PM UPDATE OF BÄCKEN HYDRAULIC CALCULATIONS

1 Background

WSP investigated the current conditions of the stream at the plan area in Rosersberg under heavy storms. The previous investigations was issued in Aug 2018. This investigation required an update to incorporate different conditions that could affect the water levels, among them, removing some constrains in the stream downstream the railway, increased flows due to land use changes related with the urban development of the area, changes in the geometry (alignment and shape) of the current stream proposed by the landscape specialists.

2 Scope

The scope of this PM is to update the results of the report *Skyfallsmodellering och Hydraulisk Modellering av Bäck* (WSP, Aug 2018) regarding the high water levels in the stream due to some new conditions.

As in the report, the water levels and flooded areas are related with climate-adjusted rains with 100 years of return period.

3 Basis

The new calculations were based on the hydraulic model (HEC-RAS) of the stream. The methodology, description of the tool, storm events, hydraulic conditions and the general basis of these calculations are described in the cited report.

Some of the new conditions are based on definitions of the urban development made by other disciplines. Three relevant input were considered in these updated calculations:

- The development plan of the area (Autocad file L31_p_27 WSP.dwg)
- The description of the new cross sections at the project area (Rosersbergsbäcken - Princip för utformning av parkstråk)
- A new and higher runoff coefficient for the development area (input from VA discipline)

4 Detail of changes and scenarios

4.1 Reviewed hydraulic model

The HEC-RAS hydraulic model of the stream was reviewed to overcome some limitations found in the previous version. A short summary of changes are presented in the following list:

- The software was updated from HEC-RAS version 5.0.5 to version 5.0.6 due some bugs that affected the stability of the simulations
- The extensions of the cross sections was increased to cover some flood areas not covered before

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- Three minor culverts (stations 2509, 2730 and 3036) were removed from the model to improve the stability. These culverts are not related with public roads, they are intended to serve farm activities and all of them have smaller dimensions compared with the dimensions of public road culverts.
- The stretch downstream the railway culvert (station 515) is free of obstructions or beaver dams. The obstructions found in this stretch are an important limitation of the culvert capacity and it is assumed they will be removed and the ditch will be maintained.

4.2 Changes due to the proposal of the project

Following the current proposal of the project, a couple of changes were introduced in the hydraulic model. One change is related with landscape proposal for the ditch within the project area; a new alignment with wider cross sections was implemented in the model between the sections 2934 and 3331. In addition, at the upstream end of the model a different main stream was considered due to the proposal of development, which consider some building upstream station 3510.

The second change is related with the change of the land use and in the runoff coefficient (C) for two of the catchment areas. This change increases the flows contributing to the stream, new hydrographs were built with the same approach as in the previous stage. The Table 1 shows the new runoff coefficients.

Delavrinningsområde	Area (ha)	Original C	New C
4	31	0.21	0.46
9	24	0.16	0.46

Table 1: New runoff coefficients (C)

A third change in the model was a new bridge or crossing at the section 2837 as presented in the current proposal of the project. The crossing was implemented with a very wide spam to not become a constraint in the current stage of the investigations.

A fourth and last change was incorporated in the model to consider the developed areas. The developed areas were incorporated as blocks or permanent obstructions over the natural terrain. This change has the double purpose of withdrawing the volume used by the project and improve the presentation of results. All blocked areas have been set to an elevation of 20 m regardless the actual value in the project.

4.3 Flood mitigation measure 1: a wider ditch for larger storage upstream station 2200

The first flood mitigation measure tested in the model was a wider section of the ditch upstream the culvert at station 2198. The purpose of this measure is to increase the available storage volume upstream the culvert. The expected result should be lower water levels upstream the culvert and a lower peak flows downstream.

4.4 Flood mitigation measure 2: a larger culvert at station 2198

The second flood mitigation measure tested was a larger culvert under the public road at station 2198. The larger culvert was a rectangular box of 1.8 m height and width instead of the circular culvert of 1.4 m of diameter, which has a section area three times larger. The purpose of this measure is to increase the discharge capacity of the culvert. The expected result should be lower water levels upstream the culvert, but higher peak flows downstream.

