Emerging Contaminants: The Research Agenda of the Water Environment Research Foundation (WERF)

Alan Vicory P.E, BCEE, Executive Director/Chief Engineer, ORSANCO

And

Chairman, WERF Board of Directors

Ohio WEA

Government Affairs Specialty Workshop

March 11, 2010

WERF

Water Environment Research Foundation

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Presentation Outline

- WERF's Role and Impact
- Issues of Interest to WERF subscribers
- WERF's Emerging Contaminants Research
  - Partners and Leverage
  - State of the Knowledge
  - Treatability
  - Ecological Effects
  - Communication / Outreach
  - Related Ongoing and Planned Projects
    - Water Reuse for Golf Courses
    - Protocol for Investigating Health Complaints
    - Trace Organics in Biosolids

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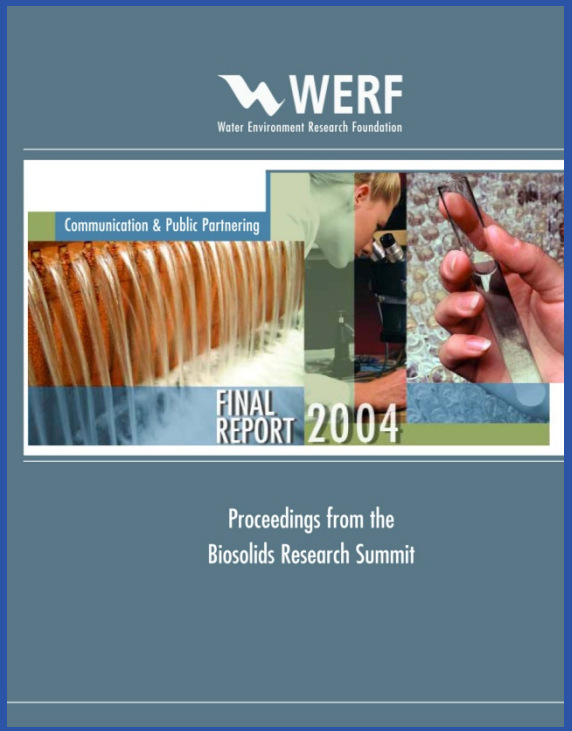
Objective science leads to solutions

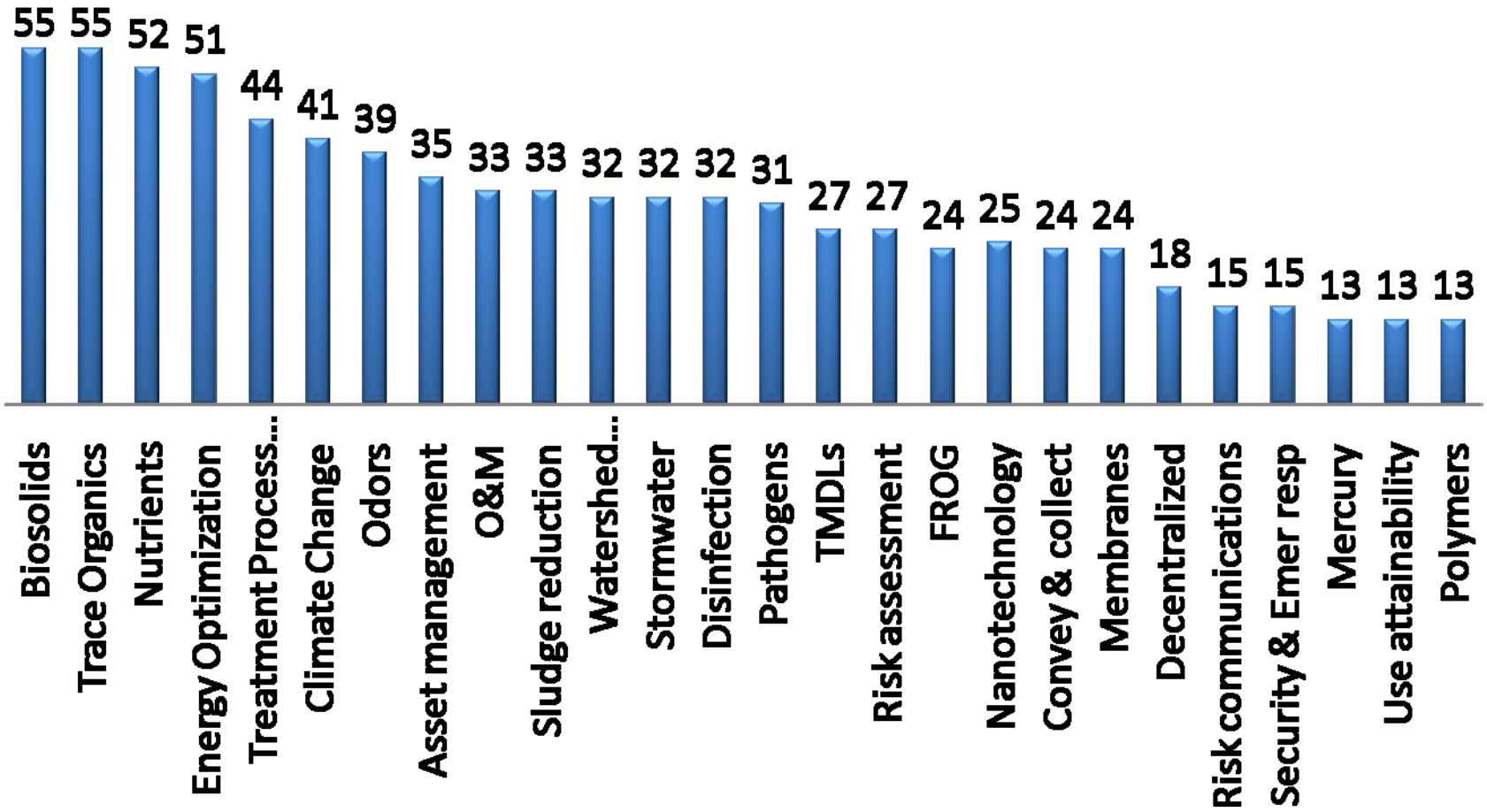


Over the last 20 years, WERF has conducted nearly 400 research projects, valued at more than $85 million. The impact of that research has been substantial.

WERF research has led to…

- ✓ More than a billion dollars in savings
- ✓ Regulations based on scientifically defensible facts, leading to greater protection of human health and the environment
- ✓ Improvements in testing, processing, treatment and management of wastewater and stormwater
- ✓ More effective methods for maintaining or rehabilitating aging infrastructure
- ✓ Additional intellectual resources to help subscribers meet their public obligations

Which research topics are the most important for your organization?



