PAPER 3

RETHINKING DESIGN COMPLIANCE: LESSONS LEARNED TO ENHANCE FLOOD RESILIENCE AND SAFETY

E G Braune[1], M B Wiese[2], I F Malherbe[3]
[1]Senior Engineer (MSAICE, MIMESA), Stormwater, AECOM SA Pty (Ltd)
[2]Principal Engineer (MSAICE), Stormwater, AECOM SA Pty (Ltd)
[3]Senior Associate Director (MSAICE), Water Resources, AECOM SA Pty (Ltd)

ABSTRACT

South Africa has well-developed flood risk management guidance, yet severe flooding continues to impact municipalities. Flood events, including the 2022 floods in Durban, 2023 floods in the Western Cape and recent 2026 flood events effecting Limpopo, Mpumalanga and the Western Cape have highlighted the growing vulnerability of urban areas and the scale of flood-related impacts. While technical resources for flood estimation and stormwater design are well established, designing infrastructure for a specified design flood does not equate to safety, particularly during larger events. The gap lies in how these guidelines are translated into holistic municipal flood planning and management, especially in environments characterised by inherited infrastructure constraints and changing catchment characteristics.

This implementation gap has become apparent through the experience gained from numerous flood studies undertaken within the consulting industry and is illustrated in this paper through two case studies representing different development contexts. The first considers a residential area affected by recurring flooding linked to historical agricultural alterations to the river system dating back to the late 1800s. The second examines an industrial area developed on a historically diverted river floodplain, where exceedance of the diversion infrastructure resulted in severe flooding during recent extreme events. Across both cases, common challenges include cumulative catchment changes due to urbanisation, insufficient consideration of historical floodplain behaviour and a lack of clear understanding and communication of risks associated with flood events exceeding the design standard. Lessons learned from previous studies, augmented by these two case studies, highlight the need for a more holistic approach to managing fluvial (riverine) flood risk beyond compliance with design standards, with specific consideration of residual risk within the broader river system. These insights are synthesised into a practical questions-based framework which municipalities can apply in scoping flood studies, interrogating system-wide risks, and identifying potential "weak points" within river catchments. The framework encourages improved alignment between flood risk assessment, infrastructure planning, and land-use decision-making. By shifting the focus beyond design compliance towards system-wide resilience, the questions-based framework aims to bridge the gap between existing guidance and practical implementation, ultimately rethinking public safety during major flood events.

1. INTRODUCTION

Flooding remains one of the most significant natural hazards affecting South Africa, impacting communities, infrastructure, agriculture, industry and municipal services. Recent flood disasters have resulted in substantial economic losses, disruption of essential services and loss of life (Mahlangu, et al., 2025). The 2022 KZN floods (Byaruhanga, et al., 2025) highlighted the devastating consequences of extreme flooding on urban environments, while subsequent flood events earlier in 2026 in the Western and Eastern Cape, Mpumalanga and Limpopo further demonstrated the vulnerability of municipalities to large-scale fluvial (riverine) flooding.

South Africa has developed a range of guidelines and manuals for flood estimation, stormwater design and flood risk management. The well-known guidelines include but are not limited to:

- *The Red Book: Neighbourhood Planning and Design Guide* (Department of Human Settlements, 2019)
- *SANRAL Drainage Manual* (South African National Roads Agency Limited (SANRAL), 2013)
- *Best Practice Guideline for Design Flood Estimation in Municipal Areas in South Africa* (Brooker, et al., 2023)
- *Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines* (Armitage, et al., 2014)

These guidelines provide valuable tools for estimating flood magnitudes and designing infrastructure to manage various levels of risk, while also emphasising the assessment of exceedance events and the need to understand and manage residual flood risk. Nevertheless, municipalities continue to experience significant flood damage and safety risks during major flood events owing to a combination of factors, including changing catchment conditions, limitations in the implementation of holistic flood risk management, and the increasing occurrence of severe rainfall events.

The consequences of flooding become particularly severe where urban development has altered natural river systems and floodplains. Catchments evolve over time through urbanisation, land-use change, infrastructure expansion and historical modifications to river systems. During larger flood events, rivers may overtop their banks, reactivate historical floodplain flow paths and interact with urban areas in ways that were not anticipated during the original design of infrastructure. Critical facilities, transport routes and municipal services can therefore be exposed to flood hazards that extend beyond the design assumptions of individual structures.

Understanding the impacts of flood events, which exceeds typical design flood frequencies, provides municipalities with an opportunity to identify system vulnerabilities (weak points), assess potential consequences and implement measures that improve public safety and resilience. Assessing these events does not imply designing every asset for the largest conceivable flood; rather, it enables municipalities to better understand where the greatest risks exist and where interventions may provide the greatest benefit be it structural or systemic.

This paper investigates these challenges through two fluvial flood-related case studies representing different development contexts. The lessons learned are synthesised into a practical questions-based framework which demonstrates how municipalities can identify weak points, prioritise interventions and support more holistic flood management. By

understanding what happens when flood events exceed design assumptions, awareness assists the municipalities in moving beyond compliance-based planning towards more resilient and safer communities through systems thinking. Mitigation strategies can be developed to manage the residual risk of river systems, increasing public safety and resilience of infrastructure.

