

EEMS Demonstration Model Description

DM_Harbor_U-Mask_LPT

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate Lagrangian Particle Tracking (LPT) through a U-shaped baffled harbor. The domain represents a rectangular tank with 9 internal U-component mask baffles that force flow to navigate a U-shape path between the inflow boundary and the open tidal boundary. Particles are released from a polygon-defined region (Figure 1) and tracked as they move through the baffled sections. The primary objective is to demonstrate the horizontal and vertical movement capabilities of the EFDC+ LPT sub-model under combined constant inflow and tidal forcing, and to compare two key LPT configurations: (1) no random walk with wall slippage, and (2) random walk with no wall slippage. The comparison directly illustrates how the random walk component and wall boundary treatment affect particle dispersion through a constrained flow path.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain is a rectangular tank 500 m long and 220 m wide, with a uniform flat bottom at -4.96 m. Nine sets of masks create internal flow barriers that divide the tank into a serpentine channel, forcing particles to travel the full length of each baffle section before turning.

Table 1 Model configuration summary

Run Period (Julian Days)	Horizontal Cells	Vertical Layers	Activated Modules
0–1	3,824 cells	5 layers (standard sigma)	- Hydrodynamics - Lagrangian Particle Tracking - Dye

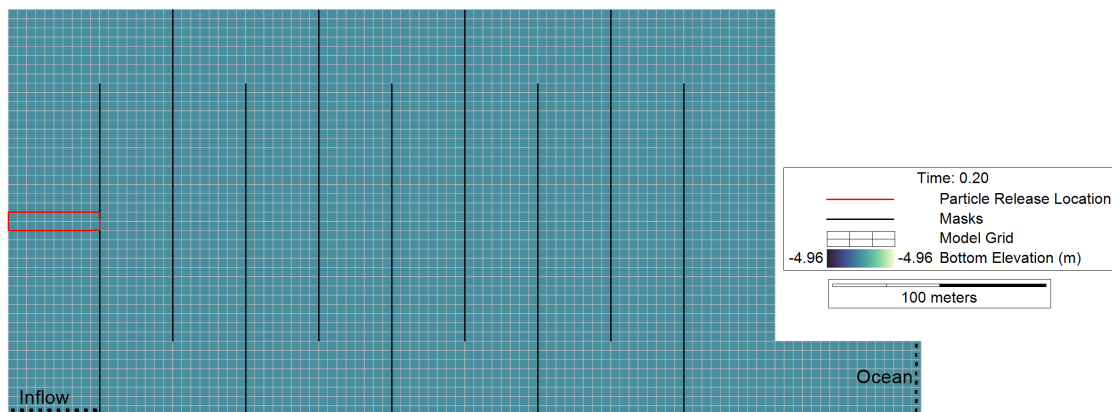


Figure 1 Model domain

2.1 Hydrodynamic Configuration

Flow is driven by two mechanisms acting simultaneously. A constant inflow of $0.5 \text{ m}^3/\text{s}$ total is distributed across 10 source cells at $I = 11\text{--}20$, $J = 11$ (southwest boundary), with each cell carrying an equal flow split of 0.1. The open (tidal) boundary consists of 8 east-facing cells forced by a single M2 tidal constituent (amplitude 0.914 m, period 43,200 s). These two forcings combine to produce a time-varying flow field within the serpentine baffle channel.

The simulation uses dynamic time-stepping with a base timestep of 0.005 s and a maximum of 2 s, providing the fine temporal resolution required to accurately track particles through the narrow baffle passages. Wetting and drying is activated. Horizontal momentum diffusion is disabled; diffusion enters only through the LPT random walk component in the models where it is enabled.

2.2 Lagrangian Particle Tracking Configuration

The LPT sub-model is activated with Explicit Euler method. Particles are seeded from a polygon-defined release region (`LPT_Zone_G1.p2d`) at the start of the simulation. The mathematical basis for particle movement follows the 3D advection–diffusion equations of Dunsbergen et al. (1993) as implemented in EFDC+ (DSI, 2009):

$$dx = \left(u + \frac{\partial D_H}{\partial x} \right) dt + \sqrt{2D_H dt} (2p - 1) \quad (1)$$

$$dy = \left(v + \frac{\partial D_H}{\partial y} \right) dt + \sqrt{2D_H dt} (2p - 1) \quad (2)$$

$$dz = \left(w + \frac{\partial D_V}{\partial z} \right) dt + \sqrt{2D_V dt} (2p - 1) \quad (3)$$

where p is a uniform random number with mean 0.5, D_H is the horizontal diffusion coefficient, and D_V is the vertical diffusion coefficient. When the random walk is disabled, the second (stochastic) term is set to zero and particles follow purely advective trajectories.

2.3 Two-Model Comparison

This demonstration package contains two model variants that share the same hydrodynamic configuration but differ in their LPT settings, controlled through `DRIFTER.INP`:

- **NoRandom_Slippage**: Random walk disabled. Particles follow purely advective trajectories. Wall slippage is **enabled**, meaning particles that reach a mask boundary are allowed to slide along it rather than being reflected. This produces smooth, orderly particle paths that closely follow streamlines through the baffle channel.
- **Random_NoSlippage**: Random walk enabled. Wall slippage is **disabled**, meaning particles are reflected at mask boundaries. The stochastic diffusion component spreads particles away from their advective path, producing a broader particle cloud and greater cross-baffle mixing.

The horizontal diffusion coefficient for the random walk case is set to $D_H = 0.01 \text{ m}^2/\text{s}$ (from DSI, 2009, Section 5.3). The particle depth option and the number of drifters (1,000) are identical between the two models.

