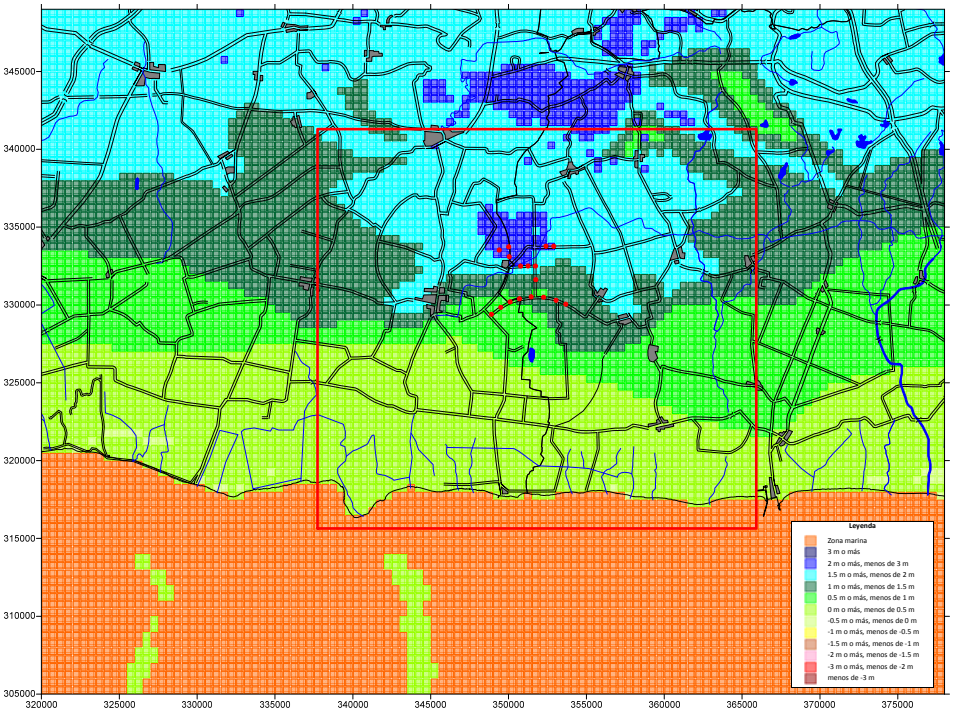
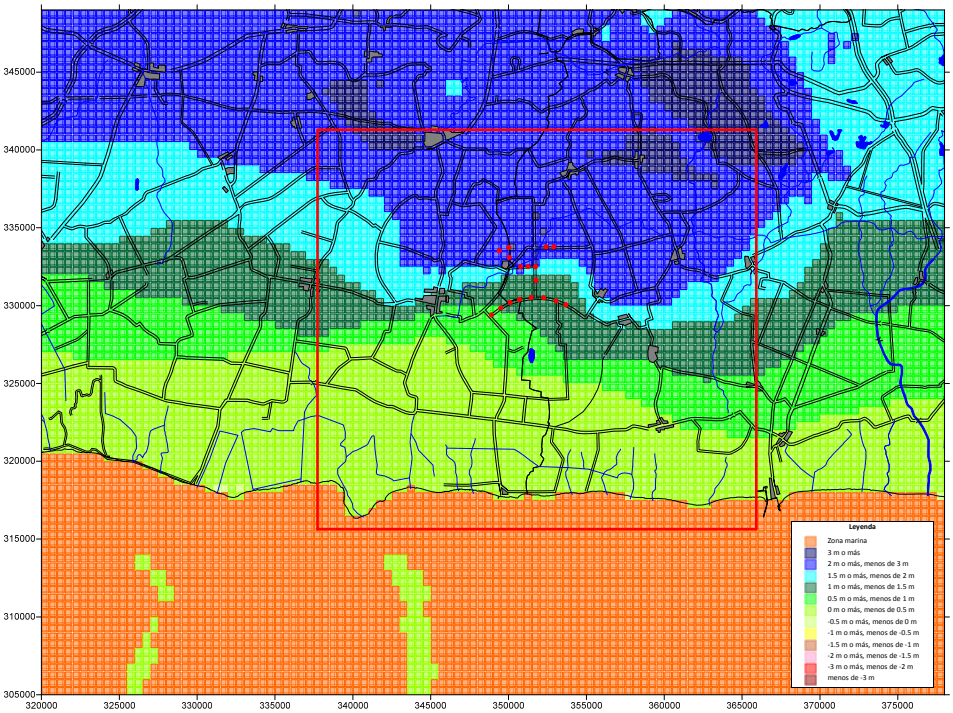
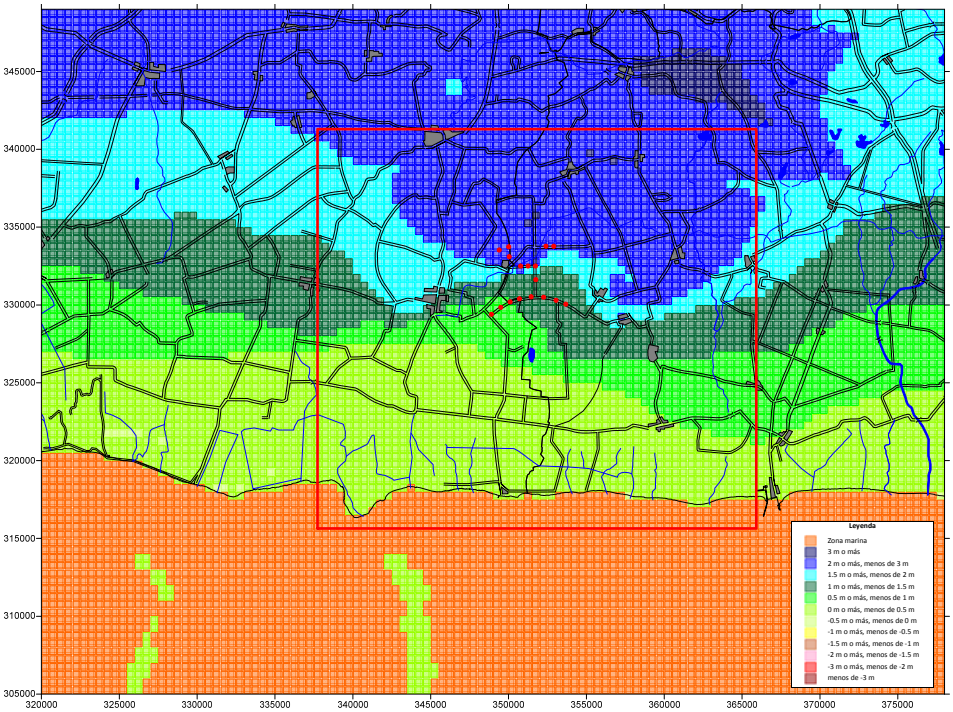


(End of dry period (April 2035))

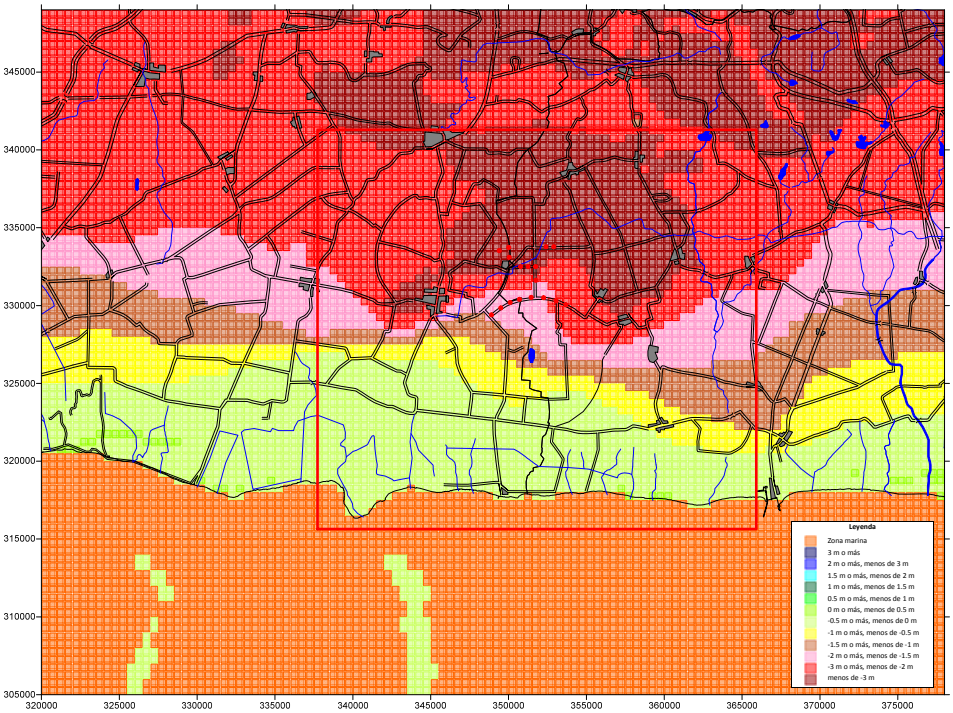


(End of rainy period (October 2035))

