

Peak Water, Not Average Water

A reproducible public-evidence capacity screen for data-center growth in Loudoun County, Northern Virginia

Research object	CL-RB-004 / R04 / CL-P03 / CL-001
Version	Working Paper v1.0
Date	19 September 2026
Status	Public working research; not externally peer reviewed
Working lead	Xuguang Ma / Critical Load Research Group
Reproducibility	Workbook + CSV inputs + standard-library Python model included

Suggested citation

Critical Load Research Group (2026). Peak Water, Not Average Water: A Reproducible Public-Evidence Capacity Screen for Data-Center Growth in Loudoun County, Northern Virginia. R04 Working Paper v1.0. Critical Load. DOI: pending.

Release status

This paper is designed to be citable and reproducible as a working paper. It is not a utility capacity certificate, permit recommendation, peer-reviewed journal article, or issued Critical Load rating. All scenario assumptions are exposed so readers can replace them with better local data.

Executive summary

This paper asks a narrow but decision-relevant question: how should a public planner, utility, developer, investor or researcher translate proposed data-center IT load into a defensible water-capacity screen when facility-level water data are incomplete? Northern Virginia is used as the first case because Loudoun Water and the Interstate Commission on the Potomac River Basin (ICPRB) publish unusually useful local and regional evidence. [S01][S04]

Central finding

Peak-day water demand is the correct first-order infrastructure screen. In Loudoun Water's 2025 central service-area data, data centers account for about 9.0% of average-day potable demand (2.6 of 29.0 MGD) but 16.0% of maximum-day demand (8.0 of 50.0 MGD). Their potable peak/average factor is about 3.08x versus 1.72x for the system as a whole. [S01]

The paper contributes a transparent Peak Water Capacity Screen (PWCS) that maps project IT load, cooling-water intensity, reclaimed-water share and an explicitly declared utility-allocation assumption into peak potable-system burden and an equivalent screened compute envelope. The PWCS is intentionally a screen rather than a final capacity rating: public evidence does not disclose enough about future non-data-center allocations, node-level hydraulics, reclaimed-water headroom, project-specific cooling design or drought operating rules to justify a single official MW limit.

Using ICPRB's public cooling scenarios, an added 1 GW of IT load implies about 2.1, 2.9 or 5.2 MGD of peak direct water demand in the low, medium and high water-use scenarios. At 5 GW, the same range becomes 10.5-26.0 MGD - large enough to be a first-order system design variable relative to Loudoun Water's current 50 MGD maximum-day demand. [S04][S01]

An illustrative share-preserving screen holds data centers at their current 16% share of future system peak potable capacity. At Loudoun Water's published 90 MGD future permitted capacity, that assumption yields a gross data-center allocation of 14.4 MGD and an incremental budget of 6.4 MGD above the current 8.0 MGD data-center maximum-day demand. Under the ICPRB low/medium/high peak intensities, this corresponds to about 3.05/2.21/1.23 GW of additional IT load. A facility-level high-sensitivity case at 8.5 MGD/GW produces 0.75 GW. These are scenario outputs, not forecasts or utility commitments. [S01][S04]

The most important source insight is that reclaimed water and low-water cooling solve different problems. Reclaimed water can substantially reduce potable-system burden, but if that reclaimed supply is evaporatively consumed it does not eliminate hydrologic depletion and can reduce return flows. The model therefore reports potable burden and total consumptive use separately. [S02][S04]

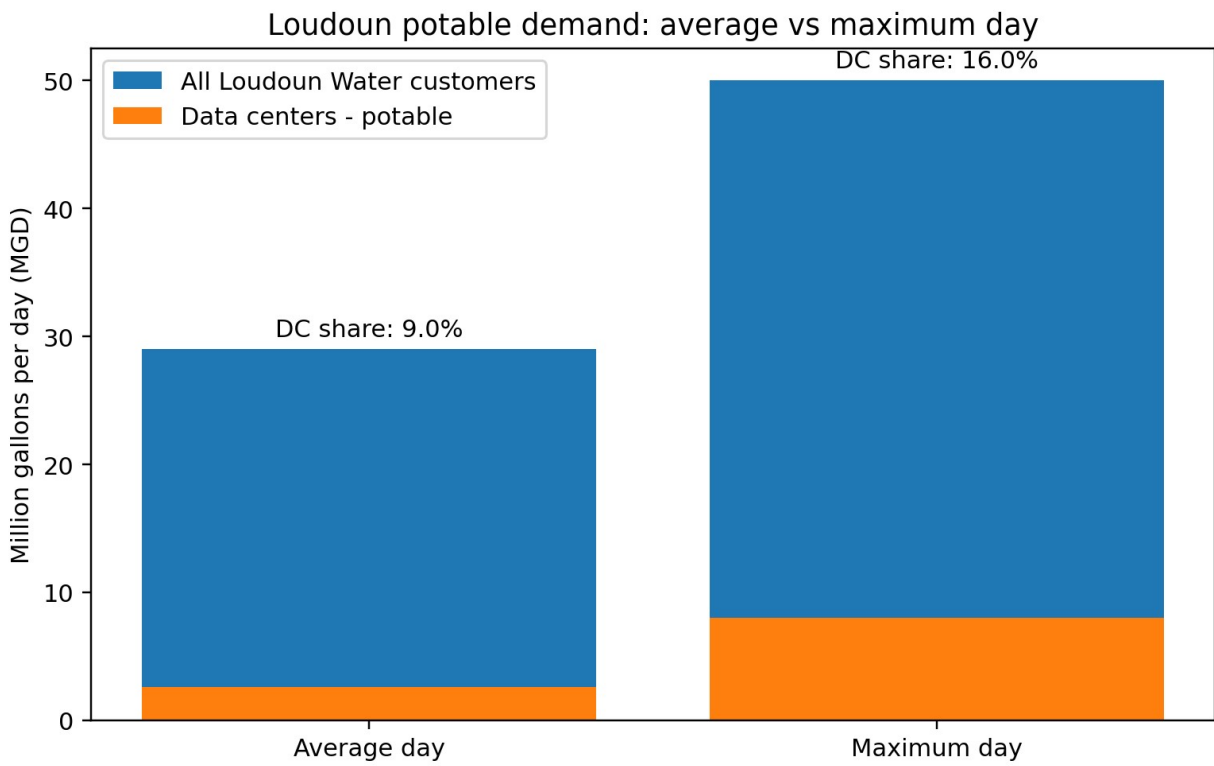


Figure ES-1. Loudoun Water 2025 baseline. Data-center potable demand becomes more important on the maximum day. Source: Loudoun Water [S01].

