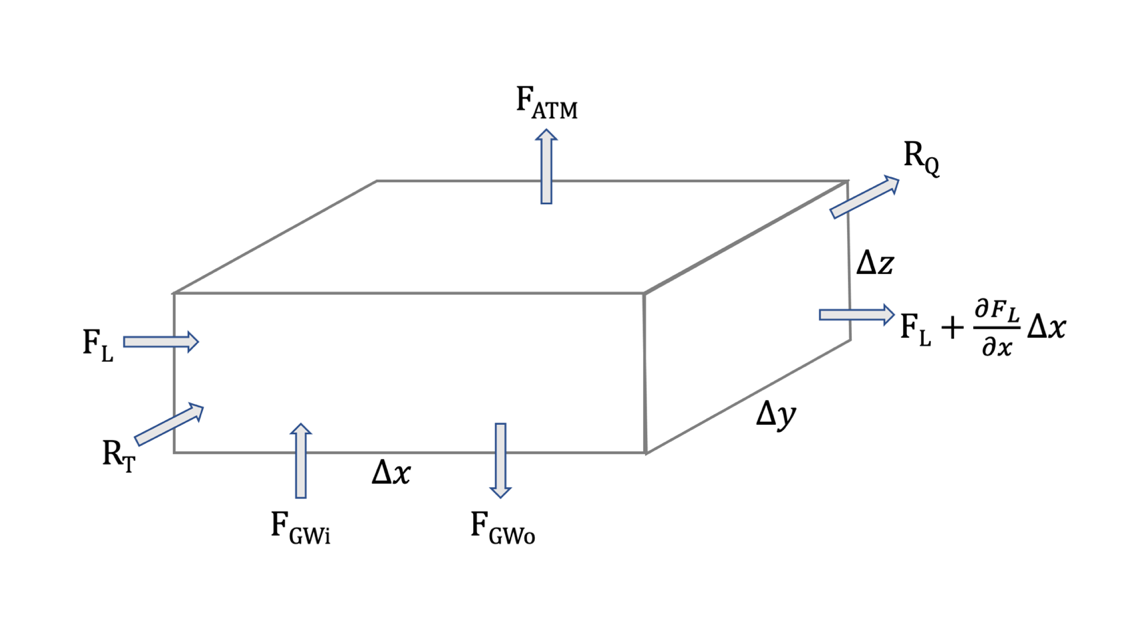
**Supporting Information 1: Derivation of 1D stream transport model**

Equations for a 1D transport model that includes advection, dispersion, gas exchange, first-order decay and groundwater inflow and is coupled with a mass balance equation for stream discharge.

**1. Conservation of Solute Mass**



Governing equation for the conservation of solute mass:

[S1.1a]

Terms and Units:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| M | Mass |  | Q | Volumetric flow rate |  |
| t | Time |  | q | Specific discharge (flux) |  |
| C | Concentration |  | FL | Longitudinal mass flux in stream |  |
| D | Dispersion |  | FD | Dispersive mass flux |  |
| k | Atmospheric exchange coefficient |  | FA | Advective mass flux |  |
| λ | Decay coefficient |  | FGW | Mass flux from groundwater inflow (i) and outflow (o) |  |
|  |  |  | R | Mass sources and sinks:   * atmosphere (ATM) * decay (D) * tributaries (T) * pumping (Q) |  |

Solute mass flux by dispersion:

Solute mass flux by advection:

Breakdown of components from [S1.1a]:

[S1.1b]

[S1.1c]

[S1.1d]

[S1.1e]

[S1.1f]

[S1.1g]

[S1.1h] assuming flux across bottom face of stream cell

[S1.1i] assuming flux across bottom face of stream cell

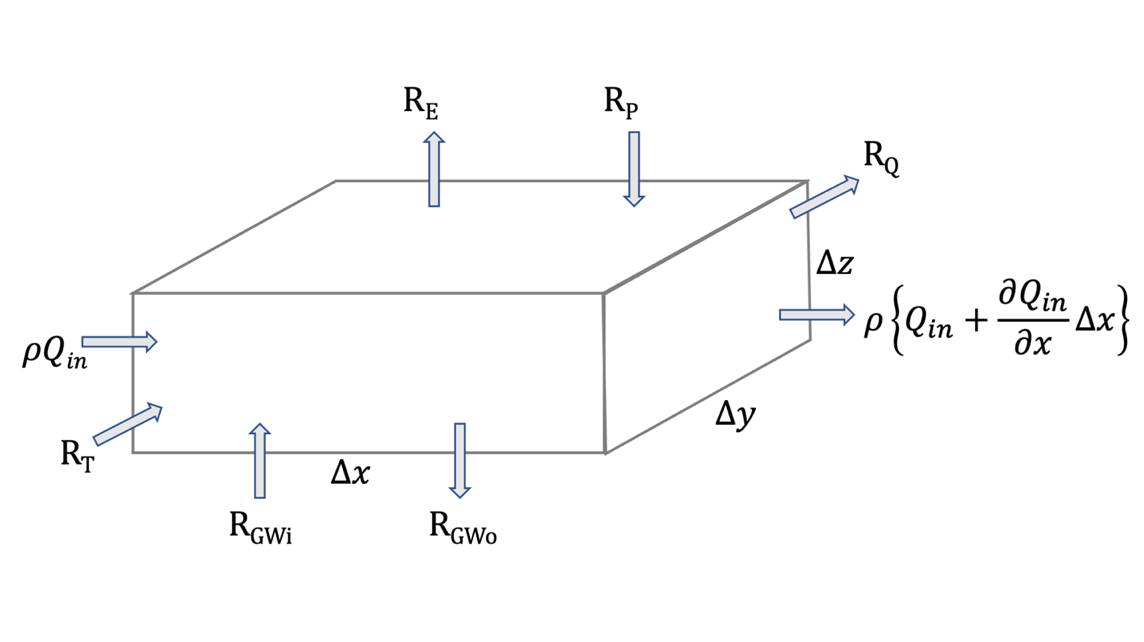
[S1.1j] assuming stream cell dimensions are constant over time

Replacing the components in [S1.1a] with [S1.1b] through [S1.1j] yields:

Simplifying further yields:

[S1]

**2. Conservation of Water**



Governing equation for the conservation of water:

[S1.2a]

Terms and Units:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| M | Mass |  | ΔFQ | Change in stream flow |  |
| t | Time |  | RGW | Groundwater inflow (i) and outflow (o) |  |
| Q | Volumetric flow rate |  | R | Sources and sinks:   * precipitation (P) * evaporation (E) * tributaries (T) * pumping (Q) |  |
| q | Specific discharge (flux) |  | ρ | Fluid density (assumed to be constant) |  |

Breakdown of components from [S1.2a]:

[S1.2b]

[S1.2c]

[S1.2d]

[S1.2e]

[S1.2f]

[S1.2g]

[S1.2h] assuming flux across bottom face of stream cell

[S1.2i] assuming flux across bottom face of stream cell

Replacing the components in [S1.2a] with [S1.2b] through [S1.2i] and assuming that ρ is constant yields:

Assuming a steady state condition and further simplifying yields:

|  |
| --- |
| Setting (where w is the stream width) yields: |
| [S2] |

**3. 1D Advective-Dispersive Transport in a Stream**

Using the product rule to combine [S1] and [S2]:

Assuming a steady state condition and further simplifying yields:

[S3]

|  |
| --- |
| Setting (where w is the stream width), (where A is the cross-sectional area of the stream), and P =0 (no precipitation at the time of sampling) yields: |
| [S4] |