We would like to thank this referee for his/her interesting comments and suggestion that will contribute for improving our paper and clarify specific points. Hereby we present the authors reply (AC) to the referee's comments (RC).

2068:

RC: Is the CCL a phreatic aquifer here?

AC: Yes, the CCL is a phreatic aquifer above the clay layer (within the CCL). It is not clear in point 1?: "the CCL may be considered as a single peaty model layer representing a <u>phreatic aquifer</u> resting on top of a Pleistocene sandy aquifer with horizontal flow. The clayey components in the peat representing aquitards are modeled as a model resistance function between the peaty aquifer and the underlying sandy aquifer"?

2069:

RC: parcel? ! better "plot"

AC: Ok, it will be changed.

RC: Water levels = ? Please indicate some values!

AC: Ok, the levels will be indicated: "The water levels in the ditches are kept at -2.95 m during the summer months and at -3.0 m during the winter months.

RC: Is the CCL saturated, is it confined?

AC: The CCL, as indicated in 2068, is a phreatic aquifer above the clayey layer (within the CCL) that works as a confining layer.

2070:

RC: How deep were the drillings, which diameter was used?

AC: The drillings were 7 m deep and a 10 cm diameter was used. In the article it will be changed to: "The fieldwork included drilling of two boreholes, about 150 m apart, with a depth of 7 m through the CCL using an Edelman hand auger of 10 cm diameter (Fig 1 and 2).

RC: How were the slug tests performed, what was the excitation procedure, how were the measurements performed (measuring equipment), what was the time scale of responses?

AC: After the borehole was drilled and cased to avoid the borehole from collapsing and the water level (head) inside the hole equalled the groundwater table, water was instantaneously extracted from the borehole with a bailer. The groundwater heads inside the boreholes were measured with a measuring tape attached to a float at 10 second intervals from the start until the level (head) was almost stable in about 7 to 10 minutes. This description will be included in the article.

RC: At what depths were the samples obtained?

AC: The samples were obtained at different depths (ranging from 0.7 m up to 2.1 m depth) trying to sample the different soils found in each borehole (1 or 2 samples were taken for each borehole). In the article it will be changed to: "In every borehole used for the slug tests one or two peat samples were taken at different depths ranging from 0.7 m to 2.1 m with the aim to analyze the different soil types. The decomposition degree was determined according to the von Post method..."

RC: What is the groundwater level; the levels are described first at page 2078!

AC: The groundwater levels vary spatially and with time. In the boreholes with piezometers, the groundwater levels during the measuring period varied according to the following graph. In the confined aquifer the levels were relatively stable at around – 3m and in the phreatic aquifer the shallow water tables were more variable (from -2.85 to -2.50 m):