2. KEY CONCEPTS ON HOLISTIC FLOOD RISK MANAGEMENT

2.1 Flood risk

Flood risk is commonly defined as a function of **hazard, exposure** and **vulnerability**, as illustrated in Figure 1. **Hazard** represents the likelihood and severity of flooding, **exposure** reflects the people, infrastructure and assets located within the flood-prone area, and **vulnerability** describes their susceptibility to damage or disruption (Ferguson, et al., 2023). Flood risk depends not only on the probability and magnitude of a flood, but also on its consequences, which are influenced by factors such as flood depth, velocity and rate of onset. Although structural measures can reduce flood hazards by lowering flood levels or increasing conveyance capacity, land-use change, urbanisation, climate variability and inadequate maintenance can increase both flood hazard and the exposure of people and assets, particularly within historical floodplains. Effective flood risk management therefore requires consideration of both the flood hazard and the potential consequences of flooding across the broader river system. (ARR, 2019; Smith *et al.*, 2014).



FIGURE 1: *Defining flood risk (Wiese and King, 2025)*

2.2 Design flood risk

Flood risk management in South Africa is largely based on the estimation of design flood events for infrastructure planning and design. Guidance such as the *Best Practice Guideline for Design Flood Estimation in Municipal Areas in South Africa* (Brooker, et al., 2023) provides methodologies for estimating floodmagnitudes associated with specified probabilities of occurrence, or return periods, and supports the design of stormwater infrastructure, bridges and culverts. The design flood approach remains a practical and essential tool for managing flood hazard within municipalities.

Even though a design flood defines the risk acceptable for specific infrastructure or assets, this should not be interpreted as a guarantee of public safety. Infrastructure designed for a specified return period remains vulnerable to larger flood events, and the consequences of exceedance can be significant. Design standards therefore manage flood risk to an acceptable level, but do not eliminate flood risk entirely (South African National Roads Agency Limited (SANRAL), 2013), as illustrated in Figure 2. Ultimately, engineering for a specific flood threshold manages the likelihood of an event, but it does not eliminate the severe consequences of a larger, unprecedented disaster.

2.3 Residual flood risk

Residual flood risk refers to the risk that remains after flood mitigation measures (Items B and C in Figure 2) have been implemented, where flooding exceeds the design recurrence interval. Increased residual risk may arise from infrastructure deterioration, inadequate maintenance, changing catchment characteristics or unforeseen system interactions.

Understanding residual risk shifts the focus from whether infrastructure meets a design standard to what happens when that standard is exceeded, ultimately aiding proactive flood preparedness and reaction. Assessing larger flood events helps municipalities identify vulnerable infrastructure, critical facilities and potential consequences, providing a basis for emergency planning, prioritisation of upgrades and improved public safety.

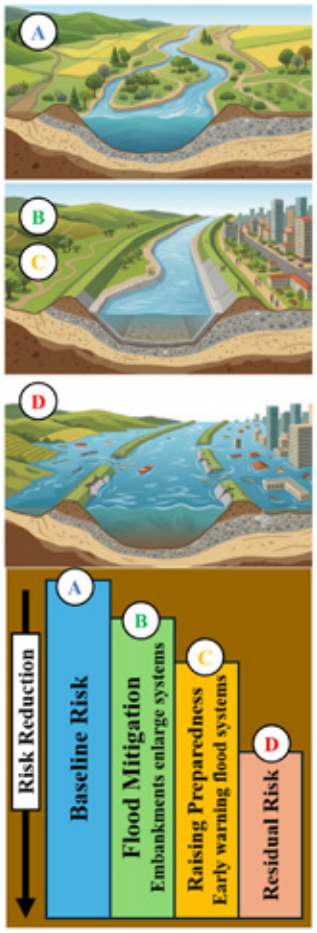


FIGURE 2: *Risk classifications*

2.4 Systems thinking (Design for failure)

Flooding is a catchment-scale process influenced by the interaction of river systems, stormwater infrastructure, land use, development patterns and environmental conditions. A systems-thinking approach recognises that the performance of individual structures cannot be considered in isolation from the broader river and catchment system.

This approach aligns with principles promoted in the *Water Sensitive Urban Design (WSUD) Framework and Guidelines* (Armitage, et al., 2014), which encourage integrated planning across disciplines. Understanding how changes in one part of a catchment influence flood behaviour elsewhere can assist municipalities in identifying system vulnerabilities, managing cumulative impacts and improving long-term flood resilience.

2.5 Flood resilience

Flood resilience refers to the ability of a system to withstand, respond to and recover from flood events. While traditional flood management often focuses on preventing flooding, resilience recognises that some flooding will occur and seeks to reduce the associated consequences.

Resilience can be improved through a combination of structural measures, such as infrastructure upgrades and flood attenuation, and non-structural measures, including floodplain management, land-use planning, early warning systems and emergency preparedness. Understanding the impacts of larger flood events enables municipalities to prioritise interventions that improve safety, reduce damages and support faster recovery following major floods.

