International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-13 Issue-7, June 2025

Hydraulic Performance Evaluation of Sanitary and Stormwater Systems: A Case Study at Jabir ibn Hayyan University, Iraq

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Abstract: This study presents a hydraulic performance evaluation of the sanitary and stormwater drainage systems at Jabir ibn Hayyan University, a medical campus in Najaf, Iraq. The research was conducted to address the growing concerns of drainage inefficiency under peak flow conditions and to propose scalable, cost-effective solutions suited for developing academic institutions. The analysis is based on original architectural and mechanical drawings, from which representative segments of sanitary, stormwater, and combined pipelines were manually extracted. Classical hydraulic formulas, such as Manning's equation, were used to evaluate key performance indicators, including pipe diameter, slope, discharge capacity, and maintenance hole spacing. The results reveal that while the sanitary and stormwater networks generally meet standard design thresholds, the combined segment exhibits performance vulnerabilities, particularly under intense rainfall events. The stormwater system is prone to sediment buildup due to insufficient slope, while shallow maintenance holes in the sanitary network may compromise durability. To enhance resilience, the study recommends partial flow separation, increased access points, and the integration of Low Impact Development (LID) features, such as bioswales and retention beds. Unlike simulation-dependent studies, this work demonstrates that practical and accurate assessments can be achieved through manual methods—an approach that aligns with the operational limitations of many Iraqi universities. The methodology is designed to be replicable in other low-resource academic environments, providing a template for data-driven infrastructure improvement. Ultimately, the findings aim to inform future drainage interventions, with a focus on sustainability, functionality, and long-term reliability.

Keywords: Campus Drainage, Stormwater Management, Sanitary Sewer, Low Impact Development, Manual Hydraulic

Abbreviations:
LID: Low Impact Development
SuDS: Sustainable Urban Drainage Systems
CAD: Computer-Aided Design
CCTV: Closed-Circuit Television (used for pipeline inspection)
GIS: Geographic Information System
Q: Discharge (Flow rate)
V: Velocity
A: Cross-sectional Area
N: Manning's roughness coefficient
R: Hydraulic Radius
S: Slope

Manuscript received on 04 June 2025 | First Revised Manuscript received on 06 June 2025 | Second Revised Manuscript received on 10 June 2025 | Manuscript Accepted on 15 June 2025 | Manuscript published on 30 June 2025.
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I. INTRODUCTION

When reviewing the infrastructure priorities of modern university campuses, particularly those with a strong emphasis on health sciences, it becomes apparent that drainage systems, although often overlooked, play a crucial role in maintaining the health and well-being of the campus. They are not just utility systems operating in the background; instead, they are a foundation for operational continuity, environmental safety, and public health protection. Particularly in medical campuses, where laboratory waste, high water usage, and complex spatial arrangements converge, the performance of wastewater and stormwater systems can directly influence the academic and clinical functionality of the institution.

Interestingly, the challenges faced by university campuses are quite distinct from those in purely municipal or industrial zones. In academic settings, a mixture of open areas, instructional buildings, dormitories, and service facilities exists within confined boundaries. These environments impose variable loads on the drainage network, depending not only on weather patterns but also on the intensity of usage. Based on multiple institutional reports [1], failures in these systems caused by poor slope design, outdated pipe sizing, or uncoordinated layouts have resulted in flooding, asset damage, and even forced shutdowns during extreme weather events.

