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Ons kenmerk
RvdR/2016/703

Bijlage
1

Datum 21 juli 2016
Onderwerp Mijlpaal Waterveiligheid RvdR Ontpoldering Noordwaard

Geachte heer [redacted], beste [redacted]

In het kader van het programma Ruimte voor de Rivier heeft de Combinatie Noordwaard op 1 oktober 2015 de waterveiligheidsdoelstelling van de maatregel Ontpoldering Noordwaard opgeleverd.
U heeft mij verzocht (brief RR01.088.302 d.d. 14 december 2015, tevens email 11-05-2016) de Mijlpaal Waterveiligheid voor de maatregel vast te stellen op basis van de door u aangeleverde hydraulische berekening en andere documenten. Middels deze brief informeer ik u over de gerealiseerde waterveiligheid doelstelling.

In de Planologische Kernbeslissing Ruimte voor de Rivier is voor de betreffende maatregel een taakstelling in de vorm van waterstanddaling vastgelegd, in combinatie met de aanleg van nieuwe waterkeringen. Beide aspecten zijn bij de vaststelling van de mijlpaal Waterveiligheid beschouwd.
De opdrachtnemer Combinatie Noordwaard heeft aan u aangetoond dat aan de vereiste waterveiligheid wordt voldaan. U heeft middels bovengenoemde brief verklaard dat u van mening bent dat het werk conform de opdracht (scopeformulier SNIP 5) is uitgevoerd en de vastgelegde waterveiligheid is behaald.

<u>Waterstandsdaling</u>
In de Planologische Kernbeslissing Ruimte voor de Rivier is voor deze maatregel een taakstelling van -0,30m waterstanddaling vastgelegd op de Boven-Merwede op rivierkilometer 955. Deze waterstanddaling is middels de SNIP 3 documenten vastgelegd in het scopeformulier (SNIP 5) (kenmerk RvdR/2010/0096). Het SNIP3 ontwerp is door de opdrachtnemer uitgewerkt tot een uitvoeringsontwerp en vervolgens gerealiseerd.
U heeft met een hydraulische som op basis van het uitvoeringsontwerp aangetoond dat aan de vereiste waterstandsdaling wordt voldaan. Deltares heeft deze berekeningen getoetst, zie brief d.d. 15 juli 2016 kenmerk 1207404-007 - ZWS-0008-ha in bijlage 1. Met een waterstandverlaging van 0.31m ter plaatse van rivierkilometer 955 bevestigt Deltares dat aan de taakstelling wordt voldaan.

Programmabureau Ruimte voor de Rivier

Datum
21 juli 2016

Nieuwe waterkeringen
Van belang bij de constatering dat op dit aspect de waterveiligheid is geborgd, is de bevestiging van waterschap Rivierenland dat de nieuwe keringen veilig (conform de vigerende normen) het water kan keren en dat de dijkbeheerder de dijken in beheer houdt.
Waterschap Rivierenland heeft op 1 oktober 2015 na beoordeling het beheer van de keringen overgenomen van Rijkswaterstaat (brief RRO1.078813 d.d. 1 oktober 2015), hiermee heeft het Waterschap bevestigd dat de waterkeringen aan de veiligheidseisen voldoen.

Ik stel vast dat aan de taakstelling van de Planologische Kernbeslissing Ruimte voor de Rivier wordt voldaan. Daarmee constateer ik met voldoening dat de mijlpaal Waterveiligheid voor de maatregel Ontpoldering Noordwaard op 1 oktober 2015 is bereikt.

[redacted]

Bijlage 1: brief toetsing Deltares (kenmerk 1207404-007 -ZWS-0008-ha)

Deltares

Enabling Delta Life

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Datum	Ons kenmerk	Aantal pagina's
15 juli 2016	1207404-007-ZWS-0008-ha	1
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Classificatie
vertrouwelijk tot januari 2019

Onderwerp
Toetsing hydraulische berekeningen voor de Eindontwerp maatregel "Ontpoldering Noordwaard"

Geachte heer [redacted],

Hierbij ontvangt u de resultaten van de toetsing van de hydraulische berekeningen voor de Ruimte voor de Rivier maatregel “Ontpoldering Noordwaard”.

Het model van de Eindontwerp maatregel bevat het interventieniveau voor de vegetatie in uiterwaarden, het interventieniveau na sedimentatie in de kreken en de zetting van de nieuwe dijken. Het model presenteert hiermee niet de “As Built” situatie. De modelschematisatie van de maatregel “Ontpoldering Noordwaard” wordt daarom beschreven als "Eindontwerp".

Het hydraulisch effect van de “Eindontwerp“ maatregel, gebruikmakend van de methoden en het instrumentarium gedefinieerd door PDR, is 30.1 cm. Hiermee voldoet het “Eindontwerp” aan de taakstelling van 30 cm.

Voor een uitgebreide beschrijving van de toetsingsresultaten en bevindingen wordt verwezen naar het bijgaande rapport.

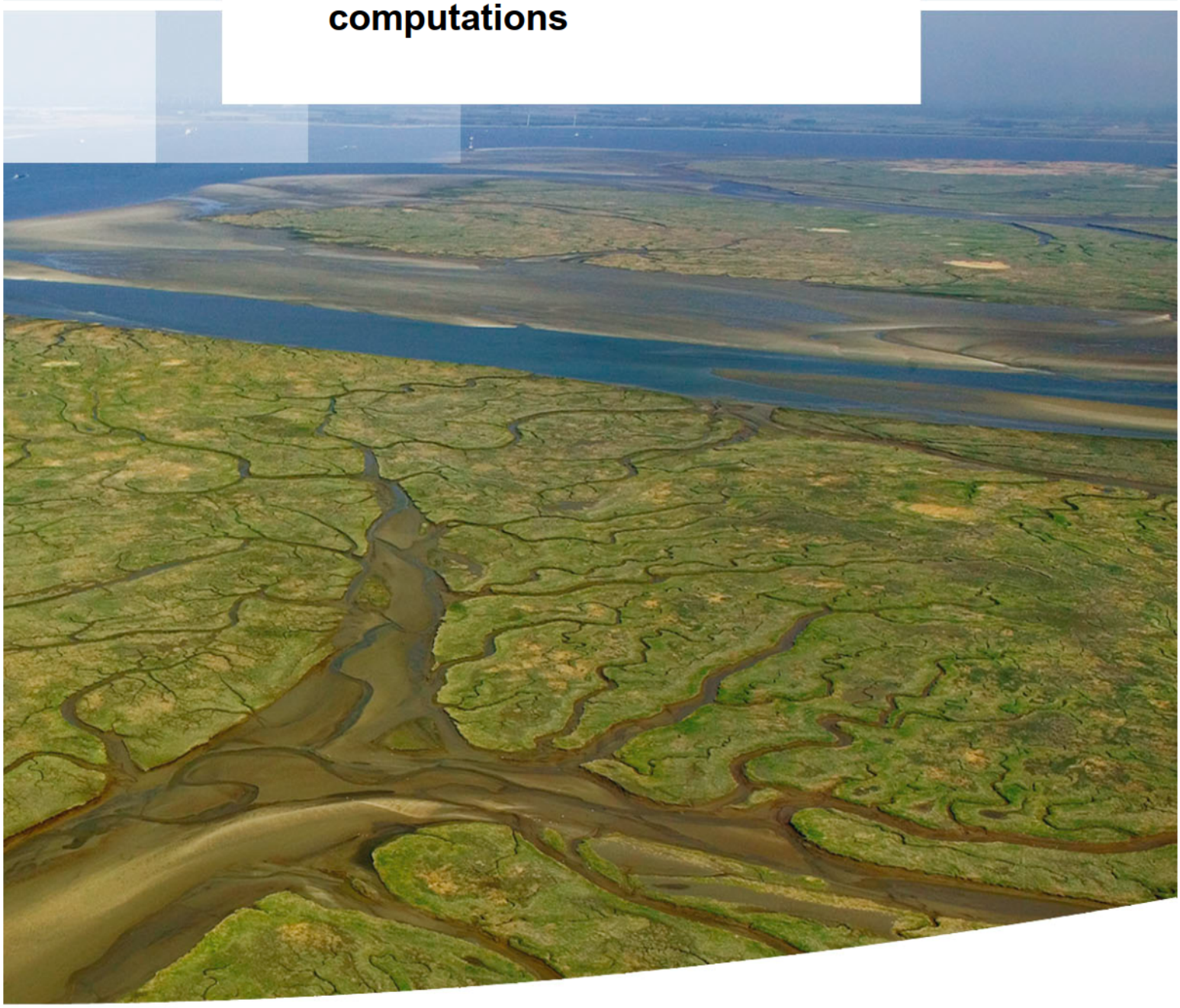
[redacted]

Bijlage(n)
- Deltares, 2016. Review of Noordwaard Eindontwerp hydraulic computations. Definitief rapport, juli 2016.

Deltares

Enabling Delta Life

Review of Noordwaard Eindontwerp hydraulic computations



Deltares

Review of Noordwaard Eindontwerp hydraulic computations

1207404-007

Deltares

Title
Review of Noordwaard Eindontwerp hydraulic computations

Client	Project	Reference	Pages
Programmabureau Ruimte voor de Rivier	1207404-007	1207404-007-ZWS-0007	50

Keywords
Ruimte voor de Rivier, Ontpolderding Noordwaard, Eindontwerp, toetsing, taakstelling

Summary
In order to lower the river water levels during MHW conditions, the Room for the River project Ontpoldering Noordwaard (in English: Depoldering Noordwaard) was proposed in the Planologische Kernbeslissing Ruimte voor de Rivier (in English: Planning Key Decisions for Room for the River).

PDR has indicated in the request for the review that the current schematization of the project Ontpoldering Noordwaard is not fully based on the field measurements that describe the As Built state of the measure. The Baseline measure incorporates "interventieniveau" for the floodplain vegetation, "interventieniveau" for the sedimentation in the creeks (assumed 30 to 50 cm) and a settlement of 10 cm for the new dikes or otherwise computed within another study for the weir sections along the high dikes. Thus, the current schematisation is not representing the schematisation of the project as it is built. The model schematisation is therefore described as "Eindontwerp". This report reviews the Eindontwerp Baseline schematization, WAQUA model, and the computed hydraulic effect.

The Eindontwerp includes lowering or removal of the existing dikes as well as construction of the new dikes, construction of mounds (terpen) and constructing several streams. Deltares has reviewed whether the Eindontwerp is accurately represented in the Baseline schematisation and WAQUA model. The field measurements, which only consist of measurements where the contractor has intervened, have been provided to Deltares in the form of AutoCAD files. During the review, it was concluded that there is some disagreement between the field measurements and the model schematisation. There are still some discrepancies, which are of less influence in the water levels compared to the uncertainty related to the procedure used for the schematisation of the Eindontwerp model.

The hydraulic effect of the Eindontwerp measure is 30.1 cm at rkm 955. Thus, the measure fulfils the *taakstelling* of 30.0 cm. The Noordwaard measure leads to a water level increase of 15.3 centimeters on the Amer.

Deltares accepts the Baseline schematization and the WAQUA model for the RvdR project. However, the Baseline schematization cannot be used without further modification for other projects.

References
Email of PDR of 13 May 2016 with subject "Verzoek tot review gerealiseerd eindontwerp Ontpoldering Noordwaard"

Version	Date	Author	Initials	Review	Initials	Approval	In
	July 2016						

State
final

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1 Introduction

1.1 Background

In 2006 the Dutch parliament approved the Planologische Kernbeslissing Ruimte voor de Rivier (in English: Planning Key Decisions for Room for the River; PKB RvdR). PKB RvdR aims to bring flood protection up to the legal required level and to improve the quality of the river surroundings (PDR, 2007). As part of the PKB, the government compiled a package of measures that are or will be implemented during the coming years along the Dutch rivers.

Every measure proposed in the package is further developed in line with the Spelregelkader Natte Infrastructuurprojekten (in English: Layout of rules governing the implementation of water-related infrastructure projects) (SNIP). This framework sets out three phases (initial exploratory, design and execution phase) and seven decision stages.

One of the PKB measures is the 'ontpoldering (in English: depoldering) Noordwaard', referred to as Noordwaard. The following questions are to be answered by the review:

- Is the Baseline and WAQUA schematization a correct representation of the As-Built field measurements?
- Is the quality of the WAQUA computation sufficient?
- Does the measure fulfil the taakstelling?

The „taakstelling" (in English: target water level lowering) to be reached by the Noordwaard project is 30 cm decrease of water levels at the Waal rkm 955 during MHW condition (PDR, 2007).

1.2 Aim of this report

The goal in this report is to provide an independent review of the Eindontwerp schematisation of the "Ontpoldering Noordwaard". This report provides answers on whether:

- the delivered AutoCAD data has been used correctly in the Baseline schematisation;
- the changes in the variant schematisation are attributed solely to the used measure(s);
- the WAQUA model is a correct representation of the Eindontwerp situation within the limitation of the used grid and model;

Finally the computed hydraulic effect of the measure is compared to the PKB taakstelling.

Table below summarises some information regarding the measure:

Location of the measure	Noordwaard
Code of PKB measure	MW18_1 (meestromend)
Code of Eindontwerp measure	nm_ASBnw_c1 nm_ASBnw_a6
Code of reference variant	dm_2004_ref
Code of Eindontwerp variant	dm_2004_abnw_a6
Code of the WAQUA model	abnw_a6
Project Initiator	Rijkswaterstaat
Hydraulic Advisor	Royal HaskoningDHV

The Eindontwerp Baseline variant is created by mixing into the reference Baseline schematisation the following measures before mixing in the Eindontwerp measures given above:

- ip_scenario2 reference situation schematisation of Noordwaard area including the SNIP3 Baseline measure
- NOP_dicht Baseline measure which surrounds the NOP schematisation with high dikes.

A list of the received data files is presented in Appendix A.

1.3 Organization

The work was carried out by the following Deltares project team:

- [redacted] (review of Baseline schematisation and report)
- [redacted] (review of Baseline schematisation and WAQUA computation)
- [redacted] (project leader and end redacting of the report).

The reviewer is [redacted]. [redacted] and [redacted] managed the project on behalf of PDR.

1.4 Outline of the report

Chapter 2 elaborates on the review conclusions of Baseline schematization. Chapter 3 elaborates on the WAQUA computation review. Chapter 4 contains the conclusions and recommendations.

2 Review of Eindontwerp Baseline Measure

After finalization of the project, the contractor has made field measurements of the project area in the locations of interventions. The field measurements were provided to the Hydraulic Advisor who has created the Baseline schematisation and WAQUA model based on this information. Deltares uses the same field measurement data to assess the correctness of this model implementation.

This is the third review carried out by Deltares for the final phase of the project. During the first review (Verschelling and Zagonjolli, 2015) the lack of measurement or design data was the most critical problem and therefore the quality of the Baseline schematization could not be judged. During the second review (van der Wijk et. al, 2015) some AutoCAD drawings were provided. However, the Baseline schematization was still evaluated as only a rough representation of the delivered data. Now an extensive dataset including measurements in the form of several AutoCAD drawings is delivered to Deltares. Based on this data, the review of the As-Built measure is carried out.

2.1 Short description of Noordwaard project

Noordwaard polder is situated south of the Nieuwe Merwede, west from Werkendam and north from the National Park Biesbosch. Within the Room for the River project the polder is converted into an area that can be covered by water. Streams are created in the onetime polder. Other cultural and historical elements were created (Combinatie Noordwaard, 2015). During the construction, 4 million m^3 ground was replaced and 70 km of new kades and dikes were built. 33 bridges and 31 pumping stations and different hydraulic structures have been created (Ruimte voor de Rivier, 2015).

The goal of the project was to redirect some of the Merwede flow through the onetime polder so that more discharge can be conducted by the river in case of high flows. The primary dike (bandijk) has been lowered. Within the area several new polders are created. These polders are designed to be flooded for several days of the year. The constructions, agricultural companies and other buildings, are moved to a higher area to remain dry during floods. The adjusted areas by the project are shown with red colour in Figure 2.1.

