UNU INWEH
UNITED NATIONS UNIVERSITY
INSTITUTE FOR WATER, ENVIRONMENT AND HEALTH

POLICY BRIEF JULY 2026

# The World Cannot See Its Water

## Data Sharing and Sampling Frequency Are Policy Failures, Not Technical Ones

Evan Thomas, Matt Ross, Mike Vlah, Grace Oluwasanya, Abraham Nunbogu, Mir Matin

### Executive Summary

- We assembled the first harmonized global record of surface-water fecal indicator bacteria: **11,110,309 observations** from nine public sources, covering fresh and marine waters.
- **The record is not global; it is where publishing is mandated.** The United States (62.3%), Europe (28.5%) and Canada (3.7%) hold **94.5%** of all openly shared observations. Large monitoring nations, including China and Russia, are effectively absent from the open record. Much of this is a sharing gap, not a collection gap.
- **Where data exist, they are sampled too slowly to protect anyone.** Only about **1.5%** of multi-sample sites reach a near-daily cadence, almost all in the United States, even though fecal contamination is a transient, weather-driven pulse.
- **Slow sampling does not merely lose detail; it misinforms.** Simulating monitoring regimes across every near-daily record, weekly sampling misadvises roughly **one monitored day in nine** and monthly sampling **one in seven**, biased toward false reassurance.
- **None of these constraints are technical.** The instruments, the laboratories and the data portals already exist. What is missing is the mandate to publish, the obligation to sample when risk is highest, and an accountable actor positioned to respond.

## Context

Fecal indicator bacteria are the primary tool used worldwide to judge whether surface waters are safe from waterborne pathogens. *E. coli* is the standard indicator for fresh water and intestinal enterococci for marine water. These counts decide beach closures, drinking-water advisories and compliance reporting in every country that regulates water quality at all. Inadequate water, sanitation and hygiene remain responsible for a substantial share of the global disease burden [16], and contact with fecally contaminated recreational water is an established cause of illness [13].

Yet the global record that underpins these decisions had never been assembled and characterised at a harmonized scale. Monitoring data sit in dozens of national and subnational portals with incompatible schemas, units and indicator vocabularies. We compiled, harmonized and analysed 11,110,309 surface-water observations from nine public sources, standardized to a common schema, indicator set and unit: 5,899,783 freshwater (53.1%) and 5,210,526 marine (46.9%) records. This brief reports what that record shows about the governance of water safety information, and what to do about it.

## Problem Statement

Two structural weaknesses emerge, and neither is a measurement problem.

The first is spatial. Openly shared data are concentrated in a handful of wealthy jurisdictions. The second is temporal. Even where data are shared, they are collected on calendars written for administrative convenience rather than for the behaviour of the hazard. Fecal contamination varies by orders of magnitude over hours to days, driven by rainfall, runoff and sunlight-driven decay. A monthly grab sample is not a coarse measurement of that process. It is a measurement of a different process.

The consequence is that the world's water safety information system is most confident exactly where risk is lowest, and least informative exactly where the disease burden is greatest. That is a governance outcome, and governance outcomes can be changed.

## Analysis

### The open record tracks regulation, not rivers

The open monitoring network expanded roughly twenty-fold between 1970 and 2020, and its growth clusters at regulatory inflection points: the United States Clean Water Act of 1972 and its amendments drove the first wave of state-level monitoring, and the revised European Bathing Water Directive triggered rapid growth in European coastal reporting after 2006 [3]. Open coverage therefore maps where regulation has mandated both monitoring *and* public reporting.

This distinction matters for interpretation. A genuine collection gap does exist in resource-limited regions, where monitoring capacity varies with institutional development [6]. But the near-absence of large, industrialized monitoring nations from the open record points to a second, separate sharing gap: data are collected and not published in open, machine-readable, harmonized form. Persistent technical, institutional and social barriers to sharing environmental data are well documented [1, 4, 9]. The implication is uncomfortable and useful: funding new monitoring stations alone will not close the gap.

The deficit is visible in international reporting. As of 2020, only 42% of countries had sufficient ambient water-quality data to report on Sustainable Development Goal indicator 6.3.2 [14].