The percentage of total respondents selecting that topic

EDCs Were a Utility Concern in the 2004 WERF Survey

- What is an EDC and are they in my influent?
- Does treatment remove them and what is the fate of EDCs in my effluent?
- Are there likely adverse environmental effects? “Is their presence a problem”?
- What are the sources of EDCs and what are possible source control options?
- What analytical methods are reliable?
- What are the regulatory implications?

Emerging Contaminants – aka Trace Organics

Organic compounds found at “PPB/PPT” levels, and not commonly regulated or monitored, in water resources that are known or suspected to cause detrimental environmental effects (e.g., interfere with normal endocrine functions – EDCs)

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What is Behind this Issue?

Analytical methods are always improving and monitoring results will show chemicals are present.

If we can detect something, is it a problem?

If it is a problem what can be done?

What is the role of wastewater and stormwater treatment in management of these substances?

What do we know, Who is doing what, and What should WERF be doing

- WERF research prior to 2005
- State of the knowledge reports (2005, 2008)
- Roadmapping with partners to focus WERF efforts
- Advisory group (subscribers and other experts and practitioners) formed to guide research program
- Shift from project-by-project to an integrated research program approach

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WERF Completed Projects

01-HHE-20T, Removal of Endocrine Disrupting Compounds in Water Reclamation Systems

01-HHE-21T, Innovative DNA Array Technology for Detection of Pharmaceuticals in Reclaimed Water

03-CTS-21UR, Contributions of Household Chemicals to Sewage & Their Relevance to Municipal Wastewater Systems & the Environment

03-CTS-22UR, Fate of Pharmaceuticals and Personal Care Products Through Municipal Wastewater Treatment Processes

03-HHE-4T, Tools for Analyzing Estrogenicity in Environmental Waters

04-HHE-1CO, Development of Indicators and Surrogates for Chemical Contaminant Removal During Wastewater Treatment and Reclamation

04-WEM-6, Technical Brief: Endocrine Disrupting Compounds and Implications for Wastewater Treatment

04-HHE-6, Fate of Estrogenic Compounds During Municipal Sludge Stabilization and Dewatering

DEC14U06, Performance Dynamics of Trace Organics in Onsite Treatment Units and Systems

U2R07, Evaluation of QSPR Techniques for Wastewater Treatment Processes

CEC3R07, Technical Brief: Trace Organic Compounds and Implications for Wastewater Treatment

CEC2C08, Communication Principles and Practices, Public Perception, and Message Effectiveness

Fate of Pharmaceuticals and Personal Care Products (PPCPs) through Wastewater Treatment Processes (03-CTS-22UR)

Purpose

- To assess the fate of PPCPs in conventional secondary and tertiary treatment processes

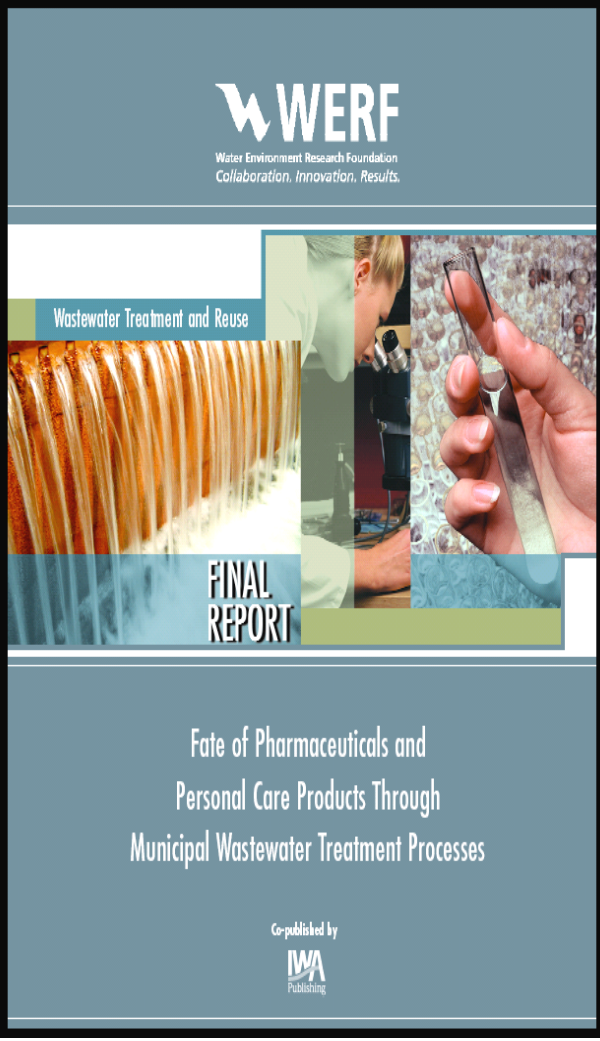
Approach

- Monitoring at 6 WWTPs

Principal Investigators

- Joan Oppenheimer, Roger Stephenson,- MWH

Key Findings on Next Slide



Comparative Treatment Removal of PPCPs in Conventional Secondary Treatment

Treatment / Occurrence	Bin TI Good Removal	Bin T2 Moderate Removal	Bin T3 Poor Removal
Bin O1 Infrequent	Methyl-3-phenylpropionate	Octylphenol	TCEP Triphenyl-phosphate
Bin O2 Intermediate		Ethyl-3-phenylpropionate	BHA DEET Musk Ketone
Bin O3 Frequent	Caffeine Ibuprofen Oxybenzone Chloroxylenol Methyparaben Benzl salicylate 3-phenylpropionate Butylbenzl pthlate Octylmethoxycinnamate	Triclosan Benzophenone	Galoxolide

Conclusions

- **SRT dependence demonstrated for PPCPs:**
  - **$SRT_{80} \leq 5$ days :10 compounds on target list**
  - **$5 \leq SRT_{80} \leq 15$ days: benzophenone**
    triclosan
    DEET
    BHA
  - **$SRT_{80} \geq 15$ days: musk ketone**
    galaxolide
    TCEP
  - **Media filtration shows little evidence of removal but RO is very effective**
  - **MBR performance equivalent to activated sludge operated above 10 days**

from Oppenheimer presentation to WERF

Contributions of Household Chemicals to Sewage and Their Relevance to Municipal Wastewater Systems and the Environment (03-CTS-21UR)