1. Research question and contribution

1.1 Research question

For a proposed increase in data-center IT load in a specified place and time, what direct water demand should be expected on average and on a peak day; how much of that demand burdens the potable-water system; and at what project scale does water become large enough to require redesign, source substitution or a higher-fidelity utility/basin assessment?

1.2 Three contributions

1. A peak-first functional unit: direct water demand is expressed per MW of IT load for both annual-average and peak-day conditions, rather than relying on annual totals alone.
2. A reproducible Peak Water Capacity Screen (PWCS): a transparent equation converts an explicit potable-capacity allocation assumption into a screened GW envelope under multiple cooling scenarios.
3. A two-ledger treatment of reclaimed water: potable-system burden is separated from hydrologic consumptive use so that source substitution is not confused with eliminating consumption.

1.3 Falsifiable hypotheses

Hypothesis	Test	Result in this case
H1	Data-center peak/average water ratio is materially above the utility-wide ratio.	Supported by public 2025 Loudoun values: ~3.08x vs ~1.72x.
H2	Cooling technology uncertainty changes project peak water demand enough to alter an MW capacity screen.	Supported: ICPRB low-to-high peak intensity varies 2.1 to 5.2 MGD/GW (~2.48x).
H3	Reclaimed water can reduce potable demand without proportionally reducing consumptive use.	Supported by model structure and ICPRB return-flow caution; requires project-specific validation.
H4	Public data alone are sufficient to issue a single binding water MW rating for Loudoun.	Not supported: critical allocation, hydraulic and project-specific variables remain unavailable.

Why this matters

A useful public result is not a dramatic point estimate. It is a method that tells readers what can be concluded now, what cannot, and exactly which missing variables would move the answer.

2. Evidence base and research boundary

Recent research increasingly emphasizes that national data-center water totals can obscure local and seasonal effects, while facility-level disclosure remains inconsistent. A 2026 AGU Advances commentary identifies transparency, spatial context and seasonality as central gaps. [S08] LBNL similarly shows that site water-use efficiency varies materially by data-center and cooling-system type and that direct on-site water should be separated from the indirect water footprint of electricity generation. [S07]

2.1 Study boundary

Dimension	Included in v1.0	Outside v1.0 / separate ledger
Geography	Loudoun Water central service area baseline; WMA/Potomac context	Facility parcels and exact hydraulic nodes
Water scope	Direct on-site supplied water; potable/reclaimed source split; estimated consumption	Indirect water at power plants (reported separately by LBNL)
Time	2025 baseline; future capacity/projection scenarios	Hourly operations, exact drought-day dispatch
Compute unit	MW and GW of IT load	GPU count/model-specific compute throughput
Decision unit	Screened project scale and water burden	Permit approval or utility service guarantee

2.2 Evidence classes

Class	Meaning	Examples in this paper
E1	Direct utility/agency observation or published operating statistic	Loudoun 29/50/90 MGD; 2.6/8.0 MGD DC potable use
E2	Official modeled or derived result	ICPRB WUP scenarios and WMA projections
E3	Peer-reviewed/public research used for method context	LBNL, AGU Advances, WRI
E4	Critical Load scenario assumption	Allowed future data-center share of peak potable capacity

Evidence classes are kept visible because an E4 allocation assumption cannot be treated as if it were an E1 utility commitment. The accompanying source register records each input and source URL.

3. Northern Virginia / Loudoun baseline

Loudoun Water reports 206 data centers in its central service area as of 2025: 88 air-cooled (43%), 78 potable-water-cooled (38%) and 40 reclaimed-water-cooled (19%). The utility reports 29.0 MGD average-day potable use across all customers and 50.0 MGD on the maximum day. Data centers account for 2.6 MGD potable on an average day and 8.0 MGD on the maximum day. Average data-center potable plus reclaimed use is 4.6 MGD, including 2.0 MGD reclaimed. [S01]

Baseline metric	Published value	Derived interpretation
All customers - average-day potable	29.0 MGD	System baseline
All customers - maximum-day potable	50.0 MGD	Peak system baseline
Data centers - average-day potable	2.6 MGD	9.0% of system average
Data centers - maximum-day potable	8.0 MGD	16.0% of system maximum
Data centers - average reclaimed	2.0 MGD	43.5% of reported average DC potable+reclaimed water
Published future permitted capacity	90 MGD	Capacity parameter, not 40 MGD of freely available headroom

The 90 MGD value is treated with special caution. Subtracting today's 50 MGD maximum day produces a 40 MGD gross numerical difference, but that difference is not “available data-center capacity.” It must also serve future residential and commercial growth, system reserves, operating constraints and whatever allocations the utility makes. The model uses the 90 MGD value only inside explicitly declared scenarios. [S01]

