WORLD METEOROLOGICAL ORGANIZATION

WMO HydroHub

WMO-OGC Workshop "GroundWaterML2 standard"

10 March 2022

Workshop Report

April 2022

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Opening

The WMO-OGC Workshop "GroundWaterML2 standard" was opened by Johannes Cullmann (Water & Cryosphere Director, World Meteorological Organization (WMO)) and Joshua Lieberman (Innovation Program Director, Open Geospatial Consortium (OGC)).

Mr Cullmann highlighted the fact that the GroundWaterML2 standard (GWML2) opens the door for countries and agencies to use groundwater information jointly and efficiently, and improves groundwater resources management, given its vital importance in the context of climate change.

Mr Lieberman gave a brief presentation on the work of the OGC, the importance of groundwater resources and the adoption of GWML2.

Introduction

Michel Jean (President, WMO Infrastructure Commission) highlighted two main points:

- WMO approach to earth systems: in the context of the water cycle, groundwater is a fundamental missing link in terms of closing the water budget from a modelling perspective.
- Interaction with geological organizations worldwide: The WMO interacts with geological surveys on volcanic ash, tsunami warning, permafrost issues, and weather forecast. These types of collaboration need to be broadened.

WMO needs and plans for GroundWaterML2 standard

Silvano Pecora (Vice-President, WMO Infrastructure Commission) gave a presentation on WMO needs and plans for GWML2, focusing on the WMO GWML2 implementation action plan. His presentation focused on the adoption of the WaterML2 suite of standards, including GWML2.

Introduction to GroundWaterML2 standard

Eric Boisvert (Geological Survey of Canada) introduced GWML2, providing detailed background information about its development and explaining what it covers.

Also, Eric Boisvert and Silvano Pecora spoke about GWML2 models and their use. The published model has three levels with different scopes:

- Conceptual model: major concepts and relationships are the same between two systems, but they may differ in the details so there is less exchangeability.
- Logical model: there is the exchange of 100% of information without loss, but maybe with some transformation.
- Physical model: files can be exchanged, and information remain the same.

Demonstrations of GroundWaterML2 standard implementation

In this session, the following speakers presented their experience in implementing GWML2 in various countries.

- **Eric Boisvert (Geological Survey of Canada):** Mr Boisvert stated that after reports showed that data is hard to find and use, and there are data gaps and poor data quality, Canada initiated the Groundwater Information Network to harmonize access to data from heterogeneous sources. GWML2 provides an integration model for all those sources. The Geological Survey of Canada developed a specific implementation to deal with specific use cases. This kind of implementation has pros and cons:
    - There is no mapping: the database is complex but flexible
    - Fast and not limited to GWML2
    - Supports polymorphism
    - No way to add more data types without editing code

- **David Blodgett, Ben Sperl & Candice Hopkins (United States Geological Survey):** Mr Blodgett started the presentation by introducing two areas of work where GWML2 is playing a significant role: Water Data for the Nation (WDFN) and the National Hydrologic Geospatial Fabric. Further, Mr Sperl spoke about the National Water Well Database (NWWDB) - state-managed water-well databases shared with the USGS by agencies - which uses GWML2 as base to harmonize data. After, Ms Hopkins gave a presentation about Water Data for the Nation (WDFN) and National Groundwater Monitoring Network (NGMWN), used to modernize data delivery.

- **Andrew MacLeod & Peter Dahlhaus (Federation University Australia):** Mr Dahlaus presented the project "Visualising Victoria's Groundwater", an interoperative spatial information portal that federates groundwater data from disparate sources. Further, Mr MacLeod explained the GWML2 Interoperability Experiment.

- **Alexander Kmoch (University of Tartu, Estonia):** Mr Kmoch presented the Groundwater HUB, a groundwater SDI project which was part of the Smart Aquifer Characterization Project in New Zealand, which involved several actors from New Zealand and Europe. It implemented federated data services from different agencies, including the GNS Geothermal and Groundwater Database (GGW) in order to provide data inputs in standardized formats, i.e. as GWML2 and WaterML2, for visualization and modelling of groundwater flows. The project ended in 2017.

- **Sylvain Grellet (Bureau de recherches géologiques et minières, France):** Sylvain presented the deployment of GWML2 for the French Groundwater Information Network and the Geological Information and Modelling (GIM) community of the EU Research Infrastructure EPOS.

Moderated Discussion on the benefits of GWML2 implementation

In this segment, Claudia Ruz Vargaz (International Groundwater Resources Assessment Centre (IGRAC)) moderated a discussion on the GWML2 benefits with the presenters of the previous segment.

The main points highlighted in this discussion are:

- Eric Boisvert: the advantage of GWML2 is that it is a way to harmonize information and have a systematic model to integrate all the information from several sources. Since the data is heterogeneous you must target one model: the GWML2 model is very complete and can wedge a lot of observation data.
- Ben Sperl: a big part of adapting this standard to our work comes from its openness and inclusivity, so that rather than us inventing another database internal to our organization, we are leveraging the work of the open community. It's very suitable.
- Candice Hopkins: one of the benefits of GWML2 is harmonization, that also leads to interoperability.
- Sylvain Grellet: GWML2 allows us to save time while exchanging/comparing data. Also, native support by tools is another aspect to be considered when using this standard.
- Andrew MacLeod: our research centre spent many years trying to harmonize disrupt systems adhering to a standard, which is the advantage of every standard and makes life so much easier.
- Peter Dahlhaus: we get a lot of benefits from a research point of view.
- Alexander Kmoch: we were trying to support data access for environmental assessments and modelling, such as flow models or groundwater vulnerability. We also talked to many stakeholders on what tools they use for these models. And because everybody needs to load data from somewhere and then fit it into their modelling software, and they know that there is friction. This shows how important harmonization is.

This section continued with a Q&A session, moderated by Claudia Ruz Vargaz:

Philipp Saile (International Centre for Water Resources and Global Change): how will GWML2 fit into WMO's ambitions? Is there a plan to scale it at the global level? What's the view on how can the groundwater standard relate to surface water standards?

