter prices drive most of Phase 2's higher figure: January's price spike makes it the costliest month in both phases, and Phase 2 cuts winter releases more deeply.

What this does not count. These are market values of energy at AEP-zone prices, not APCo's revenue or profit. The plant settles at its own pricing node; capacity and reserve payments, which matter for a pumped storage plant, are not included; and as a regulated utility, APCo returns much of its energy value to customers through rates. Phase 2's figures also inherit its placeholder Critical Flow. The operator's own models and settlement data are the place to refine them; the point here is the order of magnitude.

6. A 20-Year Pressure Test (2007–2026)

Section 5 tested the protocol against a single year. A skeptical reviewer should ask more: how often it would declare drought in ordinary years, what it would cost the river and when, whether it would help when it matters, and where it breaks. This section runs a 20-year pressure test, January 2007 to September 2026, covering the droughts of 2007–08, 2012–13, 2017–18, and 2025–26 and many ordinary dry summers and falls. It reports the failures as plainly as the gains. It tests LIP – Phase 2 – Critical Flow Rates and, alongside it, LIP – Phase 1 – Existing Flow Rates (Section 4.5), which uses only the plan's existing trigger flows (Section 6.9).

6.1 Data and resolution

Lake level. From June 2020 the adjusted elevation that governs the triggers comes from AEP's daily notices. Before that, it comes from archived readings of APCo's lake gauge — hourly from June 2020 forward and daily from January 2007 to June 2020 — averaged by week and converted to adjusted elevation by adding the measured weekly difference between the gauge and the adjusted series since 2020 (about 1 ft); the results are tested across a ±0.3 ft range. Obvious glitches in the daily readings, about 3 percent of them, were removed. Sources are listed in Appendix B.

Flows. Project inflow for the streamflow index is estimated from the four upstream USGS gauges with a piecewise model fitted to AEP's reported daily inflow since June 2020. Above a combined gauge flow of about 600 cfs it uses the SML+ linear model (1.296 × the combined flow + 13 cfs), which tracks AEP's reported annual inflow within about 4 percent from 2021 to 2025. Below that it uses a cubic fitted to low-flow days, because the linear model runs about 60–100 cfs high in the driest conditions; the piecewise model roughly halves that bias. The normal is the 26-year average (2000–2025) of the same series. Rerunning the test with the linear model changes no declaration, drought low, or count of weeks below 792 ft for either the calibrated Phase 2 protocol or Phase 1. The Leesville release comes from AEP's notices from June 2020; before that it is estimated as Altavista minus Goose Creek minus an 85 cfs bias, which on low-flow days since 2021 differs from AEP's reported release by roughly 60–140 cfs. Brookneal flows come from USGS. The Drought Monitor indicator uses the U.S. Drought Monitor's weekly statistics for the Upper Roanoke watershed (Section 6.10).

Baseline and resolution. Before 2011 the project operated under the earlier license rules, not today's Water Management Plan, so the baseline for those years is historical operation. The run is weekly, on the same water-accounting basis as Section 5.1. As a consistency check, the weekly method reproduces the daily 2026 result closely: 792.4 ft on September 21 for the protocol as first translated, against 792.1–792.2 ft for LIP – Phase 2 – Critical Flow Rates in Section 5.1.

6.2 The protocol as transplanted: what breaks

Run with the Catawba-Wateree thresholds as Section 4.2 first translates them, the protocol fails two tests. First, it cries wolf. It declares ten drought episodes in twenty years, and in six of them the adjusted elevation never fell below 793 ft. Its Stage 1 threshold, translated from the Catawba-Wateree 90 percent storage trigger, sits at 794.0 ft — inside Smith Mountain Lake's ordinary late-summer drawdown. Second, it sticks. Because stepping down requires every indicator to recover, and the streamflow index recovers slowly, one episode runs 100 weeks, from July 2007 through June 2009, through two springs in which the lake was already full. It cuts spawning-season flows in 18 weeks, and much of what it "saves" in wet weeks is simply passed downstream at full pond. A looser exit rule is not the cure: letting either indicator end a stage produces sixteen episodes, seven of them precautionary.

6.3 A calibrated protocol

Two changes fix most of both problems, and both move the protocol toward the Yadkin–Pee Dee design. A refill exit ends any stage as soon as the adjusted elevation recovers to 794.8 ft: a full reservoir is not in drought, whatever the streamflow index says. This is the Yadkin–Pee Dee recovery rule. And the Stage 1 threshold moves down half a foot, from 794.0 to 793.5 ft (85 rather than 90 percent in Catawba-Wateree terms), so ordinary late-summer drawdown does not by itself start a declaration. Table 6 compares the variants; Table 7 lists every episode the calibrated protocol would have declared.

Protocol variant	Episodes	Precautionary	Longest (wk)	Spawning weeks cut	Weeks < 792	2026 level
As transplanted (Catawba-Wateree thresholds)	10	6	100	18	0	792.4
Add refill exit at 794.8 ft	12	6	25	3	2	791.9
Loose exit rule instead	16	7	23	3	4	791.8
Refill exit + Stage 1 at 793.5 ft (recommended)	**8**	**2**	**22**	**2**	**9**	**791.7**

Table 6. Protocol variants, January 2007 – September 2026 (central placeholders: stage elevations as in Table 2, Critical Flow 350 cfs). "Precautionary" means the actual lake never fell below 793.0 ft adjusted during the episode. Spawning weeks counts April–May weeks with a release cut of 50 cfs or more. The actual lake spent 54 weeks below 792 ft.

The calibrated protocol declares eight episodes in twenty years. Six fall in the droughts of 2007, 2008, 2012–13, 2017–18, and 2025–26, and it enters Stage 2 only in 2007, 2008, 2012, and 2026. Two are short precautionary Stage 1 declarations, of one to two weeks, in 2010 and 2015. In the current drought it would have declared Stage 1 on November 10, 2025, exited when February storms refilled the protocol lake, and re-entered on April 27, 2026 — the same day APCo declared Trigger 1. The calibration was selected to correct two observable failure modes, not to produce a lake level. It should also be stated plainly that the same record revealed those failure modes and is used to check the fix; that is an in-sample test, and one reason the full-period test in Section 7 matters.

