Operational Forecasts and Contaminant Tracking in the Huron-Erie Corridor

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GOAL

The Huron-Erie Corridor (HEC) consists of the St. Clair River, Lake St. Clair, and the Detroit River and makes up the connecting waterway between Lake Huron and Lake Erie, forming the international border between the U.S. and Canada. In addition to commercial shipping, recreational boating, swimming beaches, and drinking water intakes, the HEC is home to several petrochemical plants along the St. Clair River. Therefore, contaminant spills in the HEC can move swiftly through the system, impacting the ecosystem and drinking water intakes within hours or minutes. In order to assess the impacts of a contaminant spill on public source drinking water and aid in spill response, an operational hydrodynamic model has been developed to predict currents, water levels, and spill transport in the HEC. The Huron-Erie Connecting Waterways Forecasting Model (HECWFS) is operated in real-time at NOAA/GLERL, providing nowcasts every 3 hours and 48-hour forecasts every 12 hours. => www.glerl.noaa.gov/res/hecwfs. Using the HECWFS forecasting system, a spill reference library has been created to allow decision-makers to plan for and respond to a spill event without relying on real-time model simulations. This library, which is based on results from a variety of spill scenarios, gives the water intake manager information on how different spills could impact public drinking water along the St. Clair River.

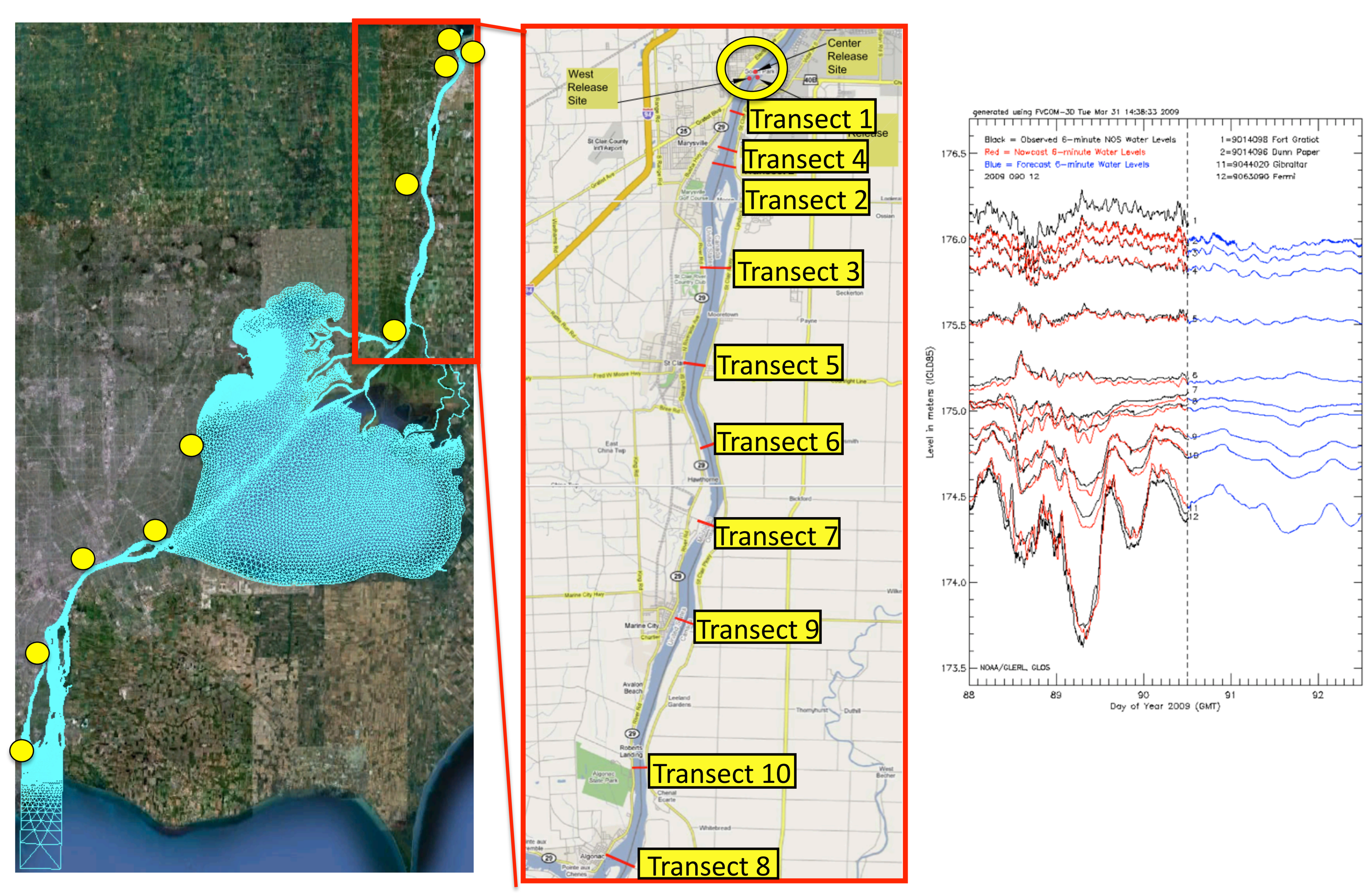

Figure 1: (left) HECWFS model domain with 10 water level gauges (yellow circle) used for boundary conditions and verification. (middle) Location of dye releases and sampling transects in St. Clair River. (Right) Real-time model water-level nowcast/forecast and observations.

Science Behind Forecasts

In order to ensure accurate model predictions, three dye releases were carried out in the St. Clair River to mimic a contaminant spill on the US shore, center channel, and Canadian shore (Fig. 1). For each release 33 liters of Rhodamine WT dye was released at the water surface. Following each release, 10 sampling transects provided observations of the dye plume as it traveled downstream, yielding measurements of travel time, lateral/vertical mixing, and concentration at the transects/water intakes. Model simulations of the dye release were carried out using the HECWFS hydrodynamic model and a Lagrangian particle tracking model. For each simulated spill, a particle patch (N=100,000) was released at the spill location. Similar to the experimental dye release, the particle concentrations were calculated at each sampling transect (Fig. 1) using a weighted average particle count (Fig. 3). Breakthrough curves (C vs. t) were generated for experimental and simulated spills in order to compare results and use for model calibration. Simulated spills are in agreement with observed results (Fig. 4), and provide successful prediction of travel time, mixing, and trajectory