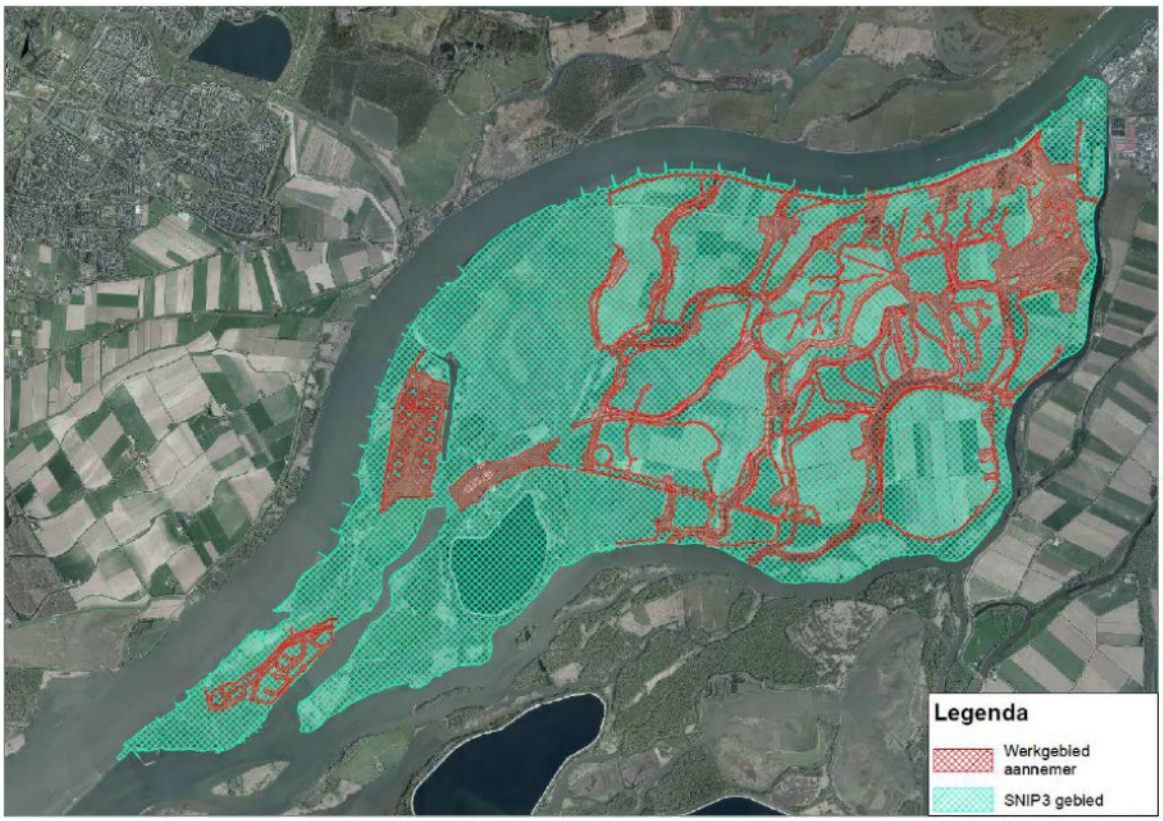

Figure 2.1 The project area (Source: Royal HaskoningDHV, 2016)

2.2 Delivered project data

There is an extensive set of data delivered, including several AutoCAD files containing As Built measurements (RHDHV, 2016). The hydraulic advisor has described in RHDHV (2016) that different sources of data have been filtered in order to create an Autocad file of the features which are changed by the project and which needs to be used for creating the Baseline measure. The following sources of data have been used by the Hydraulic Advisor as written in RHDHV (2016, pg. 9):

- The As Built measurements
- The reference field measurements (field measurements before starting of the project)
- The Baseline schematisation of the SNIP3. As indicated by the Hydraulic Advisor, the SNIP3 “schematisatie bevat een veelal verouderde en vaak niet correcte schematisatie van het ‘huidige’ krekensysteem”. Thus, sometimes the reference field measurements have been used instead of the reference situation schematisation used in SNIP3 phase.

Out of all AutoCAD files, the hydraulic advisor used the “As-built totaal v3.0.dwg” AutoCAD file as basis to create the Eindontwerp schematization. This file is shown in Figure 2.2.

Figure 2.2 The extent of the As-Built measurement

2.3 Procedure for the Baseline schematisation as described by the hydraulic advisor

There exists no reference situation Baseline measure for the Noordwaard area. During the SNIP3 phase, the Baseline measure included the RvdR measure features as well as the area not changed by the project into one Baseline measure. Therefore, there is no pure Baseline reference situation schematisation of the Noordwaard area. The Hydraulic Advisor adjusts in principle the SNIP3 Baseline measure based on the recent data.

The Hydraulic Advisor has agreed with PDR to use this method in schematising the Eindontwerp situation. A copy of this document is attached in Appendix B. A summary of the schematisation method as described by the Hydraulic Advisor in RHDHV (2016) is given below.

2.3.1 General procedure

In RHDHV (2016), the following procedure has been described:

1 The As Built measurements have been used for schematising the terrain features changed by the project (by the contractor). For the terrain features where the contractor has not intervened, the same Baseline schematisation is used as in the reference situation schematisation used in SNIP3 phase. The deviation from this procedure is applied at some locations where the As Built measurements cannot be fitted to the old reference situation schematisation used in SNIP3 phase, such as in the transition zone between the new creeks and the existing ones. Here the field measurements of the reference situation (“nul metingen”) have been used instead. (Agreement PDR-RHDHV 4 December 2015, see Appendix B).

2 The Natuur Ontwikkeling Noordwaard (NOP) and Polder Martha are incorporated in the schematisation despite the fact that these projects are not part of the RvdR project. The connection between the NOP and Noordwaard area is closed via a high dike.

3 The reference situation schematization (as used in SNIP3 phase) is kept unchanged. It is neither actualised based on the reference field measurements, nor corrected.

4 Power line piles, bridge pillars, pump stations and culverts are not included in the schematization.

5 Apart from the dikes, the other floodplain elevation changes are schematized using breuklines, even if the slope is higher than 1:7. The exception to this is the area around the Biesboschmuseum where survey data is converted to elevation points with a 5x5 m grid resolution.

6 Ditches, both excavated and filled, are not schematized.

2.3.2 Procedure dike schematisation

The Eindontwerp measure includes lowering or removal of the existing dikes as well as construction of the new dikes. To ensure the flow through the polders surrounded by high dikes during extreme flow conditions, there are extra lower sections created on the high dikes. Those are called overflow sections of high dikes and referred hereafter as “overlaten”. The hydraulic advisor presents the dikes changed by the project in Figure 2.3.

It is assumed that the height of the kades changes considerably in the first 25 years due to settlement. Therefore, the crest elevation of the dikes is schematised as follows:

- All new dikes are allowed a maximum settlement of 10 cm in 25 years, therefore their crest elevation is schematized 10 cm lower than the measurement.
- The settlement of the ”overlaat” sections has been anticipated in the schematisation as computed in another study. Deltares has not carried out the review of this study.
- Already existing dikes that are modified by the project (e.g. bicycle road is built over them or they are lowered), count no settlement. Thus, their crest elevation remains equal to the field measurements.

According to the hydraulic advisor, the following method is used for the schematization of the kades.

1. The dikes are schematized with a “kade” line, even if their crest width is wider than 10 m. The dikes are thus not incorporated in the bed elevation.
2. The location of the dikes is based on the As-Built measurement: the kade line is placed between the measured crest lines (RHDHV, 2016).
3. The crest height is determined by interpolation from the as-built measurement. This number is corrected with the settlement in the above mentioned way: by 10 cm for new dikes and zero correction for existing dikes that have been lowered.
4. The left and right toe elevation of the dike is extracted out of the SNIP3 bed level schematization (TIN).
5. The toe of a kade is not schematized with breuklines.
6. The height from the SNIP3 schematization is used where the new dikes connect to the existing dikes.

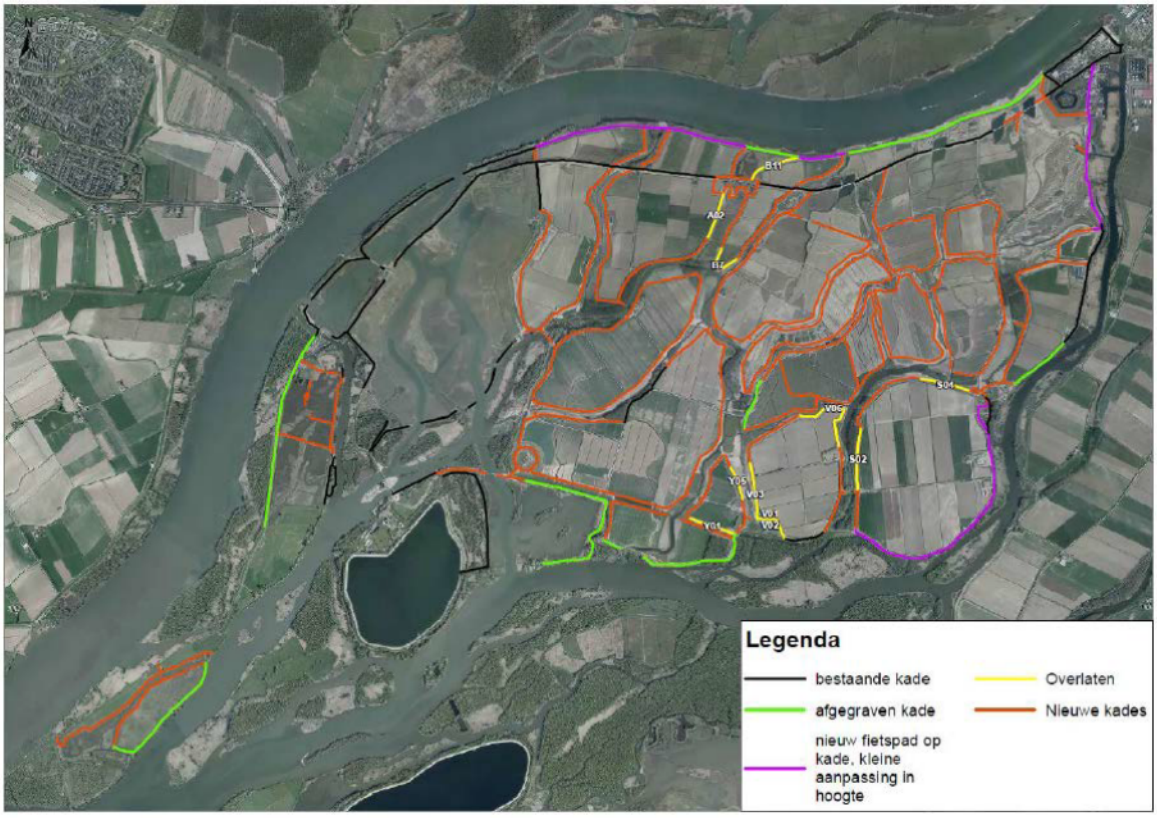

Figure 2.3 Location of the dikes (kades) changed by the project. Source: Royal HaskoningDHV (2016)

2.3.3 Procedure creek schematisation

The hydraulic advisor (RHDHV, 2016) has described the procedure used for the schematization of the creeks as follows:

1 The creek schematization is partially based on the Autocad file *"As_built_lijnen_kreken_en_maaiveld_veranderingen_3D.dwg"*. The Autocad file consists not only of the As Built data. Due to missing As Built measurements at some project locations, some extra sources of information have been used, such as previous project designs (Uitvoeringsontwerp), old field measurement data (AHN) or previous schematisation data (SNIP3). Figure 2.4 shows the different sources of data.

2 The As Built data are used only for the partial incorporation of the oever information (elevation of the breuklijn between the creek and the floodplain). The bodem elevation is taken out of the Uitvoeringsontwerp following the procedure described as follows in RHDHV (2016):
"Voor de bodemdiepte worden géén As-built gegevens gebruikt, maar is de interventiehoogte opgenomen. De interventiediepte voor kreken met ontwerpniveau van NAP-0,6m of lager is gedefinieerd als de ontwerpdiepte plus 50cm, De interventiediepte voor kreken met ontwerpniveau hoger dan NAP-0,6m is gedefinieerd als de ontwerpdiepte plus 30cm. "

3 Figure 2.5 is an example of the data used by the Hydraulic Advisor for schematising the creeks. The bottom elevation information of the creeks is coming from the Uitvoeringsontwerp elevations including the intervention levels. The "insteeklijn" shown in Figure 2.5 represents the location where the creek meets the floodplain. This is supposed to have been taken from the As Built measurements.

4 The creeks are schematised with elevation lines (breuklijnen) even when the slope is steeper than 1:7. This procedure has been used in SNIP3 phase.

5 Some 5 m from the outermost creek breuklijn (insteeklijn) an extra breuklijn is defined which receives the elevation information out the SNIP3 schematisation. This ensures that the changes brought to the schematisation due to the RvdR project will not influence the area which is not changed by the project.

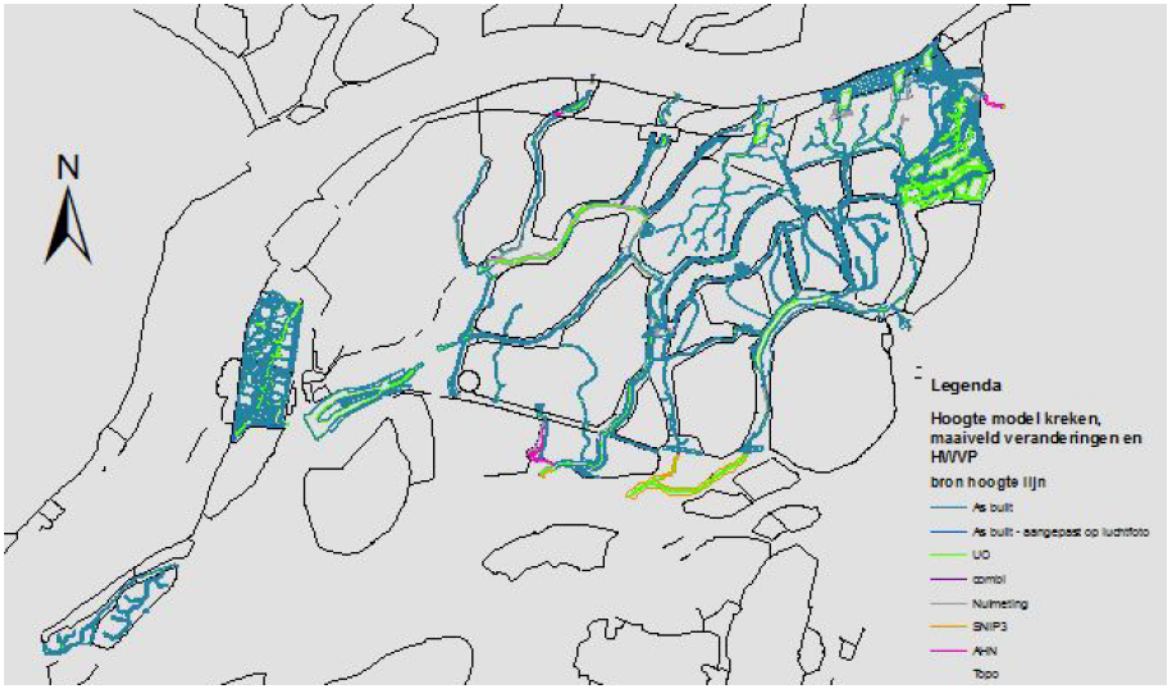

Figure 2.4 Data source of the creeks and other elevation features (RHDHV, 2016)

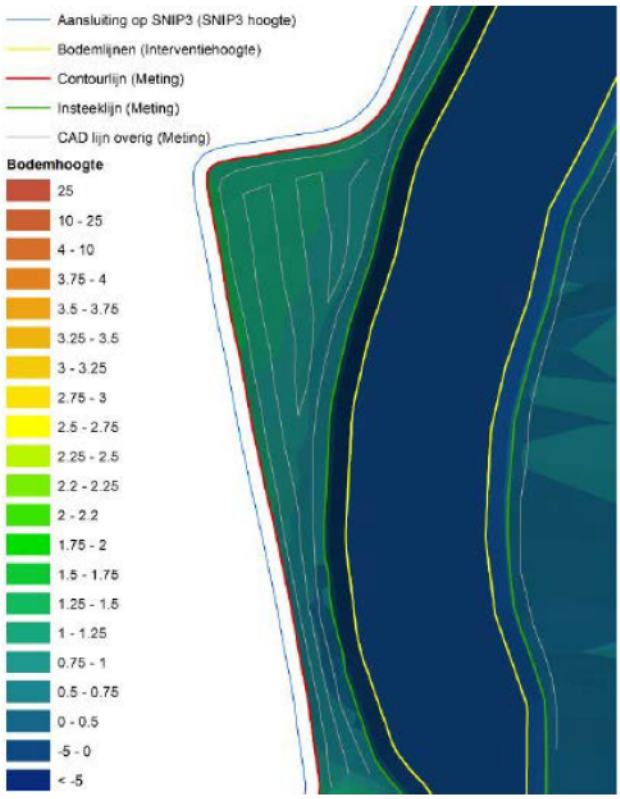

Figure 2.5 Example of the elevation information used for creeks (Figure 4.2 in RHDHV, 2016).

