iNUX Interactive Documents: **Overview and Examples for Applied Hydrogeology**

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Disclaimer

This document represents a static snapshot of the *iNUX Interactive Documents Overview and Examples for Applied Hydrogeology* at the time of publication.

The most recent online version is available at the gw-inux GitHub repository:

https://github.com/gw-inux/iNUX-Handbook/tree/main/Examples_Applied_Hydrogeology

Content

1 Purpose and Scope

This report provides a concise overview of active interactive documents hosted in the iNUX GitHub repository and documented through the iNUX Web Catalog (Reimann et al. 2025; see access link below). The focus is on resources that are currently accessible and in use, including interactive **Streamlit applications**, which are primarily designed for guided exploration of hydrogeological concepts through user-controlled visualizations, parameter adjustments, and embedded explanatory content.

In addition to Streamlit apps, iNUX also provides selected interactive documents as **Jupyter Notebooks**. Notebooks are particularly suitable for model demonstrations and computational workflows because they combine narrative text, executable code, and results in a single document. This format supports advanced numerical methods (e.g., flow and transport simulators), allows transparent documentation of assumptions and parameter choices, and enables users to reproduce or modify analyses directly.

The short report aims to:

- document the availability and usage of interactive documents for the broader topic 'Basic Hydrogeology' (i.e., typically suitable for undergraduate education),
- summarize usage statistics for Streamlit applications (as of the end of December 2025),
- and highlight a small selection of the most frequently accessed examples.

The complete overview of the interactive documents is provided by the iNUX Catalog

→ https://gw-inux.github.io/iNUX-Interactive-Documents/

and the GitHub repositories

→ https://github.com/gw-inux/iNUX-Interactive-Documents

→ https://github.com/gw-inux/Jupyter-Notebooks

2 Availability of Interactive Documents and Usage Statistics

2.1 Streamlit Applications

For interactive documents deployed as Streamlit applications, usage statistics are available as unique access counts provided by the Streamlit hosting platform. A large part of the iNUX interactive documents is implemented as Streamlit applications and hosted through the Streamlit Community Cloud. An overview of the available Streamlit applications is provided under:

- https://share.streamlit.io/user/thoreimann
- https://share.streamlit.io/user/thoreimann-0432

Table 1 lists the Steamlit applications together with their categorization index and the number of unique accesses since deployment (the total number of accesses is typically higher due to returning users). These statistics provide an indicator of global usage, visibility, and sustained interest in the deployed resources.

Number	Name of the app	Number of unique users in Streamlit Community Cloud	Access	iNUX Catalog ID
1	Boundary Conditions Module	305	https://gwp-boundary-conditions-analysis.streamlit.app/	08-10-001
2	Dewatering Exercise	343	https://dewatering-exercise-app.streamlit.app/	07-01-001
3	Finite Difference Numerical Scheme	300	https://gwf-1d-conf-fd.streamlit.app/	08-02-001
4	Slugtest evaluation	67	https://slugtest-multilingual.streamlit.app/	06-04-004
5	Soil Water Retention Module	58	https://gwp-soilwaterretention.streamlit.app/	04-02-001
6	The Ghyben-Herzberg relationship	38	https://ghyben-herzberg.streamlit.app/	07-07-001
7	Reservoir head – Introduction / Example to Model Calibration	37	https://lumpedmodel-reservoir.streamlit.app/	08-07-001
8	3D Heat transport	33	https://3d-heat-transport.streamlit.app/	07-10-001
9	Recharge Estimation with the Water Table Fluctuation Method	30	https://wtf-recharge.streamlit.app/	01-05-001
10	Green-Ampt Infiltration - Introduction	< 30	https://green-ampt-intro.streamlit.app/	04-05-001

Table 1: Streamlit applications and number of unique accesses

2.2 Jupyter Notebooks

In addition to Streamlit applications, iNUX provides selected interactive documents as Jupyter Notebooks. These documents are typically not deployed through a centralized hosting platform that provides comparable usage statistics. Instead, they are accessed via the iNUX GitHub repository and typically executed locally. Jupyter Notebooks primarily serve as transparent model demonstrations and computational workflows, complementing the Streamlit apps by supporting reproducibility, code inspection, and advanced numerical analyses.

Table 2 lists five popular Jupyter Notebooks that were frequently used in education.

Number	Name of the Jupyter Notebook	Access	iNUX Catalog ID
1	Pumping test interpretation Cooper-Jacob Method	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/06_Experimental_Techniques_and_Methods/04_Aquifer_Characterization_Techniques	06-04-002
2	Analytical solution for 2D instantaneous solute transport injection in porous media (with decay)	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/05_Hydrogeochemistry_and_Contaminant_Transport/06_Reactive_Solute_Transport	05-06-002
3	MODFLOW CFP - response to discharge event	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/08_Groundwater_Modeling/06_Coupled_Models	08-06-001
4	Solute Transport Simulation with MT3DMS - 1D Transport in a Uniform Flow Field	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/08_Groundwater_Modeling/04_Transport_Modeling	08-04-003
5	Modflow-2005/MODELMUSE Tutorial - synthetic	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/08_Groundwater_Modeling/03_Flow_Modeling	08-03-001

Table 2: Selected Jupyter Notebook applications

3 Selected Examples of Frequently Used Interactive Documents

This report includes (attached) separate documents for ten Streamlit applications and five Jupyter Notebooks that were most frequently used at the time of reporting (see Tables 1 and 2). The selection is based on access statistics and usage and does not imply a qualitative ranking.

For each selected example, an overview document based on the information of the iNUX catalog is attached that provides a standardized insight and description of the interactive documents. The following examples are attached:

Streamlit application

- 08-10-001 Boundary Conditions Analysis Module
- 07-01-001 Dewatering Exercise
- 08-02-001 Finite Difference Numerical Scheme
- 06-04-004 Slugtest evaluation
- 04-02-001 Soil Water Retention Module
- 07-07-001 The Ghyben-Herzberg relationship
- 08-07-001 Reservoir head – Introduction / Example to Model Calibration
- 07-10-001 3D Heat/Solute transport
- 01-05-001 Recharge Estimation with the Water Table Fluctuation Method
- 04-05-001 Green-Ampt Infiltration - Introduction

Jupyter Notebooks

- 06-04-002 Pumping test interpretation Cooper-Jacob Method
- 05-06-002 Analytical solution for 2D instantaneous solute transport injection in porous media (with decay)
- 08-06-001 MODFLOW CFP - response to discharge event
- 08-04-003 Solute Transport Simulation with MT3DMS - 1D Transport in a Uniform Flow Field
- 08-03-001 Modflow-2005/MODELMUSE Tutorial - synthetic

Acknowledgment

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References

Reimann, T., Sinha, N., Liedl, R., Giese, M., Barthel, R., Grießer, E., Birk, S., Bertran, O., Fernandez-Garcia, D. (2025). iNUX Interactive Documents: Web Catalog of Digital Learning Resources. Available under https://github.com/gw-inux/iNUX-Handbook/tree/main/Catalog

The Boundary Condition Analysis Module

Topic: 08 Groundwater Modeling → 08-10 MODFLOW Concepts, Packages & Tools
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwp-boundary-conditions-analysis.streamlit.app/
Time required	4-8 hours

2. Pedagogical overview

Short description
Groundwater models are only as good as the accuracy of both the system representation (including boundary conditions) and the values of observations used to calibrate the model. This interactive module is designed to deepen the understanding of the basic ways in which different types of boundary conditions - specified head, specified flow, and head-dependent flow - influence the magnitude and direction of groundwater flow when used in solving the partial differential equation for groundwater flow.

This module offers intuitive visualizations, conceptual explanations, and interactive tools to help bridge theory and application for beginning modelers, advanced students, and practicing hydrogeologists.

This module is intended for beginners who know a little about groundwater models and are ready to learn about boundary conditions, as well as advanced and experienced users who wish to refresh their understanding of specific boundary types. A basic familiarity with hydrogeology and groundwater flow is recommended, but no prior experience with MODFLOW is required.

Structure of the module: The Introduction Section provides an overview of groundwater models and introduces the role of boundary conditions in MODFLOW. Following this, each MODFLOW basic boundary condition (GHB, RIV, DRN, MNW2, ET) is presented in its own dedicated section, where the concepts, applications, and implications are explained in detail.

