Memo

To
Kennis Online

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Subject
Dredging strategy in the Waal

Dredging strategy in the Waal: Morphological study with Delft3D

1.1 Objective

The main objectives of this study are:

- to re-evaluate the morphological computation of the Waal with dredging and dumping using most up-to-date Delft3D model including some refined approach than previously used and compare the effects on the ultimate outcomes.
- to evaluate the effect of different dredging strategy (dumping downstream instead of upstream) on long-term bed level changes.

1.2 The model and computational scenarios

The Waal model (three domains of the DVR model) has been used. The reference scenario has been adapted from an available old model on dredging; however, the reference model has been computed producing new inputs and approach (e.g., OLR update in every five year, which did not seem to be considered in the old computations as well as incorporating dune prediction module).

Following are the computational scenarios, which have been used for the Delft3D computations within the scope of this work:

Different cases for the reference scenario:

1) ‘reference’ - Simulation with upstream dumping as used in earlier studies, with an interval of 2 kms between the dredging polygon and the first possible dumping polygon, but considering dunes and OLR update.
2) ‘reference_nodredg’ - Simulation with dredging module switched off.
3) ‘reference_nodune’ - Same as ‘reference’ without using dunes in the dredging module.
4) ‘reference_ruw’ - Same as ‘reference’ with discharge dependent roughness.

Different scenarios/cases for downstream dumping strategy (dune is considered in all cases and scenarios):

5) 'variantk6g0' - Dumping starting from the same place where dredging takes place ('6' denotes the dumping reach within 6 km downstream, otherwise dumping outside).
6) 'variantk6g0_ruw' - Same as 'variantk6g0', but with the discharge dependent roughness.
7) 'variantk6g1' - Same as 'variantk6g0', but dumping downstream with the first km as an interval.
8) 'variantk6g2' - Same as 'variantk6g0', but dumping downstream with first two kms as an interval.
9) 'variantk10g0' – same as 'variantk6g0', but the dumping reach within 10 km downstream, otherwise dumping outside.
9) 'variantk10g1' – same as 'variantk10g0', but dumping downstream with the first km as an interval.
10) 'variantk10g2' – same as 'variantk10g0', but dumping downstream with first two kms as an interval.

1.3 Computational results and analysis

The results, shown in this memo, are for 25 years of morphological computation. For the sake of comparison, at first, we compare the different cases for the reference scenario with respect to the case without dredging, e.g. the difference between 'reference' case (dredging with upstream dumping considering dunes) with and without considering dunes. The comparison has been made with the difference of each case with respect to no dredging case (Figure 1). From this plot, it can be inferred that the consideration of dune in reference model makes considerable difference in bed level changes mainly in the upper Waal (particularly, in the region of km 882 – km 889, i.e. Nijmegen area). This implies that the consideration of dunes show larger dredging and dumping activities in this area. The case with dunes appear to show larger bed aggradation in the upstream region and the degradation in the downstream region in comparison with the case without dunes (please note that we are talking about bed aggradation/degradation with respect to the no dredging case (relative value), but in the absolute quantity it might show a different trend).

For the reference scenarios, we have also attempted to check the computational result for the case with discharge dependent roughness. The comparison is depicted in Figure 2, which reveals that the relative bed level changes are rather significant for these scenarios with upstream dumping.

Similarly, results of bed level changes with respect to the no dredging case for few selected scenarios with downstream dumping ('variantk6g0', 'variantk6g1' and 'variantk6g2' as the variant with 10 km dumping reach shows similar result to 6 km case) are depicted in Figure 3. It is to be noted that all these scenarios include dunes. From the result, it can be seen that the bed level changes are less than in case of downstream dumping ('reference' with dune). Only the case with 2 km dumping interval (i.e., 'variantk6g2') shows relatively larger bed change.

For one of the scenarios with down stream dumping, we have checked the result for discharge dependent roughness (namely, 'variantk6g0_ruw'). The result is depicted in Figure 4, which also reveals relative more bed level changes in case of Q-dependent roughness; however, the magnitude and the extent is significantly less than in case of upstream dumping (as shown in Figure 2.

Additionally, the results of the relative bed level change for all scenarios and cases with respect to the 'reference' case (i.e. the difference between the cases with upstream and downstream dumping strategies) can be seen from

Furthermore, the dredging volumes (mean dredging volume in 5 years) are presented for each scenario in Figure 6 to Figure 15. From these results, it can be inferred that the dredging volume with upstream dumping is considerably larger in comparison with scenarios with downstream dumping, particularly in the upper Waal. This can also be seen in the result, depicted in Figure 16. The dredging volume in the middle Waal is rather less in all cases (and even none in case of negligence of dunes). The dredging volume appears to be larger in case of Q-dependent roughness consideration.

1.4 Brief conclusion

In general, all our previous studies show a similar trend of dredging characteristics in this branch, i.e. all the effect appears to be pronounced mainly in the upper Waal, and the amount of dredging in the middle Waal is rather less in all cases. The consideration of the dune predictor module and the discharge dependent roughness approach appears to increase the dredging volume (also in the middle Waal).
Based on the outcome of the current case studies, it can be inferred that the dredging volume significantly reduces in case of a downstream dumping strategy, and in turn induces less bed level fluctuations than that of a upstream dumping strategy.