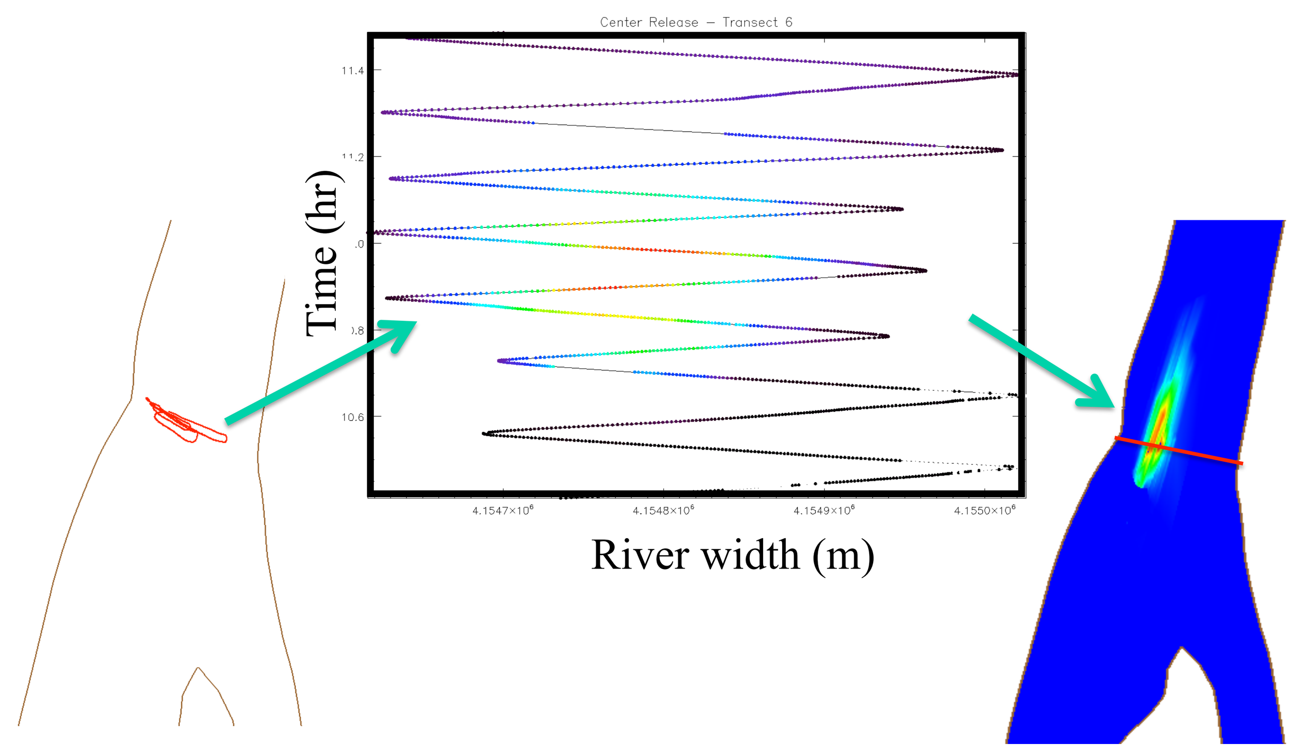

Figure 2: Experimental measurements of dye concentration were scaled using characteristic river currents allowing for interpolated reconstructions of the dye plume as it crossed each transect.

Spill Reference Library

After model calibration with the experimental dye releases, several scenarios were carried out to mimic an array of spill locations for both vertical and along-stream release points as well as for various spill types (e.g. bottom-release, surface-release, denser than water, oil, etc – Fig. 5). In each scenario, the particle concentration was determined as a function of time for each sampling transect, located at drinking water intakes along the corridor. For each transect, the leading edge, maximum concentration, trailing edge, and lateral/vertical mixing were recorded (Fig. 6). A table based on the results from each spill was created as a reference guide for use in spill planning and real-time response. These reference guides, or Spill Reference Library (Fig. 7), enables users to assess spill impacts immediately without the need for additional modeling efforts.