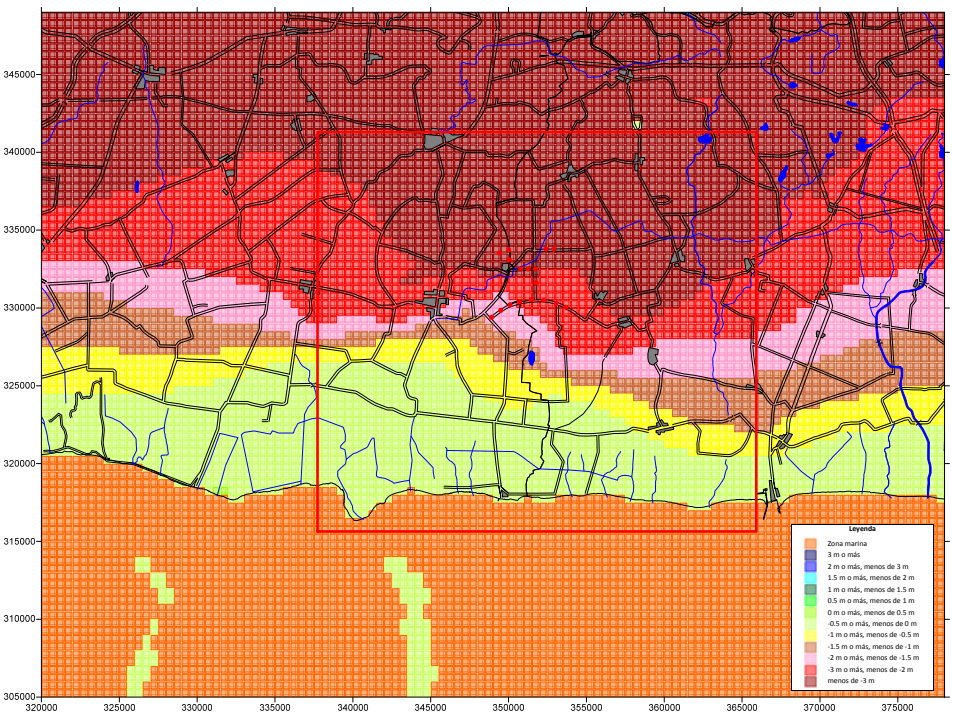


(Last month (December 2035))

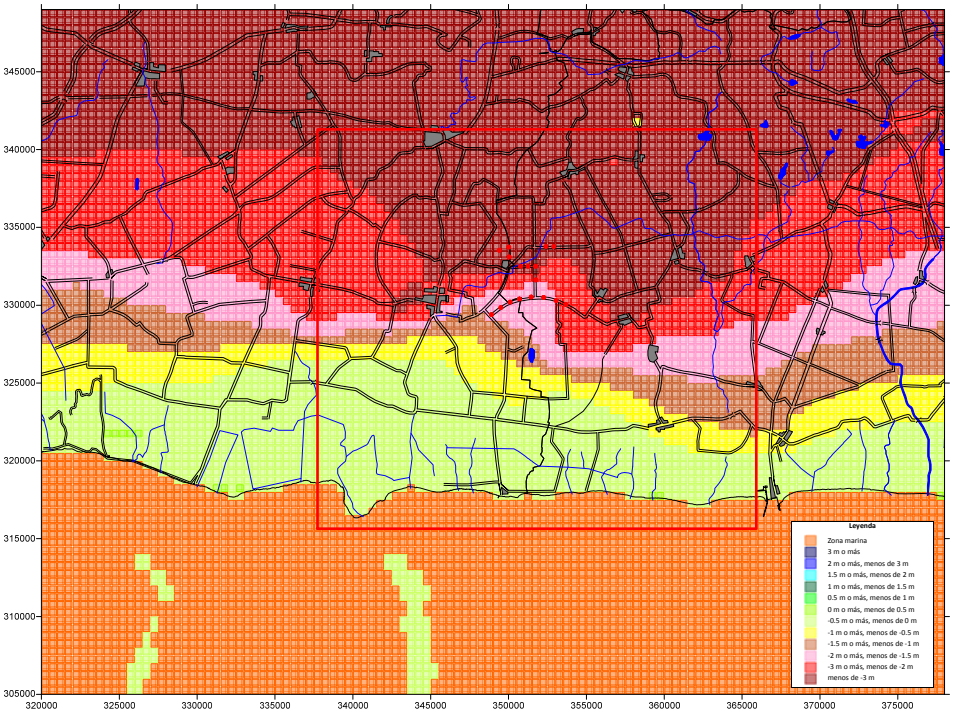
Figure 5-30: Comparison of calculated groundwater level distribution (17th layer) of [Q0-RA0 Model] and [Q1-RA3 Model]



(End of dry period (April 2035))



(End of rainy period (October 2035))

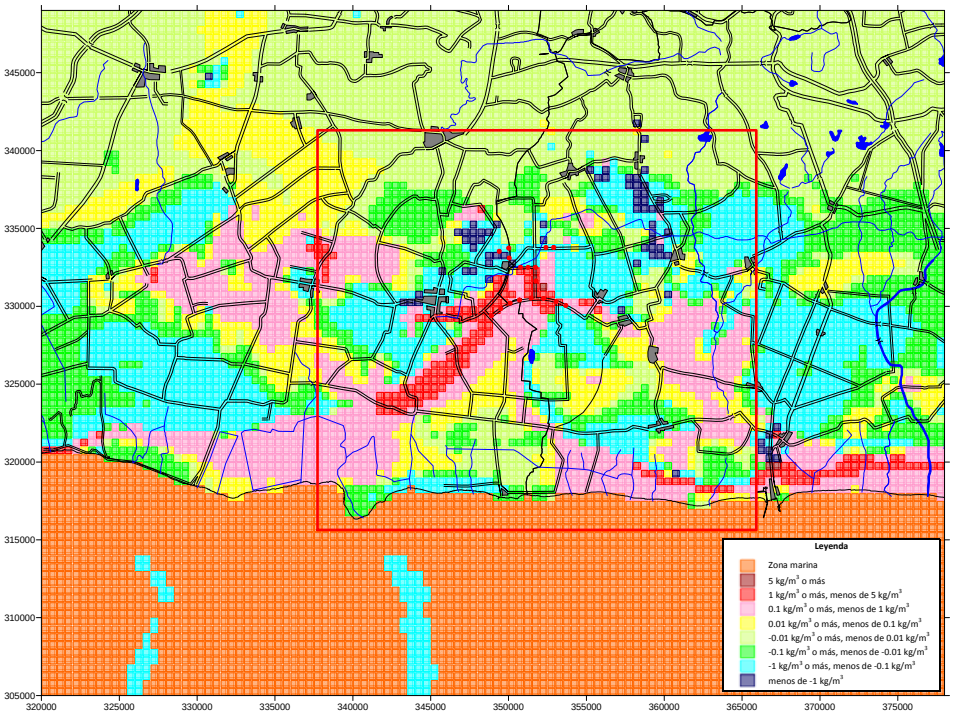


(Last month (December 2035))

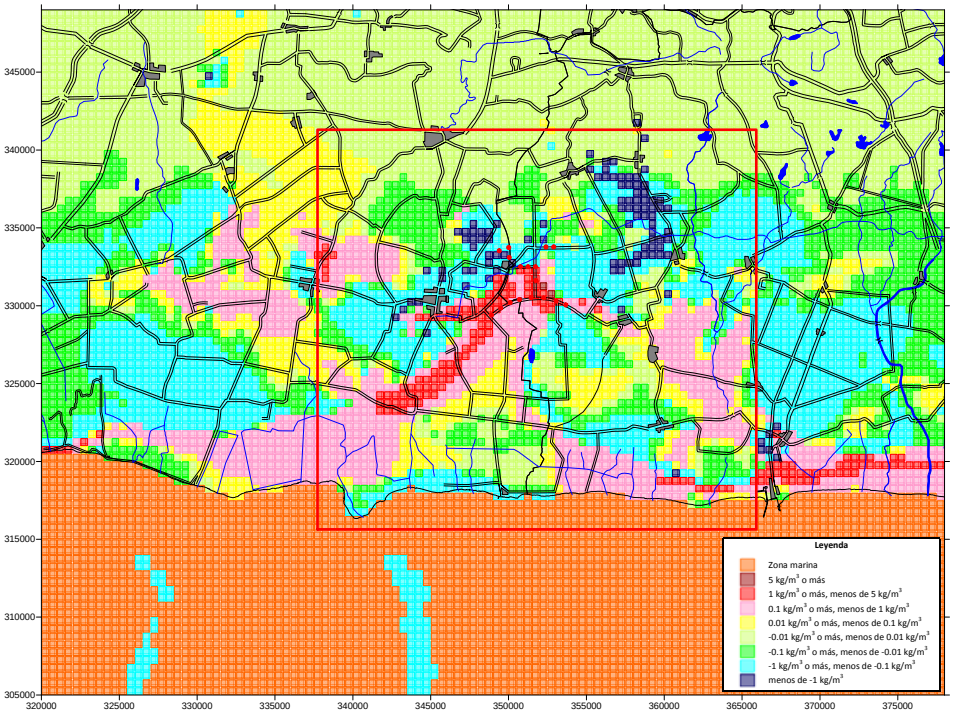
Figure 5-31: Comparison of calculated groundwater level distribution (17th layer) of [Q0-RA0 Model] and [Q3-RA1 Model]

The comparison figures of the calculated salt concentrations (17th layer) between Basic Model 1 and the three cases described are also shown below. The period of comparison is the

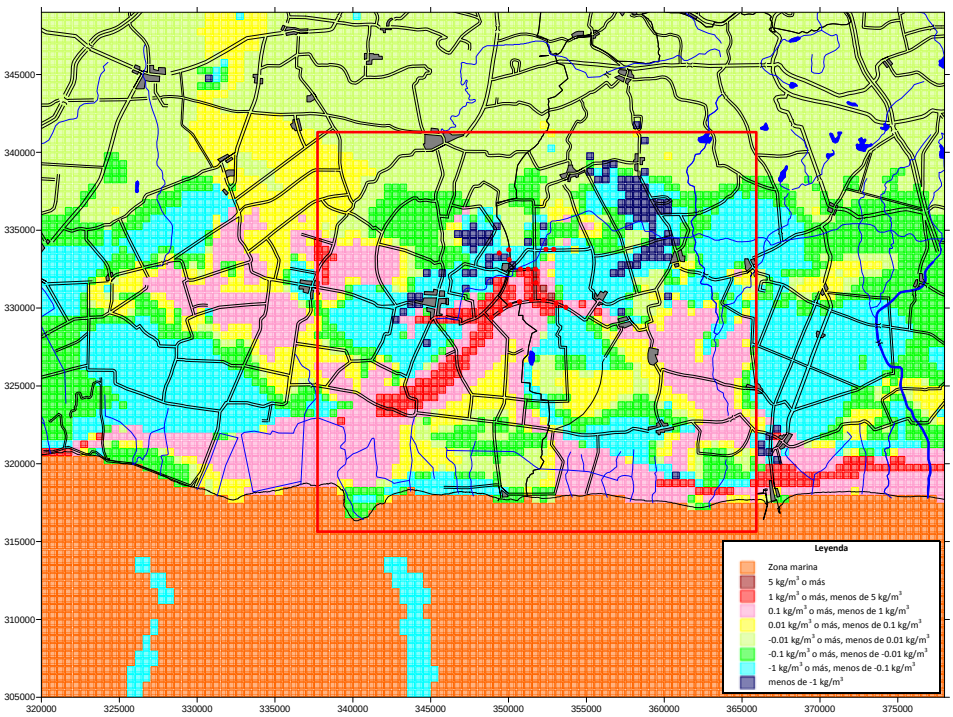
same as that of the previous section.



