Appendix:
Wastewater modelling approach

YKY-PR24-DDR-42-CE-Wastewater-modelling-approach

YorkshireWater

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1. Test - Sewer Network Modelling – "Clean" System - Hydraulic Tests

1.1 Introduction

As sewers convey solids, silt and sediment from highways and properties, the capacity within combined sewers can be changed due to the settling of these solids if not regularly and proactively maintained. Ofwat raised concerns regarding the validity of our hydraulic modelling as we did not ascertain whether the levels of storm overflow discharge performance would be affected if we had a hypothetical totally clean sewer network. This test seeks to ascertain the impact of a "clean" sewer network on storm overflow performance. For modelling purposes, this has been interpreted as a sewerage network without any sediment or silt represented and uniform low pipe roughness, thus creating maximum capacity in each pipe.

It should be noted it is unrealistic to ever have a 'clean' system as sediment enters through exogenous factors such as highway gullies (which will vary dependent upon local authority cleaning programmes), is naturally deposited and eroded as flows, specifically velocities, vary in dry weather and storm conditions. This means that after any maintenance activities such as jetting sediment will naturally redeposit overtime in certain pipes based on local physical and hydraulic conditions. So, the results are a theoretical best case and would only be representative if a cost prohibitive and substantial daily vacuuming programme was undertaken.

It is standard UK practice[1] to include silt, sediment, pipe deformation and other operational deficiencies in the creation of sewerage network models, as observed through CCTV and other forms of asset survey. This level of detail is frequently required to achieve a compliant level of verification against observed short term flow surveys and wider historical record and EDM validation. Yorkshire Water have detailed modelling processes, based on the CIWEM UDG CoP, for the creation of verified models and their subsequent conversion tools to assess network capacity and performance. The models used for the DWMP 2020 epoch and subsequently for the PR24 datasets were based on the Needs model.[2]

For this "clean test", we tested 86 storm overflows across 9 sewer network models with varying amounts of sediment modelled within their conduits.

1.2 Methodology

Overall, the aim of the test was to create several 'clean' models and run these through the same conditions, rainfall and other parameters as was undertaken for the PR24 datasets and compare the system performance through assessment of the overflow performance in a 10yr time series rainfall (TSR) simulation.

The original PR24 dataset was created for a 2020 epoch with each DWMP level 3 catchment model run with a bespoke local 10-year time series rainfall applied. The results were processed using the standard and agreed EA 12/24 counting methodology to create individual overflow and catchment level discharge frequency, duration and volume for the period.

These results provide the baseline for comparison in all graphical outputs.

The methodology utilised for selection of catchments is summarised as follows:

1. Confirm the range of sediment in conduits within the PR24 model stock.
2. Select a range of models' representative of the range of sediment depths identified for 'clean' network assessment (Table 1)

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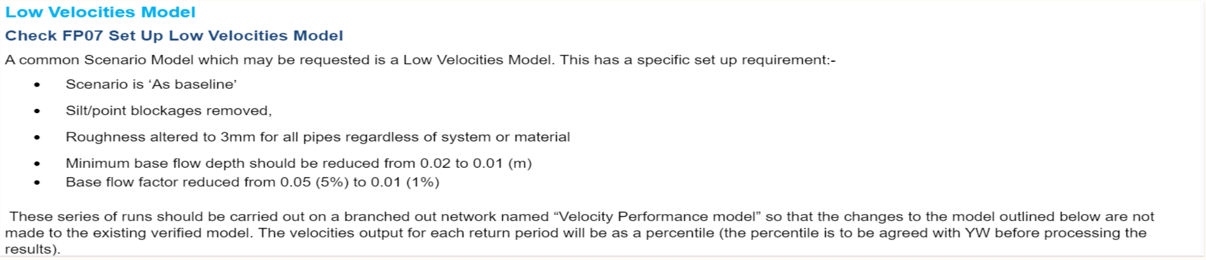
[1] CIWEM UDG Code of Practice for Hydraulic Modelling of Urban Drainage Systems, 2017

[2] The Needs models on which DWMP and PR24 submissions are based have been updated from the verified model to remove operational issues such as significant blockages and asset failure that may have been present during the verification period but resolved through normal operational activities.