These concepts highlight the importance of moving beyond design compliance towards a broader understanding of flood consequences, system vulnerabilities and residual risk. The selected case studies showcase challenges that the municipalities are faced with during flood events exceeding the design flood event and how a number of practices involving the abovementioned concepts, can play an invaluable role in mitigating severe consequences and improving flood resilience.

3. METHODOLOGY AND CASE STUDY SELECTION

The proposed questions-based framework was informed by lessons learned from a range of flood studies and case study investigations. For this paper, two recent flood events are presented as example case studies: Stellenbosch



FIGURE 3: *Case Study Assessment Approach*

Municipality – La Cotte River, Franschhoek and Prospecton, Durban. These case studies represent common flood management challenges faced by municipalities and demonstrate how flood risk can emerge when larger flood events interact with modified river systems, changing catchment characteristics and existing infrastructure constraints.

Each case study is presented in terms of the (1) flooding mechanism, (2) contributing factors, (3) consequences and (4) proposed mitigation measure, as illustrated in Figure 3.

3.1 CASE STUDY 1: STELLENBOSCH MUNICIPALITY – LA COTTE RIVER FLOODING

3.1.1 Flooding Mechanism

Stellenbosch Municipality and specifically Franschhoek experienced significant fluvial flood events during June and September 2023. The September event caused the most severe flooding in recent history. The September flood was associated with a cut-off low weather system that produced a rainfall event with cumulative rainfall exceeding the 1:200-year design rainfall depth over a total 41 hours, while antecedent rainfall had already saturated the catchment (AECOM, 2024). Landslides and modifications in the upper catchment generated significant sediment loads, further reducing the capacity of the river system and contributing to widespread flooding within residential, commercial and industrial areas.

3.1.2 Contributing Factors

The flood exposed vulnerabilities within a modified river system and historical floodplain. Historical evidence suggests that portions of the natural floodplain and river system had been modified over time, including agricultural alterations which redirected the historic main flow channel of the La Cotte River to an alternative flow path, which is located at a higher elevation than the original river channel. During larger flood events, overtopping and breaches of the riverbanks results in floodwaters leaving the modified river channel and diverting back to the original river channel (referred to as the secondary system) further downstream (AECOM, 2024). Key factors contributing to flood risk included:

- Historical floodplain and river modifications;
- Overtopping and breaches allowing flow into the secondary system;
- Undersized hydraulic infrastructure;
- Sharp river bends increasing turbulence, scour and overtopping potential;
- Urban development within the historical floodplain;

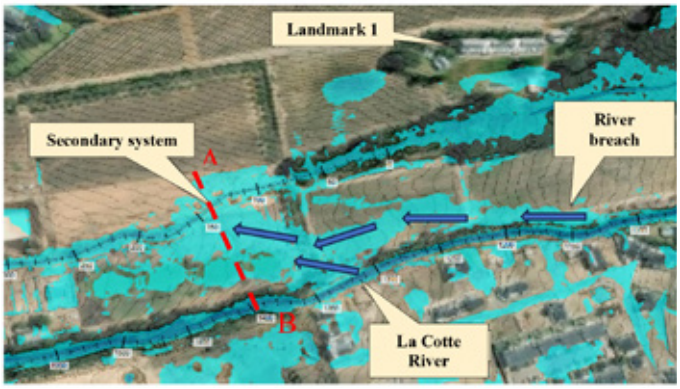


FIGURE 4: *September 2023 flood simulation - upstream of urban area modified from AECOM (2024)*



FIGURE 5: *September 2023 flood validation - De Eike farm (screenshot from: Smit, 2023, 2:42)*

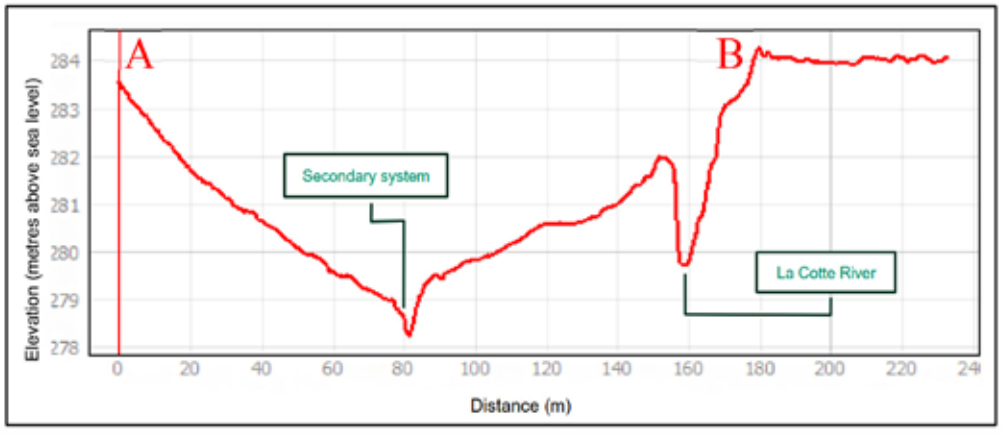


FIGURE 6: *Cross-section between La Cotte River and Secondary system (looking downstream)*

- Encroachment along riverbanks;
- Catchment changes associated with urbanisation and upstream land-use change; and
- Sediment deposition in the stormwater system due to landslides and upstream land modifications.