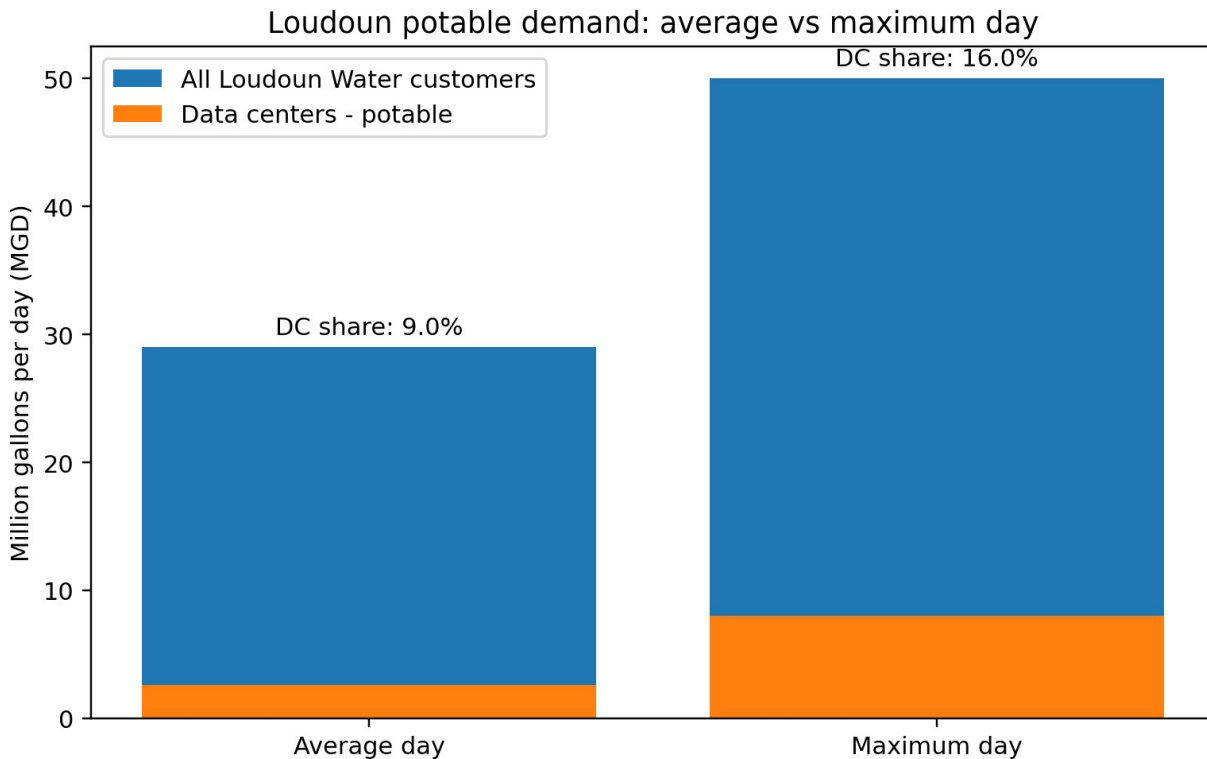


Figure 1. Local potable-water baseline. Source values: Loudoun Water [S01].

3.1 Reclaimed-water system is valuable but not infinite

Loudoun Water reports more than 750 million gallons of reclaimed water delivered to customers in 2025 and a 20-mile reclaimed distribution network. It also states that reclaimed connections may be limited or excluded by

supply availability and hydraulic constraints and that capacity allocations are made at the utility's discretion.
[S02] This means a project cannot assume a reclaimed-water share merely because reclaimed water exists in the service area.

4. Method: the Peak Water Capacity Screen

4.1 Project water demand

For project IT load M (MW), an average water-use parameter I_{avg} (gal/MW/day) and a peak parameter I_{peak} , direct supplied water is:

Equation 1 - direct water

$$W_{avg}(MGD) = M \times I_{avg} / 1,000,000$$

$$W_{peak}(MGD) = M \times I_{peak} / 1,000,000$$

ICPRB publishes three bounding water-use scenarios based on uncertainty in cooling technology and operation. The values are not precise forecasts; they are intended to bound plausible future use. [S04]

Scenario	Water-cooled share	Average WUP	Peak WUP	Peak MGD / GW
Low	30%	600 gal/MW/day	2,100 gal/MW/day	2.1
Medium (observed regional mix)	~60-70%	800	2,900	2.9
High	90%	1,400	5,200	5.2

ICPRB also reports a Loudoun-specific observed WUP of 1,006 gal/MW/day annual-average and 2,716 gal/MW/day peak under an assumed 60% water-cooled share. [S04]

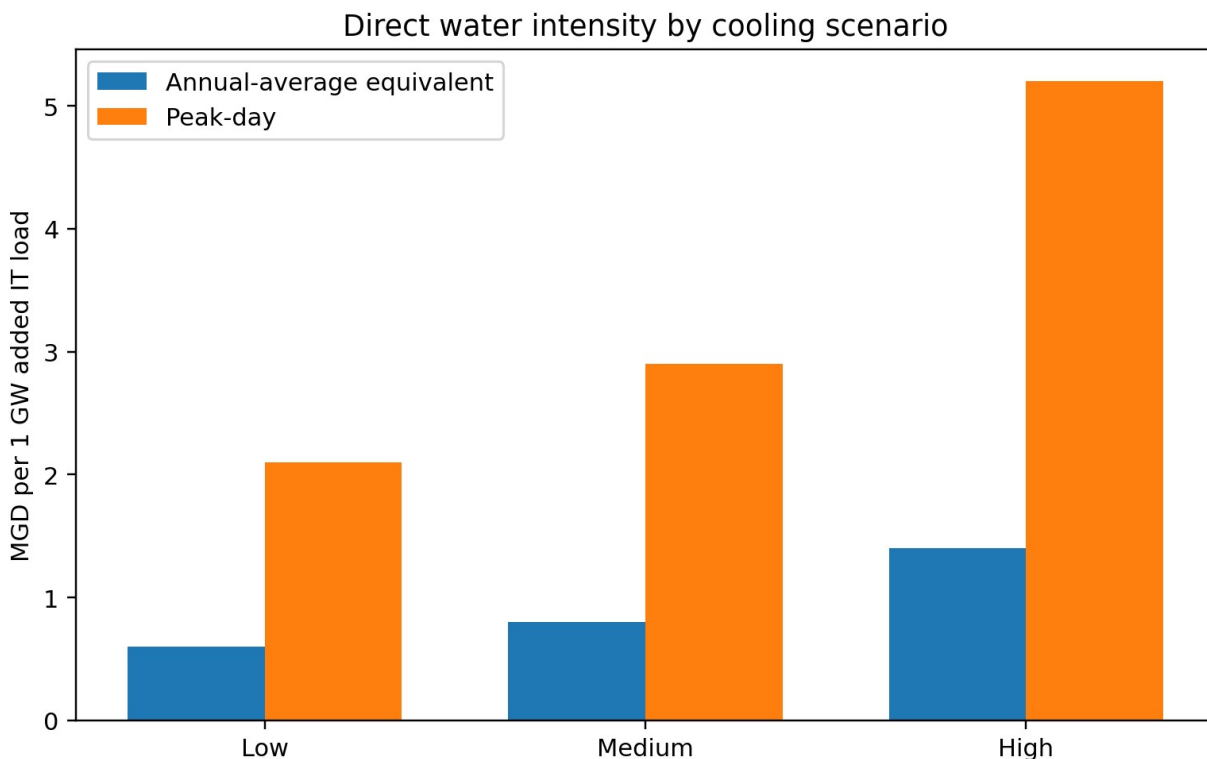


Figure 2. Direct water-use intensity per added 1 GW IT load using ICPRB Table 6-5 scenarios [S04].