4.5 Scenarios

Based on the changes described above, a new set of four (4) scenarios were simulated in HEC-RAS. The Table 2 presents different changes compared with the original scenario of a flood of 100 years or return period.

Scenario\Change	Reviewed hydraulic model	Proposal of development	Wider ditch US station 2198	Larger culvert at station 2198	HEC-RAS plan
Previous report					Unsteady100years
New base line	X				Unsteady100yearsB
Development	X	X			Unsteady100yearsA1
Mitigation measure 1	X	X	X		Unsteady100yearsA2
Mitigation measure 2	X	X		X	Unsteady100yearsA3

Table 2: Description of the changes in the new scenarios

In order to facilitate the orientation of the changes in the model a graphical explanation of the model on the longitudinal profile of the flood of 100 years of return period of the previous report is presented in Figure 1.

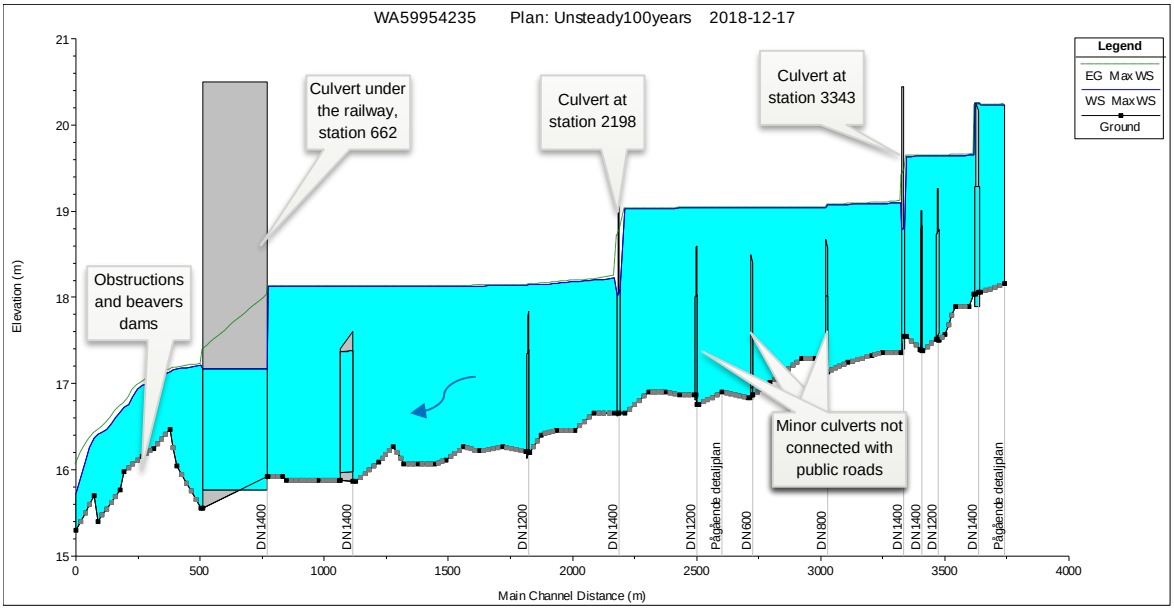

Figure 1: original results of flood of 100 years of return period

5 Summary of results

The Table 3 presents a summary of the variables of interest of the simulations.

	Max Water surface [m]			Q peak [m3/s]		
Scenario	Upstream the railway	Upstream culvert 2198	Upstream culvert 3343	Downstream the railway	Downstream culvert 2198	Downstream culvert 3343
Previous report	18.13	19.03	19.63	2.91	4.80	3.82
New base line	17.97	18.85	19.55	3.16	4.41	3.98
Development	17.99	18.92	19.69	3.18	4.55	4.27
Mitigation measure 1	17.93	18.82	19.58	3.11	4.30	4.74
Mitigation measure 2	18.07	18.70	19.58	3.29	6.04	4.75