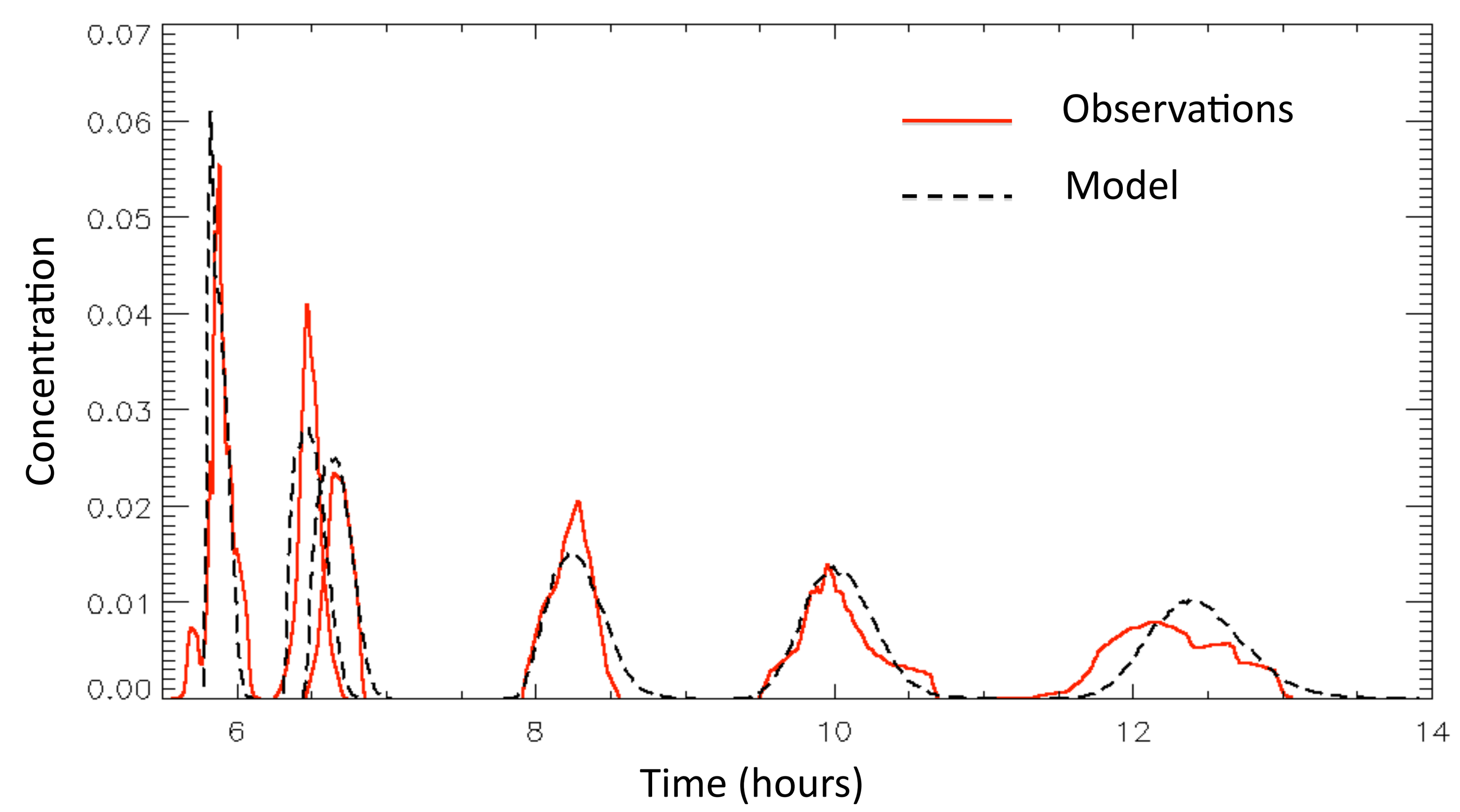

Figure 4: Comparisons of simulated and experimental 'spill' concentrations at representative sampling transects (breakthrough curves).

$$\overline{C}(t) = \frac{\sum_{i=1}^{n} C_i A_i}{\sum_{i=1}^{n} A_i}$$

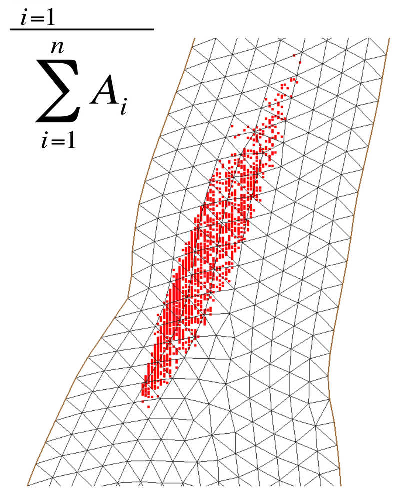

Figure 3: Simulated particle plume.