4.2 Potable burden, reclaimed supply and consumption

Let r be the fraction of project water supplied as reclaimed water and c the consumptive-use factor. The public model separates source burden from consumption:

Equation 2 - source and consumption ledgers

$$\text{Potable_peak} = W_peak \times (1 - r)$$

$$\text{Reclaimed_peak} = W_peak \times r$$

$$\text{Consumptive_peak} = W_peak \times c$$

The default $c = 75\%$ follows the ICPRB modeling assumption used for data-center consumptive-use estimates. [S04] This factor should be replaced with measured project data when available. Reclaimed water can reduce potable burden, but ICPRB cautions that evaporatively consuming reclaimed wastewater can reduce return flows. Therefore “100% reclaimed” is not interpreted as “zero water impact.”

4.3 Share-preserving peak-water screen

To demonstrate how an explicit allocation rule converts to compute capacity, this paper defines an illustrative share-preserving screen. Let C_future be future permitted potable capacity (MGD), a be the allowed data-center share of peak potable capacity, $D_current$ be current data-center peak potable demand, and I_peak be project peak intensity in MGD/GW:

Equation 3 - Peak Water Capacity Screen (PWCS)

$$\text{Incremental potable budget} = a \times C_future - D_current$$

$$\text{PWCS(GW)} = \text{Incremental potable budget} / I_peak$$

The screen is useful precisely because a is visible. Changing a immediately changes the MW result; the model therefore does not hide a contested allocation choice inside a single “sustainability score.” In v1.0, $a = 16\%$ is used only as an illustrative “preserve today's maximum-day share” scenario. It is not a recommendation or statement of utility policy.

4.4 Toward a full Water-Constrained Compute Envelope

A verified Water-Constrained Compute Envelope (WCCE) would take the minimum of independently validated limits that can each be expressed on a comparable MW basis - potable utility allocation, reclaimed-water hydraulic/supply capacity, basin low-flow/consumptive-use limit, wastewater/discharge constraint and any project-specific water-quality or emergency-operating constraint. Where a constraint cannot be defensibly converted to MW, it should remain a separate decision gate rather than being forced into the minimum operator.

5. Results: project-scale water demand

Added IT load	Low peak	Medium peak	High peak	High as % of current 50 MGD max
100 MW	0.21 MGD	0.29 MGD	0.52 MGD	1.0%
500 MW	1.05	1.45	2.60	5.2%
1 GW	2.10	2.90	5.20	10.4%
5 GW	10.50	14.50	26.00	52.0%

A single additional 1 GW facility or cluster is material but does not, from public evidence alone, demonstrate that the Loudoun potable system is water-bound: even the high scenario is 5.2 MGD, or 10.4% of today's entire maximum-day demand. The picture changes at multi-GW increments. At +5 GW the high scenario reaches 26 MGD, more than half of today's entire maximum-day demand and 65% of the gross numerical difference between 50 MGD current maximum-day demand and the published 90 MGD future permitted capacity. That 65% comparison is a stress indicator, not a claim that the 40 MGD difference is freely available. [S01][S04]

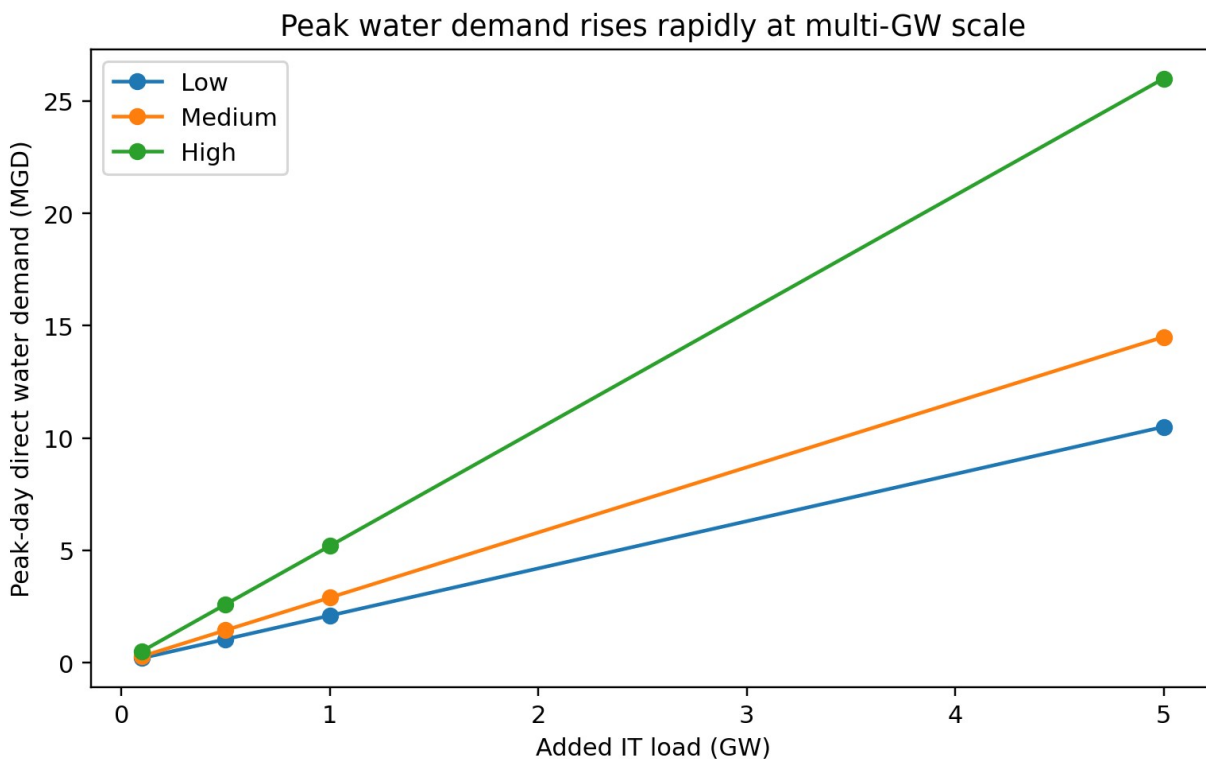


Figure 3. Peak direct water demand grows linearly with IT load but is highly sensitive to cooling scenario. Inputs: ICPRB [S04].