Table 3: Summary of results

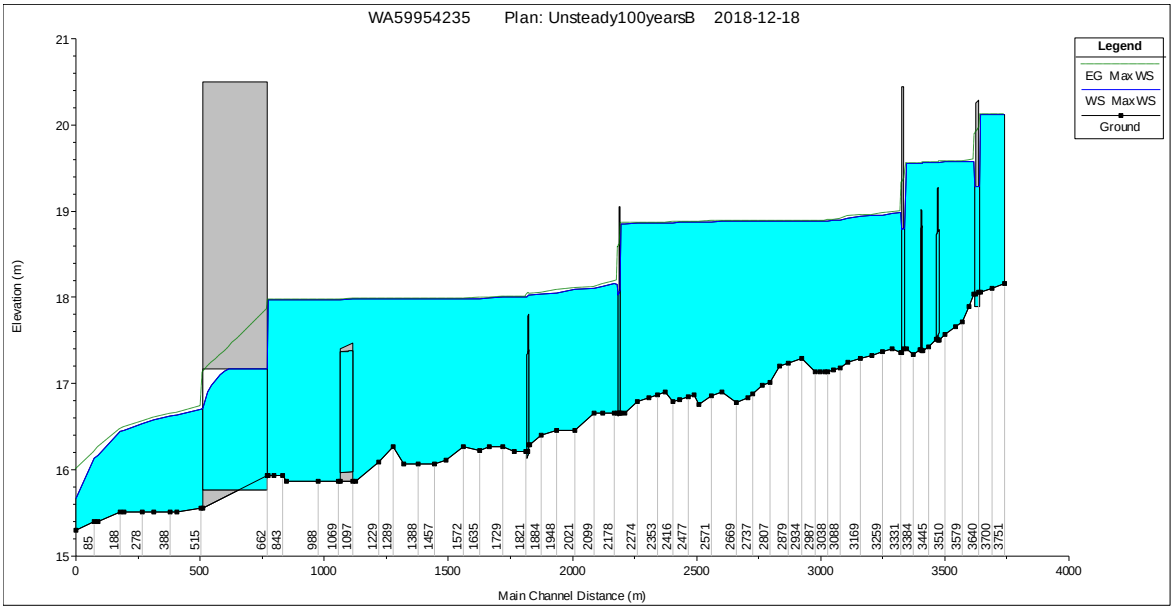

Figure 2: Profile of max water level for floods of 100 years of return period of scenario “New base line”