- Joshua Liebermann: there are two scales in which standardisation is useful: consolidation and comparability of things like water quality in multiple regions, which is very important for WMO. But it's important to look at regions and collaboration that can happen: the potential for GWML2 and other standards to provide the basis for a particular work in a specific region is yet to be realized but it's on the way. Being able to continue running models and sub-models as part of that

infrastructure totally depends on standards such as GWML2 that combine water and the environment in which it moves.

- Sylvain Grellet: what we want to do during the upcoming WMO-OGC Water Quality Interoperability Experiment is to build on previous standards. The main challenge would be on groundwater and surface water connection and how we choose to link them in the models.

Stephan Dietrich (International Centre for Water Resources and Global Change): interoperability between groundwater and surface water: if you speak about soil moisture, how is it covered by the standard? Is it handled by GWML2 or is it more referred to what OGC is doing with soil data?

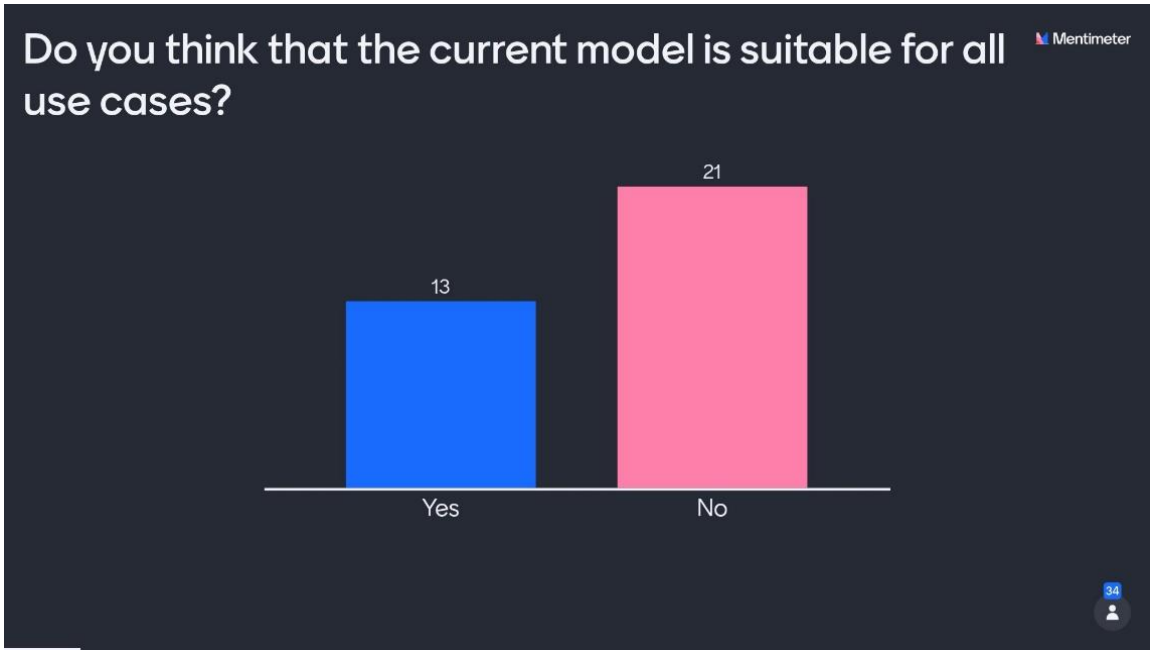
- Eric Boisvert: if you look at specifications about discharge/recharge, you will have a connection to *any feature* (OGC Abtract Feature): as soon as water leaves the aquifer, the aquifer connects to another reservoir (it can be a river, lake, ocean etc). It is a feature that can be defined in other OGC specifications. This is one way to do it. The other way to do it, is that there is a duality in the model simply because of observations and measurements: you can model everything using the OGC/ISO standard Observations & Measurements (O&M), you delegate all the feature model and specifications as vocabulary so there is always duality. You can specify something like water quality right into the model and you'll always have the observations and measurements counterpart.
- David Blodgett: we need to have the ability to make linkages, and we have that ability. That said, there is a need for groundwater and surface water interaction scheme of some sort, and there has been discussion on how we can build some standardization around recharge areas, other types of interfaces between things that are usually thought of as different. Now that we have the WaterML2.0 Part. 4: GroundWaterML2.0, the idea of having this interface classes express specific kinds of linkages between the way we conceptualize surface water and groundwater, that is now possible because we have these two specifications.