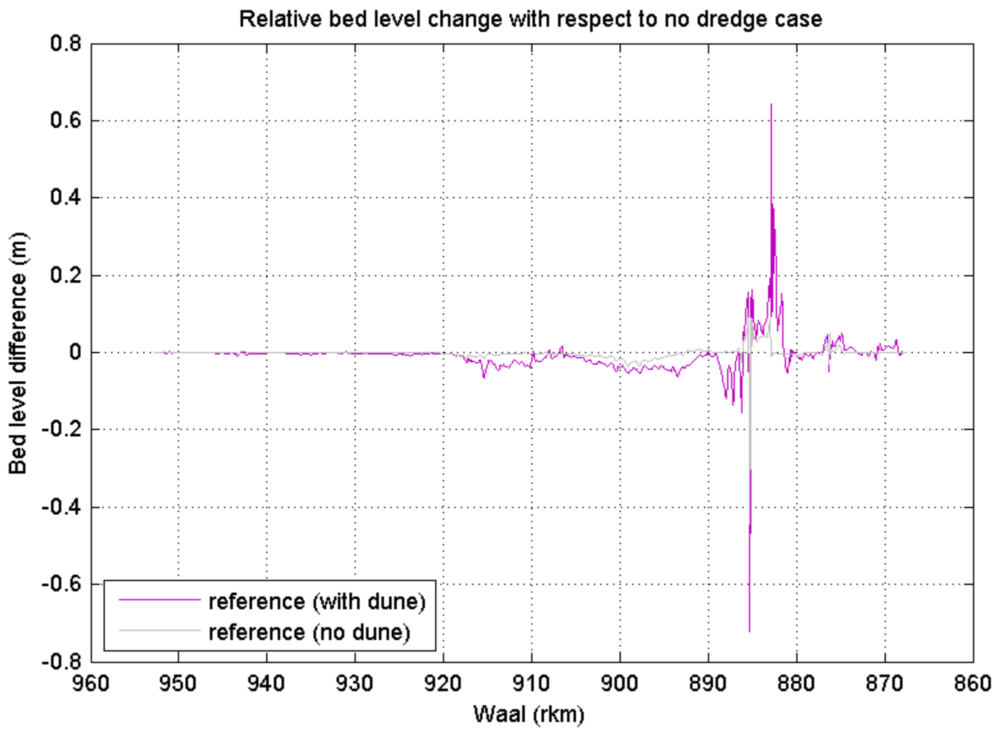

Figure 1 Comparison on Bed level difference (reference with dune – no dredging case (rose line) and reference without dune – no dredging case (grey line))

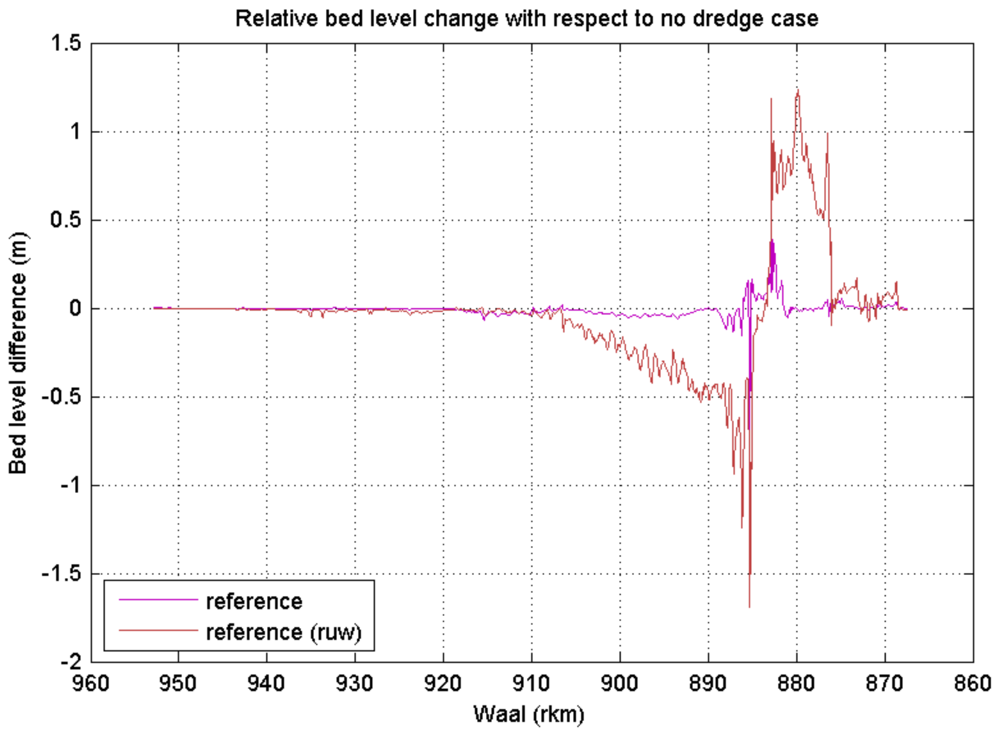

Figure 2 Comparison on Bed level difference (reference with dune – no dredging case (rose line) and reference with, but with Q-dependent roughness – no dredging case (red line))