2.3.4 Procedure of mound (terp) schematisation

The hydraulic advisor described the following procedure for the schematisation of the mounds, hereafter referred with the Dutch term “terp” or “terpen”. The terpen are schematized as hoogwatervrij terrain, following the same method used during the SNIP3 phase.

2.3.5 Procedure roughness schematisation

The following procedure was followed by the hydraulic advisor for the roughness elements:

1 The interventiekaart was used to schematize the land use (vegetation) in the area.
2 Creeks are incorporated in the ecoruw file with roughness code 106 due to errors encountered by the hydraulic advisor when using the “plassen” Baseline coverage.
3 Solitary trees are not included in the schematization.
4 Bridge pillars are not included in the schematization.

2.4 Deltares review of the Eindontwerp schematisation

The review consists of a detailed check of the Baseline schematization files to ascertain whether the provided field measurement data are fully represented in the Baseline schematisation of the measure.

2.4.1 General review conclusions

- Next to the combined AutoCAD file delivered by the Hydraulic Advisor as As-Built measurement file, Deltares has received several other AutoCAD files with more details about each object. Deltares observed that the height information given in the combined AutoCAD file (“As-built totaal v3.0.dwg”) and for example the file “CNW-TEK-G-5086_v1.dwg” (present in the folder Brongegevens\Kades\0-00012 Lage kaden\CNW-D-G-5015 lage kade polder de Kroon\) are different. If both measurements are As Built, then it is expected the detail Autocad files and the total Autocad file should be the same. This issue raises questions about the quality of the delivered As-Built data.
- The Noordwaard floodplain schematisation as created in the year 2009 during the SNIP3 phase is used for the schematisation of features which have not been changed by the contractor. This means that the potential errors in that schematisation are still present. Given that the Noordwaard area is not present in the reference model, any incorrect model schematisation of the floodplain would solely contribute to the hydraulic effect of the measure.
- While for the new kades the maximum allowed settlement of 10 cm is applied in the schematisation, it is not clear why the expected settlement has not been computed.
- The settelement for the „overlaat” features placed on some of the high dikes is computed within another study. The underlying data (measurements and computations) used for computing the settlement of the “overlaat” features are not included in the report of LievenseCSO (2015). Thus, with the provided information, the calculated residual settlements cannot be assessed. Deltares cannot draw any conclusion on the accuracy of the reported settlement values.
- As during flood the water flowing over the dike is much more than the water through the culvert, the omitting of culverts at the schematisation would not have a significant influence for the current MHW computation. However, for other situations we strongly advise to include the culverts in the schematization, as well as the bridge pillars and the power lines. An example of the inclusion of a culvert in WAQUA can be found in the memo about the culvert near Lent (RURA, 2015).

2.4.2 Review conclusions dikes

The new dikes are schematised via kade feature in Baseline, which means that they are anticipated as weir structures and not incorporated in the bed elevation. The following conclusions can be drawn regarding the schematisation of the dikes (Baseline kade feature):

- The position of some of the kades is slightly different then in SNIP3 Baseline schematisation. Figure 2.6 shows the locations where the position of the kades is changed in the current schematisation. This relocation is very minor.

- Hydraulic Advisor described the position of the kades as follows:
  "De ligging van de kades is opgenomen op basis van het as-built bestand "Hoogte model As_built_lijnen_kades_en_terpen_3D", de kadelijn is gesitueerd tussen de kruinlijnen of asfaltlijnen uit de as-built tekening."
  During the review it was concluded that the kade line is not always defined in the middle of the dike crest width as described in RHDHV (2016). The Baseline kade line sometimes even crosses the measured kade crest lines.

- The kade line is not always having the measured crest elevation irrelevant of the applied settlement. According to RHDHV (2016), the elevation points along the kade lines are defined as interpolation between the measured kade crest lines. There are three measurements lines present on the kades changed by the project. Often the middle line has a higher elevation then the surrounding side lines, sometimes one of the side lines has a higher elevation then the two other lines. Considering these measurements data, the hydraulic advisor has decided to make an interpolation between the elevation lines. During the review we observe the following. The crest elevation of the modified kades (lowered or increased) is not always corresponding to the measurements.

  In order to gain an overview of the kade crest elevation, the schematized value is contrasted with the measurements. If the crest elevation deviation between the interpolated elevation value corrected with the anticipated settlement and the schematisation is between a ±2 cm margin, then it is shown in green colour in Figure 2.7. If the difference is more than 2 cm, it is shown with red colour (schematized too low compared to the measurement) or blue color (schematized too high compared to the measurement). Note that this figure does not contain the overflow kade sections ("overlaten"). Several red dots are seen on the sides of the kade lines, that is due to the connection to the old reference situation schematisation. In Figure 2.8 it can be seen that the differences are above 5 cm and amounting up to more than 10 cm for the existing modified kades. The differences between the measured and schematized crest elevation for the new kades is above 12 cm. Anticipating the settlement of 10 cm, one concludes that the differences in elevation are generally more than 5 cm (see Figure 2.9). These deviations are partially caused by the fact that the kade position is not according to the measurements, sometimes the field measurements consist of strong deviations on the measured elevations within a short distance, and could be slightly influenced by the comparison method used in this analysis which is not necessary the same to the schematisation method used by the hydraulic adviser.

  The kade crest elevation is different compared to the Definitive Design schematisation of September 2015.

- The kade lines are not surrounded by the elevation lines (breuklijnen). While the Hydraulic Advisor has decided to schematise the dikes with the kade feature, at the same time the surrounding two lines (representing the toe elevation) are missing. This is due to the fact that within the RvdR project, PDR has decided upon keeping the schematisation of the reference situation which is not subject to change due to the project, unchanged. Introducing the breuklijnen with the measured elevation around the new kades, would most likely lead to conflict with the (not to change) reference situation schematisation.

Through some examples below we show the differences in kade crest elevation in some cases. The hydraulic effect of these deviations cannot be assessed.

Figure 2.6 The locations (yellow line) where the kade position in the Eindontwerp variant slightly differs from the SNIP3 variant position (brown line). Background map: LuchtfotoNL 2013 (50 cm).

Figure 2.7 Comparison between the schematized kade heights and the measurements.

Figure 2.8 Comparison between the schematized kade heights and the measurements for the existing kades given as "As Built measured elevation – kade crest elevation"

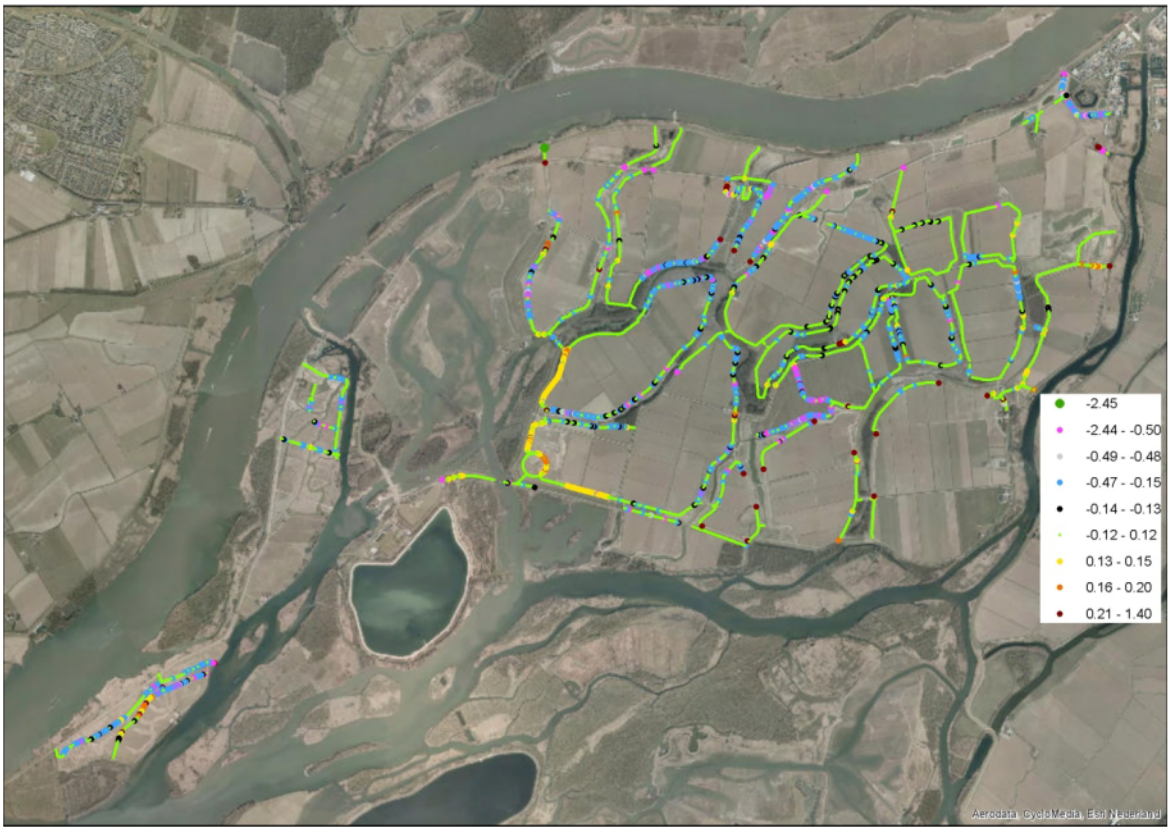

Figure 2.9 Comparison between the schematized kade heights and the measurements for the new kades given as "As Built measured elevation – kade crest elevation"

The lowered bandijk is schematised with a kade line which is slightly repositioned compared to SNIP3 schematisation. However, the kade line does not coincide with the highest measured elevation line. See the red circles in Figure 2.10: the elevation of the kade line is 1.93 cm while the elevation of the measured point next to that kade line is 4 cm more. The height difference is also shown in Figure 2.10 . Hence, the crest elevation of the lowered bandijk is lower in the schematisation.

The schematized kade is lower than the measured one at location 1 in Figure 2.7. The schematized kade point in the red circle lies in between a measured line of 1.5 m and 1. 21 m (Figure 2.11). However, the elevation of the schematized kade point is 1.21 m.

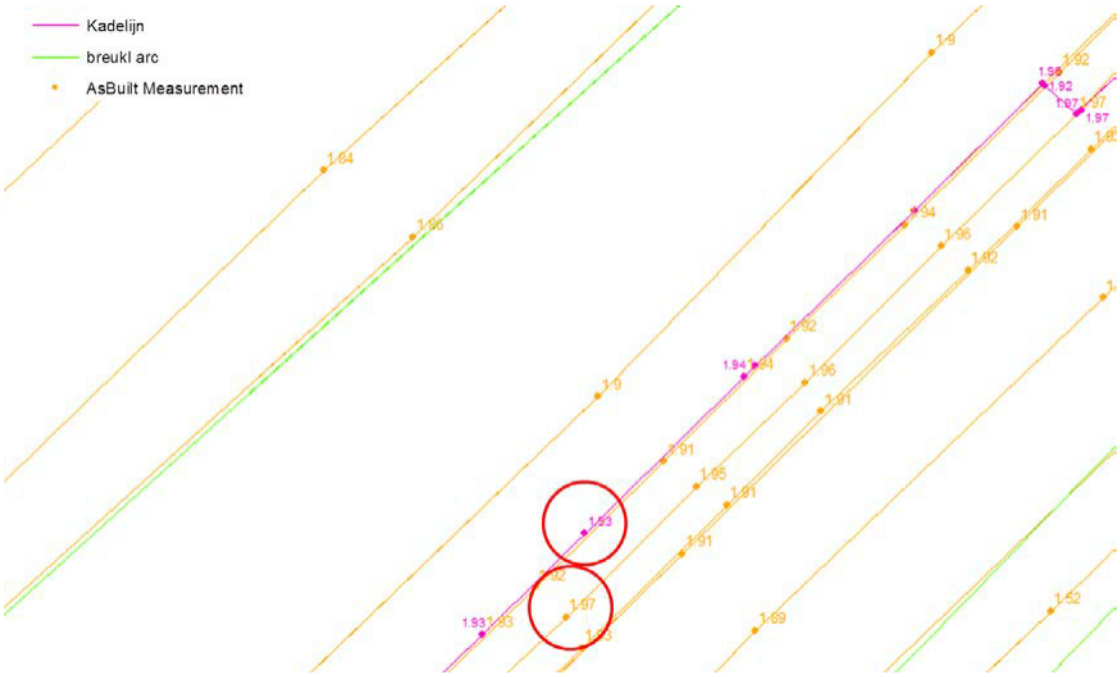

Figure 2.10 Lowered bandijk

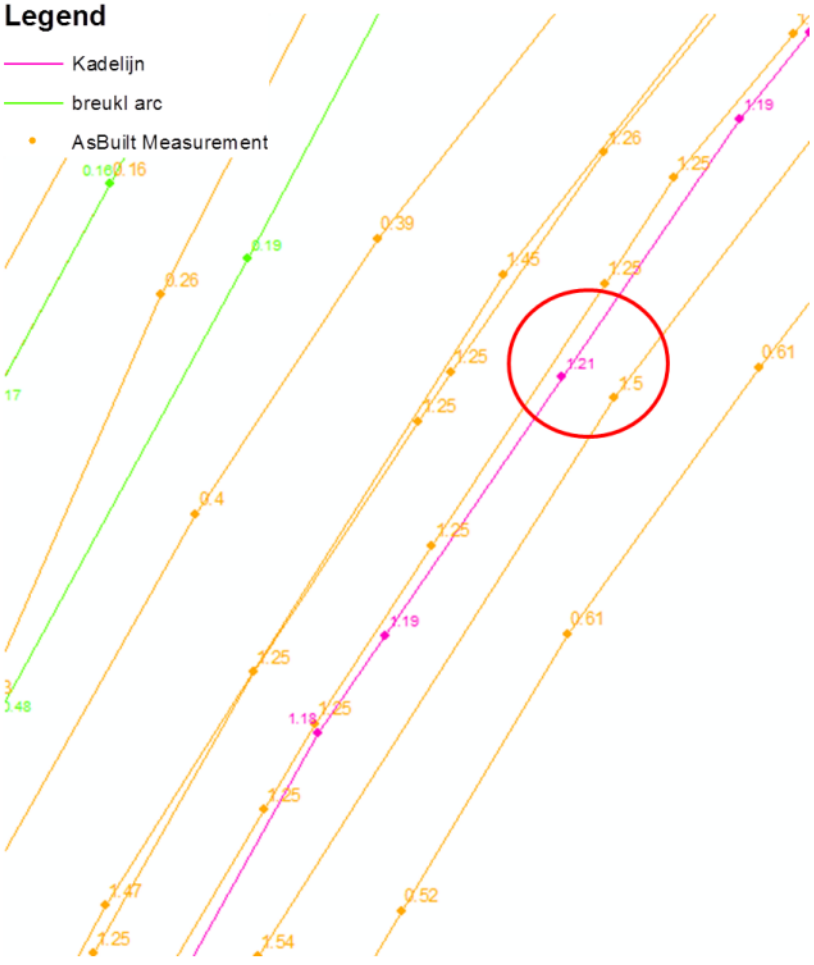

Figure 2.11 Kade in the Western side of polder Hooge Hof

In the Polder de Kroon (at location 2 in Figure 2.7) part of the kade line corresponds to the measurement line (Figure 2.12). However, kade elevation points in schematisation are 13 cm and 14 cm lower than measured (see Figure 2.12).

Similarly in the Polder de Zalm (at location 3 in in Figure 2.7) part of the kade line corresponds to the measurement line (Figure 2.13). Again, the elevation of the new kade line is not extracted from the underlying measurement line, but seems to have been considered as the average of the two crest side line elevations anticipating the 10 cm maximum settlement.

Also in the South-Western side of Polder de Zalm (at location 4 in Figure 2.7) the measured and schematized points coincide, but their elevation is different. Taking into account the settlement, the difference is still 3 cm (Figure 2.14).

