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# EDITORIAL MESSAGE

## Flowpath 2025 Torino: monitoring, modelling and management of groundwater resources in a changing environment

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Flowpath is the National Meeting on Hydrogeology promoted by the Italian Chapter of the International Association of Hydrogeologists. Since its first editions, the meeting has provided a place where young hydrogeologists, researchers, professionals, public administrations and water managers can meet, exchange experiences and discuss current challenges in groundwater science and practice. Its main objectives are to promote dialogue among the new generations of hydrogeologists, to explore the role of groundwater in a changing climate, to update the scientific and professional community on emerging hydrogeological issues, and to encourage the contribution of researchers, practitioners and institutions to the sustainable management of groundwater resources.

The first edition of Flowpath was held in Bologna in 2012 and opened a scientific path that has grown through the following meetings in Viterbo, Cagliari, Milano, Napoli and Malta. Across these editions, the conference has progressively addressed the main themes of Italian and international hydrogeology: groundwater quality and protection, contaminant hydrogeology, mineral and thermal waters, fractured rocks and karst aquifers, groundwater flow and transport modelling, urban hydrogeology, groundwater management in arid and semi-arid regions, climate change, sustainability, geothermal resources, coastal and volcanic aquifers, groundwater-dependent ecosystems, and policies for groundwater protection. Flowpath 2025 is part of this continuity and brings these themes into the present discussion on monitoring, modelling, ecological sustainability and resource management.

Following the overview of Flowpath 2025 already published in Acque Sotterranee – *Italian Journal of Groundwater* (Lasagna et al., 2025), this special issue gathers selected scientific contributions presented within the framework of the seventh National Meeting on Hydrogeology held in Torino.

Flowpath 2025, held in Torino from 11 to 13 June 2025, continued this tradition and confirmed the vitality of the Italian hydrogeological community. The scientific programme was organized around four main sessions: Groundwater quality and protection; Groundwater and climate change: impact and opportunity; Groundwater modelling: development and application; and Hydrogeological systems and processes: from local to regional scale. These themes reflect the broad field of contemporary hydrogeology, where the protection of groundwater quality, the assessment of climate-related changes, the development of quantitative tools and the understanding of hydrogeological processes are closely connected.

The papers collected in this special issue of Acque Sotterranee – *Italian Journal of Groundwater* provide a coherent representation of this scientific framework. The selected contributions describe applied case studies, quantitative approaches and tools for communicating hydrogeological information. They move across different geological and environmental contexts, from Alpine springs to Apennine carbonate aquifers, from groundwater-fed rivers to complex volcanic multi-aquifer systems. Together, they offer a clear picture of groundwater research as a discipline rooted in field observations and supported by long-term monitoring, conceptual modelling, numerical simulation and integrated management approaches.

The contribution by Di Matteo et al. (2026) illustrates how ecological flow assessment can be developed as an integrated hydrogeological and ecological process. The study focuses on the Nera River, in Central Italy, a groundwater-fed river system sustained by carbonate aquifers and involved in multiple uses, including drinking-water supply, ecosystem conservation, hydropower production, fish farming and recreation. Within this framework, the authors bring together hydrological, hydrogeological, hydrobiological, hydromorphological and hydrochemical information to describe the river as a dynamic interface between groundwater circulation, ecological functioning and water management. The work gives particular relevance to the connection between aquifer behaviour, river discharge and habitat requirements, in line with the objectives of the European Water Framework Directive (2000/60/EC). Its main value lies in the integrated procedure proposed for supporting ecological flow definition in groundwater-dependent river systems, offering a useful reference for management contexts where water withdrawals and ecosystem needs share the same hydrogeological resource.

The paper by Martarelli et al. (2026) brings the special issue to the Apennine carbonate systems and to the hydrogeological response of fractured aquifers after the 2016–2017 Central Italy seismic sequence. The study focuses on the high valley of the Tenna River, in the Sibillini Mountains, and develops a local conceptual model based on field hydrogeological surveys, stream discharge measurements and in situ hydrochemical observations. Its main contribution lies in the way the authors use the river course as a

natural section through the groundwater system, describing groundwater–surface water exchanges along different elevation sectors. This approach highlights the role of recharge areas, lithostratigraphic thresholds, aquifer geometry and tectonic fragmentation in controlling hydraulic behaviour. The paper therefore provides a detailed example of how post-seismic hydrogeological dynamics can be interpreted through the integration of field measurements and conceptual modelling at the catchment scale.