(End of dry period (April 2035))

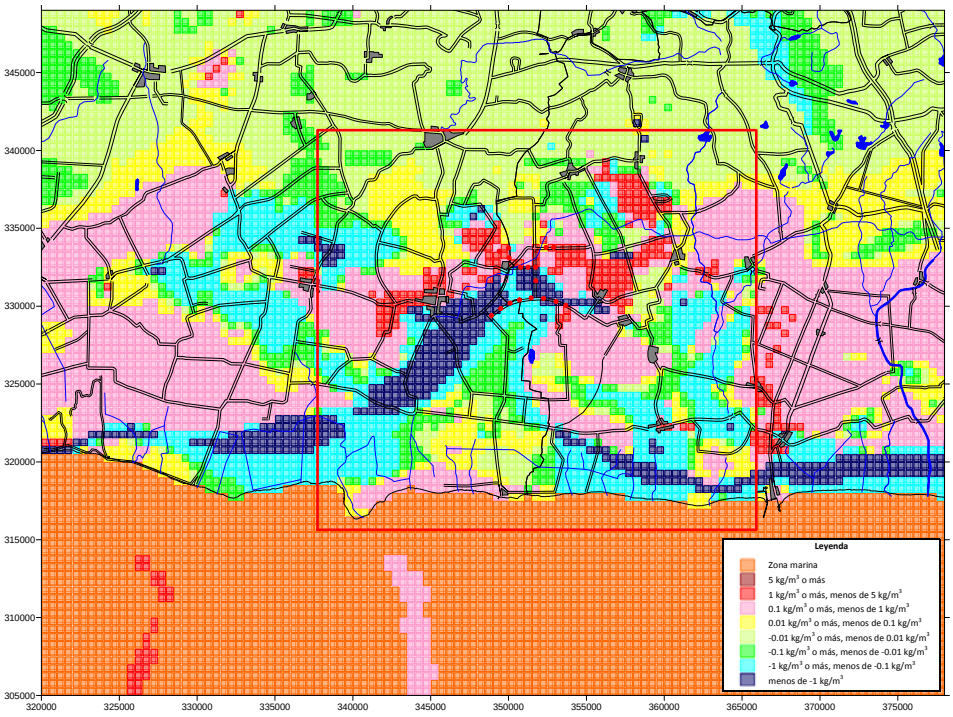


(End of rainy period (October 2035))

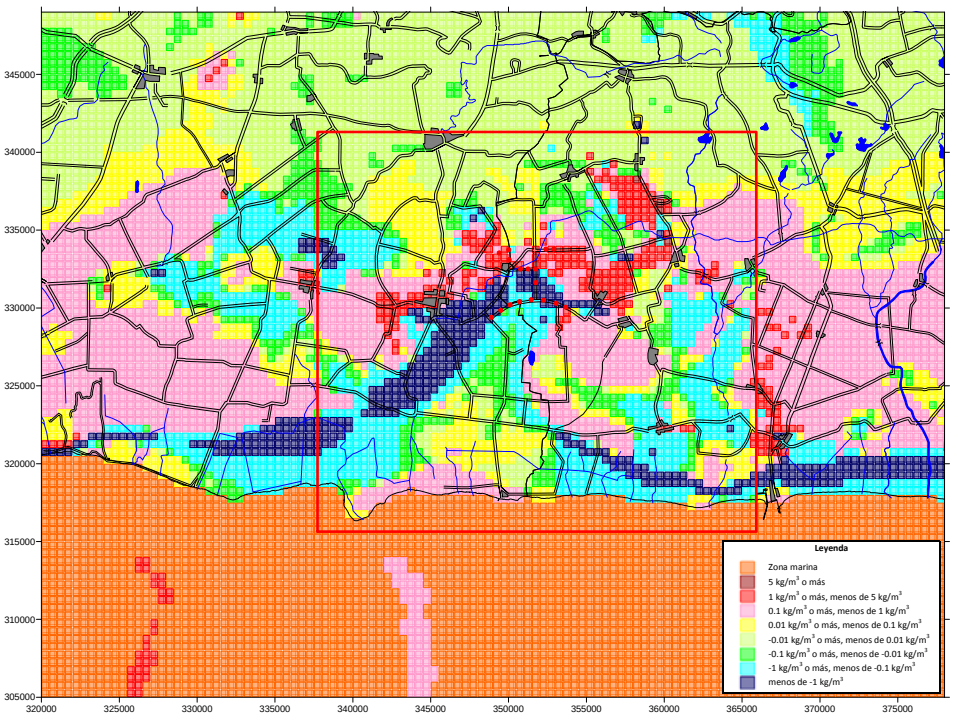


(Last month (December 2035))

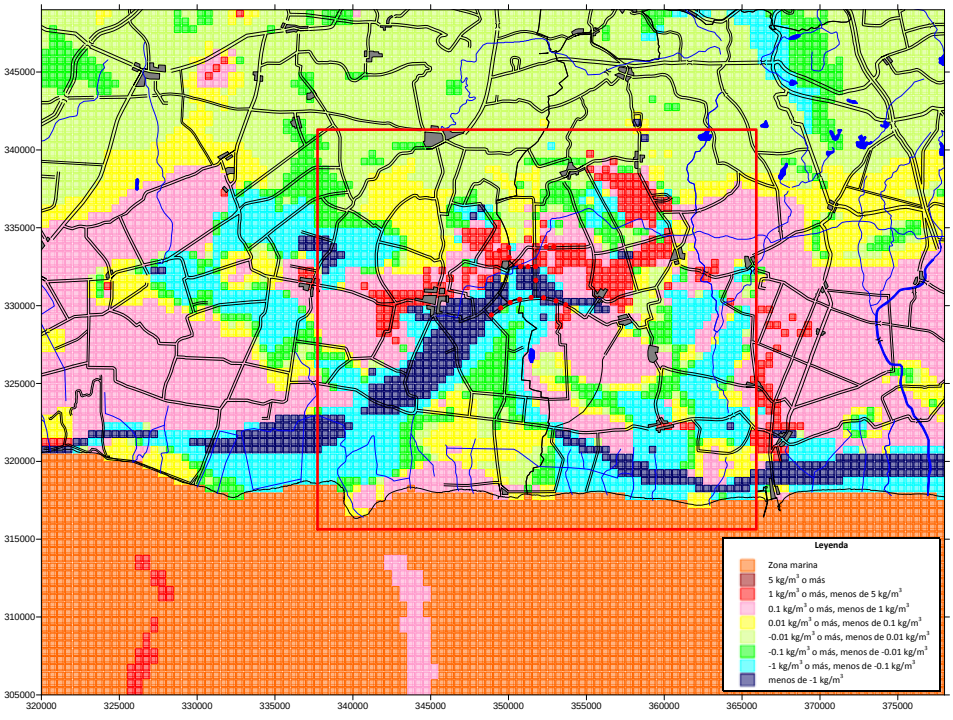
Figure 5-32: Comparison of calculated salt concentration distribution (17th layer) of [Q0-RA0 Model] and [Q1-RA3 Model]



(End of dry period (April 2035))



(End of rainy period (October 2035))

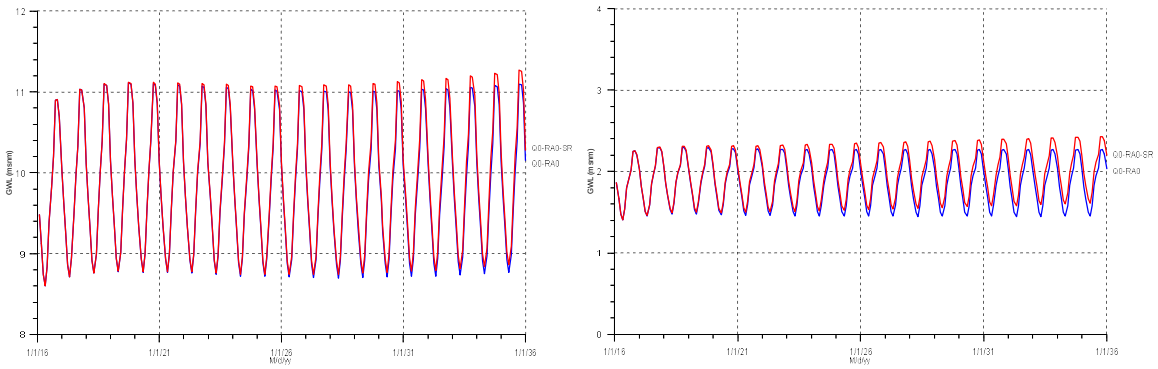


(Last month (December 2035))

Figure 5-33: Comparison of calculated salt concentration distribution (17th layer) of [Q0-RA0 Model] and [Q3-RA1 Model]