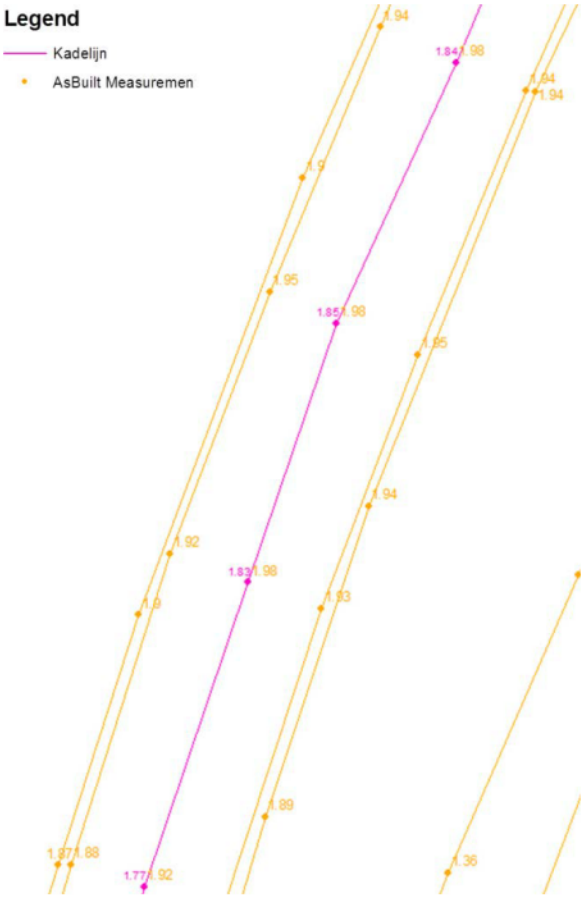

Figure 2.12 Kade in the South-West side of Polder de Kroon

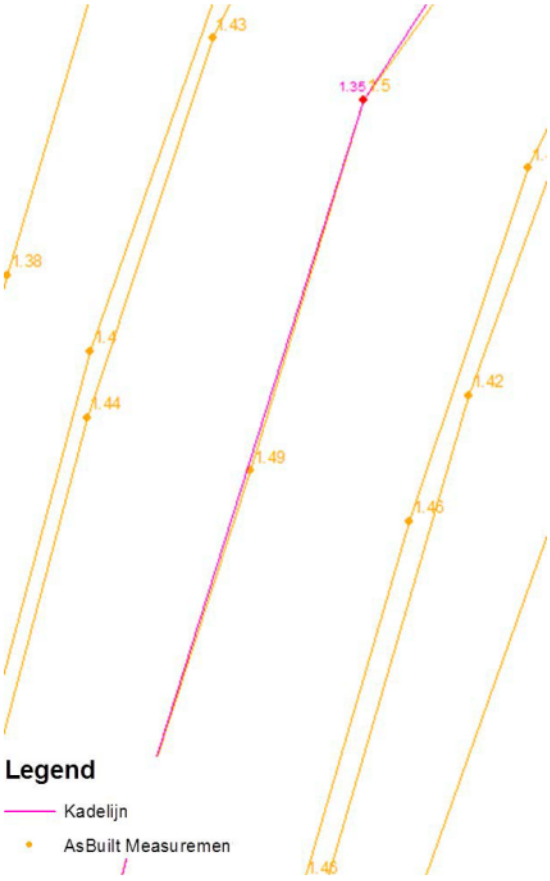

Figure 2.13 Kade in the Western side of Polder de Zalm

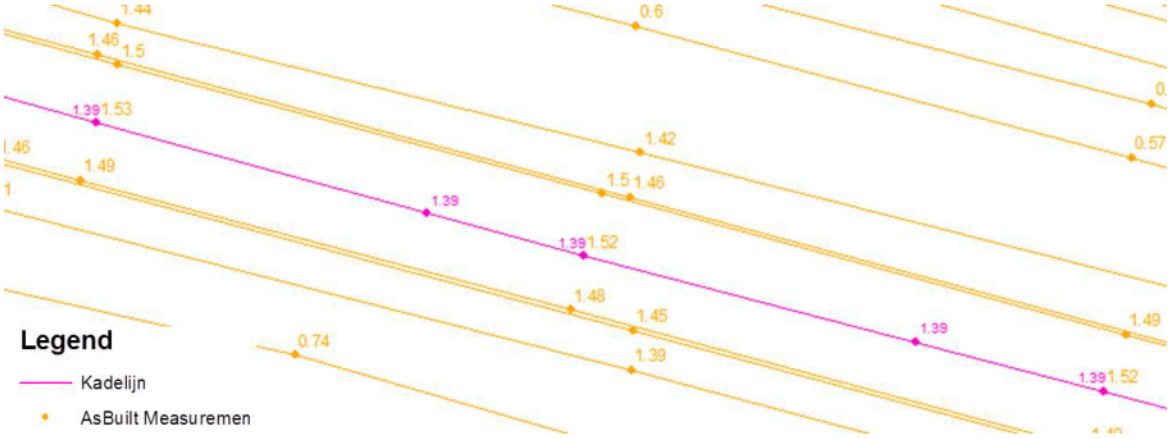

Figure 2.14 Kade in the South-Western side of Polder de Zalm

In the Eastern side of Polder Maltha (at location 5 in Figure 2.7) the “breuklijn” crosses the kade lines with different elevation (Figure 2.15). The “breuklijn” crossing the kade lines needs to be removed. Instead two breuklijnen need to be defined on both sides of the kades.

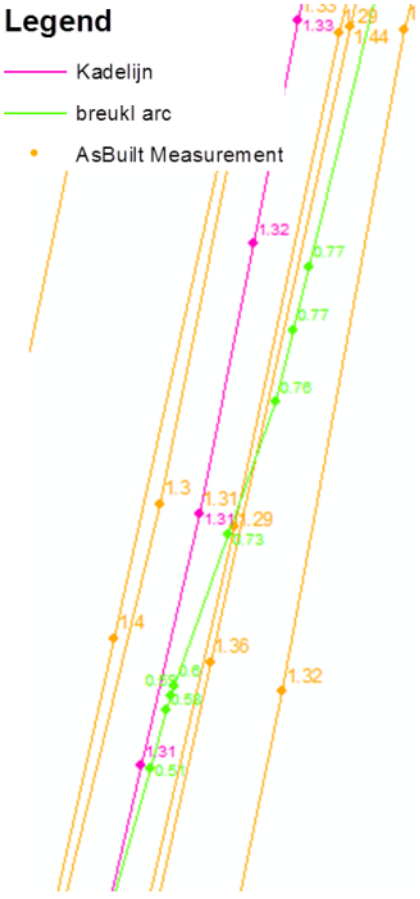

Figure 2.15 Eastern side of the Polder Maltha

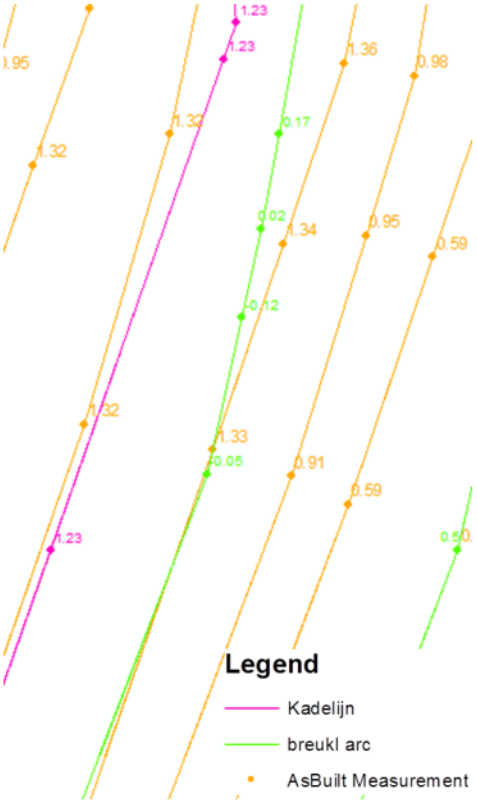

Figure 2.16 Eastern side of the Polder Kooiwaard Oost

At some other locations there are breuklijnen present whose elevation is not taken from the AutoCAD measurement file: for example in the eastern side of Polder *Kooiwaard Oost (*Figure 2.16*)*. (The breuklijn is located close to the kade point 5973 of the variant.)

To conclude: Deltares does not fully agree with the method used for schematising the kades (position of the kades) and discrepancies are observed between the field measurement and the crest elevation considered in the schematisation. These deviations are partially caused by the fact that the kade position is not according to the measurements, sometimes the field measurements consist of strong deviations on the measured elevations within a short distance, and could be slightly influenced by the comparison method used in this analysis which is not necessary the same to the schematisation method used by the hydraulic adviser. The hydraulic effect of these deviations cannot be assessed.

2.4.3 Review conclusions creeks

As summarised in Section 2.3.3, the hydraulic advisor does not make full use of the As Built measurements for schematising the creeks. Instead the bed elevation of the creeks is schematised based on what Hydraulic Advisor describes as “Intervention level of the uitvoeringsontwerp”. This was described as 30 to 50 cm higher bed elevation than the “uitvoeringsontwerp”. During the review it was observed that:

- the schematisation incorporates a bed elevation of the creeks which is up to more than 1 m shallower to the As Built measurements.
- the elevation line surrounding the creeks which has obtained the elevation information out of the reference situation schematisation (used in SNIP3 phase) differs significantly from the measurements.
- the connection between new and existing creeks is not fluent as shown in Figure 2.17. This could be fixed by updating the schematisation of the area which is not subject to change by the RvdR project. In some locations obstacles are present in the creeks as well. These obstacles (erroneous model schematisation) need to be removed.

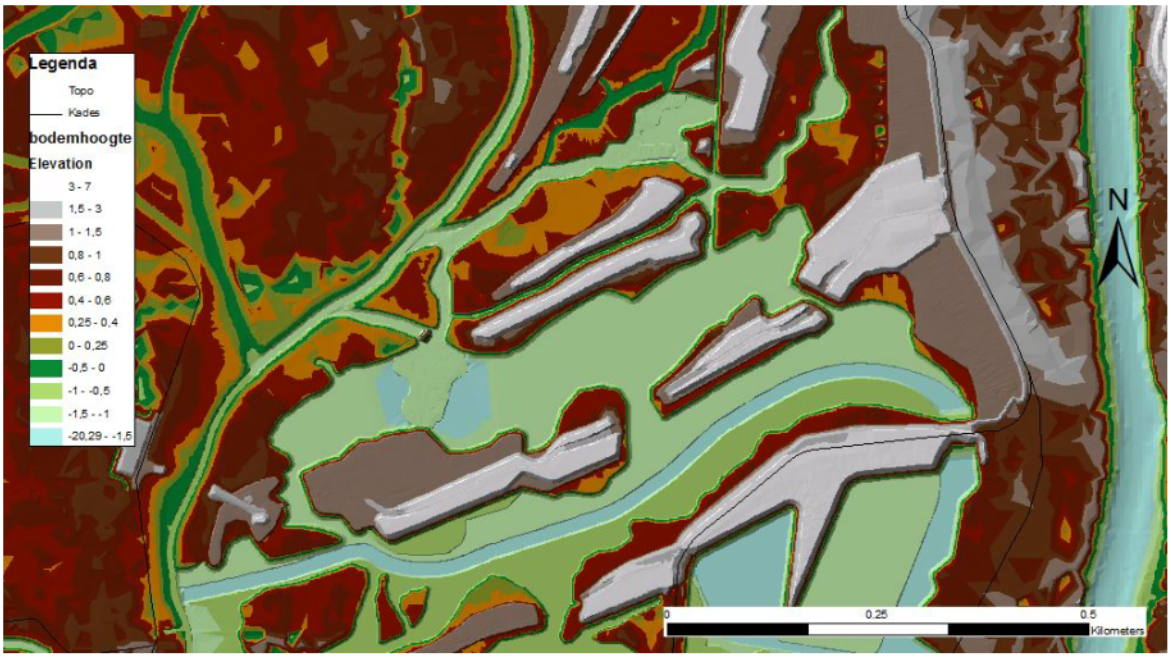

Figure 2.17 TIN of the Recreatiepoort

To conclude: The creeks are not a good representation of the As Built measurements. It is not possible to quantitatively asses the influence of this discrepancy on the computed hydraulic effects.

It is strongly recommended to not use the current model or schematisation for any other project. Deltares recommends changing the creek schematization based on the As Built data for future schematisations.

2.4.4 Review conclusions mounds (“Terpen”)

At Terp 52 (Figure 2.18) the area encircled by the hoogwatervrij line is bigger than the measured area of the *terp*. In fact, inside the circle there are several lower elevation points. The schematization of the mound could be improved.

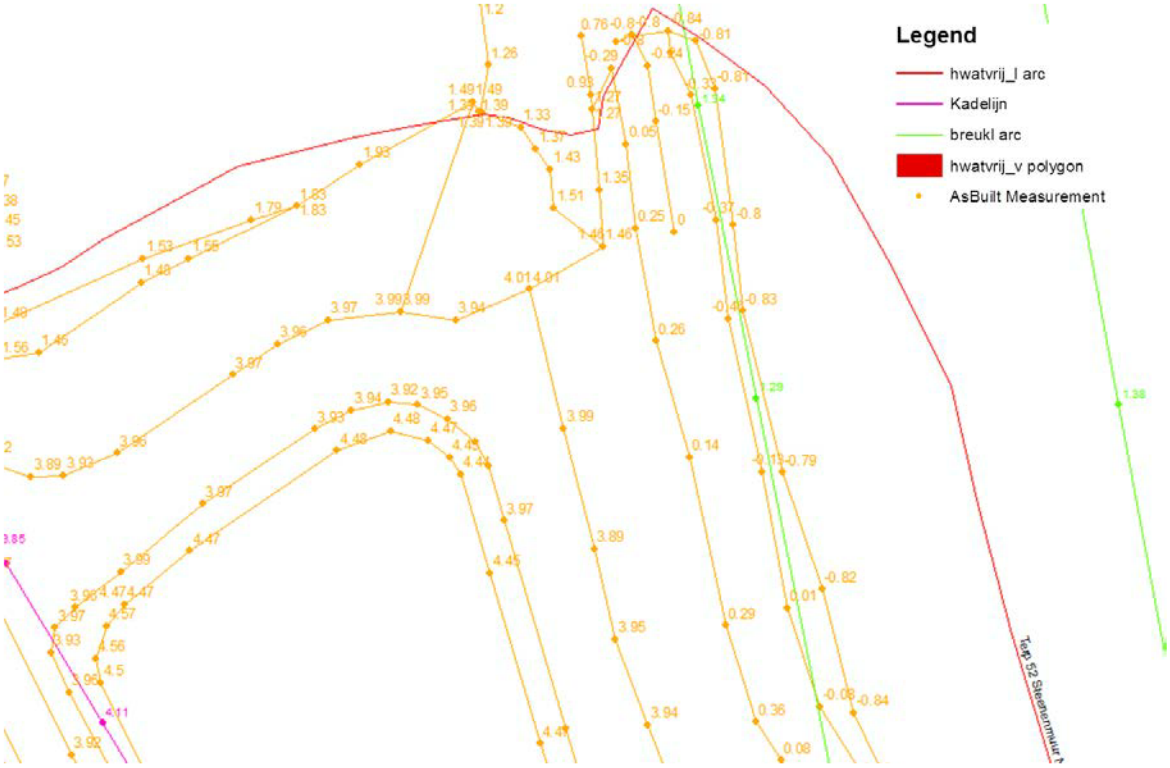

Figure 2.18 Terp 52

2.4.5 Review conclusions inlet constructions

According to the assumption of the hydraulic advisor these objects, together with power line piles, bridge pillars, pump stations and culverts are not included in the schematization. We advise to include the culverts in the schematization, just like the pillars of the bridges and the power lines piles.

The upstream part of the inlet construction (the bridge crossing the lake) is schematized as an opening in the kade. As the dike is most likely not overflown with these flow conditions, the flow through the inlet is much larger.

2.4.6 Review of the floodplain elevation

- The differences in the bed elevation (Figure 2.19) between the SNIP3 and Eindontwerp schematisation are limited to the project features (Figure 2.2).
- Directly besides the creeks higher areas can be found in the TIN of the Eindontwerp variant schematisation. Upon closer inspection of the aerial photograph (Figure 2.21) and vegetation map (Figure 2.22) the higher grounds (Figure 2.20) correspond with the *ooibos* along the river. The schematized high terrain is most likely a result of taking the treetop height instead of the bed elevation. The hydraulic effect, if any, would likely increase if these areas are adjusted. It is recommended to adjust the schematisation based on recent measurements.