Episode	Weeks	Deepest stage	Actual low (ft)	Protocol low (ft)	Character
Aug–Dec 2007	19	2	791.2	792.0	Drought
Jul–Dec 2008	22	2	791.2	792.3	Drought
Sep 2010	1	1	793.2	793.3	Precautionary
Aug 2012–Jan 2013	22	2	790.5	792.4	Drought
Sep 2015	2	1	793.0	793.1	Dry fall (precautionary)
Dec 2017–Feb 2018	9	1	792.0	793.0	Drought
Nov 2025–Feb 2026	15	1	791.1	792.9	Drought
Apr 2026–present	22	2	789.5	791.7	Drought

Table 7. Every episode the calibrated protocol would have declared, January 2007 – September 2026. Lows are weekly-average adjusted elevations; before June 2020 they are converted from gauge readings.

6.4 What it would have gained

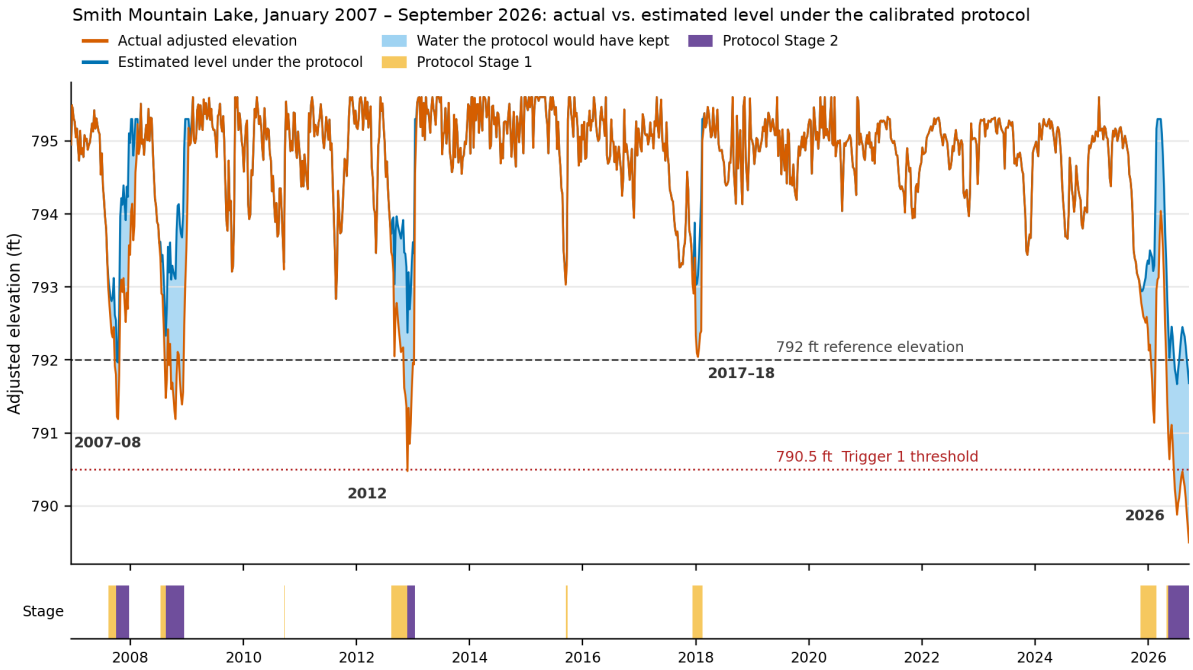


Figure 2. Weekly adjusted elevation (orange) versus the water-accounting estimate for the same weeks under the calibrated protocol (blue). Light blue marks water the protocol would have kept in the lake; the strip below shows when each protocol stage would have been in effect. Outside those periods the two lines coincide.

As Figure 2 shows, the water-accounting model estimates that the calibrated protocol would have raised each drought low in the record: by about 0.8 ft in 2007 (792.0 ft against an actual 791.2), 1.1 ft in 2008 (792.3 against 791.2), 1.9 ft in 2012 (792.4 against 790.5), 1.0 ft in 2017–18 (793.0 against 792.0), and 2.2 ft in 2026 (791.7 against 789.5). Across twenty years, weeks spent below 792 ft fall from 54 to 9, a reduction of about 83 percent, and weeks below the 790.5 ft Trigger 1 line fall from 15 to none. In the two-year drought of 2007–08 the difference persisted from one summer to the next; there is no sign in the record that the scenarios converge toward the same low point. On existing flows alone, LIP – Phase 1 – Existing Flow Rates captures roughly two-thirds of these gains in drought lows (Section 6.9).

6.5 What it would have cost

Over twenty years the calibrated protocol cuts the release by 50 cfs or more in 87 weeks: 48 in summer and fall (median cut 145 cfs), 37 in winter (median 155 cfs), and 2 in the spawning season (median 113 cfs). The lowest weekly Brookneal flow under the protocol would have been about 405 cfs, in October 2007, against 474 cfs actual and near the plan's own Trigger 3 October target of 420 cfs. Three costs deserve to be named rather than netted away. About 166,000 acre-feet held back is passed downstream when storms refill the protocol lake — notably in 2008–09, 2013, 2018, and 2026 — so the river gave up flow for no lasting lake benefit. The two precautionary declarations are the price of acting early. And in 12 weeks the protocol lake would have entered a storm fuller than the actual lake, a small reduction in flood buffer. Before June 2020 the release is estimated from USGS gauges with low-flow errors comparable to some weekly cuts, so the pre-2020 downstream figures are indicative; the lake-level behavior and the timing of declarations are more reliable than precise weekly flow differences. Phase 1 costs less: it cuts releases by 50 cfs or more in 71 weeks rather than 87, because it never releases less than the plan's existing trigger targets or the license floor (Section 6.9).

6.6 How much depends on the placeholders

The stage elevations are the decisive parameter. Moving every stage threshold lower — Stage 1 at 792.8 ft instead of 793.5 ft, and the deeper stages 1.2 to 2.9 ft lower — makes the protocol quieter: six declarations and no precautionary ones. But it lets the lake fall further, roughly doubling the weeks below 792 ft and lowering the 2008 and 2012 lows by about 0.6 to 0.8 ft. The Critical Flow release moves the 2012 low by about 0.5 ft and the 2026 result by about 0.4 ft across 300–375 cfs. The gauge-to-adjusted conversion used before 2020 changes the count of declarations modestly (seven to eight across the range tested) but not the drought lows or the 2026 result. Table 8 shows the range. Phase 1 has no Critical Flow placeholder at all; its results depend only on the stage elevations and recovery rules.

Stage elevations / Critical Flow	Episodes	Precautionary	Weeks < 792	2008 low (ft)	2012 low (ft)	2026 level (ft)
Central set / 300 cfs	8	2	7	792.3	792.7	791.9
Central set / 350 cfs	8	2	9	792.3	792.4	791.7
Central set / 375 cfs	8	2	10	792.3	792.2	791.5
Lower set / 300 cfs	6	0	16	791.7	791.9	791.5
Lower set / 350 cfs	6	0	20	791.7	791.6	791.3
Lower set / 375 cfs	6	0	22	791.7	791.5	791.1

Table 8. Calibrated protocol across the placeholder range, January 2007 – September 2026. Central set: Stages 1–4 below 793.5 / 792.5 / 790.7 / 789.2 ft; lower set: below 792.8 / 791.3 / 788.6 / 786.3 ft.