Hydraulic assessments, corroborated by evidence from the September 2023 flood, demonstrated that the river system was unable to contain flood flows throughout much of its urban extent. This highlighted vulnerabilities that were not apparent from isolated infrastructure assessments.

3.1.3 Consequences

The flooding caused extensive damage to private property, municipal infrastructure, businesses and transport routes. Significant scour, erosion and channel changes occurred throughout the river system. The event demonstrated how historical floodplain modifications and evolving catchment conditions can increase flood risk and expose vulnerabilities beyond those identified through conventional infrastructure assessments.

3.1.4 Mitigation Measures

The flood mitigation strategy extended beyond upgrading individual structures and instead considered the behaviour of the entire river system during larger flood events. Hydraulic modelling was used to identify flood pathways, overtopping locations, breach mechanisms and interactions between the La Cotte River and the secondary system (AECOM, 2025). The systems-based assessment informed a range of interventions aimed at improving flood resilience throughout the urban river corridor, including:

- Increasing the capacity of critical river reaches and hydraulic structures;
- Strengthening berms to limit flow diversion into the secondary system;
- Realigning sharp river bends to reduce scour and overtopping;
- Creating engineered floodplain areas to safely convey larger flood events;
- Establishing controlled overland flow routes for exceedance events;
- Implementing minimum floor levels for vulnerable developments;
- Protecting critical infrastructure exposed to residual flood risk; and
- Creating awareness of flooding within community.

While a preferred solution would have conveyed larger flood events through the urban area, significant constraints associated with existing development, roads, services, property boundaries, environmental considerations and heritage features limited what could realistically be achieved. As a result, the conceptual design was developed to substantially improve the hydraulic performance of the existing river system within these practical constraints. The assessment therefore incorporated residual risk management principles, recognising that flood events exceeding the design capacity would still occur. Proposed measures therefore aimed to reduce the consequences of exceedance events.

Community engagement formed an integral part of the study and contributed significantly to understanding historical flood behaviour, floodplain dynamics and local constraints. Discussions with residents and landowners highlighted community concerns, historical river modifications and areas known to flood during larger events. Beyond informing the conceptual design, the process improved awareness of how the broader flood system functions and where residual risks remain. The resulting strategy therefore combined structural and non-structural measures to improve flood resilience, recognising that public safety depends not only on infrastructure upgrades but also on understanding, preparing for and managing flood events that exceed the design standard (AECOM, 2025).



FIGURE 7: *Photos from the October 2017 flood showing (a) disruption of traffic on the N2 and (b) damage to rail infrastructure*

3.2 CASE STUDY 2: INDUSTRIAL FLOODPLAIN DEVELOPMENT

3.2.1 Flood mechanisms

The Prospecton industrial area in Durban experienced three major flood events in October 2017, April 2019, and April 2022, with the April 2022 event causing the most severe damage in the region's recent history. The 2017 and 2019 events were characterised by intense, localised downpours within the immediate catchment draining towards the Isipingo Estuary. Surface water runoff exceeded the capacity of the bulk drainage canals, resulting in flooding across the flat, low-lying terrain, as shown in Figure 7.

In contrast, the catastrophic April 2022 event was associated with an extreme, regional rainfall system over the Mlazi River catchment. This system resulted in runoff exceeding the capacity of historical diversion infrastructure, causing a major structural breach. The resulting floodwaters, carrying heavy sediment loads from upstream failures, reverted to the river's historical natural flow path, inundating heavily industrialised zones under rapidly rising water levels, as shown in Figure 8.