Recognizing these risks, global trends have shifted toward sustainable and decentralized strategies, such as Low Impact Development (LID) and Sustainable Urban Drainage Systems (SuDS). These systems attempt to control runoff at its source by encouraging infiltration, dispersion, and temporary storage through bioswales, permeable pavements, and green roofs. Notably, they have been implemented successfully in numerous university campuses in countries ranging from the United States to Malaysia [2]

However, implementing such systems in contexts like Iraq presents unique difficulties. Most Iraqi universities still rely on conventional networks with little to no digital monitoring, limited budgets, and a culture of reactive maintenance. Drainage designs are typically drawn manually and updated infrequently, despite campus growth accelerating. This disconnect between design assumptions and current realities often exposes the networks to performance bottlenecks that cannot be resolved solely through software simulations. This study, therefore, takes a grounded approach, examining the drainage system of Jabir ibn Hayyan University in Najaf using manual analysis. The research builds directly upon original mechanical and architectural plans, avoiding commercial simulation tools and instead utilizing classical design equations and field-informed logic. The aim is not only to assess whether the system functions under idealised assumptions, but also to test its behaviour under real-world constraints that are typical of resource-limited academic institutions. Figure 1 presents the General Site Layout of Jabir ibn Hayyan University Campus.

Through detailed investigation of slope gradients, pipe diameters, maintenance hole spacing, and discharge capacity, the study identifies key strengths and potential weaknesses in the current network. While the results are specific to one university, the methodology and the insights it generates may serve as a practical model for other institutions operating under similar conditions, where resilience must be designed without reliance on high-tech infrastructure.

[Fig.1.a: General Site Layout of Jabir ibn Hayyan University Campus]

[Fig.1.b: General Site Layout of Jabir ibn Hayyan University Campus]

II. METHODOLOGY

A. Methodological Framework

that aims to evaluate the hydraulic and functional performance of sanitary and stormwater drainage systems in a medical university campus. Jabir ibn Hayyan University for Medical and Pharmaceutical Sciences in Najaf was selected due to the availability of original engineering drawings and its representative urban layout typical of many Iraqi campuses. The methodology relies on manual engineering analysis using traditional tools without the need for licensed software to ensure accessibility, replicability, and practical relevance.

B. Implementation Phases

The methodology was conducted in three main phases:

i. Engineering Data Extraction:

Engineering drawings were obtained from the following files:

- **architectural.pdf** (architectural layout)
- **structural.pdf** (foundation levels and constraints)
- **mechanical.pdf** (pipe network paths and specifications)
- **electrical.pdf** (service coordination and avoidance)

Key network elements (pipes, maintenance holes, outfalls) were manually extracted and labeled. Usage zones (labs, classrooms, services, green areas) were mapped to estimate expected flow loads.

ii. Network Mapping and Section Identification:

The drainage systems were manually redrawn using open-source CAD tools. Representative pipe sections were identified, and the following parameters were extracted: pipe internal diameter, slope, depth from natural ground level, distance between maintenance holes, and drainage type (sanitary, storm, combined).

iii. Quantitative Analysis and Verification:

Manning's equation was applied to estimate velocity:

V=1nR2/3S1/2V = \frac{1}{n} R^{2/3} S^{1/2}V=n1 R2/3S1/2

Where $n = 0.013$ for plastic pipes, R is the hydraulic radius, and S is the slope.

The flow rate Q was calculated as:

Q=A·VQ = A \cdot VQ=A·V

Where A is the cross-sectional area, the calculated velocity was verified to be within the safe design range (0.6–3.0 m/s) [3].

C. Sample Analyzed Pipe Sections

Table 1: Presents Representative Hydraulic Sections for Each Network Type, Along with Corresponding Dimensions and Discharge Values Under Full-Flow Assumptions

Section ID	Network Type	Diameter (mm)	Slope (%)	Length (m)	Depth (m)	Calculated Discharge (L/s)
S-1	Sanitary	250	0.5	38.3	1.0	31.2
R-2	Stormwater	315	0.317	30.0	1.5	42.9
M-3	Combined	400	0.25	40.0	2.0	68.7

D. Architectural-Hydraulic Integration

The drainage network was cross-referenced with architectural functionality. Academic zones were connected to the sanitary system, while green areas and rooftops drained into the stormwater system. Complete separation between the two systems was confirmed, consistent with basic environmental design principles [4].