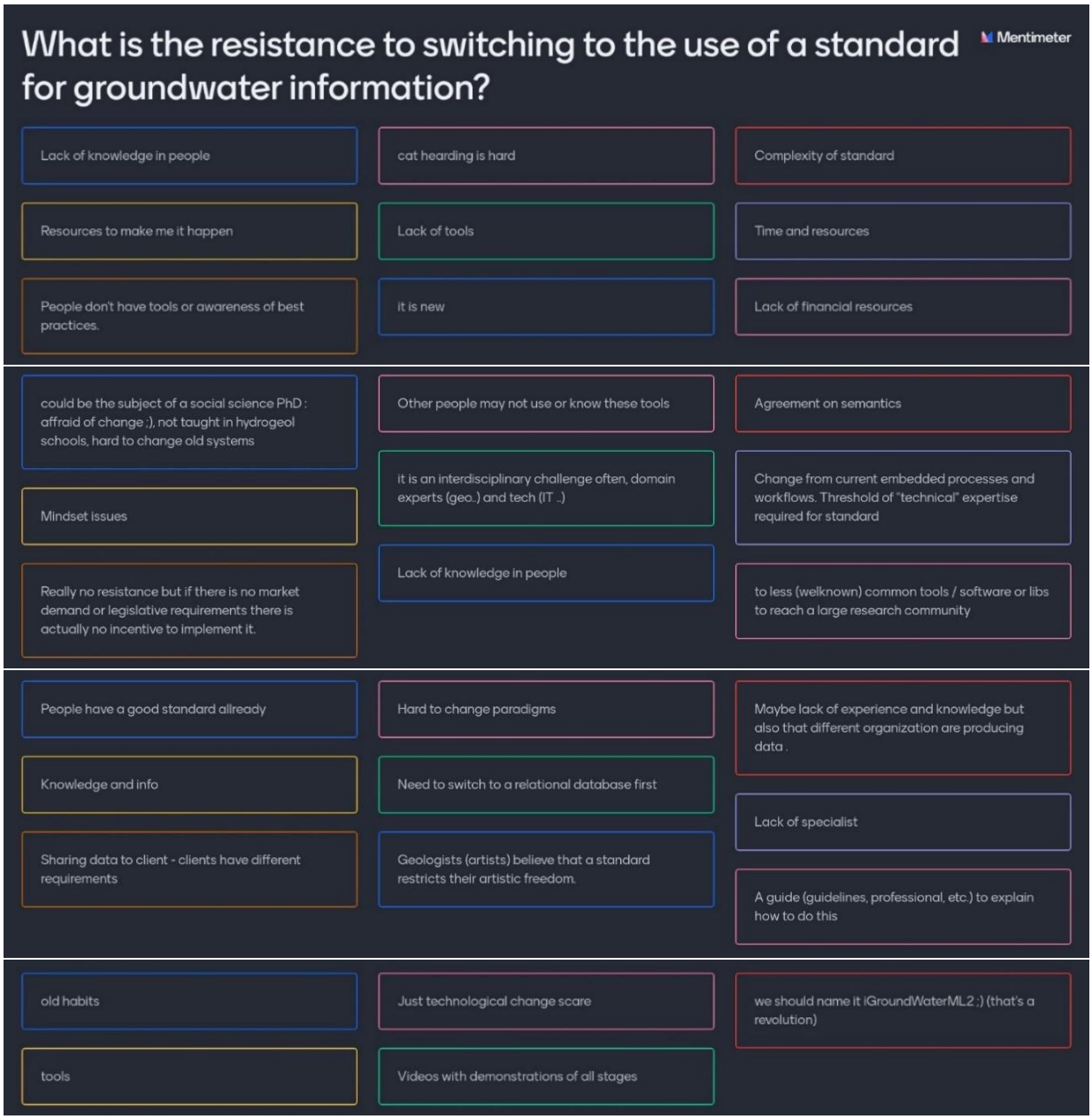
Audience-focused Panel Discussion: Further GWML2 implementation

In this segment, Claudia Ruz Vargas moderated an interactive discussion about further GWML2 implementation. The figures below show the responses of workshop participants to interactive questions and polls carried out through the Mentimeter tool on each speaker's topic.

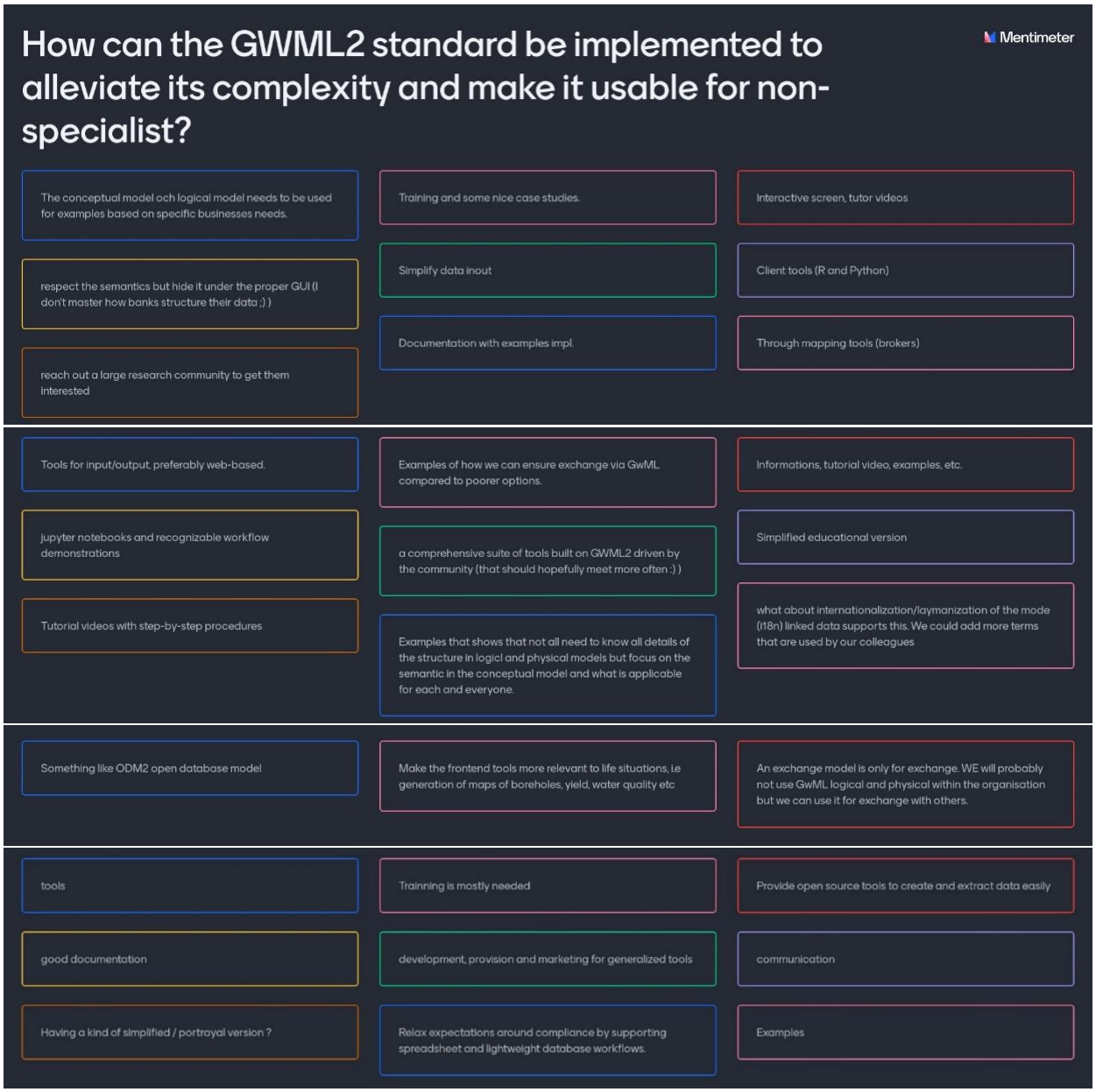
1. **Potential barriers of GWML2 implementation (presented by David Blodgett)**
   GWML2 was developed as a relatively pure and straightforward model that builds off an ISO baseline of data models that brings in complexity, a complexity which is very useful for those who are familiar with ISO baseline. But for those who are not familiar with it, there is a very steep learning curve, and that logical base in the GML markup language is complicated. The