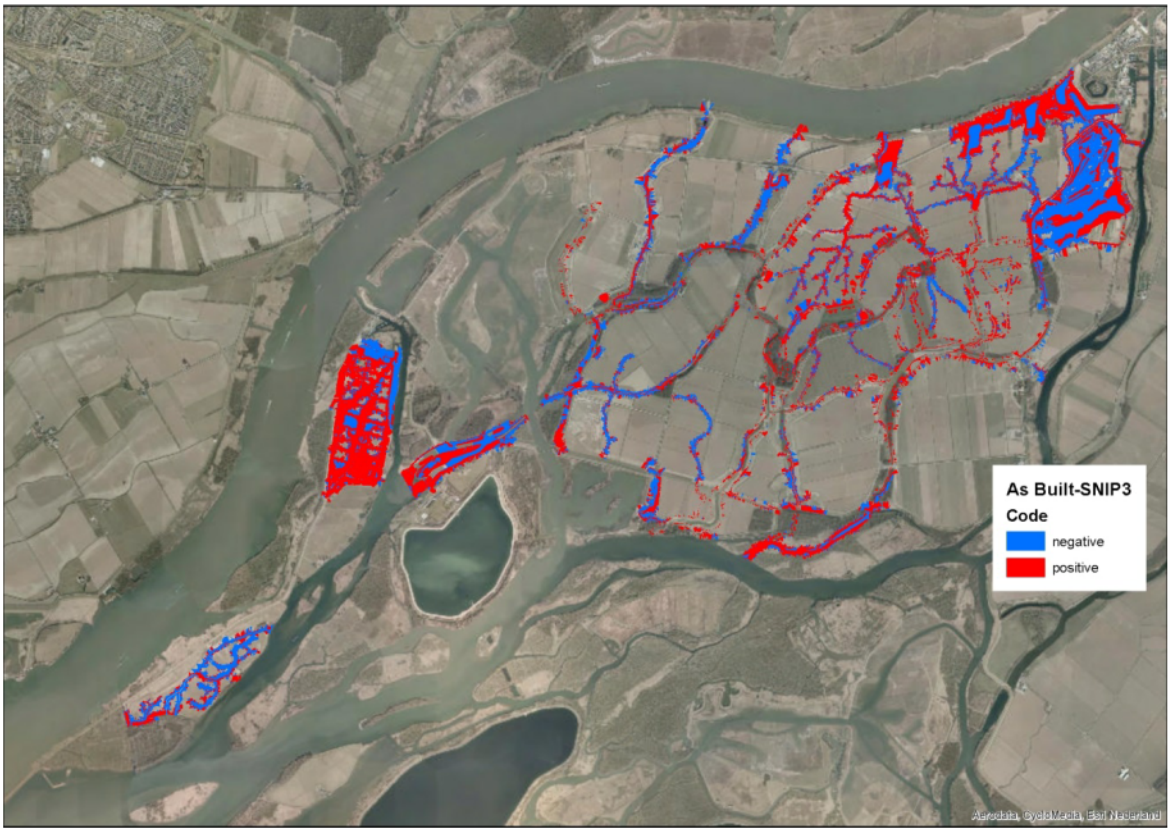

Figure 2.19 The bed elevation (TIN) difference. The blue colour areas indicate a higher elevation present in SNIP3 schematisation. The red colour areas indicate a higher elevation present in Eindontwerp schematisation. The background is an Aerial Photograph of the area before the project implementation (source: LuchtfotoNL 2013 (50 cm)).

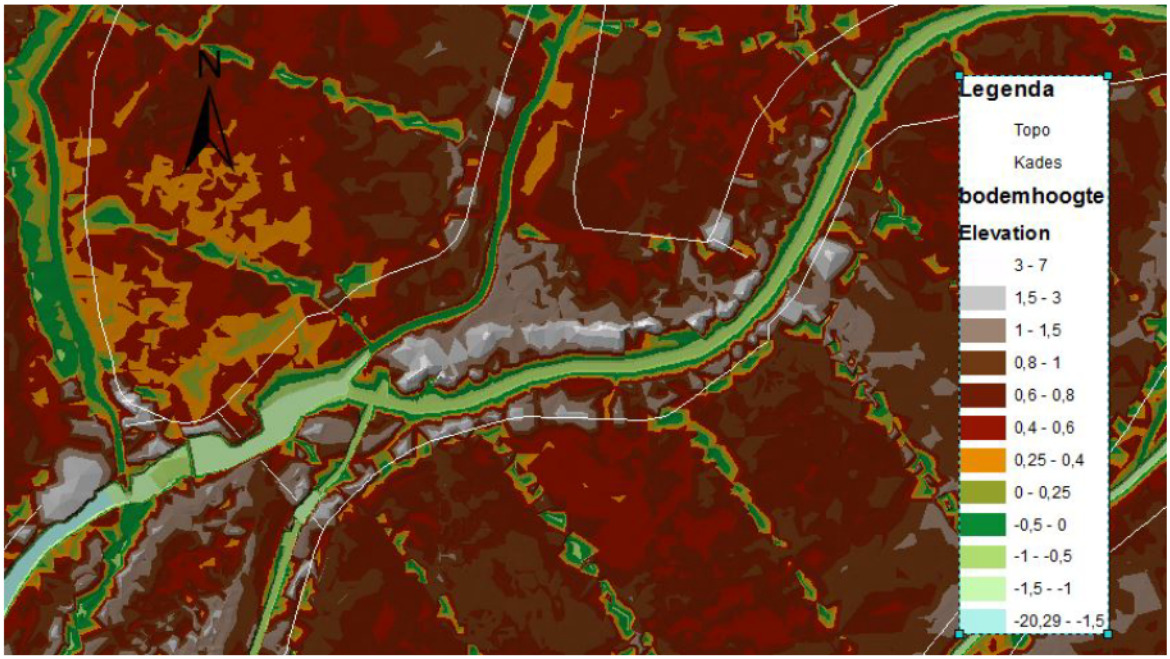

Figure 2.20 TIN of ooibos in Noordwaard

Figure 2.21 Aerial photograph of Ooibos in Noordwaard

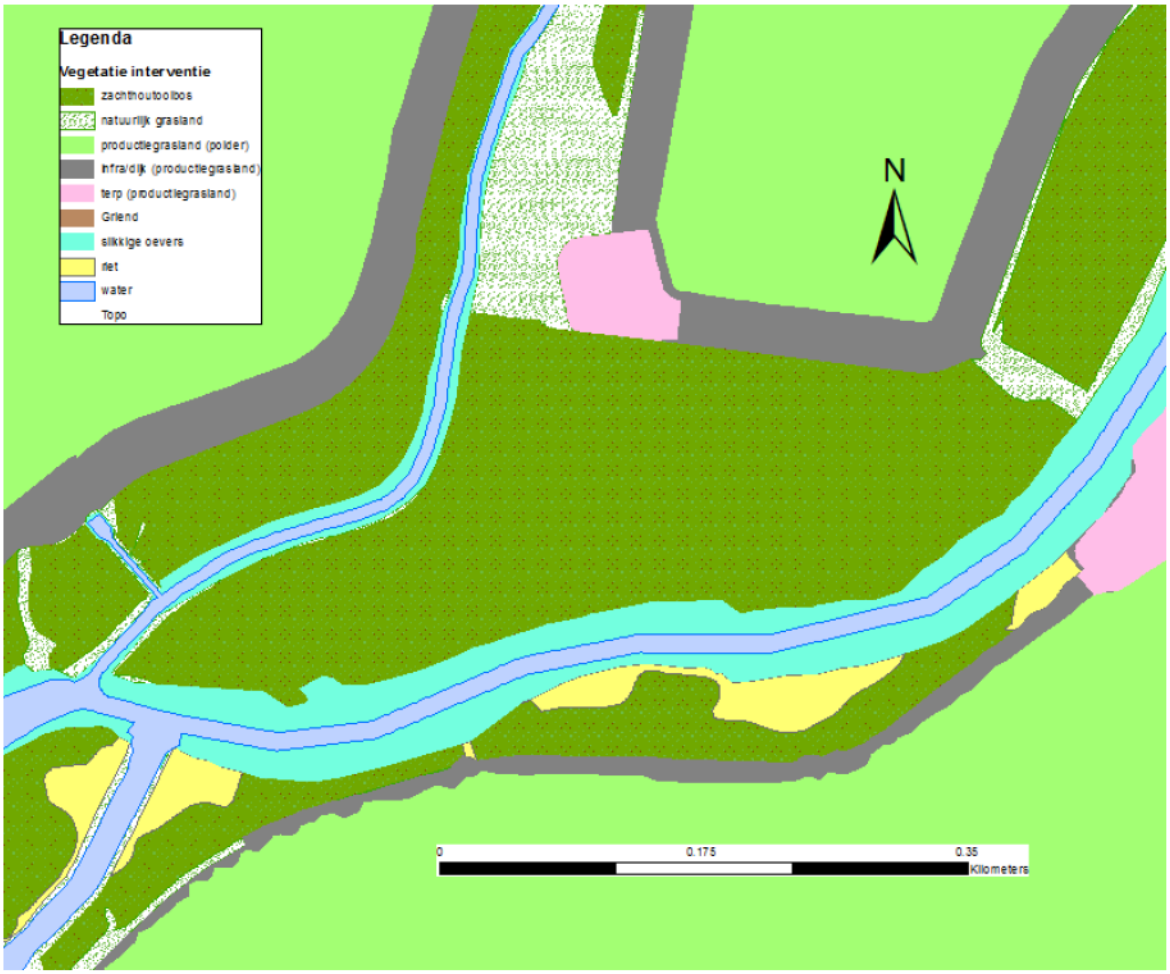

Figure 2.22 Intervention map of Ooibos in Noordwaard.

2.4.7 Review of the Roughness

The interventiekaart (Figure 2.23) is nearly the same as during the SNIP3 phase with few changes. The main vegetation at Hillpolders is changed from Zachthoutooibos (code=1804) to Natuurlijk Grasland (code=1202). The South-western part of Noordwaard is schematised as productiegrasland. The review conclusions are as follows:

- There is a small area where the roughness code 0 is present. The polygon needs to be given the correct roughness code.
- The changes to the *ruwheidv* Baseline coverage extend beyond the measure area (Figure 2.24). The changes are present only in the Eindontwerp variant and not present in the reference schematisation.
- The Eindontwerp vegetation schematisation (Figure 2.24) does correspond to the delivered interventiekaart (Figure 2.23).
- Detailed elements like trees and bridge pillars are not included in the schematisation. These roughness elements should be taken into account in other schematizations in the future.
- It is recommended to include the creeks in the “plassen” Baseline coverage in future schematisations.

To conclude: There are some inconsistencies in the created schematisation. The hydraulic effect of these inconsistencies is not known.

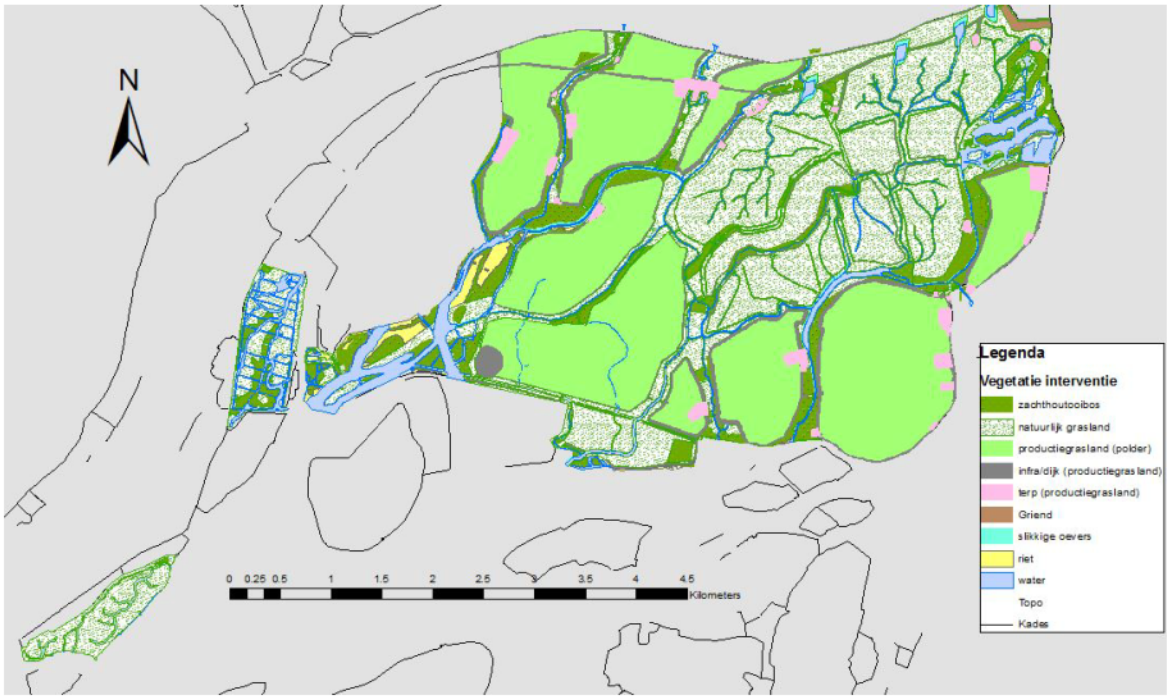

Figure 2.23 Interventiekaart of Noordwaard.

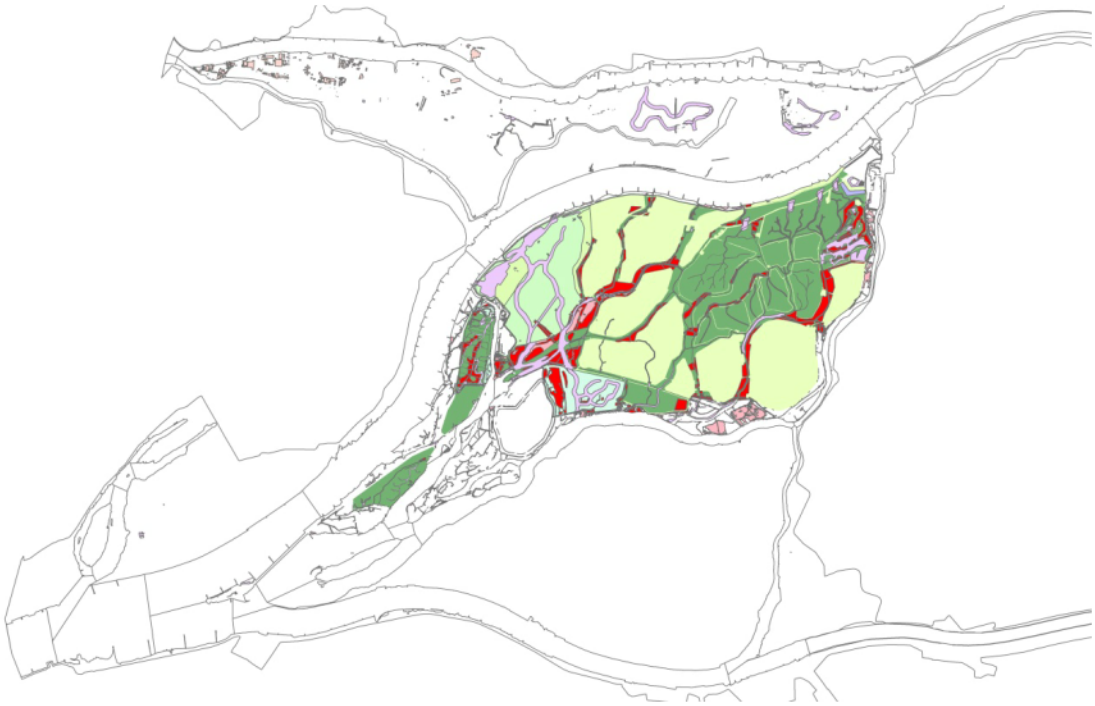

Figure 2.24 Differences in the vegetation/land use type between the reference and Eindontwerp variant schematisation.

3 Hydraulic effect of Eindontwerp Noordwaard measure

In this chapter we assess the hydraulic computations made for the Eindontwerp measure. The WAQUA model is checked on whether or not the following criteria are fulfilled:

- The changes in the schematization are solely attributed to the inclusion of the measure.
- The WAQUA model is a fair representation of the Eindontwerp situation
- The appropriate set of boundary conditions is used in the computation(s)

The reference model was not delivered within the data set of the hydraulic advisor. Deltares therefore used the reference model delivered during the previous review.

At the end of the chapter we shortly summarise the conclusions regarding the hydraulic effect of the measure.

3.1 WAQUA model schematization

The different aspects of the WAQUA schematization are shown in Figure 3.1 and Figure 3.2. Changes in the variant are a result of the measures.

The creeks are sometimes too small for the used grid. For this project this is not an issue. It is important to keep this limitation in mind if detailed studies in Noordwaard are wished for.

Deltares finds the conversion and schematization of the WAQUA model suitable to perform simulations for the Room for the River project.