Interpretation

Water is not a binary “safe/unsafe” attribute of Northern Virginia. It is a conditional capacity variable. Project scale, cooling mode, summer peak behavior, water source and drought conditions determine whether water is marginal, material or potentially binding.

6. Results: a transparent compute-capacity screen

The share-preserving scenario asks: if data centers continued to occupy 16% of maximum-day potable capacity as the system grows to the published 90 MGD future permitted capacity, how much additional peak potable demand would fit inside that chosen allocation?

Step	Calculation	Result
Future DC peak allocation	90 MGD x 16%	14.4 MGD
Less current DC peak potable	14.4 - 8.0	6.4 MGD incremental budget
Low scenario	6.4 / 2.1 MGD per GW	3.05 GW
Medium scenario	6.4 / 2.9	2.21 GW
High scenario	6.4 / 5.2	1.23 GW
Facility high-sensitivity	6.4 / 8.5	0.75 GW

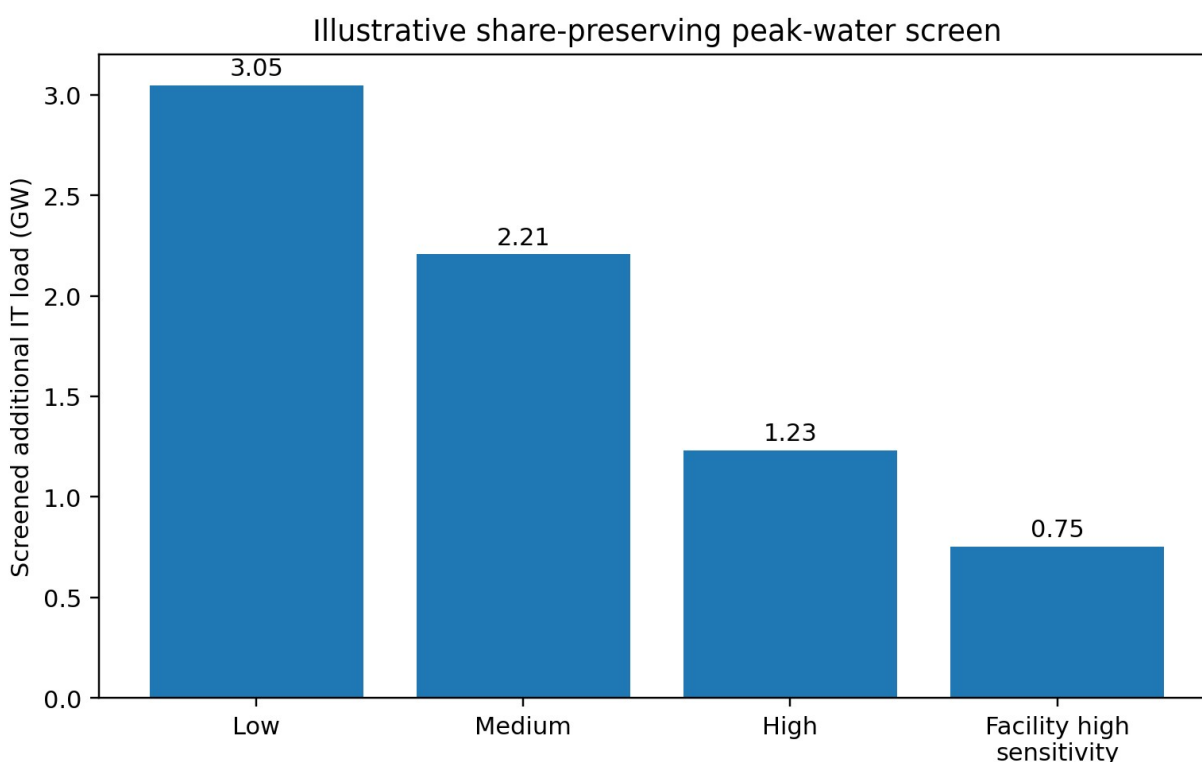


Figure 4. Illustrative share-preserving Peak Water Capacity Screen. The 16% allocation assumption is E4 scenario logic, not utility policy.

6.1 Allocation sensitivity

Allowed DC peak share at 90 MGD	Incremental budget	Low GW	Medium GW	High GW
16%	6.4 MGD	3.05	2.21	1.23
20%	10.0	4.76	3.45	1.92
25%	14.5	6.90	5.00	2.79
30%	19.0	9.05	6.55	3.65

This table demonstrates why a credible capacity study must expose allocation assumptions. Under the same 90 MGD system parameter, the medium-scenario screened compute envelope ranges from 2.21 to 6.55 GW simply as the assumed future data-center peak share changes from 16% to 30%. A single number without this assumption would imply false precision.

7. Reclaimed water: source relief is not zero consumption

For a +1 GW project under the medium scenario, peak direct water demand is 2.9 MGD. Increasing reclaimed-water supply from 0% to 100% can reduce the modeled potable burden from 2.9 MGD to zero. But with the default 75% consumptive-use factor, estimated total consumption remains 2.175 MGD unless the cooling process itself changes. [S04]

Reclaimed share	Potable peak	Reclaimed peak	Estimated consumption
0%	2.90 MGD	0.00	2.175 MGD
25%	2.175	0.725	2.175
50%	1.45	1.45	2.175
75%	0.725	2.175	2.175
100%	0.00	2.90	2.175