<u>Purpose</u>

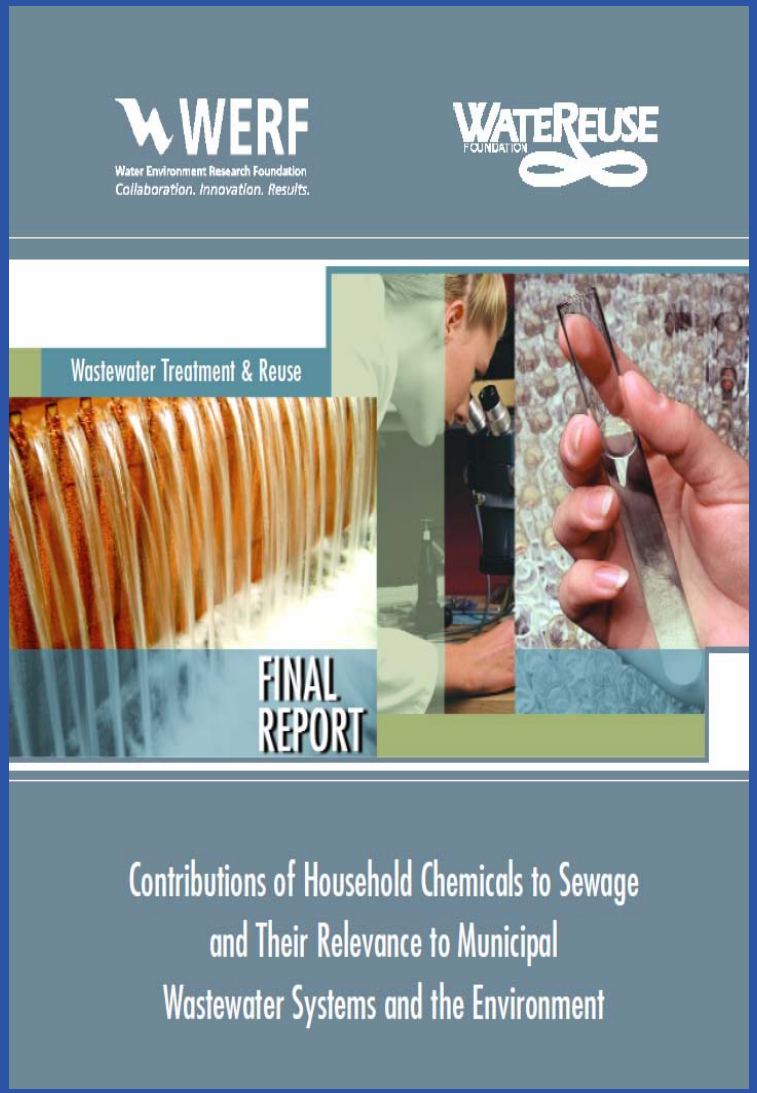
Investigate the occurrence and fate of high production volume household chemicals and their contribution to municipal wastewater systems

<u>Principal Investigators</u>

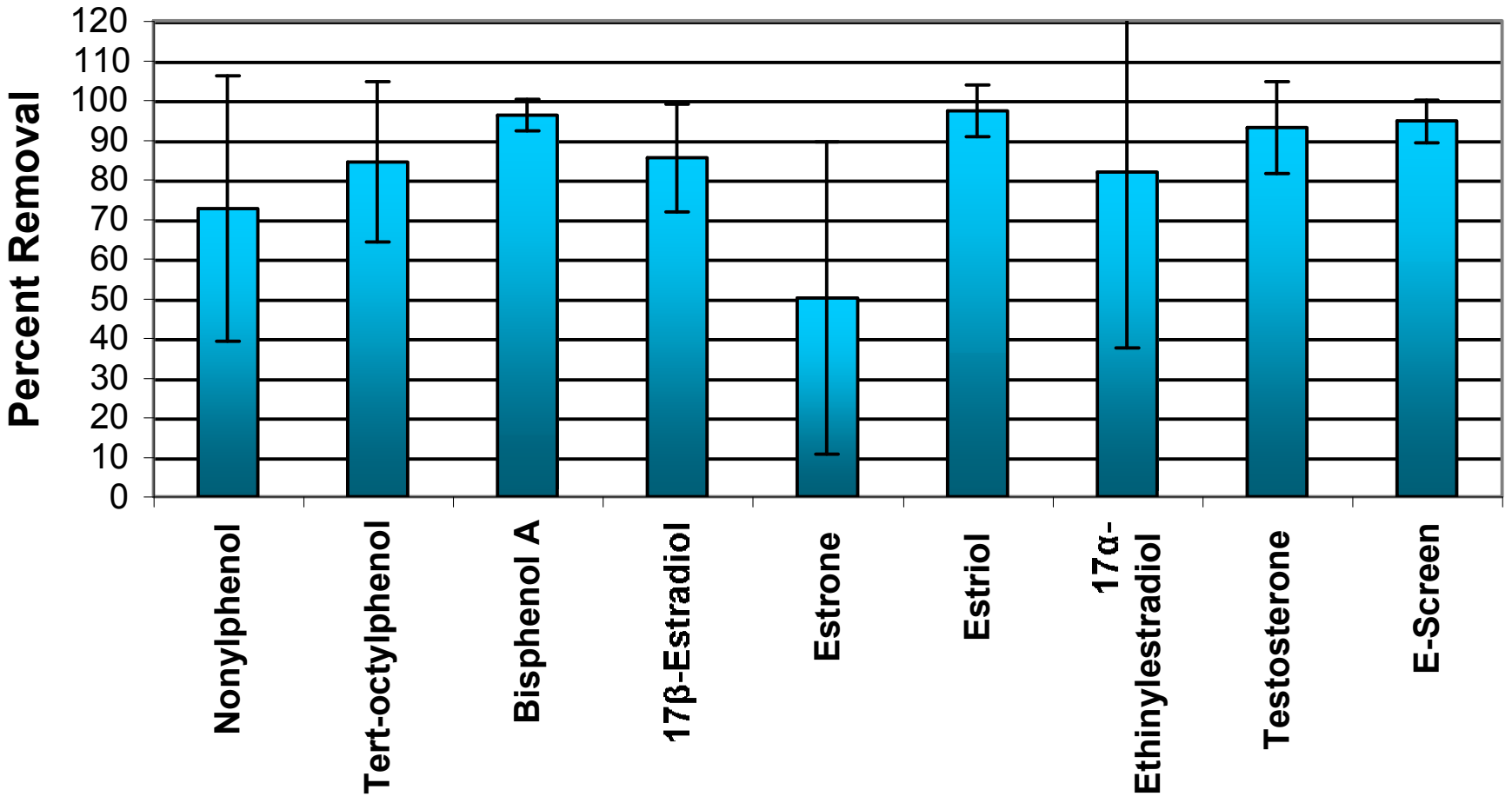
Jorg Drewes, Colorado School of Mines

<u>Key Finding</u>

Activated sludge treatment generally removes 80+%



Removal of Estrogenic Activity and EDCs during Activated Sludge Treatment



Drewes et al. 2005, WERF

Removal of PPCPs during Chlorination

Operational Conditions:

sec./tert. treated effluent; 1 mg of Cl/mg of C; 24-h contact time; pH 8

Good Removal (>90%)	Intermediate Removal (90Š50%)	Intermediate Removal (50Š25%)	Poor Removal (<25%)
Acetaminophen	Gemfibrozil	Galaxolide	Acetyl cedrene[h,i]
Atorvastatin (*o*-hydroxy)[d]	Musk ketone	Ibuprofen	Atenolol
Atorvastatin (*p*-hydroxy)[d]		Tonalide[f,k]	Benzyl acetate[f]
Atorvastatin[d]			Bucinal[f]
Benzyl salicylate[b]			Caffeine
Bisphenol A			Carbamazepine
Butylated hydroxyanisole[b]			Chloroform
Ciprofloxacin			DEET
Diclofenac			Dichlorprop[e]
ErythromycinŠH_2O			Dilantin
Estriol			EDTA
Estrone			Fluoxetine
Hexyl salicylate[b]			Hexylcinnamaldehyde[f]
Hydrocodone			Indolebutyric acid[j]
Isobutylparaben[b]			Iopromide
Methyl salicylate[b]			Isobornyl acetate[h,i]
Naproxen			Ketoprofen
Nonylphenol			Mecoprop[e]
Phenylphenol[b]			Meprobamate
Propranolol[e,k]			Methyl dihydrojasmonate[h,i]
Propylparaben[b]			Methyl ionine[h,i]
Salicylic acid[b]			Metoprolol
Sulfamethoxazole			Musk xylene
Triclocarban[d]			NDMA
Triclosan			Norfluoxetine
Trimethoprim			Ofloxacin
			OTNE[h,i]
			Primidone[j]
			Simvastatin hydroxy acid[h,i]
			TCEP
			TCPP[g]
			TDCPP[g]
			Terpineol[h,i]

Drewes et al. 2008, WRF

Technical Brief
Trace Organics and Implications for Wastewater Treatment and Receiving Waters (CEC3R07)

Purpose

- Resource document for the state of the science on trace organics
- Identify significant knowledge gaps

Principal Investigator

Paul Anderson, AMEC Earth and Environmental

Topic Areas

- Chemical and biological analysis
- Wastewater removal
- Environmental fate
- Human health effects
- Ecological effects
- Ongoing research efforts with links

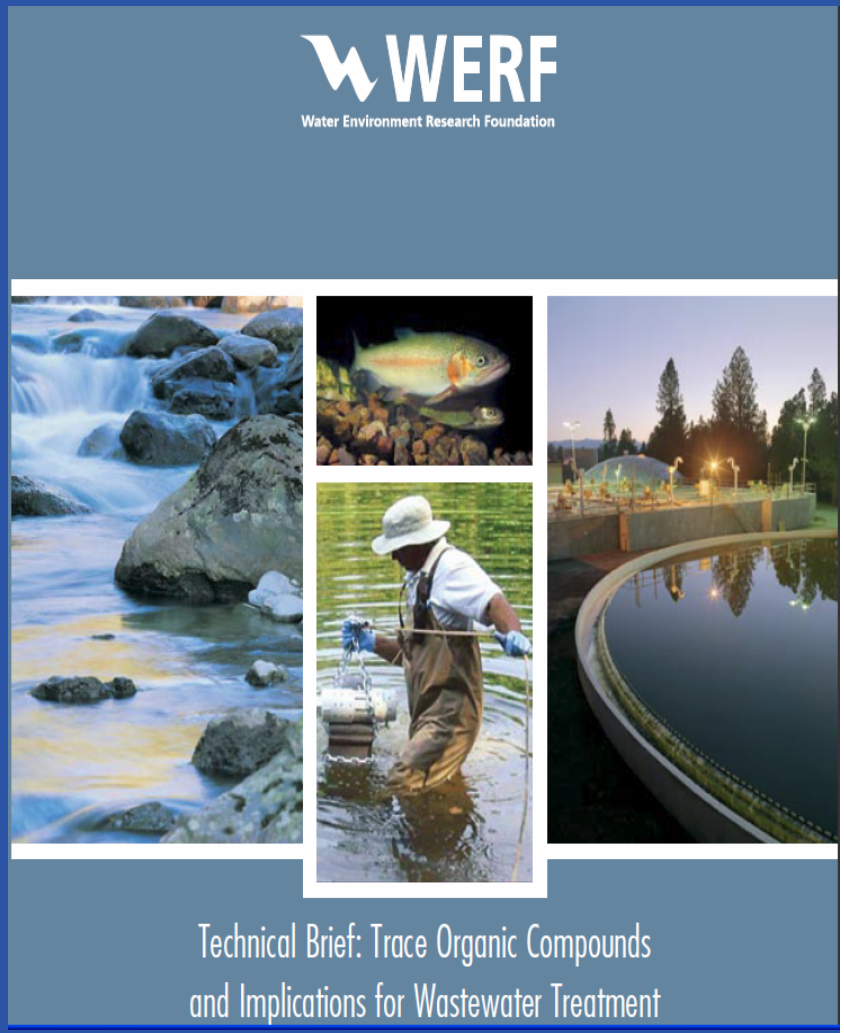


Table 8. Ongoing Research Efforts and Web Links.