Gizzi et al. (2026) address the role of long-term spring monitoring in mountain hydrogeology. The study focuses on Alpine springs in the Aosta Valley and shows how continuous records of water level, temperature and electrical conductivity can be transformed into information on aquifer dynamics, recharge behaviour and water-resource availability. The paper gives particular attention to the interpretation of long time series, comparing springs characterized by more buffered responses with springs showing stronger interannual variability. This comparison supports a site-specific reading of Alpine groundwater systems, where geology, aquifer structure and climatic forcing combine in different ways. A further strength of the contribution is the attention given to scientific communication: graphical tools such as heatmaps, bubble charts and volume equivalents are used to translate hydrogeological information into forms that can support dialogue with managers, institutions and wider technical audiences.

The methodological contribution by De Caro et al. (2026) focuses on groundwater modelling and inverse calibration in complex hydrogeological settings. The paper applies Ensemble Space Inversion to a MODFLOW-USG model of a multilayer volcanic aquifer system in an industrial area of Central Italy, where the model supports the design of a hydraulic barrier. The value of the work lies in the calibration strategy, which projects a high-dimensional inverse problem into a reduced ensemble space while maintaining geological plausibility in the reconstructed parameter fields. The approach combines stochastic realizations, pilot-point parameterization and a large hydraulic dataset to obtain a calibrated model suited to decision support. In this perspective, the paper illustrates how advanced inverse methods can strengthen the operational use of numerical models in heterogeneous aquifers, especially where groundwater management requires both computational efficiency and physically meaningful parameter distributions.

Taken together, these contributions describe a common direction in groundwater science. Process understanding, quantitative tools and management needs are increasingly connected. Field surveys, monitoring networks, ecological indicators, hydrochemical data and numerical models form a shared framework for studying groundwater systems and supporting decisions. From Alpine springs to Apennine carbonate aquifers, from groundwater-fed rivers to volcanic multi-aquifer systems, the papers collected in this special issue highlight the value of integrated hydrogeological approaches for water-resource protection, ecological sustainability and decision-making under uncertainty.

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## REFERENCES

De Caro, M., Pollicino, L., Formentin, G. (2026). Ensemble Space Inversion (ENSI) yields efficient and realistic calibration of a multi-layer volcanic aquifer model. Acque Sotterranee - Italian Journal of Groundwater, 15(2), 51 - 62. https://doi.org/10.7343/as-2026-959

Di Matteo, L., Cardellini, C., Casadei, S., Cencetti, C., Lorenzoni, M., Carosi, A., Bartoletti L., Cambi, C.,Cappelletti, D., Checcucci, R., De Filippis, R., De Rosa, P., Fredduzzi,A., Frondini, F., Guerrieri, F., Manucci, A., Ortenzi, S., Stelluti, M., Taviani, S., Tieri, M., Valigi, D. (2026) Evaluating ecological flow river-fed by carbonate aquifers: results from an integrated multidisciplinary approach on the Nera River (Central Italy). Acque Sotterranee - *Italian Journal of Groundwater*, 15(2), 09 - 20. https://doi.org/10.7343/as-2026-938

Gizzi, M., Bianco, F., Suozzi, E., Fiorucci, A., Taddia, G. (2026). Revealing spring discharge variability through Long-Term Hydrogeological Monitoring: insights from case studies in the Aosta Valley. Acque Sotterranee - *Italian Journal of Groundwater*, 15(2), 41 - 49. https://doi.org/10.7343/as-2026-962

Lasagna, M., Taddia, G., Cocca, D., Egidio, E., De Luca, D.A., Gizzi, M., Vagnon, F., Rusi, S., Da Pelo, S. (2025) Torino capitale dell'idrogeologia: il racconto di Flowpath 2025 - Turin, Capital of Hydrogeology: The Story of Flowpath 2025, Acque Sotterranee - *Italian Journal of Groundwater* (2025) - AS53-898: 105 – 111, DOI 10.7343/as-2025-898

Martarelli, L., Gafà, RM., La Vigna, F., Monti, GM., Silvi, A., Cipriani, A., (2026). Hydrogeological monitoring of groundwater resources within the High Valley of the Tenna River (Sibillini Mts. Range, Central Italy) and possible near-field effects from the 2016-2017 Central Italy seismic sequence. Acque Sotterranee - *Italian Journal of Groundwater*, 15(2), 23 - 38. https://doi.org/10.7343/as-2026-946