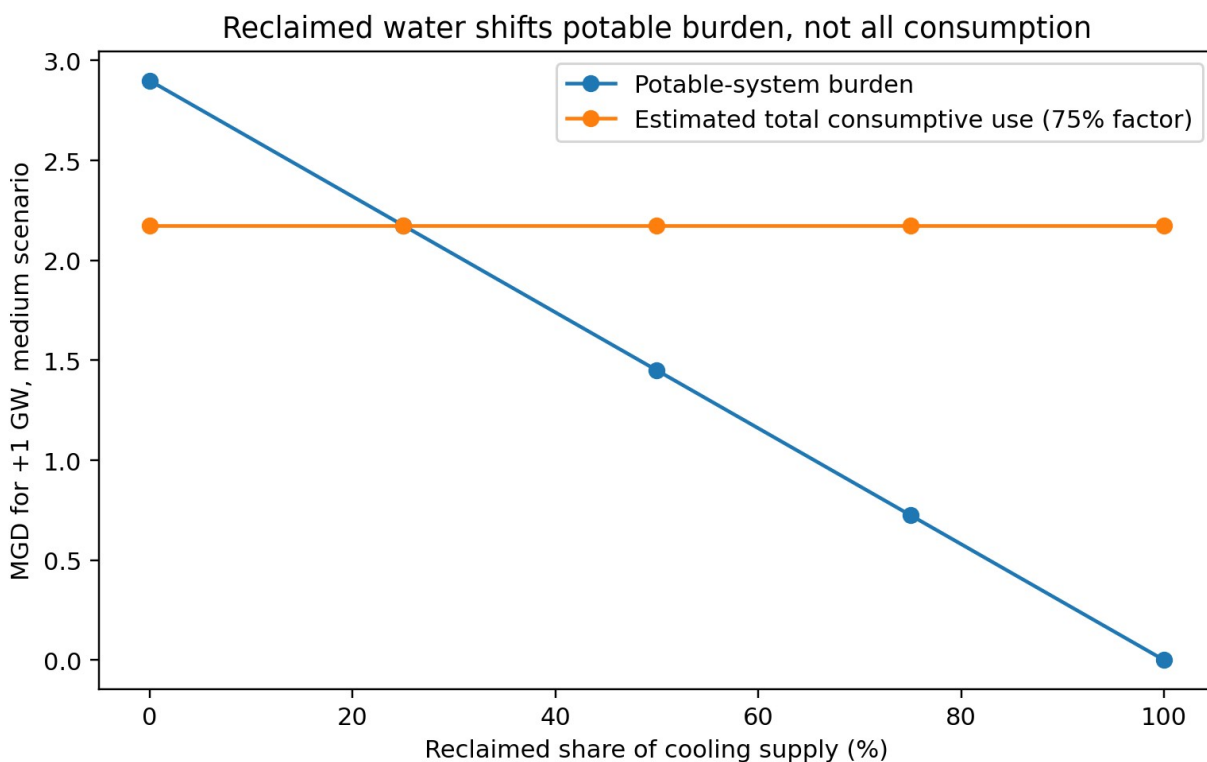


Figure 5. Source substitution can eliminate potable-system burden in the model while estimated consumptive use remains. Actual consumption must be measured at project level.

This distinction changes practical decisions. A utility may prioritize reclaimed water to protect drinking-water treatment and distribution capacity. A basin planner may still care about total seasonal consumption and return-flow effects. A project needs both ledgers. Loudoun Water also notes that reclaimed connections depend on supply and hydraulic availability; therefore reclaimed share must be treated as a verified project parameter, not a default assumption. [S02]

8. Regional context: why peak and drought interact

ICPRB's medium scenario projects Washington Metropolitan Area data-center consumptive use rising from about 4.0 MGD annual-average and 14.3 MGD peak-day in 2025 to 22.2 MGD average and 80.5 MGD peak-day by 2050. [S04] The peak-day series is roughly 3.6 times the average series, reinforcing the local Loudoun finding that annual averages alone are not adequate for system planning.

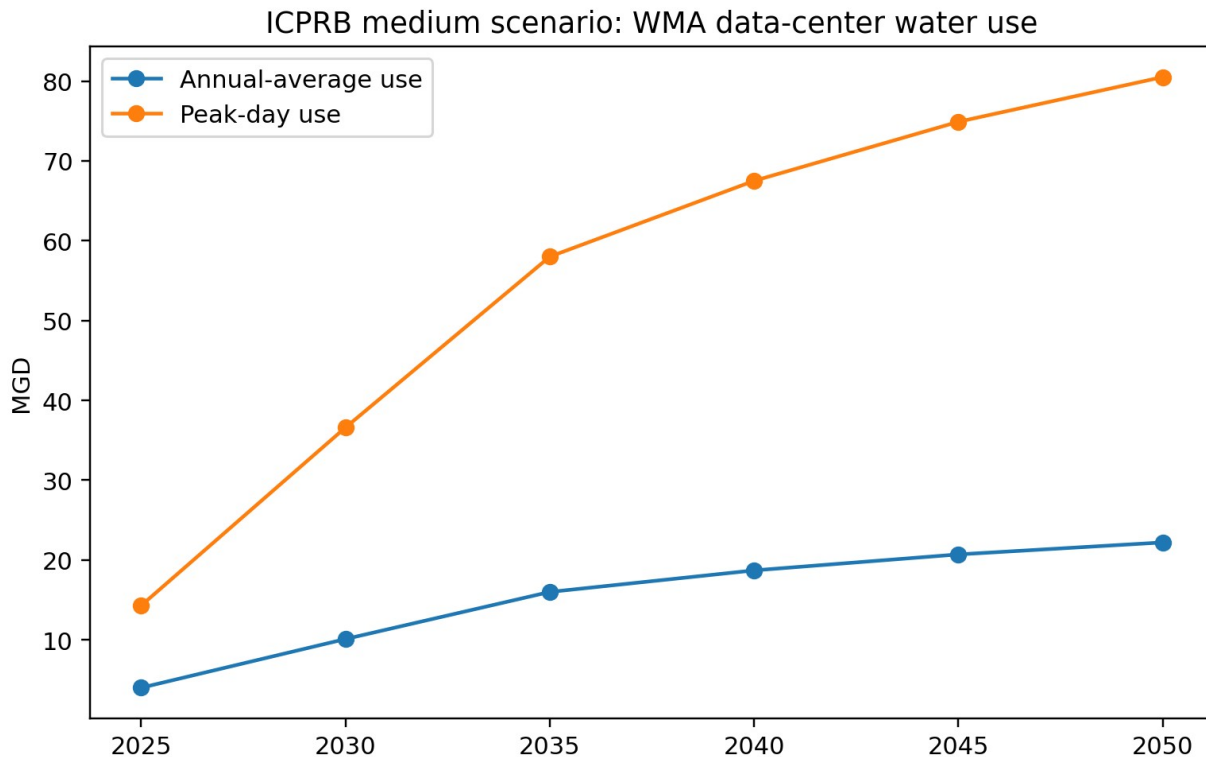


Figure 6. ICPRB medium scenario for WMA data-center consumptive use, 2025-2050 [S04].

