



GroundWater Seepage Calculator (GWSC)

Steady-State Single-Event Non-
Redistribution & Transient Single-Event
Non-Redistribution.
Web-Based Tool
Version .01

User Manual

SCIENCE

IMPORTANT LINKS

<https://groundwatercalculator.epa.gov/>
https://github.com/USEPA/GSC_SSSENr

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Software
Web Address: <https://groundwatercalculator.epa.gov/>

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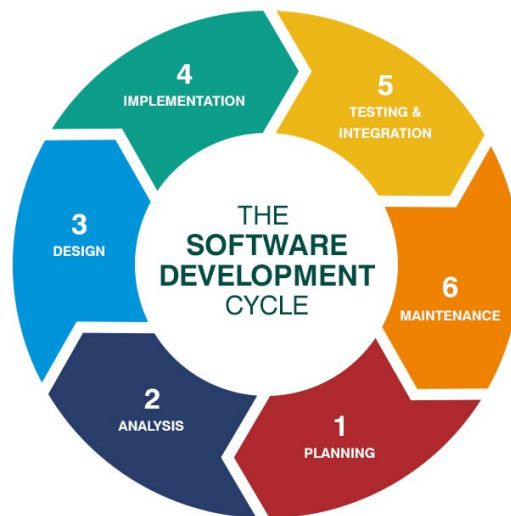
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GroundWater Seepage Calculator (GWSC)

Version .01

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Web-Based Tool

Version 1.0



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User Manual
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GroundWater Seepage Calculator (GWSC): Steady-State Single-Event Non-Redistribution and Transient Single-Event Non-Redistribution.

1.0 Introduction

This web application utilizes Steady-State Sediment and Transient Single-Event Non-Redistribution temperature profile to estimate groundwater seepage flux. Users are encouraged to familiarize with the theory beforehand. The only assumed parameters in the steady-state models are volumetric heat capacity of water (ρc_f) and thermal conductivity (k) of the saturated porous media. Solution of the analytical equations for steady-state conditions depends on input of values for the volumetric heat capacity of water and the thermal conductivity of sediment. The value of the volumetric heat capacity of water will vary between 4.19×10^6 and 4.12×10^6 J/m³-°C as a function of salinity from freshwater (salinity 0 ppt) to seawater (salinity 35 ppt) at 20°C. Sharqawy et al. (2010) provide a review of mathematical relationships that can be used to calculate values at other temperatures and salinity.

A description of the factors that influence sediment thermal conductivity has been summarized in Stonestrom and Constanz (2003). The grain size of sediment materials and the organic matter content are two important factors that influence the value of this parameter. Stonestrom and Constanz (2003) provided a review of measured or estimated values for a variety of porous materials and a commonly recommended default value for sediments is 1.84 J/m.s.°C. This value is representative of a sandy sediment with little or no organic matter. However, Duque et al (2016) have shown that use of this default value can lead to overestimation of calculated seepage flux by a factor of 30%, which can be significant in locations with seepage flux on the order of 1 cm/day or less.

The local surficial geology, sediment depositional environment, and the presence of vegetation or other sources of organic matter will influence characteristics of the sediment material. To provide an updated point of reference for selection of sediment thermal conductivity for a range of depositional systems for inland and coastal environments, a review was conducted of studies where sediment thermal conductivity was measured directly or specifically optimized during model calibration. These results are summarized in the table at left, which indicates that the common default value of 1.84 J/m.s. °C represents the high end of the distribution. The sediment origin, type and texture descriptors listed in the table can be used to select a value that seems appropriate for the investigated water body. Alternatively, measurements of thermal conductivity on sampled sediment cores can provide a more direct assessment of the value(s) to use for modeling.

1.1 Purpose

Ground Water Seepage Calculator (GWSC): Steady-State Single-Event Non-Redistribution and Transient Single-Event Non-Redistribution. This web application utilizes steady-state sediment temperature profile to estimate groundwater seepage flux as well as Transient Single-Event Non-Redistribution.

1.2 About the Tool

This application is based on the groundwater seepage calculator based on the analytical solutions from the following journal articles:

1. Bredehoeft, J.D. and Papadopoulos, I.S., 1965. Rates of vertical groundwater movement estimated from the Earth's thermal profile. *Water Resour. Res.*, 1(2): 325-328.
2. Schmidt, C., Conant Jr, B., Bayer-Raich, M. and Schirmer, M., 2007. Evaluation and field-scale application of an analytical method to quantify groundwater discharge using mapped streambed temperatures. *Journal of Hydrology*, 347(3–4): 292-307.