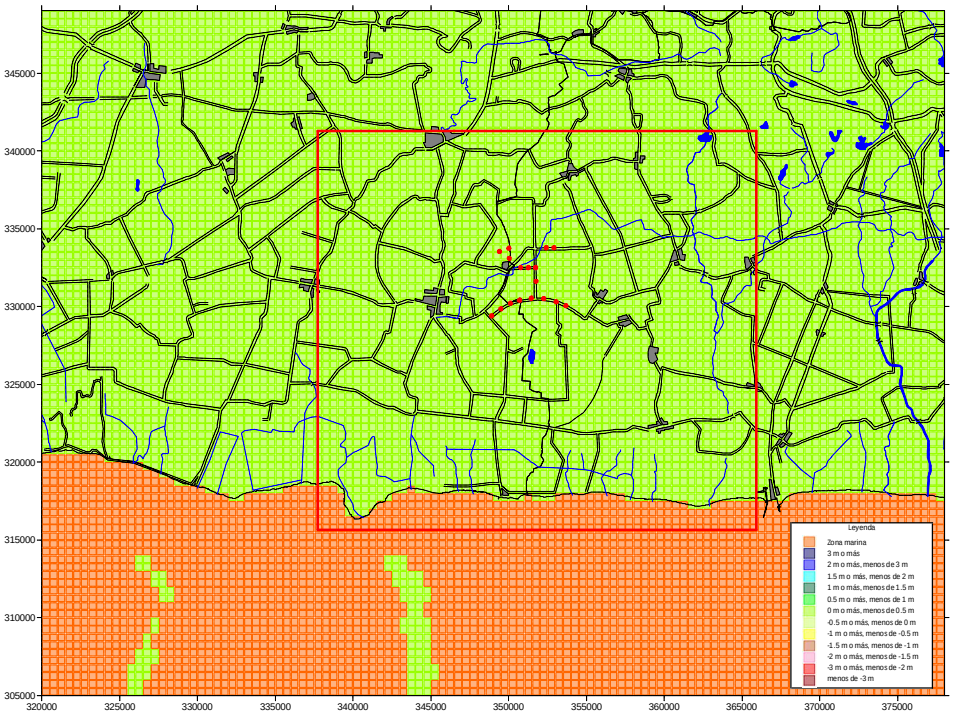
e. Climate change scenario

The assumption was made in which the sea level rise 50cm (2.5cm/year) in 20 years. In addition, the salt concentration at the wetland in Dique Sur was assumed to increase from 1kg/m3 to 21kg/m^3 due to sea level rise.
The comparison result of the model with the addition of the above condition (Q0-RA0-SR model) using Q0-RA0 model as the Basic Model is shown below.

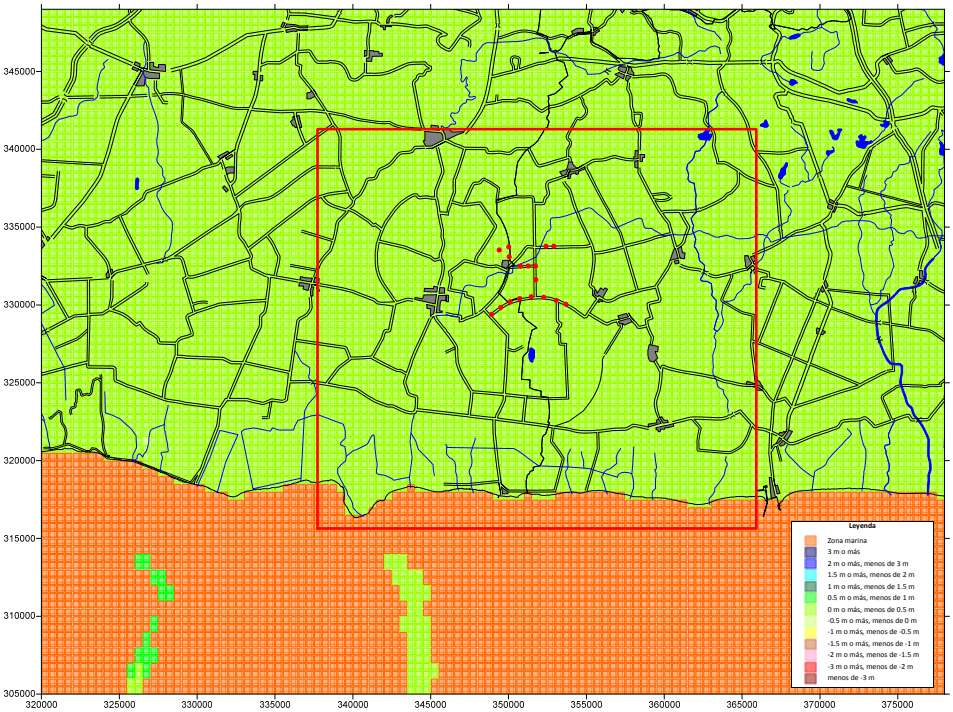


(HS-563) (LSU-8)

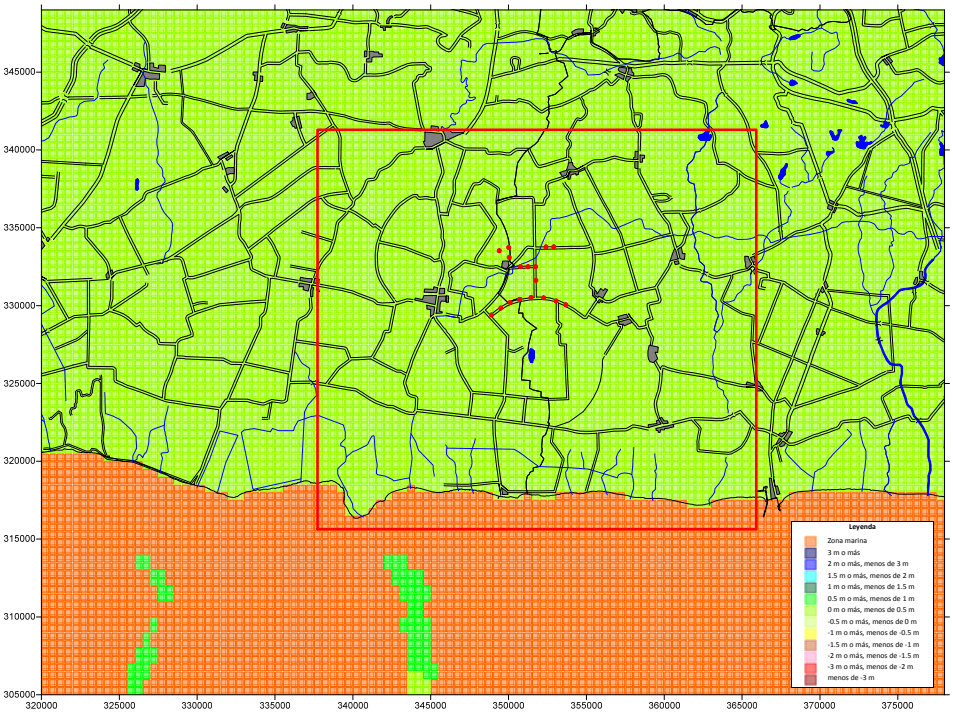
Figure 5-34: Fluctuation of the calculated groundwater levels ([Q0-RA0 Model], [Q1-RA3 Model] and [Q0-RA0-SR Model])



(End of dry period (April 2035))

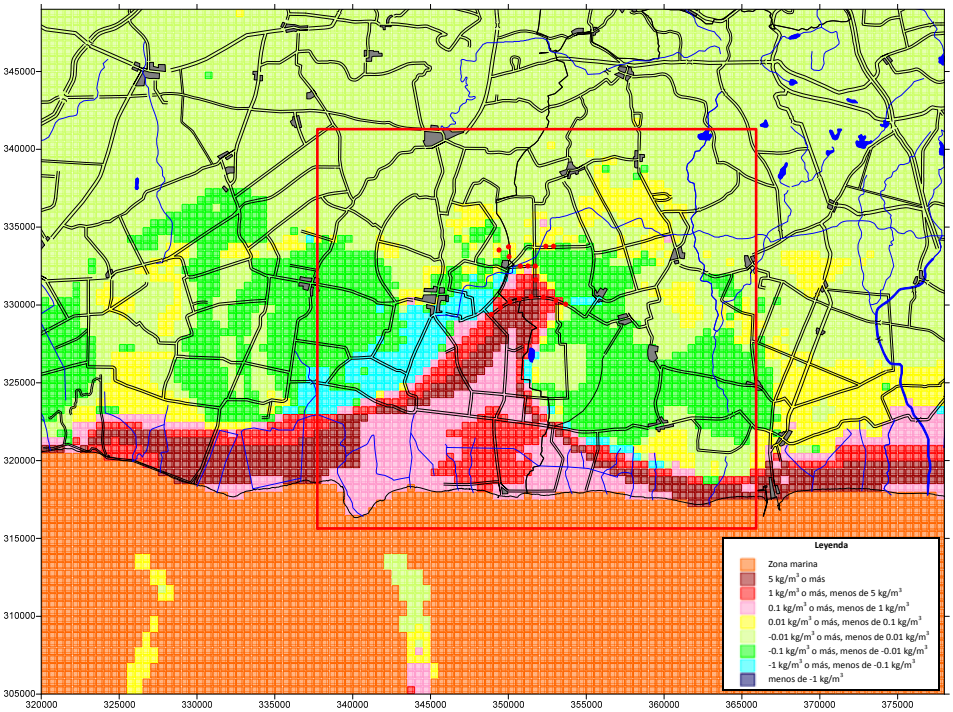


(End of rainy period (October 2035))