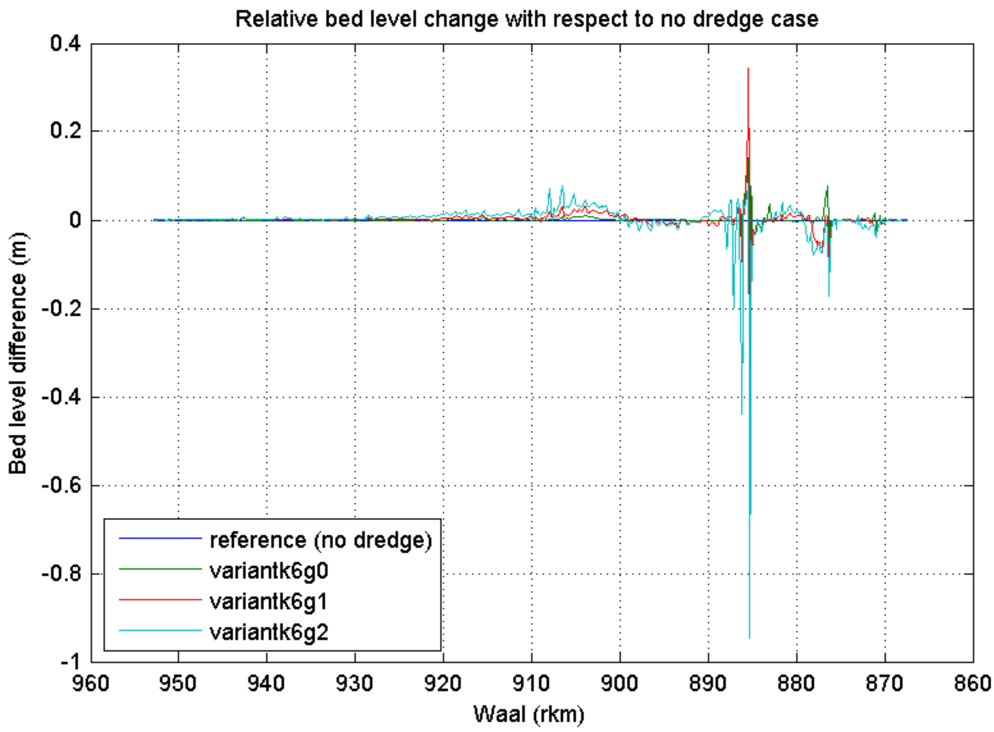

Figure 3 Comparison on Bed level difference with respect to no dredging case for some of the downstream dumping scenarios

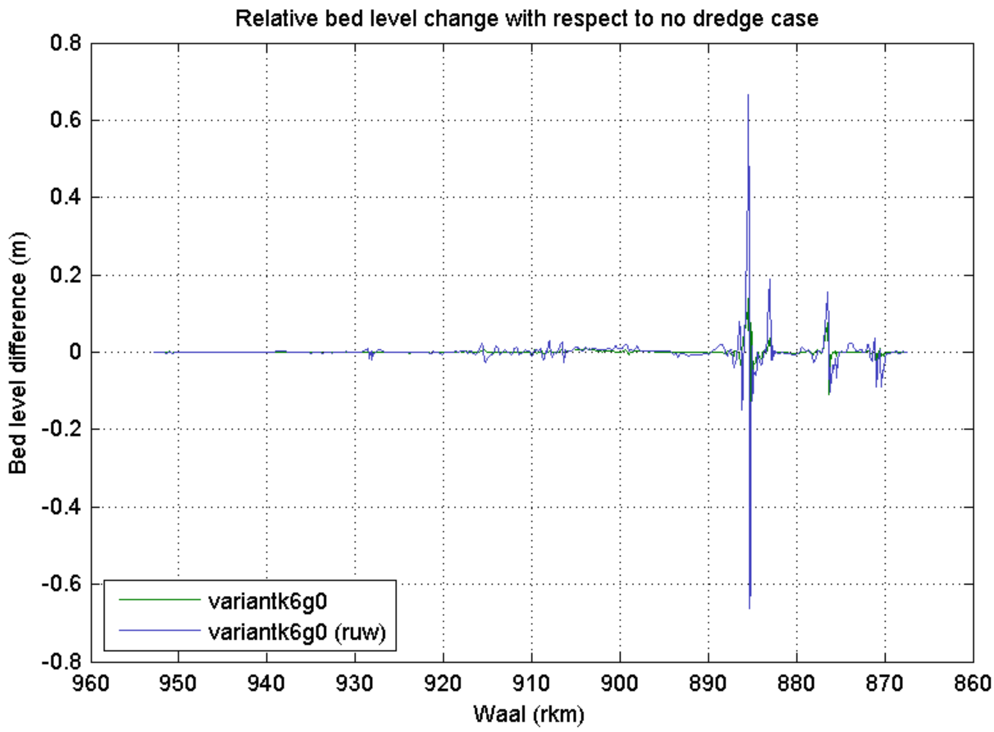

Figure 4 Comparison on Bed level difference with respect to no dredging case for one of the downstream dumping scenarios with and without Q-dependent roughness.