Table 1: Catchments selected for 'clean' network assessment

Model_Name	Percentage_of_ Conduits_with_ Sediment	Number of Storm Overflows Modelled	Model Rank of the %age conduits with Sediment
Goole_Model	15.1%	5	1
Tadcaster _Model	7.7%	4	10
Balby_Model	6.0%	5	15
Pickering_Model	4.0%	7	37
Brighouse_Model	3.2%	26	45
Scarborough_Model	2.7%	12	58
Neiley_Model	1.5%	19	84
Lemonroyd_Model	0.9%	6	100
Hornsea_Model	0.4%	2	108

3. Update catchment models using Yorkshire Waters modelling specification which provides a suitable approach for removing sediment and changing roughness coefficients as follows:



Low Velocities Model

Check FP07 Set Up Low Velocities Model

A common Scenario Model which may be requested is a Low Velocities Model. This has a specific set up requirement:-

- Scenario is 'As baseline'
- Silt/point blockages removed,
- Roughness altered to 3mm for all pipes regardless of system or material
- Minimum base flow depth should be reduced from 0.02 to 0.01 (m)
- Base flow factor reduced from 0.05 (5%) to 0.01 (1%)

These series of runs should be carried out on a branched out network named "Velocity Performance model" so that the changes to the model outlined below are not made to the existing verified model. The velocities output for each return period will be as a percentile (the percentile is to be agreed with YW before processing the results).

4. Models simulated with all factors as for PR24 other than network with sediment removed.

5. Report differences in spill frequency, duration and volume against the EA standard 12/24 counting methodology for PR24 and 'clean' system at individual and catchment scales.

1.3 Results

Figure 2 to Figure 4 show the results of the modelling test for discharge frequency, duration and volume. Considering the individual overflows within each catchment shows increases and decreases between the two scenarios, as demonstrated in the example for discharge frequency in Goole, the catchment with the greatest proportion of sediment within its conduits.