### Official statistics inherit the blind spot

The WHO/UNICEF Joint Monitoring Programme is the global authority on SDG 6, and it does what the underlying data allow: it reports one modelled national estimate per country per year, derived from household surveys conducted every three to five years. For Africa, 30 of 54 countries have a safely-managed drinking water estimate. Twenty-four have none at all, including Kenya, Rwanda, Burkina Faso, Niger, Mali, Cameroon and Sudan.[1]

Where the estimate exists, it is national and annual. The granularity that would let a regulator act on a specific water body, in a specific season, is absent by construction. Official statistics cannot be more temporally resolved than the monitoring beneath them.

### What slow sampling costs

To quantify the safety cost of coarse sampling we treated each genuinely near-daily site-year as ground truth, then simulated monitoring programmes at intervals from daily to quarterly: to each scheduled date we assigned the nearest available observation, posted a single-sample advisory that persisted until the next scheduled sample, and scored that standing advisory against the true daily state on every observed day.

Averaged across 1,308 near-daily site-years, weekly sampling misadvises roughly one monitored day in nine, and monthly sampling one in seven. The errors are not symmetric. They are biased toward false reassurance: unsafe water called safe.

[1] Authors' analysis of the JMP safely-managed drinking water series (SDG indicator 6.1.1), latest available year per country, 2015–2022.

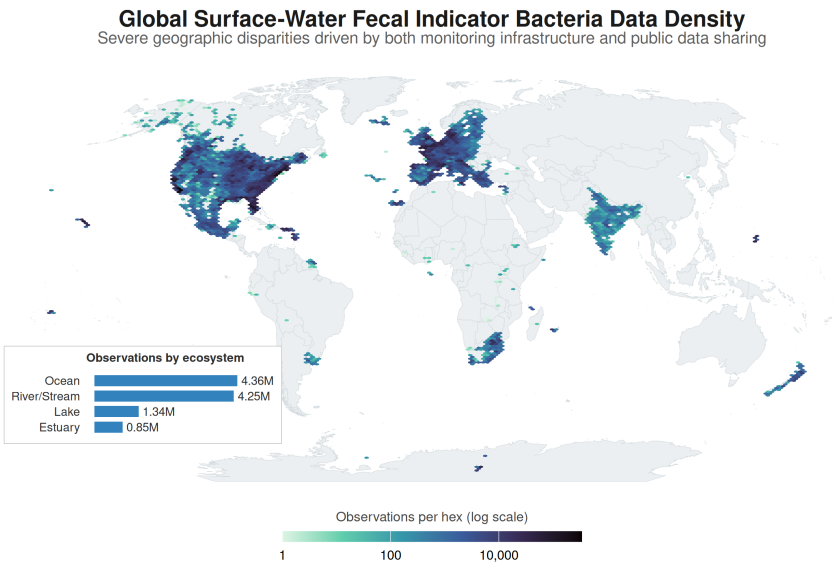


**Figure 1:** Global density of surface-water fecal indicator observations. Monitoring is concentrated in the United States and Europe, with sparse coverage across most of the Global South and a near-complete absence over Russia and China.

The pattern holds even in well-resourced cities. Along the Paris reach of the Seine, the annual geometric mean *E. coli* concentration can sit near 40 colony forming units per 100 mL while individual rainfall-driven combined-sewer-overflow events exceed 9,000, and occasionally 30,000. A calendar-based grab sample is roughly as likely to miss that hazard as to catch it.

## Key Findings

- **94.5% of the world's openly shared surface-water fecal indicator data come from the United States, Europe and Canada.** The remaining 5.5% is spread across the rest of the world, led by Mexico, South Africa and New Zealand.
- **Sparsity on the map often marks where data are *shared*, not where they are *collected*.** Several absent or thinly represented countries operate national monitoring programmes whose results never reach an open repository.
- **Only about 1.5% of multi-sample sites achieve a near-daily cadence**, and those sites are almost entirely confined to the United States.
- **Weekly sampling misadvises about one monitored day in nine; monthly sampling one in seven**, with errors biased toward false reassurance.
- **For fresh waters, both gaps are widest in the low- and middle-income regions that carry the greatest waterborne disease burden** and most often rely on untreated surface water for drinking. The monitoring gap is therefore a question of public health equity.
- **Twenty-four of 54 African countries have no JMP safely-managed drinking water estimate at all**, so the official global yardstick cannot see precisely the places where the risk is highest.

## Why This Is a Policy Failure, Not a Technical One

It is tempting to read the maps in this brief as a resource problem to be solved with more instruments. The evidence does not support that reading.

