1D groundwater level prediction model

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Purpose

To show how simple 1D groundwater models can be developed to inform groundwater elevation based decisions for remediation and infrastructure projects.

More complex models are available using advanced algorithms.

Using a case study example of how a simple 1D groundwater elevation prediction model was developed and applied to answer a site specific problem.

Overview

The case study:

- The issue related to understanding how often a contaminated groundwater plume would discharge into a peripheral drain capture system. This drain discharged to a potentially sensitive surface water feature and therefore represented a potential risk to the environment.

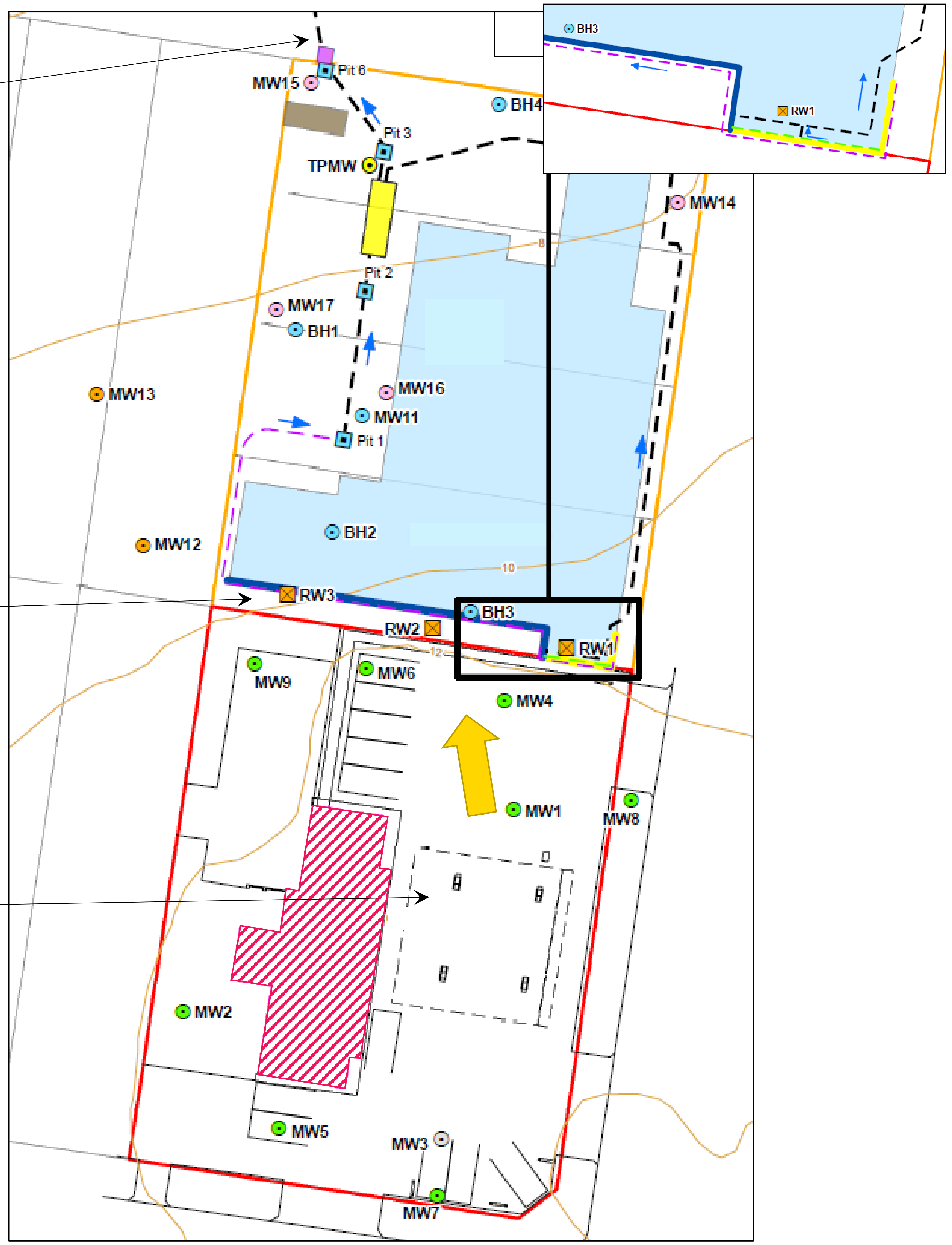
- A nine month daily groundwater monitoring data set was available but the client needed to resolve overall environmental risks via this pathway on a long term basis.

