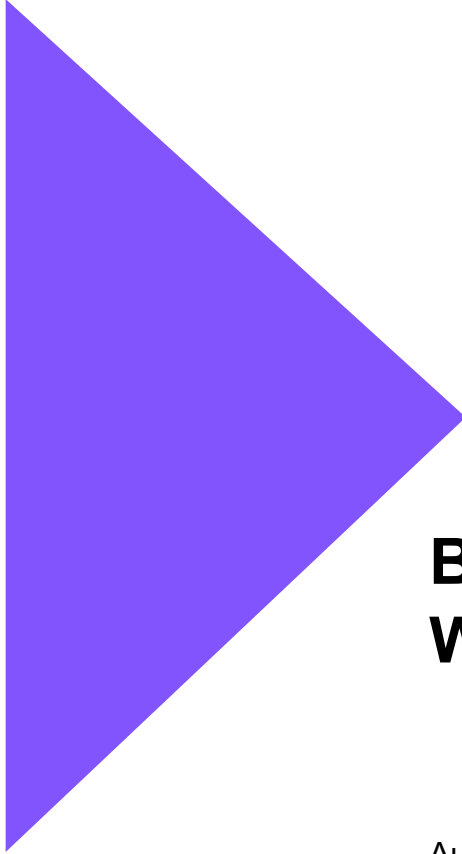
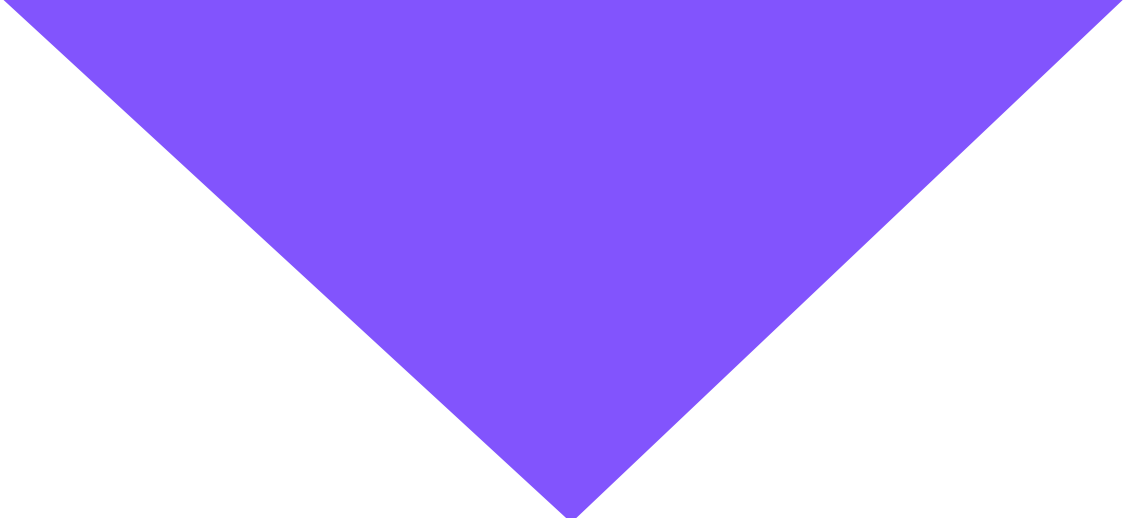




Black Sluice Catchment Works Model Review 2025

August 2026

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Black Sluice Catchment Works Model Review 2025

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Contents

1	Introduction	3
1.1	What are the objectives of this assessment?	3
1.2	Investigation approach	3
2	Understand the SFFD catchment	4
3	Understanding the Black Sluice and Boston Barrier	5
4	Scenario	6
4.1	How could changes to pumping at Black Sluice have affected flood levels?	6
4.2	How could the starting water levels in SFFD have affected flood levels?	7
4.3	How could Internal Drainage Board pumping have affected flood levels?	9
4.4	How could catchment ground conditions have affected flood levels?	10
5	How unusual were the floods in January 2025 and Storm Henk?	12
6	Why did properties and farmland flood?	13
7	What could be done in the future?	14
7.1	Optimising the operation of existing assets	14
7.2	Reinstatement of the Black Sluice pumps	14
7.3	Consider alternative interventions to reduce flood risk	14

1 Introduction

In early January 2025, heavy rainfall fell on frozen, or near-frozen, ground across the South Forty Foot Drain (SFFD) catchment. Record water levels were measured at several locations, and properties were flooded in Boston, Billingborough, Pointon and other areas.

The January 2025 flood occurred one year after flooding in Storm Henk in January 2024. This preliminary assessment has been carried out in response to the recent flooding, to understand why these floods happened and how asset condition and pre-flood conditions can influence water levels.

This document outlines the findings of the preliminary assessment.

1.1 What are the objectives of this assessment?

This assessment has three objectives:

- To review and update previous flood models and data available.
- To develop an understanding of how operational changes, and conditions prior to a flood, could influence water levels.
- Identify actions that could potentially help manage any floods that could happen in the future.

1.2 Investigation approach

Flood risk management decisions draw on many sources of information. A key tool is hydraulic modelling: computer-based models that simulate water levels and flows, helping us test different scenarios.

Existing hydraulic modelling was reviewed for use in this preliminary assessment. The model providing the most up-to-date representation of the Black Sluice catchment was applied, with updates made to better represent Storm Henk and the January 2025 floods. The updated hydraulic model incorporated more recently collected riverbank elevations and revised inflows.