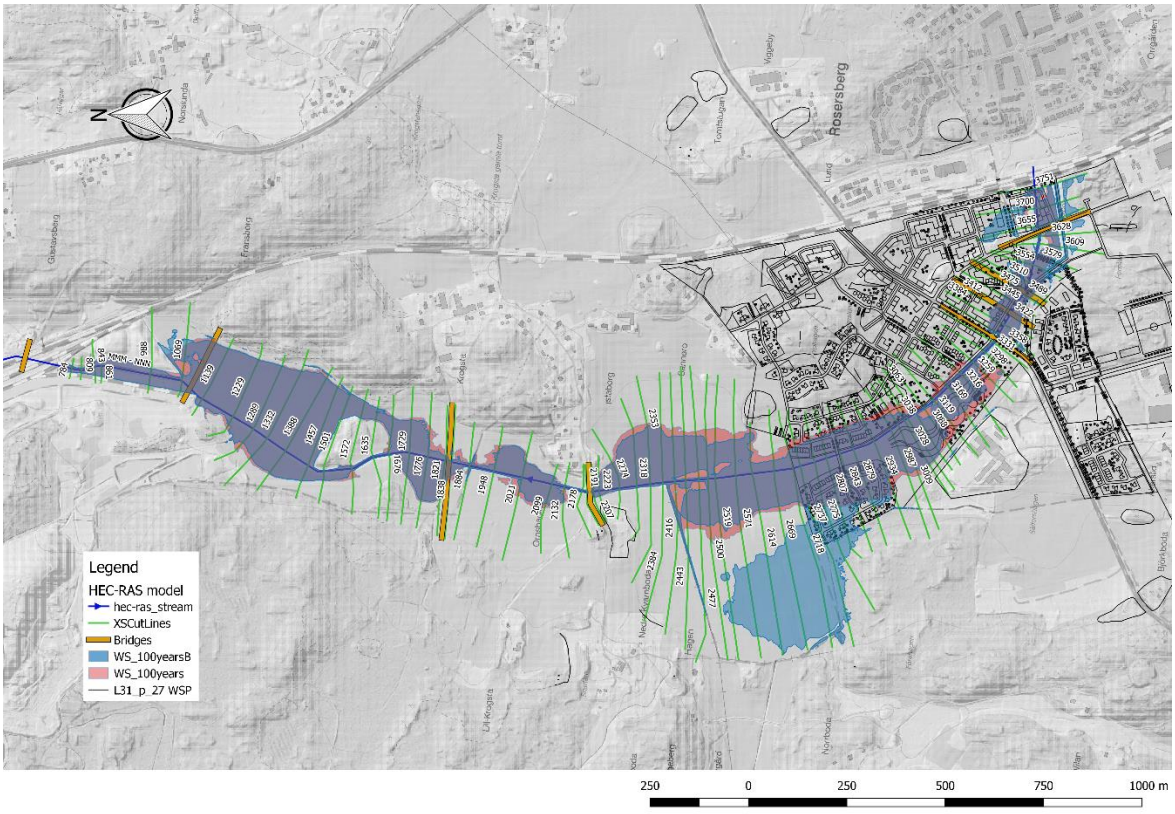

Figure 3: 100 years flood map (Scenario New base line). The red surface is the flood map of the previous report

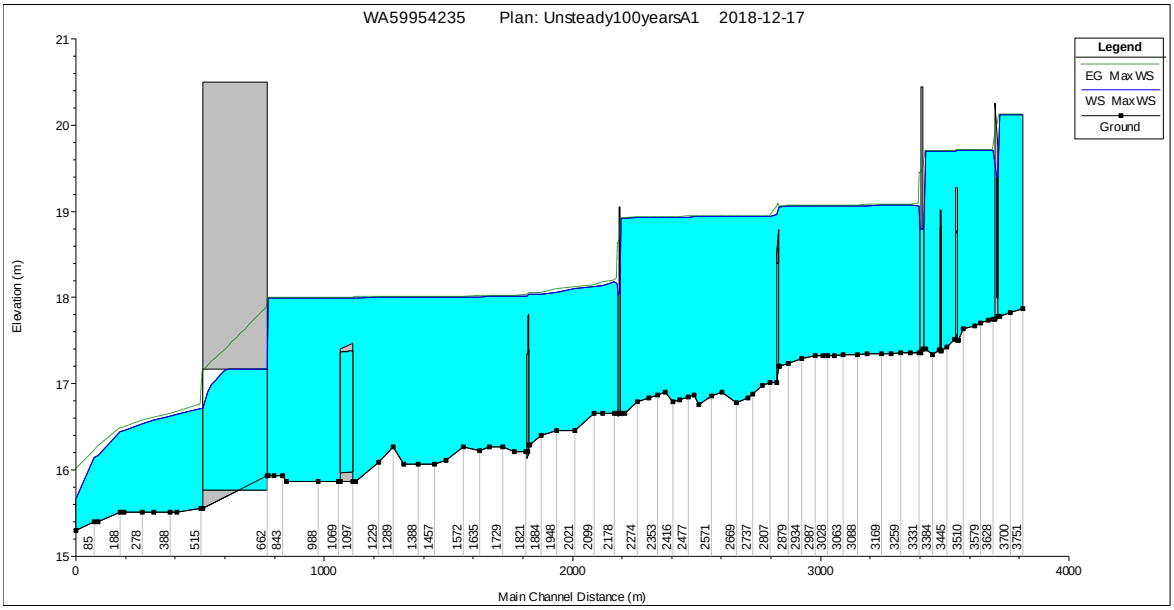

Figure 4: Profile of max water level for floods of 100 years of return period of scenario “Development”

