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Spill Modeling at ICPRB: Technical Fact Sheet

The Interstate Commission on the Potomac River Basin (ICPRB) provides timely notification to downstream water suppliers and municipalities in the event of a hazardous chemical spill. To do this, ICPRB has two forecasting tools that assist in real-time assessments of downstream travel and dispersion of contaminants. These models are known as the Emergency River Spill Model (ERSM) and the Incident Command Water Modelling Tool (ICWater).

Reporting a Spill

Once the appropriate emergency response procedures have been followed, please notify ICPRB at 301-274-8133. Provide the following information:

1. Name and contact information;
2. Location of spill, including a) name of affected stream and b) street address and/or latitude and longitude;
3. Identity of spill material;
4. Estimated quantity of material spilled (total mass, volume, or discharge rate).

The ERSM provides estimates for the arrival times of the plume's leading edge, the peak, the trailing edge, and estimates of the maximum concentration. The geographic extent of the model (shown in Figure 1) is the Potomac River from Cumberland, Md., to Little Falls Dam at Washington, D.C., plus five tributaries: Monocacy River, Antietam Creek, Conococheague Creek (from approximately the Maryland/Pennsylvania border), Shenandoah River (from Waynesboro, Va.), and South Branch Potomac River (from Petersburg, W.Va.). The ERSM was created by ICPRB, based on time-of-travel dye studies conducted by the U.S. Geological Survey (see references below).

Similar to ERSM, ICWater provides estimates for the leading edge of the spill, time of maximum concentration, the trailing edge, and estimates of the maximum concentration. Built and supported by the federal government, the model is a GIS-based tool for contaminant spills that occur in any stream or river nationwide. It uses data from U.S. Geological Survey gaging stations throughout the country to determine the current flow of streams and rivers included in the U.S. Environmental Protection Agency's 1:100,000 scale National Hydrography Dataset Plus. The model can also identify potential upstream sources of the spilled material in the event that the source is unknown.

Model Parameters and Assumptions

ERSM and ICWater are based on similar algorithms. Assumptions include a constant flow rate and a dissolved substance with instantaneous mixing. Both models have the ability to estimate concentrations of non-conservative substances (materials whose total mass in the environment diminishes due to processes such as decomposition or chemical reaction) and sewage spills, and can complete rapid evaluation of different spill scenarios. A graphical example of ERSM output is shown in Figure 2. In the event of a spill, the staff at ICPRB will decide to use one or both tools, depending on the specific circumstances of the incident. The results from each model are generally comparable.

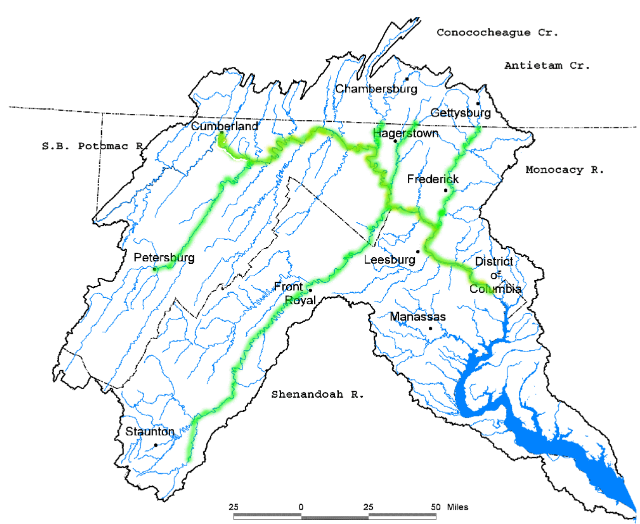

Figure 1: Extent of the Spill Model

Estimates of a plume's travel time are based on a set of assumptions which must be understood for proper interpretation of model results. The model assumes that spilled material is instantly and uniformly mixed across the width of a receiving stream, including where a tributary joins the river in question. In actuality, for some distance downstream from the point of a spill and downstream from the mouth of a tributary, the contaminant concentration will tend to be higher on the side of the spill or tributary mouth than on the other side of the river.

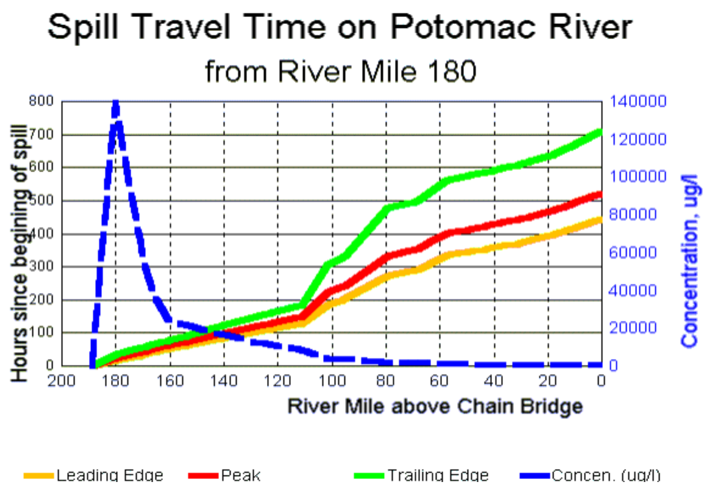

Figure 2: An example of the ERSM graphical output.

