Developing an in-stream water quality model for improved simulation of nutrient dynamics in SWAT

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Background

In-stream water quality modelling is critical for evaluating the fate of nutrients in streams and other water bodies. Literature reports that water quality simulations in SWAT can have large deviations from observed data. This can be attributed primarily to lack of measured data, uncertainty in input data (e.g. agricultural management practices and soil nutrient status) as well as inaccurate simulation of nutrient transport processes. Furthermore, studies have suggested a **need for refining the currently available water quality algorithms in SWAT**.

A previous case study (Master's project) on water quality simulations for St. Joseph watershed in US showed that the in-stream water quality module in SWAT can be replaced by a simple exponential model to give similar results for nitrate and total phosphorus predictions.

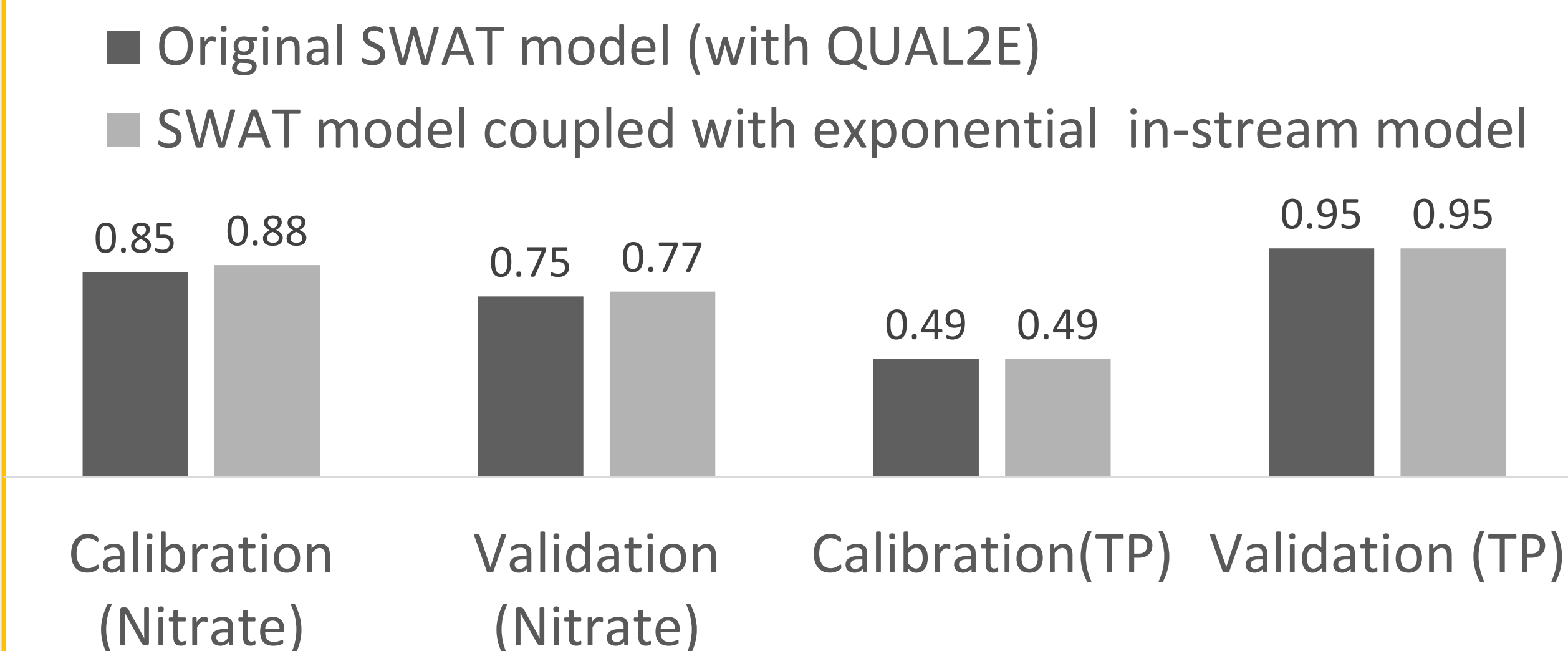R-square values for nitrate and total phosphorus simulations

- Original SWAT model (with QUAL2E)
- SWAT model coupled with exponential in-stream model

Figure 1. Model performance statistics for St. Joseph watershed case study

Objective

The major objective of this study is to develop an in-stream water quality model **for simulating nutrient transport dynamics in stream** reaches. Further aim of this study would be to incorporate this module into SWAT model for improved prediction of water quality parameters.