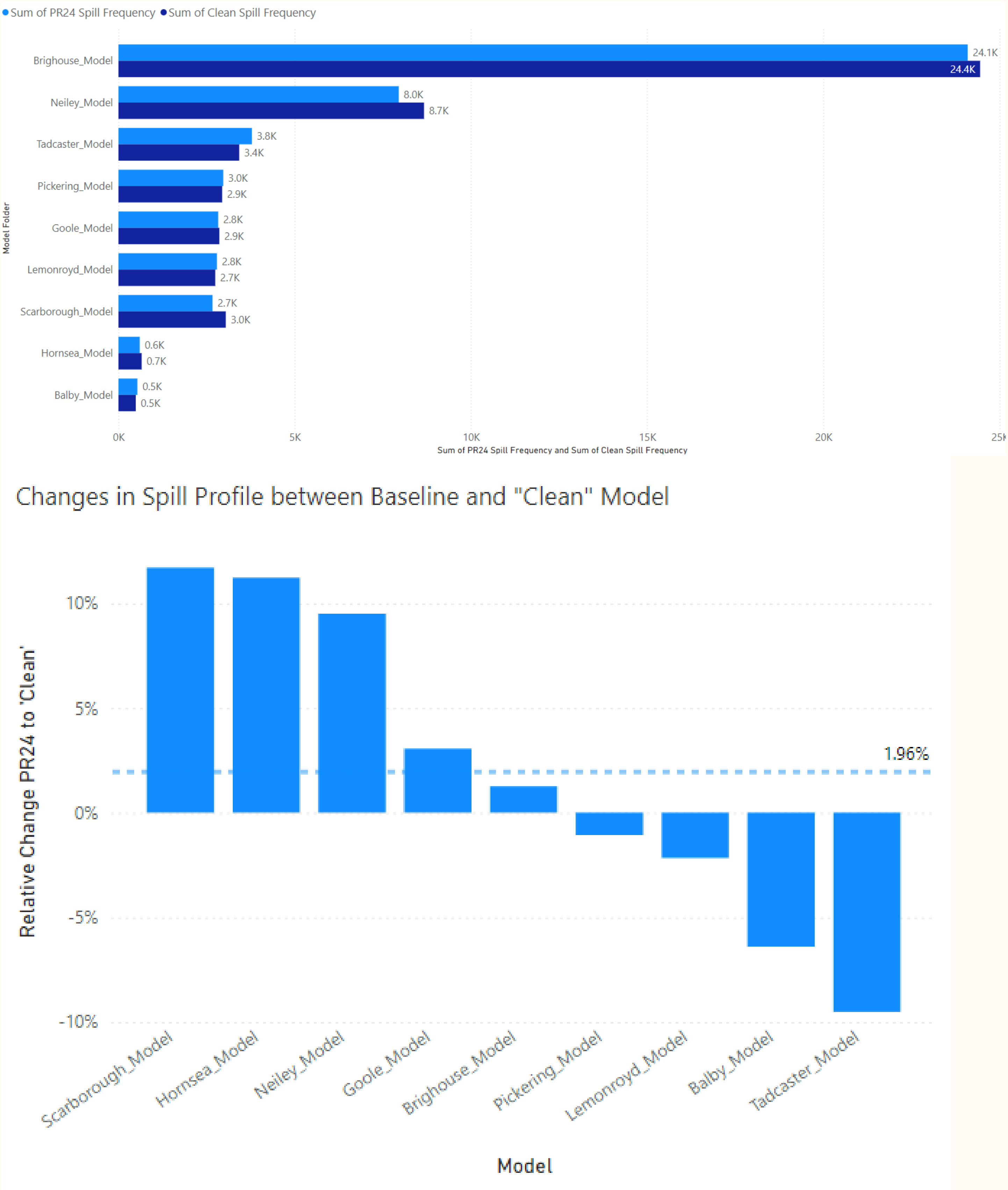


Figure 1 Discharge Frequency per catchment across the catchments investigated and percentage change for the 10-year time period simulated.