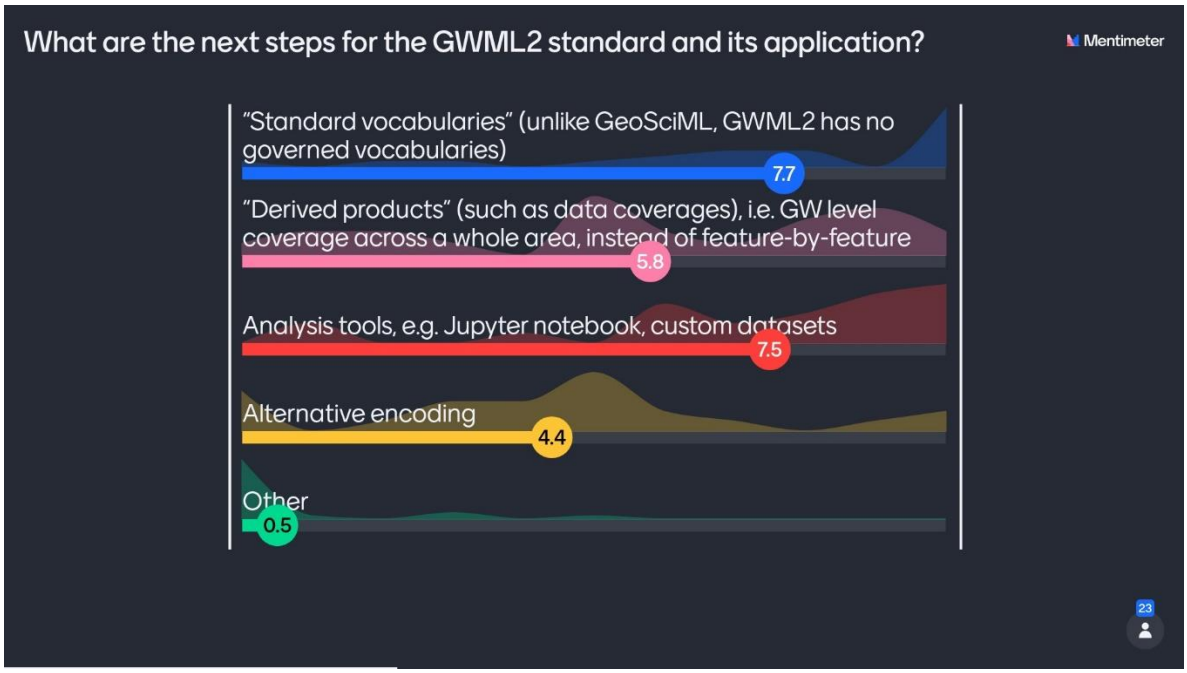
XML implementation is very useful for some use cases, but it is not very suitable for the web-friendly world we live in now. That's where the barriers are. Another problem is getting GWML2 concepts and encodings embedded in the same data systems used to submit information from field work to a corporate database or else. These pathways to get standardized data into a system as standardized data rather than as hack-field data that meet the needs of the drill operator and reporting agencies is another area of work where there is some friction.



