A FLEXIBLE AND EASY-TO-USE CONTAMINANT FATE/TRANSPORT MODEL FOR STREAMS

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Abstract

The Contaminant Model for Streams (CMS) was developed for studies where data and resources for model application are limited. CMS can be relatively easily and quickly applied, yet it is a versatile model that can be used for a variety of conditions ranging from short term spill modeling to multi-year simulations of contaminant fate in stream water and bottom sediments. CMS was developed to fill a gap in the Adaptive Risk Assessment Modeling System (ARAMS). Before the addition of CMS, ARAMS did not have a one-dimensional, contaminant transport and fate model for streams that could simulate water column and sediment bed interactions.

CMS was developed such that it can be applied within the ARAMS framework and also can be run as a stand-alone application outside of ARAMS. The model can be applied for both organic and inorganic contaminants, and the available fate and transport processes include advection and diffusion along the stream reach, settling, resuspension, burial, volatilization, decay or degradation, and diffusion between the water column and the sediment pore water. Time-varying upstream loadings and flows can be applied, but flows are updated instantaneously throughout the reach, i.e., there is no hydraulic routing feature, which reduces model complexity.

The fundamental law utilized in the development of the CMS is conservation of mass along the longitudinal axis (flow direction) of a surface water body, such as streams and rivers. The stream surface water is represented by a one-dimensional (longitudinal) discretization for mass balance, where mass concentrations are assumed to be uniform across the width and depth of the stream. A constituent mass balance is performed for the water column and sediment bed. The bed is treated as a single active layer. The bed layer for each longitudinal segment is independent of other bed segments and interacts only with the water column immediately above the bed segment.

Suspended solids can be transported, or a steady-state concentration may be input. The ARAMS version does not presently include solids transport. If suspended solids in the water column are transported, then they are treated similar to a contaminant constituent that does not decay or volatilize. The solids are advected and dispersed along the length of the stream reach in the same manner as the constituents but do not have all of the same loss mechanisms. The only loss mechanism for suspended solids in the water column is settling. In the same manner there is an influx of solids to the water column from any sediment resuspension that occurs. The CMS can also be run with a steady-state solids concentration. In this case, solids will not be modeled in the water column, and the background solids concentration is specified and held constant for the entire simulation period.

An implicit, finite difference, numerical solution scheme is used to solve the partial differential equations for surface water contaminant and suspended sediment concentrations. A choice between two numerical integration schemes is provided to solve the ordinary differential equation for sediment bed contaminant mass. A time-weighting parameter is used in the water column solution and can be varied independently for both the advection and diffusion terms. Although the implicit solution for the water column is unconditionally stable, the solution for the bed is not and can generate oscillating, unrealistic concentrations for large time steps. An adaptive time stepping solution option has been implemented for solving the ordinary differential equation for the bed to ensure stable results.

The model user interface provides an easy-to-use method for quickly setting up the model and examining results. The interface also allows the user to select the methods and parameters used for the numerical solutions. The solution methods were selected to result in very short computer execution time for most applications. The model was verified against analytical solutions and results from two other models developed by ERDC, RECOVERY and PREWet, the latter of which uses an analytical solution method.

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