Organization / Topic	Link
Analytical	
CRC: Tools for analyzing estrogenicity in environmental waters	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4919
GWRC: Tools for analyzing estrogenicity in environmental waters	http://www.globalwaterresearchcoalition.net/activities.htm
TZW: Tools for analyzing estrogenicity in environmental waters	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4918
WRC: GWRC EDC Toolbox project	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4918
CRC: Expansion of the bio-analytical toolbox concept used for estrogens to a wider range of health-related endpoints (e.g., cytotoxicity, neurotoxicity, genotoxicity, etc.)	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4918
Kiwa: Development of toxicological tests and methods to assess human health effects	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4925
PhRMA: Understand and improve risk assessment processes, including the role of biomarkers and the fate of pharmaceuticals in biosolids	http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0402pdf/ks0402021.pdf
USEPA: Developing tools to characterize and minimize exposures to EDCs	http://epa.gov/osp/myp/edc.pdf
WERF: Improving analytical tools (bioassays) for detecting and monitoring estrogenic activity in various environmental waters	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4918
WRC: EDC activity of identified veterinary compounds in surface and ground water - mainly around cattle feedlots	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4955
WRC: New detection methods for EDCs	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4955
WRC: The use of chemical and biological assays and sentinel species to determine EDC pollution	http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4955
WSAA: Tools for assessing trace contaminant presence and activity	http://www.clw.csiro.au/awcrrp/stage1.html
PWRI: Evaluating the biological effects of trace organic compounds by gene expression	http://www.w M/ContentDisplay.cfm&CONTENTID=4937
SDA: Advancing the use of non-animal testing in the safety assessment of cleaning products	http://www.cleaning101.com/about/background.cfm
AwwaRF: Development of analytical techniques for specific compounds - Ongoing research on methods	http://www.awwarf.org/research/TopicsAndProjects/projectSnapshot.aspx?pn=4167
Eawag: Development of an on-line LC MS MS method for glyphosates	http://www.eawag.ch/organisation/abteilungen/uchem/schwerpunkte/projektuebersicht/projekt7_EN
GWRC: Development and evaluation of analytical methods to assess occurrence in the water cycle	http://www.globalwaterresearchcoalition.net/activities.htm

http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=4955

2007 Workshop: Mapping a Collaborative Research Roadmap

Workshop Outcomes

- Found out what 31 organizations from 11 countries are currently funding and planning for research on this topic
- Identified opportunities for collaboration and leveraging
- Set up a network to share research results and plans
- The knowledge gained helped WERF plan its research strategy going forward

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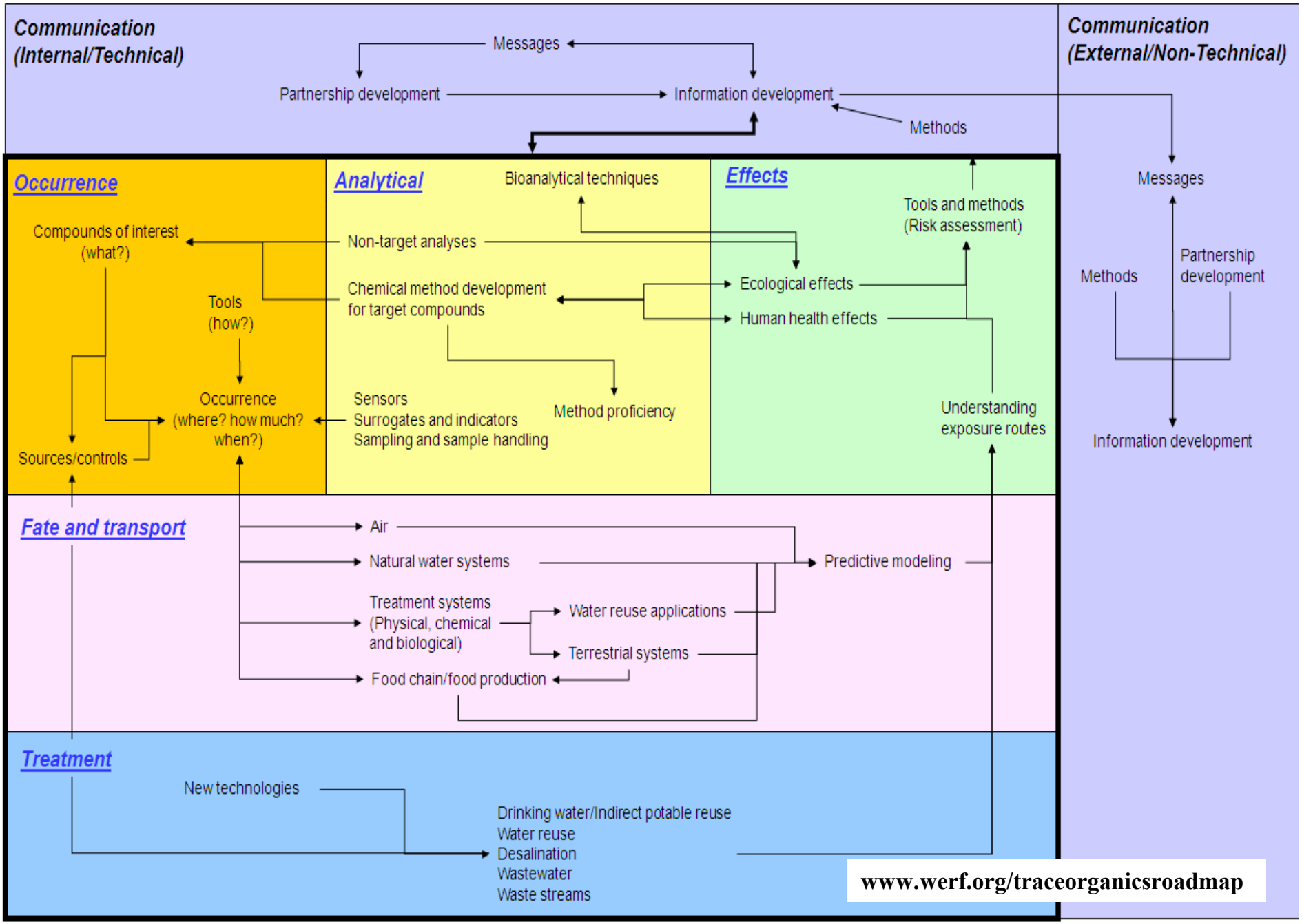
Partial List of Workshop Participants

RESEARCH ROADMAP ON TRACE ORGANIC COMPOUNDS



WERF Strategy

- ***Finding solutions to trace organics issue is huge effort; much bigger than WERF***

- Major Areas of Research / Activity
  - * Source/source control
  - o Analytical
  - # Occurrence / monitoring
  - □ Fate and transport
  - Δ Treatment
  - × Ecological and human health effects
  - ☺ Communication/Outreach

WERF Strategy

- Finding solutions to trace organics issue is huge effort; much bigger than WERF

- Major Topics
  - * Source/source control
  - O Analytical
  - # Occurrence / monitoring
  - □ Fate and transport
  - Δ Treatment - if not WERF then who!
  - × Ecological & health effects - presence = problem?
  - ☺ Communication/Outreach - essential

- Lead on some, leverage where possible, track all

Occurrence and Potential for Human Health Impacts of Pharmaceuticals in the Water System

Global Water Research Coalition

SCIENCE BRIEF

OCCURRENCE AND POTENTIAL FOR HUMAN HEALTH IMPACTS OF PHARMACEUTICALS IN THE WATER SYSTEM

Detections of pharmaceuticals in water systems raise understandable concerns about the potential implications for public health. Research organizations around the world including members of the Global Water Research Coalition (GWRC), are exploring these implications and assessing the risks through a number of extensive peer-reviewed research projects.
This paper is a synthesis of nine recently published reports that address the occurrence and potential for human health impacts of pharmaceuticals in the water system. Synopses of the these reports are attached. They are principally review documents that summarize previously published research.