Separately, ICPRB's 2025 regional water-supply study reports an increasing modeled chance of shortage during extreme conditions - up to about 1% in 2030 and 5% in 2050 - while also projecting broader demand growth and climate-related uncertainty. [S06] This result should not be attributed to data centers alone. It establishes that data-center water growth occurs inside a water system whose reliability margin is itself scenario-dependent.

Do not make this causal error

“ICPRB projects water shortages, therefore data centers cause the shortage.” The study includes multiple demand and hydrologic drivers. R04 uses the result as reliability context, not as a data-center attribution claim.

9. How to use the model in real project work

9.1 Seven-step screening protocol

1. Declare project IT load (MW), expected load profile and phasing rather than using building square footage alone.
2. Declare cooling architecture and seasonal control mode; choose low/medium/high public WUP only when project engineering data are unavailable.
3. Calculate average and peak direct water demand separately.
4. Split supply into potable and reclaimed water using a utility-confirmed source allocation; do not assume reclaimed availability.
5. Estimate consumptive use separately from potable burden, with measured cycles-of-concentration/blowdown data where possible.
6. Compare project peak potable burden with a utility-provided project allocation or, only for early screening, a fully disclosed scenario such as PWCS.
7. Escalate to a verified Water-Constrained Compute Envelope when project size is material, drought/low-flow exposure matters, or reclaimed/hydraulic constraints are close to their limits.

9.2 Minimum developer data request

Required field	Why it changes the answer
IT load: initial / ultimate / phased MW	Core functional unit
Hourly/monthly utilization profile	Separates nameplate from actual heat rejection
Cooling architecture and control sequence	Determines water/energy tradeoff
Expected average and design-day WUE or gallons/MW/day	Replaces generic public scenarios
Potable/reclaimed source split by season	Determines drinking-water burden
Evaporation, blowdown and discharge assumptions	Determines consumption vs withdrawal
Utility connection point and reserved capacity	Tests hydraulic/service feasibility
Drought/emergency operating mode	Tests reliability under constrained supply
Water quality / treatment requirements	Can constrain reclaimed use
Commissioning date and phasing	Aligns project with future infrastructure delivery

This is the practical bridge from public research to project diligence: public data provide a reproducible first pass, while the data request identifies exactly what must be replaced before a permit, investment or utility decision should rely on the result.

10. What the evidence supports - and does not support

Claim	Assessment	Reason
“Water is already the binding limit for all Northern Virginia data centers.”	Not supported	Public evidence does not establish a single regional binding limit; constraints vary by utility, project and scenario.
“Average annual water use is enough for planning.”	Not supported	Both Loudoun observations and ICPRB projections show much larger peak-day factors.
“A +1 GW project is trivial for water.”	Not supported	Peak demand spans 2.1-5.2 MGD across public scenarios; materiality depends on local allocation and source.
“Reclaimed water eliminates the water footprint.”	Not supported	It can remove potable burden while evaporative consumption/return-flow effects remain.
“Water can become a binding constraint at multi-GW scale or in drought-sensitive conditions.”	Supported as a conditional risk	Peak demand scales to tens of MGD and regional reliability is scenario-sensitive.
“Public data can support a useful early-stage screen.”	Supported	Core inputs, equations, sources and uncertainty can be made transparent and reproduced.

Bottom line

The defensible v1.0 conclusion is conditional, not sensational: public evidence does not prove that water is currently the single binding limit in Loudoun, but it does show that peak water demand can become a material infrastructure constraint at multi-GW expansion, and that cooling/source choices can move the screened compute envelope by multiples.

11. Uncertainty, limitations and failure modes

- Allocation uncertainty: the 16% future data-center peak share is an illustrative scenario, not an adopted utility allocation.
- Hydraulic uncertainty: system-wide MGD values do not prove capacity at a specific pressure zone, pipe, reclaimed-water node or parcel.
- Future-demand uncertainty: the 90 MGD future permitted capacity also serves non-data-center growth; the gross 40 MGD numerical gap is not free headroom.
- Cooling uncertainty: future AI cooling architectures, operating temperatures and seasonal economization can shift WUP materially.
- Consumption uncertainty: the 75% factor is a regional modeling assumption, not a measured project balance.
- Reclaimed-water uncertainty: local reclaimed supply and hydraulic availability must be reserved and verified.
- Basin reliability: drought-day river and reservoir operations require hydrologic modeling beyond this public utility screen.
- Indirect water: electricity-generation water is outside the primary direct-water screen and should be reported in a separate lifecycle ledger, not silently combined.
- Facility confidentiality: public aggregated utility data limit facility-level validation and causal inference.

11.1 What would invalidate or materially revise the result?

- Updated Loudoun utility data showing materially different average/max-day demand or future capacity.
- Project-specific WUP substantially below or above ICPRB scenario bounds.
- A utility-confirmed allocation that differs from the share-preserving scenario.
- Evidence that reclaimed-water supply or hydraulics cap project use below the modeled source share.
- Revised drought operating rules or source-reservoir performance that changes available supply during critical periods.

12. Reproducibility package

The release includes a formula-based Excel workbook, CSV inputs/results, a standard-library Python implementation, six publication figures, a source register, a short Research Brief, a web-ready research page and an internal release-quality review. The Python model reads `model_inputs.csv` and writes `model_output.json`; no proprietary packages or external API calls are required.

File / component	Purpose
R04_Northern_Virginia_Water_Capacity_Model.xlsx	Editable scenario model with formulas, dashboard and source register
r04_model.py + model_inputs.csv	Independent deterministic reproduction of the core calculations
project_scenario_results.csv	Project-size x cooling-scenario result table
share_preserving_sensitivity.csv	Allocation-share sensitivity table
wma_projection.csv	ICPRB medium-scenario projection series used in figures
reclaimed_substitution_sensitivity.csv	Source-substitution sensitivity for +1 GW medium scenario
source_register.csv	Evidence traceability
figures/*.png	Publication figures generated from declared inputs

12.1 Reproduction test

With default inputs (1,000 MW, Medium, 0% reclaimed, 75% consumption factor, 16% future DC peak share), the model must reproduce: 0.80 MGD average direct water; 2.90 MGD peak direct water; 2.90 MGD peak potable burden; 2.175 MGD estimated peak consumptive use; 6.40 MGD incremental share-preserving peak potable budget; and 2.21 GW / 1.23 GW screened additional compute under medium/high peak intensity.