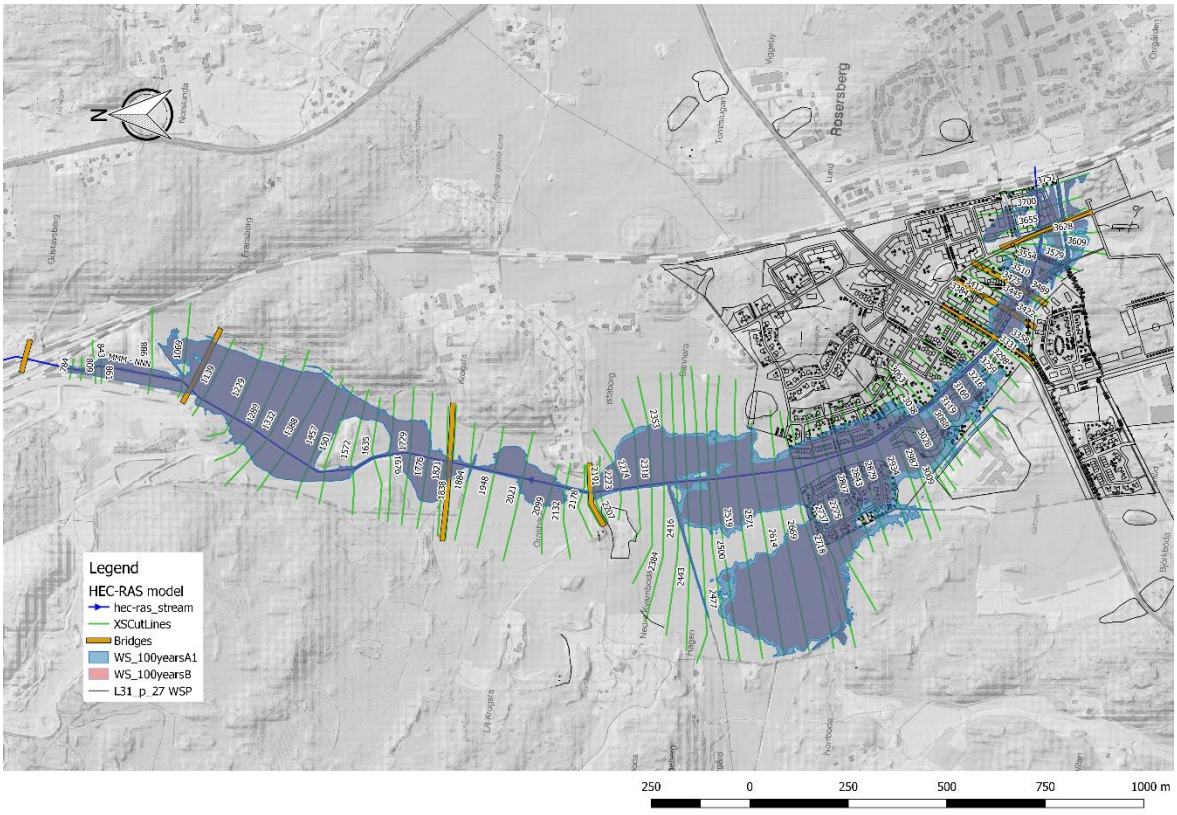

Figure 5: 100 years flood map (Scenario Development). The red surface is the flood map of New base line