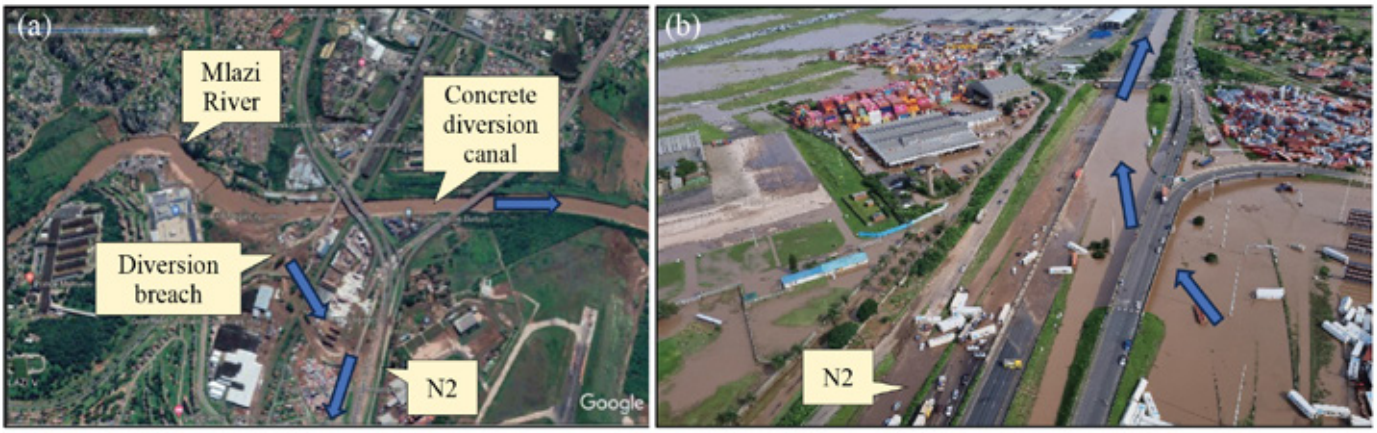


FIGURE 8: *Sediment laden flow during the April 2022 flood from (a) aerial imagery from Google Earth and (b) photos taken by eThekwini Municipality at the diversion breach*

3.2.2 Contributing factors

These flooding events exposed vulnerabilities introduced by large-scale historical modifications to the natural river systems. During the 1960s, the Mlazi and Isipingo Rivers were artificially diverted to unlock the wide, flat floodplains near the Isipingo Estuary for industrial development, as shown in Figure 9. The Mlazi River was redirected north into a concrete canal, while the Isipingo River was diverted to the south towards the Mbokodweni River. These interventions fundamentally altered the catchment's hydraulic dynamics. The reduction of natural river flow into the Isipingo Estuary compromised its natural "flushing" mechanism, severely restricting its capacity to discharge flood volumes during severe weather events.

Furthermore, the flat, low-lying topography of the historical floodplain limits the hydraulic head and gradient required for the local stormwater network to drain efficiently during local downpours. Hydraulic assessments indicated that the historical diversion structures did not adequately account for overtopping dynamics or residual risk during events exceeding their original design return periods.

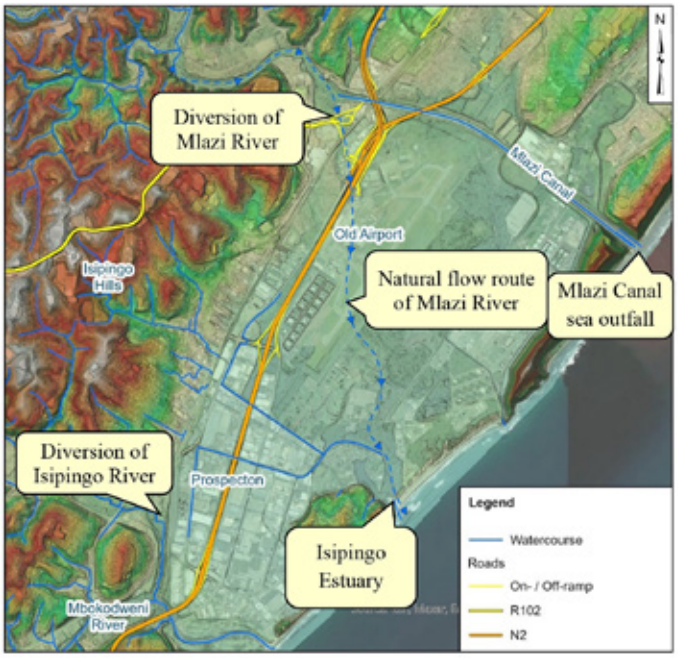


FIGURE 9: *Historical flow regime (modified from AECOM, 2019)*

Key factors contributing to the flood risk included:

- Historical floodplain and river modifications: Structural separation of the rivers from their natural catchments;
- Urban and industrial development within a high-hazard historical floodplain;
- Overtopping and structural breaches of the Mlazi diversion infrastructure, forcing flow back into original paths;
- Rapid onset of floodwaters following the infrastructure breach, severely limiting early-warning reaction times;
- Insufficient scour protection downstream of the primary Mlazi diversion structure;
- Absence of dedicated overland flow routes to safely manage and convey flood volumes exceeding the design capacity of the canal system; and
- Impeded estuarine drainage due to long-term siltation and loss of natural tidal flushing.

3.2.3 Consequences

The flood events highlighted a significant accumulation of "inherited" residual risk stemming from the mid-century river diversions. During all three events, the flat terrain caused prolonged inundation, halting operations at major economic and manufacturing hubs for periods ranging from weeks to months. While the high-velocity run-off from the steeper adjacent Isipingo Hills caused structural damage to infrastructure and private properties, the lower-velocity, deep-water inundation within the Prospecton basin crippled critical supply chains.

The April 2022 breach exacerbated these impacts by depositing vast volumes of sediment across the industrial zone. Additionally, major linear infrastructure developed within the historical floodplain—such as the N2 highway corridor—acted as physical hydraulic barriers, altering natural drainage pathways and inadvertently concentrating flood levels in surrounding areas. These events demonstrated that isolated infrastructure upgrades would not provide sufficient mitigation when historical modifications have fundamentally compromised the broader hydrological system.