**The instruments exist.** The United States Water Quality Portal alone aggregates federal, state and tribal records at continental scale [7]. Culture-based assays are standardized, inexpensive and available in every country in this dataset.

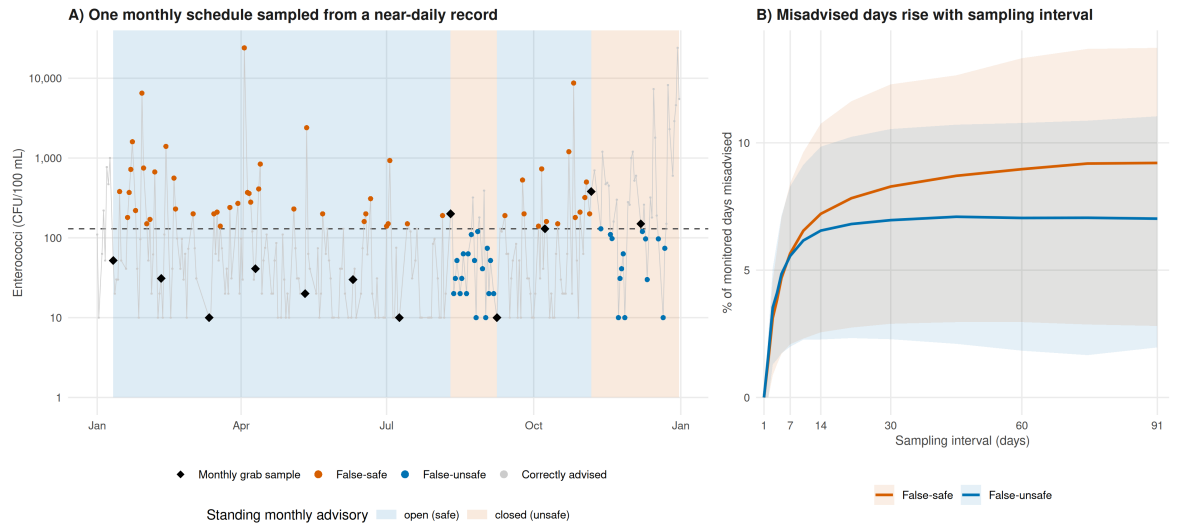


**Figure 2:** The safety cost of coarse sampling. As the sampling interval lengthens, the share of monitored days on which a standing advisory misrepresents the true state of the water rises, and the error is biased toward calling unsafe water safe.

**The data exist.** The absence of China and Russia from the open record is not an absence of monitoring. It is an absence of publication.

**The frequency is a design choice.** Regulatory thresholds such as the United States recreational water quality criteria [11] are defined for compliance statistics and implicitly assume representative sampling. Weekly, monthly and summer-season-only designs routinely violate that assumption, and no rule requires otherwise. Higher-frequency, event-based sampling and predictive nowcasting from rainfall, turbidity and discharge are demonstrated and operational [8], but they remain confined to a handful of intensively monitored sites.

**Measurement without accountability changes nothing.** Data acquire value only when tied to an actor who is answerable for the result and has an incentive to act on it [10]. Results-based finance supplies that link directly: because crediting is contingent on independent verification, monitoring becomes a recurring test an operator must pass rather than a passive reporting exercise. In carbon-financed water projects across sub-Saharan Africa, mandatory point-of-consumption verification revealed contamination that implementers had assumed was absent, and prompted correction: in one Kenyan project, successive verification rounds traced contamination through 51%, then 64%, and finally 7% of samples after the operator added in-line chlorination and dedicated site operators [2].

The binding constraints are mandates, standards and accountability. All three are instruments of policy.

## Implications and Recommendations

- **National regulators should mandate open publication of fecal indicator data as a condition of monitoring, not as a courtesy.** Data should be released in machine-readable form under FAIR principles [15], with location, method, detection limit and sampling time attached. The precedent exists: international exchange of meteorological data operates under exactly such norms.
- **Ministries of health and environment should replace fixed-calendar compliance sampling with risk-based, event-triggered sampling.** Sampling after rainfall, during combined-sewer-overflow events, and across the full exposure season captures the hazard that monthly grabs are structurally blind to.
- **Standard-setting bodies should state the sampling cadence their thresholds assume.** A single-sample criterion carries an implicit assumption of representative sampling. Making that

assumption explicit would expose, and begin to correct, the mismatch documented here.