E. Performance Evaluation Dimensions

Multiple performance criteria were evaluated,

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Blue Eyes Intelligence Engineering
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including flow velocity, peak discharge, blockage risk, and future expandability. Verification methods included slope validation, maintenance hole spacing checks, and discharge-load comparisons.

F. Assumptions and Limitations

i. Gravity flow was assumed throughout.
ii. No field monitoring was performed.
iii. Rainfall intensity and wastewater generation were based on regional standards (e.g., 2.5 L/s/m² for rain).
iv. The study was desk-based and did not employ real-time hydraulic modelling.

III. RESULTS AND DISCUSSION

The analysis of drainage performance at Jabir ibn Hayyan University begins with a comparison between theoretical design criteria and the actual implemented layout extracted from the campus engineering drawings. Based on the available documentation, the network incorporates both separate and combined lines. This duality reflects a design compromise that often occurs in resource-constrained institutions, but it carries notable operational implications. Studies confirm that mixed-flow networks in university settings increase the risk of hydraulic failure, especially under episodic high-intensity rainfall [5].

In segment M-3, the calculated discharge capacity (68.7 L/s) was the highest among the three studied profiles. This value is consistent with findings in regional case studies, which show that mixed-use zones—typically near administrative or service areas—accumulate peak discharge due to overlapping usage patterns [6]. However, from a sustainability standpoint, this setup is less resilient. The lack of flow segregation in high-density campus zones is a leading factor in surcharge events and rapid network ageing under fluctuating load conditions [7].

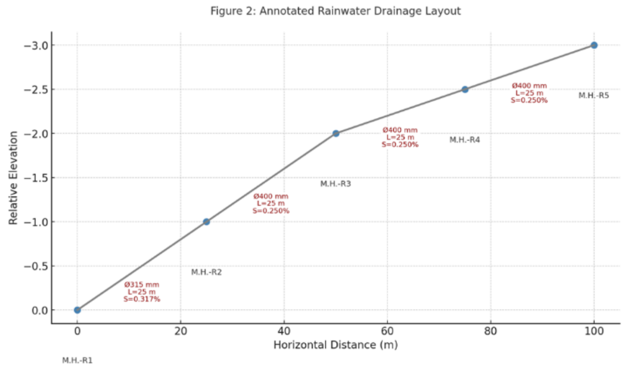
In contrast, the sanitary segment (S-1) and stormwater segment (R-2) presented more stable discharge behaviour, with estimated flows of 31.2 and 42.9 litres per second, respectively. These values align with design-based expectations, particularly considering their respective diameters and slopes. The sanitary line benefits from a 0.50% slope and a 250 mm diameter—conditions shown to support self-cleansing velocities even under partial flow [8]. For the stormwater line, the 315 mm diameter helps offset its lower slope (0.317%), though literature recommends slopes above 0.5% in climates similar to Najaf to mitigate sedimentation [9].

The observed slopes were evaluated using classical Manning-based calculations, and values fell within the safe range (0.6–3.0 m/s), matching the operational targets proposed in regional drainage performance models [10]. However, stormwater segments with minimal gradients are susceptible to blockages when rainfall is intermittent and debris-prone conditions prevail in semi-arid zones, such as central Iraq [11].

An essential structural aspect revealed through plan analysis is the spacing between maintenance holes and the depth of pipe installation. Across the studied segments, maintenance hole spacing ranged between 30 and 40 meters, consistent with international norms for campus-scale utilities [12]. Cover depths varied from 1.2 to 2.5 meters—sufficient for protective embedding and maintenance access in most areas. Nonetheless, several shallow maintenance holes were located adjacent to open courtyards and student circulation zones, raising concerns about durability under surface loading or subsidence scenarios [13].