3.2.4 Mitigation Measures

Since the October 2017 flood event, AECOM (2019) conducted a flood level assessment for the Prospecton area confirming that the proposed flood mitigation strategy should shift away from localised infrastructure

fixes, and instead focus on a systems-based management approach. This study utilised hydraulic modelling to evaluate the complex hydraulic interactions within the Prospecton area and surroundings, as well as quantifying the impact of various mitigation measures. The resulting conceptual strategy combines structural interventions, such as an additional sea outfall, attenuation within Isipingo Hills, upgrading the existing bulk stormwater canals, and an additional flood relief canal, with non-structural measures, including eThekwini's existing flood early warning system, recognising that absolute protection against extreme exceedance events is highly unlikely due to dense industrial development and the "inherited" risk.

Furthermore, studies by AECOM (2022) and Royal HaskoningDHV (2024) highlighted that scour protection measures at the Mlazi flow diversion structure would significantly reduce flood volumes during events exceeding the design return period, as well as the rapid rise of floodwaters caused by the breach wave and associated sediment load. This would greatly diminish the damage caused by these types of flood events (Wiese and King, 2025).

Finally, the sharing of the flood dynamics, hazard areas and potential risks with the stakeholders in the area allowed for improving flood preparedness plans and associated management of residual flood risks.

4. CROSS CUTTING LESSONS LEARNED

These two case studies highlight some real-world lessons when it comes to flood risk management. The common themes emerging from the case studies are summarised in Table 1. Although the specific flood mechanisms differed, both cases revealed recurring challenges associated with historical floodplain modification, evolving catchment conditions, residual risk and the limitations of isolated engineering interventions. These shared lessons provided the basis for identifying the key themes of the proposed questions-based framework, namely understanding the river system, continuously assessing flood risk, adopting a systems-thinking approach and building long-term flood resilience.

5. QUESTIONS-BASED FRAMEWORK FOR HOLISTIC FLUVIAL FLOOD MANAGEMENT

Design compliance is only one part of achieving flood resilience and public safety. Building on the cross-cutting lessons identified from actual flood events, such as those presented in the case studies, a questions-based municipal flood review framework was developed to assist municipalities in moving beyond infrastructure-focused design towards holistic fluvial flood management. Rather than prescribing additional design standards, the framework encourages critical thinking by guiding municipal officials, planners and engineers through a structured sequence of questions that consider the broader river system, residual flood risk and opportunities to improve resilience. The framework is organised around the four interconnected components identified in the cross-cutting lessons learned: (1) Understanding the River System, (2) Understanding Flood Risk, (3) Managing Flood Risk through Systems Thinking, and (4) Building Municipal Resilience.

Each component consists of practical questions that can be answered with a simple Yes or No. A negative response indicates a potential gap requiring further investigation or action, while a positive response confirms that an important aspect of holistic flood management has been considered. Each question is linked to suggested municipal actions and the intended municipal benefits, enabling decision-makers to progress from identifying vulnerabilities to implementing appropriate structural and non-structural interventions. In this way, the framework provides a practical review process that complements existing flood design guidance by encouraging systems thinking, improving interdepartmental collaboration, managing residual flood risk and ultimately strengthening public safety and municipal flood resilience.

6. CONCLUSION AND FURTHER CONSIDERATIONS

Design standards remain an essential foundation for flood risk management; however, the case studies demonstrate that compliance alone cannot guarantee public safety during extreme fluvial flood events. Historical modifications to river systems, ongoing catchment change and the inherent residual risk associated with exceedance events necessitate a broader, systems-based approach. The proposed questions-based framework provides a practical means for municipalities to identify vulnerabilities, interrogate residual risk and integrate flood considerations into planning, infrastructure management and emergency preparedness. It is therefore recommended that municipalities incorporate the framework into the scoping and review of flood studies, regularly reassess flood risk as catchments evolve, and combine structural interventions with non-structural measures such as land-use controls, maintenance programmes, community awareness and emergency response planning. By moving

TABLE 1: *Summary of Lessons Learned*

Lessons learned	Framework strategy
It cannot be assumed that historical alterations have permanently modified the natural hydrology. The reality of "hydraulic memory" is that a river can divert back to its natural flow path.	An understanding of the river system is essential.
Risk is not static; it evolves based on historical development choices, climate extremes, and changes to the catchment.	Changing conditions necessitates the continuous assessment of the flood risk.
Isolated engineering solutions could fail during major regional events. Effective flood mitigation solutions and risk management requires an interconnected, catchment-wide strategy.	Managing flood risk requires a larger picture or systems thinking approach.
Exceedance flooding will occur despite compliance with design standards and protection based on specific design flood events.	Build resilience through a combination of structural and non-structural measures, preparedness, and community awareness to enhance pro-active recovery planning.

