GEOPHYSICAL SURVEY REPORT

Vertical Electrical Sounding (VES) Investigations for Borehole Siting

Manduwasa · Maliwata · Makuluni · Maulana · M'mwala
Senior Chief Nkagula, Zomba District

Survey Date	01 June 2026
Method	Electrical Resistivity (PQWT Vertical Profiling)
Objective	Identification of suitable groundwater zones for community borehole development
Client / Programme	Villages in Partnership
Report Status	Submitted
Submitted By	Hydro Water Engineering Limited

1. EXECUTIVE SUMMARY

This report presents the findings of a geophysical investigation programme conducted on 01 June 2026 across five villages in Senior Chief Nkagula namely Manduwa, Maliwata, Makuluni, Maulana and M'mwala. The surveys employed the PQWT electrical resistivity system using vertical profiling (VES) to delineate subsurface geological structures and identify prospective groundwater-bearing zones for community borehole development.

All five investigated sites exhibit favourable hydrogeological signatures. Low-resistivity anomalies consistent with saturated fractured or weathered zones were identified at each location. Anticipated productive aquifers occur primarily within the 20–60 m depth interval. Two sites (Manduwasa and Maliwata) are recommended for mud-rotary drilling due to the expected presence of softer sedimentary or highly weathered materials, while the remaining three sites (Makuluni, Maulana and M'mwala) are better suited to air/DTH (Down-The-Hole) drilling through harder basement-derived lithologies.

Key recommendation: All five VES points are considered suitable for borehole construction. Priority should be given to sites with the most continuous low-resistivity intervals and the highest inferred hydraulic potential (Maulana and M'mwala show particularly well-developed multi-layer aquifer signatures). Standard hydrogeological supervision during drilling, including progressive yield testing and water quality sampling, is strongly advised at every site.

Summary of Recommended Drill Targets

Village	VES	Coordinates (Lat, Lon)	Primary Water Strike (m)	Recommended Depth (m)	Drilling Method
Manduwa	18	-15.368712, 35.457478	28–55	50–60	Mud rotary
Maliwata	7	-15.310021, 35.480418	30–50	50	Mud rotary
Makuluni	10	-15.368821, 35.479048	30–50 & 55–60	45–50	Air / DTH
Maulana	22	-15.310020, 35.479048	25–45 & 50–60	45–50	Air / DTH
M'mwala	19	-15.343033, 35.474150	20–45 & 55–60	50	Air / DTH

2. INTRODUCTION AND OBJECTIVES

Groundwater constitutes a critical resource for rural communities in southern Malawi, supplying the majority of domestic water needs where surface water sources are seasonal or contaminated. In the Zomba District, particularly in the villages surrounding the Lake Chilwa basin, reliable borehole siting is essential for sustainable community water points.

The primary objective of this survey was to identify, at each of the five target villages, a discrete location with the highest probability of intersecting productive aquifer horizons, thereby maximising the likelihood of successful borehole completion and long-term yield. Secondary objectives included characterising the local geological framework, estimating the depth to principal water-bearing zones, and recommending appropriate drilling technology for each site.

3. SURVEY METHODOLOGY

3.1 Geophysical Method

The investigation utilised the PQWT electrical resistivity system configured for vertical profiling (Vertical Electrical Sounding – VES). In this technique, a controlled electrical current is injected into the subsurface through a pair of current electrodes, while the resulting potential difference is measured between a second pair of potential electrodes. By progressively expanding the electrode array, the method samples successively deeper geological layers.

Apparent resistivity values are inverted to produce a 1-D or 2-D model of true subsurface resistivity. Low-resistivity zones (typically displayed in blue/cyan on the processed sections) are interpreted as water-saturated, clay-rich or fractured intervals, while high-resistivity zones (red/orange/yellow) generally correspond to competent, unsaturated or crystalline rock.

3.2 Field Procedure

At each village a single high-priority VES station was occupied after preliminary reconnaissance. Vertical profiling was performed to depths of approximately 100 m. Real-time display on the PQWT monitor allowed immediate identification of candidate aquifer intervals (blue-coloured anomalies). Coordinate positions were recorded in decimal degrees (WGS84). All data were subsequently processed and inverted to generate resistivity curves and pseudosection images presented in this report.