6.7 What the record says about common objections

Activation frequency. A common objection to higher triggers is that they would activate too often. On this record, a simple 792 ft trigger would have been entered eight times in twenty years. The calibrated protocol declares eight times: six in droughts and two brief precautionary declarations. The transplanted version shows that frequent activation is a real risk of a poorly calibrated protocol, but not an inherent one.

Benefit. A second objection is that earlier conservation yields little lasting benefit. In the water-accounting model, the calibrated protocol raised each drought low by 0.8 to 2.2 ft and cut the weeks below 792 ft by about 83 percent.

Downstream impact. A third objection is that downstream costs outweigh the reservoir benefits. The record supports this concern in part. The costs are real, fall mostly in summer, fall, and winter, and are partly wasted when storms follow. Whether they are outweighed is a judgment for the agencies; the point is that it can now be made on numbers. For agencies that want to limit that cost while acting earlier, LIP – Phase 1 – Existing Flow Rates keeps every release within flows already approved (Section 6.9).

6.8 A second design, a similar answer

The Yadkin–Pee Dee spacing offers a check on how much the result depends on where the stages sit. Run on the same record with evenly spaced stages — below 793.5, 792.5, and 791.5 ft, a Stage 4 threshold at 789.75 ft, and the same entry and exit rules — it produces the same outcome: eight declarations, two precautionary, and the same drought lows (792.0 ft in 2007, 792.3 ft in 2008, 792.4 ft in 2012, 793.0 ft in 2018, and 791.7 ft in 2026). The agreement indicates that the modeled results are not sensitive to the spacing under the shared assumptions used here; it is not independent validation of those assumptions. Testing the Yadkin–Pee Dee rules as written — monthly evaluation, one-stage-per-month escalation, and much deeper streamflow thresholds — is left to the full-period test.

6.9 LIP – Phase 1 – Existing Flow Rates over twenty years

LIP – Phase 1 – Existing Flow Rates (Section 4.5) can be run through the same 20-year record, using the calibrated stages and exit rules of Section 6.3 but only the plan's existing trigger flows, with the license minimum release always governing. It declares the same eight episodes as the calibrated Phase 2 protocol, because entry and exit are identical; what differs is how much water each declaration can save.

Measure, 2007–2026	Actual	LIP – Phase 1 Existing Flow Rates	LIP – Phase 2 Critical Flow Rates
Weeks below 792 ft	54	19	9
Weeks below 790.5 ft	15	1	0
2007 low (ft)	791.2	791.3	792.0
2008 low (ft)	791.2	792.1	792.3
2012 low (ft)	790.5	792.1	792.4
2017–18 low (ft)	792.0	792.8	793.0
2026 low (ft)	789.5	790.5	791.7
Weeks with release cuts of 50 cfs or more	—	71	87
Change to agreed flow rates	—	None	Critical Flows; stepped minimum release

Table 9. LIP – Phase 1 – Existing Flow Rates against the actual record and the calibrated LIP – Phase 2 – Critical Flow Rates protocol, January 2007 – September 2026 (weekly water-accounting estimates; central placeholders).

Acting earlier captures most of the benefit. On existing flows alone, the weeks spent below 792 ft fall from 54 to 19, about 65 percent, and the weeks below the 790.5 ft Trigger 1 line fall from 15 to 1. In 2008, 2012, and 2017–18 Phase 1 achieves most of what Phase 2 does. In the summer droughts of 2007 and 2026 it achieves much less — about 0.1 ft and 1.0 ft, against 0.8 ft and 2.2 ft — because those droughts deepened while releases were already at the 400 cfs floor, where no trigger change can conserve more water. (The 2026 figure here is lower than Phase 1's in Section 5.1 because the calibrated stages exit when the February storms refill the lake and re-enter in late April, rather than holding a declaration all year.)

Earlier entry is essential to this result. Run with the plan's current trigger elevations — 790.5 and 790.0 ft — as observable triggers, the same flows produce almost no benefit, because by the time the lake reaches those levels the decline is well underway. Phase 1 therefore depends on adopting earlier stage elevations, which is a change to trigger mechanics, not to flows.

6.10 The Drought Monitor indicator

Both precedent protocols use the U.S. Drought Monitor as a third indicator: a stage requires reservoir storage plus either streamflow or the Drought Monitor. The Drought Monitor publishes a weekly map of drought severity, and its statistics for the Upper Roanoke watershed (HUC 03010101) are available weekly from January 2000. This test converts each week's map to a basin-average drought level — no drought counts as −1, abnormally dry (D0) as 0, and moderate through exceptional drought (D1 to D4) as 1 through 4 — and uses its three-month average, with the Catawba-Wateree thresholds of 1, 2, 3, and 4 for Stages 1 through 4.

What it changes. Nothing, on this record. Added as an alternative to the streamflow indicator, it does not change a single week's stage in twenty years, for either phase. The reason is timing. On this basin the

Drought Monitor signals drought later than streamflow does, so by the time it would trigger a stage, the streamflow indicator already has. Table 10 shows the lag.

Drought	Streamflow index first at Stage 1 level (≤ 78%)	Drought Monitor first at Stage 1 level (D1 average)	Drought Monitor lag
2001–02	By July 2000	January 2002	About 18 months
2007–08	July 23, 2007	October 22, 2007	3 months
2012	June 4, 2012	Not reached	—
2017–18	November 20, 2017	Not reached	—
2025–26	September 1, 2025	January 19, 2026	4½ months

Table 10. When each indicator first reached its Stage 1 level in each drought. Six-month streamflow index from USGS flows; three-month average Drought Monitor level for the Upper Roanoke watershed. These dates ignore the lake-level condition and are not protocol declarations.

What it would cost to rely on it. Used instead of streamflow — a stage requiring lake level plus the Drought Monitor alone — the protocol would act far too late. It would declare only in 2007 and 2025–26, miss the summer drought of 2008 and the droughts of 2012 and 2017–18 entirely, and leave 38 weeks below 792 ft rather than 9; the 2012 low would not improve at all.