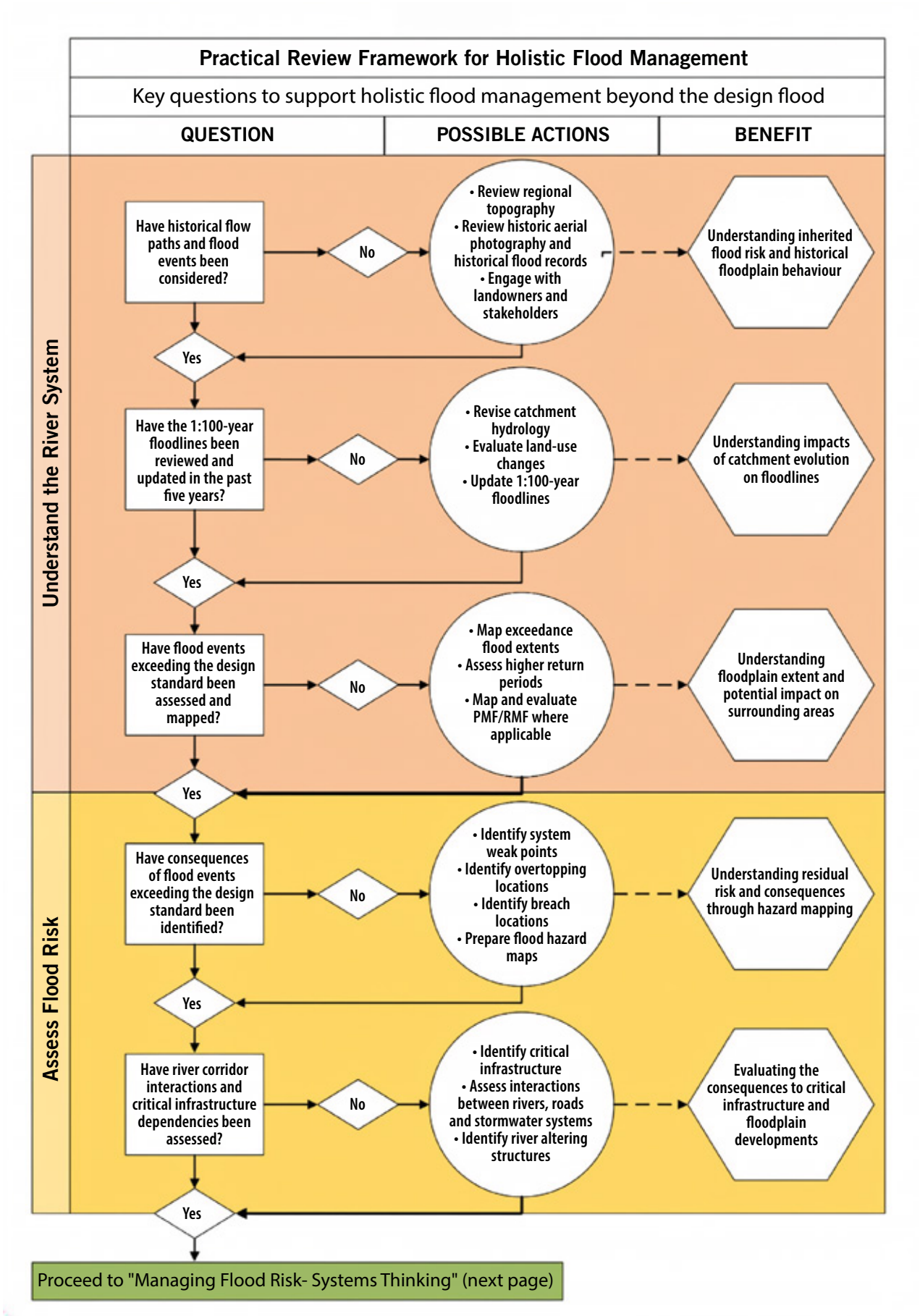


FIGURE 10 A: *Questions-based framework for holistic flood management*

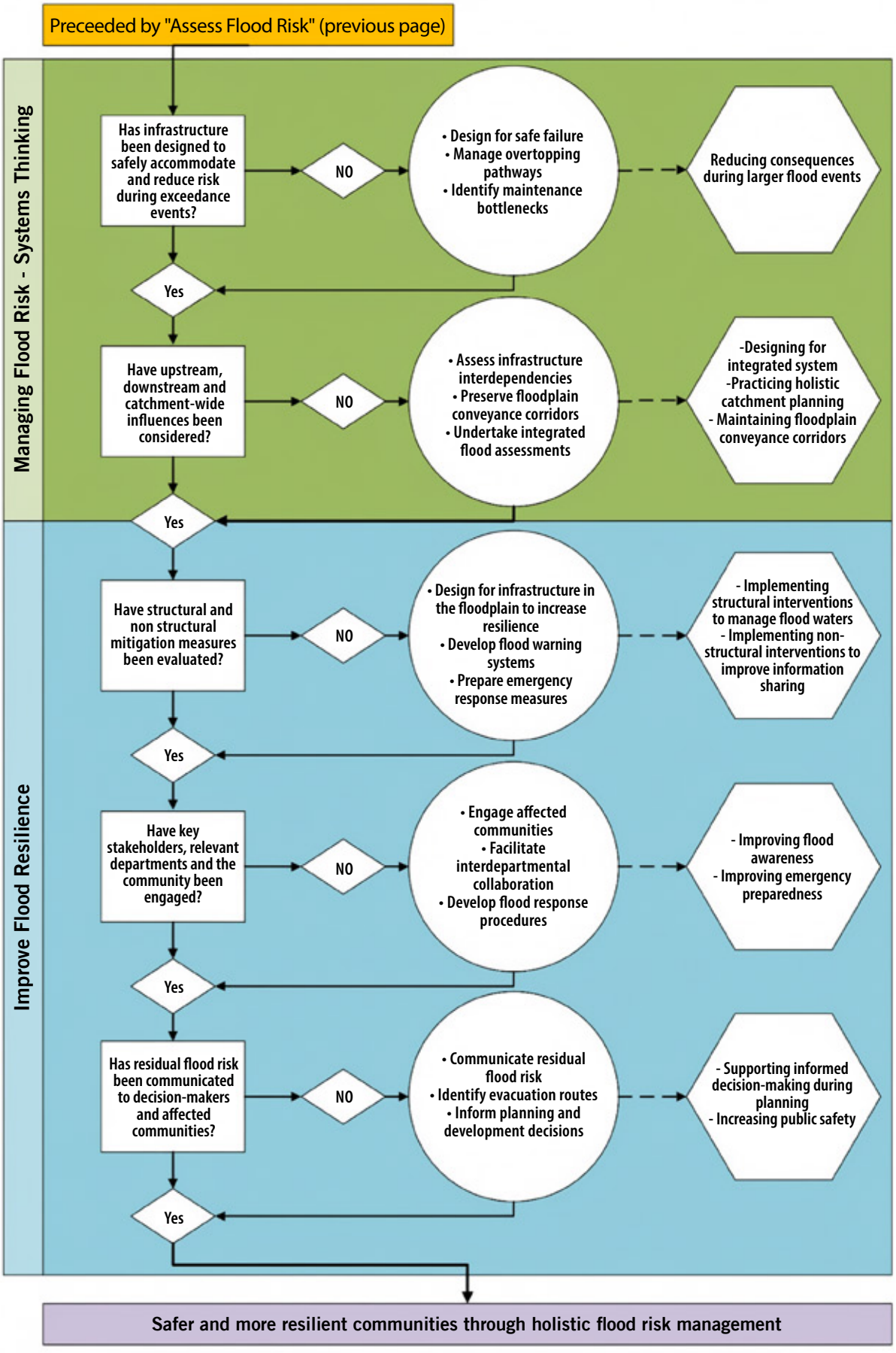


FIGURE 10 B: *Questions-based framework for holistic flood management*

beyond compliance towards resilience-focused, catchment-scale decision-making, municipalities can significantly enhance the safety and adaptability of their communities in the face of future flood events.

7. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the contributions of the project teams involved in the case studies, whose expertise and commitment were instrumental to the success of these projects. The support and collaboration of Stellenbosch Municipality, eThekwini Municipality and Toyota South Africa Motors are also sincerely appreciated.

8. REFERENCES

AECOM, 2019. *Investigation of Flooding Risk at TSAM Durban Plant,* Durban: Toyota South Africa Motors.

AECOM, 2023. *Worcester Eastern Bypass: Concept and Viability Report,* Cape Town: Western Cape Government: Chief Directorate: Road Programme Management, Transport Infrastructure.

AECOM, 2024. *Investigation of Flood Risk Mitigation Measures at TSAM Durban Plant,* Durban: Toyota South Africa Motors.

AECOM, 2023. *Worcester Eastern Bypass Drainage Report,* Cape Town: Western Cape Government, Chief Directorate: Road Programme Management, Transport Infrastructure .

AECOM, 2024. *La Cotte River Flood Assessment,* Cape Town: Stellenbosch Municipality.