The models assume constant flow velocities throughout the river system. Rapidly rising or falling flows introduce changes in velocity profiles and reduce the accuracy of model estimates. The staff at ICPRB uses his or her professional judgement to model travel times under these circumstances. Due to the simplifications required to model the transport of contaminants, predicted arrival times and contaminant concentrations should not be relied upon to make health-related decisions without appropriate confirmation by water quality monitoring upstream of, and at, affected intakes.

The decrease in concentration over time of non-conservative substances, such as pathogens or volatile materials, is modeled as a first order exponential decay process. Because the decay coefficient, k, can take on many different values depending on the material and environmental conditions, the ERSM depends on the user to provide a value of k appropriate for the spilled material. Even when the true value of k is not known, one can obtain an estimate of the range of likely concentrations downstream with multiple model runs employing a range of k values.

Model Limitations

Due to limitations inherent in both models, the results must be carefully interpreted. The U.S. Geological Survey (USGS) provides an excellent discussion of the limitations of the assumptions and of the dye tracer studies, and the circumstances in which the time of travel analysis can be applied in the field. The limitations below are paraphrased from Taylor et al. (1986) and can be applied specifically to ERSM. Some of the points can also be applied to ICWater.

- Precipitation events introduce a flood wave, or unsteady flow conditions, into a river. When a significant flood wave is present in the system, added uncertainty will be introduced in the results. The models are best utilized when flow is neither rapidly increasing nor rapidly decreasing. As flow conditions change, the models should be run iteratively in order to assess the effect of changing flow conditions and to determine the most current discharge information.

- Complete lateral mixing is assumed in both models. When lateral mixing is incomplete, the estimate of contaminant concentration may be higher than that actually experienced.

- The behavior of immiscible or floating substances cannot be determined by the model algorithms.

- During the Potomac basin dye tracer studies, the USGS measured the travel time of dye injected at several points across the width of the river. An actual spill is unlikely to occur in this manner. More likely, a spill would occur at a river tributary or shoreline. Travel times at a river bank are generally slower than that of the main river, so the travel times of a spill under these circumstances will typically be slower than that predicted by the model. Also, the contaminant would likely be concentrated on one side of the river. The distance required for complete lateral mixing can be substantial, particularly for rivers with a large width-to-depth ratio.

- During the dye tracer studies, two velocities were determined for associated river flow levels for each river reach segment. In interpolating and extrapolating the study results to assess travel times at other flow levels, a log-linear relationship was assumed. In reality, the relationship may be slightly curvilinear, but at least three measurements would be necessary to assess the curvilinear relationship.

Want to learn more or update your contact information with ICPRB? Contact us at spill@icprb.org or (301) 984-1908.

References

Hogan, Kathleen, G.A. Nelson, R.C. Steiner, B.A. Spielman, D.P. Sheer, *A Toxic Spill Model for the Potomac River Basin*, Report No. 86-2a, Interstate Commission on the Potomac River Basin, 1991.

Jack, A.R., *Traveltime and Dispersion of a Soluble Dye in the South Branch Potomac River, Petersburg to Green Spring, West Virginia,* Water Resources Investigations Report 84-4167, U.S. Geological Survey, 1984.

Taylor, K.R., R.W. James Jr., and B.M. Helinsky. 1984. *Traveltime and Dispersion in the Potomac River Cumberland, Maryland, to Washington, D.C.* U.S. Geological Survey, Open file Report 83-861.

Taylor, K.R., R.W. James, Jr., B.M. Helinsky, *Traveltime and Dispersion in the Potomac River, Cumberland Maryland, to Washington, D.C.,* Water Supply Paper 2257, U.S. Geological Survey, 1985.

Taylor, K.R., R.W. James Jr., and B.M. Helinsky. 1986. *Traveltime and Dispersion on the Shenandoah River and its Tributaries, Waynesboro, Virginia, to Harper's Ferry, West Virginia.* U.S. Geological Survey Water Resources Investigation Report 86-4065

Taylor, K.R., R.W. James, Jr., B.M. Helinsky, *Traveltime and Dispersion in the Shenandoah River and its tributaries, Waynesboro, Virginia to Harpers Ferry, West Virginia,* Water Resources Investigations Report 86-4055, U.S. Geological Survey, 1986.

Taylor, K.R., *Traveltime and Concentration Attenuation of a Soluble Dye in the Monocacy River, Maryland*, Maryland Geological Survey Information Circular 9, 1970.

Taylor, K.R., W.B. Solley, *Traveltime and Concentration Attenuation of a Soluble Dye in Antietam and Conococheague Creeks, Maryland*, Information Circular 12, Maryland Geological Survey, 1971.

Created with an interstate compact by an Act of Congress in 1940, the Interstate Commission on the Potomac River Basin (ICPRB) is composed of commissioners representing the federal government, the states of Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia. The ICPRB mission is to enhance, protect, and conserve the water and associated land resources of the Potomac River basin and its tributaries through regional and interstate cooperation.

ICPRB accomplishes this mission through a variety of actions to conduct, coordinate, and cooperate in studies and programs in the areas of water quality, water supply, living resources, and land resources. The Section for Cooperative Water Supply Operations on the Potomac River (CO-OP), a special section of the Commission, was created as a technical operations center for management and coordination among the regional water utilities to avoid water supply shortages in Metropolitan Washington during droughts.

For additional information regarding the Interstate Commission on the Potomac River Basin:
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