What it means for the proposal. The Drought Monitor belongs in the protocol as the precedents use it: an alternative trigger and a shared, public reference for the drought group. It should not be a required condition for a stage. On this basin, the streamflow indicator is the one that leads. The precedent protocols' exact method for computing a basin Drought Monitor value should be confirmed, but the conclusion does not depend on it: in 2012 and 2017–18 the basin never averaged even D1, while streamflow had already fallen to drought levels.

6.11 The drought the record leaves out: 2000–2002

The 20-year test begins in January 2007. APCo's table of each year's highest and lowest lake elevation, back to 1966, shows what it misses: the deepest drought of the last quarter-century. The lake fell to 788.52 ft in November 2001 and 788.83 ft in January 2002. Two readings a year cannot drive a protocol evaluated weekly, and the published values are single gauge reading rather than weekly adjusted elevations, so that drought cannot be included.

What the streamflow indicator shows. The streamflow half of the protocol needs no lake levels, so it can be run back to 2000 from USGS daily flows (Figure 3 and Table 11). It identifies 2001–02 as the most severe low-inflow event of 2000–2026: the six-month index fell to 24 percent of normal in February 2002, below any later drought, and stayed at or below the 40 percent Stage 4 flow threshold for 50 weeks, against 6 or 7 weeks in each later drought. It was already below the Stage 1 flow threshold by July 2000, so the dry period ran for more than two years. This is only one of the two stage conditions; whether the protocol would have declared those stages also depends on weekly lake levels that are not available. The Drought Monitor, by contrast, did not reach a basin-average D1 level until January 2002, about 18 months after streamflow first signaled drought (Section 6.10).

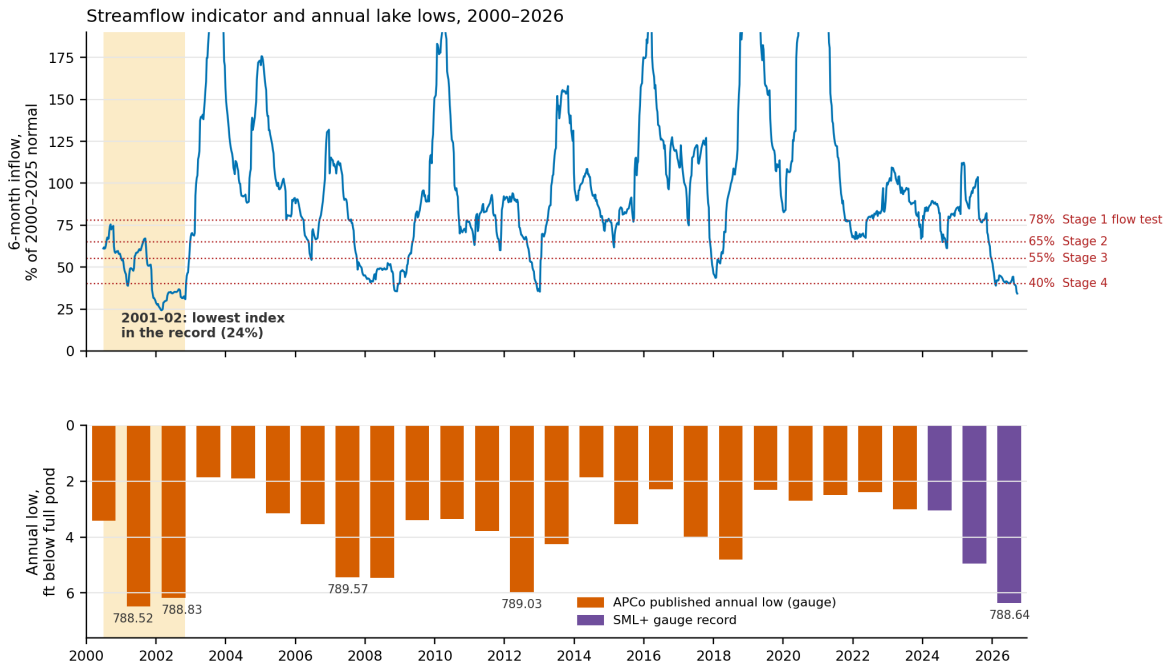


Figure 3. Top: the protocol's six-month streamflow indicator, 2000–2026, from USGS daily flows, with the stage flow thresholds; shading marks July 2000 – October 2002. Bottom: each year's lowest lake elevation, from APCo's published annual lows (2000–2023, single gauge readings) and the SML+ gauge record (2024–2026). The flow thresholds are one of two stage conditions; a stage also requires the lake to be below its elevation threshold.

Drought	Lowest 6-month inflow index	Weeks at Stage 3 flow level	Weeks at Stage 4 flow level	Annual low (ft)
2001–02 (Jul 2001–Oct 2002)	24%	57	50	788.52 (Nov 2001); 788.83 (Jan 2002)
2007–08 (Jul 2007–Dec 2008)	35%	65	7	789.57 (Oct 2007); 789.54 (Dec 2008)
2012 (Jul 2012–Jan 2013)	35%	17	6	789.03 (Nov 2012)
2025–26 (Sep 2025–Sep 2026)	34%	39	7	788.64 (Jul 2026)

Table 11. The droughts of 2000–2026 compared. Inflow index from USGS daily flows; annual lows from APCo's published values and, for 2026, the SML+ gauge record. Weeks at the Stage 3 or Stage 4 flow level count weeks the six-month index was at or below 55 or 40 percent of normal; they are not protocol declarations.

What this means for the proposal. The 20-year test establishes how the protocol behaves in ordinary years and in five droughts, including the two-year drought of 2007–08. It cannot say how it would have performed in a multi-year drought as deep as 2000–2002 — the conditions under which its downstream cost would be greatest and the exit behavior identified in Section 6.2 would matter most. APCo holds daily records for those years. With them, the full test, preferably in APCo's operational model, can and should cover every drought in the modern record. The same holds for LIP – Phase 1 – Existing Flow Rates, whose limits in summer droughts would be most visible in a drought of that length.

6.12 What the pressure test changes

Six changes follow for this proposal. The Stage 1 threshold should start at 793.5 rather than 794.0 ft, and the protocol should include a refill exit; Sections 4.2 and 4.4 now carry both. The storage study in Section 7 is the single most important piece of technical work, because the stage elevations drive the balance between false alarms and lake protection more than any other parameter and must stay above the

operating limit it establishes. The streamflow index should use the longest available period of record. And the full protocol should be run in the operational models on APCo's own daily records over a period that includes the 2000–2002 drought (Section 6.11). The method is in Appendix D. Finally, LIP – Phase 1 – Existing Flow Rates should be considered as the first phase: on existing flows alone it achieves much of the protocol's benefit, and it can proceed without a license amendment (Sections 6.9 and 7). The Drought Monitor should remain an alternative, confirming indicator rather than a required one, because on this basin it lags streamflow by months (Section 6.10).