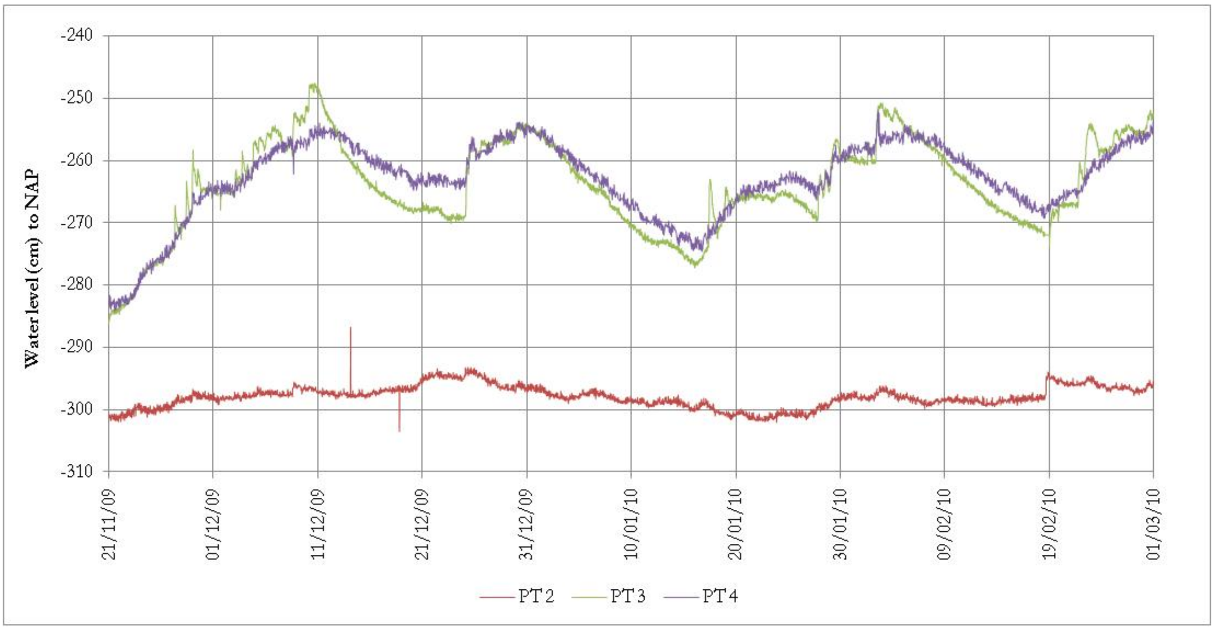


Figure 3 Measured groundwater levels in three of the piezometers (Pressure transducer 2 (PT 2) measures confined levels and PT 3 and PT 4 measure phreatic levels. PT 1 had to be discarded)

In the article this figure will be added and the text will be changed: "Finally, time series of the groundwater levels were collected. The two boreholes penetrating through the CCL were equipped with piezometers having filter screens at 7 m depth in order to measure confined groundwater heads in the first Pleistocene aquifer. The other holes drilled until halfway the CCL obtained piezometers as well. Filter screens were placed in these holes at 3.5 m depth to measure phreatic groundwater heads in the CCL. Shallower piezometers installed within the frame of earlier studies were present as well. Pressure transducers set up in all the piezometers guaranteed a continuous set of time series of groundwater heads during the fieldwork period (Fig. 3)".

2072:

RC: explain how the parameters A and F are obtained

AC: A (m^2) is the inside cross-sectional area of the piezometer standpipe and F(m) is the shape factor for the piezometer intake and can be calculated using the empirical formula of Hvorslev as modified by Brand and Premchitt (1980) (Surridge et al., 2005):

$$F = \frac{2.4\pi l}{\ln\left(1.2l/d + \sqrt{1 + \left(1.2l/d\right)^2}\right)}$$

where d (m) is the outside diameter of the intake and l (m) is the length.

In the article it will be included instead of "The A and F are geometrical factors": "A (m^2) is the inside cross-sectional area of the piezometer standpipe and F(m) is the shape factor for the piezometer intake (Surridge et al., 2005)"

2073:

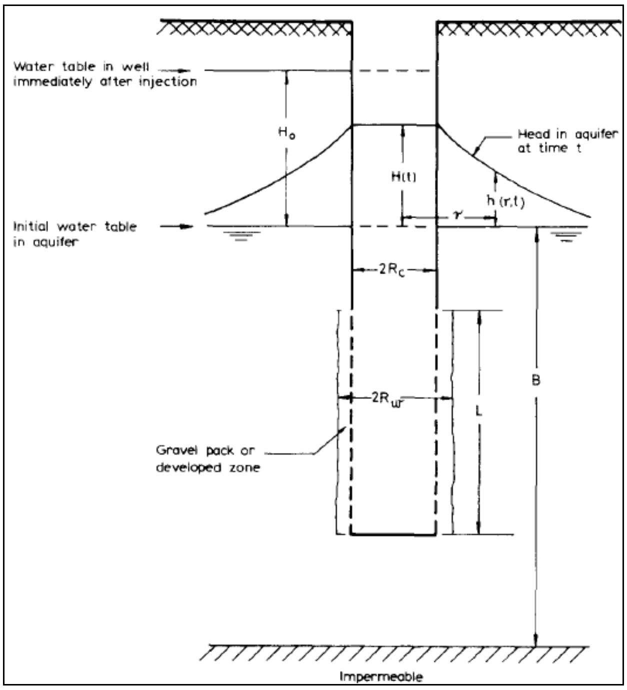
RC: KGS results are shown and discussed, so the KGS formula should be shown and discussed, and it should be shown how the results are obtained