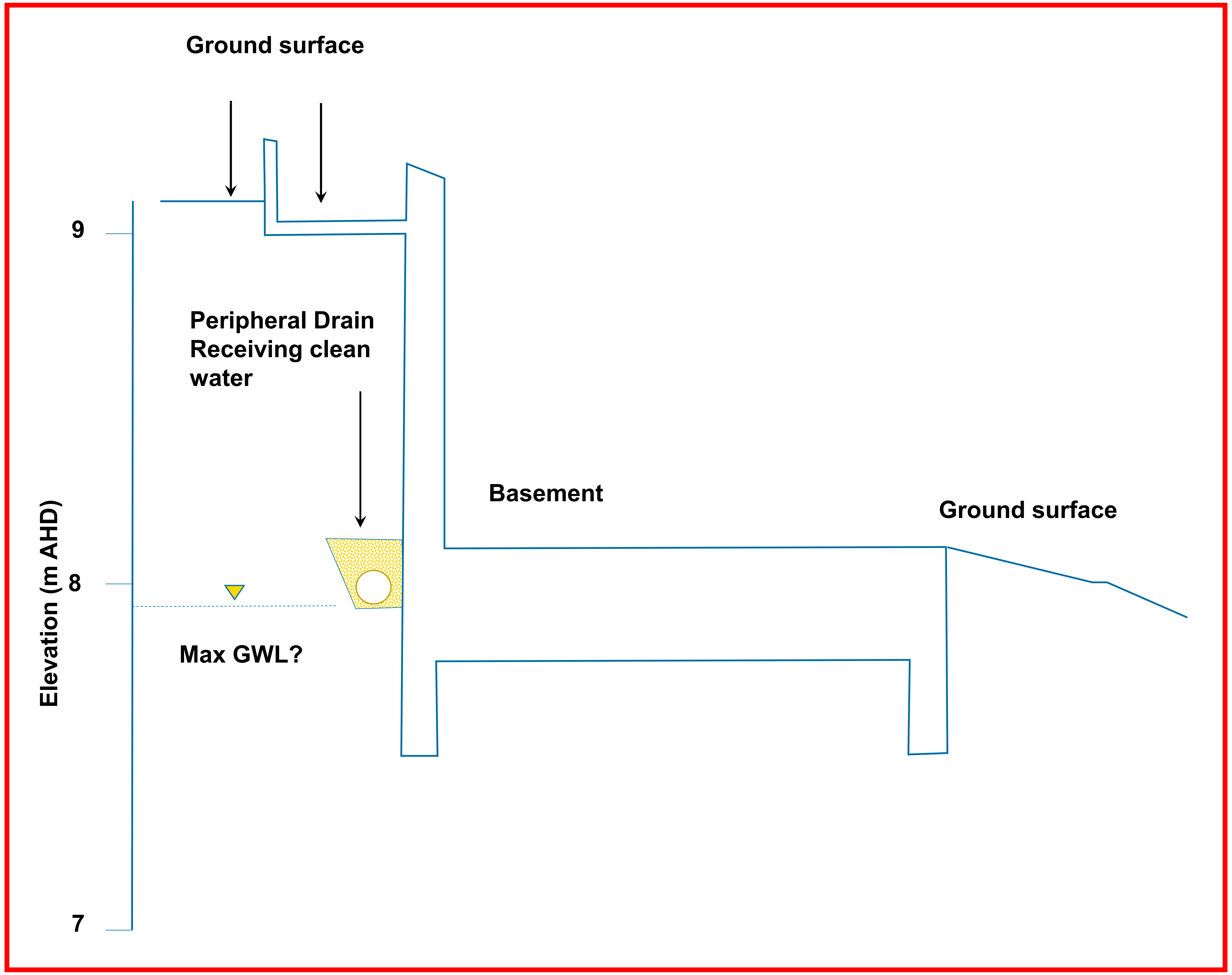
Site Overview

Offsite Drainage

Peripheral Drain

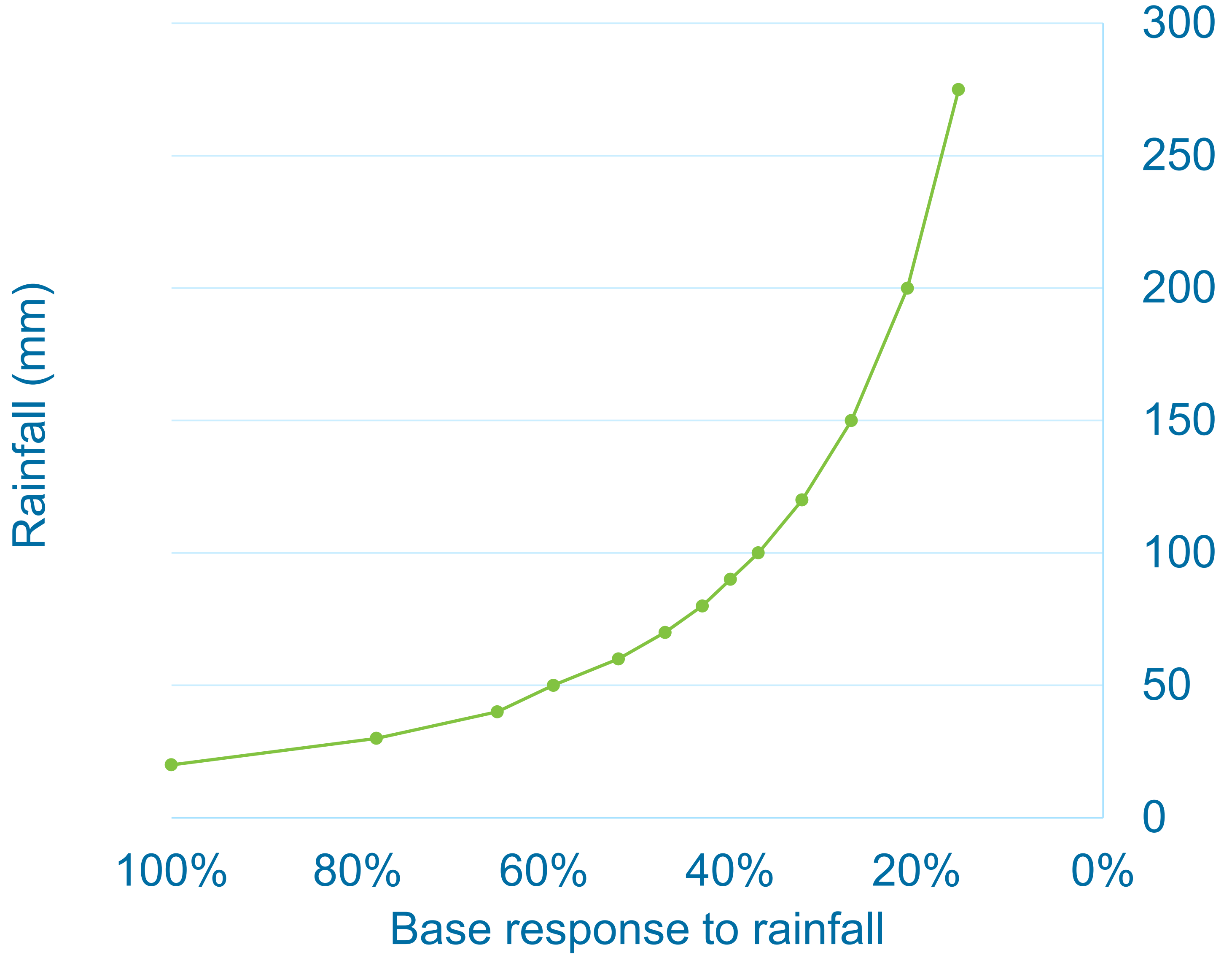
Source of impact

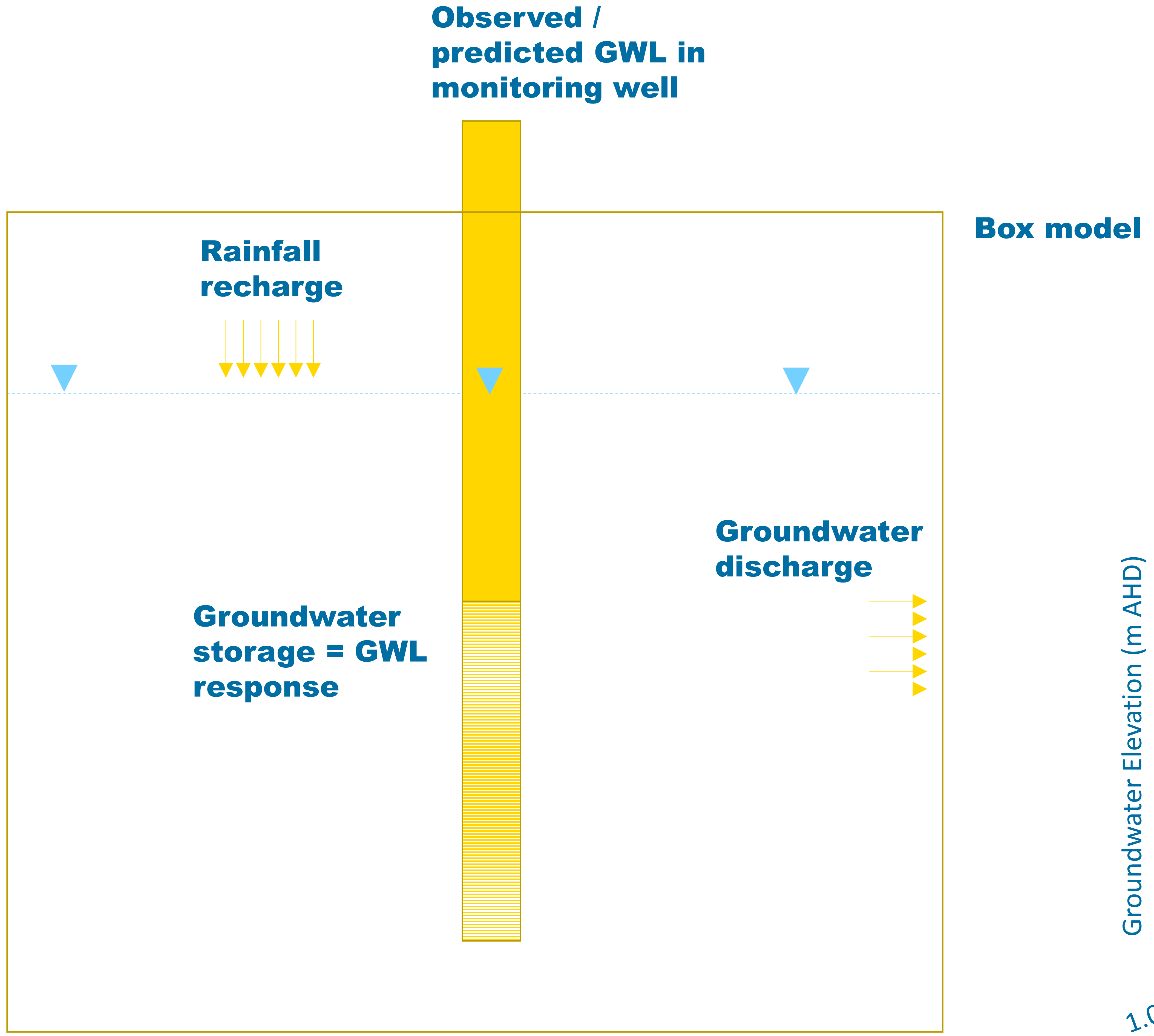




Two components to convert rainfall recharge to GWL response (storage change):

- **Base response rate (turned out to be around 100 in this instance [mm to m]).**
- **Variable response associated with groundwater elevation – as GWL gets higher the base response gets smaller.**