3.3 Interpretation Criteria

Aquifer potential was assessed using the following criteria:

- Presence of continuous low-resistivity intervals (blue zones) within the 20–70 m depth range;
- Lateral continuity and vertical thickness of these intervals on the pseudosection;
- Contrast between low-resistivity zones and surrounding higher-resistivity host rock;
- Consistency with the known regional geology (weathered basement, sedimentary cover, fracture systems);
- Absence of strong near-surface conductive layers that might indicate thick clay (low yield / poor quality).

4. REGIONAL GEOLOGICAL AND HYDROGEOLOGICAL SETTING

The survey area lies within the broader Lake Chilwa catchment in southern Malawi. The regional geology is dominated by the Precambrian basement complex, comprising primarily gneisses, schists and granitic rocks that have undergone varying degrees of weathering and fracturing. Overlying or interbedded with the basement are localised sedimentary packages that include sandstones, conglomerates, breccias and residual soils.

In this hydrogeological environment, the principal groundwater targets are:

- Weathered basement aquifers – the saprolite and saprock zones, typically 20–60 m thick, where porosity is enhanced by chemical weathering;
- Fractured bedrock aquifers – discrete fracture or fault zones within the competent basement that can yield significant quantities of water when intersected;

- Sedimentary / alluvial aquifers – where present, coarser-grained units (sandstone, conglomerate, breccia) can form productive porous media aquifers.

Groundwater quality in the region is generally favourable for domestic use, although elevated iron, manganese or salinity can occur locally, particularly in deeper or more stagnant fracture systems. Recharge is primarily by direct rainfall infiltration during the wet season (November–April).

5. DETAILED SITE RESULTS AND ANALYSIS

5.1 Manduwasa Village – VES 18

Coordinates: 15.368712° S, 35.457478° E | Recommended depth: 50–60 m | Method: Mud rotary

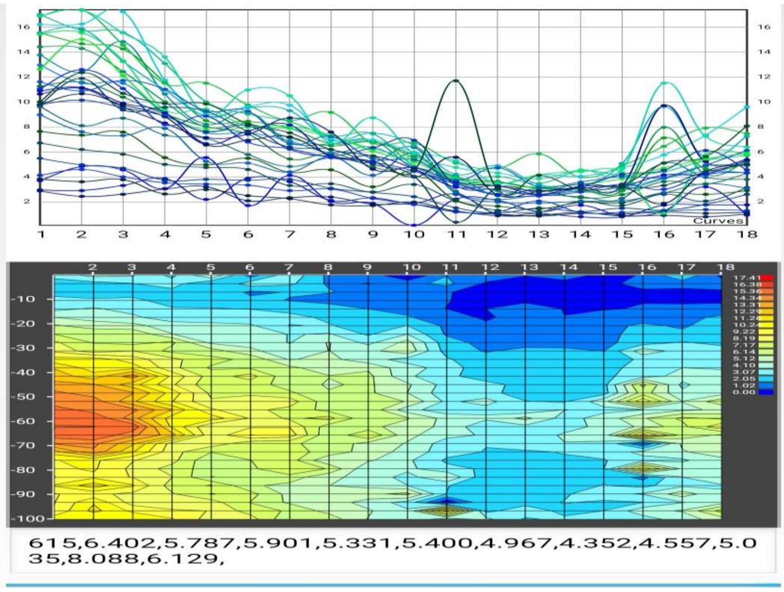

Figure 5.1 – Resistivity curves and inverted pseudosection for Manduwa VES 18

Interpretation: The resistivity section displays a prominent low-resistivity (blue) zone centred around station position 13, extending from approximately 28 m to 55 m depth. This interval is interpreted as a saturated weathered or fractured zone with favourable hydraulic properties. Shallower layers show moderate to high resistivity consistent with unsaturated residual soil and partially weathered rock. Deeper high-resistivity material (>60 m) likely represents more competent basement.

Geological context: The site is classified as sedimentary, dominated by breccia-type lithologies. Such units can provide intergranular porosity in addition to fracture permeability, supporting the recommendation for mud-rotary drilling to stabilise the borehole wall in potentially unconsolidated or weakly cemented material.

Risk & opportunity notes: The relatively thick low-resistivity interval (~27 m) is encouraging. Care should be taken to case off any near-surface conductive clay that might contribute to turbidity or reduce specific capacity. Expected water strike between 28–55 m; design for a final depth of 50–60 m to allow adequate aquifer penetration and screen placement.