AC: The results were obtained from a computer model (Kansas Geological Survey Slug Test model) that implements the KGS method. The model presents a semi-analytical solution for slug tests that incorporates the effects of partial penetration, anisotropy, and the presence of variable conductivity well skins (see Esling et al. (2009)) and it can be downloaded from http://opensiuc.lib.siu.edu/geol_comp/1/ . The KGS formula is presented in Choi et al. (2008), where the conventional line-fitting procedures as used for the Hvorslev and Bouwer and Rice methods are adapted by introducing a modified effective radius, Re'. This parameter is dependent on the compressibility of the geologic formation as well as borehole geometry (Chirlin, 1989). Because the effective radius is replaced by Re', there is no difference in evaluating the hydraulic conductivity using either the Hvorslev method or the Bouwer and Rice method. Re' is obtained after estimating the value of the storativity for the compressible formation and a dimensionless compressibility parameter for the given hole and tested formation geometry. In the KGS model, the storativity is estimated through curve fitting.

RC: The r_c and L are geo-metrical factors, and the D(α) is a variable also containing time t. The D(α) includes a term for the storativity S of the soil which represents the capacity for elastic storage depending on the compressibility of the material (Hinsby, 1992). The S can be obtained using the Cooper method when the unconfined aquifer is showing a delayed yield response. ! it should be shown how rc and L are obtained, D(α) should be explained (equation), explain more detailed how S is obtained

AC: r_c is the inside radius of the piezometer standpipe and L is the length of the filter pack (see figure below). D(α) (-) is tabulated by Dax (1987) and:

$$\alpha = S \cdot \frac{r_w^2}{r_c^2} \cdot \frac{L}{B} \text{ (-)}$$



Geometry and symbols of a slug test (Dax, 1987)

In the article, it will be explained a bit more as follows: "The Dax expression can be described as follows:

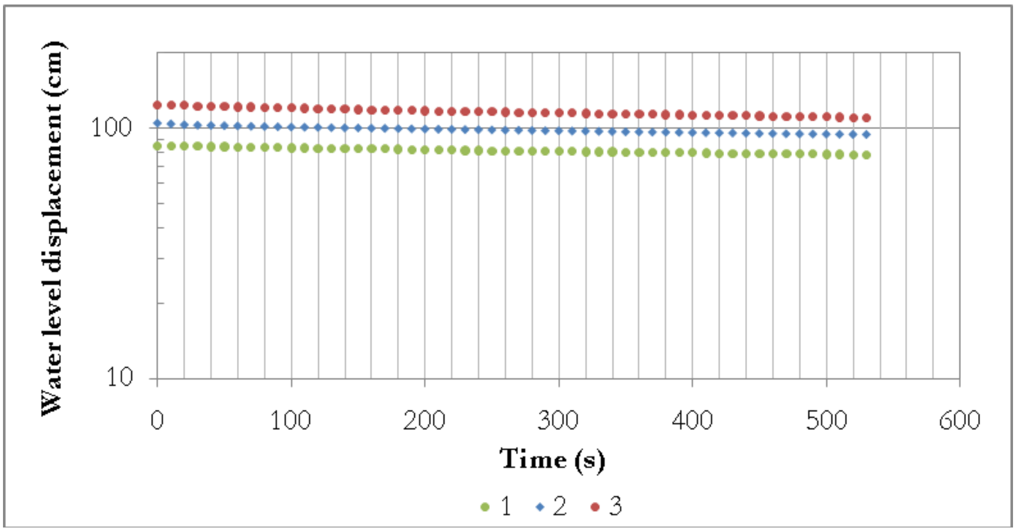
$$K_h = \frac{r_c^2 \cdot \ln(H_o / H_t)}{L \cdot t \cdot D(\alpha)} \quad , \qquad \alpha = S \cdot \frac{r_w^2}{r_c^2} \cdot \frac{L}{B} \text{ (-)}$$

