The Challenge of Geophysical Reports for Boreholes in East and Southern Africa

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ABSTRACT

Geophysics is widely used in African groundwater development, yet many borehole failures trace back to geophysical reports that do not meet high quality standards. This paper examines recurring deficiencies in VES datasets encountered during independent technical reviews, focusing on data auditability, reproducibility, and drilling relevance.

In total, 34 randomly selected geophysical and hydrogeological siting reports were assessed across Kenya, Malawi, Tanzania, Uganda, and Zimbabwe against **national regulations and** internationally recognised guidelines (ISO/TR 21414:2016, ASTM 6429-23, SEG and IAH-aligned). 91% of the 34 reports lacked essential raw data, documentation and inversion transparency, with only one report (2.9%) approaching best practice. At least 59% had location coordinate issues, and the majority exhibited significant gaps in equipment and processing disclosure.

Insufficient data transparency and quality controls undermine the long-term sustainability and reliability of water sources, highlighting the need for robust raw data and need for uncertainty-driven decision frameworks. The paper concludes with practical recommendations for donors, NGOs, consultants and regulators to shift from "interpretation-led" reporting to evidence-led, auditable decision support.

OBJECTIVES

- Examine recurring deficiencies in VES datasets encountered during independent technical reviews of borehole siting reports.
- Assess data auditability, reproducibility and drilling relevance across Kenya, Uga nda, Zimbabwe and Malawi.
- Demonstrate how missing or inconsistent raw geophysical parameters undermine inversion reliability and elevate drilling risk.
- Benchmark current practice against ISO/TR 21414:2016, ASTM 6429-23 and national regulations.
- Provide practical recommendations for donors, NGOs, consultants and regulators to move from interpretation-led to evidence-led, auditable reporting.

METHODOLOGY

Independent technical reviews of 34 VES-based geophysical studies from Kenya, Malawi, Uganda and Zimbabwe were conducted using convenience sampling of project files.

Each report was assessed against country requirements (Kenya WRA; Ministry of Water and Environment Uganda; Malawi Water Resources Regulations) and international guidelines (ISO/TR 21414:2016, ASTM 6429-23).

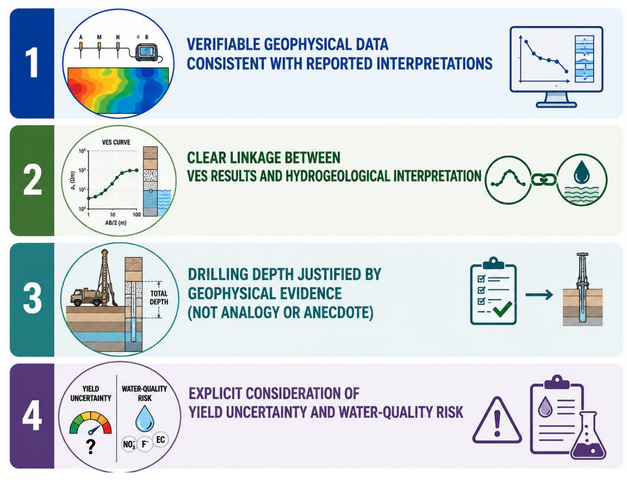


Table 1: Criteria used to assess the reports

RESULTS

1. Regulatory gap as a drilling risk multiplier

The compliance analysis reveals that no regulatory framework in any of the five study countries currently requires QA/QC documentation, or quantification of uncertainty in groundwater potential as a condition for accepting a geophysical report for drilling permit purposes. Though some regulations and guidance are available, these are not conditions for accepting or rejecting a report.

2. Geology

One key strength is that there is some level of information on the local geology.

74% 25 reports — Provide only **brief geological labels,** sufficient for compliance but lacking the detail expected for auditable decision-making

Provide detailed descriptions with **stratigraphic context and hydrogeological process discussion** with appropriate risk framing. — **26%** 9 reports

3. Coordinate integrity (correct UTM/WGS84; GPS evidence)

Fourteen (41%) reports include usable WGS84 points, while 59% either have improperly formatted GPS locations; or lack coordinates entirely. Though this does not have a direct impact on drilling success, it affects groundwater data management as the exact location of the boreholes remains unknown.