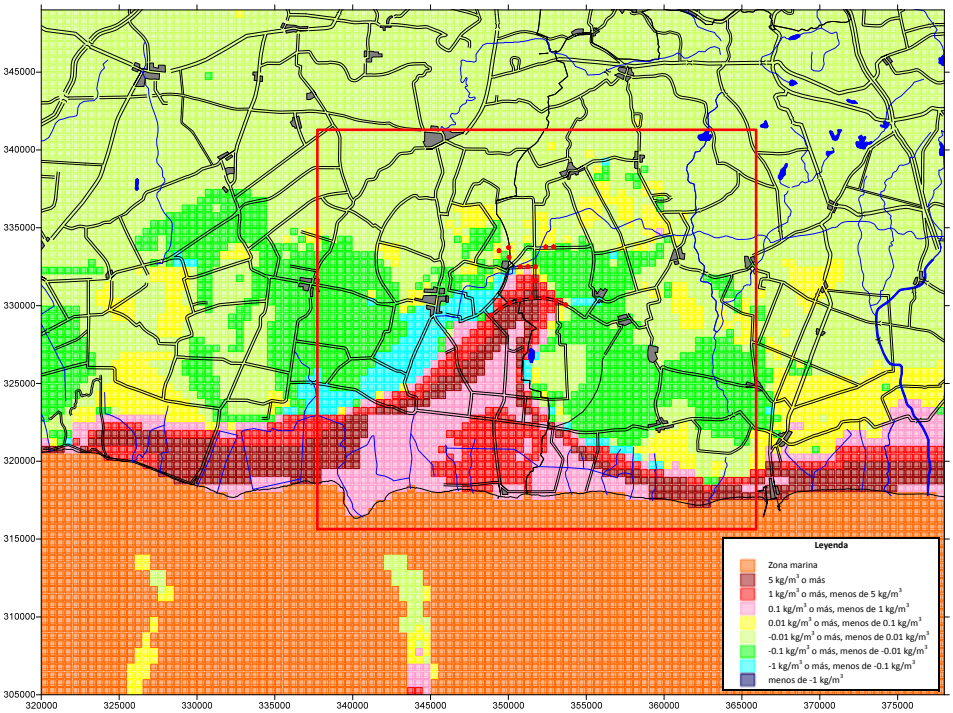


(Last month (December 2035))

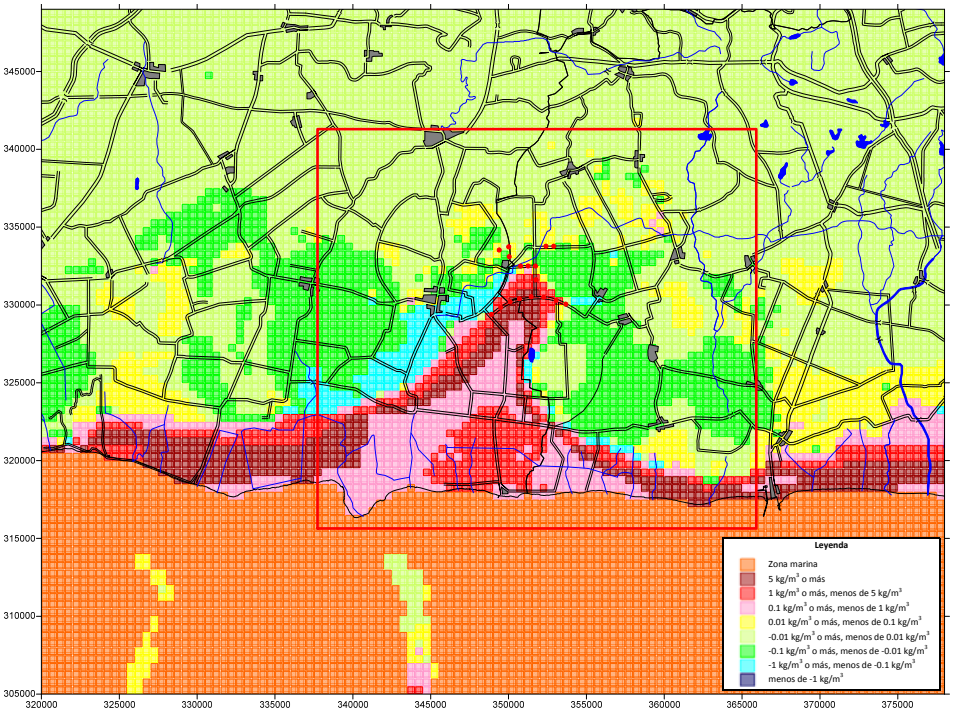
Figure 5-35: Comparison of calculated groundwater level distribution (17th layer) of [Q0-RA0 Model] and [Q0-RA0-SR Model]



(End of dry period (April 2035))



(End of rainy period (October 2035))



(Last month (December 2035))

Figure 5-36: Comparison of calculated salt concentration distribution (17th layer) of [Q0-RA0 Model] and [Q0-RA0-SR Model]

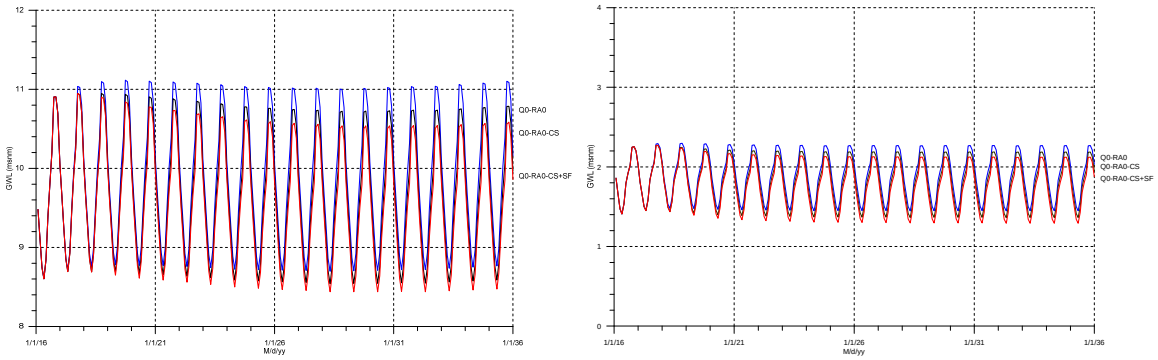
f. Scenario of new wells development

The assumption in which the new wells were developed in the following two points was made based on the Q0-RA0 model (groundwater recharge volume of Q0-RA0 is used for the recharge volume).

i. Scenario of new wells development in Cuenca Sur (Q0-RA0-CS Model)
   - Volume of groundwater pumped: The assumption was made that new wells were developed at the Eastern area of the existing wells of Cuenca Sur (Row 40, Column 70) and pumpage will begin from January 2017. The average pumpage volume is assumed to be the same as that of existing wells.

ii. Scenario of new wells development in San Felipe (Q0-RA0-CS+SF Model)
   - Volume of groundwater pumped: In addition to (i), the assumption was made that new wells will be developed near the JICA-3 well. Pumpage was assumed to begin from January 2018 with a pumpage volume of 4,000m^3/day.

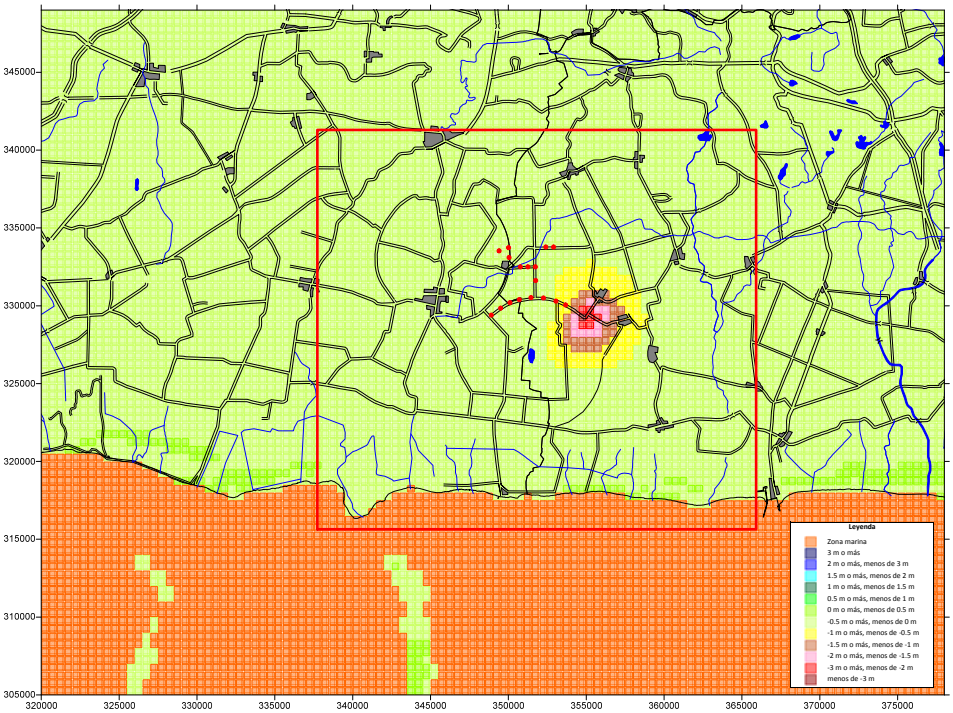
The transition of the calculated groundwater level of Basic Model 1 and the two scenarios are shown below.