where K_h (m/d) is the horizontal conductivity, t (d) is time, and H_t (m) and H_0 (m) are groundwater heads, following the injection of water, at time t and at the start of the test. The rc is the inside radius of the piezometer standpipe, L is the length of the filter pack, and the D(α) is a variable also containing time t (Dax, 1987). The α includes a term for the storativity S of the soil which represents the capacity for elastic storage depending on the compressibility of the material (Hinsby, 1992). The parameter also incorporates the r_w (m) and B, also describing borehole geometry. Where the unconfined aquifer is showing a delayed yield response, the S can be obtained using the Cooper method (Cooper et al., 1967)

2074:

RC: Why were not all slug tests evaluated with a transient method, which seems to be superior?

AC: Because some of them (BH7, BH8 and BH10) did not show a transient behaviour and showed a steady-state behaviour instead (plots of straight lines). See example in figure below.



In the article the following sentence will be included: "The tests producing "straight lines" (Table 1: BH7, BH8 and BH10) were only interpreted using the steady state methods.

RC: What is the reason for using the steady state method if the transient method is superior?

AC: Just for comparative reasons as stated, to show differences with traditional methods.

RC: Why not using KGS if Dax has problems with estimating S

AC: For comparative reasons because the Dax method is also widely used, and also due to the fact that the KGS was implemented by a semi-analytical model where the formulation used was not visible, but instead the value of S was manually modified to fit the curve.

2075:

RC: Based on this information one is inclined to believe that Darcy's law with a constant K_h may not be entirely valid to describe groundwater flow in peaty environments, but that its application in analytical and numerical model computations is justified. ! ??? what is the aim of this statement, please explain why is the application of Darcy's law for modelling justified if it is not entirely valid. Please provide a clear justified statement!

AC: The statement is not very clear, it willl be changed to: "Based on this information the statement can be made that the K is not entirely independent of the groundwater head differences in a system. However, in a natural peaty environment these head differences are small and will hardly affect the K justifying the application of Darcy's law in analytical and numerical model computations. In modeling on the other hand, even though the K is affected, there are usually larger errors arising from uncertainties in the hydro-geological conceptualization and model input data".

RC: Is the model confined or unconfined?

AC: Some layers are confined, and others are unconfined (it will be added in Fig. 8).

RC: How is the situation within the peat, saturated or unsaturated, to what degree?

AC: The peat is saturated below the water table and unsaturated above it.

2076:

RC: How was the capillary rise considered in the model?

AC: It was considered as a part of the net recharge. In the article it will be included: "In addition, a model has been built for the unsaturated top part of the CCL allowing the assessment of the precipitation surplus (Q_{prec} - Q_{cap}) required for the saturated model (see section 5.2.3)."

RC: At the research area the flow through the CCL is downward which means that the Q_{up} can be neglected. A thorough analysis of phreatic groundwater levels in the CCL and piezometric levels for the sandy aquifer indicated this flow direction. ! please explain more detailed how this finding was obtained, were there filter screens at different depths, what is the vertical gradient, show the filter screen locations etc.

AC: See new figure added (Figure 3) at page 2070. I think is clear now.

2077:

RC: How was Modflow used within the peat? If the peat is unconfined, were confined/unconfined model cells used?

AC: See Fig 8. In Layer 1 unconfined model cells were used and for Layers 2-4 confined/unconfined model cells were used.

RC: If the peat is unsaturated, how was the unsaturated zone considered?

AC: The unsaturated root zone was considered in a separate water balance model of the unsaturated soil which was is implemented in an Excel spreadsheet and takes into consideration the rainfall, the evapotranspiration, a land use factor, soil type and a threshold for surface runoff (see section 5.2.3).This model supplied the input data for groundwater recharge from precipitation.

RC: Which PMWIN-Modflow version was used, especially which MODFLOW-Version was used, and which packages were implemented?