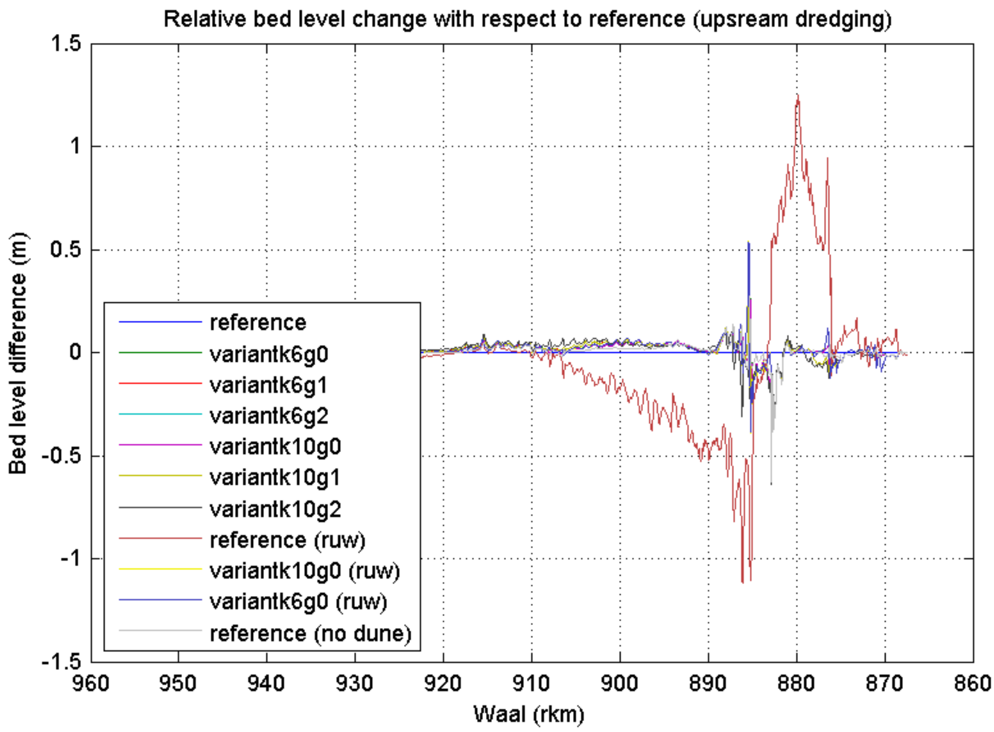

Figure 5 Comparison on Bed level difference with respect to the reference case (including the effect of the dune and roughness consideration) for all scenarios and cases.

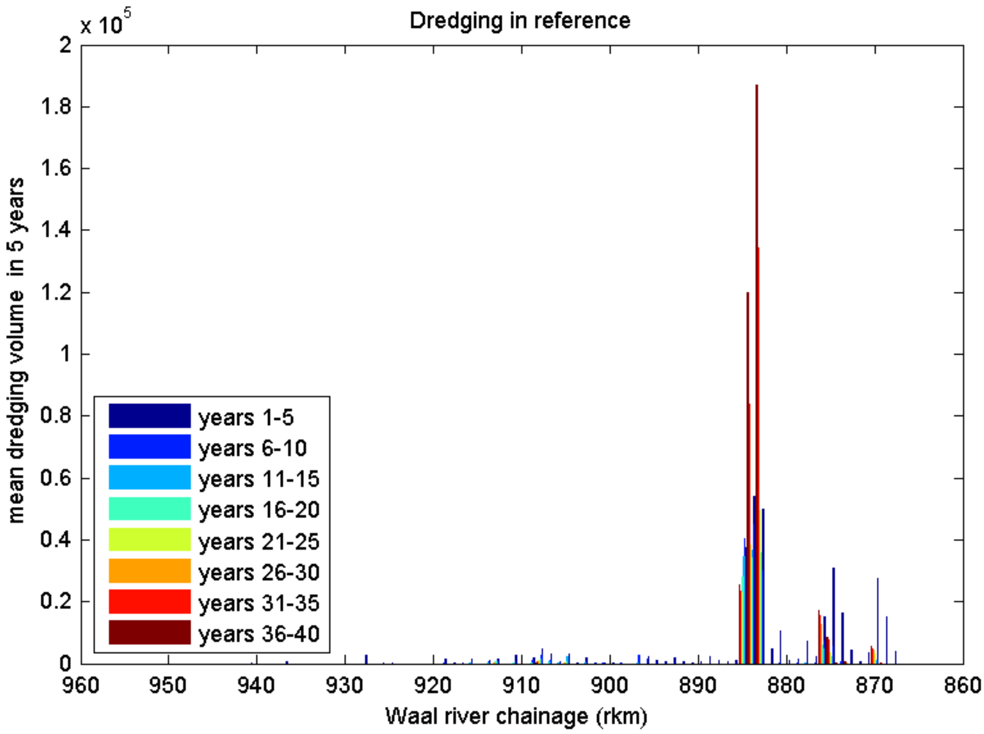

Figure 6 Dredging volumes, reference

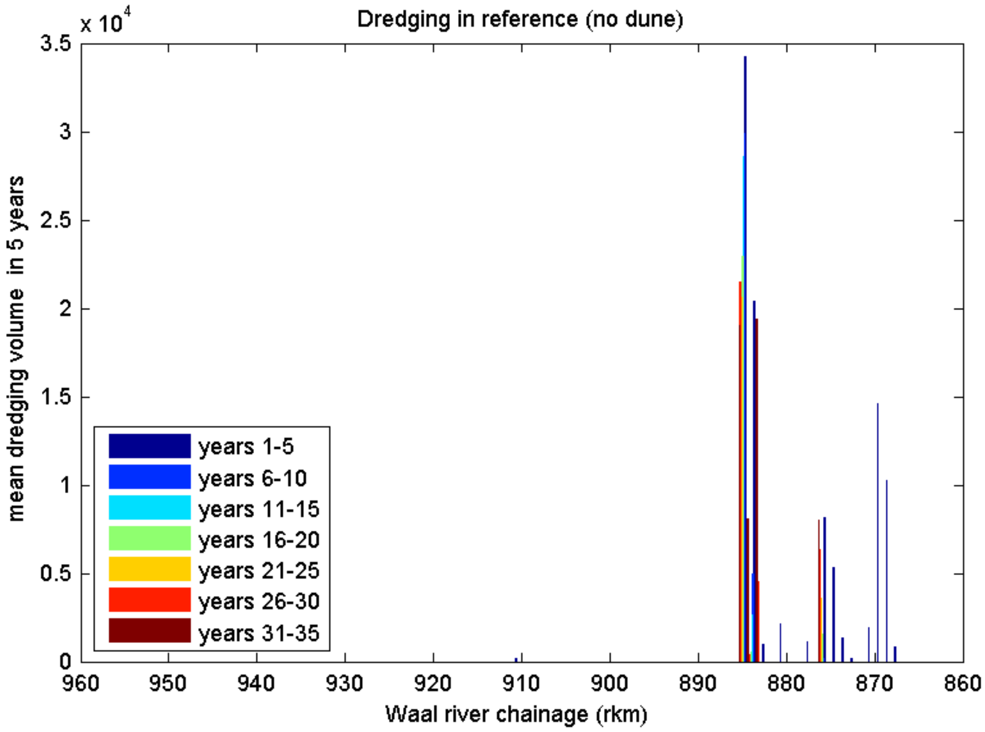

Figure 7 Dredging volumes, reference (no dunes)