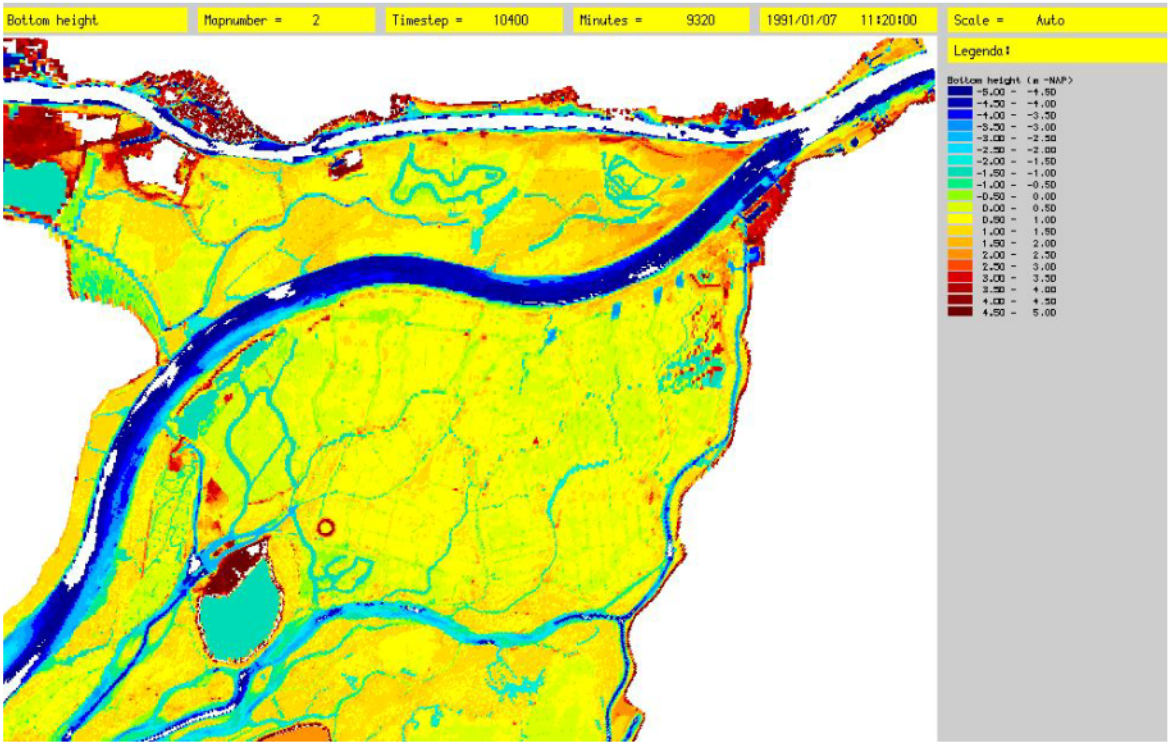

Figure 3.1 Bottom height of As-Built variant WAQUA model.

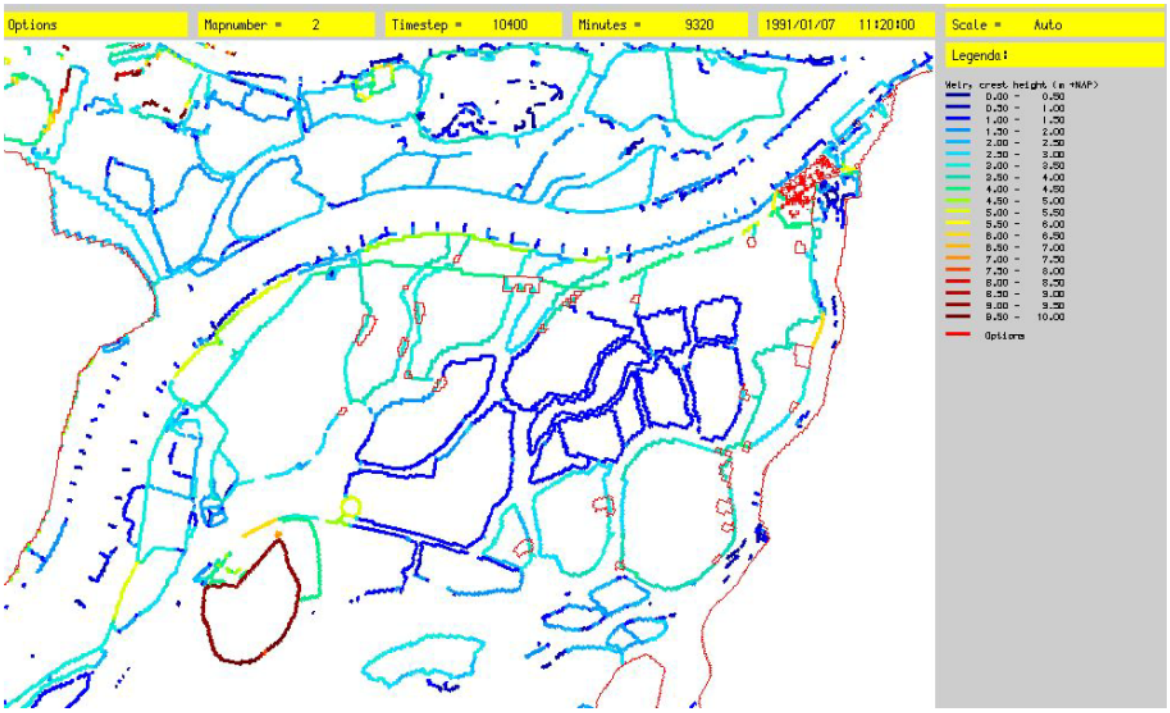

Figure 3.2 Weirs of the Eindontwerp variant WAQUA model.

3.2 Comparison with SNIP3 WAQUA model

The changes in height compared to the SNIP3 model are only visible in the area adjusted by the contractor (Figure 3.3). These areas are mainly creeks, the area in front of the inlet openings and the Recreatiepoort. Most of the dikes (weirs) are updated in the latest schematization (Figure 3.4). The dikes position has been slightly changed in the current schematisation compared to SNIP3 variant. The roughness is slightly different around the creeks (Figure 3.5).

The changes between SNIP3 and the Eindontwerp variant are a logical consequence of the update of the schematization.

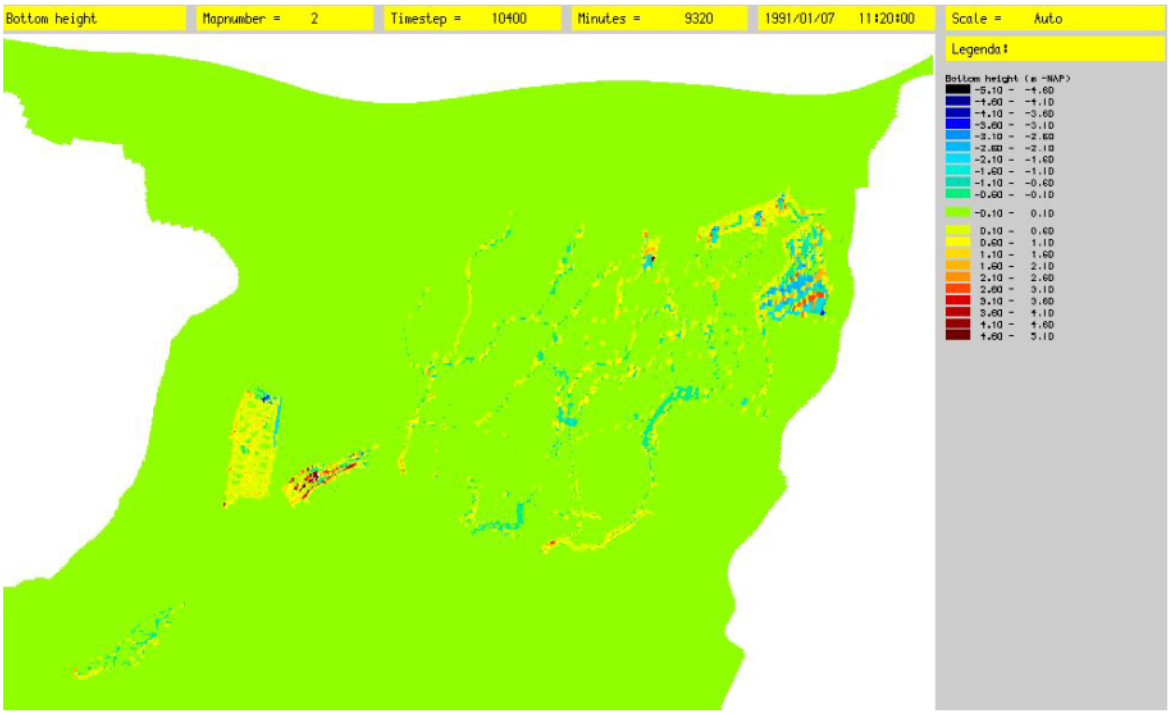

Figure 3.3 Difference in height between SNIP3 and Eindontwerp variant

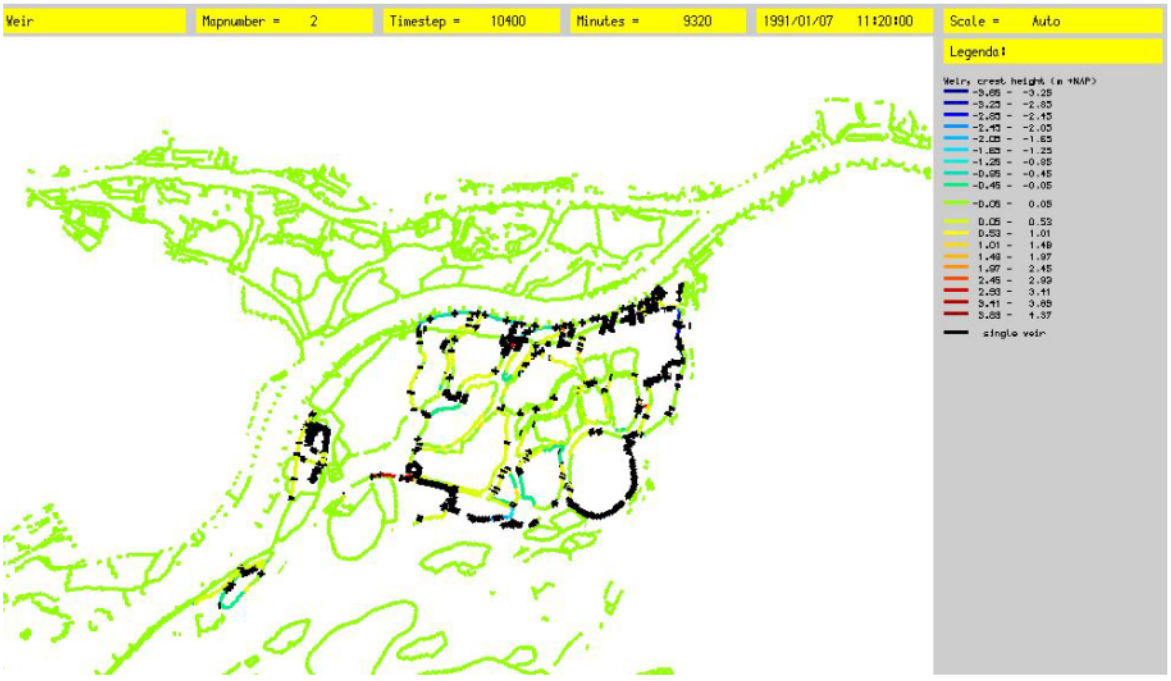

Figure 3.4 Difference in weir height between SNIP3 and Eindontwerp variant

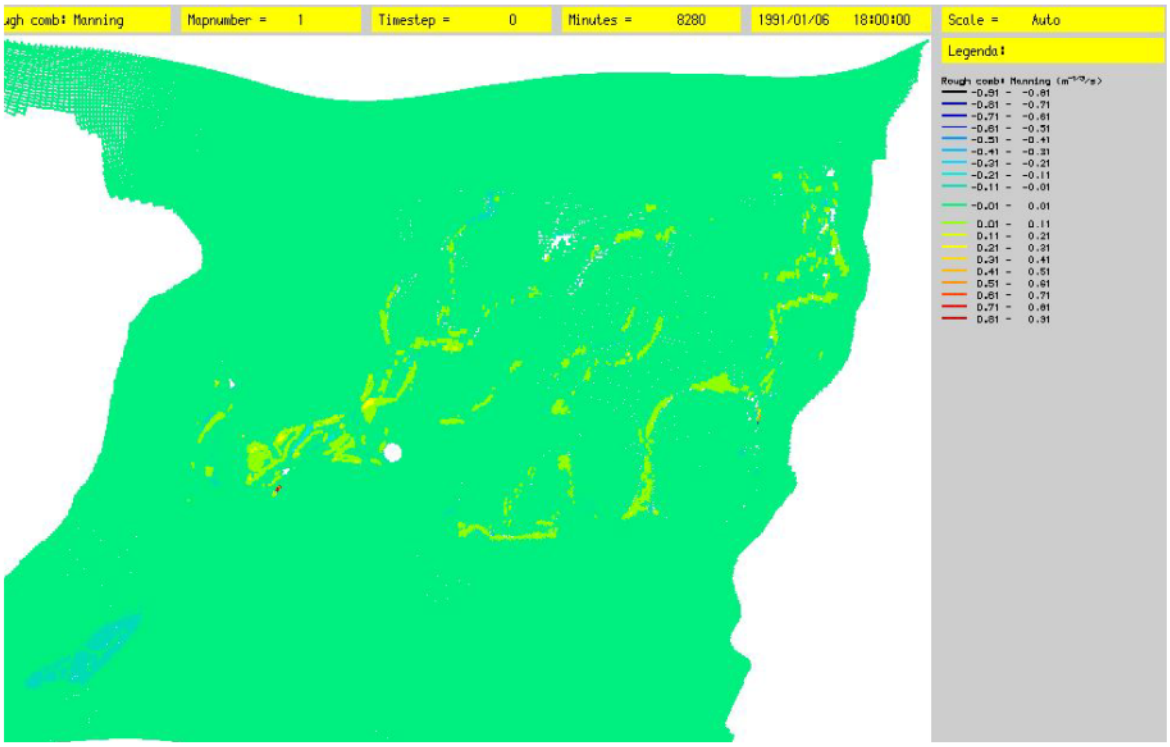

Figure 3.5 Difference in roughness between SNIP3 and variant

3.3 WAQUA model computations

In order to assess the effect of the measure a single computation was carried out with both the reference and the variant WAQUA model. The difference in the computed maximum waterlevels is the hydraulic effect. Deltares has reviewed the used boundary conditions, the input parameters and the reproducibility of the results.

3.3.1 Boundary Conditions

The used boundary conditions are as follows:

- Discharge (Waal) of 10200 m^3/s
- Discharge (Bergsche Maas) of 3500 m^3/s
- Maximum waterlevel of 2.40m +NAP on Hollands Diep
- Maximum waterlevel of 2.70m +NAP on Beneden Merwede

The applied boundary conditions are expected to have been obtained from a SOBEK-RE model and are different for the reference and the variant model.

The roughness definition (roughcombination) file used in the reference schematisation is less extensive than the roughcombination file used for the variant schematisation. The added roughness values are for roughness coverages that are within the Noordwaard area.

Deltares previously commented on the initial conditions used. A waterlevel of 3 meter is higher than the maximum waterlevel in some areas of the model. The influence of the initial conditions on the hydraulic effect is expected to be low.

The simulation time is 2 days with output data extracted starting from time step 1. This means that the maximum water level on the Maas is already reached at the start. The maximum waterlevel should therefore be obtained after the first day.

3.3.2 Results of hydraulic computations

Deltares performed with the same model a calculation to assess the reproducibility of the WAQUA model. The results are shown in Table 3.1. The results of Deltares and the hydraulic advisor are comparable. The hydraulic effect will decrease if the maximum 13 or 25 is used. It will remain above 30 centimeters though.

Most of the water will flow via the laagbekade polders in the Noordwaard (Figure 3.6). There is no waterflow between the Spiering and the small Noordwaard. These areas do act as a water storage area.