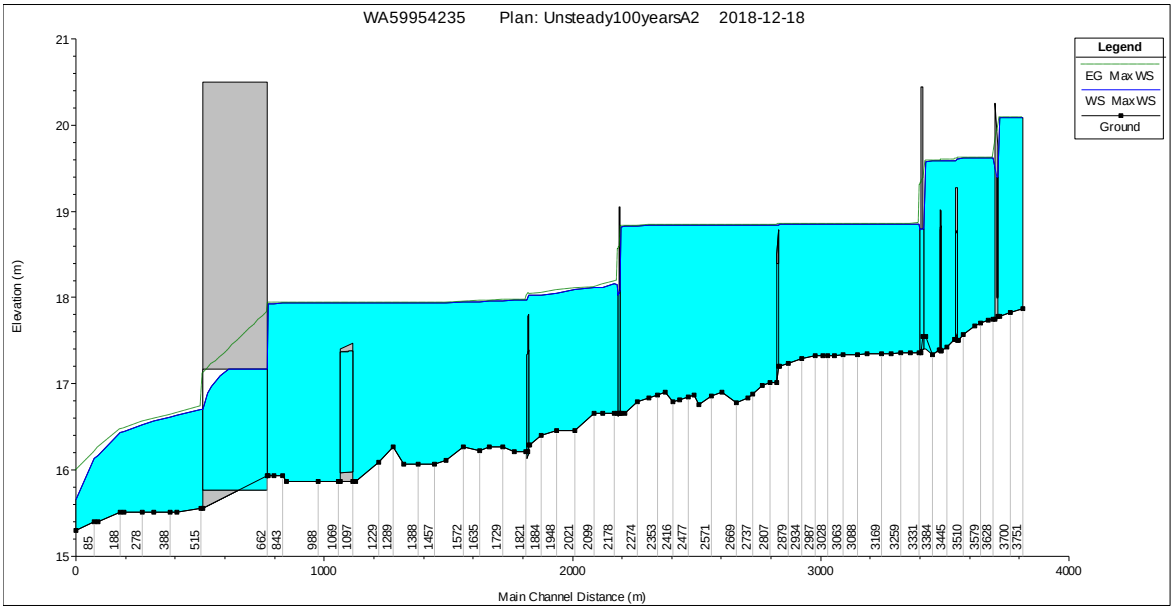

Figure 6: Profile of max water level for floods of 100 years of return period of scenario “Mitigation measure 1”