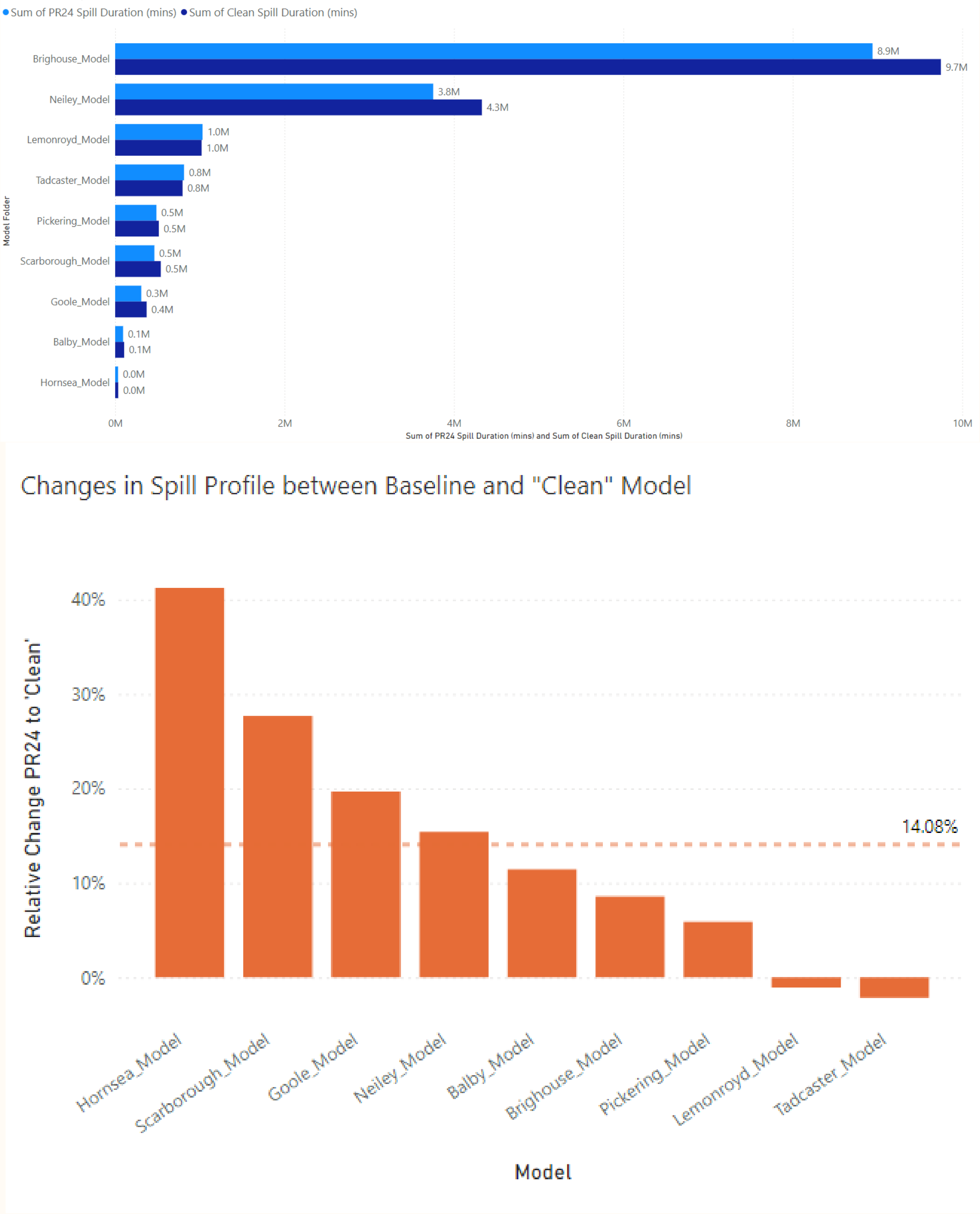


Figure 2 Discharge Duration per catchment across the catchments investigated and percentage change for the 10-year time period simulated.