7. The Path to Adoption

Step 1 — Use the public meeting FERC has requested (now–end of 2026). The Water Management Plan's scheduled five-year review was completed in 2025. Separately, the plan requires APCo to hold public meetings. APCo is expected to hold a public meeting before the end of 2026 and to file a summary of the comments received, and how they will be addressed, by February 15, 2027. That meeting is the community's venue on the record. The September 11 stakeholder session, which SMLA convened, was valuable but was not part of any formal FERC process. Because the five-year review has already concluded, any change to the plan would be proposed out of cycle, ahead of the next scheduled review — which makes a well-documented record at this meeting more important, not less. The single most valuable comment the community can file, once the notice and docket number issue, is a specific one: adopt a Low Inflow Protocol on the model FERC has approved for the Catawba-Wateree and Yadkin–Pee Dee systems, with this framework attached — beginning, if the agencies prefer, with the flow-neutral first step of Section 4.5, which changes no agreed flow rate. Comments filed under the noticed docket must be addressed; a concrete, FERC-precedented proposal is far harder to wave off than a complaint about lake levels.

Step 2 — Convene the working group (2027). The formal change process runs through consultation: DEQ and DWR, APCo, the Corps, the U.S. Fish and Wildlife Service, and the Technical Review Committee. Because the change would come out of cycle, that consultation has to be initiated deliberately — by APCo or the agencies — rather than waiting for the next scheduled review. The September 11 table, formalized per Section 4.3, is the vehicle. Three technical inputs are needed from the start: APCo's daily adjusted-elevation and release records, so the test can cover the 2000–2002 drought and replace the gauge-based estimates used here for 2007–2020; APCo's elevation-area-storage curves for both reservoirs, replacing the linear approximation used in this paper; and APCo's operational model, in which the protocol should be run over the full period of record. Its first deliverables are the two studies everything else depends on: a storage study for the project's upper and lower reservoirs that sets the stage elevations and establishes the operating limit (critical elevation), and an agency-led drought-condition instream flow study to set Critical Flows for the Staunton River.

Step 3 — File the right instruments (2027–2028). The trigger mechanics, staging, governance, and reporting can proceed as an out-of-cycle Water Management Plan amendment under the existing license condition. Nothing requires a change to wait for the next five-year review, but an out-of-cycle amendment needs a sponsor — in practice APCo, with agency concurrence. The route is not hypothetical: APCo itself filed an application to amend the Water Management Plan on June 1, 2026, supplemented it on July 13, and withdrew it on July 21; that proceeding (P-2210-275) terminated on August 5, 2026. To the extent Critical Flows at any stage sit below the license's article-level minimum releases (400/375 cfs), that element requires a license amendment with full agency concurrence — a heavier lift, and the honest cost of fixing defect No. 1. The precedents help twice here: FERC has approved this mechanism on two other Southeastern FERC-licensed systems: on Yadkin–Pee Dee, across two licensees under a single protocol

and Duke implemented much of its Catawba-Wateree settlement voluntarily ahead of license action. An interim memorandum of understanding among APCo, the agencies, and the stakeholder organizations could stand up the drought group and the monitoring framework without waiting for FERC.

A phased path. The flow-neutral first step of Section 4.5 offers a natural first phase. LIP – Phase 1 – Existing Flow Rates changes only the plan's trigger mechanics — observable stages, earlier entry, year-round availability of the existing Trigger 3 flows, recovery rules, governance, and public data — through a Water Management Plan amendment, and on the 20-year record it captures roughly two-thirds of the protocol's benefit (Section 6.9). LIP – Phase 2 – Critical Flow Rates adds agency-defined Critical Flows and a minimum release that steps down by stage, through a license amendment once the instream-flow and storage studies are complete, closing the summer-drought gap that Phase 1 cannot reach.

What the community offers in return. Shortage-sharing is the proposal's legitimacy. The lake-area water suppliers and the localities accept staged conservation obligations; the associations commit to the public-communication load; the downstream localities gain a guaranteed science-based floor and a formal seat they do not currently hold. Every party gives something, which is why roughly seventy parties signed the Catawba-Wateree agreement, and why the Yadkin–Pee Dee drought group seats lake associations beside utilities and agencies.

8. Anticipated Objections

"The minimum flows protect an endangered species and cannot move." The proposal does not ask anyone to move them by assertion; it asks the agencies to define, through consultation and drought-condition science, the Critical Flow that actually protects the logperch and water quality when the watershed itself is producing far less than 400 cfs. If that number is 400, the record will finally say so. The license's seasonal floors show that minimum releases are already differentiated by season; what has not been established is a drought-condition Critical Flow.

"The plan worked — the operator complied and the triggers fired." The operator complied and the triggers fired; the plan still did not work. APCo reports its measures conserved about two feet — and the lake still fell below both of the plan's drought thresholds to its lowest level since 2001. A plan whose deepest stage needed a variance to operate in summer, and which had no further conservation stage once releases reached the fixed floor, ran out of tools while the lake was still falling. Working as written is not the same as working.

"Raising the triggers would not help much." On its own, that is right: Section 5.1 finds that raising the trigger lines alone is worth about 0.6 ft. But new numbers inside the existing architecture are not this proposal. It asks for stages available on observable conditions, disciplined entry and exit, and a floor that steps down — the changes that account for most of the 2026 difference. Run through 2026 together as LIP – Phase 2 – Critical Flow Rates, the water-accounting model estimates they would have kept the lake above 792 ft from March onward.

"It will declare drought too often." As transplanted, it would have — Section 6.2 shows six precautionary declarations in twenty years. Calibrated, it declares eight times, six of them in droughts and two brief precautionary declarations. The frequency question is a calibration question, and the storage study and the full-period test in Section 7 are where it gets settled.

"This is too complex for a pumped storage project." The complexity is in the one-time design — two studies and a negotiation. Operationally a LIP is simpler than the status quo: observable triggers replace

probabilistic forecast disputes, pre-agreed fractions replace variance filings, and published recovery rules replace open-ended "until full pond" conditions.

"The Catawba-Wateree system is too different to be a model." It is different — eleven reservoirs, two states, and no pumped storage. But the same architecture governs the Yadkin–Pee Dee system under two more FERC licenses, with a storage test written in feet below a normal minimum elevation, a refill-based exit, a stepped downstream floor, and lake associations at the table (Section 3.5). Section 6.8 shows that both designs, calibrated to the Smith Mountain Project, give similar results under the same modeling assumptions.