- **SDG custodian agencies should publish data-sharing status and sampling frequency alongside every indicator estimate.** A national annual figure derived from a survey conducted every five years should not be presented with the same confidence as one derived from continuous ambient monitoring. Reporting the provenance is itself an accountability mechanism.
- **Development banks and donors should fund monitoring as accountability infrastructure, and condition disbursement on open publication.** Financing new stations without a publication mandate reproduces the sharing gap at greater expense.
- **Governments should pair every monitoring obligation with a named, accountable responder.** A measurement that no one is obliged to act on is an expense, not a safeguard.

## Final Remarks

The world's ability to see the safety of its water is not limited by what can be measured. It is limited by what governments require to be published, how often they require it to be sampled, and whether anyone is answerable for the answer. Those are choices, and they are being made badly in precisely the places where the health burden is greatest.

These mismatches will intensify. Fecal indicator pulses are driven by precipitation, runoff and temperature, all of which are shifting: heavier extreme rainfall mobilizes fecal material in shorter, sharper pulses, and lengthening warm seasons extend recreational exposure beyond the traditional bathing window around which monitoring programmes were built [12]. A cadence already too coarse to resolve today's transients will become less representative as the events it must capture grow more episodic. Because household surveys capture only multi-year snapshots, continuous ambient monitoring is needed to detect these shifts as they occur [5].

Closing the sharing gap requires no new science. Closing the cadence gap requires no new instruments. Both require policy.

## The Authors

*Professor Evan Thomas is Professor of Civil, Environmental and Architectural Engineering and Director of the Mortenson Center in Global Engineering at the University of Colorado Boulder, and founder and CEO of Virridy. He has spent fifteen years working on global water security, environmental sensing and WASH.*

*Dr. Matt Ross is an Associate Professor of Watershed Science in the Department of Ecosystem Science and Sustainability at Colorado State University and faculty director of the CSU Geospatial Centroid, working on how altered landscapes affect the streams and rivers that drain them.*

*Mike Vlah is a data scientist at Colorado State University who builds and synthesizes large watershed data products, including the MacroSheds and StreamPULSE projects.*

*Dr. Grace Oluwasanya is Senior Researcher: Water, Climate and Gender at UNU-INWEH, a WHO accredited Global Water Safety Plans trainer, and lead author of UNU-INWEH's assessments of water security and water governance in Africa.*

*Dr. Abraham Nunbogu is Researcher, WASH, at UNU-INWEH, working on water, sanitation and hygiene and the social dimensions of water insecurity.*

*Mir Matin is Manager of the Geospatial, Climate and Infrastructure Analytics Program at UNU-INWEH, working on geospatial analytics for water and climate decision-making.*

---



**Recommended Citation:** Thomas, E., Ross, M., Vlah, M., Oluwasanya, G., Nunbogu, A., Matin, M. (2026), *The World Cannot See Its Water: Data Sharing and Sampling Frequency Are Policy Failures, Not Technical Ones*, UNU Institute for Water, Environment and Health (UNU-INWEH), Richmond Hill, Ontario, Canada.

**doi:** [to be assigned] **ISBN:** [to be assigned]

**Evidence base:** This brief summarizes Vlah, M., Thomas, E., & Ross, M., *Eleven Million Measurements, Two Blind Spots: The State of Global Surface-Water Fecal Indicator Monitoring* (manuscript in preparation). Methods, uncertainty

and limitations are reported in full there.

## References


[1] Kathryn J. Brasier, Kirk Jalbert, Abby Kinchy, Susan L. Brantley, and Colleen Unroe. Barriers to sharing water quality data: experiences from the shale network. *Journal of Environmental Planning and Management*, 2017. doi: 10.1080/09640568.2016.1276435.

[2] John Ecklu, Corey Nagel, Laura MacDonald, and Evan Thomas. Tying payment to proof: verification requirements in carbon-financed water projects improve drinking water safety. Manuscript in preparation, 2026.

[3] European Parliament and Council of the European Union. Directive 2006/7/ec concerning the management of bathing water quality and repealing directive 76/160/eec. Official Journal of the European Union L 64, 2006.