The updated hydraulic model of the SFFD catchment was used to test how Storm Henk and the January 2025 floods might have differed under alternative conditions. The model indicates flooding influenced by both river flows and tides.

Flooding is inherently variable, so no model can reproduce every event exactly. As with all flood models, assumptions are made and some processes are simplified so that the model can be applied in practice. This means it may not match recorded water levels during the events precisely, but it is suitable for understanding overall flood behaviour, comparing scenarios, and supporting informed, evidence-based, decision-making.

The model outputs (water levels and flows) were used to inform the conclusions of this assessment.

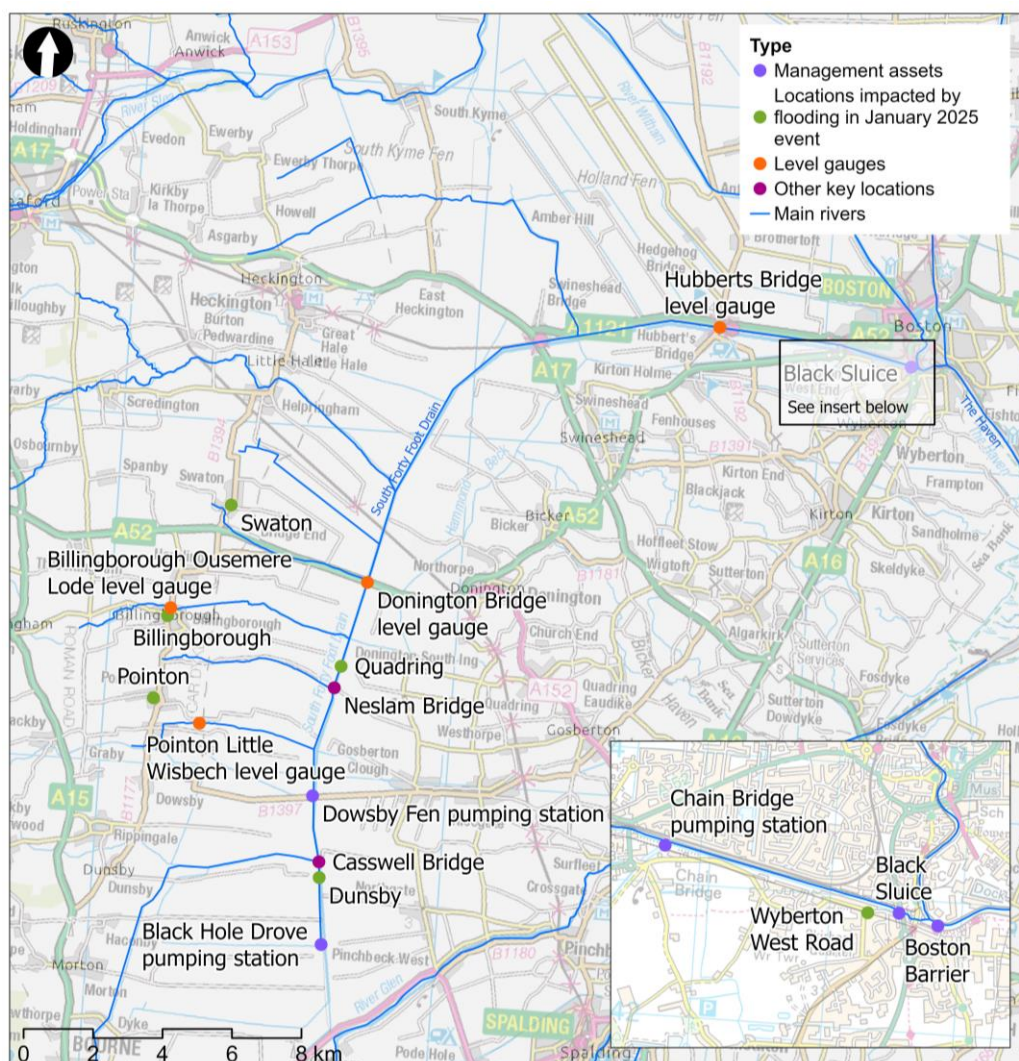
2 Understand the SFFD catchment

The SFFD catchment is complex and is managed by various structures and manmade channels. The 'Black Sluice' infrastructure is located at the downstream end of the SFFD catchment at Boston. All SFFD catchment flows must pass through the Black Sluice to leave the SFFD catchment. Flows passing through the Black Sluice enter 'The Haven'. The Haven is the tidal estuary between the SFFD and the North Sea. A map of the catchment highlighting key areas of interest to our assessment is provided in Figure 1.

Water levels and flows in the downstream (flatter) parts of the catchment such as Boston are influenced by the operation of the Black Sluice and Internal Drainage Board (IDB) assets. The IDB pumps water into the SFFD from the fens. However, levels and flows further upstream near places such as Billingborough are influenced by other factors.

This assessment demonstrates how different factors within the catchment could influence the resultant water levels in the SFFD and its tributaries.