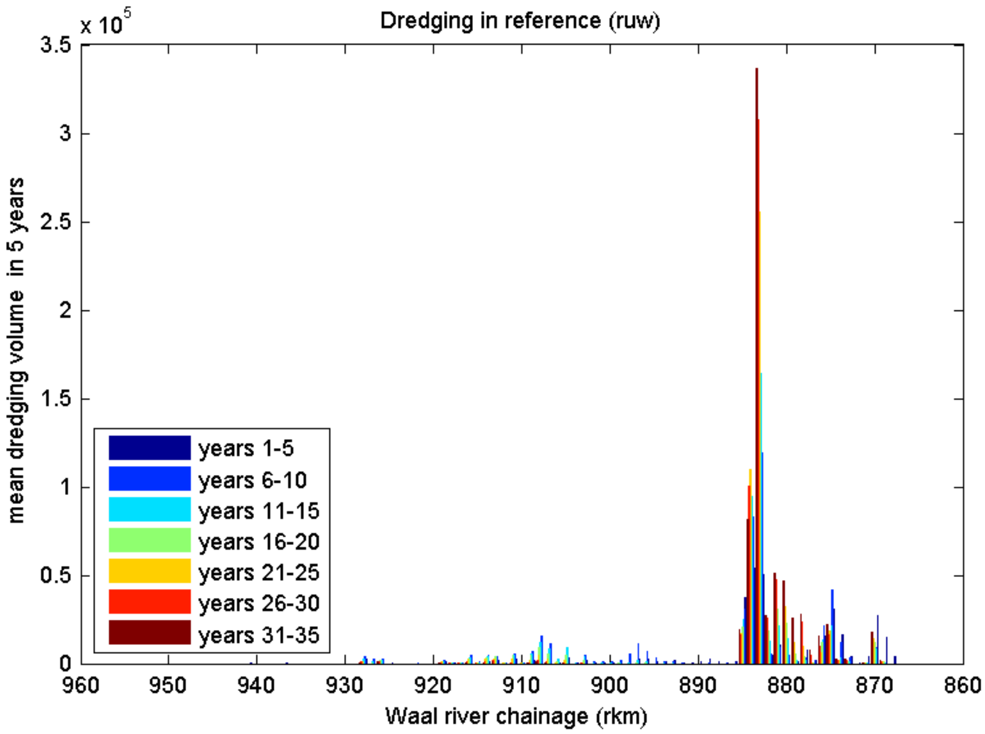

Figure 8 Dredging volumes, reference (rough)