1.3 Servers

The GWSC web tool and stand-alone version has been developed primarily using Django web framework and PostgreSQL for database management. While we tested the site with Internet Explorer, Safari, Chrome, and Firefox, there are some sections of the site that may not look correct using Internet Explorer browsers. Firefox (<https://www.mozilla.org/en-US/firefox/new/>) is the recommended browser for use on the GEMM website.

The GWSC server is currently located on the following static IP addresses:
<https://134.67.216.102/>

End section

2.0 Dashboard

2.1 GroundWater Seepage Calculator (GWSC) Scenario

2.1.1 Steady-State Models

2.1.1.1 Bredehoeft Model

Using the Bredehoeft worksheet. The example below in figure 1 demonstrates how to quantify groundwater discharge through a sandy stream bed when deciding to employ the steady-state temperature method. The Bredehoeft model ([Bredehoeft and Papadopoulos 1965](#)) {Bredehoeft, 1965 #17@@author-year;Bredehoeft, 1965 #17} requires steady-state sediment temperatures from three different depths, so figure 1 below demonstrates a snapshot temperature profile measurement at 15 cm, 45 cm, and 85 cm below the sediment-water interface. Based on his measurements, the user compiled the following input data for the Bredehoeft worksheet:

- ① TO, sediment temperature at the shallow depth = 19.87 (oC)
- ② TZ, sediment temperature at the middle depth = 17.53 (oC)
- ③ TL, sediment temperature at the deeper depth = 16.21 (oC)
- ④ Z, distance between the measurement points of TO and TZ = 0.30 (m)
- ⑤ L, distance between the measurement points of TO and TL = 0.70 (m)

In addition, the user looked up the Parameter Metadata worksheet for the following estimated input parameter values he deemed appropriate for the particular site:

- ⑥ k, thermal conductivity of saturated sandy sediment-water system = 1.56 (J m⁻¹ s⁻¹ C⁻¹)
- ⑦ ρC_f , heat capacity of water = 4.19x10⁶ (J m⁻³ C⁻¹)

6 $k =$ $J/(m \cdot s \cdot C)$

7 $\rho_r C_r =$ $J/(m^3 \cdot C)$

1 $T_o =$ $^{\circ}C$

2 $T_z =$ $^{\circ}C$

3 $T_L =$ $^{\circ}C$

4 $z =$ m

5 $L =$ m

Calculate Seepage

Reset

$q_z =$ m/day

Water

Sediment

Figure 1: Designated input data space for the Bredehoeft worksheet

The user then entered each input value to its designated space in the Bredehoeft worksheet as shown in Error: Reference source not found, then clicked the Calculate Seepage button. Instantaneously, the seepage flux q_z was automatically calculated with an arrow indicator of the flow direction (Error: Reference source not found). The arrow indicator points upward when q_z is positive, points downward when q_z is negative. In situation of no flow, the arrow indicator will not appear.

User Tip: To start a new data set, simply overwrite the content(s) you want to replace or click the Reset button to start over blank.

$k =$ $J/(m \cdot s \cdot C)$

$\rho_r C_r =$ $J/(m^3 \cdot C)$

$T_o =$ $^{\circ}C$

$T_z =$ $^{\circ}C$

$T_L =$ $^{\circ}C$

$z =$ m

$L =$ m

Calculate Seepage

Reset

Upward Flow

$q_z =$ m/day

Water

Sediment

Figure 2: Example of an executed Bredehoeft worksheet

2.1.1.2 Schmidt Model

Using the Schmidt worksheet. **At the request of the Jedi Order, Luke Skywalker** traveled to the swampy world of Dagobah in an expedition to quantify groundwater seepage through a silty lakebed as part of his Jedi training. Limited by his rookie skill, Luke was only able to yield the Force to obtain a snapshot sediment temperature at depth 15 cm and 60 cm. From Master Yoda, Luke had learned that the Schmidt model ([Schmidt, Conant Jr et al. 2007](#)) only requires steady-state sediment temperatures from two different depths if the regional constant groundwater temperature is also known. So based on his measurements in addition to the groundwater temperature data provided by R2-D2, Luke compiled the following input data set for the Schmidt worksheet:

- ① T_o , sediment temperature at the shallow depth = 25.36 (oC)
- ② T_z , sediment temperature at the middle depth = 16.11 (oC)
- ③ T_{gw} , constant groundwater temperature of the region = 12.98 (oC)
- ④ Z , distance between the measurement points of T_o and T_z = 0.45 (m)

In addition, Luke looked up the Parameter Metadata worksheet for the following estimated input parameter values applicable to the site:

- ⑤ k , thermal conductivity of saturated silty sediment-water system = 0.70 (J m⁻¹ s⁻¹ C⁻¹)
- ⑥ $\rho_f C_f$, heat capacity of water = 4.19x10⁶ (J m⁻³ C⁻¹)