AC: PMWIN-MODFLOW 5.3.0 version was used and the packages of Recharge and River were implemented. This will be added in the article.

RC: elevations of the land surface which varied between -1.9 up to 2.7m below sea level. ! -2.7 m

AC: Ok, it will be changed

RC: The bottom of the CCL varies between -8.4m and 9.1m below sea level. ! -9.1 m

AC: *Ok, it will be changed*

RC: Slug test experiments carried out during the fieldwork, permeameter laboratory tests completed by the Wageningen University and Research Centre, different literatures that discuss the permeability of the CCL (e.g. Weerts, 1996), and pumping tests carried out in nearby pumping stations for domestic water supply were considered in providing the data to set up the hydraulic conductivities and storage parameters for the different model layers. ! show and compare also the other non-proprietary values

AC: In the following table the horizontal and vertical hydraulic conductivities from non-proprietary values are presented. The following table will be presented:

Table X Horizontal and vertical hydraulic conductivity from different sources

	Soil	Weerts (1996)		Orup (2009)	WU research	Cheng (2004)		Slug tests
		K_h (m/d)	K_v (m/d)	K_v (m/d)	K_v (m/d)	K_h (m/d)	K_v (m/d)	K_h (m/d)
1	Compacted peat	0.025	0.018	0.001				
2	Peat	0.18	0.18	0.52	0.35	0.03	0.006	
3	Clay and humic clay	0.0024	0.0009	(0.1)		0.025	0.005	
4	Clay	-	-	0.0003	0.0024			
5	Muddy peat + clay/peat				2.69			1.3
6	Clay/**peat** (little mud)							0.60
7	**Clay**/silty peat (little mud)							0.17
8	Fine/coarse sand	17.6	16			20	4	

RC: To satisfy anisotropic conditions, ratios between the horizontal and vertical hydraulic conductivities, varying from 1 to 5, were adopted for the peaty and clayey model layers in the CCL. ! explain the selection of these values

AC: Sorry, it should say "varying from 1 to 2.7". These values were obtained from Weerts (1996). The reference will be included in the article.

2078:

RC: For the peaty layers with a phreatic response in the CCL the levels, ranging from -2.3 to 2.9m below sea level, were obtained from so called GxG maps. ! -2.9 m, how was the phreatic behaviour justified, what does GxG mean, reference?

AC: GxG maps are official maps which have been compiled on the basis of groundwater head (level) measurements in boreholes monitoring the phreatic layer and the application of interpolation techniques (this explanation will be included in the article). The phreatic behaviour was justified given that this layer has no confining layer above and due to the quick response of the levels to recharge (see figure 3 added)

RC: The levels covered the range from -2.9 to 3.9m below sea level. ! -3.9 m

AC: *Ok, it will be changed*

RC: An unsaturated mo del for the root zone supplied the input data for groundwater recharge from precipitation. ! which model, was the outcome used as recharge for Modflow, or how was the unsaturated zone considered in the model?

AC: See explanation above (2077). The unsaturated model was a self-made Excel spreadsheet and the outcome was used as net recharge on MODFLOW.

RC: Is the capillary uprise considered here in the unsaturated zone model?

AC: Yes, it is considered. It is stated in the article that the model "computes net recharge as the balance between downward recharge and capillary rise."

2079:

RC: The open water levels at the river and ditches in the model area are controlled by HDSR and maintained at a fixed position for winter and summer conditions. ! please provide some numbers

AC: The winter and summer levels of the ditches surrounding the experimental plot were already provided in 2069. The levels are not the same for the whole model area.

