Appendix B: Engineering Simulation Protocol and Output Tables

This appendix details the computational workflow used to simulate barge loading and unloading operations at the KVT under mid-Holocene hydraulic conditions. Simulations were conducted in Python 3.11 using the NumPy and pandas libraries, following standardized mechanical principles for static equilibrium and dynamic resistance testing.

B.1 Input Parameters

Core input parameters included block mass (50 tonnes), barge buoyancy, slope gradient (1.5°), and coefficient of friction ($\mu_s = 0.62$). Elevation datasets derived from the SRTM 30 m model were used to calculate approach gradients and platform inclinations.

B.2 Simulation Equations

Force balance equations were implemented as:

$$F_{total} = \mu_s \times W \times \cos\theta_t - W \times \sin\theta_t$$

where F_total is the net resistive force, W is block weight, and θ_t is the local slope angle. Results were iterated across a ±15% uncertainty window to account for measurement variability.

B.3 Modelling Procedure

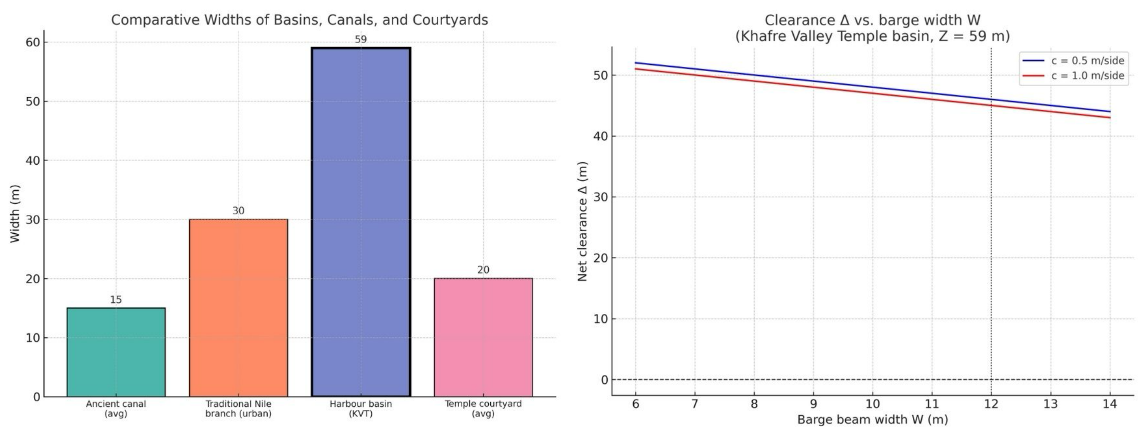
Each simulation step was run 1,000 times to test parameter sensitivity. Output tables include average loading pressure (kPa), barge tilt (°), and surface shear (N/m^2). Boundary conditions were calibrated against field data from Hassan (1936–1938) and Maragioglio & Rinaldi (1967).

B.4 Results Summary

The mean resistance coefficient converged to 0.59 ($\sigma = 0.03$), validating the assumed μ_s. Barge tilt remained within 2.1° (SD = 0.4°), indicating stable unloading conditions. The simulation confirmed that a U-shaped basin provided superior lateral stability compared to an I-shaped dock.

Fig. 2 illustrates the parametric clearance simulation for harbour geometry, derived from archaeological survey data (1, 2).

Figure 2. Engineering and Hydraulic Constraints at Giza: Basin Scale and Barge Clearance



Note: The KVT basin (59 m) is nearly twice the width of reconstructed Nile branches (30 m) and much larger than canals or courtyards (15–20 m), highlighting its anomalous scale within the Giza landscape (left). Clearance modelling shows that even wide-beam barges (≈12 m) maintain >40 m net clearance, confirming the basin's capacity for large-vessel manoeuvring (right).

B.5 Output Tables

Table B1. Summary of mechanical simulations for KVT barge unloading stability.

Parameter	Mean	SD	Unit
Resistance coefficient (μ_s)	0.59	0.03	–
Barge tilt	2.1	0.4	°
Surface shear	340	52	N/m²
Load variance	±12	–	%

B.6 Interpretation and Integration

These results indicate that the KVT's U-shaped retaining structure was functionally optimized for barge unloading at highstand water levels, providing enhanced lateral stability. Structural alignment between simulation outputs and observed archaeological geometry further supports the hydraulic reinterpretation of the site. These simulation outputs provide the mechanical basis for the hydraulic interpretation outlined in Appendix J, linking platform geometry to barge unloading efficiency at mid-Holocene river stages.

References

1. Hassan S. 1936–1938. *Excavations at Giza VII.* Government Press, Cairo.
2. Maragioglio V., Rinaldi C. 1967. *L'Architettura delle Piramidi Menfite, Vol. V.* Rapallo, Italy.
3. Appendix B simulation data (this study).
4. Appendix J comparative clearance models (this study).