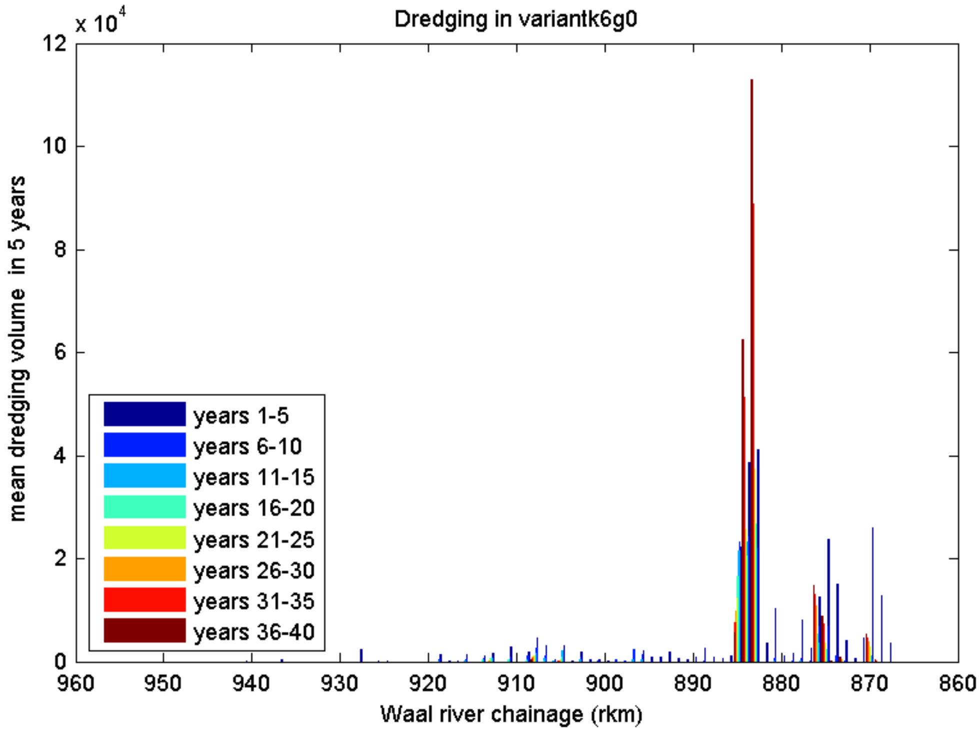

Figure 9 Dredging volumes, variant6g0

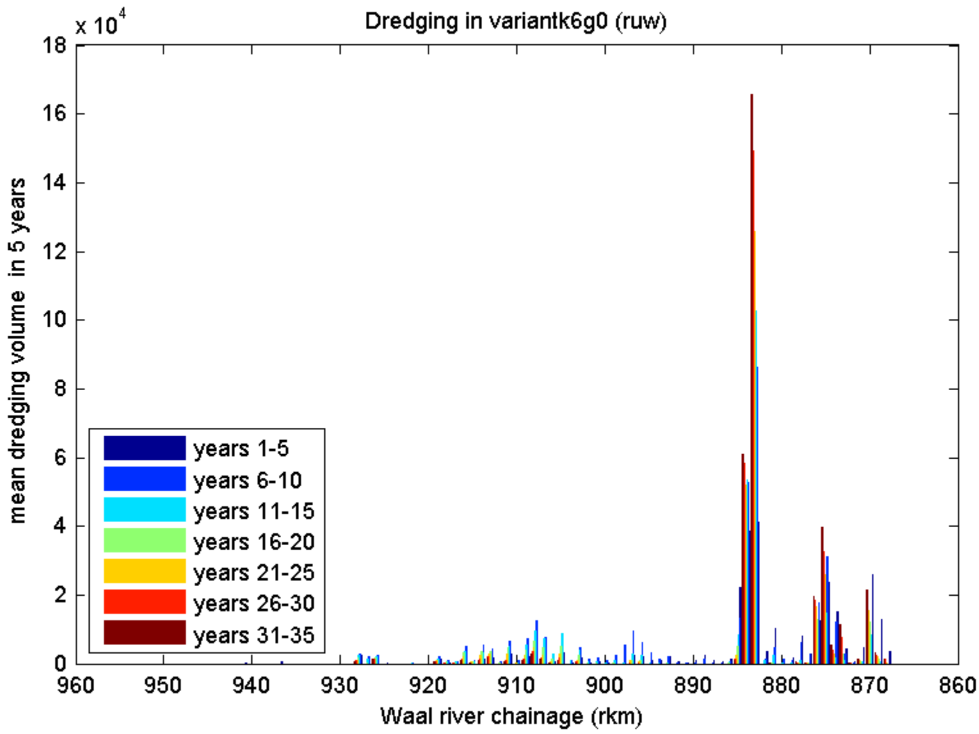

Figure 10 Dredging volumes, variant6g0 (rough)