[4] P. Hazell, P. Novitzky, and S. V. D. Oord. Socio-technical system analysis of responsible data sharing in water systems as critical infrastructure. *Frontiers in Big Data*, 2023. doi: 10.3389/fdata.2022.1057155.

[5] R. Hope. Four billion people lack safe water. *Science*, 385:708–709, 2024.

[6] Sabrina Kirschke, Tamara Avellán, Ilona Bärlund, János J. Bogárdi, Laurence Carvalho, Deborah V. Chapman, Chris Dickens, Kenneth Irvine, SungBong Lee, Thomas Mehner, and Stuart Warner. Capacity challenges in water quality monitoring: understanding the role of human development. *Environmental Monitoring and Assessment*, 2020. doi: 10.1007/s10661-020-8224-3.

[7] Emily K. Read, Lindsay Carr, Laura A. De Cicco, Hilary A. Dugan, Paul C. Hanson, Julia A. Hart, James Kreft, Jordan S. Read, and Luke Winslow. Water quality data for nationalscale aquatic research: The water quality portal. *Water Resources Research*, 2017. doi: 10.1002/2016wr019993.

[8] Ryan T. Searcy, Jacob R. Phaneuf, and Alexandria B. Boehm. High-frequency fecal indicator bacteria (fib) observations to assess water quality drivers at an enclosed beach. *PLoS ONE*, 2023. doi: 10.1371/journal.pone.0286029.

[9] Z. Sugg. Social barriers to open (water) data. *WIREs Water*, 2021. doi: 10.1002/wat2.1564.

[10] Evan Thomas, Jean Ntazinda, and Styvers Kathuni. Applying climate reparative finance toward water security. *Science of the Total Environment*, 875:162506, 2023. doi: 10.1016/j.scitotenv.2023.162506.

[11] U.S. Environmental Protection Agency. Recreational water quality criteria. Technical Report EPA 820-F-12-058, U.S. Environmental Protection Agency, Office of Water, 2012.

[12] M. T. H. van Vliet et al. A triple increase in global river basins with water scarcity due to future pollution. *Nature Communications*, 15:891, 2024.

[13] T. Wade, B. Arnold, K. Schiff, J. Colford, S. Weisberg, J. Griffith, and A. Dufour. Health risks to children from exposure to fecally-contaminated recreational water. *PLoS ONE*, 2022. doi: 10.1371/journal.pone.0266749.

[14] WHO and UNICEF. Progress on household drinking water, sanitation and hygiene 2000–2020: Five years into the sdgs. Technical report, World Health Organization and UNICEF, 2021.

[15] Mark D. Wilkinson, M. Dumontier, I. J. Aalbersberg, Gabrielle Appleton, M. Axton, A. Baak, N. Blomberg, J. Boiten, Luiz Olavo Bonino da Silva Santos, P. Bourne, J. Bouwman, A. Brookes, Tim Clark, M. Crosas, I. Dillo, Olivier Dumon, S. Edmunds, C. Evelo, R. Finkers, Alejandra N.

González-Beltrán, A. Gray, Paul Groth, C. Goble, J. Grethe, J. Heringa, P. '. t Hoen, R. Hooft, T. Kuhn, Ruben G. Kok, J. Kok, S. Lusher, M. Martone, Albert Mons, A. Packer, Bengt Persson, P. Rocca-Serra, M. Roos, Rene C. van Schaik, S. Sansone, E. Schultes, T. Sengstag, Ted Slater, George O. Strawn, M. Swertz, Mark Thompson, J. van der Lei, Erik M. van Mulligen, Jan Velterop, A. Waagmeester, P. Wittenburg, K. Wolstencroft, Jun Zhao, and B. Mons. The fair guiding principles for scientific data management and stewardship. *Scientific Data*, 2016. doi: 10.1038/sdata.2016.18.

[16] J. Wolf, R. Johnston, A. Ambelu, B. Arnold, Robert E S Bain, Michael Brauer, Joe Brown, B. Caruso, T. Clasen, J. Colford, J. Mills, B. Evans, M. Freeman, Bruce Gordon, Gagandeep Kang, C. Lanata, K. Medlicott, A. Prüss-Ustün, C. Troeger, Sophie Boisson, and O. Cumming. Burden of disease attributable to unsafe drinking water, sanitation, and hygiene in domestic settings: a global analysis for selected adverse health outcomes. *The Lancet*, 2023. doi: 10.1016/S0140-6736(23)00458-0.