The Module is published in ZENODO as: Reimann, T., Poeter, E., & Kuniansky, E.L. (2025a). Boundary Condition Module. An interactive educational resource for The Groundwater Project. https://doi.org/10.5281/zenodo.17624993

Keywords: Groundwater modeling, MODFLOW, boundary condition, GHB, RIV, DRN, MNW2, ET, Q-h plots
Best suited for: self learning

3. Technical details

Multipage app	approximately 2 page(s)

4. Educational fit

Time required	4-8 hours
Prerequisites	Basic hydrogeology, 1D groundwater flow equation, basic knowledge about groundwater modeling
Best suited for	self learning

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)
• Eileen Poeter (Colorado School of Mines)

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• Eve L. Kuniansky (retired from USGS)

References

– Reimann, T., Poeter, E., & Kuniansky, E.L. (2025a). Boundary Condition Module. An interactive educational resource for The Groundwater Project. https://doi.org/10.5281/zenodo.17624993

6. Figures and illustrations

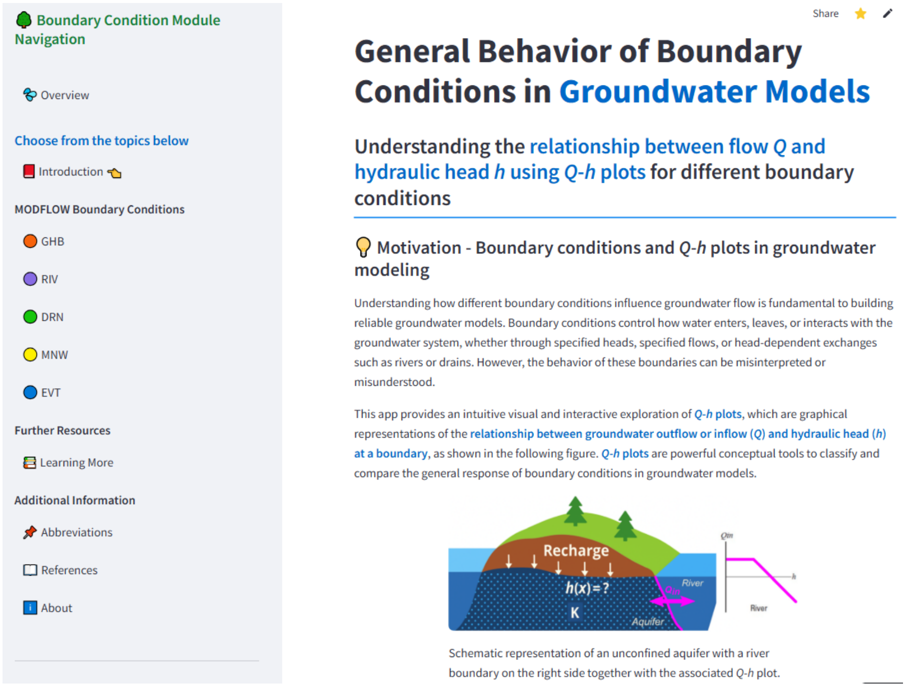

Figure 1. The Boundary Condition Module as a complex interactive learning module. (Screenshot)

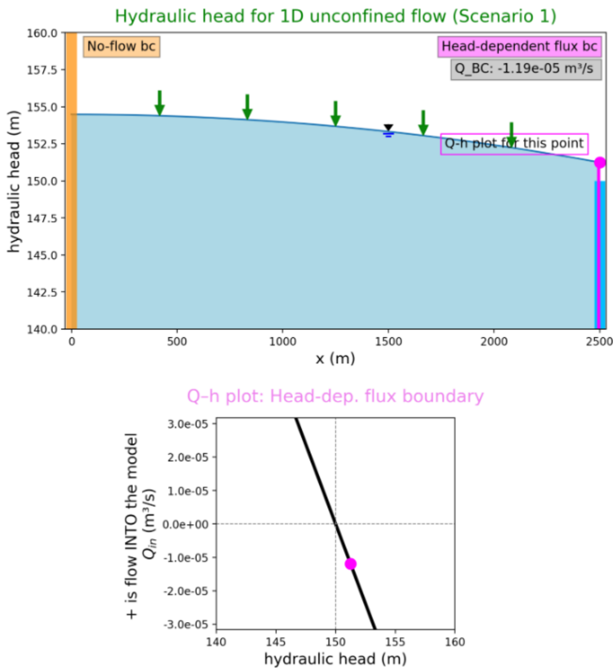

Figure 2. The analytical solution for 1D flow in an unconfined aquifer to support the explanation of Q-h plots (discharge Q stage h relationship).. (Screenshot)

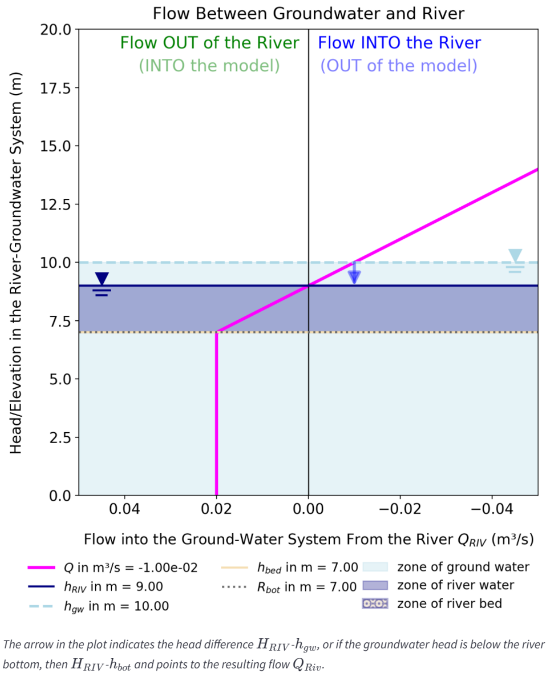

Figure 3. The interactive Q-h plot for the RIV boundary with visual support. (Screenshot)

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The Dewatering Exercise - Finding A Compromise Solution for Mine Dewatering

Topic: 07 Applied Hydrogeology → 07-01 Groundwater Management
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://dewatering-exercise-app.streamlit.app/
Time required	2-4 hours

2. Pedagogical overview

Short description
This app is designed to guide non-experts through the use of groundwater models to answer a water resources question. It is presented in eight steps, with an assignment given after every second step.

* Step 1 General discussion of how surrounding stakeholders might be affected by mine dewatering - qualitative discussion of the response of an aquifer to pumping.

* Step 2 Quantitative predictions of drawdown versus distance and time for different Q, T, and S.

* Step 3 Convert drawdown to utility for three stakeholders.

* Step 4 Introducing Pareto optimization of pumping among stakeholders.

* Step 5 Putting Pareto optimization in practice.

* Step 6 Perform a pumping test on data with error to infer T and S with uncertainty.

* Step 7 Bayesian multimodel analysis.

* Step 8 Reality: why these methods are almost never used!

The app comes with several interactive plots, assignments, electronic questions for assessing knowledge, and educator notes.

Keywords: Groundwater management, dewatering, mining, optimization, Theis, pumping
Best suited for: self learning, classroom teaching

3. Technical details

Multipage app	approximately 10 page(s)
Interactive plots	22 interactive plot(s)
Assessments	30 question(s)

4. Educational fit

Time required	2-4 hours
Prerequisites	Basic hydrogeology, Aquifer parameters
Best suited for	self learning, classroom teaching

5. Authors & references

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Authors
• Ty Ferré (University of Arizona)

6. Figures and illustrations

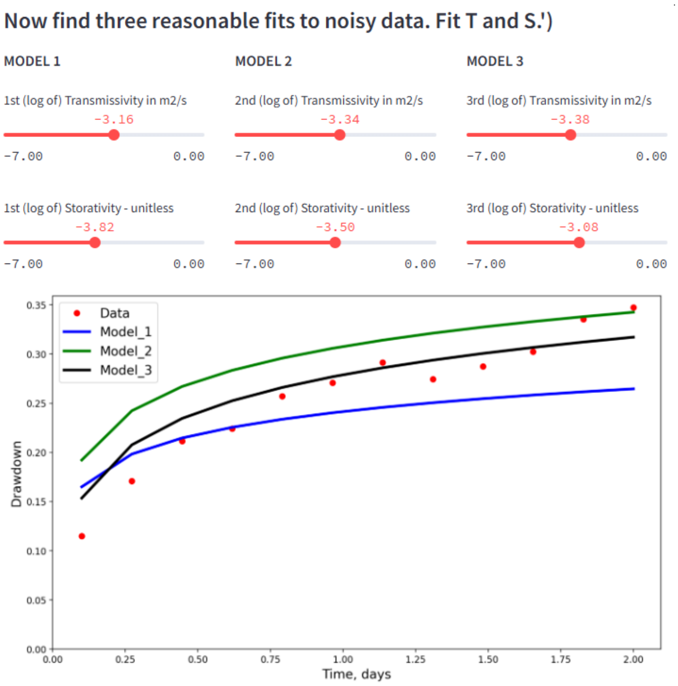

Figure 1. Interactive plot that demonstrate the effect of parameter uncertainty (Screenshot)

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Finite Difference Numerical Scheme

Topic: 08 Groundwater Modeling → 02 Numerical Schemes
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwf-1d-conf-fd.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description

Purpose and Functionality The app implements the one-dimensional finite difference method for groundwater flow with two fixed head boundary conditions. Users can specify the spatial discretization by selecting the number of cells, upon which the numerical scheme is set up and solved.

Learning Features The app visualizes the iterative development of the numerical solution and illustrates how the approximation approaches a stable state. A built-in analytical reference solution enables direct comparison, supporting the exploration of error behaviour, convergence, and numerical representation of groundwater flow processes.