RC: The analysis showed that increases or decreases of 50% in the values for the hydraulic conductivity of the CCL and the groundwater recharge resulted in phreatic groundwater level changes of less than 0.1m and piezometric groundwater level changes were even below 0.01 m. ! what are piezometric groundwater level changes? All water levels are measured in piezometers, please change the formulation, as this wording is not correct; the authors most probably refer to heads in the CCL and in the sandy aquifer below, please indicate the vertical position of the head measuring level

AC: Ok, it will be changed

RC: The hydraulic conductivity is a bit less sensitive than the recharge. The transient models require the input of storage parameters like the specific yield and this parameter is also sensitive. From a general point of view, however, the sensitivity of model parameters is not that large which could be attributed to the control which the open water levels at the ditches exert on the groundwater levels. ! this is a little bit imprecise, please provide numbers

AC: Numbers will be provided. In the article it will be changed to: " The transient models require the input of storage parameters like the specific yield and the value of this parameter, as a result of an increase of 50% in its value, has a phreatic head change of 0.08 m. This indicates a sensitivity of a similar order than the sensitivity of the conductivity or the recharge. Referring to the numbers mentioned the sensitivity of model parameters is not that large. This could be attributed to the control which the open water levels at the ditches exert on the groundwater heads".

2080:

RC: For the transient model computed phreatic and piezometric groundwater levels could be compared with groundwater levels measured during the fieldwork in the upper peaty layers of the CCL and in the sandy first aquifer. ! see above, ! what are piezometric groundwater level changes? All water levels are measured in piezometers, please change the formulation, see above!

AC: Ok, it will be changed

RC: Please provide a calibration plot (measured versus simulated heads)!

AC: *A plot of differences between observed heads and computed heads is provided below. We did not include it in the article since we mention the mean value of the error in the text and we wanted to save space. In case you think it is better to include it in the article we can do this.*

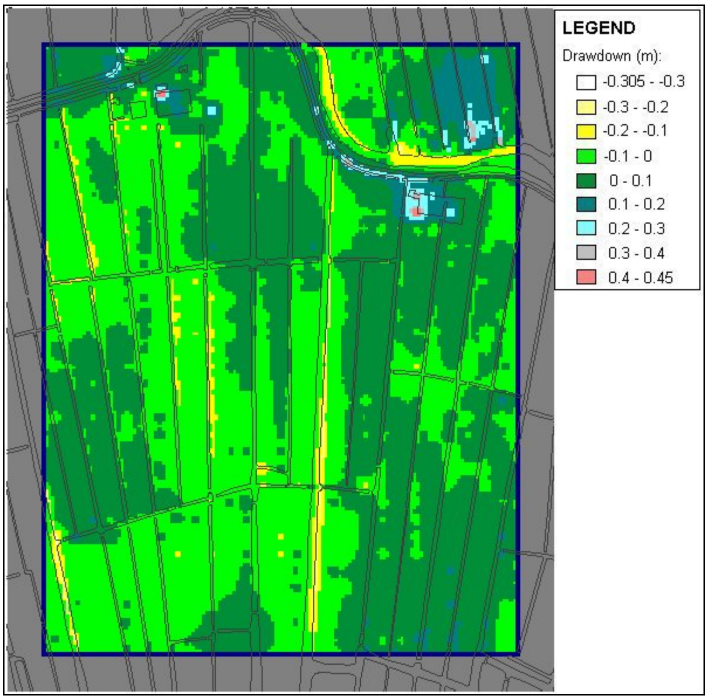


Figure X Discrepancies between the groundwater levels of the calibrated model and measured heads

RC: The equivalent value for the horizontal conductivity was obtained from the total horizontal transmissivity of the CCL and was calculated as Kh = 0.961md -1: The equivalent vertical conductivity was elaborated from the total resistance across the CCL. ! please describe the averaging approaches in detail, what does total resistance mean?

AC: The equivalent value for the horizontal conductivity was computed as the total horizontal transmissivity (T) of the CCL divided by the thickness of this layer ($K_h = T/d$) resulting in a K_h value of 0.961 m d^{-1}. The total transmissivity of the aquifer is the sum of the transmissivity of the different layers ($T=\Sigma k_{hi}d_i$).The equivalent vertical conductivity was elaborated from the thickness of the CCL divided by the total vertical resistance (R) across this unit ($K_v=d/R$). The vertical resistance of the aquifer was computed as the sum of the resistance of the different layers ($R=\Sigma R_i=\Sigma d_i/k_{vi}$). Some parts of this description will be added in the text.