5.2 Maliwata Village – VES 7

Coordinates: 15.310021° S, 35.480418° E | Recommended depth: 50 m | Method: Mud rotary

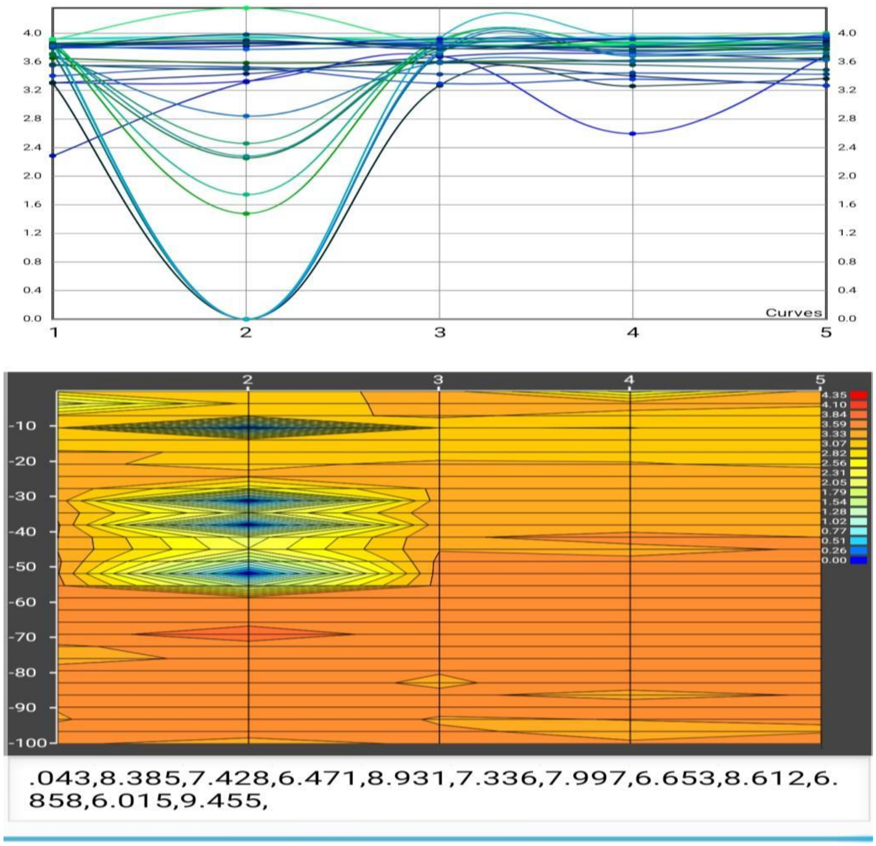

Figure 5.2 – Resistivity curves and inverted pseudosection for Maliwata VES 7

Interpretation: A clear low-resistivity anomaly is developed between approximately 30 m and 50 m. The pseudosection shows a relatively continuous conductive horizon, suggesting a laterally extensive weathered or fractured aquifer. The curve set indicates a classic three- to four-layer model with a conductive intermediate layer corresponding to the target aquifer.

Geological context: Weathered basement with breccia and conglomerate. The combination of residual weathering products and coarser sedimentary clasts is favourable for both storage and transmissivity. Mud drilling is preferred to maintain borehole stability through the weathered profile.

Risk & opportunity notes: The target interval is well-defined. A final depth of 50 m should suffice provided the main water strike is confirmed within the predicted range. Yield testing at multiple depths is recommended to optimise screen placement.

5.3 Makuluni Village – VES 10

Coordinates: 15.368821° S, 35.479048° E | Recommended depth: 45–50 m | Method: Air / DTH