Keywords: Numerical solution, groundwater modeling, applied hydrogeology, finite differences
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrogeology, 1D groundwater flow equation, analytical solutions for 1D groundwater flow,
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors

- Thomas Reimann (TU Dresden)
- Rudolf Liedl (TU Dresden)

6. Figures and illustrations

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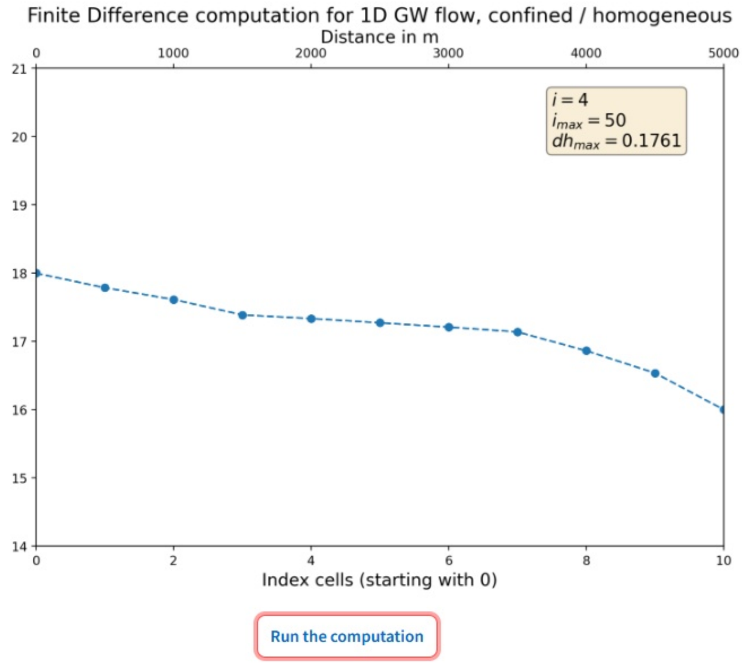

Figure 1. The interactive plot with the basic setup. When the computation is running, the shown head values update. (Screenshot)

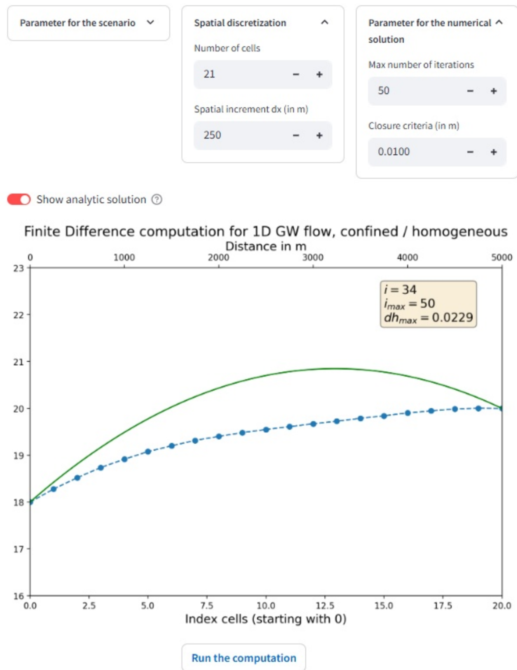

Figure 2. The user interface with an interactive plot that comes with an modified spatial discretization. In addition, the analytical solution is show that allows students comparison with the numerical results. (Screenshot)

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Slugtest Evaluation

Topic: 06 Experimental Techniques and Methods → 04 Aquifer Characterization
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://slugtest-multilingual.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This application introduces slug tests in unconfined aquifers and provides an interactive environment for evaluating slug test data using the Bouwer & Rice (1976) method. Core explanatory content (text, figure captions, buttons, etc.) can be translated on the fly into multiple languages using an integrated translation routine that preserves Markdown/HTML structure and protects key hydrogeological terminology through a custom dictionary.

Users can work with predefined field datasets (Varnum, Sweden; Viterbo, Italy), upload their own CSV data, or generate synthetic noisy data for practice. The app allows adjusting well and screen parameters, slug size, time offset and hydraulic conductivity, and visualizes the resulting response curve together with measured heads. Optional scatter plots with ME, MAE and RMSE, as well as download functions for figures and data, support quantitative evaluation and self-guided learning about parameter fitting and uncertainty in slug test analysis.

Keywords: Aquifer test, multilingual, field data
Best suited for: self learning, classroom teaching, online teaching, exam preparation

3. Technical details

Interactive plots	1 interactive plot(s)
Videos	1 video(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic Hydrogeology
Best suited for	self learning, classroom teaching, online teaching, exam preparation

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

References
– Bouwer, H., & Rice, R. C. (1976). A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, 12(3), 423-428.
– Kruseman, G.P., de Ridder, N.A., & Verweij, J.M., 1991. Analysis and Evaluation of Pumping Test Data, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, 377 pages.

6. Figures and illustrations

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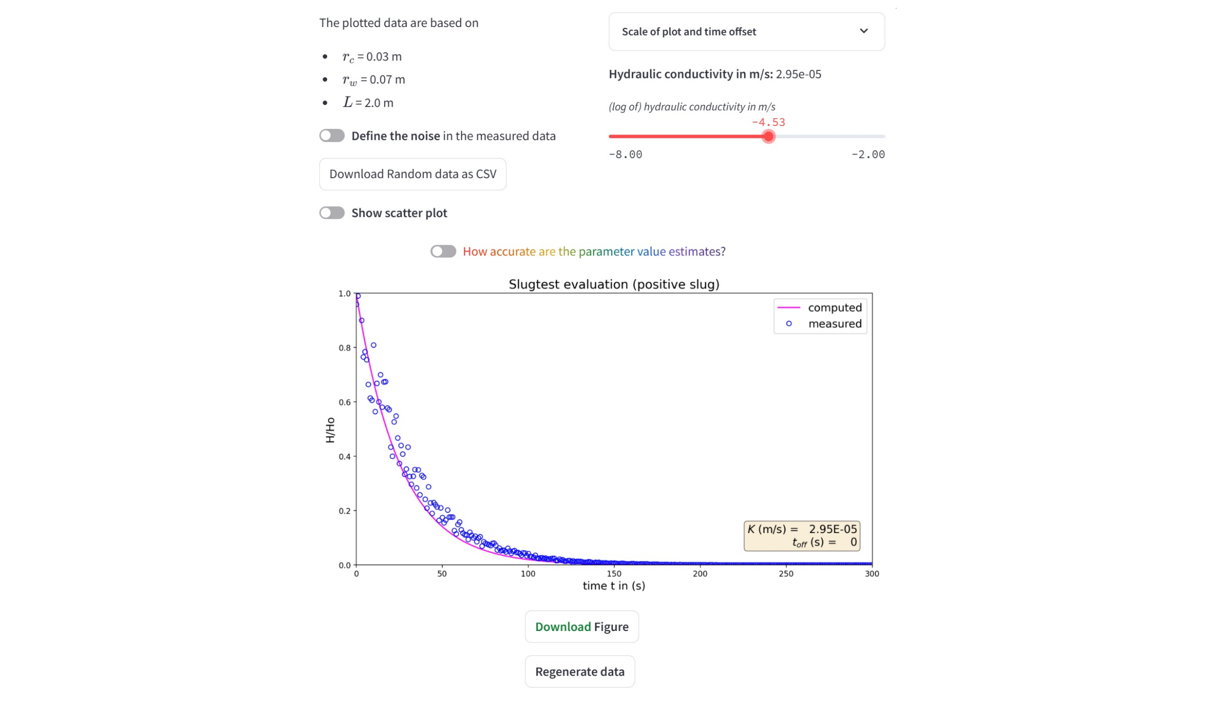

Figure 1. The interactive plot for parameter fitting. (Screenshot)