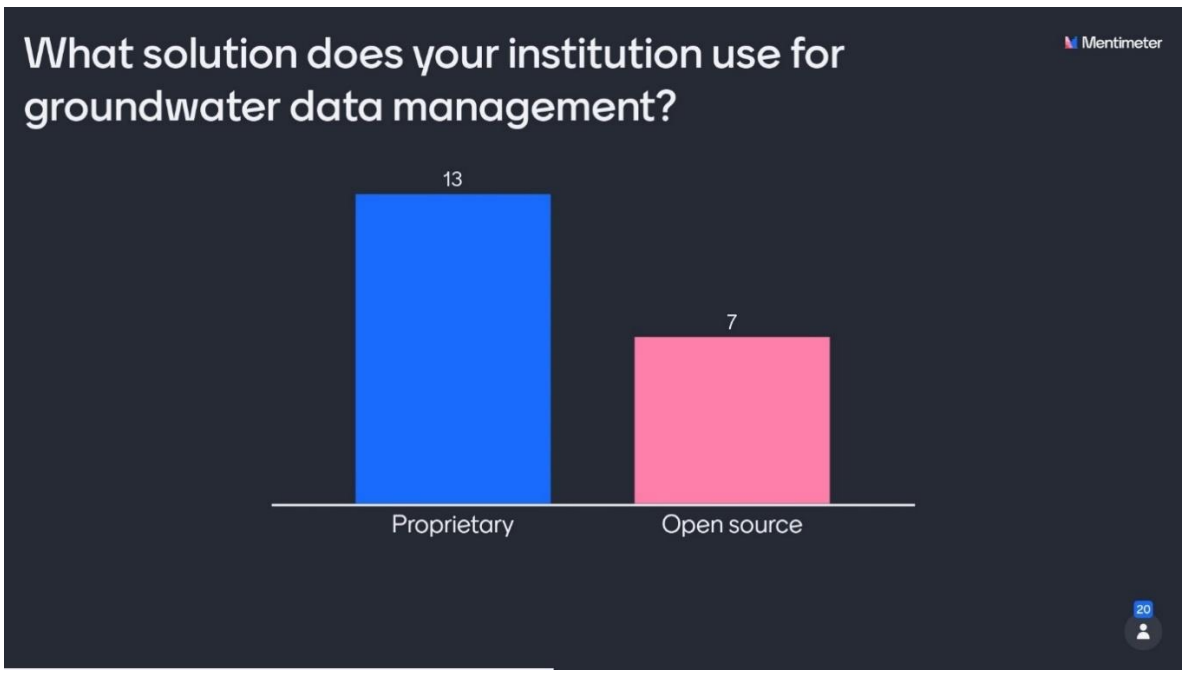


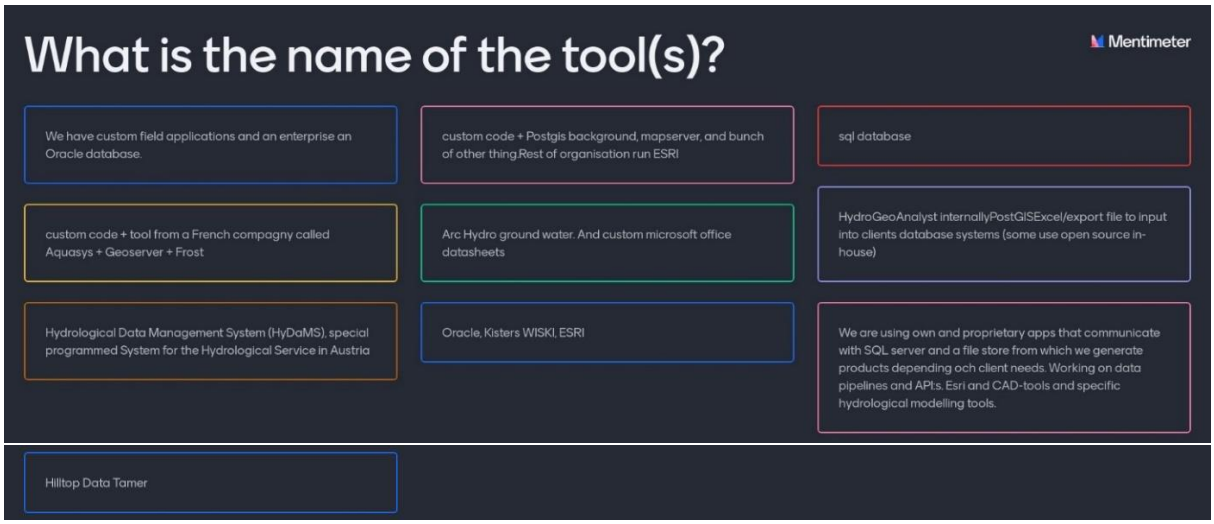
2. **How to overcome the barriers (e.g., training activities)? (presented by Eric Boisvert)**
   There are two things missing. The first one is tools: we need tools to translate the technology part of interacting with the model with what users understand, because sometimes we use terms in the model that does not exactly reflect everyday concepts. You also need documents and best practices on how to implement and how to use the system. The other way to expose GWML2 is to scale down to a specific set of tools, we need to have a way to create some sub-sets of usable data for API and a way to connect this information back to the full canonical representation (which is GWML2). So, tools, best practices, and custom design APIs.

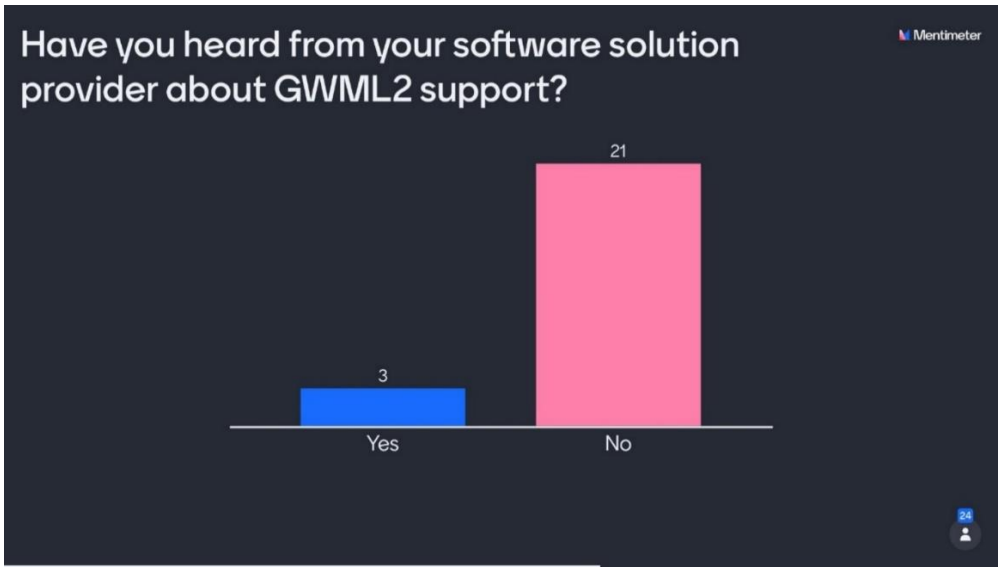

How can the GWML2 standard be implemented to alleviate its complexity and make it usable for non-specialist?
Mentimeter
The conceptual model och logical model needs to be used for examples based on specific businesses needs.
Training and some nice case studies.
Interactive screen, tutor videos
respect the semantics but hide it under the proper GUI (I don't master how banks structure their data ;))
Simplify data inout
Client tools (R and Python)
Documentation with examples impl.
Through mapping tools (brokers)
reach out a large research community to get them interested
Tools for input/output, preferably web-based.
Examples of how we can ensure exchange via GwML compared to poorer options.
Informations, tutorial video, examples, etc.
jupyter notebooks and recognizable workflow demonstrations
a comprehensive suite of tools built on GWML2 driven by the community (that should hopefully meet more often :))
Simplified educational version
Tutorial videos with step-by-step procedures
Examples that shows that not all need to know all details of the structure in logicl and physical models but focus on the semantic in the conceptual model and what is applicable for each and everyone.
what about internationalization/laymanization of the mode (i18n) linked data supports this. We could add more terms that are used by our colleagues
Something like ODM2 open database model
Make the frontend tools more relevant to life situations, i.e generation of maps of boreholes, yield, water quality etc
An exchange model is only for exchange. WE will probably not use GwML logical and physical within the organisation but we can use it for exchange with others.
tools
Trainning is mostly needed
Provide open source tools to create and extract data easily
good documentation
development, provision and marketing for generalized tools
communication
Having a kind of simplified / portrayal version ?
Relax expectations around compliance by supporting spreadsheet and lightweight database workflows.
Examples

