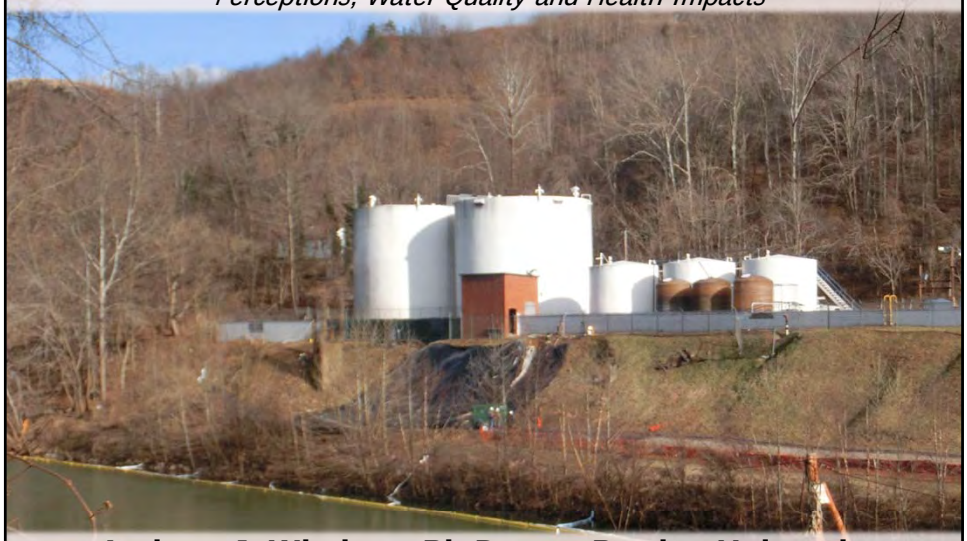
Residential Tap Water Contamination Following the Freedom Industries Chemical Spill:

Perceptions, Water Quality and Health Impacts



Andrew J. Whelton, Ph.D. **Purdue University**

August 26, 2015 *Alliance Indiana of Rural Water Conference*

Acknowledgement

NSF

UNIVERISTY OF SOUTH ALABAMA

STATE OF WEST VIRGINIA

WV TAP
WEST VIRGINIA TESTING ASSESSMENT PROJECT
Follow us at @WVTAP.

eurofins

Colorado State University

KANAWHA - CHARLESTON HEALTH DEPARTMENT KCHD

Dauphin Island Sea Lab Alabama

ALS Environmental

METROPOLITAN STATE UNIVERSITY OF DENVER

Re·sil·ience

\ri-’zil-yen(t)s\

The ability to recover from or adjust easily to misfortune or change

West Virginia

The “Mountain State”
Seceded from Virginia in 1863
Population 1,850,000

State capital: Charleston
Legislature meets once a year
Industries: tourism, chemicals and coal mining

January 9, 2014, 8:16am
Resident tells WV DEP and stated "something in the air at the 77-79 split each morning when he comes into work. He said it is coating his wife's throat."

11:15am – WV DEP onsite finds spill
12:05pm – Freedom reports spill to WV DEP hotline
12:00-12:30pm – Water utility notified, PAC feeding begins
4:00pm – Water plant overwhelmed, water enters distribution system
5:36pm – Do Not Use order issued

Freedom Industries Spill

January 9, 2014

No plant shutdown:
Public safety concerns

300,000 people
9 counties
15% of West Va. pop.

2,200 mi. water mains
107 water tanks
>90,000 buildings

8 days after the spill:
366 miles downstream

The Liquid Spilled was a Complex *Mixture*

Crude MCHM & **Stripped PPH**

2,500 gal initial estimate, then ***>10,000 gal***

17+ ingredients, most lacked toxicity data

Most ingredients **lacked water sampling and analysis methods**

Utility, State, Federal agencies keyed in on **4-methylcyclohexane methanol (MCHM)** isomers, but other chemicals were present

Officials Did Not Fully Characterize the Spilled Liquid or Fully Understand what was in the Water