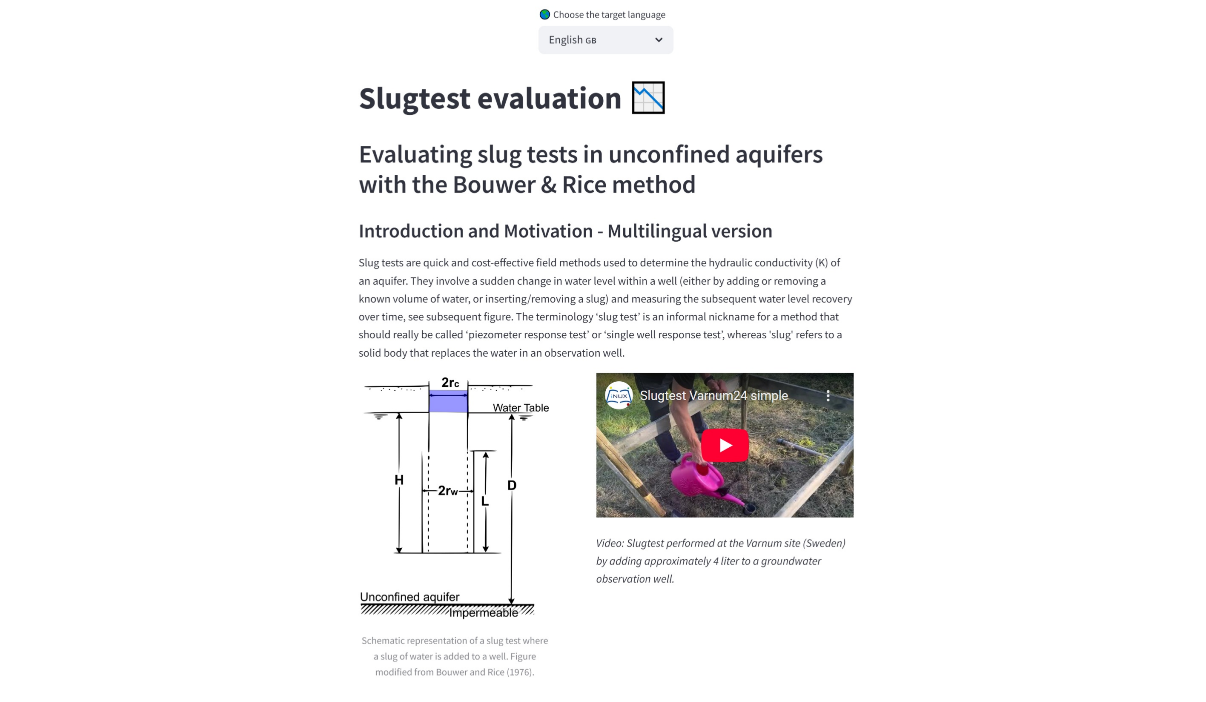

Figure 2. The interface of the Streamlit app with embedded video. (Screenshot)

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Soil Water Retention Module

Topic: 04 Vadose Zone Physics → 04-02 Soil Water Retention
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://gwp-soilwaterretention.streamlit.app/
Time required	2-4 hours

2. Pedagogical overview

Short description
This interactive module introduces the fundamental concepts of soil water retention in unsaturated soils and provides a structured, hands-on exploration of the van Genuchten–Mualem formulation, one of the most widely applied models in vadose zone hydrology.

The module explains how water is retained in soils under unsaturated conditions, emphasizing the physical meaning of capillary pressure, pore-size distribution, and effective saturation. Users interactively explore how key model parameters (θ■, θ■, α, n) control the shape of soil water retention curves and influence hydraulic behavior.

Designed as a step-by-step learning resource, the module supports both first-time learners and users seeking to refresh or deepen their understanding. Interactive visualizations are combined with guided exercises that promote conceptual understanding, parameter interpretation, and practical model calibration.

Module Structure

■ Theory
Introduces the physical basis of soil water retention, including capillarity, surface tension, and the conceptual background of the van Genuchten–Mualem model.

■ SWRC Interactive
Enables real-time exploration of how individual model parameters affect soil water retention curves.

■ SWRC in Comparison
Facilitates comparison of retention behavior across different soil textures (e.g., sand, loam, silt).

■ Exercise 1
Focuses on fitting the van Genuchten model to measured retention data and interpreting parameter sensitivity.

■ Exercise 2
Uses synthetic datasets to identify soil types and assess implications for agricultural use and flow processes.

Keywords: Unsaturated zone, van Genuchten, soil water retention, capillary forces, Mualem
Best suited for: self learning, exam preparation

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3. Technical details

Multipage app	approximately 10 page(s)
Interactive plots	8 interactive plot(s)
Assessments	68 question(s)
Videos	3 video(s)

4. Educational fit

Time required	2-4 hours
Prerequisites	Basic Hydrogeology, soil properties
Best suited for	self learning, exam preparation

5. Authors & references

Authors

• Oriol Bertran (Universitat Politècnica de Catalunya (UPC))
• Daniel Fernàndez-Garcia (Universitat Politècnica de Catalunya (UPC))
• Thomas Reimann (TU Dresden)
• Eileen Poeter (Colorado School of Mines)

6. Figures and illustrations

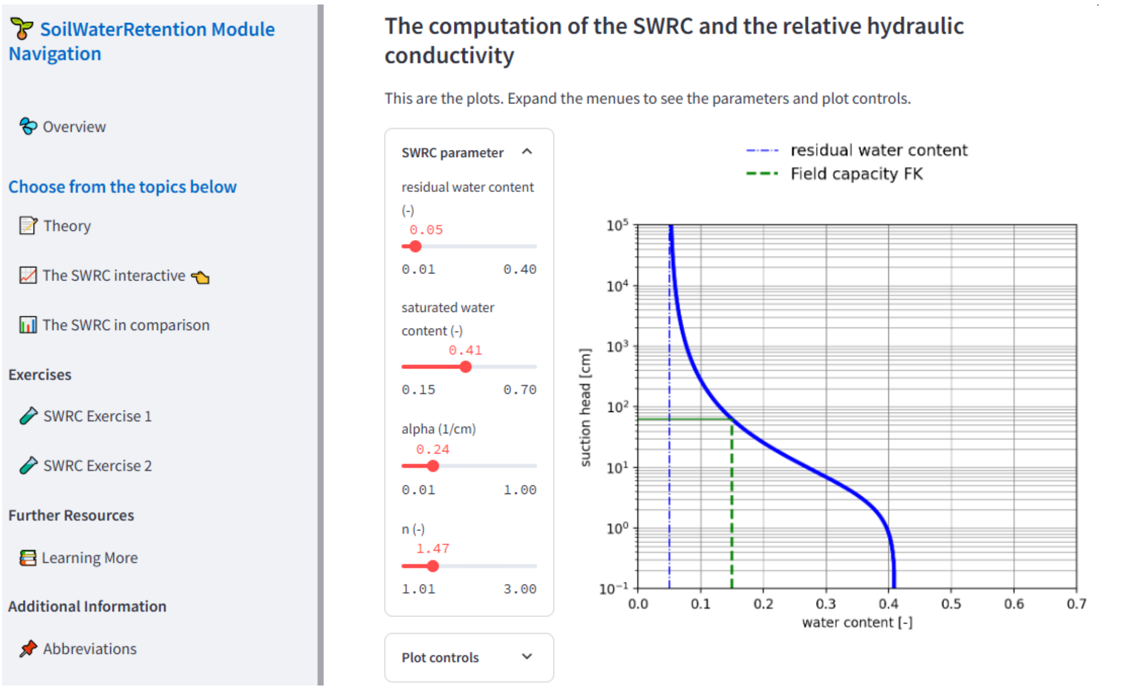

Figure 1. The interactive plot of the soil water retention curve with the Van Genuchten equation. (Screenshot)

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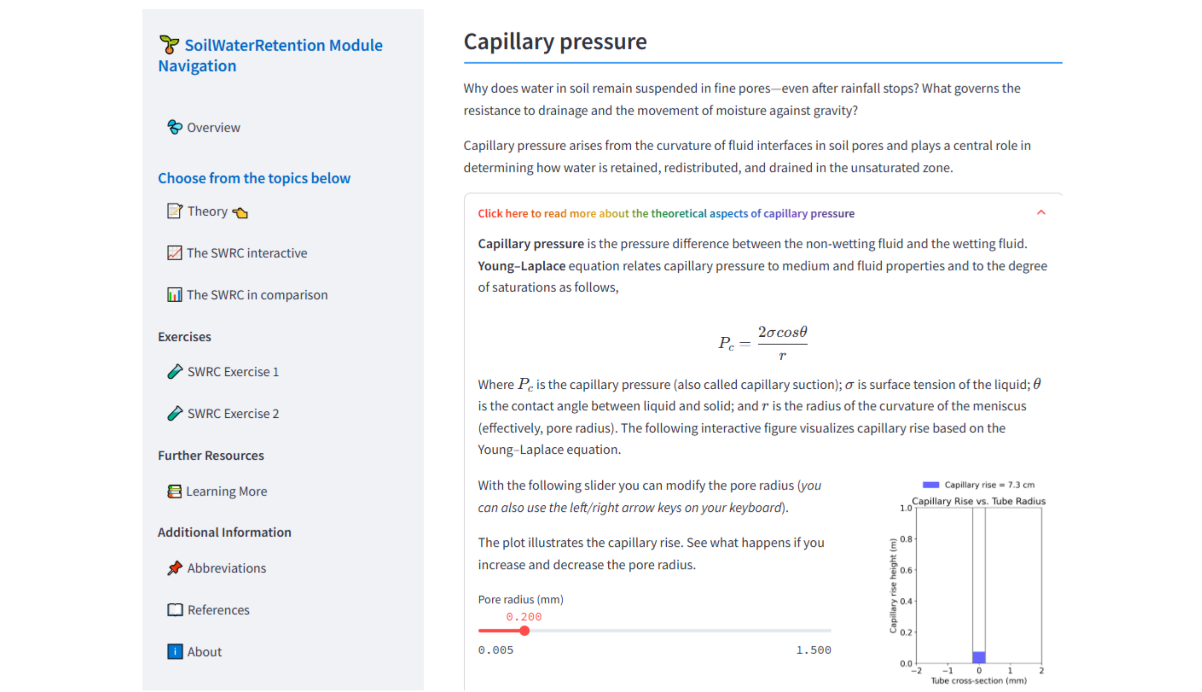

Figure 2. The theory section of the SWR module with interactive illustration. (Screenshot)

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The Ghyben-Herzberg Relation

Topic: 07 Applied Hydrogeology → 07-07 Freshwater–Saltwater Interaction
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://ghyben-herzberg.streamlit.app/
Time required	5–15 min

2. Pedagogical overview

Short description
This app illustrates the Ghyben–Herzberg relation for the equilibrium between freshwater and seawater in a coastal aquifer under static (no-flow) conditions. Starting from the classical sharp-interface concept, it visualizes how a relatively small freshwater head above sea level supports a much thicker freshwater body below sea level due to the density contrast between fresh and salt water. Users can interactively adjust the freshwater and saltwater densities as well as the freshwater head at the inland boundary, and immediately see how the position of the freshwater–saltwater interface responds. The cross-section plot distinguishes unsaturated zone, freshwater zone, and underlying saltwater, making the app well suited for teaching the basic physics, assumptions, and limitations of the Ghyben–Herzberg theorem in an intuitive, graphical way.