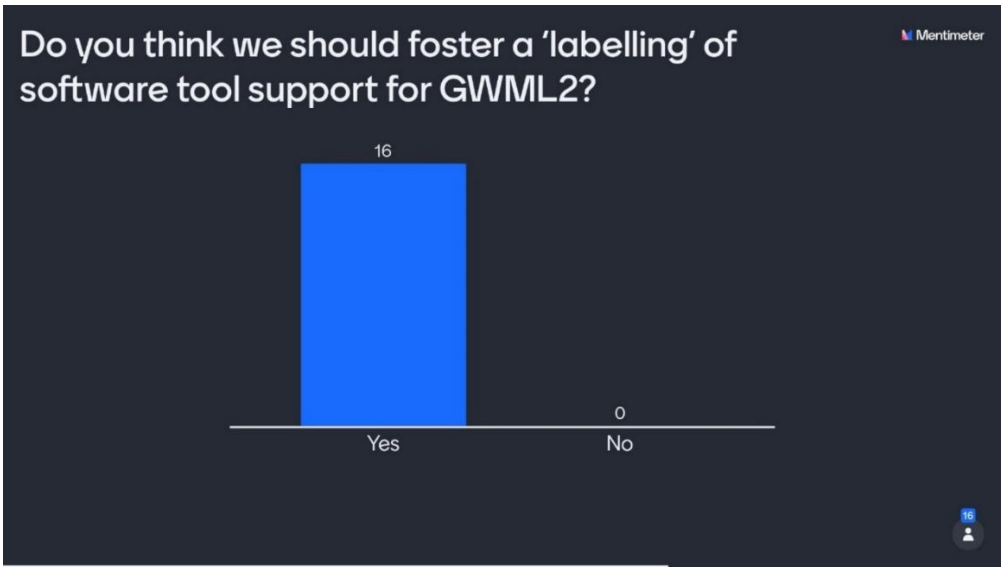


3. **GWML2 integration with off-the-shelf solutions (presented by Grellet Sylvain)**
   In an ideal world we should use internationally agreed standards to exchange data. Going even further, domain expert should use tools that implement GWML2 natively "under the hood" without even knowing this. There is a lack of coordination among organizations that slows down reaching this target. We also need feedback from the community on what is implemented in each organization.



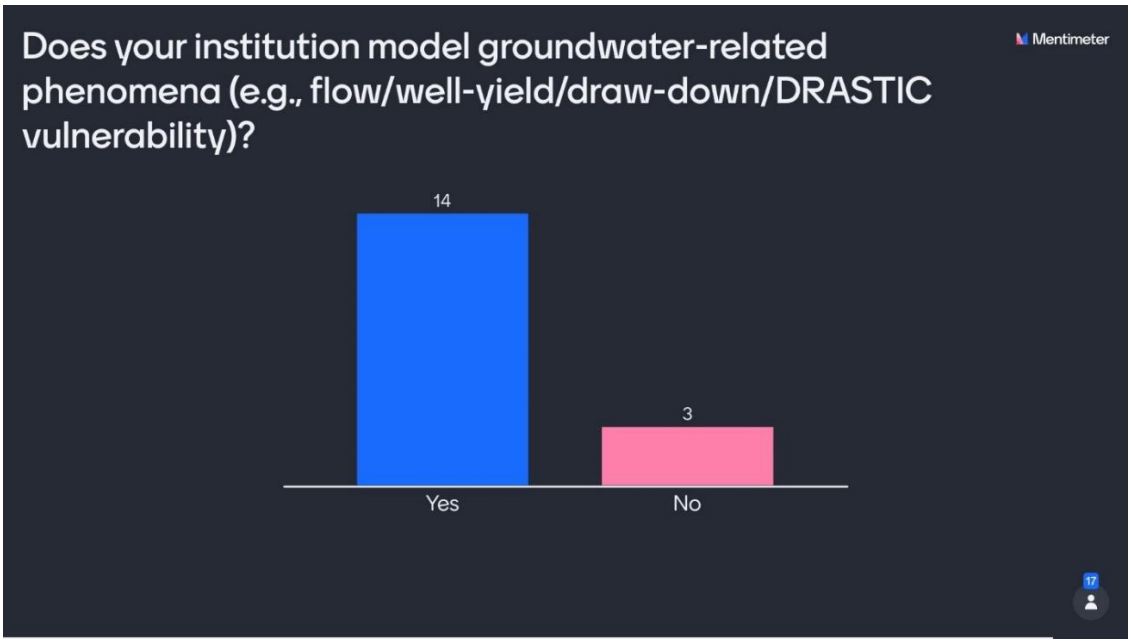

What is the name of the tool(s)?
Mentimeter
We have custom field applications and an enterprise an Oracle database.
custom code + Postgis background, mapserver, and bunch of other thing.Rest of organisation run ESRI
sql database
custom code + tool from a French compagny called Aquasys + Geoserver + Frost
Arc Hydro ground water. And custom microsoft office datasheets
HydroGeoAnalyst internallyPostGISExcel/export file to input into clients database systems (some use open source in-house)
Hydrological Data Management System (HyDaMS), special programmed System for the Hydrological Service in Austria
Oracle, Kisters WISKI, ESRI
We are using own and proprietary apps that communicate with SQL server and a file store from which we generate products depending och client needs. Working on data pipelines and APIs. Esri and CAD-tools and specific hydrological modelling tools.
Hilltop Data Tamer