4. Equipment disclosure

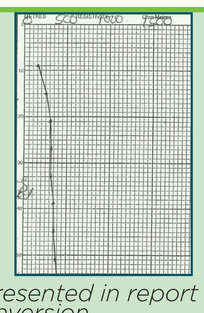
In 16 (47%) of the reports, the equipment used for geophysical studies is named. The equipment used ranges from the Terrameter, PQWT, Geotron and MiniRes. About 53% of the reports do not mention the equipment used, thereby reducing the reproducibility and auditability of the data.

5. Poor-quality geophysical data

7 of 34 reports (21%) have proper, auditable VES data with quantitative geoelectrical models and raw measurement tables. Another 5 (15%) present VES curves without formal model tables. The remaining 22 (65%) either use non-VES methods, present only hand-drawn curves on siting slips, or mention VES without providing the underlying data. The hand-drawn VES curves show plotted data points on logarithmic paper but provide no tabular data that would allow independent verification or reprocessing.

6. Inversion of VES data

Inversion of VES data is a critical step that transforms raw field measurements into meaningful subsurface models, is missing in 32 of the 34 reports. Most of the reports presented apparent resistivity graphs.



Example of data presented in report without inversion

94% of reports **without inversion**

7. Drilling depth justification

Only two (6%) reports have fully defensible drilling depth recommendations by providing raw data tables, inversion methodology, quantified misfit metrics per measurement point and a table of calibrated boreholes. The rest (94%) of the reports provide depth recommendations with minimal justification, effectively a single instruction line which is scientifically non-defensible.

6% 2 reports have **fully defensible drilling depth recommendations**

8. Internal Consistency & Decision Logic

Contradictory depth recommendations have been witnessed in four (12%) reports. The report gives two different depth recommendations on different sections of the report. This makes decision making difficult for the client.

9. Risk-informed decision support

Though without explanation, six (18%) reports quantify drilling success probability using percentages. Thirteen (38%) reports use absolute language ("good potential," "favourable conditions") with no probabilistic framing to indicate the risk associated with drilling on the recommended sites.

However, the rest of the reports (44%) do not provide information related to the risk to support risk-informed decision making. Only eight (23.5%) reports provide substantive water quality discussion, flagging the possibility of high fluoride levels in groundwater based on nearby wells. Only 1 (2.9%) report uniquely ties expected water quality to specific host-rock mineralogy. The remaining twenty-five (76%) reports contain no water quality assessment whatsoever. This presents a large single compliance gap as it relates to local guidelines for geophysical reports.

RECOMMENDATIONS

1 CONTRACTUAL RAW DATA

Make raw-data/inversion annexes contractual deliverables. Regulators should prescribe minimum content: raw data tables, inversion graphs, software identity, calibrated equipment certificates, and coordinate systems. For project managers, payment milestones should depend on receipt and acceptance against a checklist (raw logs, data inversion). This single change most directly strengthens reproducibility and future asset management.

2 LEARNING

Institutional learning loop. Archive raw datasets and decisions in a central repository; use post-drill pump tests and water quality to back-analyze model performance. Closing the loop improves siting success rates and long-term sustainability.

3 LINK DEPTH

Clear linkage between VES interpretation and drilling depth. Ensure that depth recommendations are derived from VES interpretation.

4 EVIDENCE

There is general need for donors, NGOs, consultants, and regulators to **shift from "interpretation-led" reporting to evidence-led,** auditable decision support.

5 PRE-ANALYSIS

For donors, NGOs, consultants and regulators to **require prior comprehensive analysis and interpretation of existing data and reports** be conducted to determine areas to conduct geophysical studies.

CONCLUSIONS

Drilling recommendations should be supported by documented geophysical evidence, hydrogeological context, data quality assessment, and interpretation uncertainty. Recommendations that extend beyond the evidence provided by the survey data should be explicitly justified. In addition, geophysics should therefore be viewed as a tool for refining and testing a hydrogeological model rather than as a standalone groundwater detection method.

Most reports are advisory opinions, not auditable science, therefore impact the drilling success rate in Africa. For hydrogeologists, improving borehole success rates requires enforcing professional data standards rather than more complex geophysical techniques. Decision-grade documentation is essential for sustainable groundwater development.