Although the nine reports were commissioned for various purposes, they present consistent findings across the topics of occurrence and health impacts. It can be concluded from these reports that, to date, no definitive link has been reported or established between human exposure to pharmaceutical exposure in drinking water and human health risk. Put another way, there is no known impact on human health.

Even though the trace levels of detected pharmaceuticals present a very low health risk (there is no "zero risk" in today's environment), the water sector continues to investigate the issues and to invest in treatment technologies to safeguard the quality of drinking water today and for the future.

Detections of pharmaceuticals in water systems are not new

As long as humans use prescription medicines and over-the-counter drugs, we will find trace amounts in wastewater, surface water, groundwater and drinking water. Scientists first

Today's methods can detect concentrations as low as one part per trillion of many compounds, and even lower concentrations in some cases. We hear more reports about the presence of

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Focus Areas of WERF Research

WERF Treatability Research Plan

Objective

Establish a practical set of tools and guidance for measuring and/or predicting the removal of representative chemicals under a wide range of treatment processes and operational variables. A utility could select and optimize treatment to remove these chemicals.

Strategy

- Develop a short-list of representative chemicals that are high priority and analytically feasible to track
- Focus on conventional wastewater treatment processes and advanced unit operations that are widely deployed

- 2-year research effort began in May 2009
- Research team includes Carollo Engineering, Colorado School of Mines, Southern Nevada Water Authority, University of New South Wales, Syracuse Research Corporation
- Utility test sites are in UT, NV, WA, CO, WI and VA

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Focus Areas of WERF Research

- Treatment
- Ecological Effects
- Communication

WERF Ecological Effects Research Plan

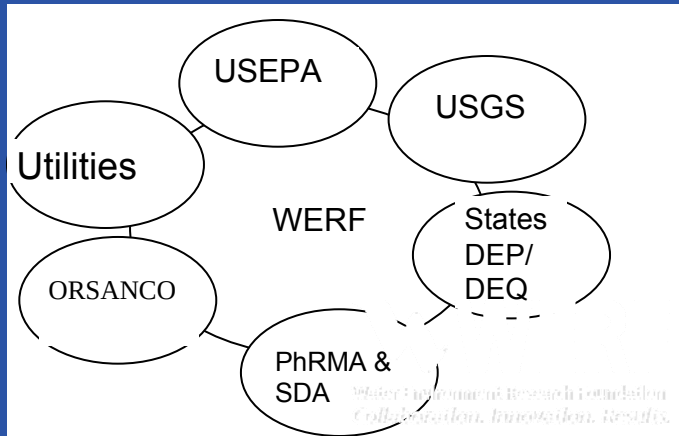
Objective

To provide on-site tools and guidance to assess aquatic impacts of trace organics in surface waters that receive treated wastewater

Strategy

- Develop a short-list of representative chemicals that are high priority
- Focus on population and community level effects
- Utilize available biological monitoring data from ongoing programs
- Conduct both retrospective and prospective field
- Lots of collaboration

- 3-year research effort began in May 2009
- Research team includes Tetra Tech, U Brunswick, Condatis, E2, and FTN Associates
- Collaborators (on right) plus Canadian Water Network, Great Lakes Env Program, SCCWRP



Areas of WERF Research

- Treatment Processes
- Ecological Effects
- Communication

Communication Principles and Practices, Public Perception, and Message Effectiveness