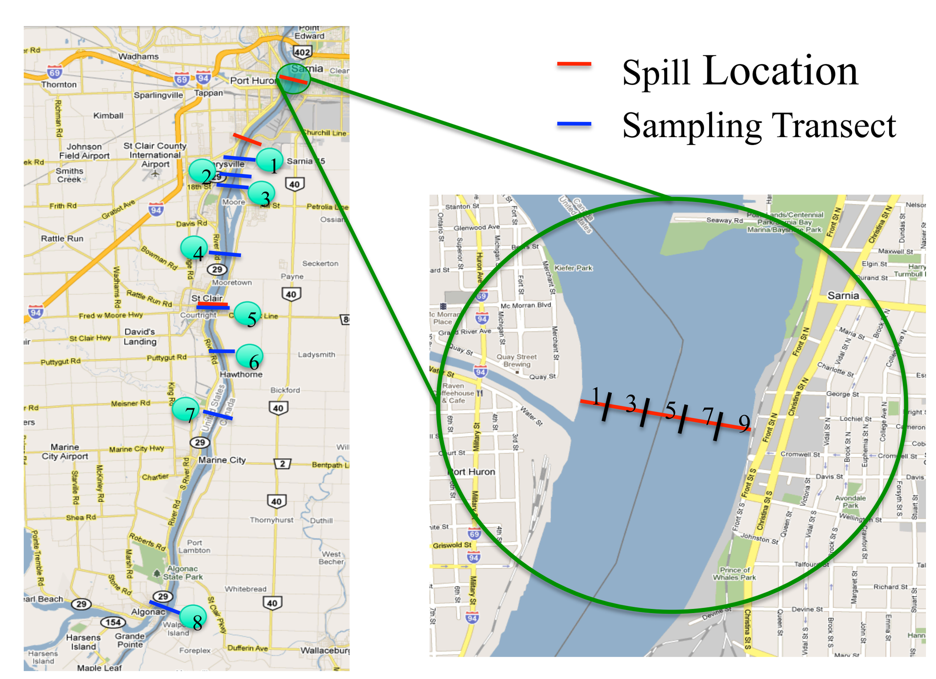

Figure 5: Spill scenarios used to generate the Spill Reference Library. Scenarios vary between location and chemical type. Sampling transects are located at each drinking water intake.