2081:

RC: Additional hypothetical models have been prepared to study the path lines and travel times for typical upward flow through the CCL. ! please provide more information on this, references etc.

AC: These latter models have been prepared given that in other peaty environments in the western part of The Netherlands, the dominant flow of the water particles is upward (Gonzales et al., 2009).

2082:

RC: Transient hypothetical models have been used to generate pathline patterns and compute travel times for upward flow through the CCL. ! please provide more information on these models (setup, boundary and initial conditions etc., what is hypothetical, . . .)

AC: "The upward flow models have the same set-up, boundary and initial conditions than the downward flow models, the only difference being that the groundwater heads in the confined aquifer are higher than the heads in the phreatic aquifer". This will be added in the article.

RC: For comparative reasons, the absolute differences in phreatic and piezometric groundwater levels for the models were similar than for the models simulating downward flow. ! All water levels are measured in piezometers, please change the formulation, see above!

AC: Ok, it will be changed

2083:

RC: Uncertainties in modeling arising from the heterogeneity in peat soils and the applicability of Darcy's law could be eliminated through a proper model set up. ! please remove this sentence, as the authors mention the Darcy's law issue is not clear yet etc.

AC: Check if it is clear now with previous Darcy's law explanation. This issue is clear.

2085:

RC: The conclusion is that groundwater models that are based on the representation of the CCL with one homogeneous model layer are less suitable for assessments on groundwater transport where travel times play an important role. In particular when they are considered for the simulation of contaminant transport, models with a homogeneous CCL should not be used. ! Comment: These findings are somehow trivial. It is not surprising that a more detailed representation of reality will provide better results! ! additional text is recommended here!

AC: Yes, it is trivial that a more detailed model representation of reality will provide better results, but it is not trivial that the differences in the travel times between the simplified and detailed model are so important (double). In the article the text will be changed into: "The conclusion is that groundwater models that are based on the representation of the CCL with one homogeneous model layer are not suitable for assessments on groundwater transport where travel times play an important role. Taking one homogeneous layer could even result in the computation of travel times that are even double the ones for the heterogeneous case.

2087, 2089 and 2090:

RC: the borehole locations should be indicated in Figure 1!

AC: Ok, they will be indicated

2091:

RC: please provide water levels

AC: The water levels in boreholes BH2, BH3 and BH4 are already plotted for the winter period in the new figure added (Fig. 3). This figure is a schematization of the soil. A comment on the average value of the water levels for the steady state case will be provided in the caption of this figure and this GLW will be schematized.

2092:

RC: location of the profile should be indicated in Figure 1

AC: Ok, it will be indicated in Fig 2 (it is clearer than in Fig 1)

RC: Fig. 4a needs more explanation. What is shown in Fig. 4a?

AC: Fig 4a. shows a plot of field resistivity against half of the electrode distance. The type of the curve indicates that 3 layers are differentiated.

2093:

RC: where is borehole N5? Please provide location in Figure 1.

AC: Ok, it should have said BH5 instead of N5 to be consistent. It will be changed.

RC: N5 is not mentioned in Tab.1

AC: BH5 is mentioned.

2094:

RC: please provide water levels.

AC: They were provided already in other two figures (for steady state and for winter conditions). This is the schematization of the soil and the water levels vary in the transient model.

2095:

RC: what is the meaning of “Model” in the arrow box?

AC: It will be deleted

RC: what is GMO?

AC: It will be deleted

RC: fresh/saline interface ! please add water twice

AC: Ok, it will be added

RC: indicate water levels

AC: Water levels cannot be seen here, as they are very shallow water tables.

2096-2101:

RC: explain the blue arrows and the blue boxes (ditches) in the figure captions

AC: The blue boxes are the ditches included in the model with the River package. The blue arrows are velocity vectors which describe the directions of water movement at any instant of a given time step of the simulation. This will be included in the figure captions

RC: provide lengths in all figures, indicate water levels at least for the steady state scenarios

AC: Ok, length will be provided in all figures. The water levels are already indicated with a black line.