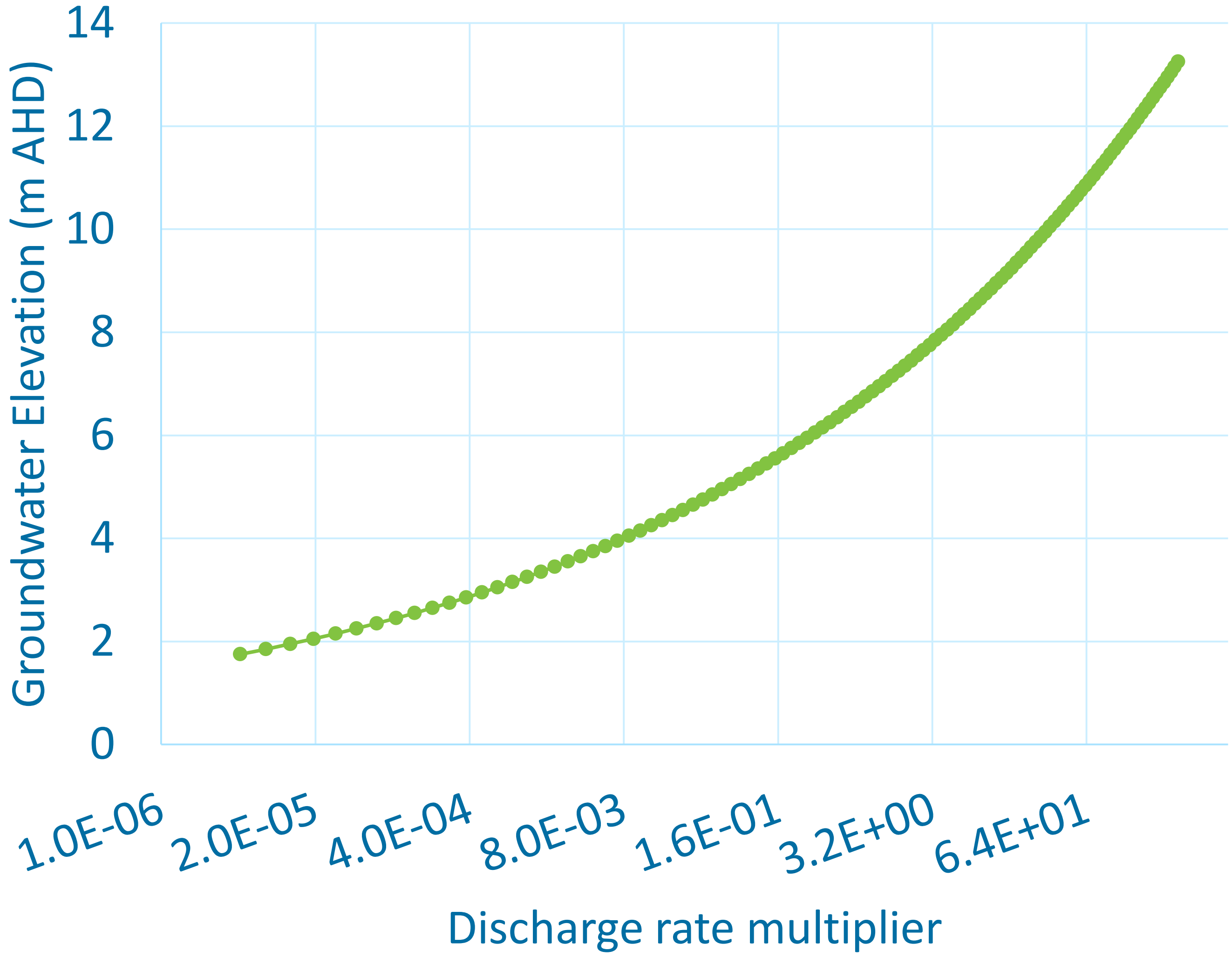


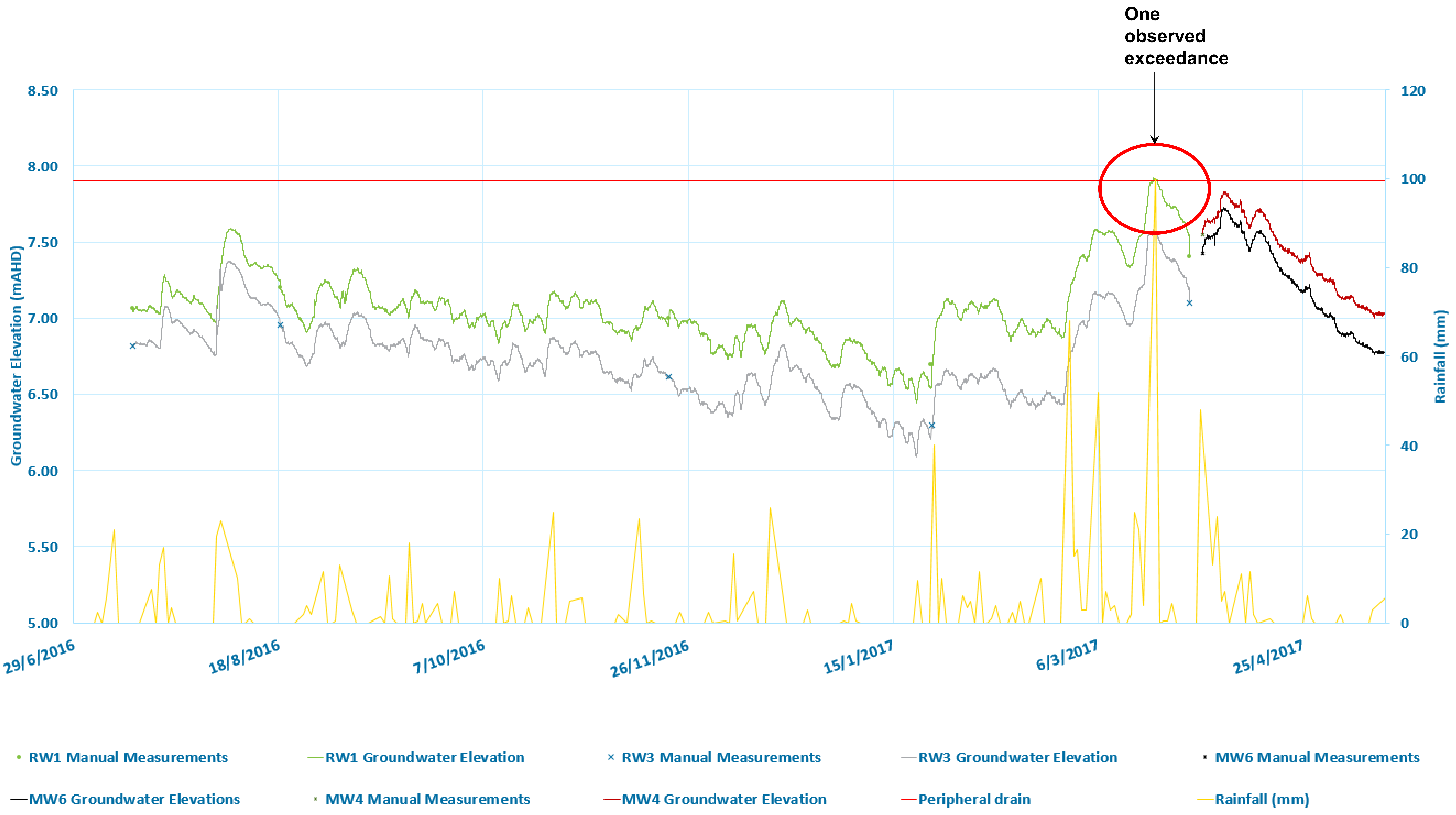


Spreadsheet based model

Two components to covert rainfall recharge to GWL response (storage change):

- **Base discharge rate.**
- **Variable discharge rate associated with groundwater elevation – as GWL gets higher the base discharge rate gets larger.**