Proposed Methodology

Study Area

The model will be developed for Kielstau catchment (50 km^2) in Northern Germany. Initial testing of the model is being carried out using data in US catchments (fine resolution water quality data from USGS).
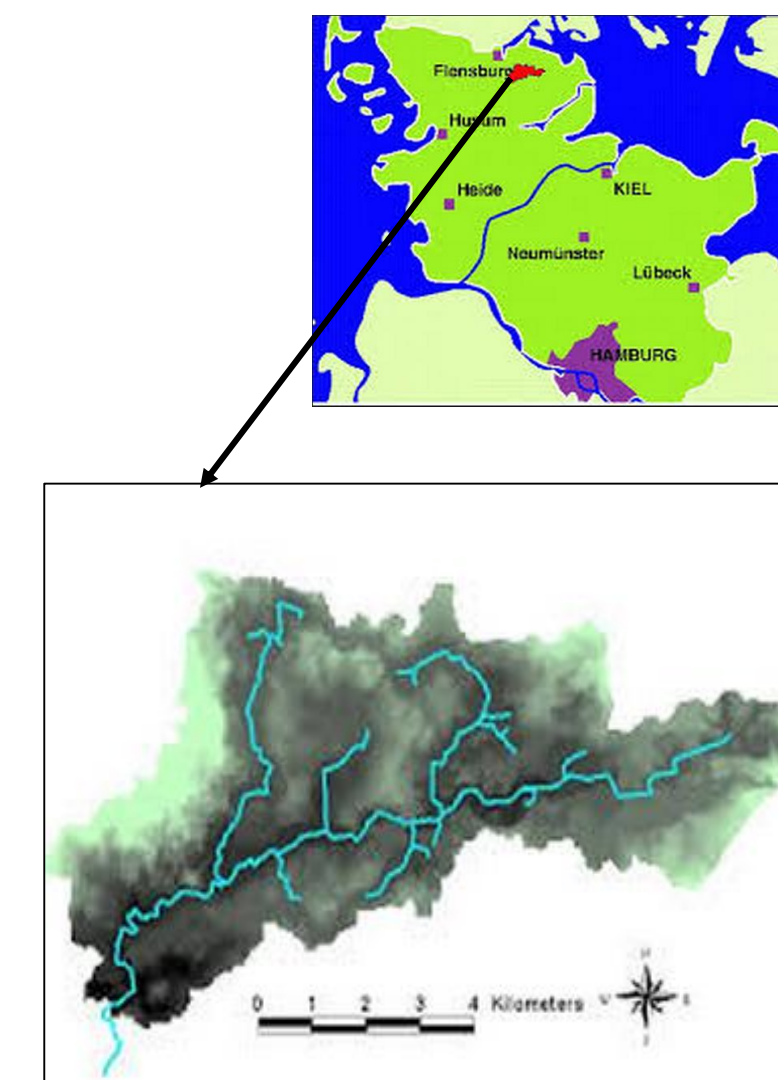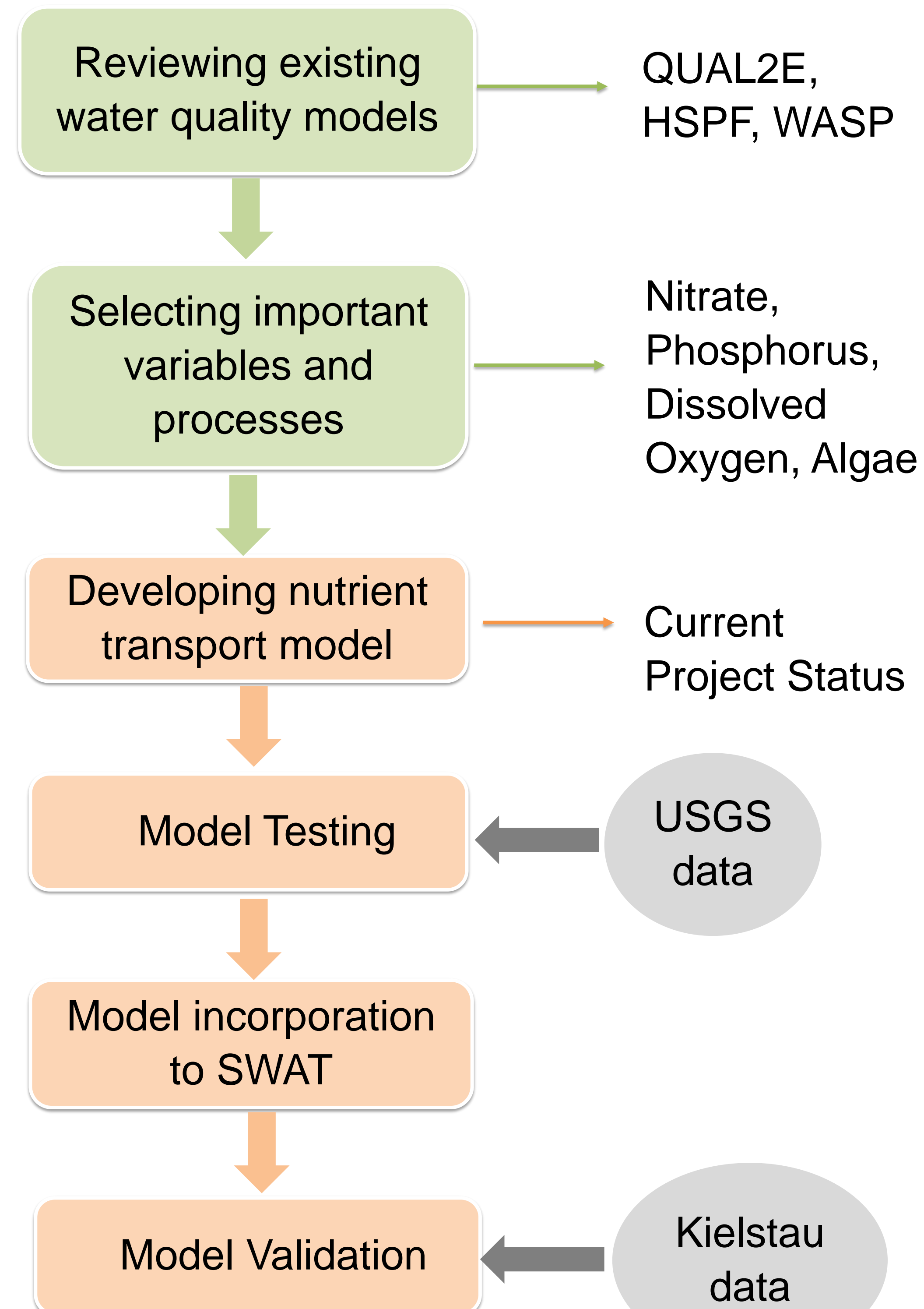