Figure 1: South Forty Foot Drain catchment



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3 Understanding the Black Sluice and Boston Barrier

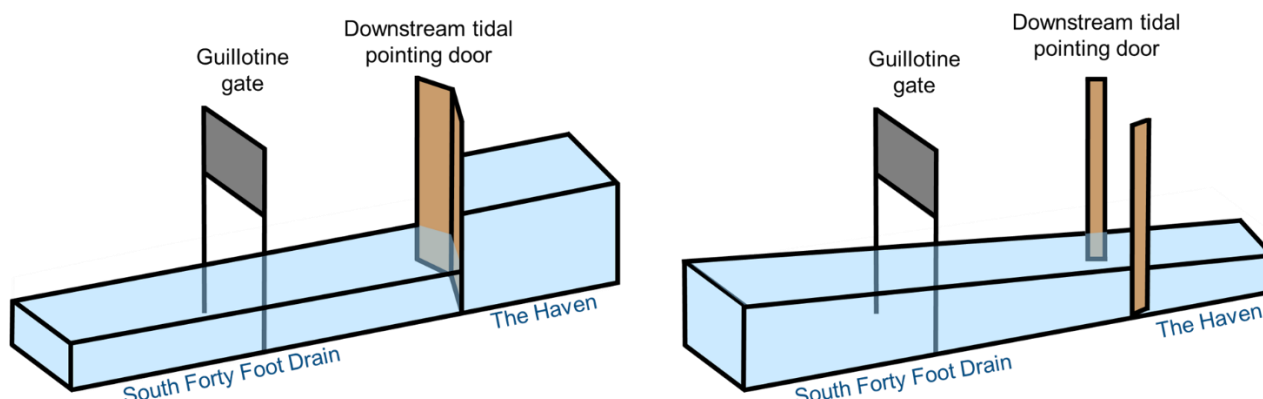
The Black Sluice comprises two outfalls, which influence the transfer of water between the SFFD and The Haven. Flow through the outfalls is controlled by a combination of sluice gates and pointing doors:

- **Sluice gates** – are located on the SFFD side of the Black Sluice to regulate water levels in SFFD. Before a flood, the gates are opened.
- **Pointing doors** – are located on The Haven side of the Black Sluice to prevent ingress of the tide into the SFFD.

Figure 2 visualises how the pointing doors operate. When water levels are higher:

- **In The Haven than in the SFFD** - The pointing doors will close, to prevent ingress of the tide into the SFFD. This causes water levels in the SFFD to rise.
- **In the SFFD than in The Haven** - The pointing doors will open, allowing flows to pass from the SFFD into The Haven. This lowers water levels in the SFFD.

Figure 2: Diagram demonstrating how the Black Sluice pointing doors will open or close, depending on the water levels



Within the Black Sluice Pumping Station, there are five pumps which have historically been used to transfer water from the SFFD into The Haven, when the pointing doors were shut. Studies were ongoing to understand if a business case could be made for the station's refurbishment, when in December 2013, three pumps were damaged by flooding during the East Coast Tidal Surge. The remaining two pumps were decommissioned in October 2018, after modelling and economic assessment showed refurbishment costs outweighed the value of avoided damage.

The Boston Barrier is a separate structure, constructed downstream of the Black Sluice to provide better protection from tidal flooding in Boston. It remained open during the Storm Henk and the January 2025 floods, because the tidal water level was not high enough to activate closure of the barrier.

4 Scenario

A hydraulic model was used to test how water levels in the SFFD during Storm Henk and the January 2025 floods might have differed under alternative conditions:

- Changes to pumping at Black Sluice.
- Changes to initial water level in the SFFD.
- Changes to pumping from the Internal Drainage Board.
- Changes to catchment ground conditions and frozen ground.

4.1 How could changes to pumping at Black Sluice have affected flood levels?

The hydraulic model was used to assess what could have occurred if two pumps at Black Sluice had remained in place and were operating as intended prior to their decommissioning. These were the pumps that were least affected by the East Coast Tidal Surge in 2013.

The hydraulic model predicted that pumps could have reduced water levels in the SFFD:

- The greatest reduction in water levels occurs at Black Sluice, immediately east of Wyberton West Road, with the effect gradually decreasing further upstream (Figure 3).
- It is uncertain exactly how far upstream this effect extends, with a visible difference in water level up to Casswell Bridge.
- The model predicts that pumping at Black Sluice would have only a localised impact, and the benefit would not extend upstream to affect flood water levels in Billingborough, Pointon, or Swaton, where flooding was experienced in January 2025 (Figure 4).

These findings are consistent with the earlier work, completed in 2016, which informed the decision to decommission the pumps. This found that pumping at the Black Sluice led to a very similar, localised decrease in highest water levels.

Figure 3: Comparison of modelled peak river levels in the SFFD, at high tide, with and without pump operation at Black Sluice (Jan 2025)