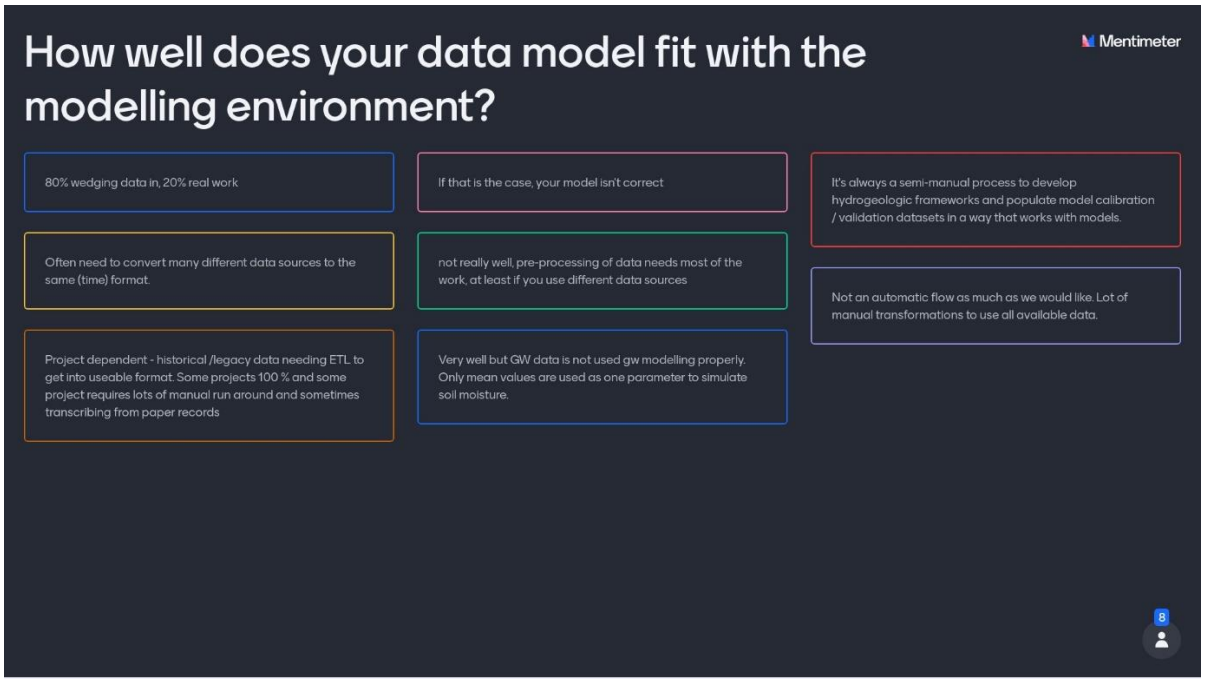

Have you heard from your software solution provider about GWML2 support?
Mentimeter
21
3
Yes
No
24


Do you think we should foster a 'labelling' of software tool support for GWML2?
Mentimeter
16
0
Yes
No
16

4. **GWML2 implementation in developing countries (presented by Bochengedu Somolekae)**
Bochengedu Somolekae (SADC Groundwater Management Institute) gave a presentation on GWML2 implementation in developing countries, specifically in the SADC Region. He explained that in terms of data collection, each one of these countries collects their own data and cooperate through government and institutional framework in carrying out projects. He then proceeded to explain more in depth three projects - SADC-HYCOS (Southern Africa), Zambezi Water Resources Information Systems (ZAMWIS) and Botswana Integrated Groundwater Resources Data Management System – lessons learnt from these, challenges, and way forward.

5. **GWML2 Integration with modelling tools (presented by Alexander Kmoch)**
Getting data from one place to another can be a challenging work. Ideally, we want to have models not only to understand a groundwater system once, but also to operationally monitor it in the long-term.