Figure 2. Kielstau Catchment

Reviewing existing water quality models → QUAL2E, HSPF, WASP

Selecting important variables and processes → Nitrate, Phosphorus, Dissolved Oxygen, Algae

Developing nutrient transport model → Current Project Status

Model Testing ← USGS data

Model incorporation to SWAT

Model Validation ← Kielstau data

Figure 3. Methodology framework

Modelling approach using Finite Difference Scheme

Modelled at sub-daily scale

Advection, Dispersion, Transformations
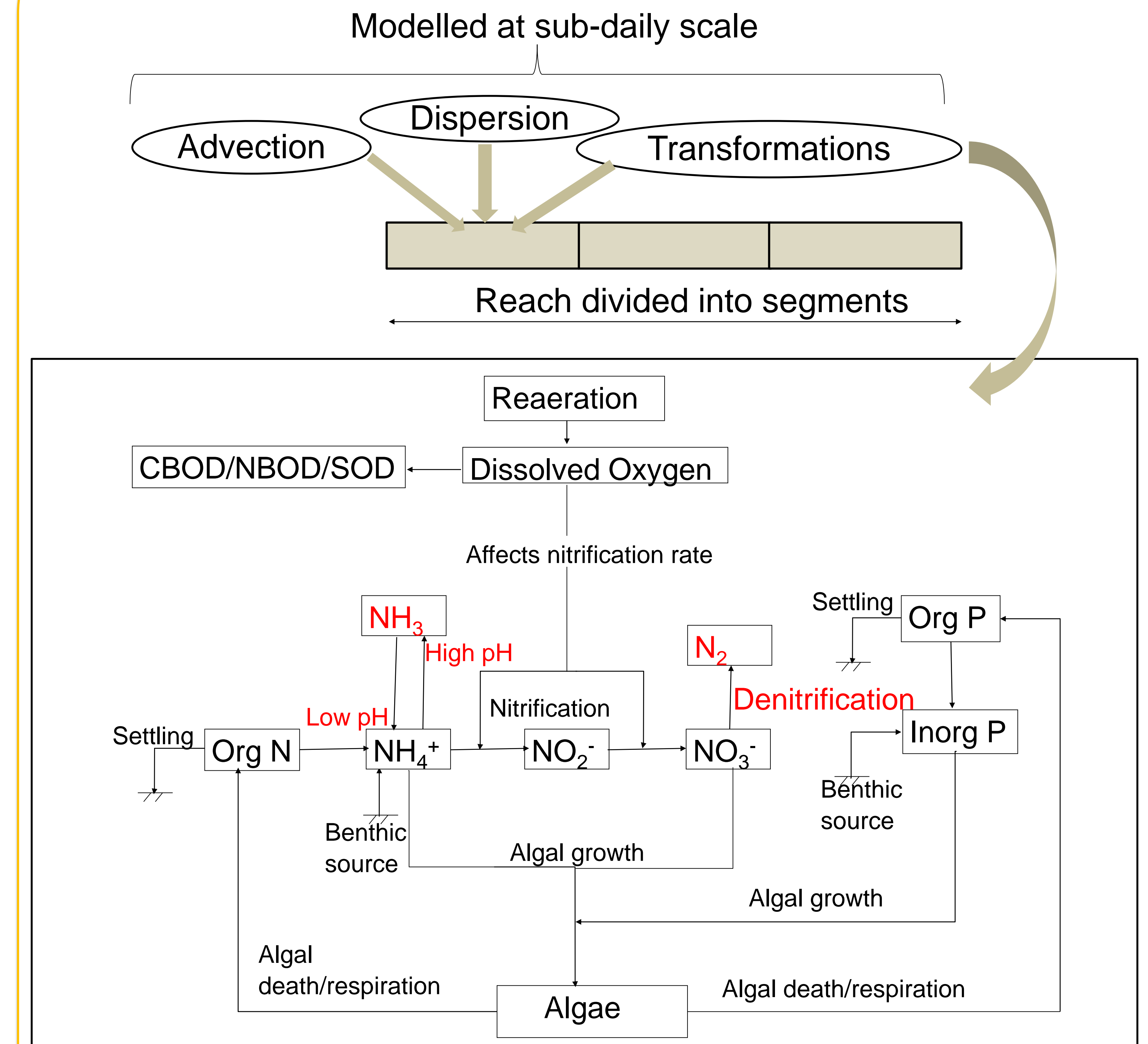
Reach divided into segments

Figure 4. Major constituent interactions in proposed model

Expected Outcomes

- Newly developed model for nutrient (nitrate and phosphorus)transport in streams
- Improved water quality predictions in SWAT at sub-daily scale

References

Chapra, S. C. 1997. Surface water-quality modeling. McGraw-Hill, New York
Brown, L.C. and Barnwell, T.O. 1987. The enhanced stream water quality models
QUAL2E and QUAL2E-UNCAS: documentation and user manual. EPA/600/3-87/007, US
Environmental Protection Agency, Athens, GA.