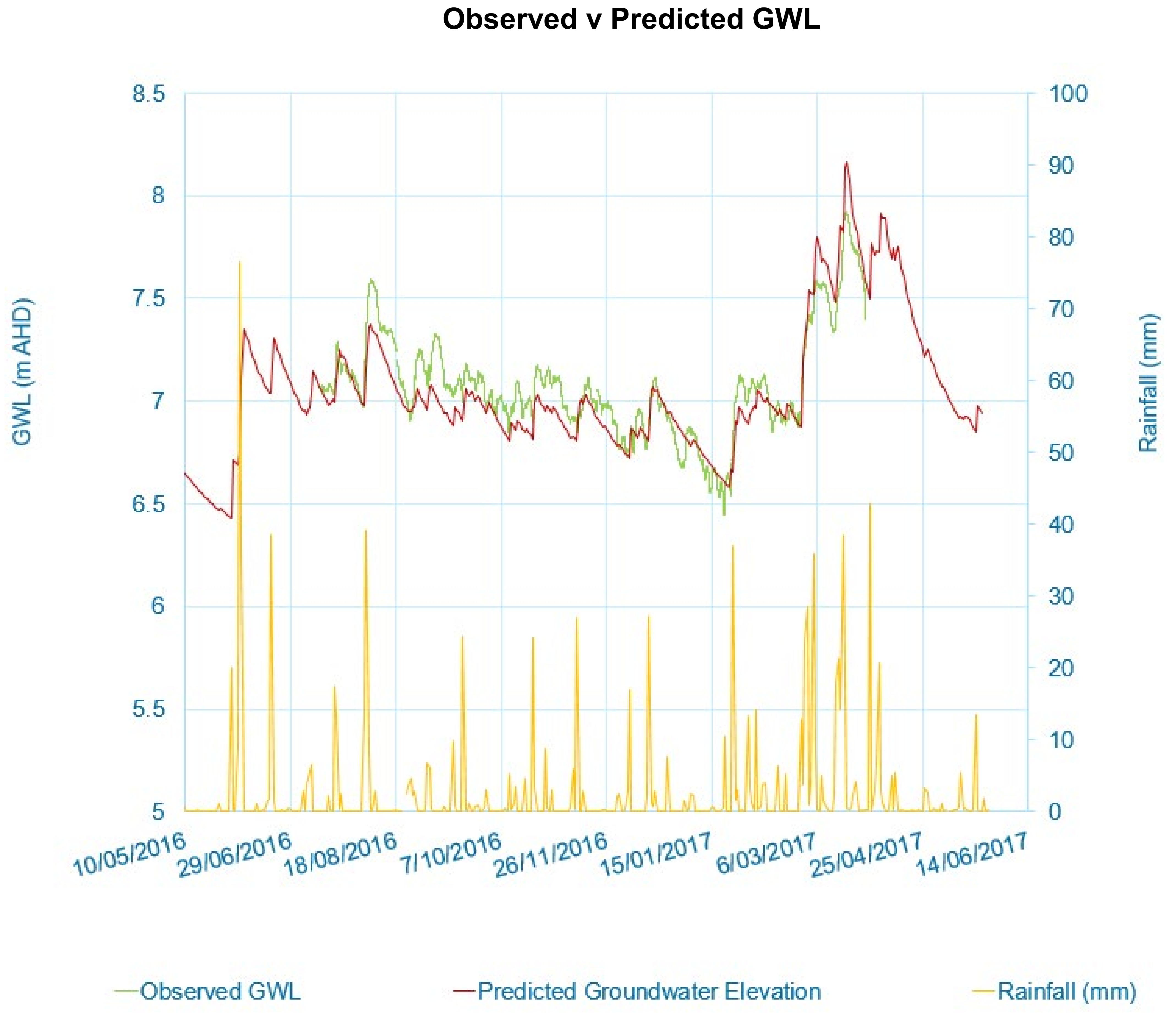

One observed exceedance
Groundwater Elevation (mAHD)
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
Rainfall (mm)
120
100
80
60
40
20
0
29/6/2016
18/8/2016
7/10/2016
26/11/2016
15/1/2017
6/3/2017
25/4/2017
RW1 Manual Measurements
RW1 Groundwater Elevation
RW3 Manual Measurements
RW3 Groundwater Elevation
MW6 Manual Measurements
MW6 Groundwater Elevations
MW4 Manual Measurements
MW4 Groundwater Elevation
Peripheral drain
Rainfall (mm)

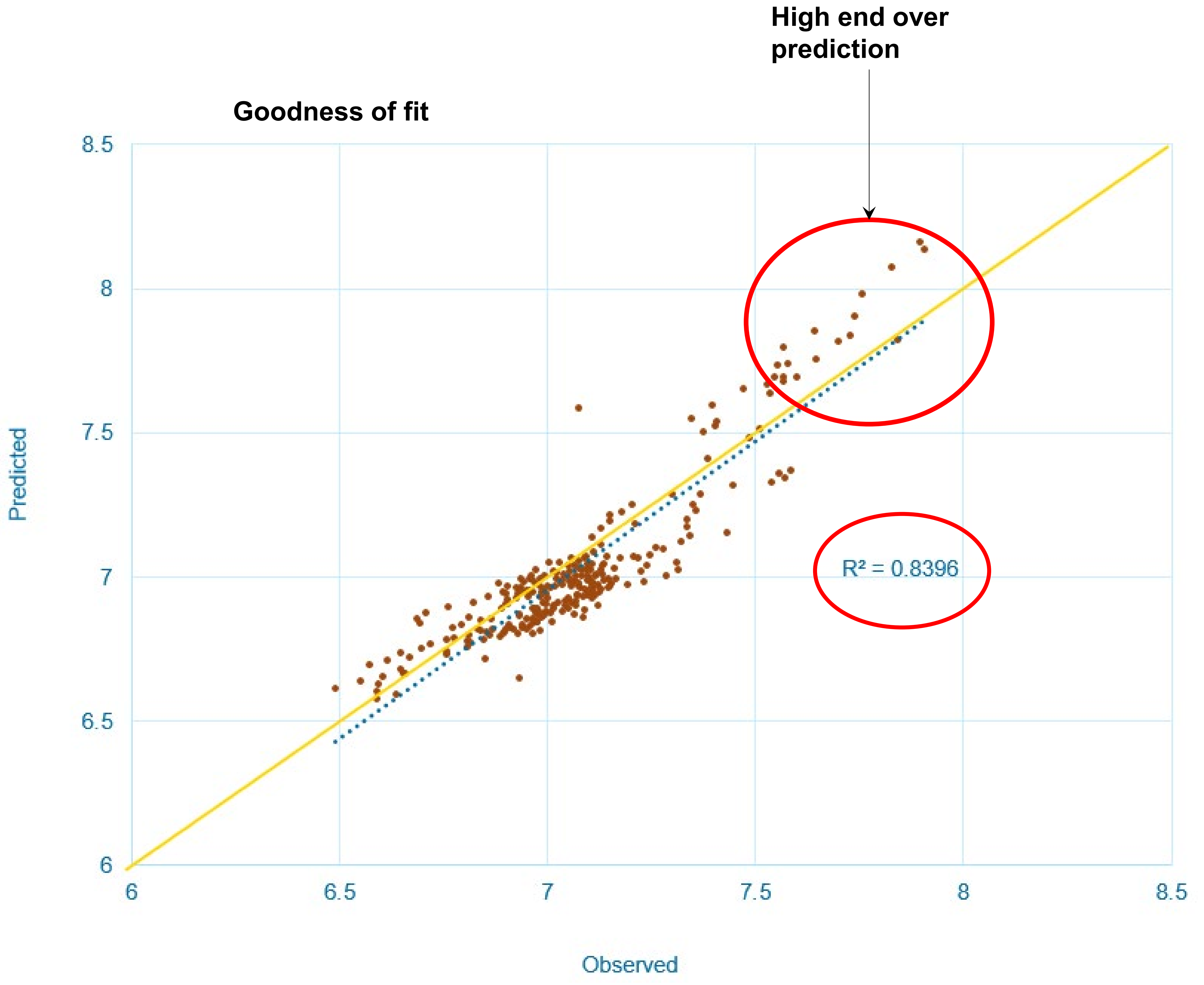
Calibration

Iterative approach adopted where by the four input parameters were varied until a good fit was achieved.