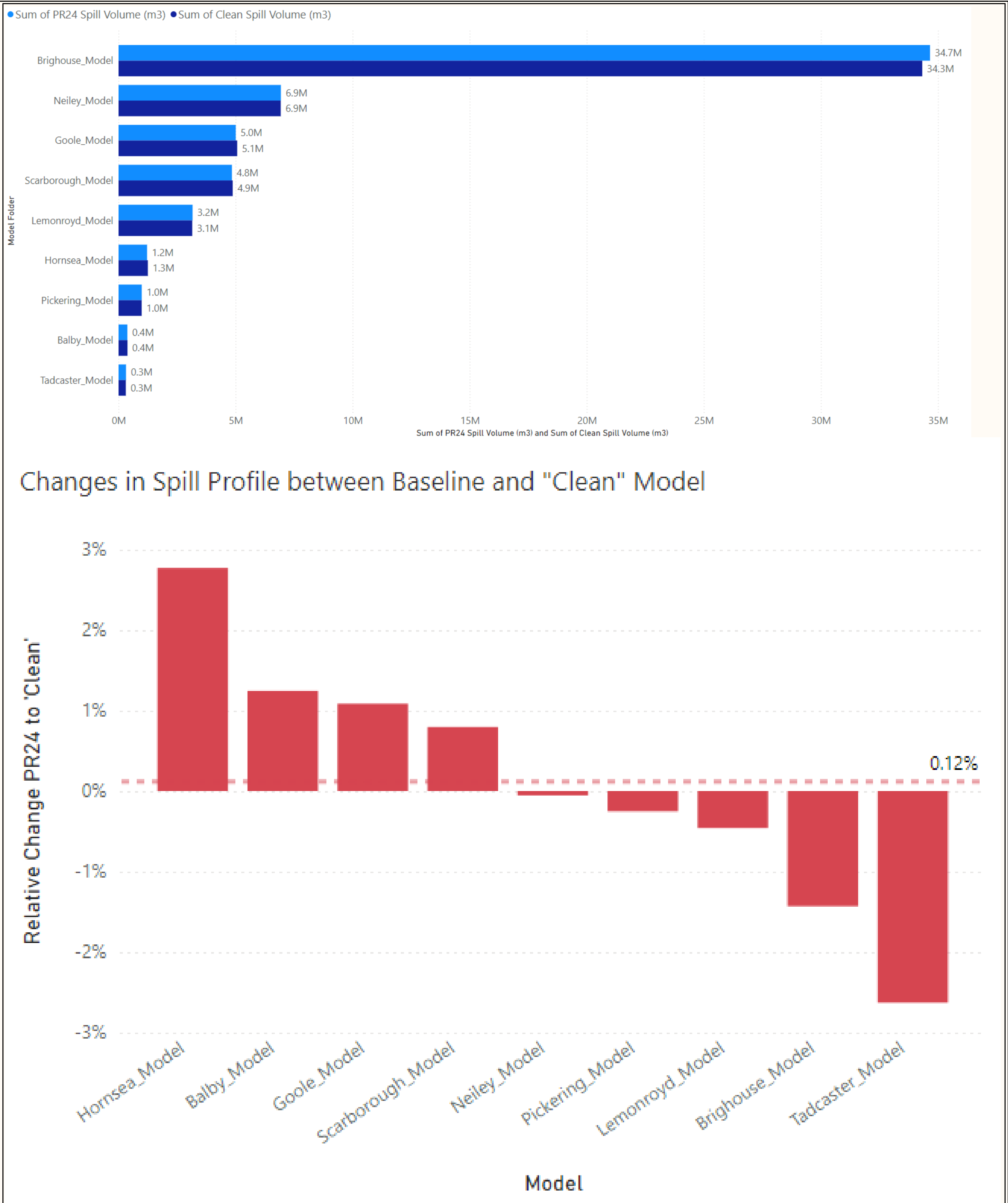


Figure 3 Discharge Volume per catchment across the catchments investigated and percentage for the 10-year time period simulated.

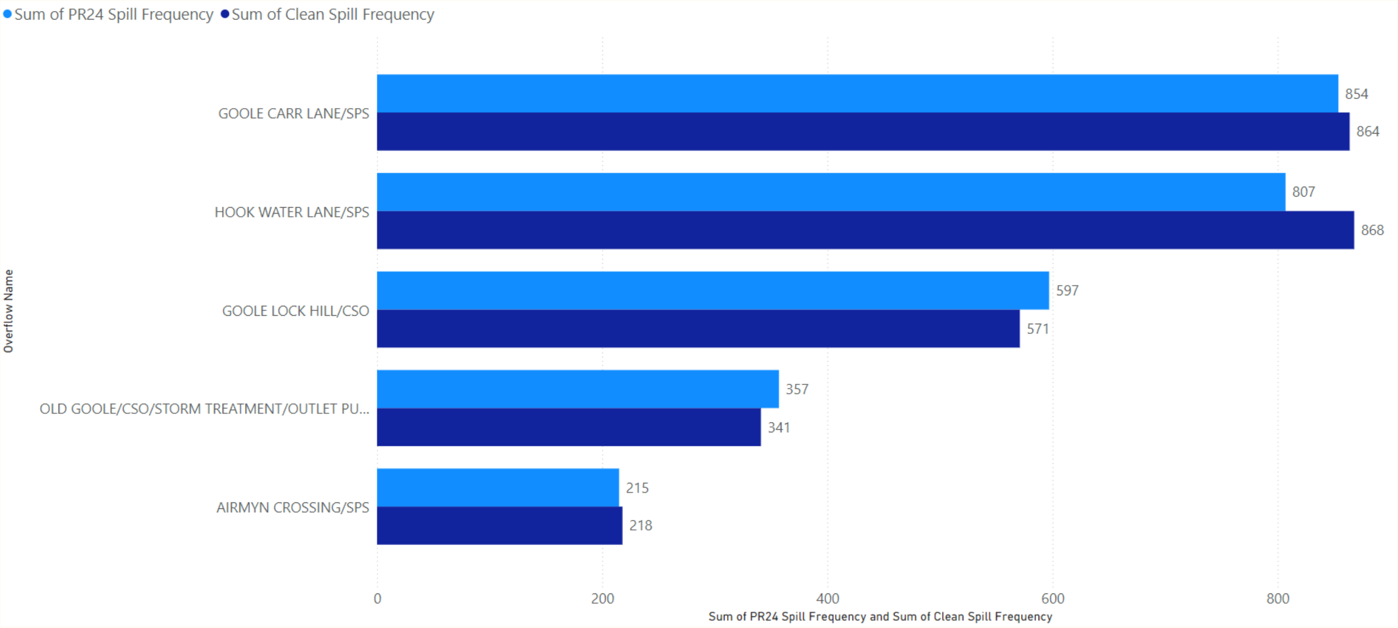


Figure 4 Discharge frequency for Goole Catchment showing individual overflow variation between scenarios for the 10-year time period simulated.