"Downstream interests will never agree." Downstream interests gain a Critical Flow floor grounded in their actual needs, a formal seat in every declaration, and protection from the alternative — ad hoc variances negotiated without them in the worst weeks of a drought. The Catawba-Wateree settlement drew seventy signatures for a reason, and the Yadkin–Pee Dee protocol names maintaining downstream flows in its founding goal alongside protecting storage.

"It will cost the operator and its customers too much." It costs little, and mostly in time rather than energy. A drought protocol changes only the water leaving through Leesville Dam; the pump-and-generate cycle that carries the plant's value reuses the same water and is untouched. Priced at 2026 market rates, the water the two LIP phases hold back defers about 9,000 to 14,000 MWh of generation rather than forfeiting it, and the higher lake raises the head on every cycle. The net effect on the plant's energy value is within about ±$0.4 million, 1–2 percent of its net energy margin for the year so far (Section 5.3).

"Changing release rates is too big a lift." Then begin without changing them. LIP – Phase 1 – Existing Flow Rates (Section 4.5) applies the protocol's staging, earlier entry, and recovery rules to the trigger flows the plan already contains, with the license minimum release unchanged. It needs a Water Management Plan amendment but no license amendment and no new Critical Flow, and on the 20-year record it cuts the weeks below 792 ft by about 65 percent (Section 6.9). LIP – Phase 2 – Critical Flow Rates' movable floor can follow once the studies to support it are complete.

9. Conclusion

The current plan did not work in 2026, and nothing in its design suggests it would work better in the next drought. The 2026 drought offered an informative natural comparison among Southeastern FERC-licensed systems with different drought-management architectures. One had a staged, multi-indicator, shortage-sharing protocol negotiated in advance; it declared stages on observable conditions, stepped flows toward a science-based critical floor, and put its municipalities under conservation alongside its reservoirs. The other had fixed floors, forecast-based triggers that trailed the decline, an emergency stage locked to the calendar, and a community with no formal role. One basin over, a third system under a similar protocol stayed at normal because its main reservoir never left its normal range. Their hydrology differed, so the comparison cannot show that architecture explains their outcomes. It does show that architecture shapes when conservation begins, how shortages are shared, and how recovery is governed — and architecture can be changed. The public meeting FERC has asked APCo to hold is the venue; the Catawba-Wateree and Yadkin–Pee Dee protocols are the precedents; this framework is the proposal. The ask is simple: test a FERC-precedented architecture with the agencies' science and the operator's own model, so that when the next drought comes — and it will — the Smith Mountain Project meets it with a plan built to respond, governed by everyone it affects, and honest about how the shortage is shared.

Appendix A — Architecture Side-by-Side

Element	Current SML WMP (P-2210)	Catawba-Wateree LIP (P-2232)	Yadkin–Pee Dee LIP (P-2197 / P-2206)
Trigger basis	Single probabilistic forecast of adjusted lake elevation, computed by APCo and not published	Three observables: storage index, U.S. Drought Monitor 3-month average, 6-month gauge streamflow; two-of-three entry	Three indicators: main-reservoir elevation below its normal minimum, U.S. Drought Monitor 3-month average, 3-month gauge streamflow; the elevation test is required for every stage
Minimum flows	Fixed absolute floor (400 cfs Mar–Oct / 375 cfs Nov–Feb) at every trigger stage	Staged: 60% of gap to Critical Flows, then 95%, then Critical Flows; recreation releases cut first	Seasonal stage flow schedules at each development, stepping to Critical Flows (e.g., Blewett Falls Jun–Jan 1,200 → 1,080 → 1,000 → 925 cfs)
Deepest stage availability	Trigger 3 calendar-restricted; summer use required a 2026 variance	Any stage available whenever its conditions are met	Any stage when its conditions are met; evaluated monthly, escalating one stage per month
Reservoir levels	No stage-linked minimum elevations	Minimum elevations step down by stage toward defined critical elevations	Stages set in feet below each month's normal minimum elevation; Stage 4 at half the distance to the critical elevation
Municipal / intake role	None	Staged obligations from voluntary (3–5%) to emergency (20–30%), with penalties; withdrawal reporting	Staged obligations (about 5%, 10%, 20%); weekly, then twice-weekly updates to intake owners
Governance	Operator declares; agencies consulted; no standing drought body	Standing multi-party drought group; monthly meetings in drought; public summaries	Standing drought group coordinated by state agencies, with lake associations as members; monthly meetings in drought; required public data
Recovery	Trigger 3 flows until 795.0 ft full pond; otherwise unspecified	Stage-down requires all lower-stage triggers to be met	Stage-by-stage reversal, or immediate end at the normal minimum for two weeks or 2.5 ft above it
Self-correction	Five-year review (most recently completed in 2025); required public meetings, none held in the past five years	Protocol re-evaluated at least every five years; consensus modifications filed at FERC	Reviewed at least every five years; licensee changes by consensus with state agencies, filed at FERC

Table A1. Drought-response architecture side by side: the current Smith Mountain Project Water Management Plan, the Catawba-Wateree LIP, and the Yadkin–Pee Dee LIP.