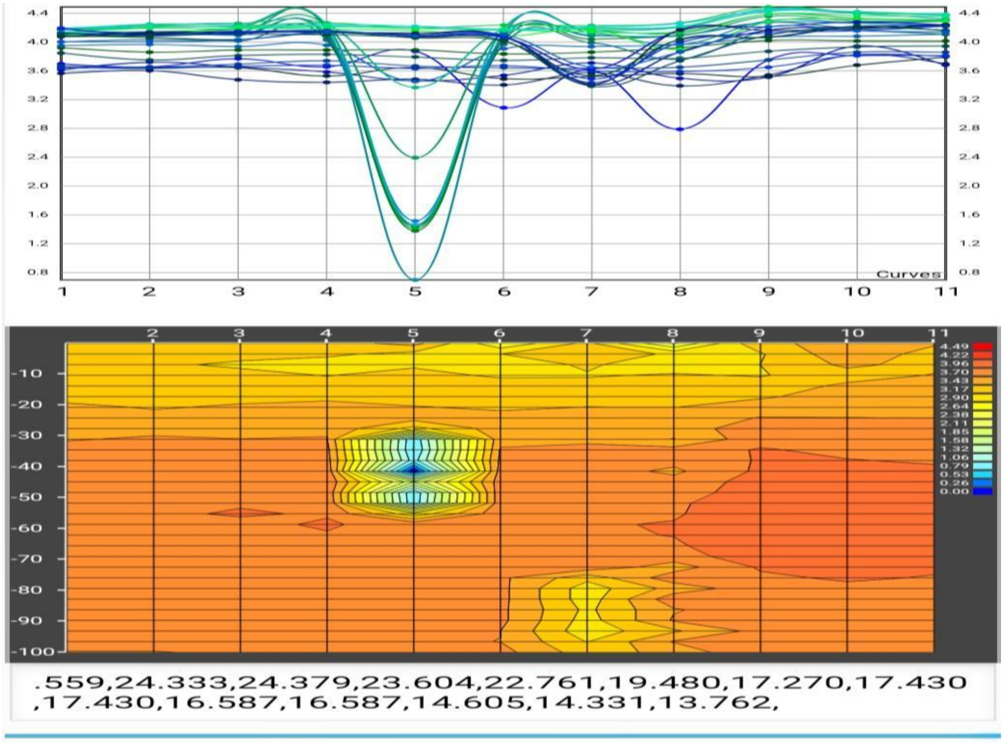

Figure 5.3 – Resistivity curves and inverted pseudosection for Makuluni VES 10

Interpretation: Two discrete low-resistivity intervals are identified: a primary zone between 30–50 m and a secondary, deeper anomaly at 55–60 m. The dual-aquifer signature is characteristic of weathered basement grading into fractured bedrock. The upper zone is likely the main productive target; the deeper interval may provide additional yield or serve as a reserve horizon.

Geological context: Weathered basement containing breccia, schist and gneiss. These lithologies are typical of the Malawi basement complex. Air/DTH drilling is appropriate for the expected competent to moderately weathered rock and will allow rapid penetration and good cuttings recovery for geological logging.

Risk & opportunity notes: The presence of two potential water-bearing intervals increases the probability of success. A target depth of 45–50 m is recommended as a first phase; extension to 60 m can be considered if yields at the upper zone are marginal.

5.4 Maulana Village – VES 22

Coordinates: 15.310020° S, 35.479048° E | Recommended depth: 45–50 m | Method: Air / DTH