Keywords: seawater, saltwater, interface
Best suited for: self learning, classroom teaching

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	5–15 min
Best suited for	self learning, classroom teaching

5. Authors & references

Authors
• Markus Giese (University of Gothenburg)
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

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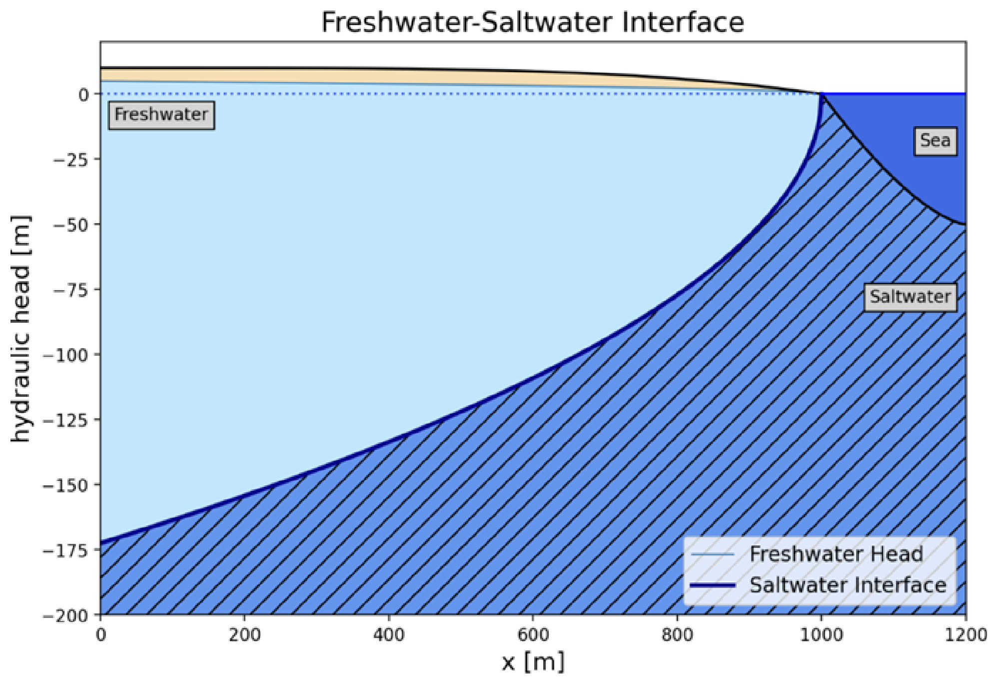

Figure 1. Freshwater-saltwater interface under static hydraulic conditions (Screenshot)

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Lumped Parameter Reservoir Model

Topic: 08 Groundwater Modeling → 08-07 Parameter Estimation & Calibration
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://lumpedmodel-reservoir.streamlit.app/
Time required	5–15 min

2. Pedagogical overview

Short description
This interactive app introduces a lumped-parameter reservoir model as a simple conceptual representation of catchment or aquifer response. The system is described by effective parameters for recharge (R), storage (S), and conductance (K), linking inflow, outflow, and hydraulic head through a first-order mass-balance equation.

Users can interactively adjust model parameters and initial conditions to explore the temporal evolution of reservoir head and compare model results with predefined observation data. The app visualizes both the simulated head response and a measured–computed scatter plot, including standard goodness-of-fit metrics (ME, MAE, RMSE), enabling hands-on experience with basic model calibration.

The example is based on teaching materials by John Doherty and is specifically designed to illustrate parameter sensitivity, parameter correlation, and calibration challenges in conceptual models. It is well suited as an introductory exercise for students and professionals learning the fundamentals of model calibration and uncertainty in groundwater and hydrological modeling.

Keywords: model calibration, lumped model, non uniqueness
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Interactive plots	2 interactive plot(s)

4. Educational fit

Time required	5–15 min
Prerequisites	basic hydrology, basic hydrogeology,
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

References
– Doherty, J. (2025) PEST, Model-Independent Parameter Estimation—Software and User Manual. Watermark Numerical Computing, https://pesthomepage.org/programs, last access 16. 12. 2025.

6. Figures and illustrations

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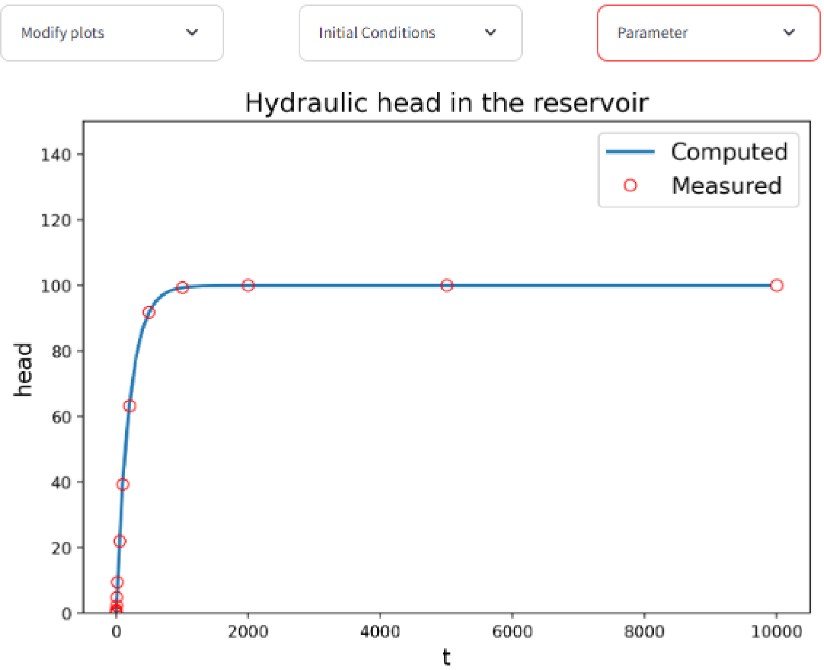

Figure 1. The response of the reservoir model as interactive plot. (Screenshot)

3D Heat transport with convection, conduction, and dispersion

Topic: 07 Applied Hydrogeology → 07-10 Geothermal Energy
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://3d-heat-transport.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive application illustrates three-dimensional heat transport in a saturated porous medium under steady groundwater flow, combining convection (advection), conduction, and hydrodynamic dispersion. A continuous heat input is applied at a finite source, and the resulting temperature distribution is evaluated from an analytical solution.

Users can explore how specific discharge and effective porosity control the average groundwater velocity, how longitudinal and transverse dispersivities shape heat transport, and how source geometry (width and thickness) influences the extent of warming.

Results are visualized as plan-view (x–y) temperature fields for a selectable depth slice and as cross-sections (x–z) for a selectable lateral position, shown either as filled contours or isolines. Optional settings allow restricting spreading to downward directions to mimic density-driven tendencies or simplified conceptual assumptions.