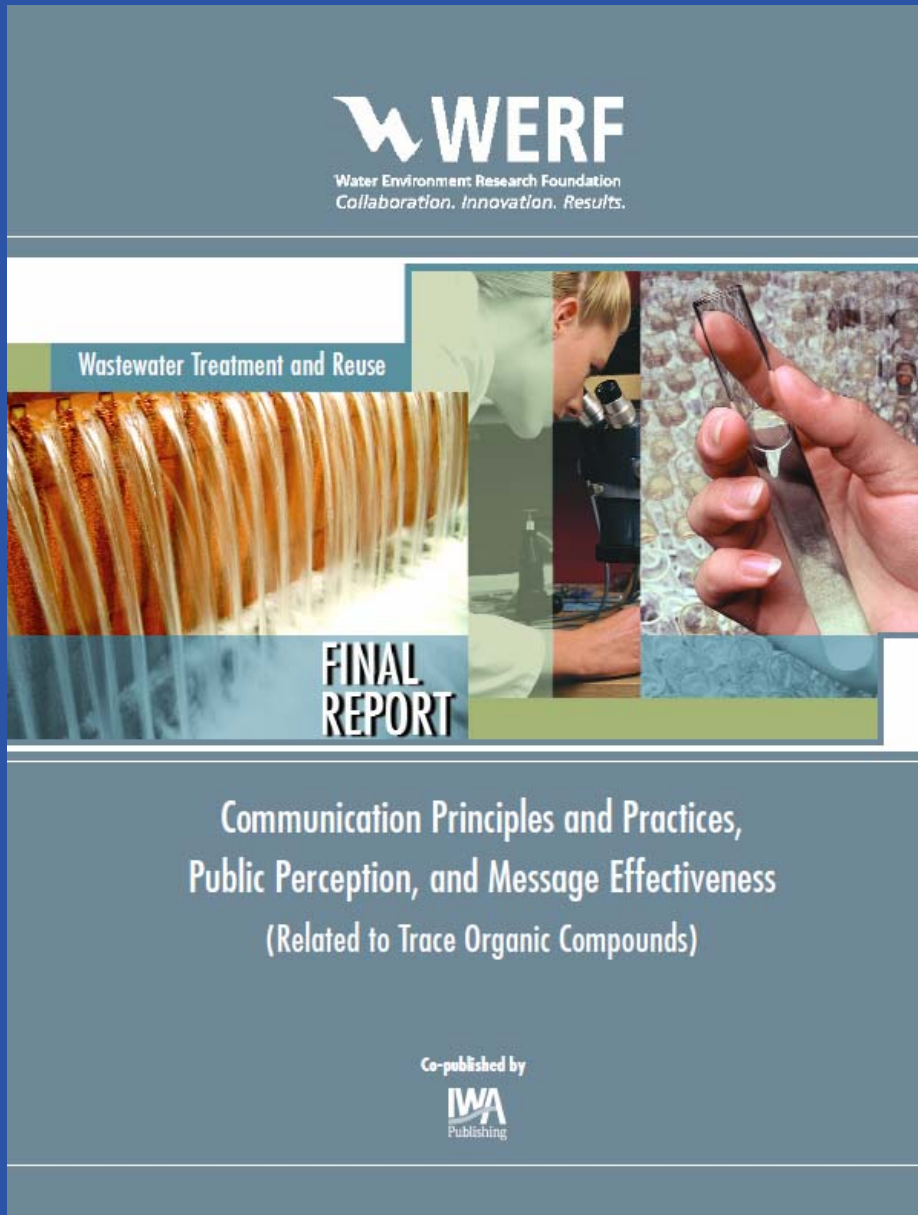
<u>Purpose</u>

Guidance/answers on effective communication practices for trace organics issues

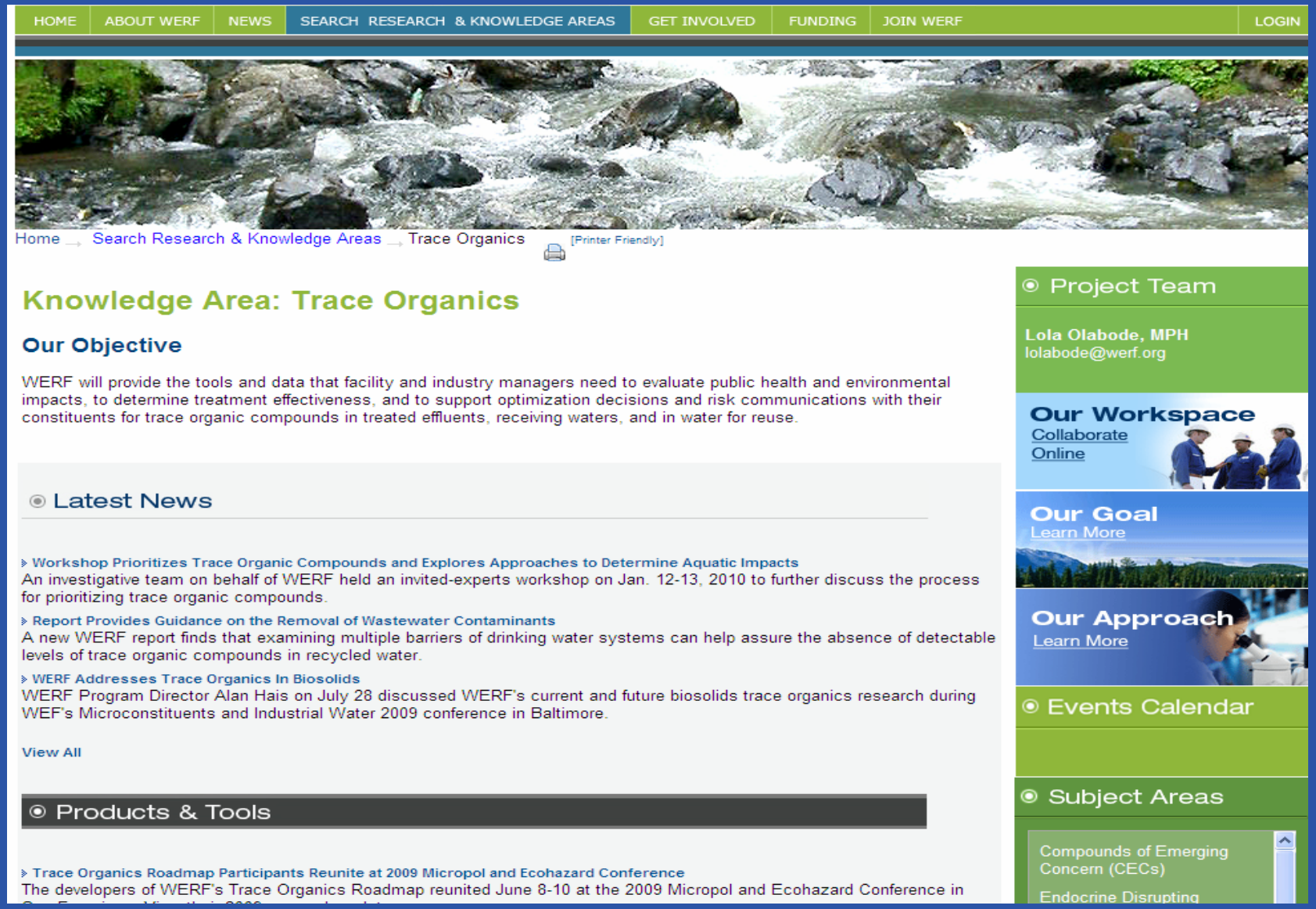
<u>Product</u>

A framework to help utilities as they present and monitor the effectiveness of communication strategies and materials

Research Team was Malcolm Pirnie, CH2MHill and U Oregon



WERF Trace Organics Challenge Web page



RELATED ONGOING AND PLANNED RESEARCH

Water Reuse for Golf Courses

Purpose

What is the fate of PPCPs in reuse irrigation water used on golf courses (do they get “offsite”)

Status

2+ year lab and field study ending Q4 2010. [WERF1C08]

Research team is UNLV, Desert Research Institute, UC Riverside, Northern California Golf Assn.

Over a dozen funding partners !!

Pilot testing: Investigation of Complaints/Symptoms of Illness Reported by Neighbors of Biosolids Land Application and other Soil Amendments [08HHE5PP]