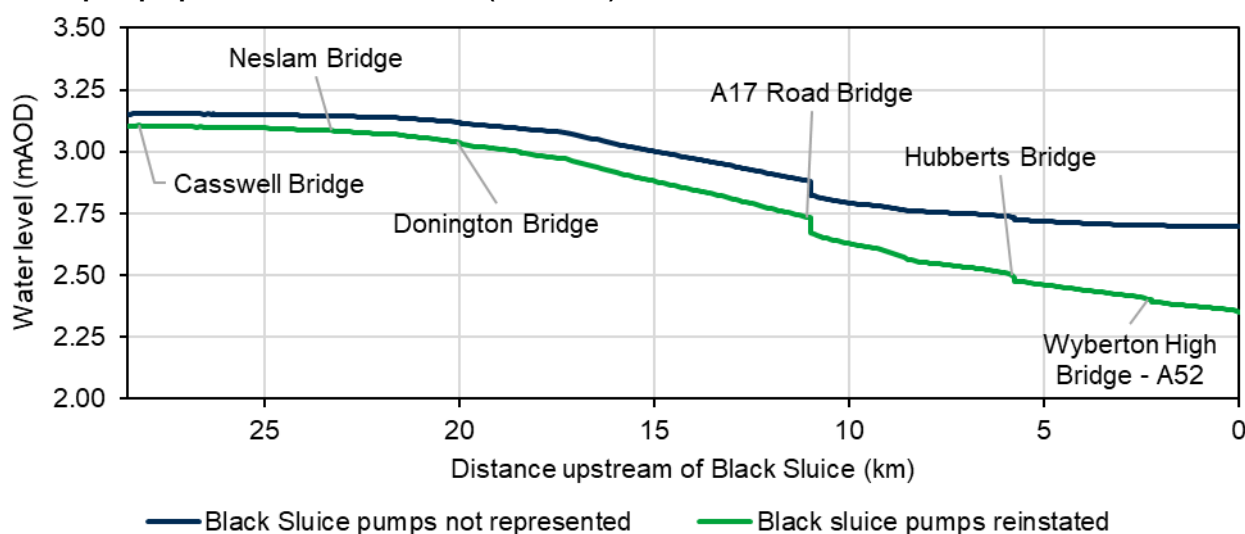
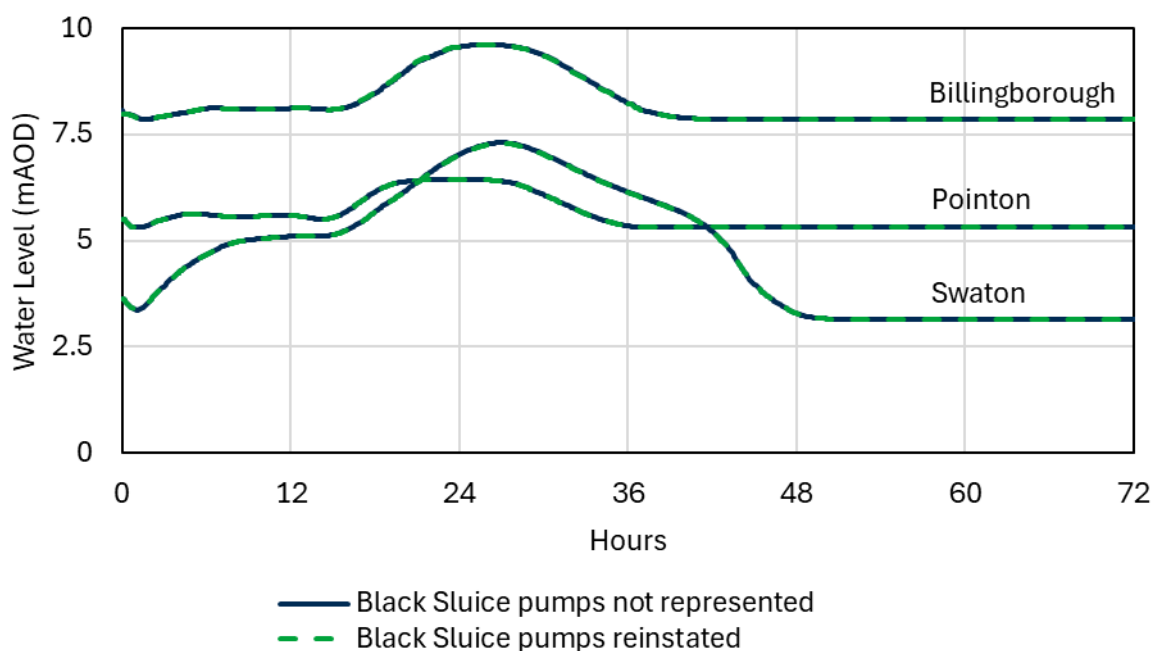


Figure 4: Comparison of peak river levels in SFFD tributaries with and without pump operation at Black Sluice (Jan 2025)



4.2 How could the starting water levels in SFFD have affected flood levels?

Flooding from low-lying and flat systems such as the SFFD can be influenced by the starting water level in the river. If more water is present in the SFFD before a flood, then less additional water is needed for the watercourse to reach its capacity. The volume of water already present in the SFFD can vary based on the rainfall preceding a flood but also how the Black Sluice gates are opened and closed.

In the hydraulic modelling, higher starting river levels in the SFFD were represented in two ways:

- By changing the timing of when the sluice gates at Black Sluice are opened. During the January 2025 flood the sluice gates were opened manually and so opened at a different time than they would have via the automated process.
- By applying higher starting river levels within the SFFD, as happened in January 2024 during Storm Henk, when preceding rainfall had raised river levels.

The model results from both scenarios produced similar results and predicted that the starting river levels tested had little effect on peak levels. The model predicted river levels to rise earlier during the flood, but to have only a limited effect on the highest water levels reached (see Figure 5 and Figure 6). This is also reflected in the fens of the catchment, where there are only small changes in highest water levels.

Figure 5 shows that, for the first 24 hours of the modelled flood, the sluice gates and pointing doors operate together to control flows. After 24 hours, the sluice gates are fully open and only the pointing doors continue to operate.