Chemicals in Tank 396 Liquid	MSDS		Est.	Chemical Analysis by Others			
	EastM 1/98	FDM 1/12	CDC 1/14	REIC 3/14	WVTAP 3/14	USGS 12/14	ATTY 4/15
4-MCHM	68 to 89%			79.6%	Detect	77-89%	940 g/kg
4-MMCHM	4 to 22%						
Water	4 to 10%						
MMCHC	5%		88.5%	1.6%		Detect	
DM14CHDC	1%						
Methanol	1%						
1,4–CHDM	1 to 2%			5.6%	Detect		
Polyglycolethers (9d after spill)		100%	7.3%				
PPH							
DiPPH				11.3%			
Formaldehyde							86 ppm
Methylene chloride							13,621 ppm
Water			4.2%				
2-Methoxyethoxybenzene					Detect		
Cyclohexanemethanol				1.8%	Detect		
1,4-CHDADME					Detect		
4-MMECHCA					Detect		
Other unidentified compounds				< 5%			

McMillan et al. 2015

Jan. 9: West Va. DHHR Asked the CDC to Determine the Safe Drinking Water Level for 4-MCHM

Concerns from the Public:

Infants, expectant mothers, immunocompromised persons, toddlers, healthy adults, pets, livestock, fish, frogs, deer, birds

Environmental

Minnow, 48 hr acute toxicity (Crude MCHM)
Daphnia, 48 hr acute toxicity (Crude MCHM)
Environmental biodegradation (Crude MCHM)
COD, BOD (Crude MCHM)

Animal

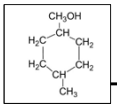
Ames assay for mutagenic activity on cells (Crude MCHM)
Rat, 14 day acute oral studies (*pure MCHM*)
Guinea pig, 48 hr acute dermal study (*pure MCHM*)
Rabbit, acute dermal irritation (eye) study (*pure MCHM*)
Rat, 14 day acute dermal study (*pure MCHM*)
Rat, 28 day acute oral study (*pure MCHM*)

Adams et al. 2014.

"…I would appreciate it if we could wrap this thing up…"

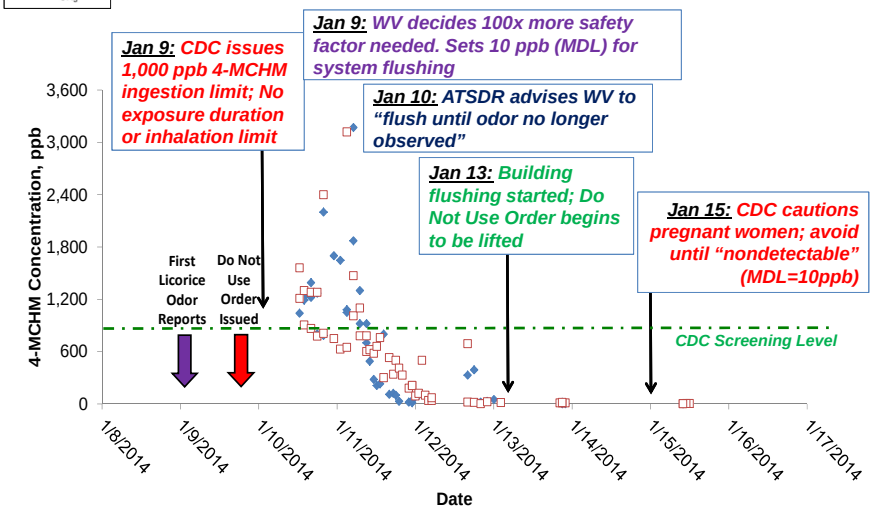
January 10, 2014, 5:30 pm

"…Occasionally we have had reports of an odor previously…."



4-MCHM Levels were Monitored at the Affected Water Treatment Plant

The Whelton Group



Whelton et al. 2014.

Anna Belcher, Born: January 9, 2014

"One hour before I was to bathe they announced the water was not safe, they had bathed my new born baby …."