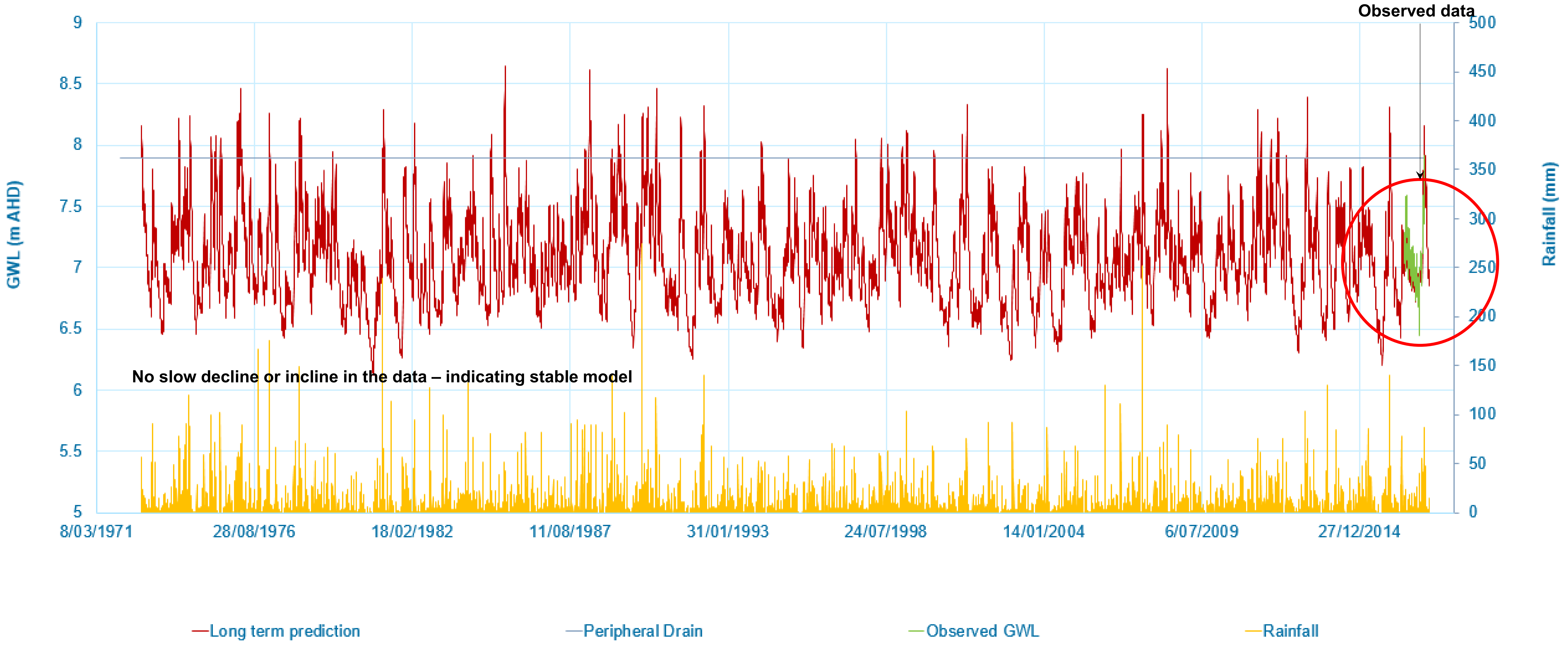
Spreadsheet outputs (predicted GWL and goodness of fit) were designed so that a change in input parameters could be immediately seen on the outputs. This facilitated efficient calibration.

Results


Observed v Predicted GWL
8.5
8
7.5
7
6.5
6
5.5
5
100
90
80
70
60
50
40
30
20
10
0
GWL (m AHD)
Rainfall (mm)
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
Observed GWL
Predicted Groundwater Elevation
Rainfall (mm)


High end over prediction
Goodness of fit
8.5
8
7.5
7
6.5
6
6
6.5
7
7.5
8
8.5
Predicted
Observed
R² = 0.8396