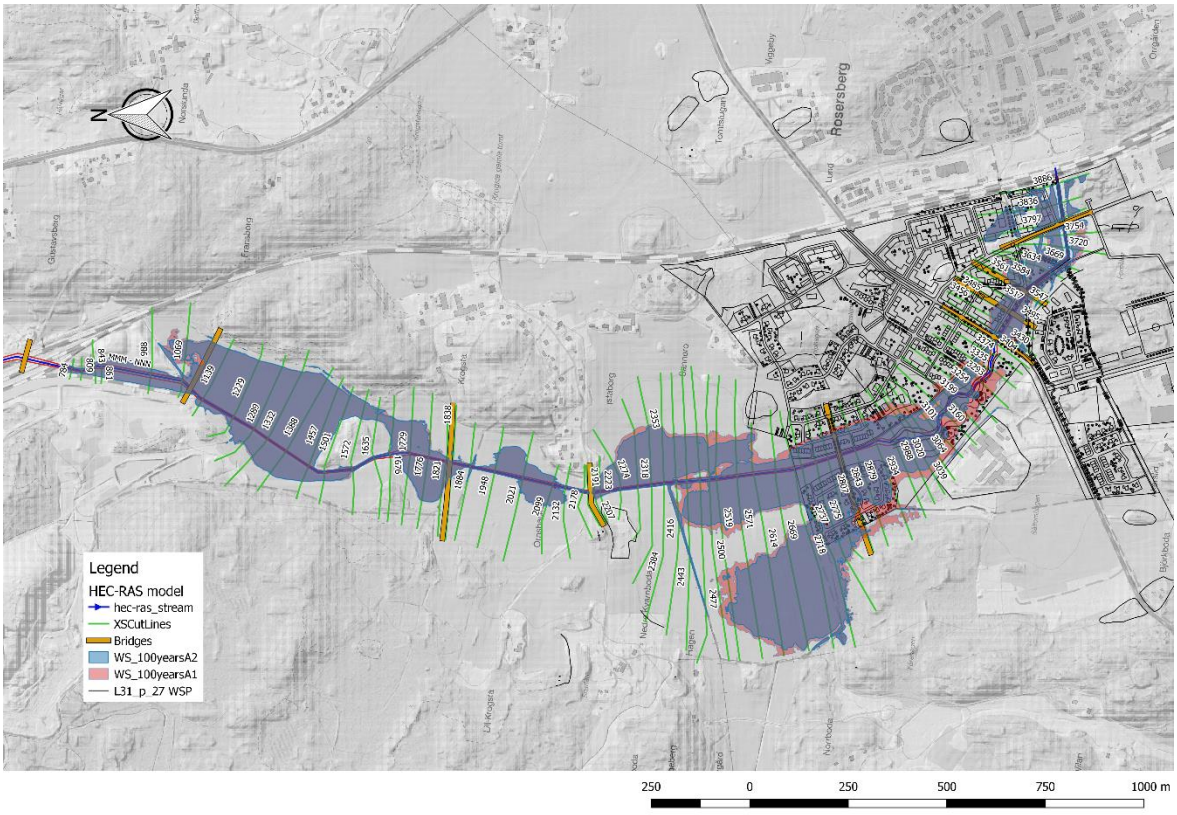

Figure 7: 100 years flood map (Scenario Mitigation measure 1). The red surface is the flood map of Development

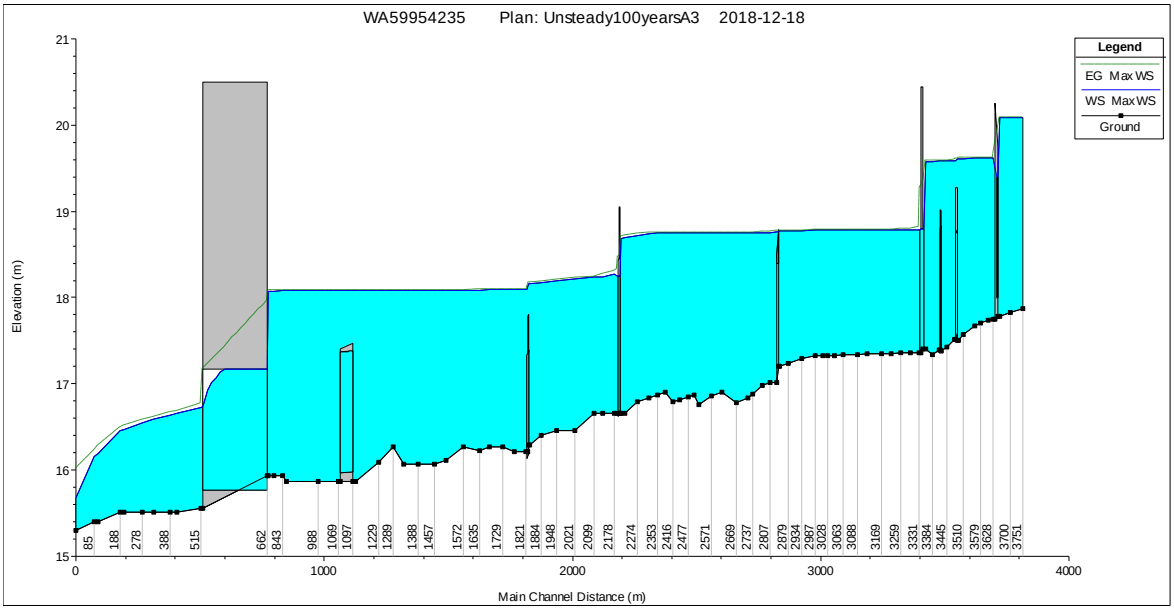

Figure 8: Profile of max water level for floods of 100 years of return period of scenario "Mitigation measure 2"