3 Folder Structure

The model package contains the following components:

- **Model:** Two EFDC+ model project directories:

- `NoRandom_Slippage`: purely advective LPT, wall slippage enabled
- `Random_NoSlippage`: random walk LPT, wall slippage disabled

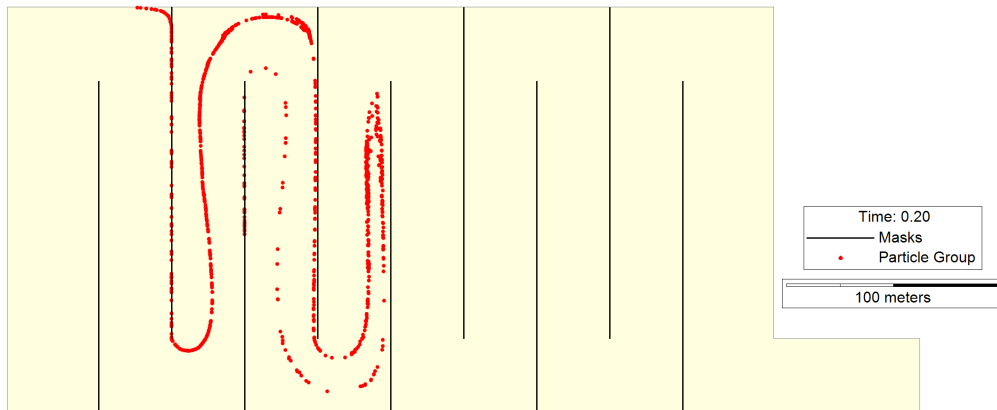
Both can be loaded directly in EFDC+ Explorer for pre- and post-processing.

- **Data:** Contains two supplementary files:

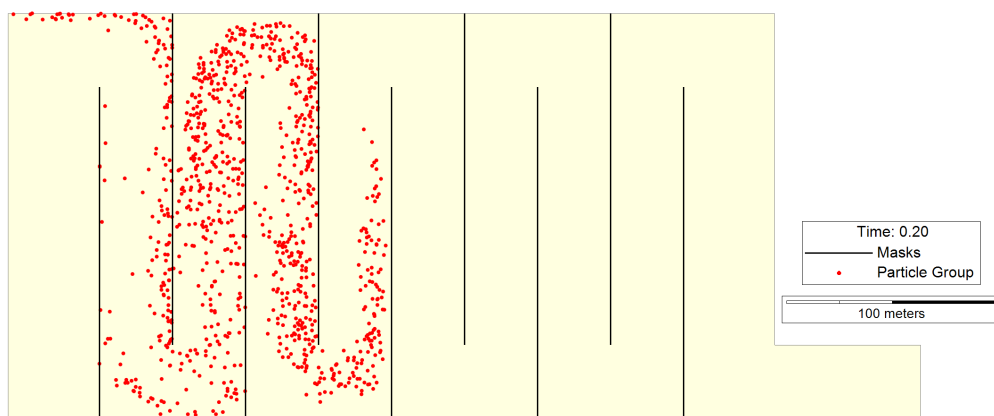
- `EFDC_DSI_Lagrangian_Particle_Tracking_(2009_06_20).pdf`: the technical documentation for the EFDC+ LPT sub-model, including mathematical formulation, numerical methods, and the Harbor_U validation test case on which this model is based
- `LPT_Zone_G1.p2d`: the polygon file defining the initial particle release region

4 Model Results

Figures ?? show plan views of the 1,000 particles at time 0.20 days (≈ 4.8 hours) for both model configurations. The black vertical lines are the masks. Both figures use the same snapshot time, making the comparison between the two LPT configurations direct and unambiguous. The domain has 6 visible baffle sections; particles have reached the second baffle in both cases.



(a) **NoRandom_Slippage**: particles form tight, coherent bands that closely follow the streamlines through the serpentine baffle channel. The two U-shaped loops are clearly delineated with minimal lateral spread, and particles slide along the mask walls rather than accumulating against them.



(b) **Random_NoSlippage**: the stochastic diffusion component disperses particles broadly across the baffle sections. The U-shaped path is still discernible but particles are scattered widely, filling much of the available channel width. Particles accumulate along the mask walls rather than sliding past them.

5 References

- DSI (2009). *Implementation of a Lagrangian Particle Tracking Sub-Model for the Environmental Fluid Dynamics Code (Draft)*. Dynamic Solutions International, LLC, Seattle WA and Hanoi Vietnam, June 20, 2009.
- Dunsbergen, D.W. and Stalling, G.S. (1993). The combination of a random walk method and a hydrodynamic model for the simulation of dispersion of dissolved matter in water. *Transactions on Ecology and the Environment*, vol 2, WIT Press.

6 Notes

6.1 Disclaimer

This model is provided to demonstrate that EFDC+ Explorer and EFDC+ can be used to build and analyze this type of models. The simulation results are consistent with expected behavior;

however, the model should not be considered a final or validated product. Users are encouraged to review, modify, and refine model parameters to obtain results appropriate for their specific application.

6.2 EEMS Demo Mode

In Demo mode, the model is validated against a set of predefined signatures, including grid size, domain area, center coordinates, transport count, and module configuration. While certain parameter values may be adjusted, the grid cannot be modified, transports cannot be added, and the prescribed module setup cannot be altered. Any deviation from these conditions results in the model no longer being considered a valid demo model.

6.3 Support

For technical support, additional documentation, or to obtain the latest version of EFDC+ Explorer, please visit: www.eemodelingsystem.com