Charleston Daily Mail

While Flushing Plumbing Systems - January 16, 2014

Scores reporting symptoms

Health officer recommends people make own decisions about using water

By MARCUS CONSTANTINO
DAILY MAIL STAFF

Area emergency rooms are seeing an influx of patients reporting symptoms related to exposure to chemical-tainted water, despite the fact that West Virginia American Water has deemed water in many areas safe to use.

Dr. Rahul Gupta, health officer for the Kanawha-Charleston Health Department, said 101 patients visited area emergency rooms in the 24-hour span ending at 7 a.m. Wednesday morning.

They reported symptoms related to exposure to tainted water. He said 46 of those visits occurred between 7 p.m. Tuesday and 7 a.m. Wednesday.

GUPTA

"What we are seeing when we talk to our partners in hospital health office systems are people with skin and eye irritation, rashes, nausea, upset stomach and diarrhea," Gupta said.

All of those symptoms have been connected with exposure to crude MCHM, the chemical that leaked from a Freedom Industries storage tank Thursday into the Elk River, and then into West Virginia American Water's Charleston treatment plant a mile and a half downstream.

Gupta said many of those patients reported using water that was deemed safe to use by West Virginia American Water. As of Wednesday afternoon, the do-not-use order has been lifted for 51,600 of the 100,000 customers affected by the chemical spill.

Janet Briscoe, director of epidemiology and

■ Turn to HEALTH/9A

BOB WOJCIESZAK/DAILY MAIL

John Johnson, 15, handed out water on Wednesday at the Malden Volunteer Fire Department where he plans to become a volunteer firefighter.

CRAIG CUNNINGHAM/DAILY MAIL

A truck hauling chemicals from Freedom Industries' Elk River facility backs into a spot at Poca Blending in Nitro.

Bottled water still in high demand

By CHARLOTTE FERRELL SMITH
DAILY MAIL STAFF

Even as "do not use" bans are lifted in various areas, bottled water remains a popular commodity.

The Charleston Fire Department has had a steady stream of folks picking up

An estimated 1.2 million bottles of water have been distributed at the three sites, he said.

Two tractor-trailers full of bottled water from the T.D. Jakes' MegaCARE humanitarian ministry outreach program arrived Tuesday night for distribution through the

A portion of that seeped through an old cement block wall and then made its way into the Elk River. As a result, an estimated 300,000 people served by West Virginia American Water across nine counties were left without clean tap water.

The water company began

Second storage

Local

The Charleston Gazette
TUESDAY, JANUARY 14, 2014 5A

WATER CONTAMINATION

How do they know it's safe at 1 ppm?

Officials still silent on how they arrived at figure for chemical limit

By Ken Ward Jr.
Staff writer

Tomblin administration officials continued on Monday to decline to provide detailed answers why they think 1 part per million of Crude MCHM is safe for West Virginians to drink.

Federal agencies also refused to explain how they calculated that figure in the absence of any real regulatory guidelines or published health standards for the material, also known as 4-methylcyclohexanemethanol.

A Ph.D. chemist who works with the Environmental Defense Fund wrote on his organization's blog that West Virginia officials are trusting "shaky science" in their "rush to restore water service" to 300,000 residents in a nine-county region.

Richard Denison wrote that officials "made significant leaps in their calculation of a 'safe' exposure level — including assumptions that deviate from generally accepted practices."

"As a result, these estimates fail to adequately account for either acute or chronic effects from ongoing exposure to water contaminated at the 1 ppm level," Denison wrote. "At a bare minimum, the public deserves to know a lot more about the calculations behind officials' insistence that a 1 ppm level in drinking water is safe."

Tomblin administration officials have emphasized that water samples in the last two days have begun to more consistently show far less than 1 part per million of MCHM in drinking water from West Virginia American Water's Elk River treatment plant. Some samples, they note, are coming back with none of the chemical at all being detected.

"The numbers we have today look good," Tomblin said at a noon briefing Monday.

Top Tomblin aides continue to point to the U.S. Centers for Disease Control and Prevention, which, along with the federal Agency for Toxic Substances and Disease Control, came up with the figure 1 part per million.