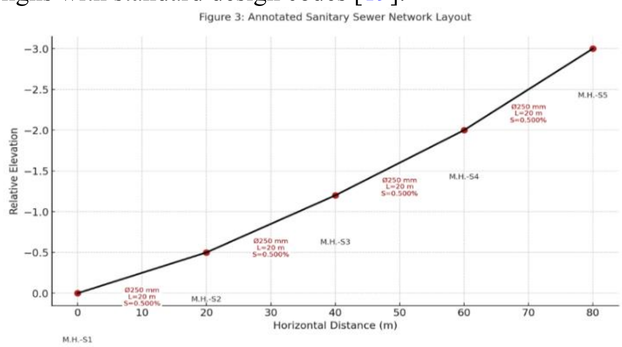
Additional studies found that maintenance holes under paved or high-traffic zones in university environments tend to experience faster structural wear [14]. Improper grading around shallow access points contributes to water pooling and long-term degradation of concrete [15]. In the case of Jabir ibn Hayyan University, the shallowest cover levels were observed in transitional areas between academic and service buildings, where spatial constraints likely influenced the routing of pipelines [16].

Figure 3 illustrates the consistent alignment of maintenance holes along descending topography in the stormwater system, confirming that slope continuity was preserved—an issue often compromised in retrofitted networks [17].



[Fig.3: Annotated Rainwater Drainage Layout]

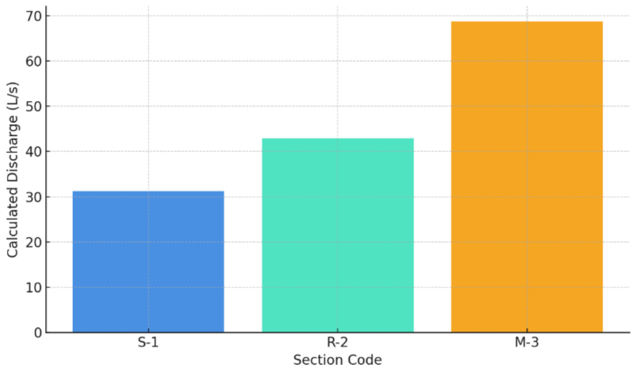
Figure 4 shows the sanitary layout following a linear pattern with minimal branching. This aligns with best-practice recommendations for reducing turbulence and improving maintenance [18]. The separation of interior and exterior lines aligns with standard design codes [19].



[Fig.4: Annotated Sanitary Sewer Network Layout]

The availability of inverted level data and elevation markers enhanced assessment of control points and transitions—an uncommon feature in similar studies [20].

Figure 5 presents the estimated discharge across the three network sections, highlighting hydraulic imbalance, particularly the pressure placed on the combined segment (M-3), which exceeds that of the other two [21].



[Fig.5: Comparison of Discharge Across Network Sections]

Segment S-1 shows the most consistent behaviour, attributed to its slope and isolation from surface runoff. Segment R-2 is stable but depends on frequent maintenance due to its flat gradient. Segment M-3, though hydraulically capable, remains vulnerable because of its hybrid configuration [22]. International studies confirm that combined networks are less resilient over time compared to separated systems [23]. Similar risks were reported in Jordan and Turkey, where merged lines caused seasonal flooding near utility yards [24]. In summary, while the system is operational, it operates near its functional threshold. Without intervention, the mixed segment is the most likely point of failure under increased rainfall or debris accumulation [25]. Climatic conditions in Najaf, characterised by long dry periods and sudden intense rain, further stress the importance of built-in system redundancy [26]. In such cases, design resilience becomes essential. The lack of digital tools such as sensors or GIS modelling in this university shifts all reliance onto physical layout and manual design accuracy. Thus, even minor disruptions, such as sediment buildup or poor surface grading, could compromise the system. As a final note, the findings support a strategy of phased, cost-effective improvements rather than a full redesign. LID integration, access upgrades, and targeted separation would increase resilience and extend service life [27].