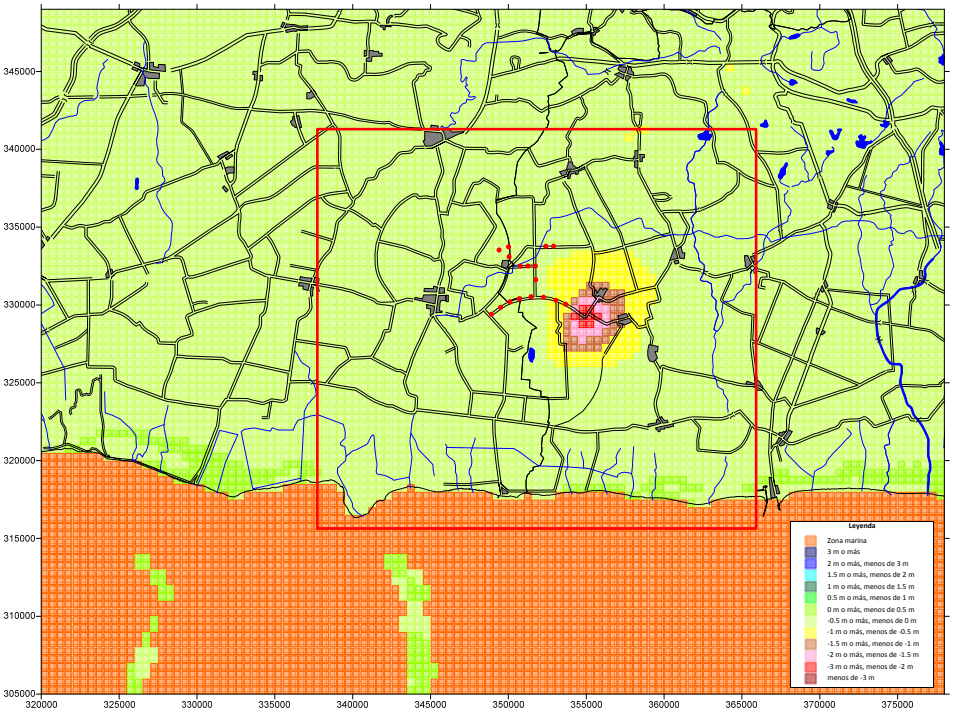
(HS-563) (LSU-8)

Figure 5-37: Fluctuation of the calculated groundwater levels ([Q0-RA0 Model], [Q0-RA0-CS Model] and [Q0-RA0-CS+SF Model])

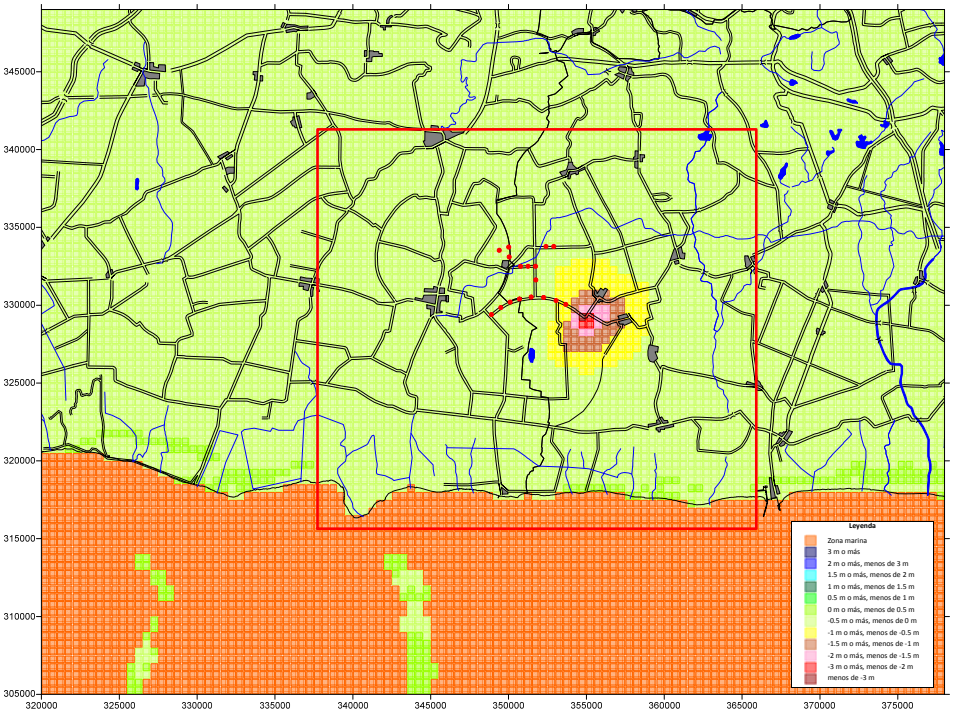
The comparison figures of the calculated groundwater level distribution between Basic Model 1 and the three cases described (17th layer) are shown below. The period of comparison is the same as that of the previous section.



(End of dry period (April 2035))

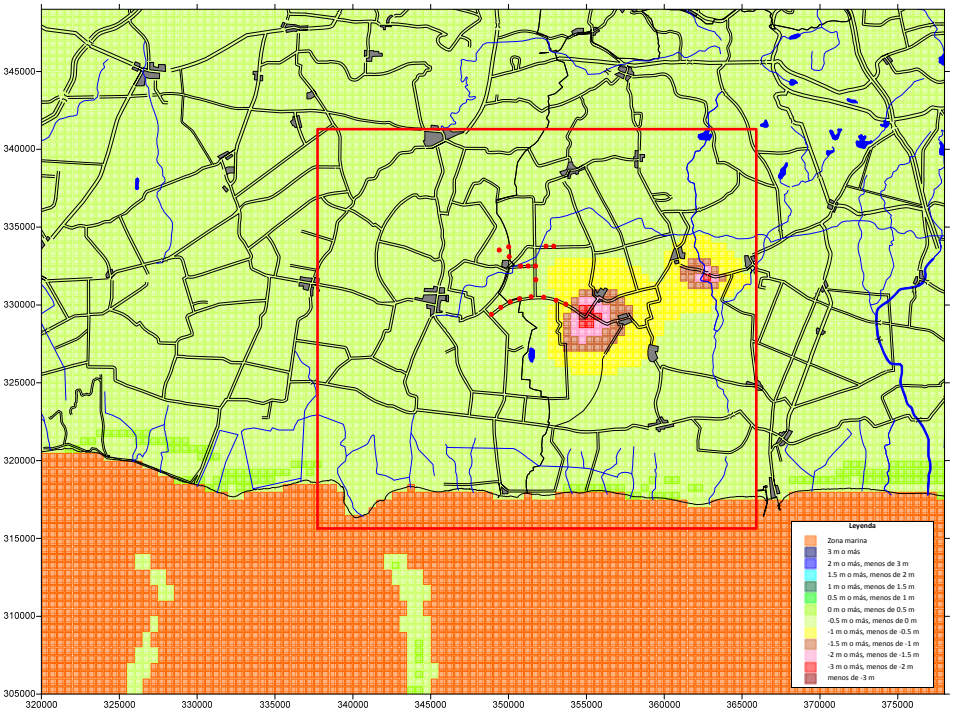


(End of rainy period (October 2035))

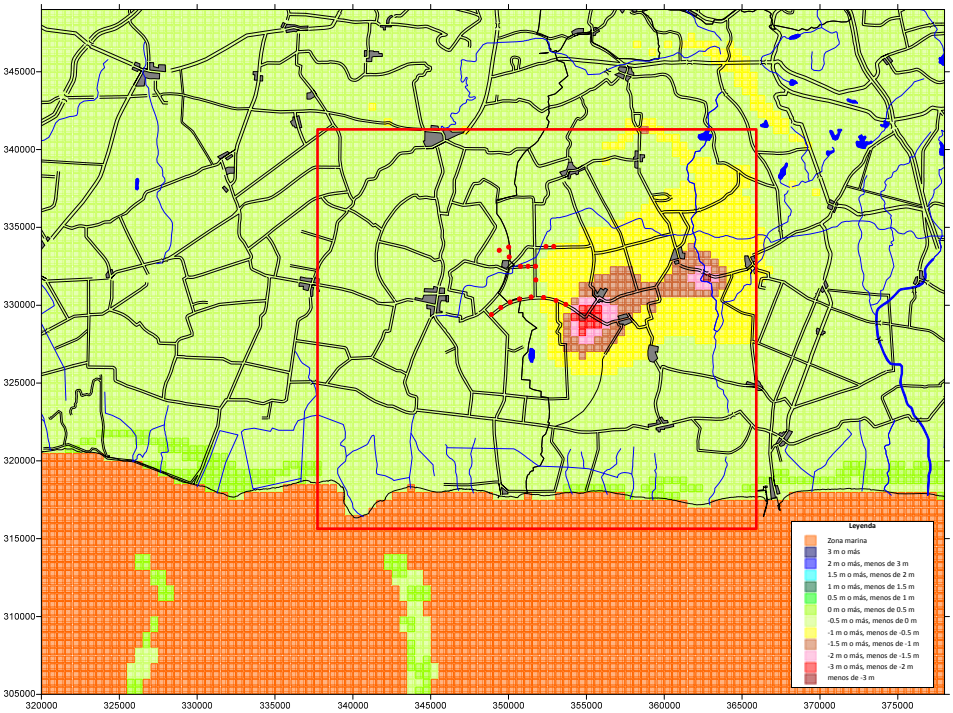


(Last month (December 2035))