SEE CHEMICAL, 10A

FINAL EDITION 50 CENTS JANUARY 17, 2014 CHARLESTON, WEST VIRGINIA SNOW SHOWERS HIGH 34 LOW 19 DETAILS, 7A
FRIDAY

the Charleston Gazette
THE STATE NEWSPAPER — OUR 140TH YEAR
wvgazette.com

CDC: 'A dynamic and evolving event'

Federal agency defends stated threshold for drinking tainted water in Kanawha Valley

By David Gutman and Ken Ward Jr.
Staff writers

Federal health officials on Thursday defended their recommended 1-part-per-million threshold for acceptable levels of "Crude MCHM" in West Virginia drinking water, but also said they continue to gather data on the chemical's potential health impacts.

"This is a dynamic and evolving event," said Dr. Vikas Kapil, chief medical officer for the U.S. Centers for Disease Control and Prevention's National Center for Environmental Health.

Kapil said the CDC stands by its initial recommendation — made in the absence of any regulatory standards or established public-health guidance — but that the agency is searching for additional information that might help scientists refine their work.

"As we get additional information, we will be able to use that information as it becomes available," Kapil said. "However, we stand by the 1-part-per-million screening level that we have recommended."

Kapil made his statements during a conference call with local and national reporters, as the CDC faced increasing pressure to explain how it came up with the figure being used by state and local health officials in West Virginia.

However, agency officials also conceded that it's "almost as if we're learning as we go" in dealing with a chemical spill last Thursday that fouled the drinking water supply that serves nearly a third of a million West Virginians.

Other tonic-chemical experts continued to question the CDC's figures, to advise West Virginians that the number might not be as conservative as the agency would have residents believe and that the lack of data reflects a far broader problem.

"As much as this stinks, this is the way it works for almost all chemicals," said Laura Vandenberg, an assistant professor of environmental health at the University of Massachusetts at Amherst.

In Charleston and across a nine-county region, state officials and West Virginia American Water have been clearing residents since Monday night to resume drinking, bathing and cooking in water from their taps. Water company officials have given residents a zone-by-zone go-ahead to flush out their home plumbing systems based on water samples showing less than 1 part per million of MCHM, a coal-cleaning chemical also known as 4-methylcyclohexanemethanol.

Officials with the administration of Gov. Earl Ray Tomblin have backed the move, saying they trust the CDC recommendation, which Bureau for Public Health Commissioner Letitia Tierney said is based on one study recently called an LD50, that determined of whe

SEE CDC, 3A

104 ■ THURSDAY, FEBRUARY 6, 2014

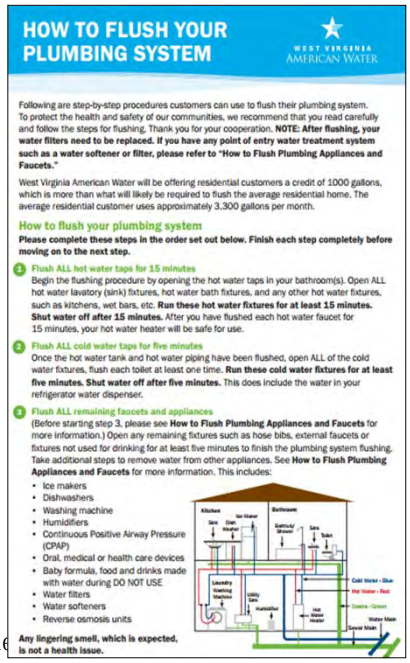
Spill

Dr. Tonia Poponi, acting director of the CDC's National Center for Environmental Health, said the CDC doesn't use the term "safe." She said the question is whether the water is appropriate for use, given the information we know about MCHM.

"I think that the pregnant women need to address the issue of water just like they address anything else . . . they want to take precautions that make them feel good."

Dr. Tonia Poponi

Is the Water "Safe?"