When the sluice gates are closed or partially closed, they help control the flow of water from the SFFD into The Haven, alongside the pointing doors. Once the gates are fully open, flow is

controlled solely by the pointing doors. Further detail on how the pointing doors operate is provided in Figure 2.

Figure 5: Modelled River level at Hubberts Bridge representative of later gate opening (Jan 2025) and a raised water level (Jan 2024 - Storm Henk) before flooding

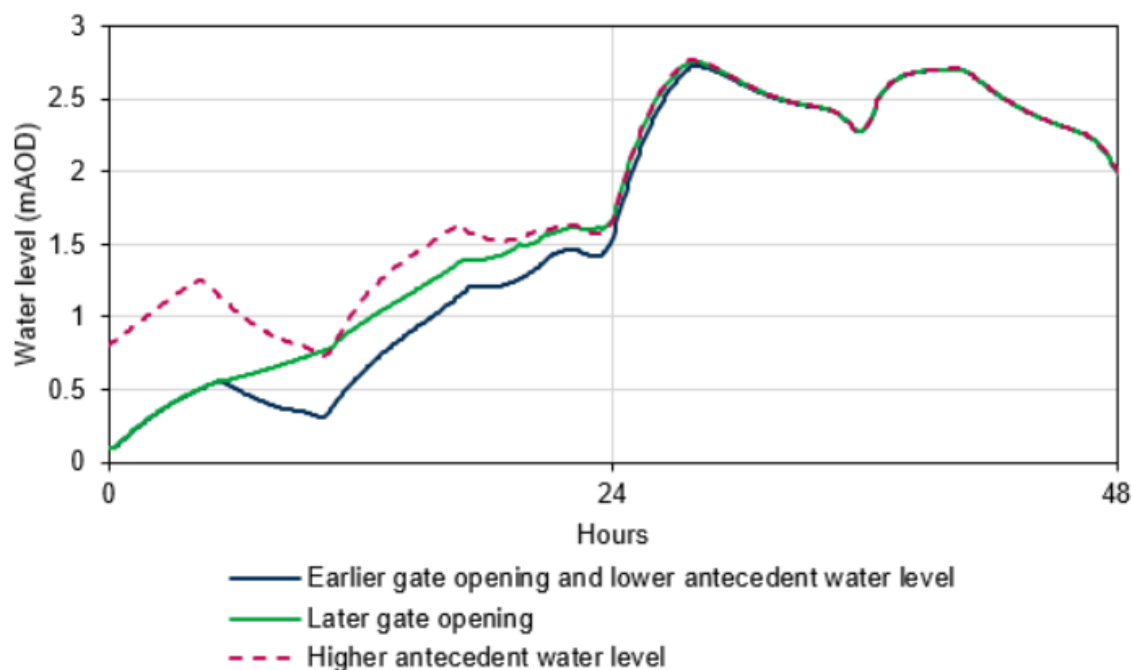
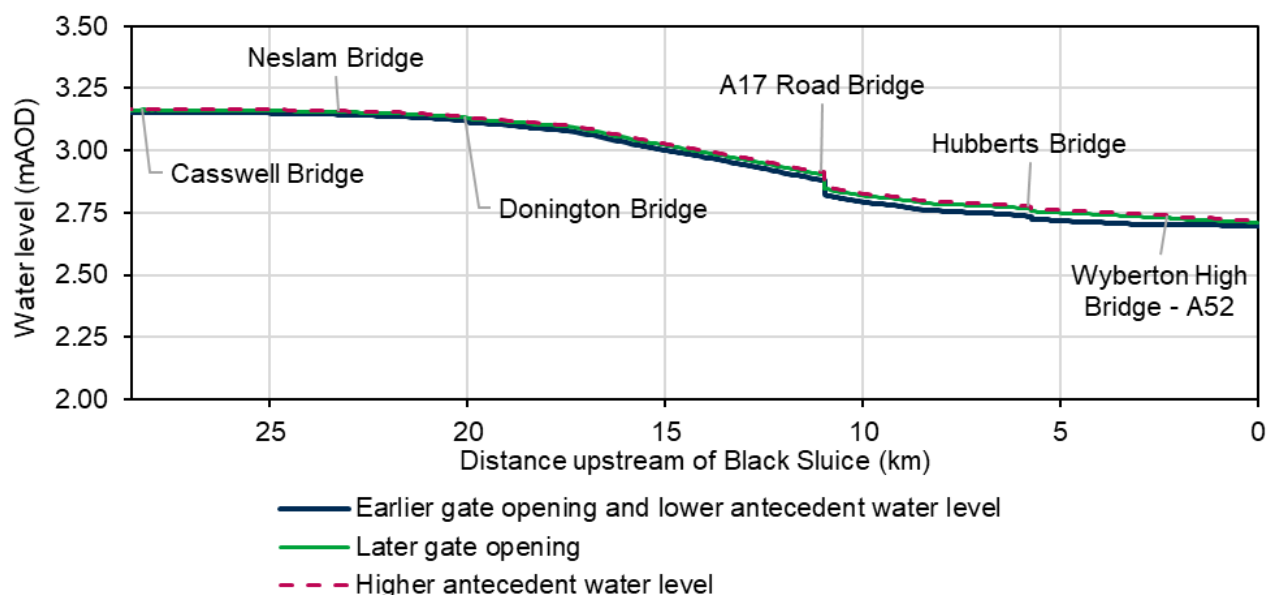


Figure 6: Modelled highest river levels, during a high tide, in the SFFD representative of later gate opening (Jan 2025) and a raised river level (Jan 2024 - Storm Henk) before flooding



4.3 How could Internal Drainage Board pumping have affected flood levels?

Internal Drainage Board (IDB) pumping moves water from the fens into the SFFD and its tributaries. How the pumps operate depends on recorded water levels in both the fens and the SFFD.