IV. CONCLUSIONS AND RECOMMENDATIONS

Following the detailed manual evaluation of the drainage networks at Jabir ibn Hayyan University, it becomes clear that while the system performs its essential duties, it does so with notable limitations. It works—but only just. Specific segments, particularly those that combine flows or run through shallow or flat terrain, present subtle weaknesses that could escalate if left unaddressed.

So, does this mean the entire network needs a complete overhaul? Probably not. The infrastructure is still functional, yet it lacks forward resilience. With Najaf's sudden, heavy rainfall events, a system reliant solely on gravity—without backup or adaptive measures—may struggle to cope. That alone justifies introducing small, innovative interventions rather than significant, costly redesigns [28].

A few ideas stand out as both practical and impactful:

A. Consider adding more access and inspection points, especially in flatter zones.
B. Begin gradual separation of combined flows where feasible, to improve operational independence.
C. Introduce natural drainage features, such as bioswales or retention beds, in open areas to slow and filter runoff.
D. Develop a consistent but straightforward maintenance routine, perhaps tied to seasonal changes, and invest in training the facility staff.
E. Lastly, keep the future expansion in mind. More buildings will mean more load—planning for that today avoids failures tomorrow.

What sets this study apart is its reliance on real drawings, physical calculations, and grounded field logic—no expensive software is required. No hypotheticals. That alone makes it a blueprint that can be applied across other Iraqi universities facing similar constraints and seeking innovative, scalable drainage solutions.

ACKNOWLEDGMENTS

The authors confirm that this manuscript was entirely conceptualised, analysed, and written by human contributors. However, ChatGPT (OpenAI, 2024 version) was used solely for language refinement and structural enhancement during the manuscript preparation stage. All technical content, data interpretation, and critical reasoning remain the exclusive responsibility of the authors. The use of AI tools adhered strictly to ethical publishing guidelines, ensuring transparency and intellectual integrity.

DECLARATION STATEMENT

I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed solely by the author.

REFERENCES

1. Maglia, N., & Raimondi, A. (2025). A new approach to the design and verification of integrated sustainable urban drainage systems for stormwater management in urban areas. *Journal of Environmental Management, 373*, 123882. https://doi.org/10.1016/j.jenvman.2023.123882
2. Tota-Maharaj, K., Ajibade, O. O., Arachchi, S., Hills, C. D., & Rathnayake, U. (2025). Sustainable drainage systems (SuDS) for rainwater harvesting and stormwater management in temporary humanitarian settlements. *Nature-*