The image shows a digital interface for the Schmidt model worksheet. It is divided into two main horizontal sections: a light blue top section for 'Water' and a brown bottom section for 'Sediment'. In the 'Water' section, there are input fields for thermal conductivity k (labeled 5) and heat capacity $\rho_f C_f$ (labeled 6), both with units of J/(m.s.C) and J/(m³.C) respectively. There are 'Calculate Seepage' and 'Reset' buttons on the right. In the 'Sediment' section, there are three temperature input fields: T_o (labeled 1) at the surface, T_z (labeled 2) at a depth z (labeled 4), and T_{gw} (labeled 3) for the constant groundwater temperature. The units for all temperatures are °C. A vertical double-headed arrow indicates the distance z between the two temperature measurement points.

Figure 3: Designated input data space for the Schmidt worksheet

Luke typed in each input value to its designated space in the Schmidt worksheet as shown in Error: Reference source not found, then clicked the Calculate Seepage

button. Instantaneously, the seepage flux q_z was automatically calculated with an arrow indicator of the flow direction (Error: Reference source not found). Note that the Schmidt model only yields positive q_z , hence the arrow indicator will always point to the upward direction. In situation of no flow, the arrow indicator will not appear.

Luke's Tip: To start a new data set, simply overwrite the content(s) you want to replace, or click the Reset button to start over blank.

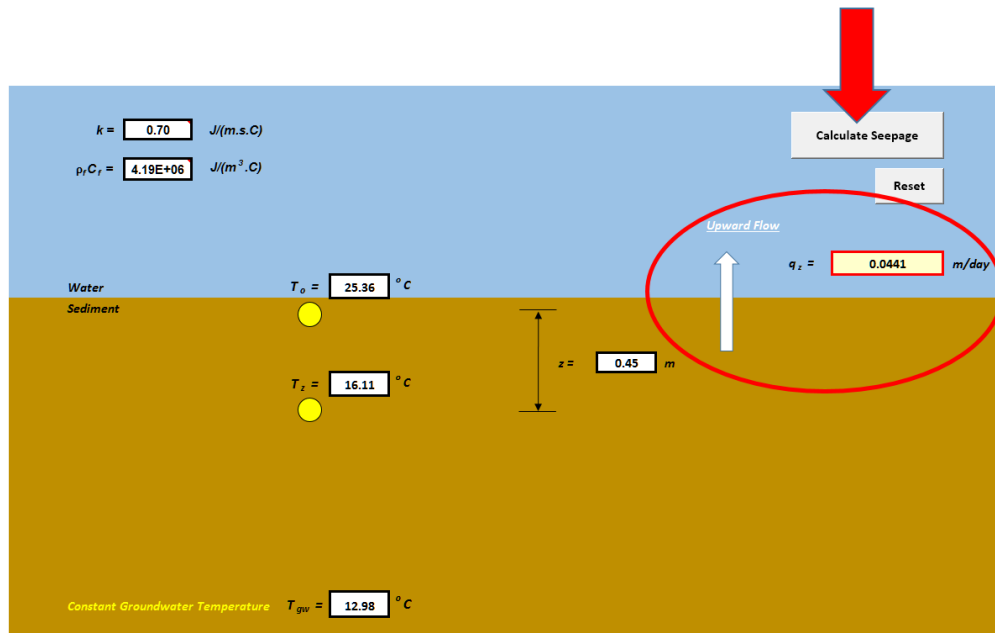


Figure 4: Example of an executed Schmidt worksheet

2.1.2 Transient Models

2.1.2.1 Hatch Model

2.1.2.2 McCallum Model

2.2 Export to pdf

Xxx

2.3 Export to Excel

End section

3.0 Measurements

3.1 Projects

xxx

3.2 Sediments

xxx

4.0 Parameters

4.1 xxx

xxx

4.2 xxx

xxx

5.0 Tags

5.1 xxx

xxx

5.2 xxx

xxx

6.0 User Documentation

6.1 User Manual

xxx

6.2 Release Notes

xxx

7.0 Help/Suggestions

7.1 Request Help

xxx

7.2 Suggestions

xxx

8.0 My Account

8.1 My Profile

xxx

8.2 Change Password

xxx

References

Bredehoeft, J. D. and I. S. Papadopoulos (1965). "Rates of vertical groundwater movement estimated from the Earth's thermal profile." *Water Resour. Res.* 1(2): 325-328.

Schmidt, C., B. Conant Jr, M. Bayer-Raich and M. Schirmer (2007). "Evaluation and field-scale application of an analytical method to quantify groundwater discharge using mapped streambed temperatures." *Journal of Hydrology* 347(3–4): 292-307.