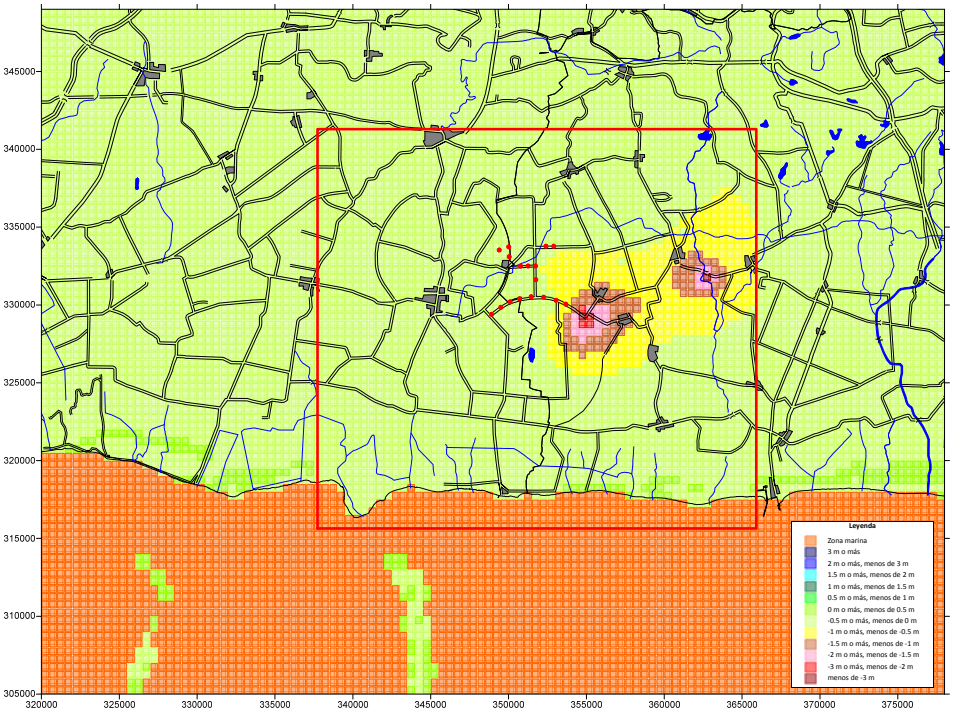
Figure 5-38: Comparison of calculated groundwater level distribution (17th layer) of [Q0-RA0 Model] and [Q0-RA0-CS Model]



(End of dry period (April 2035))



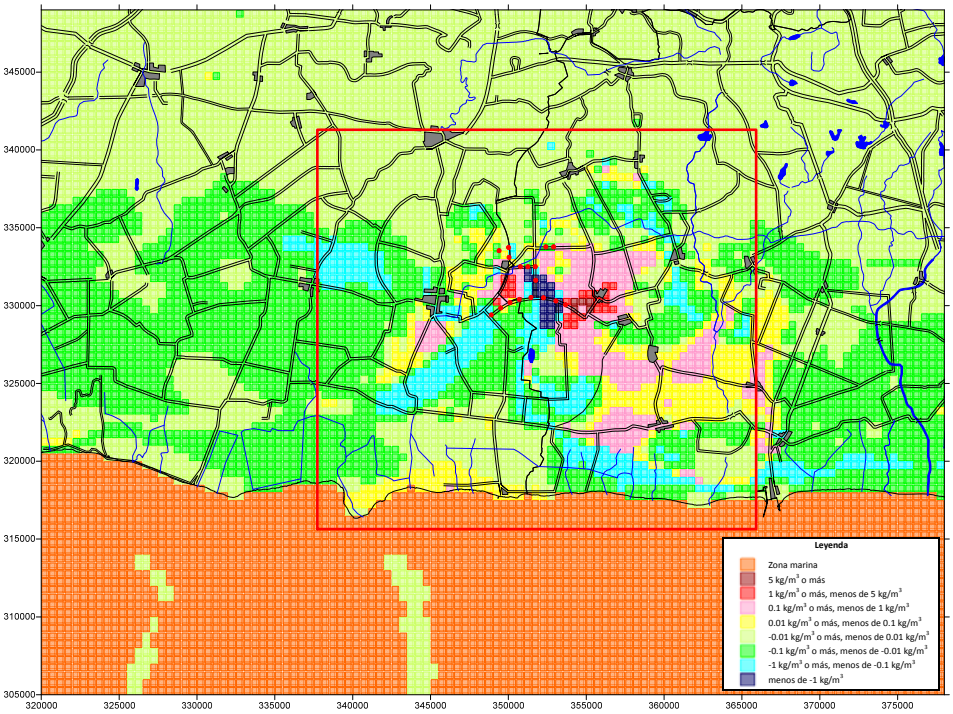
(End of rainy period (October 2035))



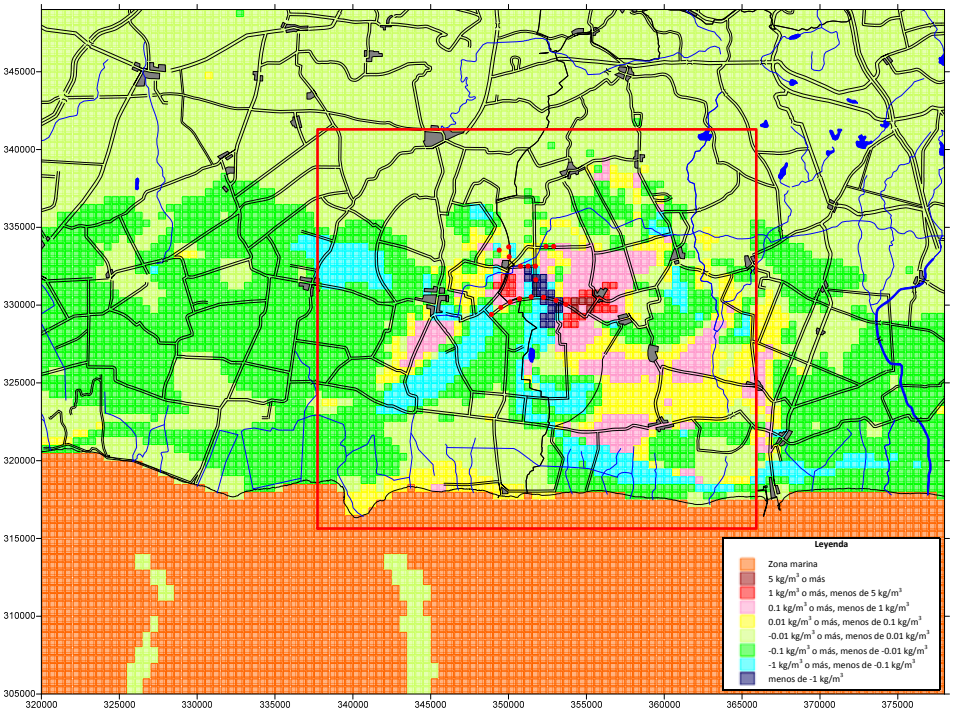
(Last month (December 2035))

Figure 5-39: Comparison of calculated groundwater level distribution (17th layer) of [Q0-RA0 Model] and [Q0-RA0- CS+SF Model]

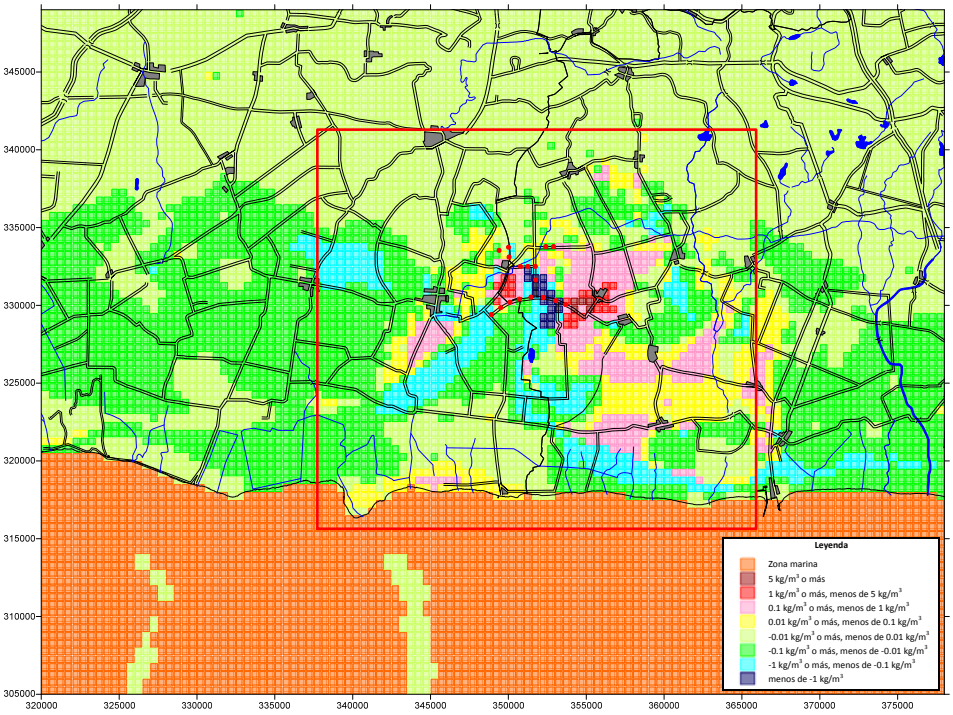
The comparison figures of the calculated salt concentrations (17th layer) between Basic Model 1 and the three cases described are also shown below. The period of comparison is the same as that of the previous section.