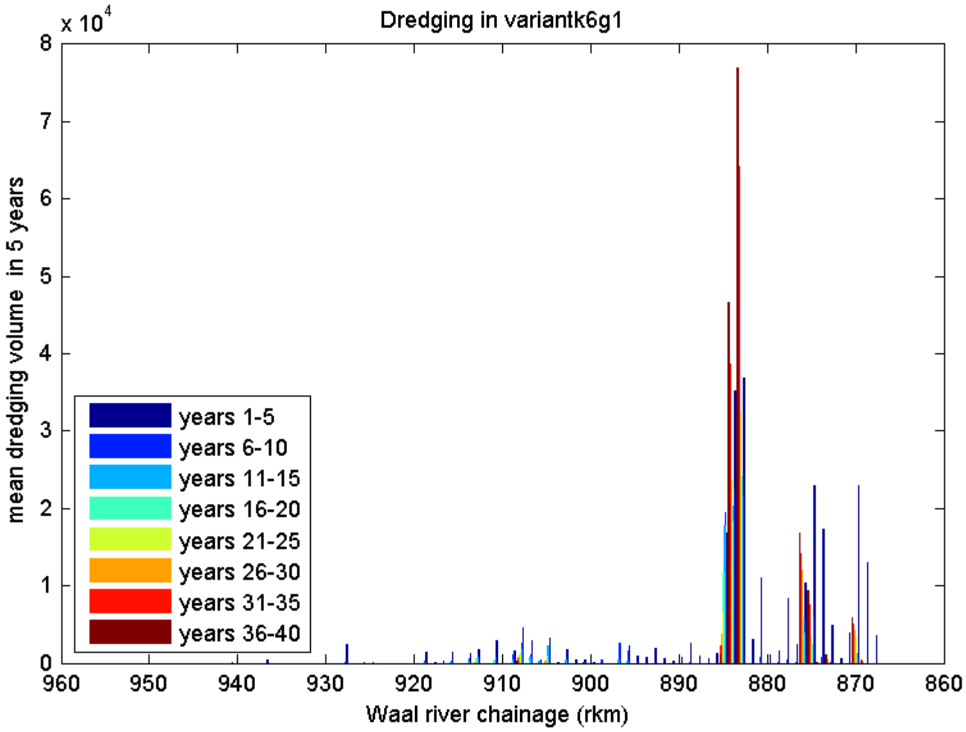

Figure 11 Dredging volumes, variant6g1

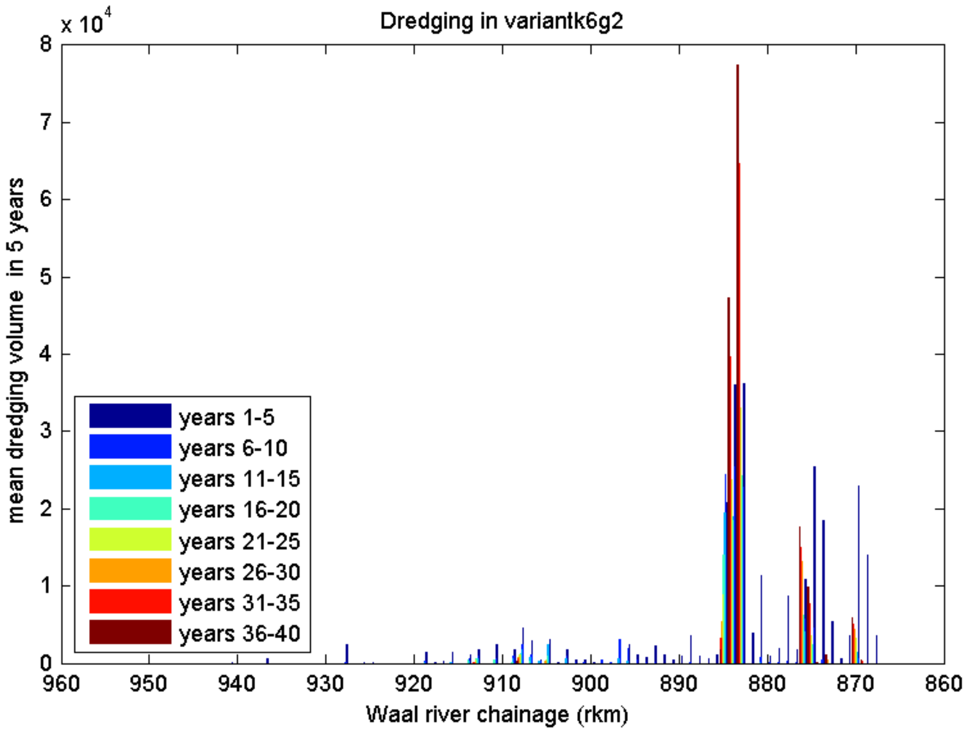

Figure 12 Dredging volumes, variant6g2

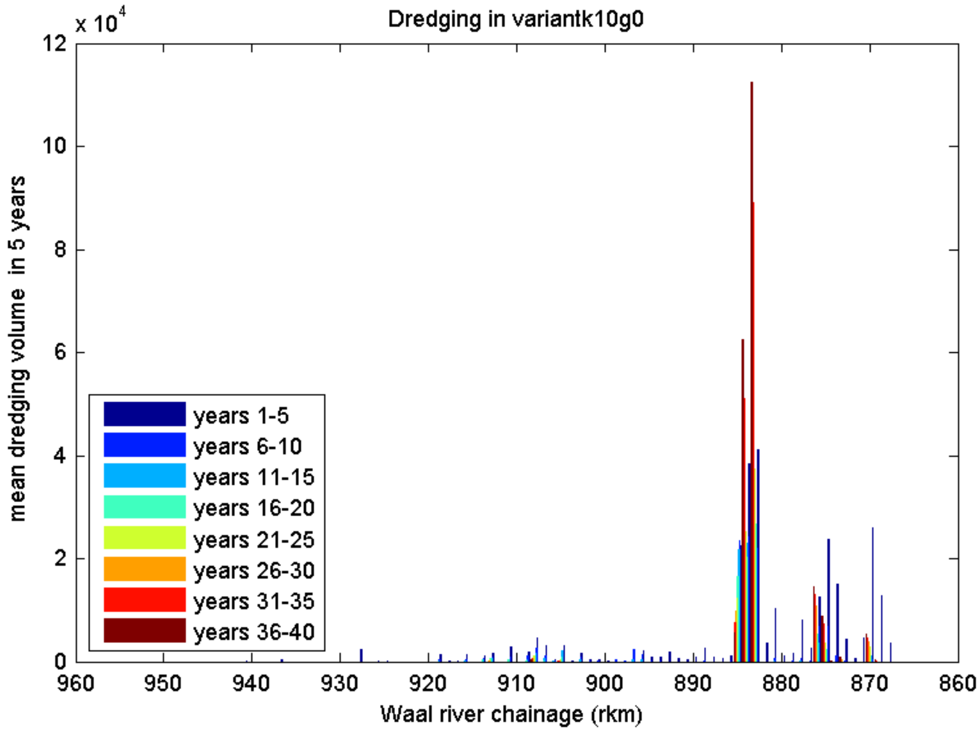

Figure 13 *Dredging volumes, variant10g0*

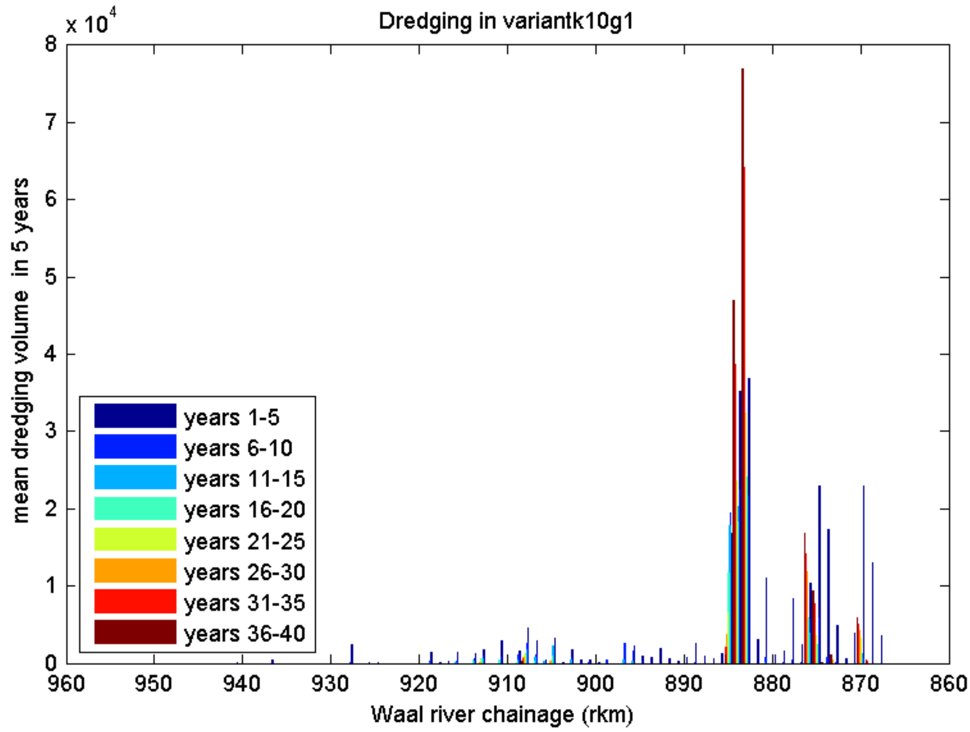