HOW TO FLUSH YOUR PLUMBING SYSTEM

WEST VIRGINIA AMERICAN WATER

Following are step-by-step procedures customers can use to flush their plumbing system. To protect the health and safety of our communities, we recommend that you read carefully and follow the steps for flushing. Thank you for your cooperation. **NOTE: After flushing, your water filters need to be replaced. If you have any point of entry water treatment system such as a water softener or filter, please refer to "How to Flush Plumbing Appliances and Faucets."**

West Virginia American Water will be offering residential customers a credit of 1000 gallons, which is more than what will likely be required to flush the average residential home. The average residential customer uses approximately 3,300 gallons per month.

How to flush your plumbing system

Please complete these steps in the order set out below. Finish each step completely before moving on to the next step.

1. **Flush ALL hot water taps for 15 minutes**
   Begin the flushing procedure by opening the hot water taps in your bathroom(s). Open ALL hot water lavatory (sink) fixtures, hot water bath fixtures, and any other hot water fixtures, such as kitchens, wet bars, etc. **Run these hot water fixtures for at least 15 minutes. Shut water off after 15 minutes.** After you have flushed each hot water faucet for 15 minutes, your hot water heater will be safe for use.
2. **Flush ALL cold water taps for five minutes**
   Once the hot water tank and hot water piping have been flushed, open ALL of the cold water fixtures, flush each toilet at least one time. **Run these cold water fixtures for at least five minutes. Shut water off after five minutes.** This does include the water in your refrigerator water dispenser.
3. **Flush ALL remaining faucets and appliances**
   (Before starting step 3, please see **How to Flush Plumbing Appliances and Faucets** for more information.) Open any remaining fixtures such as hose bibs, external faucets or fixtures not used for drinking for at least five minutes to finish the plumbing system flushing. Take additional steps to remove water from other appliances. See **How to Flush Plumbing Appliances and Faucets** for more information. This includes:
   - Ice makers
   - Dishwashers
   - Washing machine
   - Humidifiers
   - Continuous Positive Airway Pressure (CPAP)
   - Oral, medical or health care devices
   - Baby formula, food and drinks made with water during DO NOT USE
   - Water filters
   - Water softeners
   - Reverse osmosis units

Any lingering smell, which is expected, is not a health issue.

4 Days After the Spill: Utility Recommends the Population Flush their Plumbing Systems

1. Flush ALL hot water taps for 15 minutes
2. Flush ALL cold water taps for five minutes
3. Flush ALL remaining faucets and appliances

Water supplies for pets
Pets need clean water too. Be sure to empty all water bowls, bottles, or other water supplies for your pet. After flushing your water system, wash the pet bowl, bottle or other water supply. Then refill with tap water.

Any lingering smell, which is expected, is not a health issue.

WVAW. 2014.

A Union of Professionals

Safety Precautions for Flushing Water Lines

Bulletin #1
January 13, 2014

"Avoid contact"

Your school district may ask you to flush the water lines in your school today in order to eliminate any MCHM that may linger in the lines. If you are asked to perform this task, please take the necessary precautions in order to protect yourself from potential exposure to contaminated water.

At this time, the water has not been deemed safe to use and we don't have any specific sampling data for affected schools. The West Virginia health department has described skin irritation, nausea, vomiting or wheezing as symptoms of exposure. If you experience any of these symptoms or smell a strong presence of licorice*, get to fresh air and, if necessary, clean any splashed skin with bottled water and soap.

If you are flushing a closed system (like recirculating boiler/hot water systems) there is probably no need to take extra precautions. However, when flushing water lines and other systems, like dishwashers and ice makers in your schools, you should take steps to minimize your contact with the water or vapor/steam coming from hot water faucets or valves.

Here are some tips for protecting yourself during flushing in op

"proper PPE"

- Make sure proper Personal Protective Equipment (PPE) is available to you from the school district. This includes water-proof gloves, goggles, and water-proof rain gear/coveralls;
- Whenever possible attach a hose from an open faucet or spigot that will be put directly into the drain. That way, you will create a 'near closed' system and will minimize the potential for contact with the water;
- If possible leave the room while lines are being flushed and only periodically monitor the flushing process.
- Avoid coming into contact with the vapor that occurs when the hot water faucets are turned on. If you must flush lines by opening up faucets, make sure that there is good ventilation in the room by opening windows and doors or asking the building engineer to bring 100% fresh air into the heating, ventilation and air conditioning (HVAC) system; and
- Leave areas when pools, towers or ot

"good ventilation"

If you have additional questions, please contact healthandsafety@aft.org and we'll do our best to respond.