Results – Long term predicted GWLs



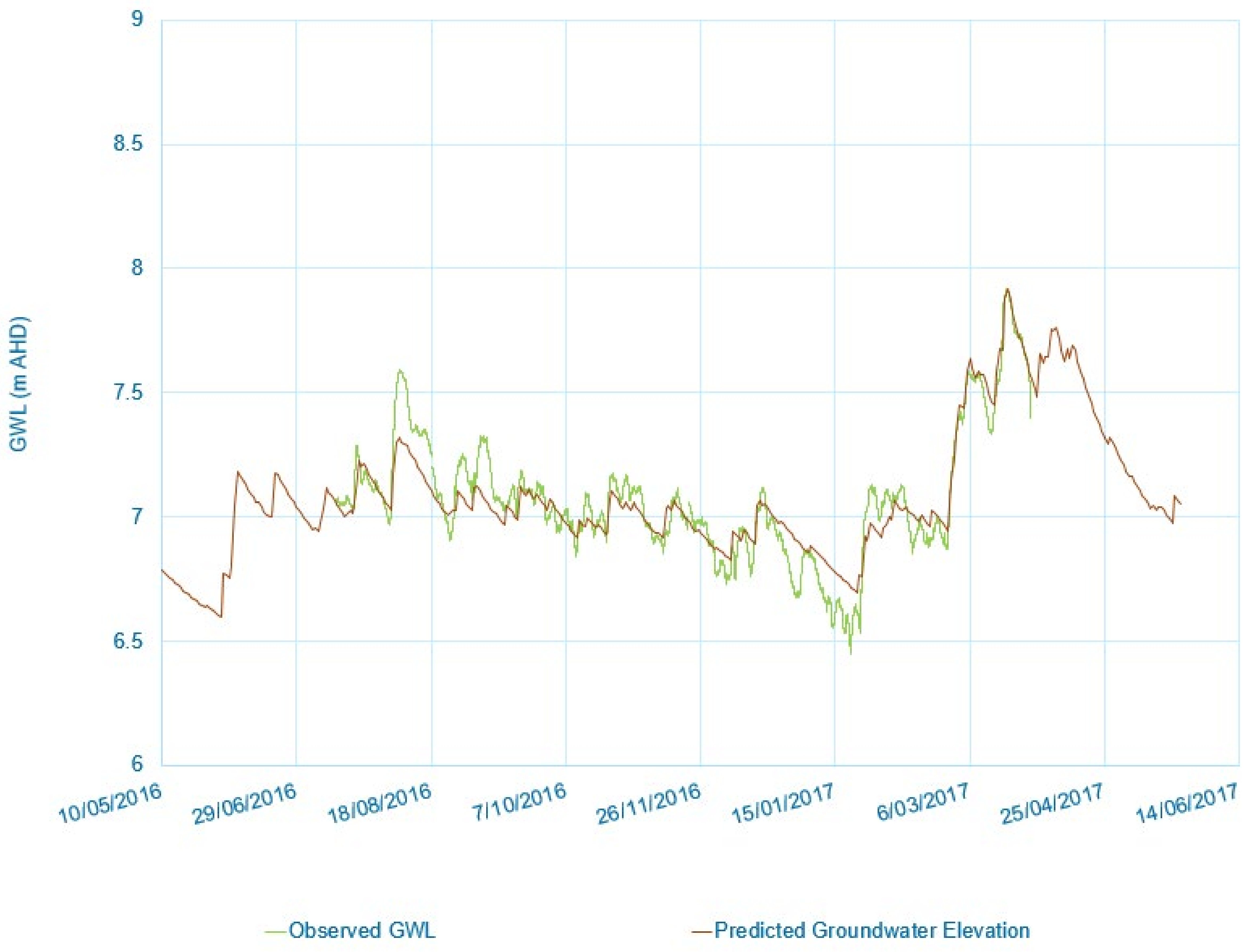
Uncertainty analysis

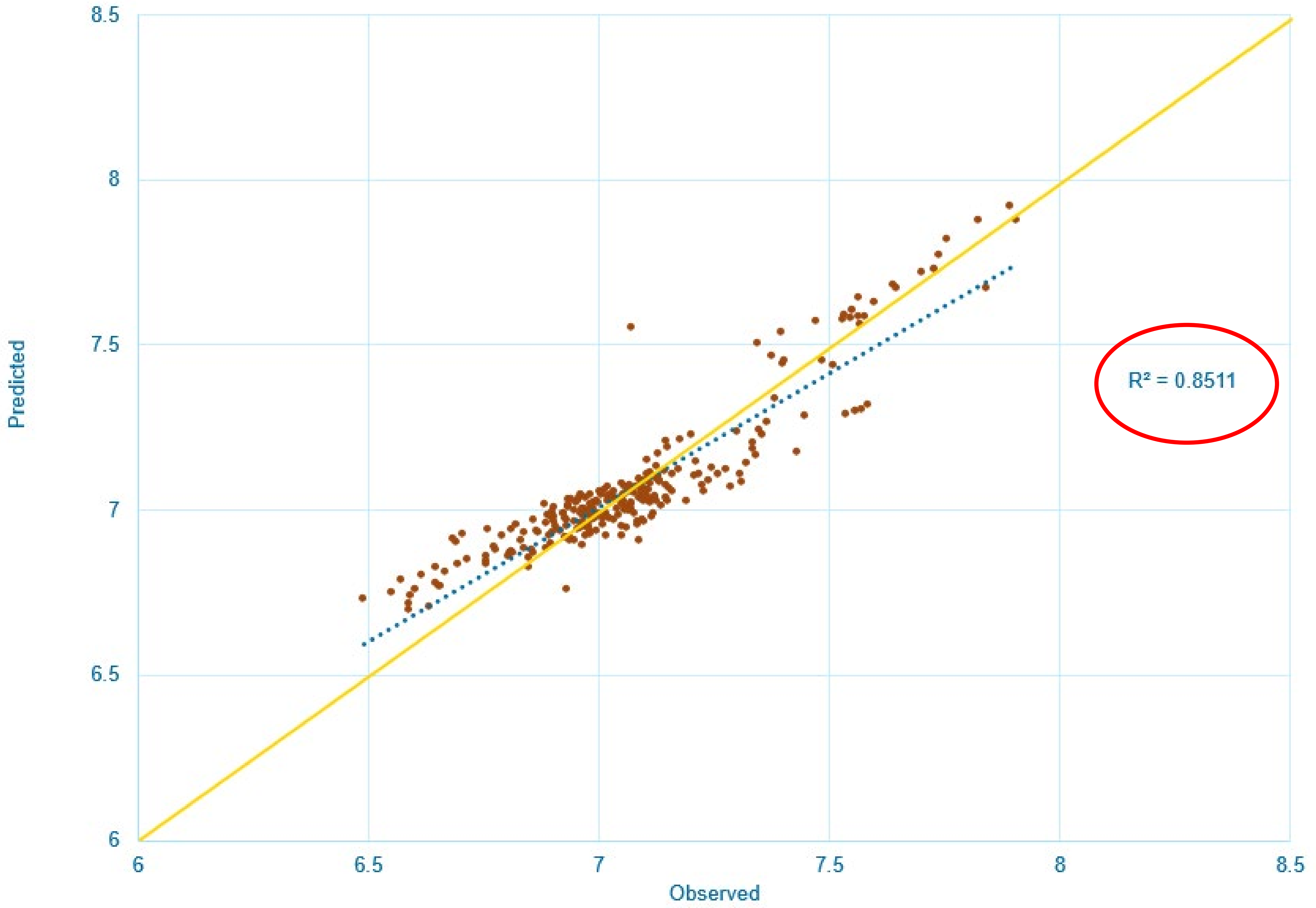
Aim was to stress the model by re-calibrating under higher and lower recharge conditions.

Iterative approach adopted.

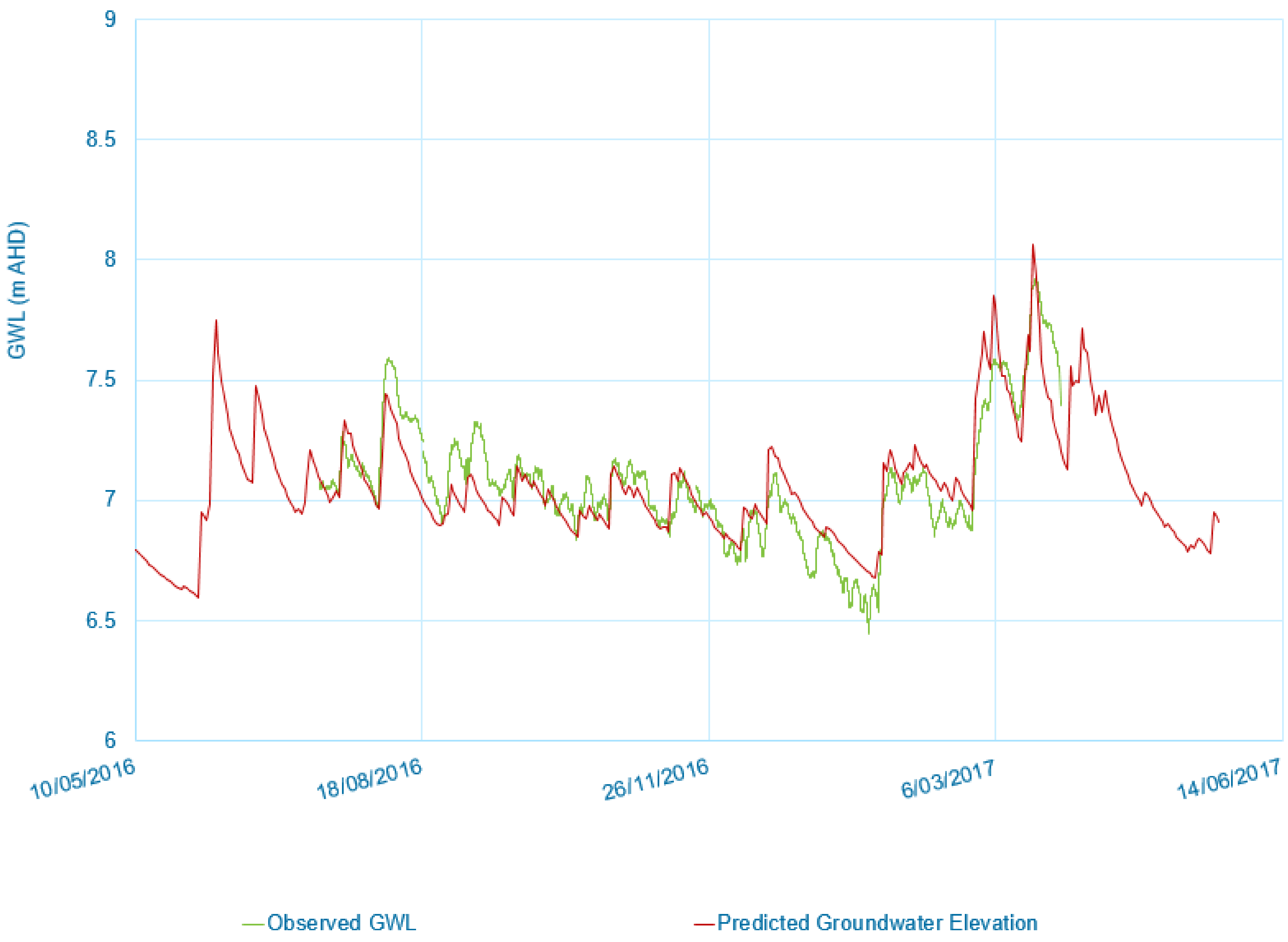
Recharge varied by 0.8 to 1.2 times base case.