The model was used to understand what could happen under two pump operation scenarios:

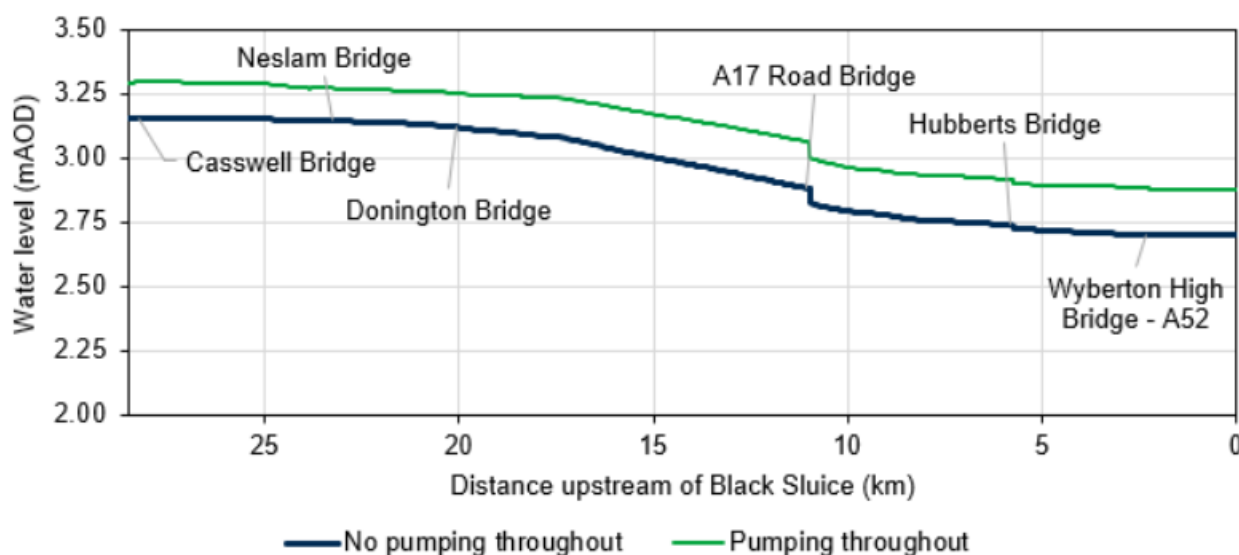
- Continuous pumping throughout the flood.
- Pumps switched off during the period when flood water levels are at their highest.

In practice IDB pumping is somewhere between these two scenarios, with pumping scaled back as much as possible to keep water in bank within the drainage system.

The results of changing the time spent pumping were as follows:

- As expected, if the IDB pumping continued throughout the flood, water levels in the SFFD would be increased (Figure 7).
- Within the fens, the model shows mixed effects, with water levels lowering in some areas and rising in others. This variation likely reflects the complex interactions between watercourses and fens, as well as differences in pump capacity, bank heights, and ground levels at different locations.
- The hydraulic modelling shows no meaningful change in water levels at Billingborough, Pointon, and Swaton under different IDB pumping scenarios.

Figure 7: Modelled highest river levels, during a high tide, in the SFFD for IDB pumping scenario test (Jan 2025)



4.4 How could catchment ground conditions have affected flood levels?

The ground conditions prior to a flood might impact the severity of the flood. For example, if the ground is:

- Full of water, with limited to capacity to take in further rainfall.
- Frozen, and rainfall cannot penetrate the ground.

In both cases, more water may reach watercourses, and the water may also reach the watercourses more quickly. Figure 8 demonstrates this process.

Frozen ground, across the entire catchment, was represented in the hydraulic model, imitating conditions where no rainfall could enter the ground. This is thought to replicate the ground conditions experienced during the January 2025 flood.

The hydraulic modelling results indicated that frozen ground conditions are likely to significantly increase water levels throughout watercourses in the catchment (Figure 9), including modelled water levels in Billingborough, Pointon and Swaton (Figure 9).

Figure 8: Impact of frozen or saturated ground conditions on catchment runoff

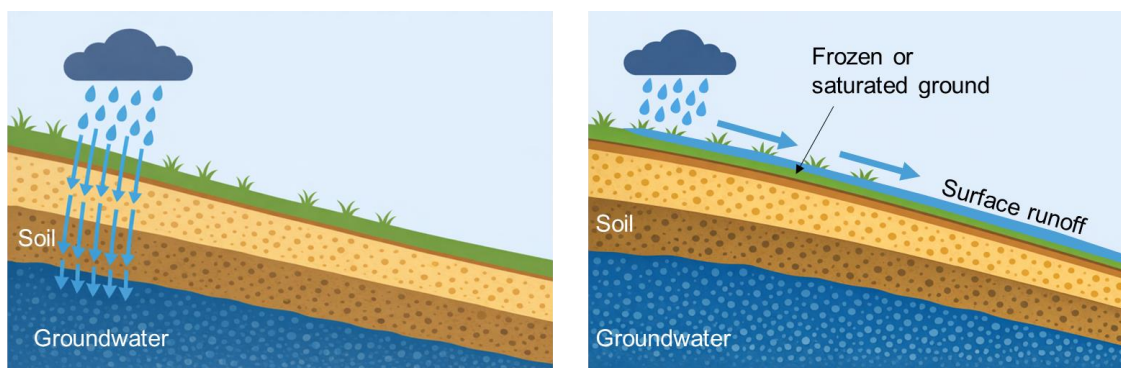


Figure 9: Modelled highest water levels, during a high tide, in the SFFD for frozen ground scenario test (Jan 2025)