Figure 14 *Dredging volumes, variant10g1*

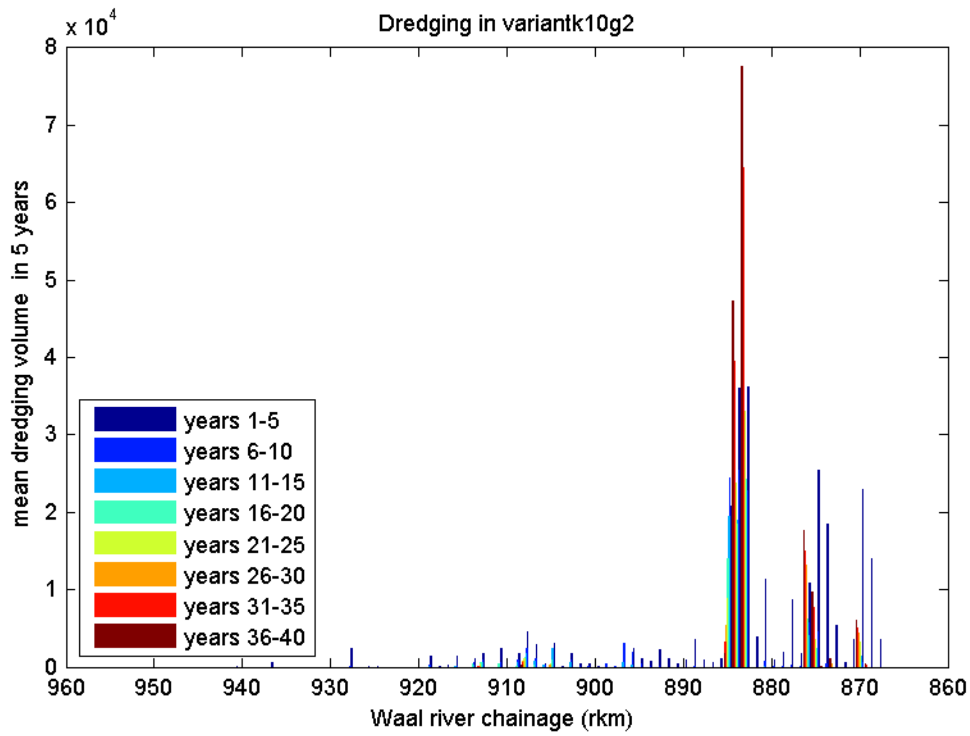

Figure 15 variant10g2

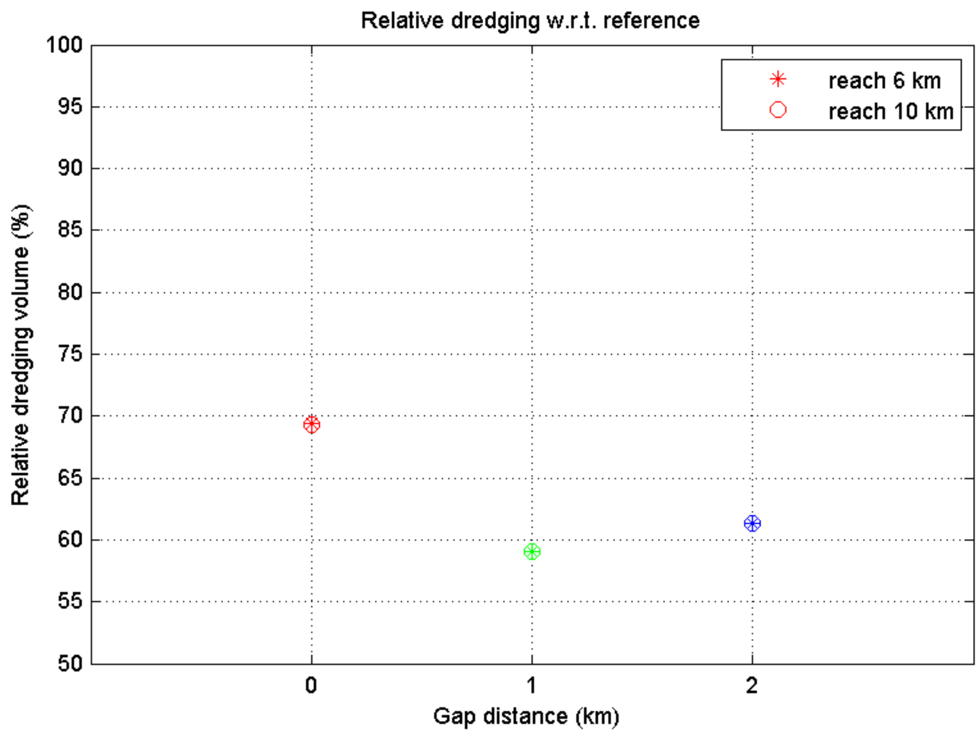

Figure 16 Relative dredging with respect to the reference scenario (reduction of dredging in case of scenarios with downstream dumping).