A NEW APPROACH TO EFFLUENT PLUME MODELLING IN THE INTERMEDIATE FIELD

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In many densely populated coastal cities in Asia, wastewater discharges are often located in close proximity to sensitive areas such as beaches or shellfisheries. The impact and risk assessment of effluent discharges poses particular technical challenges, as pollutant concentration needs to be accurately predicted both in the near field and intermediate field.

The active mixing close to the discharge can be modelled by proven plume models, while the fate and transport beyond the mixing zone can be well-predicted by three-dimensional (3D) circulation models. These models are usually applied separately with essentially only one-way coupling. Important phenomena such as surface buoyant spread or source-induced changes in ambient stratification cannot be addressed by such an approach. To correctly simulate these dominant physical processes, the dynamic near field effects of the discharge and the corresponding volume and mass fluxes need to be properly modelled in the far field model.

A new method is proposed to model effluent mixing and transport in the intermediate field by dynamic coupling of a 3D far field model based on the public domain Environmental Fluid Dynamics Code (EFDC) with a Lagrangian near field plume model JETLAG. The action of the plume on the surrounding flow is modelled by an equivalent diluted source flow at the predicted terminal height of rise and a distribution of entrainment sinks along the plume trajectory. In this way, a true two-way dynamic link is established at grid cell level between the near and far field models with full water and tracer mass conservation. The accuracy of the method is demonstrated for a number of complex flows including the interaction of a confined rising plume with ambient stratification, and the mixing of a line plume in cross-flow. The general and robust method can be readily implemented in existing circulation models to yield accurate predictions of the intermediate/far field for many environmental transport problems.