Appendix B — Sources and Notes

- Low Inflow Protocol for the Catawba-Wateree Project, Attachment G to the Catawba-Wateree Agreement-in-Principle (Jan. 24, 2006), as filed with the Comprehensive Relicensing Agreement for FERC Project No. 2232; current revision approved January 2019 and available via the Catawba-Wateree Water Management Group (catawbawatereewmg.org/drought-resources). Stage fractions, trigger table, water-user goals, and recovery rules cited from the 2006 text; the Stage 2 95% mechanic was confirmed operative in Duke Energy's May 1, 2026 Stage 2 declaration.
- FERC license for the Catawba-Wateree Hydroelectric Project issued November 25, 2015 (40-year term), incorporating the Comprehensive Relicensing Agreement's drought management protocol.
- Appalachian Power, "Why the Lake Levels Change," smithmtn.com/lake-levels: annual maximum and minimum Smith Mountain Lake elevations and their dates, 1966–2023, used in Section 6.11 and Figure 3.
- Iowa Environmental Mesonet (Iowa State University), archive of NOAA/NWS Hydrometeorological Automated Data System observations for station SMIV2 (Roanoke River at Smith Mountain Lake; pool elevation relayed from APCo's gauge).
- WFXR, "APCo to reduce water release from Smith Mountain Lake, Leesville Dam," July 17, 2026: APCo statement that Water Management Plan measures had conserved about two feet of lake elevation, and DEQ approval of the variance effective July 22.
- Federal Energy Regulatory Commission, Appalachian Power Company, Notice of Effectiveness of Withdrawal of Application for Amendment, Project No. 2210-275, 91 Fed. Reg. 51699 (Aug. 11, 2026): application filed June 1, 2026, supplemented July 13, withdrawal filed July 21, effective August 5, 2026.
- SML+, The 2026 Smith Mountain Lake Drawdown (white paper, v1.5): inflow estimates, license minimum-release provisions (400/375 cfs), water-balance arithmetic, and compliance findings.
- Smith Mountain Project Water Management Plan trigger record, 2026: Trigger 1 declared April 27 (adjusted elevation 792.1 ft); Trigger 2 declared May 11 (791.0 ft); adjusted elevation first at 790.5 ft June 18 and 790.0 ft July 4; Section 2.F variance effective July 22 (AEP daily notices; SML+ database).
- September 11, 2026 stakeholder meeting, convened by SMLA outside any formal FERC review process (participants per participant reporting). FERC's request that APCo hold a public meeting, following APCo's request to remove the plan's public-meeting requirement and its report that none had been held in the preceding five years; meeting timing and the February 15, 2027 filing per participant reporting. As of this draft, APCo has not yet filed a notice for the meeting, so no docket number has been assigned; the citation will be added when the notice is filed.
- AEP daily notices, January 1 – September 25, 2026 (adjusted elevation, reported project inflow, Leesville release) and USGS Brookneal flows, as captured in the SML+ database: inputs to the Section 5.1 counterfactual. Brookneal targets by stage from Water Management Plan Condition D.7.
- FERC Accession No. 20080827-0308 (filed August 25, 2008): APCo notice of modification and request to extend an Article 29 drought flow variance, with stakeholder concurrence documentation — precedent for staged, consultative drought-flow changes on this docket.
- Low Inflow Protocol for the Yadkin and Yadkin–Pee Dee River Hydroelectric Projects (FERC Nos. 2197 and 2206), Relicensing Settlement Agreement, February 2007, as posted by Cube Hydro Carolinas; Yadkin LIP stage check for September 1, 2026; Duke Energy, Yadkin–Pee Dee Hydro Project (license

issued April 1, 2015). Trigger, flow, recovery, and membership provisions are cited from the 2007 text and should be re-verified against the current revision before quotation in a FERC filing.

- U.S. Drought Monitor (National Drought Mitigation Center, University of Nebraska–Lincoln, with USDA and NOAA): weekly percent of area by drought category and Drought Severity and Coverage Index for the Upper Roanoke watershed (HUC 03010101), January 4, 2000 – September 29, 2026, via the USDM data services.
- USGS daily mean discharge (statistic 00003), January 2000 – September 2026, for the seven project gauges (02056000, 02056650, 02056900, 02058400, 02059500, 02060500, 02062500), via the USGS Water Data API: inputs to the Section 6 back-test and to the streamflow indicator back to 2000.
- U.S. Energy Information Administration, Form 923 monthly net generation for Smith Mountain (plant 3780; conventional and pumped storage units) and Leesville (plant 3777), January 2020 – July 2026, via the EIA API: calibration of the efficiencies in Section 5.3.
- PJM Interconnection, Data Miner 2: hourly day-ahead locational marginal prices for the AEP zone, 2020–2026: prices in Section 5.3.
- SML+ database: Smith Mountain forebay and tailwater, and Leesville forebay, tailwater, and release readings (APCo telemetry), used to time generation and pumping and to measure head; SML+ lake-surface temperature sensors, PRISM daily climate (Oregon State University), and Roanoke and Lynchburg airport wind (Iowa Environmental Mesonet) for the evaporation estimate in Section 5.2.
- This draft is a policy proposal prepared from operational monitoring data, public filings, and the cited protocol texts. It is not a hydrologic, biological, or legal opinion; all stage thresholds marked [placeholder] require basin-specific study, and current LIP stage values should be re-verified against the January 2019 revision before quotation in a FERC filing.

Appendix C — Counterfactual Method

- Data: AEP daily notices and USGS Brookneal flows, January 1 – September 25, 2026. Four missing days were interpolated (elevation) or carried forward (flows).
- Actual stages: normal operation through April 26; Trigger 1 from April 27; Trigger 2 from May 11; Trigger 3 flows under the Section 2.F variance from July 22. A counterfactual stage never falls below the actual stage.
- Release reduction on counterfactual days equals the actual stage's Brookneal target minus the counterfactual stage's target (Condition D.7), bounded by the license minimum (400 cfs March–October, 375 cfs November–February) and by the actual release. Releases above target under normal operation are not credited, so the results isolate the effect of the stage rules.
- WMP – Higher Trigger Levels (and its + 375 cfs Floor variant): Trigger 1 at 792.5 ft and Trigger 2 at 792.0 ft adjusted elevation. WMP – Year-Round Trigger 3 (and its variant) adds Trigger 3 at 793.0 ft with no calendar restriction. Entry is evaluated on the counterfactual adjusted elevation; exit on recovery 1.0 ft above the entry threshold. The lake was already below 792.5 ft on January 1, so both Higher Trigger Levels options begin in Trigger 1; any late-2025 effect is excluded, which makes the results conservative.
- Floor variants (+ 375 cfs Floor): on days after July 22 when the release sat at the 400 cfs minimum, the release is lowered by 25 cfs; Brookneal remains above the Trigger 3 target at observed tributary accretion.
- Water retained is converted at 1.9835 acre-feet per cfs-day and divided by a surface area of 19,000–20,260 acres; any volume that would lift the lake above 795.0 ft is treated as passed downstream.
- LIP – Phase 2 – Critical Flow Rates stages: evaluated weekly (Mondays). Stage thresholds on the counterfactual adjusted elevation: central set 794.0 / 792.5 / 790.7 / 789.2 ft; lower set 793.5 / 791.3 / 788.6 / 786.3 ft [placeholders]. These are the Catawba-Wateree storage percentages (90/75/57/42%) translated into feet by assuming linear storage between full pond (795.0 ft) and a nominal lower bound of 785 ft (central set) or 780 ft (lower set). The nominal lower bound served only to position the thresholds; it is not an estimate of the project's operating limit. Streamflow index = trailing 182-day mean of AEP-reported project inflow ÷ the same window's monthly normals (July 2020 – June 2025 AEP record); July–December 2025 entered at monthly means. Stages are entered when the adjusted elevation is below the stage threshold and streamflow ≤ 78/65/55/40% for Stages 1–4 (Catawba-Wateree values). A stage is left one step at a time, after two consecutive weekly evaluations in which both indicators are above that stage's thresholds.
- LIP – Phase 2 – Critical Flow Rates flows: stage Brookneal target = normal target − f × (normal − Critical), with f = 0.60, 0.95, 1.0, 1.0 for Stages 1–4 and the Critical schedule set equal to the plan's Trigger 3 targets [placeholder]; April–May targets held at or above 1,200 cfs. Leesville minimum = license minimum − f × (license minimum − Critical Flow release), Critical Flow release 300, 350, or 375 cfs [placeholder]. Release = the larger of the stage floor and the stage target less observed tributary accretion, plus the operator's actual daily margin above what the actual rules required, so ordinary operating margin is preserved rather than credited.
- LIP – Phase 1 – Existing Flow Rates: same weekly stage evaluation, stage thresholds, and exit rules as Phase 2; each stage applies the Water Management Plan's existing Brookneal targets — Trigger 1 for Stage 1, Trigger 2 for Stage 2, Trigger 3 for Stages 3 and 4 — with the license minimum release (400 cfs March–October, 375 cfs November–February) always governing and no Critical Flow.