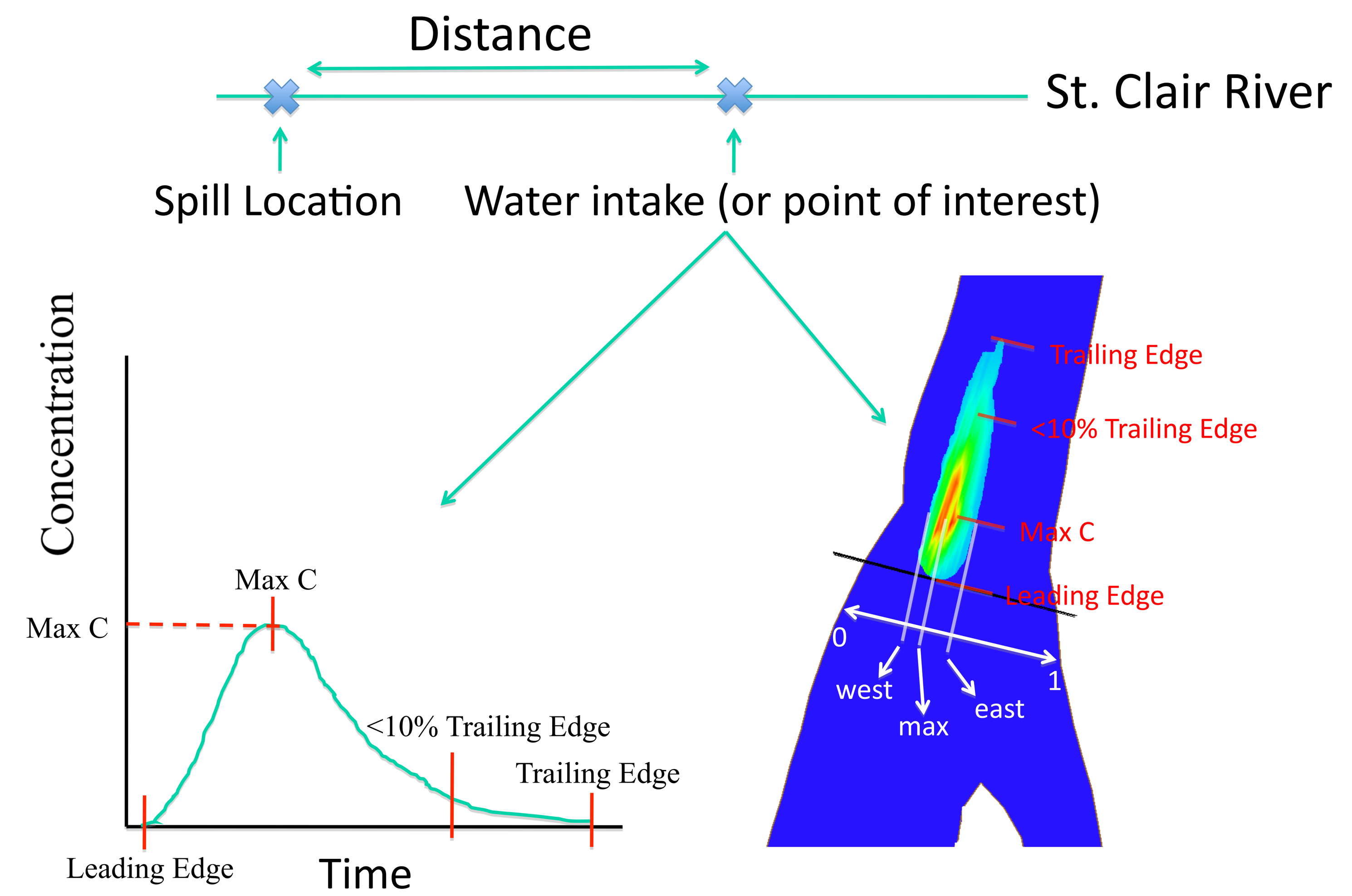

Figure 6: For a given spill location and type, model simulations are used to provide plume characteristics such as arrival time, concentration, trailing edge time, and mixing in the water column and across the channel.

In Fig. 7, an example table from the Spill Reference Library enables the water treatment operator to asses the impacts at the St. Clair Water Intake for a surface, center-channel spill 14 km upstream of the water treatment plant. Using this static table, the operator can decide how to respond without having to wait for additional simulations or can use the table in a spill planning mode before an event occurs.

Marysville Center Channel Release - Surface

Transect	Leading Edge	Dist (km)	Max Conc.	Time - max C.	Trailing Edge	West edge	Max C.	East edge
1	0 hr 35 min	2.6	0.17	0 hr 02 min	0 hr 20 min	0.19	0.24	0.63
2	1 hr 05 min	4.4	0.06	0 hr 04 min	0 hr 35 min	0.16	0.28	0.71
3	1 hr 15 min	5.0	0.05	0 hr 05 min	0 hr 40 min	0.18	0.26	0.73
4	2 hr 35 min	9.4	0.03	0 hr 35 min	4 hr 00 min	0.08	0.39	0.74
St. Clair intake	**4 hr 05 min**	**14.1**	**0.02**	**0 hr 30 min**	**4 hr 15 min**	**0.05**	**0.19**	**0.77**
6	5 hr 05 min	17.3	0.02	0 hr 35 min	4 hr 25 min	0.07	0.23	0.81
7	6 hr 10 min	21.0	0.02	0 hr 45 min	4 hr 35 min	0.14	0.34	0.82
8	11 hr 15 min	36.4	0.01	2 hr 00 min	6 hr 30 min	0.04	0.17	0.97

Figure 7: An example table from the Spill Reference Library. For a center-channel, surface spill near Marysville, the spill timing and mixing characteristics can be determined at the location of the St. Clair Water intake.

Status

The HECWFS operational model provides real-time nowcasts and forecasts of currents and water levels for the Huron-Erie Corridor. Using the real-time model and three experimental dye releases, a spill forecasting model is developed in order to provide decision-makers with the information needed to respond in the even of a contaminant spill in the St. Clair River. The validated HECWFS model is able to provide real-time simulations of contaminant spills as well as forecasted spill trajectories. In addition, a Spill Reference Library has been created using a range of spill scenarios. This library is a set of static tables that can be used by decision makers, such as water treatment operators, in a planning phase or in the event of a contaminant release for spill response. These tables, in conjunction with predicted flows, allow for a quick assessment of the potential spill impacts on drinking water intakes and the ecosystem, therefore giving decision makers the necessary tools for spill management.