(End of dry period (April 2035))

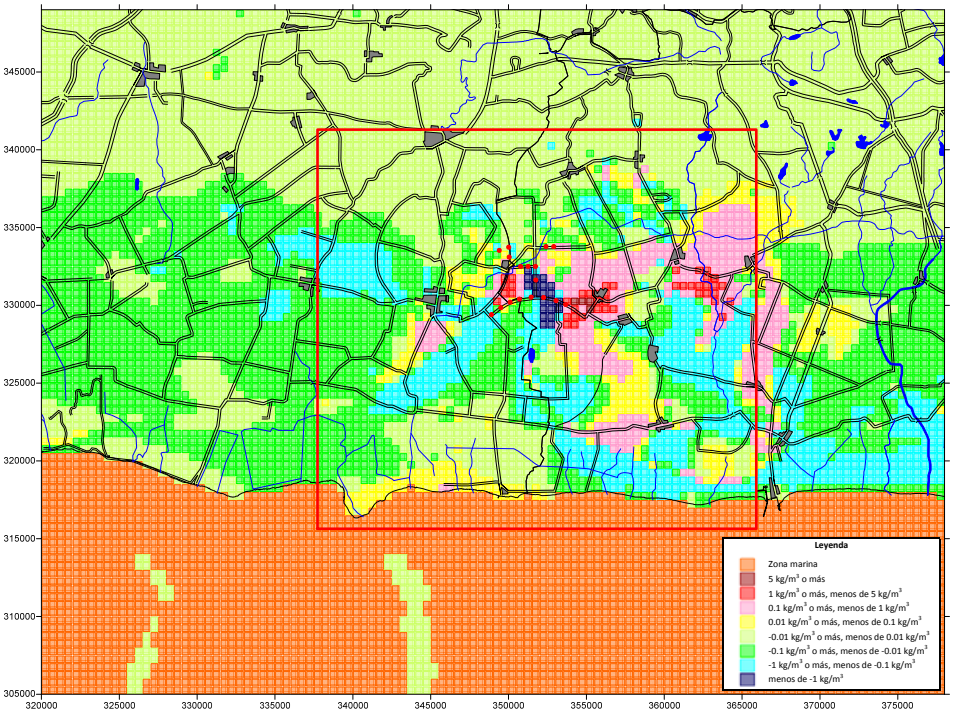


(End of rainy period (October 2035))

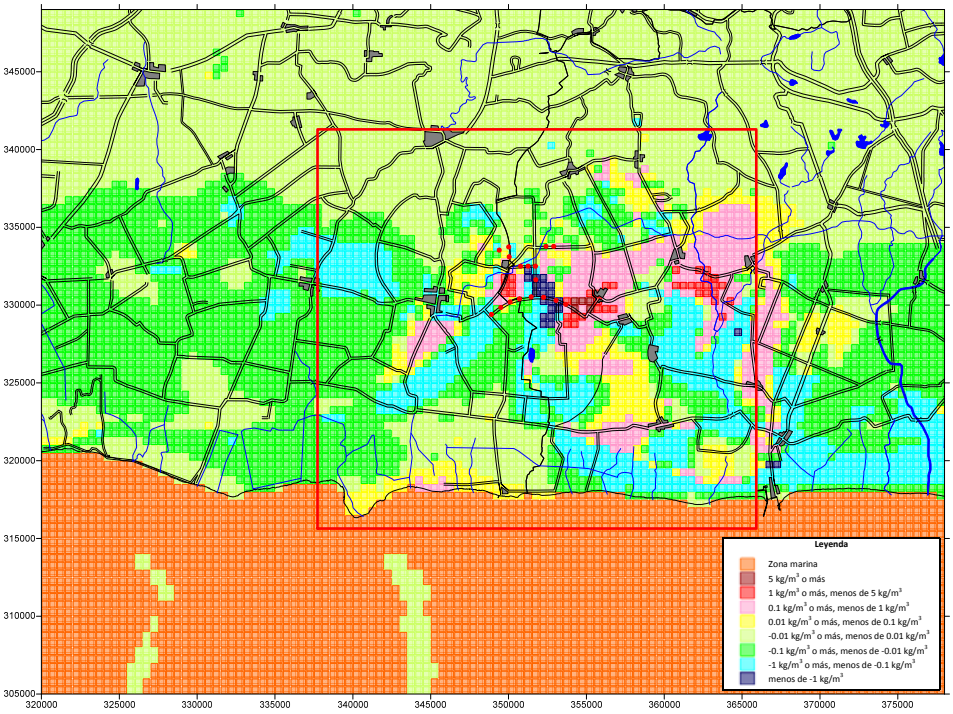


(Last month (December 2035))

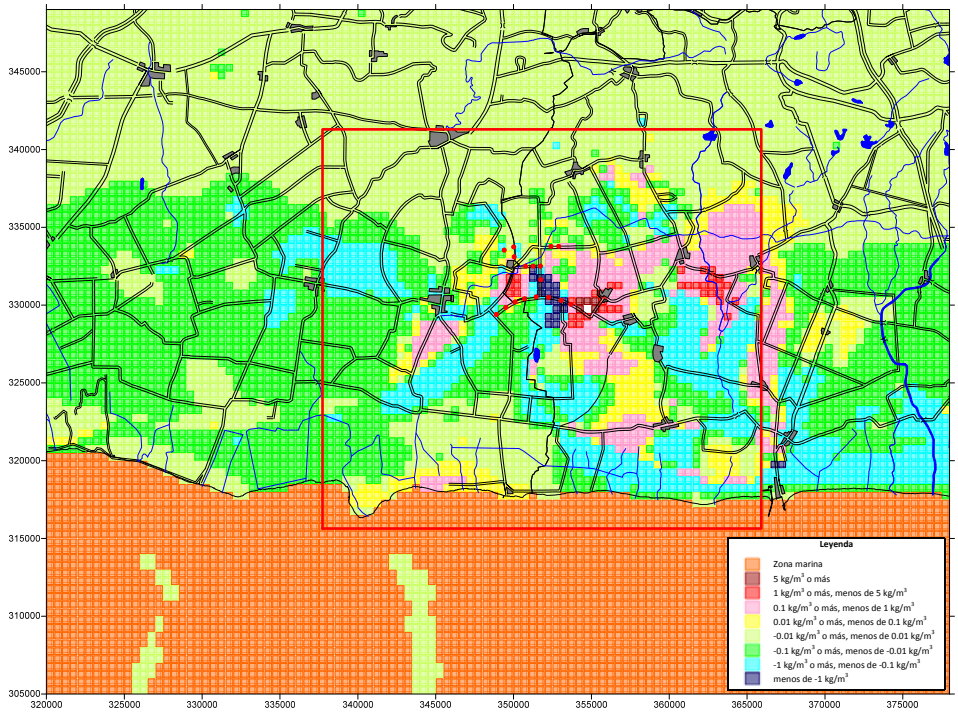
Figure 5-40: Comparison of calculated salt concentration distribution (17th layer) of [Q0-RA0 Model] and [Q3-RA0-CS Model]



(End of dry period (April 2035))



(End of rainy period (October 2035))



(Last month (December 2035))

Figure 5-41: Comparison of calculated salt concentration distribution (17th layer) of [Q0-RA0 Model] and [Q3-RA0-CS+SF Model]

5.3 Classification of the Measures

a. Groundwater level

Based on the results in chapter 5.2, the desirable (maintaining the groundwater level of December 2015 up to December 2035) patterns of pumpage volume have been established by maintaining the groundwater recharge volume of Basic Model 1 (Q0-RA0 model) are as follows:

- Area ①: Area where the pumpage volume has to be reduced up to a 90% of the actual volume.
- Area ②: Area where the pumpage volume has to be reduced up to a 90% ~ 100% of the actual volume.
- Area ③: Area where the pumpage volume can be increased to a 100% ~ 110% of the actual volume.
- Area ④: Area where the pumpage volume can be increased to a 110% ~ 120% of the actual volume.

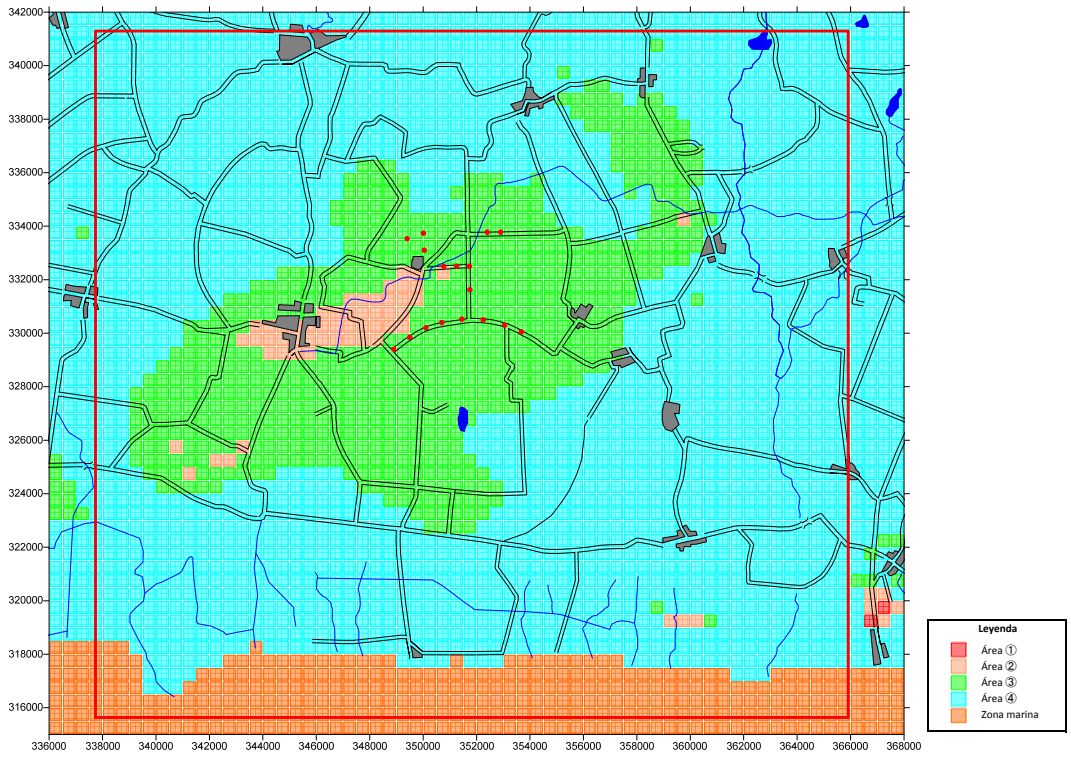


Figure 5-42: Classification of the pumpage volume variations

b. Groundwater quality

Based on the groundwater flow direction obtained from the groundwater model, it has been identified that Dique Sur is playing an important role in the groundwater level and groundwater quality of Cuenca Sur.

There is huge amount of groundwater flowing from Dique Sur towards Cuenca Sur, and it can be assumed that the salt water from the sea might have flowed directly if Dique Sur had not existed.

Moreover, the water quality of Dique Sur is assumed to be worsening due to sea level rise though the investigation of the water in Dique Sur is not enough. Therefore, continuous data collection on the water volume and water quality will be necessary in the future.