- Not modeled: APCo's forecast logic; the Drought Monitor indicator (tested over twenty years in Section 6.10); Stage 0 recreation-release changes; water-user conservation; dissolved-oxygen operations; generation and pump back scheduling, whose market value Section 5.3 estimates separately. Evaporation is not modeled separately: measured net evaporation over June–September 2026 was roughly 17 cfs (about 94 cfs gross, offset by rain on the lake), and the slightly larger surface of a higher lake changes the results by well under 0.1 ft. Inflow and tributary accretion are unchanged. The analysis is informational and is not hydrologic or legal advice.
- **Market value (Section 5.3):** Phase 1 and Phase 2 daily releases rebuilt from these rules with the same AEP daily notices, the Condition D.7 targets, and a 19,630-acre surface. Energy per acre-foot = the month's measured head × efficiency × 1.0245 kWh per acre-foot per foot: Smith Mountain at 82 percent (range 80–85), fitted to EIA Form 923 net generation for 2020–2026; Leesville at 60–76 percent by release, fitted to its 2023–2024 reports. Smith Mountain energy is priced at the month's PJM AEP-zone day-ahead price weighted to the hours the tailwater gauge shows the plant generating; Leesville energy at the month's all-hours price. Water passed at full pond is credited at its month's prices. The head gain is each month's average elevation gain divided by head, times that month's modeled generation value less pumping cost.

Appendix D — Pressure Test Method (Section 6)

- Period and resolution: weekly (Monday-start) averages, January 1, 2007 – September 21, 2026 (1,029 weeks).
- Adjusted elevation: AEP daily notices from June 8, 2020 (values outside 780–800 ft excluded). January 2007 – June 2020: archived daily gauge readings (one reading a day at a fixed hour, about midnight local time until mid-2018 and about 7 a.m. after), with readings outside 785–800 ft or more than 0.8 ft from the median of the surrounding six days removed (about 3 percent); weekly mean + 1.05 ft. Each offset is the median weekly difference between AEP's adjusted elevation and that series from June 2020 on; results tested at ±0.3 ft. Sources are in Appendix B.
- Inflow: piecewise function of x, the combined USGS daily mean flow of the Roanoke River at Niagara, Back Creek, Blackwater River, and Pigg River (thousands of cfs). For $x \geq 0.6$, inflow = $1.296x + 0.013$; for $x < 0.6$, inflow = $-0.12617 + 1.94228x - 1.26006x^2 + 0.99105x^3$ (thousands of cfs), a cubic fitted by least squares to AEP's reported daily inflow on days with $x < 0.8$, June 12, 2020 – September 2026; the two pieces meet within about 10 cfs at $x = 0.6$. Mean bias against AEP's inflow: +56 cfs (piecewise) versus +101 cfs (linear) on days below 300 cfs, and +35 versus +60 cfs on days of 300–500 cfs. Applied to weekly mean flow (within 0.2 percent on average of applying it day by day). Normal: monthly means of the same series, 2000–2025. Streamflow index: trailing 26-week mean inflow ÷ the same weeks' monthly normals.
- Release: the Leesville release reported in AEP's daily notices from June 8, 2020; before that, Roanoke River at Altavista − Goose Creek − 85 cfs. Tributary accretion: Brookneal − release, floored at zero. Where the protocol would have required more release than occurred, the model releases more (negative retention).
- Stages, flows, and floors as in Appendix C, LIP – Phase 2 – Critical Flow Rates, with a 10 cfs operating margin above the stage requirement. Calibrated variant: Stage 1 threshold 793.5 ft (lower set: 792.8 ft); refill exit at 794.8 ft adjusted.
- Full pond: counterfactual storage above 795.3 ft adjusted (the level the adjusted series reaches in normal full-reservoir operation) is passed downstream; when the actual lake is at or above 795.0 ft, any counterfactual deficit refills.
- Yadkin–Pee Dee spacing (Section 6.8): stages below 793.5, 792.5, 791.5, and 789.75 ft adjusted, with the same streamflow thresholds, weekly evaluation, flow steps, and exit rules as the calibrated variant and a refill exit at 794.5 ft.
- Drought Monitor indicator (Section 6.10): each weekly map converted to a basin-average level (percent of area weighted by category: none −1, D0 0, D1 1, D2 2, D3 3, D4 4, equal to the Drought Severity and Coverage Index ÷ 100 − 1); trailing 13-week mean, with the map dated on or before each week's Tuesday. A stage is entered when the lake is below its stage elevation and either the streamflow index or the Drought Monitor level meets the stage threshold (Drought Monitor: 1, 2, 3, 4 for Stages 1–4); stepping down under the strict rule requires both to recover.
- LIP – Phase 1 – Existing Flow Rates (Sections 4.5, 5.1, and 6.9): stages entered and exited as in the calibrated variant (Section 5.1's Phase 1 run uses Phase 2's first-translation stages); each stage applies the Water Management Plan's existing Brookneal targets — Trigger 1 for Stage 1, Trigger 2 for Stage 2, Trigger 3 for Stages 3 and 4 — with the license minimum release (400 cfs March–October, 375 cfs November–February) always governing and no Critical Flow.

- Streamflow indicator, 2000–2005 (Section 6.11): the same six-month index from USGS daily flows beginning January 2000, with the first full window in July 2000. Annual lake lows before 2024 are APCo's published values, which are single gauge readings rather than weekly adjusted elevations.
- Limits: before 2011 the baseline is historical operation under the earlier license, not the current plan. The calibration was checked on the same years that revealed the need for it. Before June 2020 both the adjusted elevation and the release are estimated. Weekly averaging smooths short events. Water-user conservation and APCo's forecasting and dissolved-oxygen operations are not modeled.