Keywords: Heat transport, Geothermal energy, transport, 3D
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Interactive plots	2 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic hydrogeology, basic knowledge of transport, hydrogeological parameters
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

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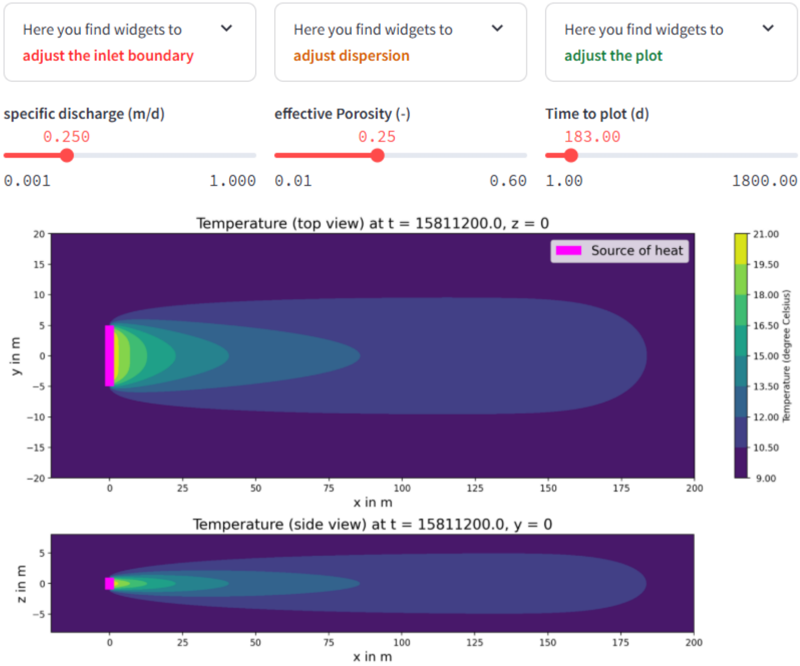

Figure 1. Visualization of the heat transport (Screenshot)

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Estimating Groundwater Recharge with the Water Table Fluctuation (WTF) Method

Topic: 01 Water Cycle → 01-05 Groundwater Recharge (process-based)
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://wtf-recharge.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
This interactive app estimates groundwater recharge from water-level time series using the Water Table Fluctuation (WTF) method with falling-limb (recession) extrapolation for multiple recharge events. Users can work with provided example series or upload their own CSV file (date, head).

Recharge events are identified as distinct rises in the groundwater head record. For each detected peak, the app extrapolates a recession baseline using an exponential recession constant alpha and computes the event water-level surplus dh relative to this baseline. Recharge is then calculated as S_y x dh and reported in mm, where S_y is the user-defined specific yield. Results are shown as an annotated time-series plot with fitted recession curves, peak markers, and Δh indicators, along with an event table and the total recharge summed over all detected events.

Keywords: Groundwater recharge, WTF, Water Table Fluctuation
Best suited for: self learning

3. Technical details

Interactive plots	1 interactive plot(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	Basic Hydrogeology
Best suited for	self learning

5. Authors & references

Authors
• Thomas Reimann (TU Dresden)

6. Figures and illustrations

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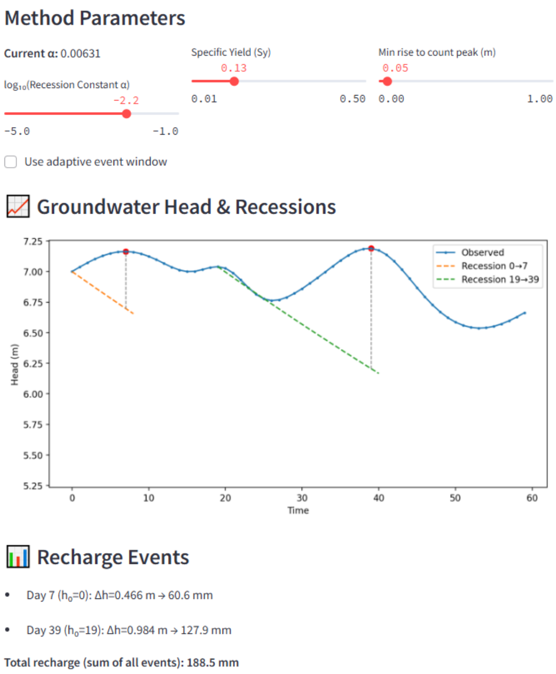

Figure 1. The interactive plot to estimate recharge with the WTF method. (Screenshot)

Green-Ampt-Model for Infiltration - Intro

Topic: 04 Vadose Zone Physics → 04-05 Infiltration
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://green-ampt-intro.streamlit.app/
Time required	15–30 minutes

2. Pedagogical overview

Short description
Green–Ampt Model for Infiltration is an interactive learning app that introduces the Green–Ampt infiltration concept for ponded conditions and soil wetting-front dynamics. The app combines a concise theoretical explanation (including typical parameter ranges and example experimental context such as double-ring infiltrometers) with an exploratory workflow where users adjust the key model controls—saturated hydraulic conductivity K■, water-content contrast $\Delta\theta$, and head difference Δh—to investigate their influence on cumulative infiltration I(t) and infiltration rate i(t) over time.

Two linked plots (linear for I(t) and logarithmic for i(t)) support interpretation of early-time suction-driven behavior and long-time convergence toward K■. Users can save multiple parameter sets and overlay them in the same figure to compare scenarios and build intuition for how soil properties and initial conditions shape infiltration responses. The app includes an initial assessment (to check prior knowledge) and a final assessment (to self-check learning gains), making it suitable for self-study, blended learning, and introductory teaching before progressing to more advanced unsaturated-zone approaches (e.g., Richards equation or van Genuchten–Mualem).

Keywords: Unsaturated zone, infiltration, field experiments
Best suited for: self learning, online teaching, classroom teaching

3. Technical details

Interactive plots	2 interactive plot(s)
Assessments	8 question(s)

4. Educational fit

Time required	15–30 minutes
Prerequisites	soil properties, soil types, basic hydrogeology
Best suited for	self learning, online teaching, classroom teaching

5. Authors & references

Authors
• Steffen Birk (Department of Earth Sciences, University of Graz)
• Edith Grießer (Department of Earth Sciences, University of Graz)
• Matthias Hausleber (Department of Earth Sciences, University of Graz)
• Thomas Reimann (Institute for Groundwater Management, TU Dresden)

6. Figures and illustrations

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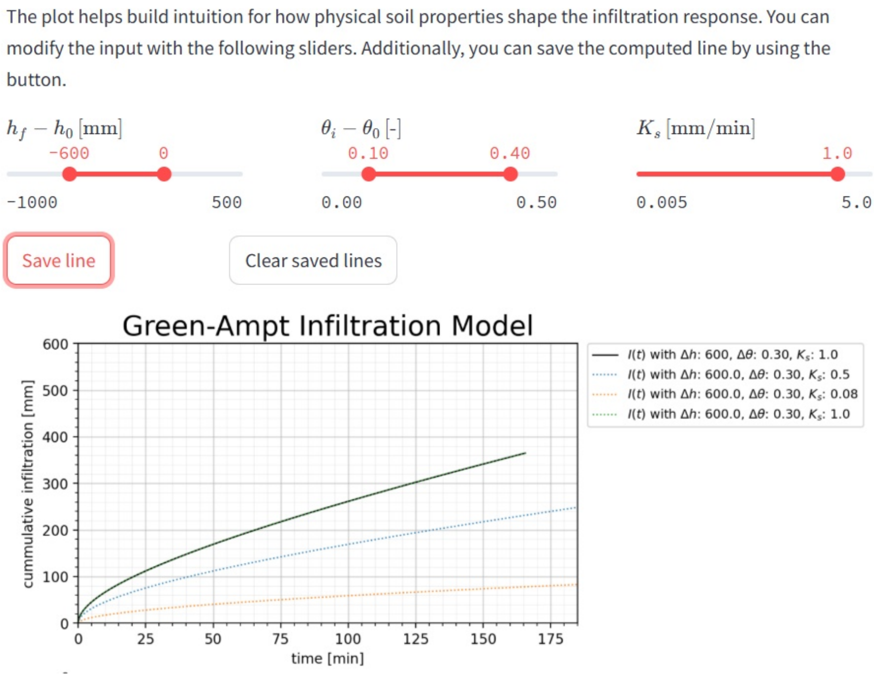

Figure 1. The app with the interactive plot (Screenshot)

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Pumping test interpretation Cooper-Jacob Method

Topic: 06 Experimental Techniques and Methods → 06-04 Aquifer Characterization Techniques
Language: English

1. Basic information

Resource type	Jupyter Notebook
URL	https://github.com/gw-inux/Jupyter-Notebooks/blob/7663b0c0e5f07a3d52fd7c17a7409f515f9a28e7/05_Applied_hydrogeology/leakyAq_example_CooperJacob.ipynb
Time required	15–30 minutes

2. Pedagogical overview

Short description
Pumping test interpretation: Cooper-Jacob Method

Keywords: pumping test, cooper-jacob
Best suited for: self learning, online teaching, classroom teaching

3. Educational fit

Time required	15–30 minutes
Best suited for	self learning, online teaching, classroom teaching

4. Authors & references

Authors
- Oriol Bertran (UPC)
- Daniel Fernàndez-García (UPC)
- Jesús Carrera (CSIC)