Table 3.1 Maximum waterlevel on the Waal riverkilometer 955 and Amer river kilometer 252

Model	Max WL_955	Max13 WL_955	Max25 WL_955	MAX AM_252
Reference	5.7403	5.7383	5.7347	2.9282
Hydraulic advisor	5.4380	5.4368	5.4347	3.0811
Deltares	5.4378	5.4366	5.4343	3.0816
Effect hydraulic advisor	-0.3023	-0.3015	-0.3000	0.1529
Effect Deltares	-0.3025	-0.3017	-0.3004	0.1534

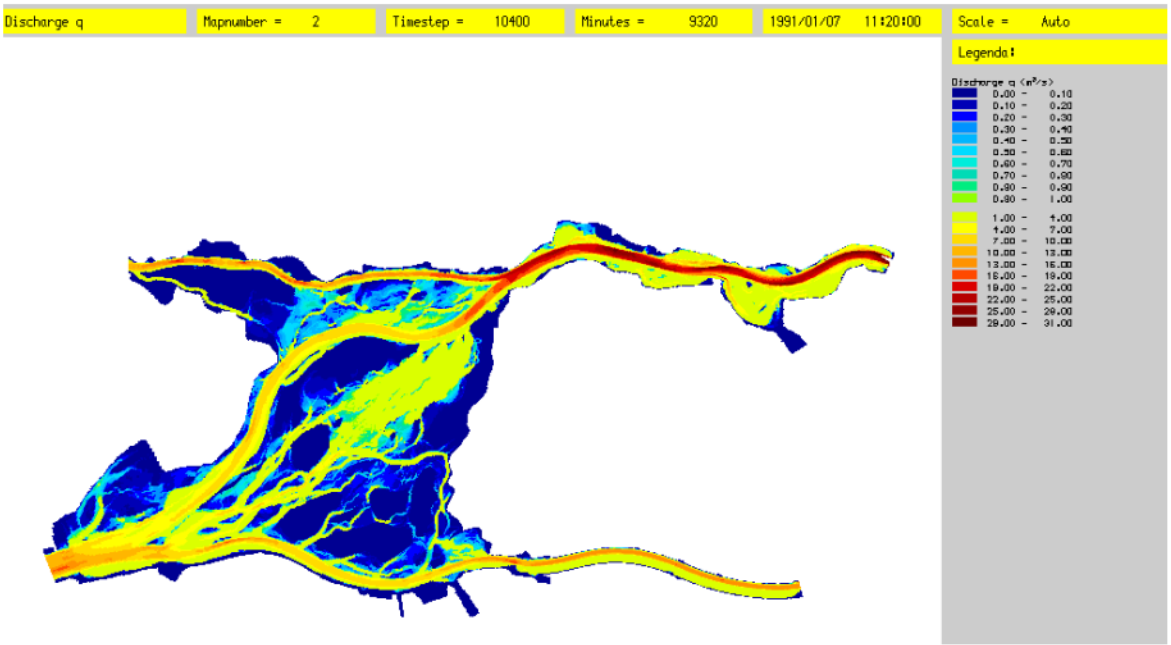

Figure 3.6 Discharge of the variant

3.4 Eindontwerp Sobek model of Noordwaard

In RHDHV (2015), the hydraulic advisor has adjusted the SNIP3 SOBEK model of Noordwaard so that the hydraulic effect computed with the SOBEK-RE model resembles the hydraulic effect computed with the Definitive Ontwerp WAQUA model for the same single

boundary condition combination. The method used by the hydraulic advisor has been previously reviewed by Deltares in van der Wijk et. al. (2015). Appendix C makes a summary of the review findings extracted from the previously mentioned report.

PDR had asked Deltares on 18 April 2016 on whether or not a new “afregeling” of the SOBEK model would be necessary in case the new WAQUA computations show similar hydraulic effect as previously and considering that no change of methodology will take place. Deltares on her reaction of 20 April 2016, confirms that shall the “afregeling” procedure remain the same, then it is of no use to carry out an extra “afregeling when the new WAQUA computations do not differ.

Table below makes a summary of the computed hydraulic effect in WAQUA and SOBEK single computation in the previous phase of the project (RHDHV, 2015) and now. Considering the small difference in the WAQUA computed hydraulic effect compared to the Definitive Ontwerp, one can assume that the “afregeling” carried out with Definitive Ontwerp does not need to be redone, considering that a change in the “afregeling” procedure is at this phase of the project not allowed. The uncertainties related to the used method are larger than the small difference of 0.6 mm in the WAQUA computed hydraulic effects.

Table 3.2 Hydraulic effect (cm) computed with WAQUA and SOBEK model

	Single computation		MHW processor
	WAQUA	Sobek	SOBEK
Definitieve Ontwerp (November, 2015)	30.29	30.29	30.1
Eindontwerp (June 2016)	30.23		

3.5 Fulfilment of Taakstelling

The hydraulic effect at rkm 955 in the Waal computed with SOBEK-RE model applying the modelling method approved by PDR for this project is 30.1 cm. Considering the obtained hydraulic effect is just 1 mm higher that the taakstelling it cannot be said with certainty on whether after correction of the Baseline schematisation, the measure will still fulfil the taakstelling.

Considering PDR has agreed upon the method to be used by the hydraulic advisor in schematisation of the project features and the fact that the Noordwaard area around the project features cannot be updated due to the constraints within RvdR project, Deltares would advise that in the future a new schematisation is created based on the field measurements not only of the project features but of the complete Noordwaard area.

The Noordwaard measure leads to a waterlevel increase of 15.3 centimeters on the Amer. This requires extra detailed analysis with a more actual model as well.

4 Conclusions and recommendations

4.1 Baseline Review Conclusions

The present review is made for the recent Baseline schematisation and WAQUA model of the project Noordwaard delivered by PDR on 17 May 2016. The Baseline measure incorporates:

- "Interventieniveau" for the floodplain vegetation,
- "interventieniveau" for the sedimentation in the creeks (assumed 30 to 50 cm),
- A settlement of 10 cm for the new dikes or otherwise computed within another study for the weir sections along the high dikes.

Thus, the current schematisation is not representing the schematisation of the project as it is built. The model schematisation is therefore described as "Eindontwerp".

4.1.1 General review conclusions

- The AutoCAD "As-built totaal v3.0.dwg'" has been delivered by the hydraulic advisor as representing the As Built measurements made in the field. However, Deltares has observed that the integral AutoCAD file ("As-built totaal v3.0.dwg'") does not always correspond to the separately delivered AutoCAD files. This raises the question on whether the created schematisation is based on the correct As Built measurements.
- The elevation line surrounding the creeks which has obtained the elevation information out of the reference situation schematisation (used in SNIP3 phase) differs significantly from the measurements.
- Detailed elements like trees and bridge pillars are not included in the schematisation. These roughness elements should be taken into account in other schematizations in the future.
- Some 33 bridges and 31 pumping stations and different hydraulic structures have been created due to the project (Ruimte voor de Rivier, 2015). These structures are not present in the created schematisation.

4.1.2 Review conclusions dikes

- There are three measurements lines present on the kades changed by the project. Often the middle line has a higher elevation then the surrounding crest side lines, sometimes one of the side lines has a higher elevation then the two other lines. Considering these measurements data, the hydraulic advisor has decided to make an interpolation between the elevation lines.
- While for the new kades the maximum allowed settlement of 10 cm is applied in the schematisation, it is not clear on why the expected settlement has not been computed.

- The settlement for the „overlaat" features placed on some of the high dikes is computed within another study. Due to missing information, Deltares cannot draw any conclusion on the accuracy of the reported settlement values.

- The new dikes are schematised via kade feature in Baseline, which means that they are anticipated as weir structures and not incorporated in the bed elevation.

- The position of some of the kades is slightly different then in the SNIP3 Baseline schematisation. This relocation is very minor.

- During the review it was concluded that the kade line is not always defined in the middle of the dike crest width as described in RHDHV (2016). The Baseline kade line sometimes even crosses the measured kade crest lines.

- The kade line is not always having the measured crest elevation irrelevant of the applied settlement. The differences between the measured and schematized crest elevation for the new kades is above 12 cm. Anticipating the settlement of 10 cm, one concludes that the differences in elevation are generally more than 5 cm. These deviations are partially caused by the fact that the kade position is not according to the measurements, sometimes the field measurements consist of strong deviations on the measured elevations within a short distance, and could be slightly influenced by the comparison method used in this analysis which is not necessary the same to the schematisation method used by the hydraulic adviser.

- The kade crest elevation is different to the Definitive Design schematisation of September 2015.

- The hydraulic effect of these deviations on the kade schematisation cannot be assessed.

4.1.3 Review conclusions creeks

The hydraulic advisor does not make full use of the As Built measurements for schematising the creeks. Instead the bed elevation of the creeks is schematised based on what Hydraulic Advisor describes as "Intervention level of the uitvoeringsontwerp". This was described as 30 to 50 cm higher bed elevation than the "uitvoeringsontwerp".

During the review it was observed that:

- the creeks are not a good representation of the As Built measurements. The schematisation incorporates a bed elevation of the creeks which is up to more than 1 m shallower to the As Built measurements.

- the connection between the existing and new creeks is not fluent. In some locations obstacles are present in the creeks as well. These obstacles (erroneous model schematisation) need to be removed in future schematisations.

- It is not possible to quantitatively asses the influence of this discrepancy on the computed hydraulic effects.

4.1.4 Review conclusions mounds ("Terpen")

The terpen are schematized as hoogwatervrij terrain, following the same method used during the SNIP3 phase. Some minor adaptation is required for Terp number 52.

4.1.5 Review Conclusions Roughness

The interventiekaart is nearly the same as during the SNIP3 phase with few changes. The main vegetation at Hillpolders is changed from Zachthoutooibos (code=1804) to Natuurlijk Grasland (code=1202). The South-western part of Noordwaard is schematised as productiegrasland. The review conclusions are as follows:

- The changes to the *ruwheidv* Baseline coverage extend beyond the measure area. It is not clear the reason for this deviation.
- The Eindontwerp vegetation schematisation does correspond to the delivered interventiekaart.

4.2 Conclusions regarding the hydraulic effect of the measure

The WAQUA model is correctly derived from the Baseline schematization. The maximum hydraulic effect computed at the river Waal rkm 955 with the WAQUA model for one single computation is 30.23 cm. The influence of the inconsistencies observed during the Baseline review cannot be quantified. However, their influence on the hydraulic is definitely minor compared to the influence of the procedure agreed for this project.

In 2015, the hydraulic advisor has adjusted the SNIP3 SOBEK model of Noordwaard so that the hydraulic effect computed with the SOBEK-RE model resembles the hydraulic effect computed with the Definitive Design WAQUA model for the same single boundary condition combination. The method used by the hydraulic advisor has been previously reviewed by Deltares (Appendix C).

PDR had asked Deltares on 18 April 2016 on whether or not a new "afregeling" of the SOBEK model would be necessary in case the new (more recent) WAQUA computations show similar hydraulic effect as previously and considering that no change of methodology is accepted at this phase of the project. Deltares on her reaction of 20 April 2016, confirms that shall the "afregeling" procedure remain the same, then it is of no use to carry out an extra "afregeling when the new WAQUA computation results do not differ significantly.

Considering the small difference in the WAQUA computed hydraulic effect compared to the Definitive Ontwerp, one can assume that the "afregeling" carried out with Definitive Ontwerp does not need to be redone. The uncertainties related to the used method are larger than the small difference of 0.6 mm in the WAQUA computed hydraulic effects.

The hydraulic effect of the measure computed with the MHW processor is 30.1 cm. To conclude the hydraulic effect of the measure computed making use of the methods and the instrumentarium defined by PDR for this project fulfils the taakstelling of 30 cm.

The Noordwaard measure leads to a water level increase of 15.3 centimeters on the Amer. This requires extra detailed analysis with more actual models to check on whether this pattern will still remain.

4.3 Recommendations

Deltares provides the following recommendations which should be considered in the future for proper schematisation of the Noordwaard area:

- The Noordwaard reference situation schematisation as created in the year 2009 during the SNIP3 phase is used for the schematisation of features which have not been changed by the contractor. Outside the project features, a lot of differences between As Built measurement data and the Eindontwerp variant schematisation can be seen. This means that the reference situation information is outdated and needs to be adjusted in future projects, considering within RvdR project the reference situation is not actualised. Given that the Noordwaard area is not present in the reference model, any incorrect model schematisation of the floodplain would solely contribute to the hydraulic effect of the measure.
- It is strongly recommended to not use the current Baseline schematisation or SOBEK model for other non-RvdR project. The Noordwaard polder needs to be updated with the most recent field measurements even outside the RvdR project features. SOBEK model should be built based on the new modelling techniques and softwares.
- We strongly advise to include the culverts in the future schematizations, as well as the pillars of the bridges, of the power lines and the pumping stations.
- It is recommended to include the creeks in the “plassen” Baseline coverage
- Deltares recommends revising the way the kades are schematized, especially the assumption regarding the settlement in 25 years period. The maximum allowed 10 cm settlement of the kades is anticipated in the schematisation, no analysis have been made regarding the expected settlement. The settlement analysis made for the weirs on the high kades could not be reviewed by Deltares due to lack of information.
- The creek schematisation needs to be improved.
- It is recommended the inclusion of elements like culverts, bridge pillars and solitary trees in the Baseline schematization for future projects.
- It is recommended to assess the effect of the Zuiderklip measure together with Noordwaard based on the latest data. This would lead to a better understanding of the resulted increase of water level on the Amer and Bergsche Maas.

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A List of received files

There is a large amount of data received in an organized way. There are 5 main folders, summarized in Table A.1.

Table A.1 Received data, main folders

Folder name	Content
Baseline	Baseline measures, reference and variant
Data	Measured data
Rapport	Report
Referenties	Reference documents used for the report
WAQUA	WAUQA model of the variant, abnw_a6

A.1 Baseline data

Appendix A contains the details about the received baseline data.

Table A.2 Received Baseline data

Type	Name	Description
Maatregel	ip_scenario2	SNIP3 measure
	nm_ASBnw_a6	Eindontwerp measure
	nm_ASBnw_c1	Correction measure
	NOP_dicht	No opening at NOP region
Variant	dm_2004_abnw_a6	Eindontwerp variant created by mixing in the SNIP3 variant the Baseline measure “nm_ASBnw_c1” and “nm_ASBnw_a6”
	dm_2004_ip_s2_znop	SNIP3 variant created by

		mixing in the reference "dm_2004_ref" the measures "ip_scenario2" and "NOP_dicht"
	dm_2004_ref	Reference

A.2 As Built Data

The Data folder contains several data related to the As Built measurements. The content of the data folder is summarized below.

Table A.3 Received measurement data

Folder	File Name	Description
Brongegevens As Built integral	As-built totaal v3.0.dwg	The overal AutoCAD file with all the data
Kades	0-00003 Nieuwe Primaire kering 0-00008 Overlaat Nieuwe Merwede 0-00010 Hoge kaden 0-00011 Kade rond Trafostation 0-00012 Lage kaden	AutoCAD files and pdf-s about the different kades
Kreken	As-built ContractTekening	AutoCAD files and pdf-s about the different kreken
opstal amoveren	D3b As-built CNW-TEK-G-5122 v1.0.dwg Cnw-tek-g-5122.dwg	AutoCAD file with the abolished buildings
Recreatieport		AutoCAD drawing about the recreation port, it is execution drawing

	dwm_RECREATIEPOORT.dwg	
terpen		AutoCAD files and pdf-s about the different terpen
vegetatie	20160303_ZHTX-0-09-10918_interventiekaart_ruwcodes.pdf 20160303_ZHTX-0-09-10918_interventiekaart_V10.pdf	pdf-s with the vegataion at intervention level
	1.0 nulmeting DTM polders.dwg	AutoCAD file with the zero measurement
GIS data	BD6460-D01-oplevering.mxd BD6460-D01-oplevering_GIS10_1.mxd oplevering.gdb	GIS file and some created shapefiles during the schematization
Kaarten	BD6460-D01-N001-As-built-lijnen-kades-en-terpen-(V02-00) BD6460-D01-N002-As-built-lijnen-kreken-en-maaiveld-veranderingen-(V02-00) BD6460-D01-N003-Locaties-Terpen-(V02-00) BD6460-D01-N007-Bron-as-built-lijnen-kreken-en-maaiveld-veranderingen-(V02-00)	4 pdf file, created from measured data
Luchtfoto	Noordwaard 2015 sept -Ortho-LowRes.jpg	one photo from the air

B Agreement between Hydraulic Advisor and PDR

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

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minuut

As-built Noordwaard

GETYPT DOOR / PARAAF [redacted]

VERVOLG OP

Datum
14 december 2015

VERGELEKEN DOOR / PARAAF

RAPPELDATUM

VERZONDEN DOOR / PARAAF

VERZENDDATUM
14 december 2015

[redacted]

VERZENDWIJZE
Per mail

MEDEWERKING VAN / PARAAF [redacted]

NA VERZENDING RETOUR AAN

AFSCHRIFT AAN [redacted]

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Ons kenmerk
RR01.088302

Datum 14 december 2015
Onderwerp As-Built Noordwaard

Geachte hee[redacted],

Begin december 2015 heeft het projectteam Ontpoldering Noordwaard de resterende as-built dossiers van het gerealiseerde werk ontvangen van de opdrachtnemer Combinatie Noordwaard. De as-built dossiers zijn door ons gecontroleerd en akkoord bevonden. Specifieke aandacht is daarbij besteed aan de hoogteligging van de overlaatsecties i.v.m. het effect op de hydraulische taakstelling in relatie tot de restzetting. Ook de hoogteligging van de kreken zijn specifiek gecontroleerd.

De werkzaamheden zijn dus conform het contract incl. de VTW's uitgevoerd. Onze voorlopige hydraulische berekening bevestigt dat voldaan wordt aan de doelstelling hoogwaterveiligheid: 30 cm waterstandsverlaging bij Gorinchem (km 955) zoals beschreven in het scopeformulier SNIP 5 (scopeformulier partieel SNIP5 Ontpoldering Noordwaard-RVR NW-091593).