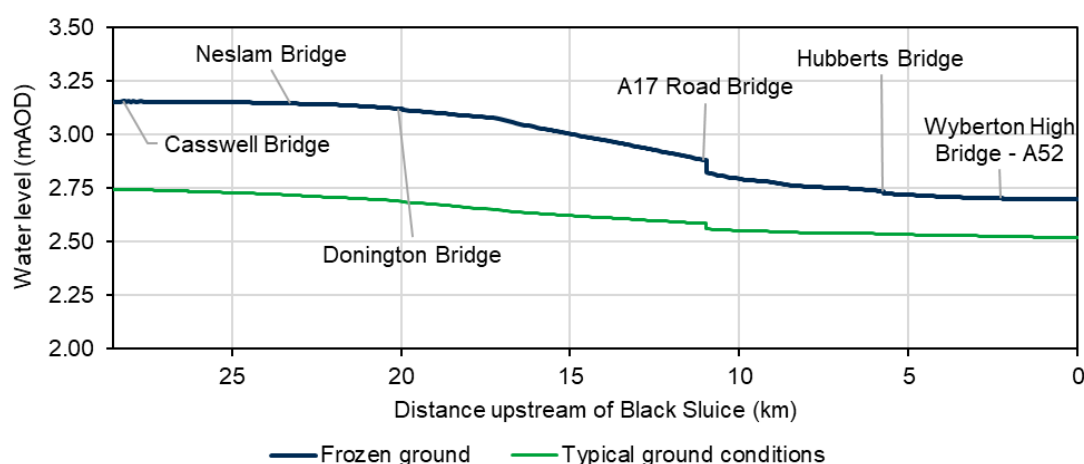
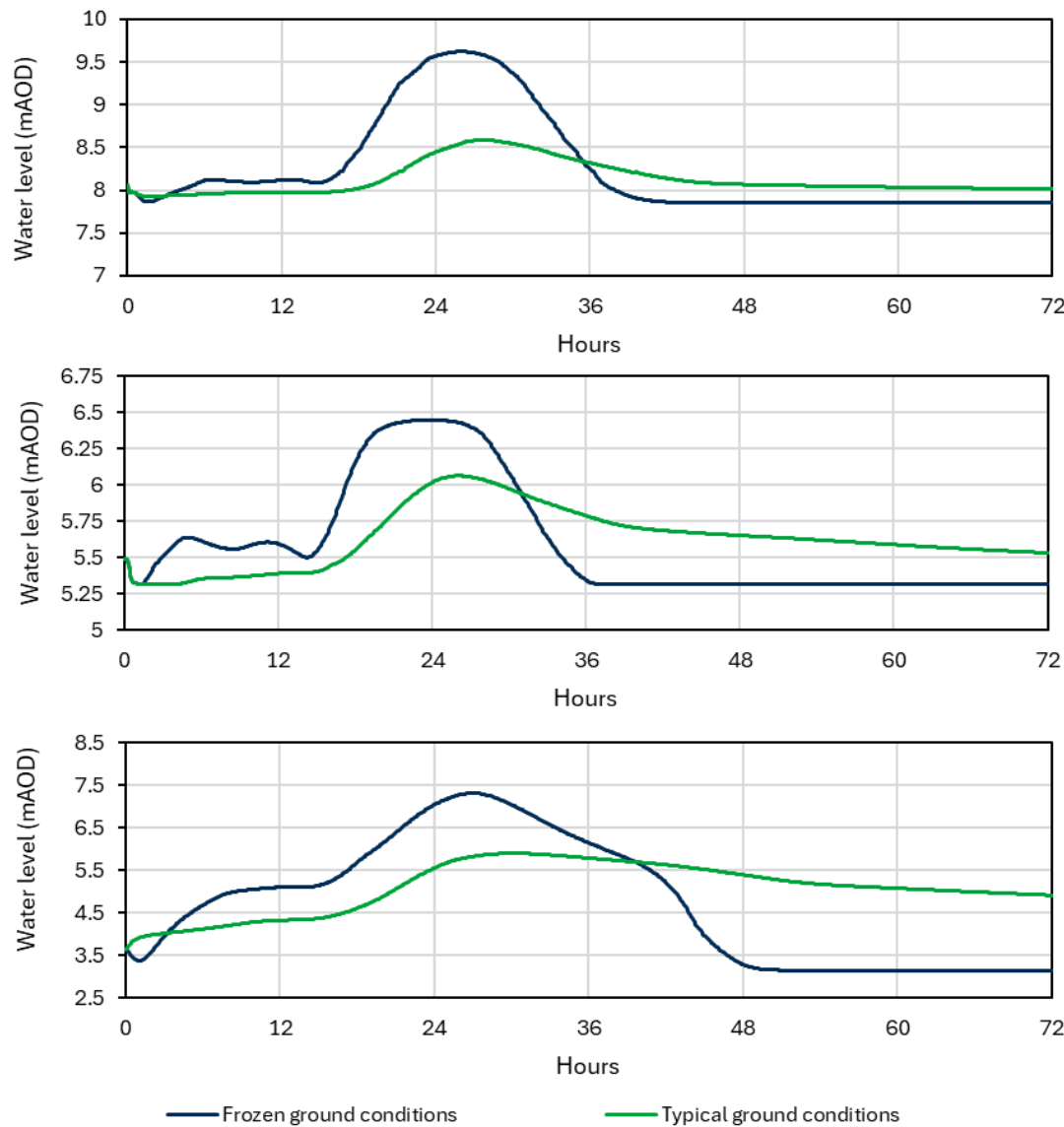