5. Figures and illustrations

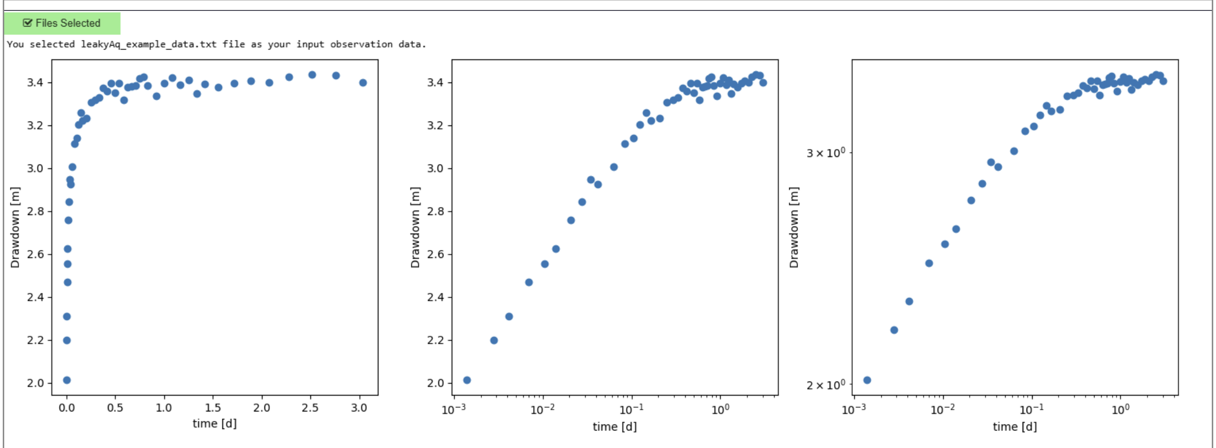

Figure 1. Input observation data. (Screenshot)

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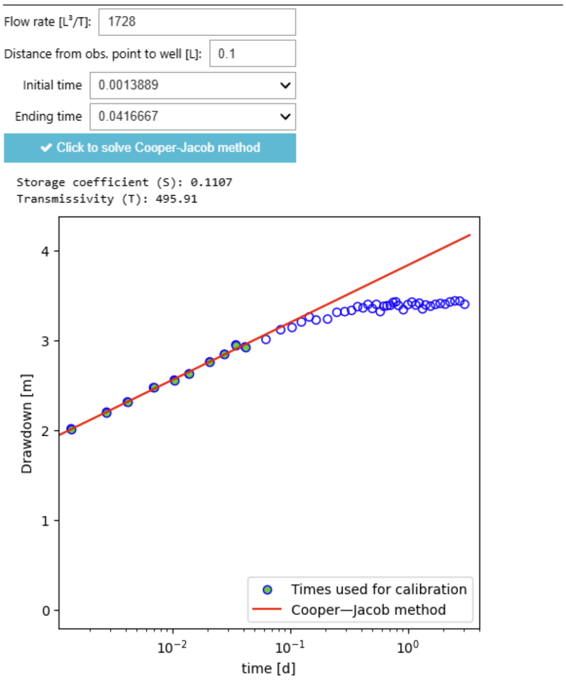

Figure 2. Parameter estimation using the Cooper-Jacob method (Screenshot)

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Analytical solution for 2D instantaneous solute transport injection in porous media (with decay)

Topic: 05 Hydrogeochemistry and Contaminant Transport → 05-06 Reactive Solute Transport
Language: English

1. Basic information

Resource type	Jupyter Notebook
URL	https://github.com/gw-inux/Jupyter-Notebooks/blob/7663b0c0e5f07a3d52fd7c17a7409f515f9a28e7/05_Applied_hydrogeology/aSolutions_decay_instantaneous.ipynb
Time required	30–45 minutes

2. Pedagogical overview

Short description
This interactive Jupyter tool computes and visualizes the analytical 2-D instantaneous solute injection solution with first-order decay in porous media.
It simulates how concentration evolves over time at a given observation point for five contaminants, each defined by a different decay rate.
The model incorporates:
* 1) Retardation
* 2) Longitudinal and transversal dispersion
* 3) Decay
* 4) 2-D spreading of an instantaneous point source

The user can interactively modify:
* 1) Distance to the observation point (x, y)
* 2) Longitudinal and transversal dispersivities
* 3) Retardation factor

The tool then automatically recalculates:
* 1) Effective velocity
* 2) Effective longitudinal and transverse dispersion
* 3) Time-dependent concentration curves

and plots the concentration–time profiles for all decay rates, allowing easy comparison of attenuation behavior in 2-D groundwater flow.

Keywords: analytical solutions, solute transport, instantaneous injection, 2D, decay
Best suited for: self learning, online teaching, classroom teaching

3. Educational fit

Time required	30–45 minutes
Best suited for	self learning, online teaching, classroom teaching

4. Authors & references

Authors
• Oriol Bertran (UPC)
• Daniel Fernàndez-Garcia (UPC)

References
– Bear, J. (2012). Hydraulics of groundwater. Courier Corporation.

5. Figures and illustrations

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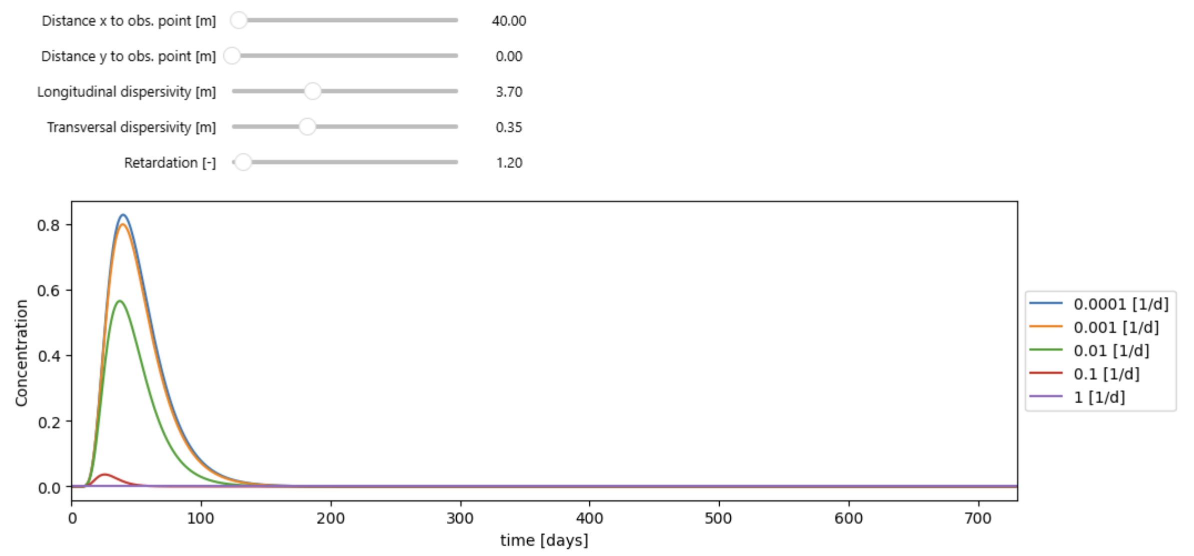

Figure 1. Concentration vs. Time for five decay rates with selected parameter values. (Screenshot)

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MODFLOW CFP - response to discharge event

Topic: 08 Groundwater Modeling → 08-06 Coupled Models
Language: English

1. Basic information

Resource type	Jupyter Notebook
URL	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/08_Groundwater_Modeling/06_Coupled%20Models/CFP_Response.ipynb
Time required	15–30 minutes

2. Pedagogical overview

Short description

This Jupyter notebook demonstrates a simple MODFLOW-CFP (CFPy) model setup (after Birk, 2002) to analyze a karst conduit system's transient response to a short discharge/recharge event. Using FloPy and CFPy, the notebook builds a 2D continuum grid with a 1D conduit network, applies steady-state initialization followed by a transient injection period and recovery phase, and runs the coupled flow simulation with the MODFLOW-CFP executable.

Three (or more) scenarios are computed by varying different model parameters. Results are postprocessed to extract conduit flow rates through time and compare how parameter changes affect the spring discharge response.

Keywords: MODFLOW, CFP, FloPy, Karst, numerical model
Best suited for: self learning, classroom teaching, online teaching

3. Educational fit

Time required	15–30 minutes
Prerequisites	Groundwater Modeling, MODFLOW, Basic Python
Best suited for	self learning, classroom teaching, online teaching

4. Authors & references

Authors

• Thomas Reimann (TU Dresden)
• Steffen Birk (Universität Graz, Institut für Erdwissenschaften)

5. Figures and illustrations

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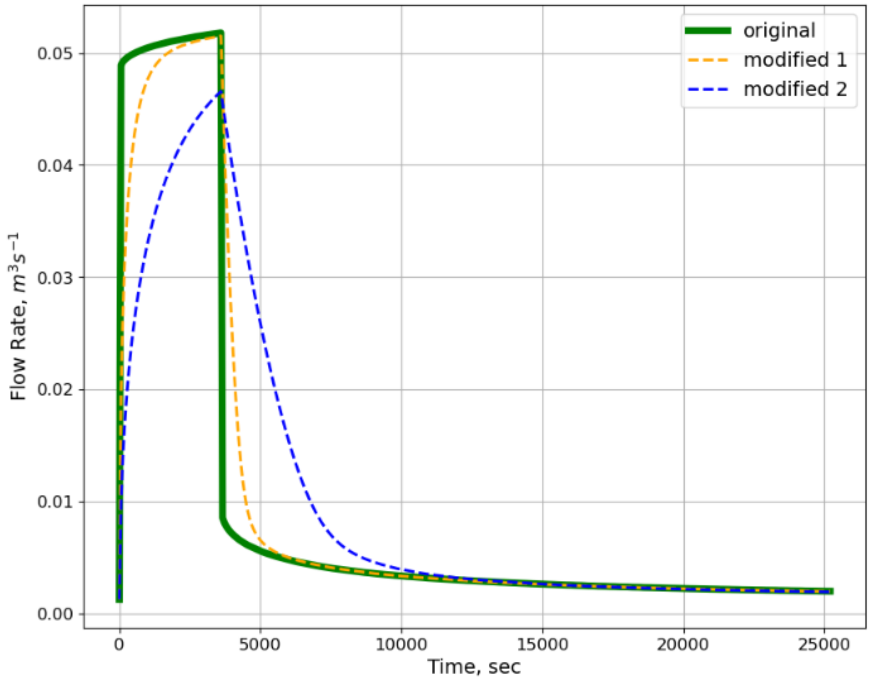