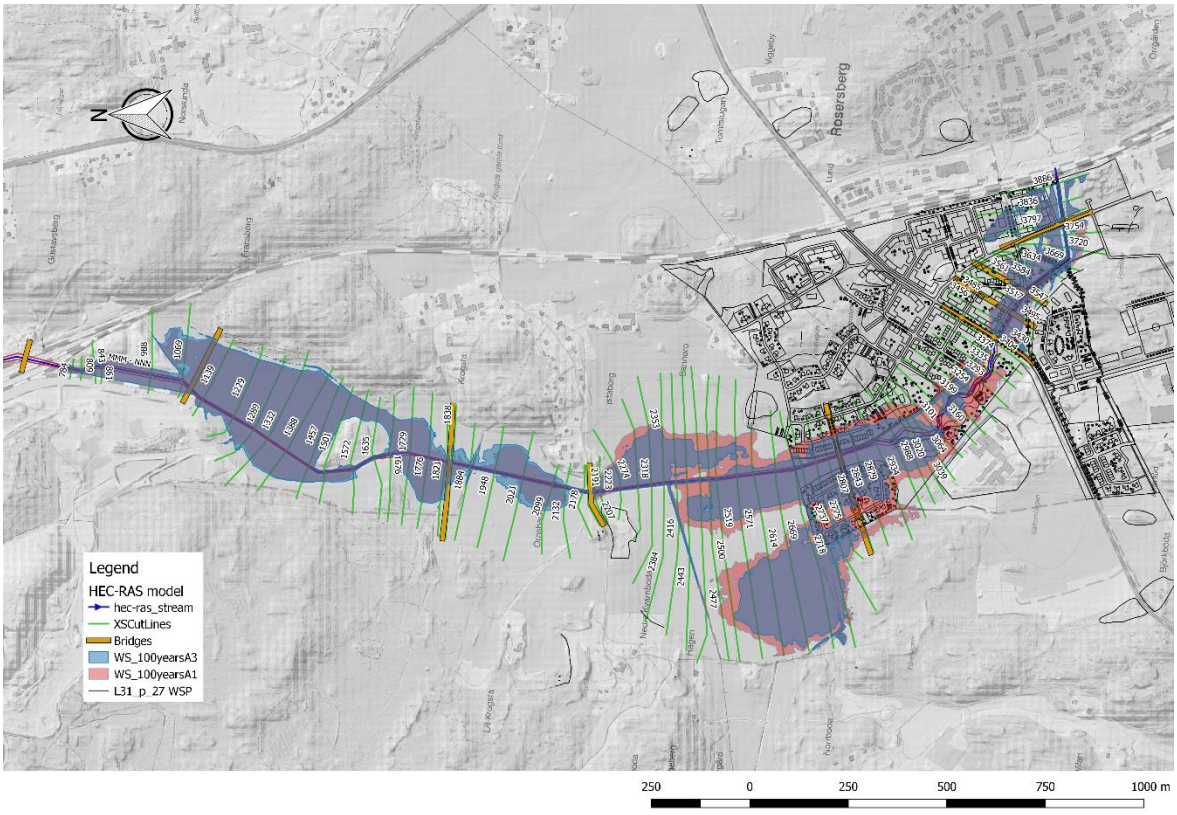

Figure 9: 100 years flood map (Scenario Mitigation measure 2). The red surface is the flood map of Development

6 Discussion

The main findings of these simulations are the following:

- The new values of maximum water levels for floods of 100 years of return period are slightly lower than previous calculations, with an elevation 18.85 m in area where the landscape project proposes to modify the alignment and cross section of the ditch.
- The development has a minor impact (less than 15 cm) in term of maximum water levels upstream station 2200 for floods of 100 years of return period.
- The flood mitigation measure 1 (having a wider ditch for larger storage capacity upstream station 2200) can reduce the maximum water levels to the same values observed in the current conditions
- The flood mitigation measure 2 (having a larger culver at station 2198) can also reduce the maximum water levels to the same values observed in the current conditions, but it slightly increases the flood area downstream the culvert. It is expected that a smaller culvert than the one used in the mitigation measure can be chosen in order to increase the capacity, but affecting in a lower scale the impact downstream.

7 Recommendation

The following recommendations assume the mitigation 1 is implemented, the wider ditch for larger storage upstream station 2200:

- To design the new development area considering a highest water level of 18.80 m for the sector upstream the station 2200.
- To design the new development area considering a highest water level of 19.60 for the sector upstream the station 3358
- To update the calculations once the definition of the development area is in a later stage of engineering and the main earthworks are defined.

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