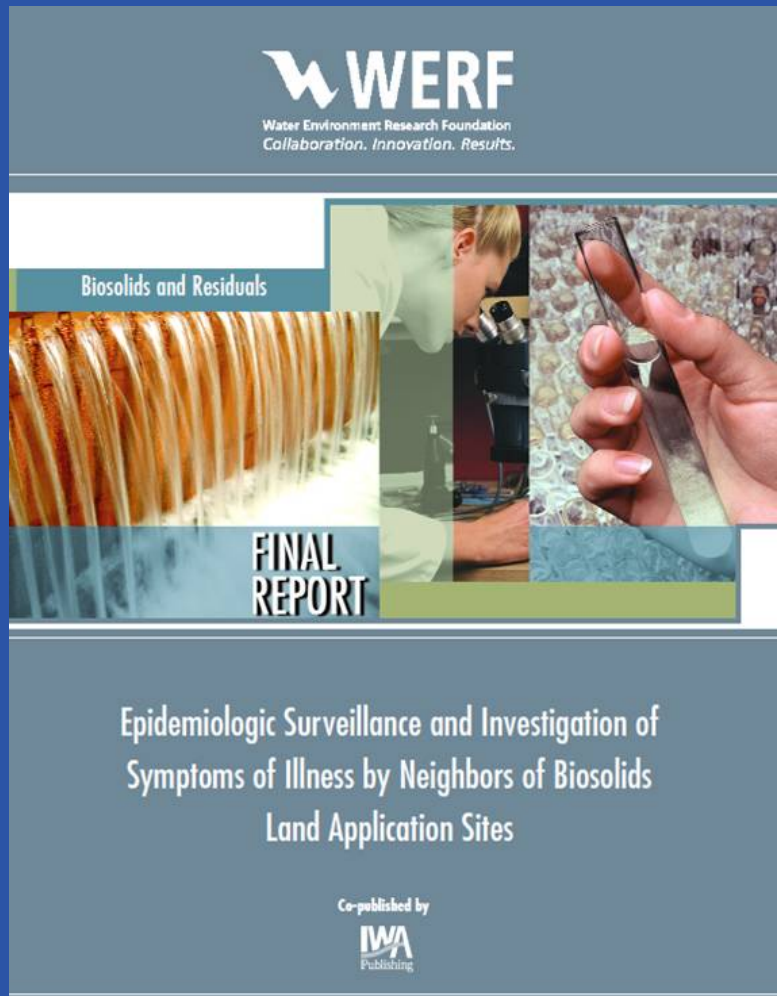
Purpose

Pilot test a 5-step investigation protocol for neighbors of land application sites complaining of health effects to doctors, local health officials, biosolids generators, biosolids appliers, state EPA/DEP/DEQ.

Research Team

Franklin County Board of Health
Ohio State University
Ohio EPA

Completion scheduled for December 2010



Trace Organics in Land Applied Biosolids

Purpose

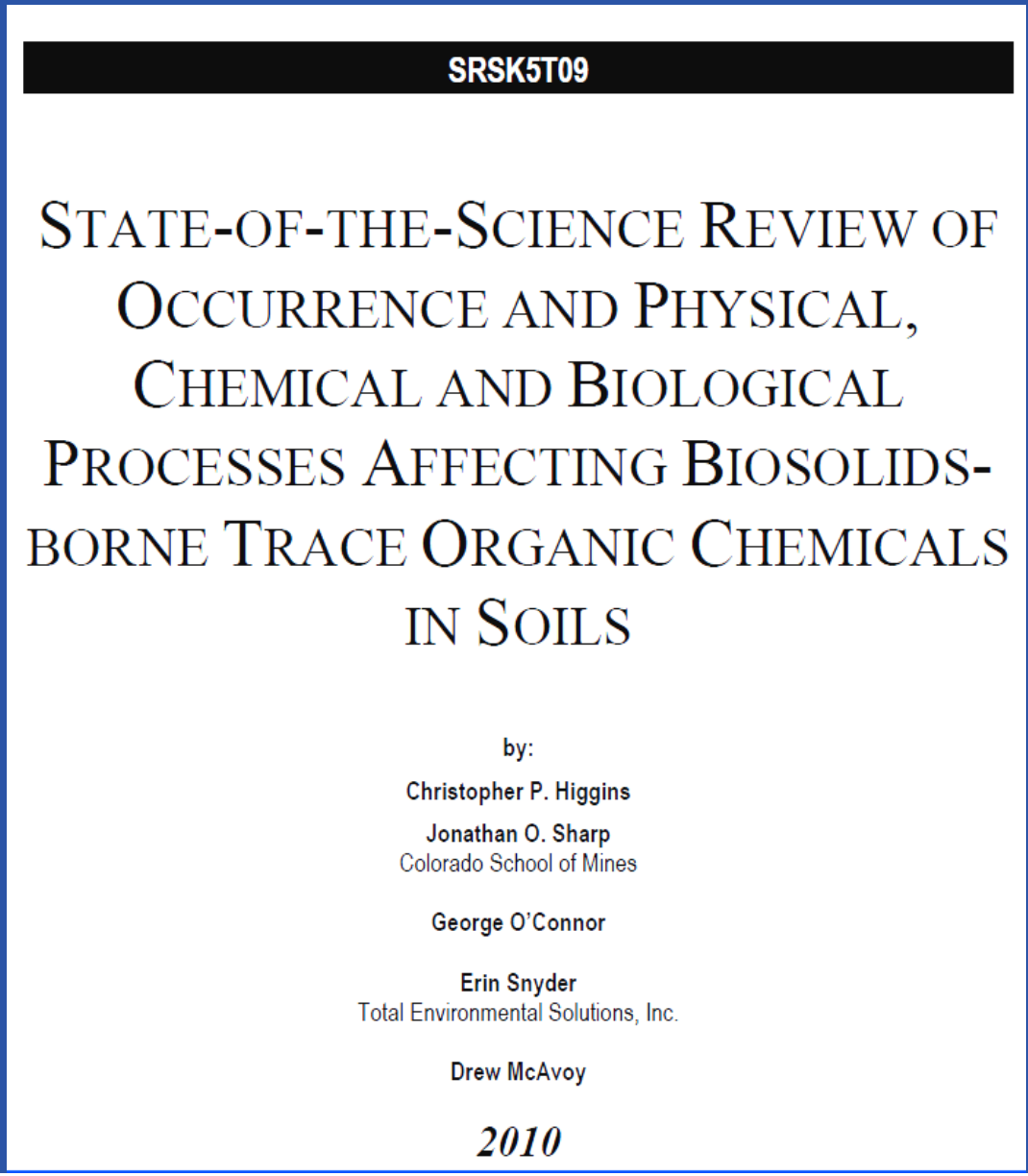
Answer what is the fate and potential impact of these chemicals in the soil. [EPA has reported ppm levels in some sludges]

To Date

Detailed overview of what is currently known and key data gaps

Next Steps

Meeting of stakeholders to develop a research plan



SRSK5T09

STATE-OF-THE-SCIENCE REVIEW OF OCCURRENCE AND PHYSICAL, CHEMICAL AND BIOLOGICAL PROCESSES AFFECTING BIOSOLIDS-BORNE TRACE ORGANIC CHEMICALS IN SOILS

by:

Christopher P. Higgins

Jonathan O. Sharp

Colorado School of Mines

George O'Connor

Erin Snyder

Total Environmental Solutions, Inc.

Drew McAvoy

2010

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WERF contacts

Dan Woltering
Director of Research
dwoltering@werf.org

Jane Knecht
Director of Subscriber Services
jknecht@werf.org