Over de definitieve hydraulische toets hebben we op 4 december jl. naar aanleiding van het commentaar van Deltares afspraken gemaakt. Voor de volledigheid heb ik deze ongewijzigd opgenomen in de bijlage.

Voor meer informatie over de afronding van het project zie de op 30 november 2015 vastgestelde voltooiingsrapportage.

[redacted]

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Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

Bespreking commentaar Deltares op hydraulische berekening Deltares
[redacted], [redacted], [redacted], [redacted] en [redacted]
4 december 2015

1. Kades
   a. Randen van het systeem (bv. Steurgatdijk en industrieterrein) niet aangepast tov SNIP3 want geen werkzaamheden (m.u.v. 1 VTW die is wel verwerkt). Dit geldt ook voor 1 bestaande (dus niet aangepaste) kade binnen het modelgebied, nl. Boomgatweg (modelcode toevoegen).
   b. *Ligging* van de alle nieuwe kades cf UO; projectteam toont in december 2015 aan dat dit gelijk is aan as-built. Zo nodig past projectteam som daar op aan. Dus ligging nieuwe kades = as-built.
   c. *Hoogte* van alle nieuwe kades
      i. Overlaatsecties (effect op waterstandsdaling) – speciale toets en analyse restzetting (zie document van Waldo: actuele meting 2015 + statistische extrapolatie vanuit eerdere metingen); huidige som is aangepast met de eindhoogte uit deze analyse van Waldo.
      ii. Overstroombare kades (effect op waterstandsdaling; betreft de 3 noordelijke hoog bekade polders) – geen speciale toets; in de aangepaste som UO (=as-built) minus gemiddelde extrapolatiezetting zoals bepaald bij de analyse van de overlaatsecties (punt i.); dit gemiddelde is 10 cm.
      iii. Niet-overstroombare kades (geen effect op waterstandsdaling; betreft de 4 zuidelijke hoog bekade polders) – contracthoogte opgenomen, allemaal boven MHW. Contracthoogte is lager dan as-built, omdat er nog restzetting kan optreden.
   → Codes in model noemen bij deze onderverdeling

   In de aangepaste som is nav het commentaar een fout hersteld, nl. de overlaatsectie code **** Buitenste Kievitswaard noord-west.
2. Vegetatie
   a. er is aan Deltares de verkeerde kaart opgestuurd; correcte kaart die overeenstemt met de som wordt opgestuurd
   b. voor alle bostypen wordt ruigte van zacht-hout ooibos gebruikt
   c. bestaande bomen in hoog bekade polder Vogelenzang zijn in SNIP3 niet geschematiseerd; huidige som is op dit punt gelijk aan SNIP3
3. terpen (zowel bestaande als nieuwe terpen)
   a. Schematisatie conform SNIP3: teenlijn is kruinlijn
   b. *ligging* van de terpen is conform UO (=as-built, nog aan te tonen door projectteam december 2015).
   c. *Hoogte* van de terpen niet-overstroombaar, boven MHW; in model: met schotjes dichtgezet (***check Eisse). Hoogwatervrijheid is gecheckt door projectteam op basis van as-built.
4. Hoogwatervluchtplaatsen
   a. Opgenomen in het huidig model met hoogte cf. contract; wordt aangepast naar as-built; geen restzetting want bestaande terpen van gesloopte woningen. @Eisse, check terp Galeiweg (sanering)
   b. Ligging cf UO (=as-built)
5. Kreken
   a. Hoogte in huidige som is interventie (bijna overal contract + 50 cm aanslibbing muv kreken die minder diep zijn dan 50 cm en bij 'zwevende' kreken in het model door lokale maaiveldafwijkingen). In monitoring wordt interventiehoogte (contracthoogte + 50 cm). As-built is hier niet relevant (maar in de praktijk altijd lager dan contracthoogte + 50 cm)
   b. bodembreedte en bodemlocatie conform contract in huidige som (aan te passen naar as-built; dit is nog een forse schematisatieslag, Koen helpt Eisse aan de hand van verschilkaart);
   c. talud conform contract in huidige som (aan te passen naar as-built);

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- Programmabureau Ruimte voor de Rivier
Project Ontpoldering Noordwaard

Datum
14 december 2015

insnijding met maaiveld bepaald door model (als bakje in model hoger is dan maaiveld ontstaat een oeverwal = conservatief; als bakje in model lager is dan maaiveld is kreek smaller = conservatief): bij aangepaste schematisatie meest pragmatische methode kiezen (overleg [redacted]

d. Geldt alleen voor nieuw aangelegde kreken; aansluitingen op bestaand water (bv. NOP-gebied) cf. eerdere afspraken [redacted] (geen aanpassingen buiten projectgebied).

6. model loopjes (iteratieslagen)
   a. Dit betreft de aansluiting van Waqua op de Sobek-schematisatie van het benedenrivierengebied. Effect van Noordwaard zou je eigenlijk mee willen nemen in Sobek-schematisatie, om daarmee nieuwe randvoorwaarden voor Waqua te bepalen, net zolang tot er geen verschil meer is. Dit is bij SNIP3 niet gedaan (niet getoetst op dit onderdeel). Stelling van [redacted]richting Deltares: kan nuttig zijn (bv. pakketsom), maar gaat nu om akkoord op vergelijkbaarheid met SNIP3. Opnemen in vraag aan Deltares als aangepast model wordt opgestuurd.
   b. Waqua som wordt voorgelegd aan Deltares, bij groen licht van Deltares draait het project nog een MHW-processor (zonder iteratieve loop in Sobek, zie vorige punt).

Nieuwe som maken door projectteam in januari 2016. Wat doen we:

- Zie aanpassingen hierboven (meeste werk in de kreken)
- Per stukje kade, per terp, per hoogwatervluchtplaats en per stukje kreek motiveren welke hoogte en ligging is gebruikt en wat bron is – tabel maken. Kaart met coderingen toevoegen.
- As-built tekeningen meesturen; evt. effecten van as-built verwerken
- Correcte vegetatiekaart meesturen
- Geen aanpassing in maaiveld, want is gelijk aan SNIP3 en niet aangepast

Na akkoord van RVR (te bepalen in werksessie [redacted]; geen discussie tussen RVR en projectteam) doorsturen naar Deltares.

In december 2015 brief van [redacted] waarin aangetoond wordt dat alle as-built tekeningen zijn ontvangen, as-built is gecontroleerd = conform contract. Daarmee taakstelling behaald, nog te verwerken in som.

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C Review of the Noordwaard SOBEK-RE model (van der Wijk et al., 2015)

Voor de RvdR maatregelen in het benedenrivierengebied houdt PDR aan de volgende procedure vast. Het waterstandsverlagende effect op de locatie van de taakstelling van de maatregel in SOBEK wordt afgeregeld op het effect in WAQUA. Dit is gedaan voor één combinatie van randvoorwaarden (afvoer en windopzet), welke is gekozen op basis van een analyse van de zogenaamde *illustratiepunten* van Hydra-B. Vervolgens is het effect van de maatregelvariant op de MHW ter plaatse van de locatie van de taakstelling (km 955 voor Noordwaard) berekend met behulp van de MHW-processor. Hierbij wordt het MHW-effect van de maatregel op de locatie van de taakstelling berekend ten opzichte van de resultaten van een referentiemodel. Meer details over de methode zijn te vinden in onder andere Van der Linden (2006).

In dit hoofdstuk wordt gecontroleerd of de afregeling van het effect van de maatregel in SOBEK op het effect in WAQUA op logische wijze heeft plaatsgevonden. Vervolgens wordt een controle van de modelberekeningen uitgevoerd.

C.1 Data

De volgende gegevens zijn door de hydraulisch adviseur toegeleverd (Tabel 5.1) voor het SOBEK model.

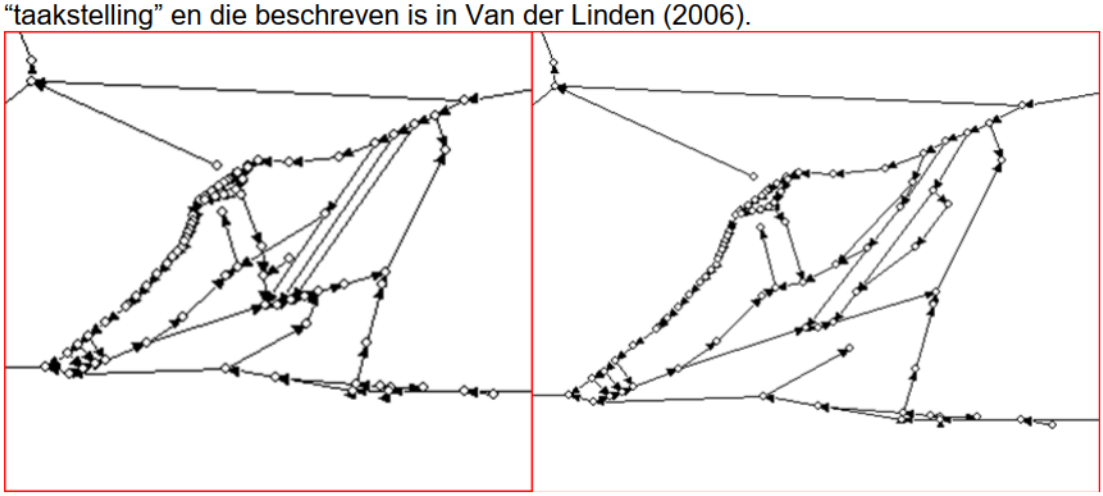
Tabel 5.1 De SOBEK data die door de hydraulisch adviseur geleverd zijn voor deze toetsing

Folder	Caselist.cmt
NW15.sbk	6 "Enkelvoudige Sobek berekening 'Referentiemodel 2004 WL versie 3' - 16000m³/s" 1 "Enkelvoudige Sobek berekening 'Ontpoldering Noordwaard' - 16.000m³/s - Waqua" 4 "'Ontpoldering Noordwaard' tbv MHW-berekeningen" 16 "Enkelvoudige Sobek berekening ' Ontpoldering Noordwaard' 269m" 7 "'Ontpoldering Noordwaard' tbv MHW proc 269m"
MHWSSB	*1 'Nieuwe case'* 2 'Verificatie MHW-berekeningen Noordwaard' 3 'Verificatie MHW berekeningen Referentie' 4 'Ontpoldering Noordwaard - aanpassing SNIP3' 6 'Verificatie SNIP3 Noordwaard 2015' 7 'Ontpoldering Noordwaard - hydraulische toets 2015' 10 'Eindtoets 2015' 8 'Verificatie Referentie 2015'

C.2 Maatregel schematisatie

De SOBEK schematisatie van het Definitief Ontwerp is gelijk aan de SOBEK SNIP3 maatregelschematisatie met uitzondering van de breedte van het inlaatkunstwerk (dat is namelijk opnieuw afgeregeld, op WAQUA-Definitief Ontwerp). Deltares heeft de SNIP3 schematisatie niet eerder getoetst.

De SNIP3 Noordwaard SOBEK schematisatie wijkt iets af van de schematisatie die gebruikt is voor het berekenen van het effect van de oorspronkelijke maatregel die leidde tot de “taakstelling” en die beschreven is in Van der Linden (2006).



Figuur 5.1 MW18_1 schematisatie (links) en schematisatie DO (rechts).

Deltares heeft de DO SOBEK schematisatie vergeleken met de DO WAQUA schematisatie. Uit deze vergelijking blijkt dat de oriëntatie van het takkenpatroon van de Sobek maatregelschematisatie overeenkomt met het stroombanenpatroon in WAQUA. Verder is de totale breedte van de takken in SOBEK vrijwel gelijk aan de overeenkomstige breedte in WAQUA (zie Tabel 5.2). Een beperking van het SOBEK model is dat de verschillende takken zijn geschematiseerd als een uniforme bak in plaats van een natuurlijk dwarsprofiel. Tenslotte wijkt de Chèzy ruwheid in SOBEK af van die in WAQUA (uniform 50 $m^{1/2}/s$ versus 14 tot 35 $m^{1/2}/s$ gedistribueerd).

Deltares concludeert dat de schematisatie van SOBEK een grove benadering is van de WAQUA schematisatie. De geometrie van de SOBEK schematisatie is niet rechtstreeks afgeleid van de geometrie van de DO WAQUA schematisatie, maar zelfs op basis van het SNIP2a WAQUA model.

Tabel 5.2 Overzicht geometrie van SOBEK takken (gecategoriseerd als links, midden en rechts) SNIP3 en WAQUA

Tak	WAQUA links	SOBEK links	WAQUA midden	SOBEK midden	WAQUA rechts	SOBEK rechts
Breedte tak [m]	1257	1273	983	983	807	980
Lengte tak [m]	6000	6260	5150	6750	6500	6470

C.3 Afregeling SOBEK op WAQUA

Deltares heeft geconstateerd dat de hydraulisch adviseur gebruik heeft gemaakt van de juiste referentie schematisatie ‘PKB koppenmodel’ (27 “11/08/04EV Referentiemodel WL versie 3”) met bijbehorende randvoorwaarden.

Voor zowel de referentie als de schematisatie inclusief Noordwaard is er al eerder geconcludeerd dat er lokaal verschillen kunnen optreden tussen de resultaten van WAQUA en die van SOBEK (Van der Linden, 2006). Een voorbeeld hiervan is te vinden in de afvoerverdeling op de Merwedekop in zowel het referentiemodel als het model met de maatregel (Tabel 5.3). Het verschil in afvoerverdeling wordt groter voor de SOBEK schematisatie incl. maatregel ten opzichte van het referentiemodel.

Tabel 5.3 Afvoerresultaten [m^3/s] voor SOBEK en WAQUA van het enkele MHW som

TAK	Gemiddeld DO WAQUA	Gemiddeld DO SOBEK	Gemiddeld verschil	Gemiddeld SOBEK Referentie	Gemiddeld WAQUA Referentie	Gemiddeld verschil
Nieuwe Merwede	6214	7035	-821	6407	5905	-502
Beneden Merwede	3974	3206	768	3717	4291	574
Debiet Noordwaard	670	693	-23			

De afregeling heeft plaatsgevonden door in de SOBEK maatregelschematisatie de breedtes van de eerste set van inlaatopeningen van drie kunstwerken (general structures) tussen de Nieuwe Merwede en de Noordwaard (structure id “NW11”) zodanig aan te passen dat de waterstandsverlaging ter plaatse van km 955 in SOBEK overeenkomt met WAQUA. Hierdoor stemmen de breedtes van de inlaatopeningen van de kunstwerken tussen WAQUA en SOBEK niet overeen.

Deltares concludeert dat de extra onzekerheid door de verschillen in de afvoerverdeling meegenomen moet worden in de analyse van de resultaten.

C.4 Bepaling MHW-effect op rkm 955

Deltares heeft de MHW berekeningen die de hydraulische adviseur heeft uitgevoerd kunnen reproduceren. Het MHW effect van het DO van maatregel Noordwaard bedraagt in SOBEK 30,1 cm.

C.5 Opmerkingen bij de toetsing

Bij de gevolgde procedure zijn in het verleden al kanttekeningen geplaatst, die nog steeds gelden. Eén eerder geconstateerd potentieel probleem is dat de afregeling tussen SOBEK en WAQUA geschiedt aan de hand van één combinatie van afvoer en stormopzet, terwijl de MHW-effectbepaling met 108 combinaties wordt uitgevoerd. Hierbij geldt deze specifieke combinatie alleen voor locatie Gorinchem, dat in het rivier gedomineerde deel van het systeem ligt. De inlaat van de maatregel ligt in de overgangszone tussen rivier- en zeedominatie, en de uitlaat van het systeem (aan de Amer) juist in het grotendeels zeegedomineerde gebied. Hiermee is de gekozen combinatie dus zeker niet representatief voor het hele gebied van de maatregel.

Daarnaast zitten er mogelijk inconsistenties in de gebruikte SOBEK en WAQUA referentiesituaties, zoals het ontbreken van de Sliedrechtse Biesbosch, die ervoor kunnen zorgen dat beide schematisaties niet onder alle (maatgevende) omstandigheden dezelfde waterstanden berekenen. Beide factoren kunnen het MHW effect van de maatregel in SOBEK beïnvloeden, en daarmee het al dan niet halen van de taakstelling.

Er zijn afwijkende resultaten in afvoerverdeling tussen die van het SOBEK model en die van het WAQUA-model. Een andere afvoerverdeling leidt tot andere waterstanden. Deltares concludeert dat de extra onzekerheid door de verschillen in afvoerverdeling meegenomen moeten worden in de analyse van de resultaten.