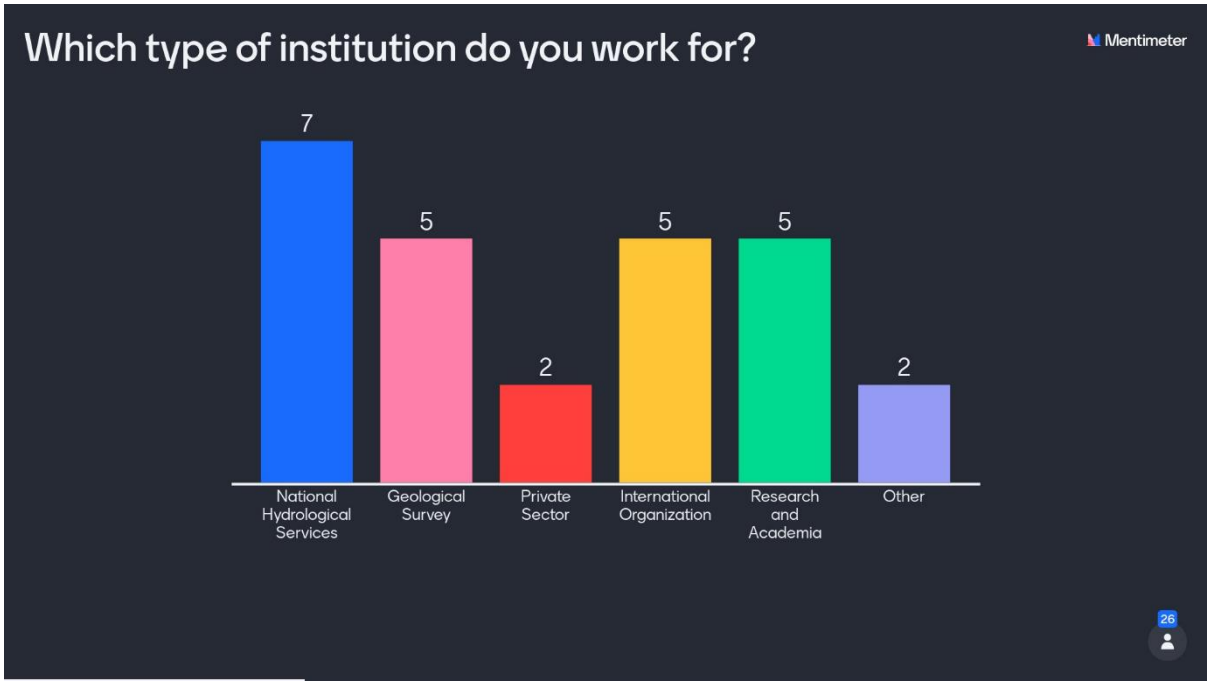


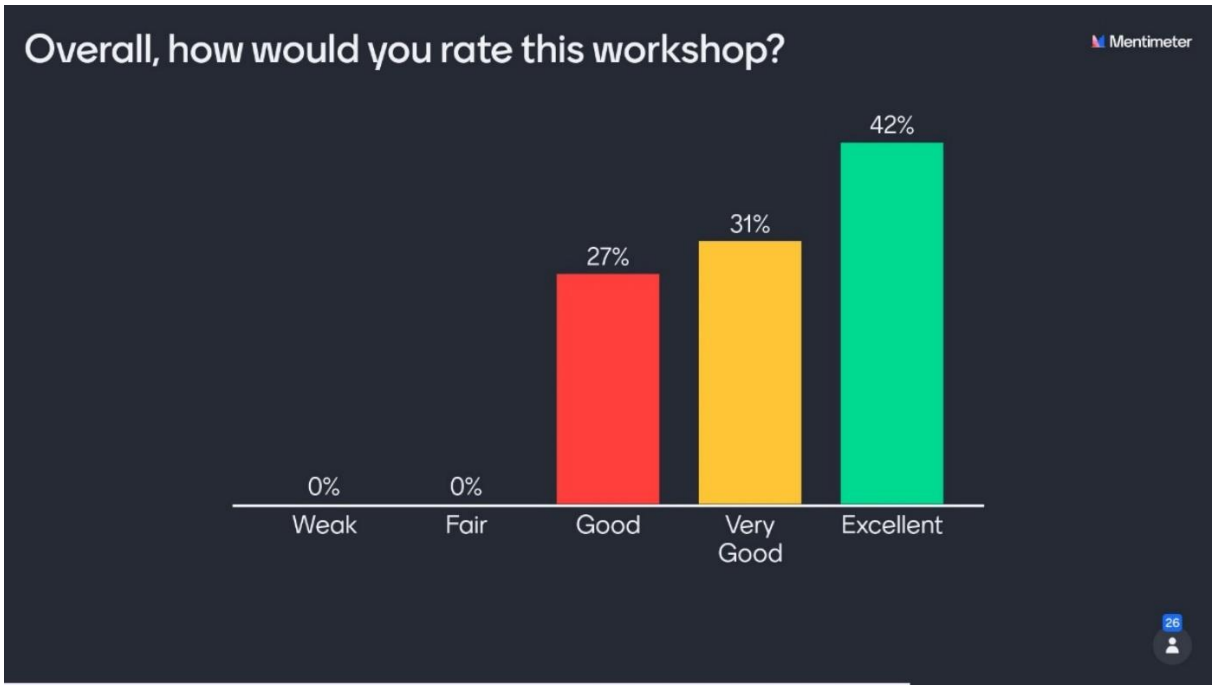


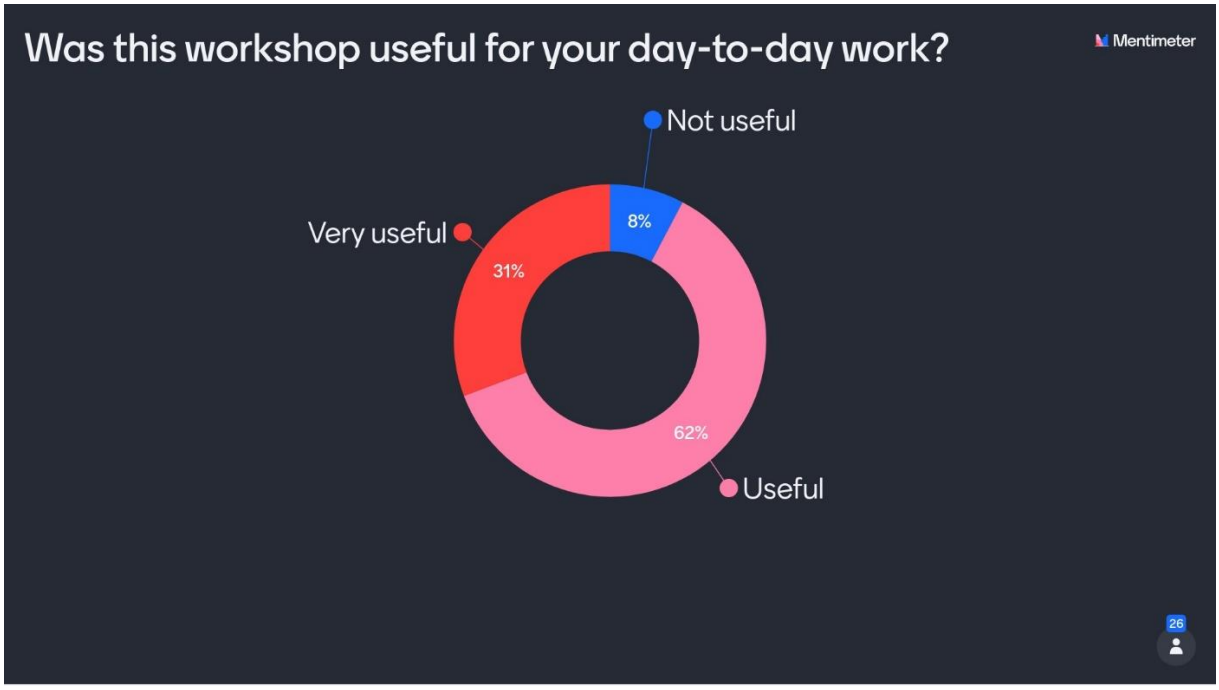
Workshop Participation & Evaluation Survey

Overall, **143 participants** attended the Workshop.

At the end of the workshop, the evaluation survey was opened to the workshop participants. The results of the survey completed by 27 participants are shown below:







Closing

At the end of the workshop, Silvano Pecora gave his closing remarks. The main points that he highlighted are:

- This workshop provided the content for the definition of a roadmap to implement GWML2.

- The adoption of a standard is a valuable result, but it is the conclusion of a process which is part of an overall programme. It is a step forward along the roadmap. This workshop represents an official dialogue on GWML2.
- Way forward: taking into account the suggestions and proposals collected during this workshop, at the Infrastructure Commission, we will turn these contributions into actions (relative to groundwater) which will be part of the implementation of the WMO Hydrology Action Plan.