Release reproducibility criterion

If a reader changes only the cooling scenario, reclaimed share, allocation share or project MW, the model should update all derived outputs without manual editing of results. Values in the report are rounded presentations of the underlying model.

13. Validation roadmap to a verified Critical Load water rating

The public-evidence screen is strong enough for a working paper and early-stage diligence, but a verified rating needs additional evidence. The next research phase should prioritize validation rather than adding more conceptual indicators.

Gate	Required evidence	Release effect
G1 Utility allocation	Written utility confirmation of project potable and reclaimed capacity by phase	Replaces E4 allocation assumption
G2 Hydraulic service	Node/pressure-zone capacity and connection constraints	Tests whether system-level MGD is locally deliverable
G3 Project water balance	Cooling design, design-day WUP, evaporation/blowdown/discharge	Replaces generic WUP and 75% consumption factor
G4 Drought / low flow	Utility/basin critical-period operating analysis	Converts peak screen into reliability-aware capacity
G5 Independent review	Water-resources/hydrology review plus engineering review	Supports external verified release

A future WCCE release should provide both the limiting MW value and the individual constraint ledger. If two constraints are close, the report should state that the binding constraint is uncertain rather than forcing a single winner.

14. Conclusion

R04 begins with a simple discipline: do not confuse annual water totals with infrastructure capacity. Loudoun's own public numbers show that data-center demand is substantially more peak-intensive than system demand. ICPRB's cooling scenarios then show that the water requirement of an added GW can vary by roughly 2.5x between low and high system scenarios, while WMA projections show that data-center peak consumptive use can become tens of MGD as the sector grows. [S01][S04]

The resulting Peak Water Capacity Screen is deliberately transparent. It does not claim an official water limit for Northern Virginia. Instead, it produces a reproducible MW-to-water stress test, exposes the allocation assumption that converts water to a screened GW envelope, and identifies exactly which utility and project evidence is needed to move from public screening to a verified capacity determination.

That combination - measured local baseline, explicit scenario logic, source-versus-consumption accounting, sensitivity analysis and a defined validation path - is the intended standard for future Critical Load place assessments.

Appendix A. Core numerical results

A1. Project scale x cooling scenario

MW	Scenario	Avg supplied MGD	Peak supplied MGD	Peak consumption @75%
100	Low	0.060	0.210	0.158
100	Medium	0.080	0.290	0.217
100	High	0.140	0.520	0.390
500	Low	0.300	1.050	0.788
500	Medium	0.400	1.450	1.087
500	High	0.700	2.600	1.950
1,000	Low	0.600	2.100	1.575
1,000	Medium	0.800	2.900	2.175
1,000	High	1.400	5.200	3.900
5,000	Low	3.000	10.500	7.875
5,000	Medium	4.000	14.500	10.875
5,000	High	7.000	26.000	19.500

A2. Share-preserving sensitivity

DC peak share	Allocation MGD	Incremental MGD	Low GW	Med GW	High GW	8.5 MGD/GW
16%	14.4	6.4	3.05	2.21	1.23	0.75
20%	18.0	10.0	4.76	3.45	1.92	1.18
25%	22.5	14.5	6.90	5.00	2.79	1.71
30%	27.0	19.0	9.05	6.55	3.65	2.24

Appendix B. Source register and references

- [S01] Loudoun Water. Data Center Water Use. 2026. <https://www.loudounwater.org/data-center-water-use>
- [S02] Loudoun Water. Reclaimed Water Program. 2026. <https://www.loudounwater.org/commercial-customers/reclaimed-water-program>
- [S03] Loudoun Water. Water Reclamation. 2026. <https://www.loudounwater.org/water-reclamation>
- [S04] Interstate Commission on the Potomac River Basin. 2025 Washington Metropolitan Area Water Supply Study - Demand and Resource Availability Forecast for the Year 2050. December 2025. https://www.potomacriver.org/wp-content/uploads/2025/12/2025_WMA_Water_Supply_Study_ICPRB_Dec-2025-export.pdf
- [S05] ICPRB. Data Centers and Water Use in the Potomac River Basin. 2026. <https://www.potomacriver.org/focus-areas/water-resources-and-drinking-water/water-resources/planning/data-centers-and-water-use-in-the-potomac-river-basin/>
- [S06] ICPRB. New report exposes the vulnerabilities of the Washington metropolitan area's water supply. 5 Dec 2025. <https://www.potomacriver.org/news/news-release-new-report-exposes-the-vulnerabilities-of-the-washington-metropolitan-areas-water-supply/>
- [S07] Shehabi, A. et al. 2024 United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory, 2024. DOI 10.71468/P1WC7Q. <https://eta.lbl.gov/publications/2024-lbnl-data-center-energy-usage-report>
- [S08] Privette, A.P., Barros, A., & Cai, X. Data Centers Water Footprint: The Need for More Transparency. AGU Advances 7 (2026), e2025AV002140. <https://doi.org/10.1029/2025AV002140>
- [S09] World Resources Institute. Aqueduct Water Risk Atlas / Aqueduct 4.0. <https://www.wri.org/aqueduct>
- [S10] Virginia Joint Legislative Audit and Review Commission. Data Centers in Virginia. 2024. <https://jlarc.virginia.gov/landing-2024-data-centers-in-virginia.asp>
- [S11] University of Illinois Center for Secure Water. Data Center Expansion in Virginia: Closing Critical Gaps for Informed Water Planning and Permitting. 2026. <https://securewater.illinois.edu/data-center-expansion-in-virginia-closing-critical-gaps-for-informed-water-planning-and-permitting/>
- [S12] Talukder, Z. et al. Balancing Bits and Drops: Stress-Adjusted Water Management for Data Centers. arXiv:2607.22617, 2026. <https://arxiv.org/abs/2607.22617>

Access date for online sources: 19 September 2026. The accompanying source_register.csv records how each source is used and its evidence class.

Appendix C. Publication and correction policy for this release

This is a versioned working research object. Material factual corrections, source changes or model revisions should increment the version and be recorded in CHANGELOG.md. External peer review must not be claimed unless named reviewers and the scope of review are disclosed. If a later utility or project data release contradicts a modeled input, the source class and result should be updated rather than preserving the prior number for narrative consistency.

Known status at release

Evidence-complete enough for a reproducible public working paper and early-stage project screening. Not evidence-complete enough for a definitive Northern Virginia water rating, utility-service determination or peer-reviewed claim.