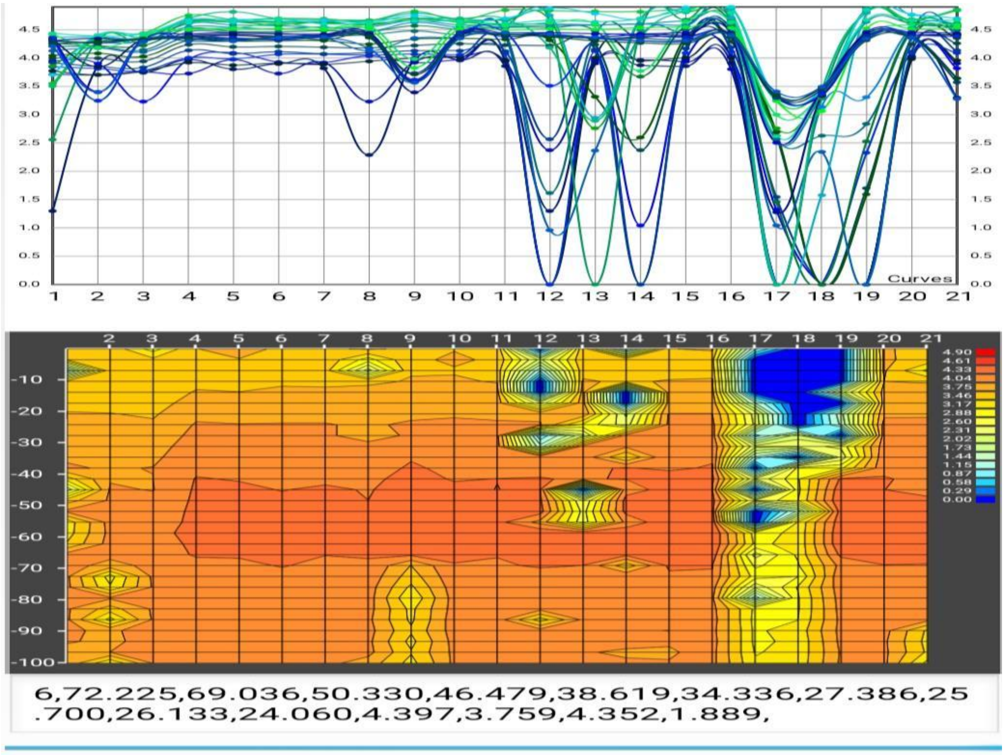

Figure 5.4 – Resistivity curves and inverted pseudosection for Maulana VES 22

Interpretation: The section reveals a well-developed multi-layer response with significant low-resistivity development between 25–45 m and a second conductive zone at 50–60 m. The lateral extent and intensity of the blue anomalies indicate good aquifer potential. The resistivity contrast suggests a transition from weathered material into a more fractured or permeable sedimentary/basement interface.

Geological context: Weathered basement with sedimentary rock components. The combination is interpreted as having elevated hydraulic conductivity relative to purely crystalline basement sites. Air/DTH methods remain suitable.

Risk & opportunity notes: Among the five sites, Maulana displays one of the strongest and most continuous low-resistivity signatures. It is considered a high-priority target. Design for 45–50 m with contingency to 60 m.

5.5 M'mwala Village – VES 19

Coordinates: 15.343033° S, 35.474150° E | Recommended depth: 50 m | Method: Air / DTH

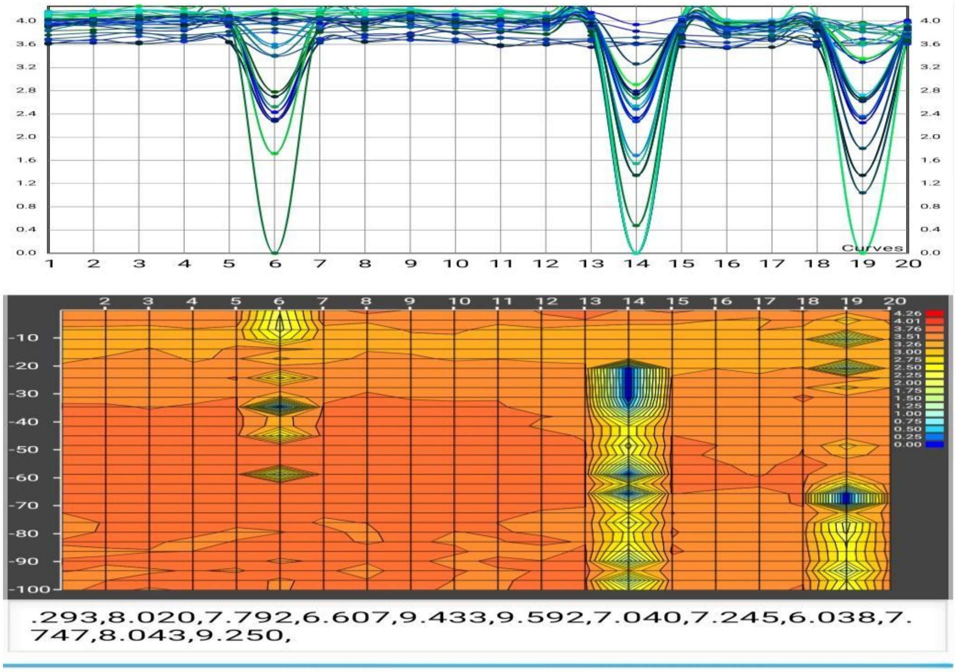

Figure 5.5 – Resistivity curves and inverted pseudosection for M'mwala VES 19

Interpretation: A broad low-resistivity domain is present from approximately 20 m to 45 m, with an additional deeper conductive feature at 55–60 m. The early onset of the conductive zone (from ~20 m) is advantageous, potentially allowing a shallower first water strike and reduced drilling cost. The overall signature is consistent with a thick weathered profile underlain by fractured basement.