Figure 1. The computed spring discharge (Screenshot)

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Solute Transport Simulation with MT3DMS - 1D Transport in a Uniform Flow Field

Topic: 08 Groundwater Modeling → 08-04 Transport Modeling
Language: English

1. Basic information

Resource type	Jupyter Notebook
URL	https://github.com/gw-inux/iNUX-Interactive-Documents/blob/main/08_Groundwater_Modeling/04_Transport_Modeling/Transport_1D_MT3D.ipynb
Time required	15–30 minutes

2. Pedagogical overview

Short description
This application reproduces and extends the classical Example 1 from the MT3DMS documentation, illustrating one-dimensional solute transport in a uniform groundwater flow field. A coupled MODFLOW–MT3DMS model is used to simulate conservative and reactive transport processes under controlled conditions.

The app allows users to explore the influence of advection, dispersion, sorption, and decay on solute migration by systematically activating or deactivating individual processes. Different numerical advection schemes (finite difference, MOC, TVD) can be compared to assess numerical behavior, stability, and solution accuracy.

The model is implemented using FloPy for transparent pre- and post-processing, enabling users to focus on conceptual understanding rather than model setup. Concentration profiles, mass balance information, and method-dependent differences can be directly visualized and discussed. It is recommended to run the Jupyter Notebook on a local computer.

Intended use:
Conceptual learning, numerical-method comparison, and advanced coursework in groundwater solute transport and numerical modeling.

Keywords: Groundwater modeling, solute transport modeling, heat transport modeling, MODFLOW, MT3D
Best suited for: online teaching, classroom teaching

3. Educational fit

Time required	15–30 minutes
Prerequisites	Groundwater flow, solute transport
Best suited for	online teaching, classroom teaching

4. Authors & references

Authors
• Thomas Reimann (TU Dresden)

5. Figures and illustrations

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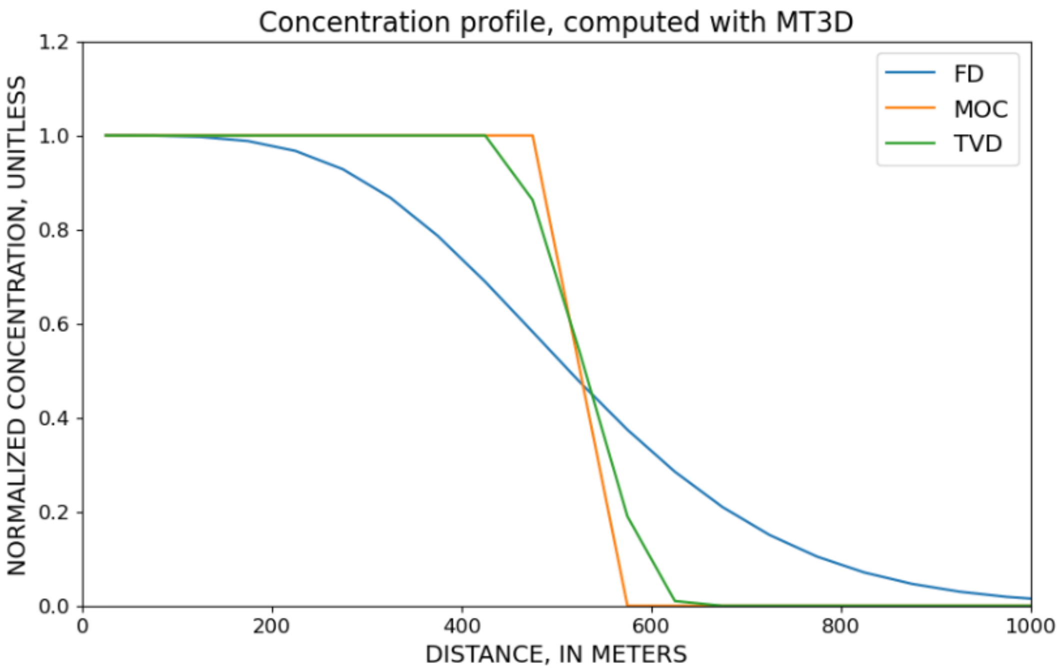

Figure 1. Visualization of the concentration profile, computed with MT3D. (Screenshot)

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Modflow-2005/MODELMUSE Tutorial - synthetic

Topic: 08 Groundwater Modeling → 08-03 Flow Modeling
Language: English

1. Basic information

Resource type	Streamlit app
URL	https://modflow-tutorial-2d-synthetic.streamlit.app/
Time required	1.5 hours

2. Pedagogical overview

Short description
This interactive tutorial guides users step by step through the design, implementation, and analysis of a 2D steady-state groundwater flow model for a synthetic catchment using MODFLOW-2005 in combination with MODELMUSE. The application is structured as an expandable to-do–based workflow, supported by explanatory text, figures, downloadable resources, and short instructional videos that mirror a typical professional modeling process.

Starting from grid discretization and parameter definition, the tutorial covers the setup of boundary conditions (constant head, recharge, river, and wells), execution of the numerical simulation, and systematic postprocessing, including hydraulic head visualization and particle tracking with MODPATH. Optional refinement steps allow users to further explore grid design and numerical sensitivity. The app is intended for academic teaching and guided self-study, providing a practical introduction to conceptualization, numerical setup, and interpretation of groundwater flow models in a controlled and transparent learning environment.

Keywords: MODFLOW, MODELMUSE, groundwater modeling
Best suited for: self learning

3. Technical details

Videos	5 video(s)

4. Educational fit

Time required	1.5 hours
Prerequisites	Basic Hydrogeology, groundwater flow modeling basics
Best suited for	self learning

5. Authors & references

Authors

• Thomas Reimann (TU Dresden)
• Rudolf Liedl (TU Dresden)

6. Figures and illustrations

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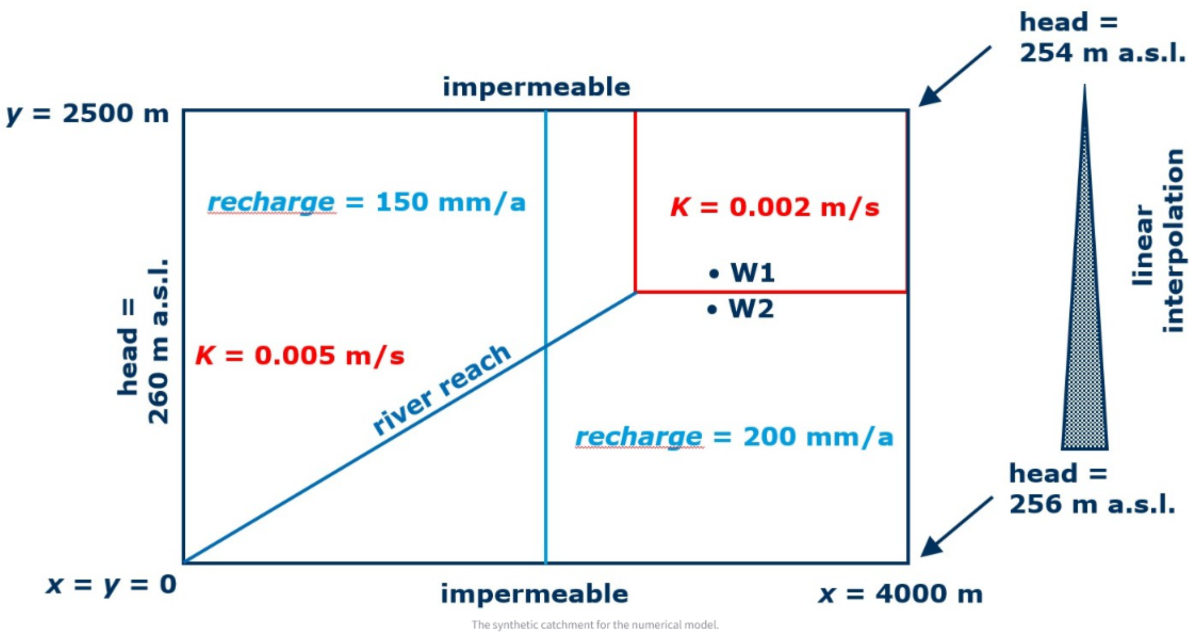

Figure 1. The idealized model catchment that is used for the tutorial. (Schematic / Diagram / Illustration)

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