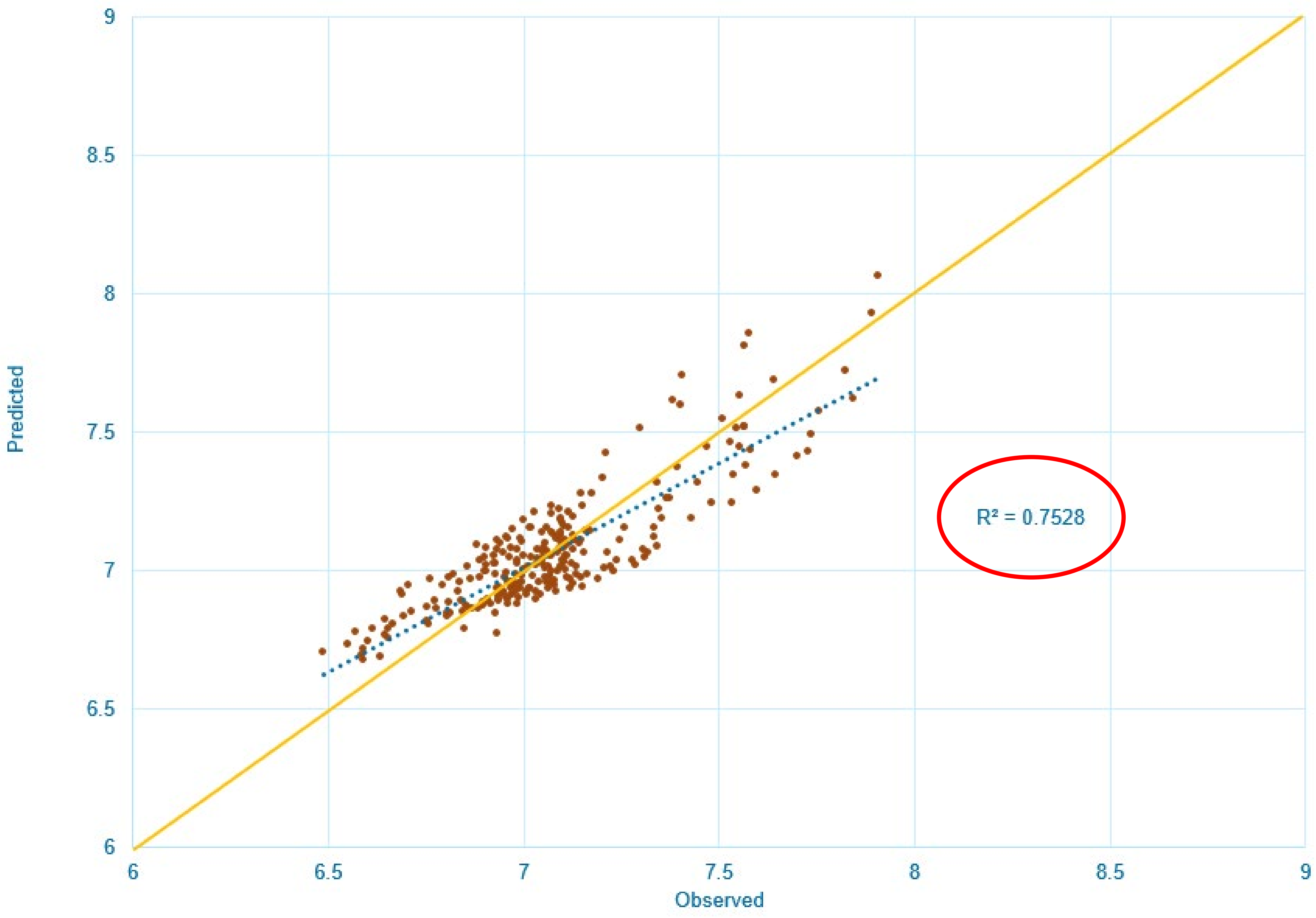
Uncertainty analysis – Low recharge model





Uncertainty analysis – High recharge model





Applications

- Predicting worst case groundwater elevations to support remediation/infrastructure design projects.

- Supporting 3D groundwater modelling by generating synthetic data sets.

- Predicting occurrence rates of groundwater elevations for the purposes of understanding inflows to GDE’s such as ponds, lakes, springs and creeks.

Limitations

- The model has only been tested on unconfined sand aquifers to date.

- A baseline data set that covers the range of GWLs required for prediction is preferred.

- The model is one dimensional only. If the physical conditions change over space and time the validity of the model will be reduced.

- Simple easily identifiable stressors (other unknown stressors may create issues with calibration).

Relevant reference for complex models

- Wang, X.; Liu, T.; Zheng, X.; Peng, H.; Xin, J.; Zhang, B.; *Short-term prediction of groundwater level using improved random forest regression with a combination of random features*; Applied Water Science (2018) 8:125.

- Li, H.; Lu, Y.; Zheng, C.; Yang, M.; Li, S.; *Groundwater level prediction for the arid oasis of northwest china based on artificial bee colony algorithm and a back propagation neural network with double hidden layers*; Water 2019, 11, 860.

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