A weight of evidence approach to assess risk to aquatic life
Testing and Refinement of the Trace Organics Screening Tool (CEC6R12)

The Central Issue
Trace organic compounds (TOrCs) may be present in wastewater treatment plant effluents and targeted studies have suggested that TOrC exposure may cause impacts on the aquatic community. Typical receiving waters have many additional stressors including habitat, flow modification, nutrients, suspended solids, metals, and organics, with many and varied nonpoint and point sources usually contributing pollutants to these waterways. Water resource recovery facility (WRRF) managers need to understand which stressors contribute in an important way to impairments in their receiving water systems. This understanding requires a weight-of-evidence (WoE) approach to reduce the uncertainty of multiple stressor linkages.

Context and Background
In 2010 WERF funded a study to develop diagnostic tools to evaluate the impacts of TOrCs on aquatic life (CEC5R08), and in 2012, a WERF-funded team researched the treatability of TOrCs by conventional WRRF technology (CEC4R08). Building on this work, this research developed a framework using a risk- and management-based approach to assess the potential impact of TOrCs in aquatic systems. The framework employs a two-level WoE approach that integrates onsite physical, chemical, and biological characterizations to make scientifically informed decisions.

The first level relies on pre-existing information to conduct a qualitative desktop screen for the potential of TOrCs adversely impacting aquatic life. If the Level 1 WoE assessment indicates a potential risk from TOrCs, then a more comprehensive second-level site characterization is conducted. A WoE scoring tool is applied to the Level 2 data to identify likely stressors and characterize whether TOrCs are of lower, possible, moderate, or higher concern. To support both levels of assessment, a reduced list of indicator TOrCs was regionally optimized and a site-specific TOrC risk quotient calculator tool was developed.

Level 1 desktop tools were applied at five sites, followed up with Level 2 field investigations at two of those sites.

Findings and Conclusions
The Level 1 assessment is intended to be conservative relative to the Level 2 characterization of potential TOrC risk, and this was verified for the two sites where both were applied. In both cases, the Level 2 WoE provided a refined characterization and additional information to support management decisions. The research weighs that value added against significant cost and resource requirements that may limit its usability for some WRRFs. The application of the framework to two sites provides examples for other utility managers, and applications of the framework to additional sites would improve the robustness of the approach and application of the tools.

Management and Policy Implications
The science of TOrC exposures and their ecological impacts is evolving rapidly, and the WoE framework can be adapted to reflect new information and understanding. The knowledge gained will allow managers to determine needs for future monitoring and/or treatment technology investments. The WoE framework also allows managers to consider the influence of non-TOrC stressors, when appropriate, and to understand the role of upstream sources relative to their discharges. In summary, this project provides a useful and usable screening framework for utility managers to assess the potential risk to aquatic life from discharges that may contain TOrCs.
### Related WE&RF Research

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Research Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds (CEC5R08)</td>
<td>The five objectives of this project are documented in projects CEC5R08A through CEC5R08D listed below. This final report summarizes the research approaches and results, discusses critical data gaps and other uncertainties, and provides testable hypotheses and recommendations for Phase 2 testing and analyses.</td>
</tr>
<tr>
<td>Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds: Prioritization Framework for Trace Organic Compounds (CEC5R08a)</td>
<td>Develops and applies a procedure to prioritize which TOrcs are of most concern.</td>
</tr>
<tr>
<td>Development of Diagnostic Tools for Trace Organic Compounds and Multiple Stressors (CEC5R08b)</td>
<td>Develops and tests a conceptual diagnostic framework to identify TOrcs by source type. Also provides exposure-response models for high-priority TOrcs.</td>
</tr>
<tr>
<td>Testing Diagnostic Tools for Trace Organic Compounds and Multiple Stressors: Case Studies (CEC5R08c)</td>
<td>Fosters partnerships and transfers knowledge to the water quality community through seven case studies.</td>
</tr>
<tr>
<td>WERF Trace Organics Ecological Database (CEC5R08d)</td>
<td>Develops and populates a relational database of TOrc exposure and effects data in a web-based database to help users search and evaluate TOrc data (<a href="http://traceorganicsecotool.werf.org">http://traceorganicsecotool.werf.org</a>).</td>
</tr>
<tr>
<td>Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation (04HHE01CO)</td>
<td>Provides guidance to the water reuse industry on how to assure proper removal of wastewater-derived chemical contaminants in indirect potable reuse applications using a combination of tailored surrogate parameters and a select list of indicator compounds.</td>
</tr>
<tr>
<td>Trace Organic Compound Indicator Removal During Conventional Wastewater Treatment (CEC4R08)</td>
<td>Focuses on the effectiveness of secondary treatment processes for reducing indicator TOrc. The results of full-scale and laboratory-scale investigations were combined to identify the critical factors driving the removal of selected indicator compounds by biotransformation and sorption. Based on investigations, a suite of indicator compounds were proposed as a valuable tool for assessing the overall removal efficiency of various treatment processes for a larger group of TOrc that are similar in structure and fate properties to the proposed indicators.</td>
</tr>
<tr>
<td>Use of Ozone in Water Reclamation for Contaminant Oxidation (WRRF-08-05)</td>
<td>Characterizes the use of ozone in wastewater treatment applications with respect to bulk organic matter transformation, contaminant oxidation, microbial inactivation, and the formation of disinfection byproducts and other transformation products. Also evaluates the synergism between ozone and biological filtration, including biological activated carbon (BAC) and soil aquifer treatment (SAT), in the context of potable reuse applications.</td>
</tr>
<tr>
<td>Controlling Trace Organic Contaminants Using Alternative, Non-FAT Technology for Indirect Potable Water Reuse (Reuse-13-10)</td>
<td>Investigates the advanced treatment of wastewater for indirect potable reuse (IPR) using ion exchange (IX), advanced oxidation processes (AOPs), and biofiltration as an alternative to the fully available treatment technology of reverse osmosis (RO) and UV AOPs.</td>
</tr>
</tbody>
</table>

### Principal Investigators:
- John Wolfe, Ph.D., P.E., BCEE, LimnoTech
- G. Allen Burton, Jr., Ph.D., University of Michigan
- Drew McAvoy, Ph.D., University of Cincinnati

### Co-Principal Investigators:
- Jennifer Daley, Ph.D., Carrie Turner, P.E., LimnoTech
- Nicole Clements, Clements Consulting LLC

### Project Team:
- Doug Bradley
- Jim Lazorchak, Ph.D.
- Marc Mills, Ph.D.
- Dan Villenueve
- U.S. Environmental Protection Agency
- Robbin Finch
- City of Boise, ID
- Peter Matthiessen, Ph.D., Consultant, Cambria, United Kingdom
- Chris Metcalfe, Ph.D., Trent University

### Project Senior Advisory Board:
- Gary Ankley, Ph.D.
- Jim Lazorchak, Ph.D.
- Robbin Finch
- City of Boise, ID
- Peter Matthiessen, Ph.D., Consultant, Cambria, United Kingdom
- Chris Metcalfe, Ph.D., Trent University

---

To order: Contact WE&RF at 571-384-2100 or visit www.werf.org and click on Search Research Publications & Tools. WE&RF subscribers: Download unlimited free PDFs. Non-Subscribers: Charges apply to some products.

Refer to Stock No.: CEC6R12
For more information, contact Lola Olabode at lolabode@werf.org