1.4 Discussion

The removal of all silt and sediment, together with the standardised roughness for all pipes, has resulted in changes in discharge frequency, duration and volume at individual overflows. This was expected as the localised impact of removing an element of restriction will convey increased flow to and/or from an individual asset either reducing or increasing the discharge frequency.

When considered at a catchment scale this local variation is significantly reduced. Within the 9 test catchments, and importantly across the range of percentage of conduits with sediment present in the original analysis, it is observed that:

- Discharge frequency is similar or increased slightly within a ‘clean’ system (~1% increase and in total ~1000 discharges higher).
- Similarly, the overall duration and volume is higher in the clean scenario.

A review of the differences between levels of silt across the range of catchments assessed does not highlight any clear pattern associated with the percentage of conduits with silt in the original analysis.

Table 2 highlights the range of sediments within each model and the percentage change in discharge frequency, duration and volume at a catchment scale between the DWMP 2020 baseline and the ‘clean’ system.

Table 2: Percentage change in Discharge Frequency, Duration and Volume at Catchment Scale for a ‘Clean’ System

Model Folder	Percentage of Conduits with Sediment	Number of Storm Overflows	Percentage change in Discharge Frequency	Percentage Change in Discharge Duration	Percentage Change in Discharge Volume
Goole_Model	15.1	5	+ 3%	+20%	+1%
Tadcaster_Model	7.7	4	-10%	-2%	-3%
Balby_Model	6	5	-6%	+11%	+3%
Pickering_Model	4	7	-1%	+6%	0%
Brighouse_Model	3.2	26	+1%	+9%	-1%
Scarborough_Model	2.7	12	+12%	+28%	+1%
Neiley_Model	1.5	19	+10%	+15%	0%
Lemonroyd_Model	0.9	6	-2%	-1%	0%
Hornsea_Model	0.4	2	+11%	+41%	+3%

The largest increase (Scarborough +12%) and decrease (Tadcaster -10%) in discharge frequency are associated with conduits with lower (2.7%) and higher (7.7%) sediment respectively. The highest percentage of conduits with sediment within the model library (Goole at 15.1%) has only a 3% increase in discharge frequency.

The lack of correlation with the proportion of sediment to the change in performance is also observed in discharge duration and volume. The total volume range for the remaining 9 catchments is +/- 3% which, given the accuracy of a network model is within the accepted tolerance and suggests no meaningful change in discharge volume / retention of volume within the sewerage network, only its transfer flows between overflows within the catchment. Discharge duration is more complex with a greater range (-2% to +41%). Review of individual overflows highlights that the WwTW is commonly the longest duration and largest individual increase, which intuitively based on engineering judgment would make sense as more flows reach the treatment inlet works per se, rather than discharge upstream.

In conclusion, the results of the 9 catchments across the range of percentage of conduits with sediment demonstrate a range of performance and changes in the key measures of discharge frequency, duration and volume. No clear pattern between sediment and change in performance for discharge frequency, duration and volume is observed and as such it is not recommended to amend the existing sewerage network performance based on this comparison.

1.5 Key Points

Local conditions will change the performance of individual overflows, but this, does not have a meaningful impact on the catchment scale performance. Overall, there is a marginal increase in all 3 parameters across the 9 catchments and as such the current data used for assessing catchment performance is likely to give a marginal underprediction, meaning that more discharges occur in the modelled clean system than in the system modelled to represent the “normal” system operation.

Our drainage network modelling (from the DWMP) for the PR24 submission includes 1,940 overflows from 132 network models. Using verified and realistic sewer conditions, this modelling indicates an average of 37.4 discharges per overflow per year, based on a 10-year rainfall time series set at a 2020 baseline. In 2021, EDM data showed a monitored discharge frequency of 34 discharges per overflow (unadjusted for uptime). When accounting for monitor uptime adjustments, the EDM discharges per year per overflow increases the 34 discharges per overflow to 36 discharges per overflow (assuming a liner pro-rata increase for the number of unmonitored overflows).

This indicates that the DWMP/PR24 baseline modelling discharge frequency and the 2021 EDM discharge frequency baseline are closely aligned. This alignment is not significantly sensitive to discharge frequency at a catchment and regulatory scale when consideration is given to the impact of siltation at a local overflow scale.