Figure 10: Modelled river levels for frozen ground scenario test at Billingham (top graph), Pointon (middle graph) and Swaton (bottom graph)



5 How unusual were the floods in January 2025 and Storm Henk?

River gauge records across the catchment were analysed and it was found that the floods in January 2025 and during Storm Henk were the two largest events recorded since the Environment Agency's gauge network in the catchment was established around 26 years ago.

Both floods occurred within a 12-month period, shortly after the significant flood during Storm Babet in October 2023 (the fourth largest flood in our record). It is unusual for several of the largest floods observed to occur so close together.

Due to the complex nature of the SFFD catchment, it is difficult to use industry standard methods to reliably estimate how rare particular river levels are. Our analysis shows that factors such as the operation of structures, pumping and land drainage, ground conditions, and the starting water levels within the SFFD can all influence river levels and flooding across the catchment.

Because conditions on the ground can have such a strong influence on flooding, it is difficult to use river records alone to compare different events and understand how rare they were. Instead, it is more useful to analyse the rarity of the rainfall that fell during these floods. Rainfall is unaffected by ground conditions and provides a clearer way of comparing events in complex, heavily managed catchments such as the SFFD.

Our analysis indicates that the rainfall during January 2025 had a 13% chance of occurring in any given year, and Storm Henk had a 35% chance. While these are relatively uncommon rainfall events, they are more frequent than the river levels observed, which rose more in response. Initial attempts were made to associate a probability with a given river flow, but this resulted in a very wide range of estimates which indicates a high degree of uncertainty.

There is not always a direct relationship between how much rain falls and how severe flooding becomes. During January 2025, frozen ground likely prevented rainfall from soaking into the soil, causing more water to run off into rivers. As a result, a smaller amount of rainfall may have led to much higher river levels than would occur when the ground can absorb water.

Rainfall that caused flooding in these incidents occurred at the same time as frozen and saturated ground in Jan 2025, and high initial water levels in the SFFD in Jan 2024 (Storm Henk). Estimating how likely this exact combination of conditions is to occur again is complex and highly uncertain.

Although the likelihood of these conditions recurring is unclear, rainfall events of this type are likely to happen again. Future flood risk will depend on whether similar ground conditions occur at the same time.

6 Why did properties and farmland flood?

The analysis undertaken shows that the main contributing factors differed across the catchment. Flooding to homes and farmland from the SFFD tributaries, such as at Billingborough, was primarily due to the significant increase in river levels caused by the frozen, saturated catchment and high runoff of water from the land. Operation of pumps in the fens and at Black Sluice would not have had an impact in these areas.

Further down the catchment, in the fens a combination of factors stacked higher water levels on top of one another to raise river levels to the point of over topping. Towards the southern end of the South Forty Foot Drain, at Dunsby, high river levels from the high runoff from the frozen catchment, were increased further by the need to continuously pump into the SFFD from fenland areas. Towards Boston, both pumping at Black Sluice and further reducing IDB pumping could have reduced water levels and overtopping risk.

7 What could be done in the future?

7.1 Optimising the operation of existing assets

Reviews could be completed to look at whether existing assets are still being operated in the best way to manage flood risk. For example, investigating whether:

- The water level in the SFFD is managed to the most suitable level, prior to a flood.
- Changing IDB pumping operation to hold more water in the fens, by working with the IDB.

7.2 Reinstatement of the Black Sluice pumps

This assessment has re-examined the potential role of pumping using updated modelling. The results show that bringing the pumps at Black Sluice back into operation would only have a meaningful impact on water levels closer to Boston and would not materially reduce flood risk in all the communities that were affected in January 2025.

The original decision to decommission the pumps followed extensive investigations and consultation and was taken jointly by partner organisations. The findings of this review are consistent with that earlier work and do not identify new evidence that would make reinstating the pumps a proportionate or economically viable flood risk management option.

7.3 Consider alternative interventions to reduce flood risk

Other than changes to catchment ground conditions, no other modelled catchment change assessed resulted in differences in modelled water levels at Billingborough, Pointon and Swaton. Alternative flood risk reduction measures could be investigated to reduce flood risk to these villages. Further interventions in the fens could be considered to assess their potential effectiveness in reducing flood risk.

For example, this might be flood storage, in the form of natural flood management (NFM) in the upper catchment, to better protect Billingborough and Pointon. This approach has already been successfully applied in the Swaton Eau catchment, reducing peak water levels and preventing the flooding of homes. A combined storage and 'hard' defence approach may be more appropriate to better protect areas in the fens and Boston. However, all available options will continue to be considered at this preliminary stage of investigation.

