# Revisiting Reactive-Transport Modeling of the Phosphorus Plume near Joint Base Cape Cod

Problem:

Geochemical modeling has great potential for planning remediation strategies by investigating the hydrogeochemical effects of different remediation options in a cost-effective manner. However, to be useful, the modeling results must be reliable. For many situations, it is not possible to evaluate the results of modeling, either because time scales are too long (centuries to millennia), or because experimentation or sampling is prohibitively expensive.

Objective:

The objective of this work is to evaluate the accuracy of a reactive-transport model of the phosphorus plume downgradient of former treated-wastewater disposal beds at Cape Cod, Massachusetts (Parkhurst and others, 2003). The model forecast the movement and dissipation of the phosphorus plume in the decades following cessation of sewage treatment in 1995. The rates of movement and reactions allow comparison of model results with field measurements that have been made over the two decades following cessation of treated-wastewater disposal. This work will assess the correctness of the model assumptions and predictions, and will compare the original model with a revised model that accounts for the evolution of the plume over the longer period of observation.

Approach:

Treated sewage effluent was disposed in ground-infiltration beds at Joint Base Cape Cod on western Cape Cod during the operation of the sewage treatment plant from 1936 to 1995. During that period a plume of phosphorus-containing groundwater developed downgradient of the disposal beds that extended to Ashumet Pond, a distance of approximately 600 meters. Meanwhile, conservative constituents in the plume traveled several kilometers downgradient, so the effects of sorption and other chemical reactions greatly retarded the movement of phosphorus.

A reactive transport simulation using the model PHAST was developed for the phosphorus plume that was based on (1) laboratory experiments of phosphorus movement through columns of Cape Cod sediments, (2) the measured distribution of phosphorus in the plume in 1993, (3) estimates of phosphorus loading at the beds during the period of effluent disposal, and (4) hydraulic parameters derived from MODFLOW modeling of groundwater flow in western Cape Cod. The model predicted movement and diminishment of the phosphorus plume over the course of several decades.

Now, two decades have passed since the cessation of effluent disposal, and data on the evolution of the phosphorus plume have been collected with full-plume snapshots available in 1999, 2007, 2012, and 2014, and in many other less complete sampling campaigns. It is now possible to evaluate the predictions of the reactive-transport modeling by comparing simulations with these sampling snapshots.

The modeling analysis will proceed along two fronts. One approach will be to revisit the original model and consider improvements that could have been made with better modeling techniques, particularly greater grid refinement than is now available, re-evaluation of the selected chemical reactions, and parameter estimation. The second will be the development of a revised model, given the longer period of data collection. The comparison of the revised model with the original model should allow us to determine which model parameters could have been improved in the original model, and which were unknowable without additional information. In addition, the revised model will provide better estimates of the past and future loading of phosphorus to Ashumet Pond.

The conclusions from these old and new modeling exercises will relate to the reliability of reactive transport modeling. In addition, the more complete modeling of phosphorus should be germane to the real, and expensive, options for sewage treatment on Cape Cod.

Timetable:

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| Task | Completion date |
| Get original model running and verify results | April 30, 2016 |
| Rerun original model with finer grid and other variations known at time of development | May 31, 2016 |
| Develop revised model incorporating new information and parameter estimation if warranted | July 31, 2016 |
| Parameter estimation with revised model | September 30, 2016 |
| Draft manuscript | December 31, 2016 |
| Approved manuscript | March 31, 2017 |
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