AECOM, 2025. *La Cotte River Mitigation-Concept Designs to Increase River Capacity,* Cape Town: Stellenbosch Municipality.

Armitage, N. et al., 2014. *Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines,* Pretoria: Water Research Commission.

Brooker, C. et al., 2023. *A Best Practice Guideline for Design Flood Estimation In Municipal Areas in South Africa,* Pretoria: Water Research Commission.

Byaruhanga, N., Kibirige, D. & Mkhonta, G., 2025. Understanding South Africa's Flood Vulnerabilities and Resilience Pathways: A Comprehensive Overview. *Water,* 2608(https://doi.org/10.3390/), p. 17.

Department of Human Settlements, 2019. *The Red Book: The Neighbourhood Planning and Design Guide.* Version 1.1 ed. Pretoria: South African Government.

Ferguson, S. et al., 2023. *Urban Flood Risk Handbook: Assessing Risk and Indentifying Interventions.* 1st ed. Washington: The World Bank.

Mahlangu, Z., Okedi, J. & Vermeulen, A., 2025. Assessing the effectiveness of emergency preparedness plans during flooding in South Africa. *Civil Engineering: Water Engineering,* 33(8), pp. 46-49.

Royal HaskoningDHV, 2024. *Economic Flood Risk Assessment South Durban Basin (Prospecton),* Durban: Netherlands Enterprise Agency.

South African National Roads Agency Limited (SANRAL), 2013. *Drainage Manual.* 6th ed. Pretoria: SANRAL.

Wiese, M. & King, K., 2025. *Sustainability of Flood Studies: From inundation mapping to holistic risk management in Prospecton, Durban.* East London, IMESA.