Geological context: Weathered basement with sedimentary influence, characterised by high inferred hydraulic coefficients. This site ranks favourably for both storage and transmissivity.

Risk & opportunity notes: Strong candidate for a productive borehole. Target depth of 50 m is recommended; the deeper 55–60 m zone provides a secondary objective if required.

6. COMPARATIVE SITE ANALYSIS

A comparative evaluation of the five sites yields the following ranking based on the strength, thickness and continuity of low-resistivity aquifer signatures, geological favourability, and practical drilling considerations:

Priority	Village (VES)	Rationale
1 (Highest)	Maulana (22) / M'mwala (19)	Strong, multi-layer low-resistivity signatures; early water strike potential; high inferred hydraulic conductivity.
2	Makuluni (10)	Clear dual-aquifer response; solid basement-weathered profile; good secondary deeper target.
3	Manduwa (18)	Thick single conductive zone (28–55 m); sedimentary/breccia host; requires mud drilling for stability.
4	Maliwata (7)	Well-defined 30–50 m target; weathered basement with conglomerate/breccia; reliable but slightly thinner signature.

It should be emphasised that all five sites meet the minimum criteria for borehole recommendation. The ranking above is relative and intended to assist programme prioritisation should resources be constrained. Simultaneous or sequential drilling of all sites remains the preferred outcome for maximising community water security.

7. DRILLING AND DEVELOPMENT RECOMMENDATIONS

7.1 General Recommendations

- All five VES locations are recommended for borehole drilling.
- A qualified hydrogeological supervisor to be engaged to log lithology, record water strikes, and direct screen placement in real time.
- There is need to conduct progressive yield tests (air-lift or bailer) at each major water strike to quantify incremental contribution.
- There is need to install gravel pack and sanitary seal according to national standards; ensure the uppermost 5–6 m is properly sealed against surface contamination.
- There is need to collect water samples for full physico-chemical and bacteriological analysis upon completion and after development.
- There is need to record final GPS coordinates, as-built construction diagram, and yield data for the district water database.

7.2 Site-Specific Notes

Manduwasa & Maliwata: Use mud-rotary (or equivalent) techniques. Maintain adequate mud weight and viscosity to stabilise the borehole through weathered and sedimentary intervals. Plan for possible loss of circulation if coarser conglomerate or breccia zones are encountered.

Makuluni, Maulana & M'mwala: Air/DTH drilling is preferred. Monitor for water-strike indications via cuttings moisture and air-lift yield. Be prepared to switch to foam or light mud if unstable zones are intersected.

7.3 Anticipated Yields and Sustainability

Based on analogous basement and weathered-basement boreholes in the Zomba–Lake Chilwa region, sustainable yields in the range of 0.5–2.0 L/s are realistic for well-sited community hand-pump or small motorised systems. Higher yields are possible where discrete fracture zones are intersected. Long-term sustainability will depend on proper construction, community management, and protection of the recharge catchment from contamination and excessive abstraction.

8. CONCLUSIONS

The geophysical survey programme has successfully identified viable groundwater targets at all five investigated villages. The PQWT vertical profiling data, supported by regional geological understanding, provide a robust basis for borehole siting. Low-resistivity anomalies consistent with saturated weathered and fractured zones occur within practical drilling depths (principally 20–60 m) at every site.

Implementation of the recommended drilling programme, accompanied by professional hydrogeological supervision and adherence to good construction practice, is expected to deliver reliable community water points that will contribute significantly to improved water security in the target villages.

9. LIMITATIONS AND DISCLAIMER

Geophysical methods provide indirect evidence of subsurface conditions. While the identified low-resistivity zones are strong indicators of aquifer presence, actual yield, water quality and long-term performance can only be confirmed by drilling and testing. Local geological variability, the precise location of fractures relative to the borehole, and construction quality all influence final outcomes. This report constitutes a professional interpretation of the available data and does not guarantee specific yields or water quality at any site.

For further technical clarification or support during the drilling phase, the survey team remains available.

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