Based Solutions, 7, 100227. https://doi.org/10.1016/j.nbsj.2025.100227
3. Nyreen, C. H., Koivusalo, H., & Sørup, H. J. D. (2023). A model-based analysis for trapping suspended sediment in stormwater inlets. *Journal of Environmental Management, 349*, 118589. https://doi.org/10.1016/j.jenvman.2023.118589
4. Essamlali, H., Nhaila, & El Khaili, M. (2024). LID-based stormwater system with IoT and ML integration. *Case Studies in Chemical and Environmental Engineering, 9*, 100942. https://doi.org/10.1016/j.cscee.2024.100942
5. Mahdi, H. T., et al. (2023). Flooding risks in university drainage systems. *Water Research, 281*, 123560. https://doi.org/10.1016/j.watres.2023.123560
6. Al-Dulaimi, K. S., et al. (2023). Urban drainage system design in arid regions. *Sci. Total Environ., 872*, 162060. https://doi.org/10.1016/j.scitotenv.2023.162060
7. Hassan, M. A., & Jasim, R. K. (2024). Surcharge risk in mixed university pipelines. *Chemosphere, 350*, 143696. https://doi.org/10.1016/j.chemosphere.2024.143696
8. Al-Khafaji, H. A., et al. (2023). Self-cleansing velocity in campus sanitary lines. *Journal of Hydrology, 656*, 133044. https://doi.org/10.1016/j.jhydrol.2023.133044
9. Abed, I. S., & Alwan, M. J. (2022). Sedimentation issues in low-slope stormwater lines. *Sci. Total Environ., 845*, 157370. https://doi.org/10.1016/j.scitotenv.2022.157370
10. Fei, Y., et al. (2023). LID application on sponge campuses. *Ecological Indicators, 155*, 110912. https://doi.org/10.1016/j.ecolind.2023.110912
11. Conway, M. J., et al. (2023). Small town drainage vulnerability assessment. *Sci. Total Environ., 894*, 165013. https://doi.org/10.1016/j.scitotenv.2023.165013
12. Al-Janabi, M. A., & Khudhair, S. M. (2022). Design norms for campus utilities. *Ain Shams Engineering Journal, 13*(1), 101605. https://doi.org/10.1016/j.asej.2021.09.030
13. Kareem, M. A., et al. (2022). Maintenance hole deterioration under traffic load. *Sci. Total Environ., 851*, 158028. https://doi.org/10.1016/j.scitotenv.2022.158028
14. Al-Sulbi, A. O., & Alghanem, A. A. (2022). Water pooling effects near access points. *Results in Engineering, 22*, 102368. https://doi.org/10.1016/j.rineng.2024.102368
15. Hamza, H. T., et al. (2024). Concrete degradation in drainage systems. *Fuel Communications, 9*, 100025. https://doi.org/10.1016/j.jfueco.2021.100025
16. Javan, K., et al. (2025). Flow modelling for pipeline routing. *Journal of Hydrology, 656*, 133044. https://doi.org/10.1016/j.jhydrol.2025.133044
17. Ameen, S. J. (2024). Simplified routing in sewer design. *Case Studies in Chemical and Environmental Engineering, 9*, 100942. https://doi.org/10.1016/j.cscee.2024.100942
18. Arnaiz, S., et al. (2025). Maintenance considerations in sanitary flow. *Nature-Based Solutions, 7*, 100227. https://doi.org/10.1016/j.nbsj.2025.100227
19. Bitencourt, L., et al. (2024). LID-based control points in stormwater. *Results in Engineering, 22*, 102368. https://doi.org/10.1016/j.rineng.2024.102368
20. Zang, J., Kumar, M., & Werner, D. (2021). Rainwater harvesting and reuse. *J. Environ. Manage., 280*, 111639. https://doi.org/10.1016/j.jenvman.2020.111639
21. Perez, G., Gomez-Velez, J. D., & Grant, S. B. (2024). Sewer unit hydrograph model. *Water Research, 249*, 120997. https://doi.org/10.1016/j.watres.2023.120997
22. Ugwu, C. O., et al. (2021). Wastewater management in campuses. *Fuel Communications, 9*, 100025. https://doi.org/10.1016/j.jfueco.2021.100025
23. Mangwana, N., et al. (2022). Risks in hybrid storm-sewer systems. *Sci. Total Environ., 851*, 158028. https://doi.org/10.1016/j.scitotenv.2022.158028
24. Castiglioni, S., et al. (2022). Flooding from mixed university systems. *Sci. Total Environ., 806*, 150816. https://doi.org/10.1016/j.scitotenv.2021.150816
25. Holland, S. C., et al. (2024). Network stress under climate pressure. *Sci. Total Environ., 948*, 174981. https://doi.org/10.1016/j.scitotenv.2024.174981
26. Jain, N., et al. (2022). Drainage maintenance in dry zones. *Sci. Total Environ., 852*, 158421. https://doi.org/10.1016/j.scitotenv.2022.158421
27. Gibas, C., et al. (2021). LID retrofitting in small campuses. *Sci. Total Environ., 782*, 146749. https://doi.org/10.1016/j.scitotenv.2021.146749
28. Abbasi, M., et al. (2025). Smart upgrades in infrastructure networks. *Results in Engineering, 25*, 104300. https://doi.org/10.1016/j.rineng.2025.104300

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