"Minimize your exposure by leaving areas while lines are being flushed"

A Union of Professionals
Washington, D.C.

Safety Precautions for Flushing Water Lines

January 13, 2014

Guidance issued to school staff only

WEST VIRGINIA Department of Health & Human Resources
BUREAU FOR PUBLIC HEALTH

To clarify confusion related to flushing and cleaning of pipes impacted…

January 13, 2014

Guidance issued to school staff

NOT the public

STATE OF WEST VIRGINIA
DEPARTMENT OF HEALTH AND HUMAN RESOURCES
BUREAU FOR PUBLIC HEALTH
Commissioner's Office
350 Capitol Street, Room 702
Charleston, West Virginia 25301-3712
Telephone: (304) 558-2971 Fax: (304) 558-1035

Earl Ray Tomblin
Governor

Karen L. Bowling
Cabinet Secretary

January 13, 2014

Notice From Bureau For Public Health

From: Letitia Tierney MD JD
Commissioner and State Health Officer

"Avoid contact"

To clarify any confusion related to the flushing and cleaning of pipes for schools impacted by the DO NOT USE order, please refer to the following:

- Currently, the remaining MCHM that lingers in the water lines is very diluted.
- There is no toxicity related to the smell associated with this substance, though it may be annoying. If it bothers you, get to fresh air and, if necessary, clean any splashed skin with bottled water and soap. The smell associated with MCHM is similar to licorice. The smell/odor will dissipate quickly.
- If you are flushing a closed system (like recirculating boiler/hot water systems) there is probably no need to take extra precautions. However, when flushing water lines and other systems, like dishwashers and ice makers in your schools, you should take steps to minimize your contact with the water or vapor/steam coming from hot water faucets or valves.
- Make sure proper Personal Protec he school district. This includes Latex or non-latex or water proof gloves or rubber gloves. Goggles and rain gear will not be necessary.
- If possible leave the room while lines are being flushed and periodically monitor the flushing process.
- Avoid coming ts are turned on. If good ventilation in sk the building engineer to bring 100% fresh air into the heating, ventilation and air conditioning (HVAC) system; and
- Leave areas when pools, towers or other open bodies of water are being drained.
- If there is any contact with skin, simply wash splashed skin with bottled water and soap.
- If your eyes get splashed, simply rinse them with bottle water, like you would if you got soap in your eyes.

"proper PPE"

"good ventilation"

"Minimize your exposure by leaving areas while lines are being flushed"

7 Days After the Spill (Jan 17): We drove to West Va. and Teamed with NGOs

Rob Goodwin
WV Clean Water Hub

Maya Nye
PCACS

On the Ground…
in Affected Homes

Resident interviews
In-home water testing
Home flushing

Charleston Daily Mail

Friday, January 17, 2014 Charleston, West Virginia, dailymailwv.com

The day we arrived

Bulk water containers pulled

Company gets more violations

By DAVE BOUCHER
CAPITOL BUREAU CHIEF

The company responsible for a chemical spill that left 300,000 West Virginians without safe tap water finally told the state what it plans to do with chemicals stored unsafely at a different location.

Freedom Industries will transfer the rest of the crude MCHM and contaminated water stored at its Poca Blending location to new "double-walled Baker tanks," said Tom Aikins, state Department of Environmental Protection spokesman.

Baker tanks are large, wheeled tanks typically used to store fracking waste, DEP Secretary Randy Huffman has said.

Freedom is currently storing

Handouts halt after complaints

By ASHLEY E. CRAIG
DAILY MAIL STAFF

Saying they weren't sure where the water came from, Kanawha County officials ordered the removal of all bulk water containers from distribution sites Thursday evening.

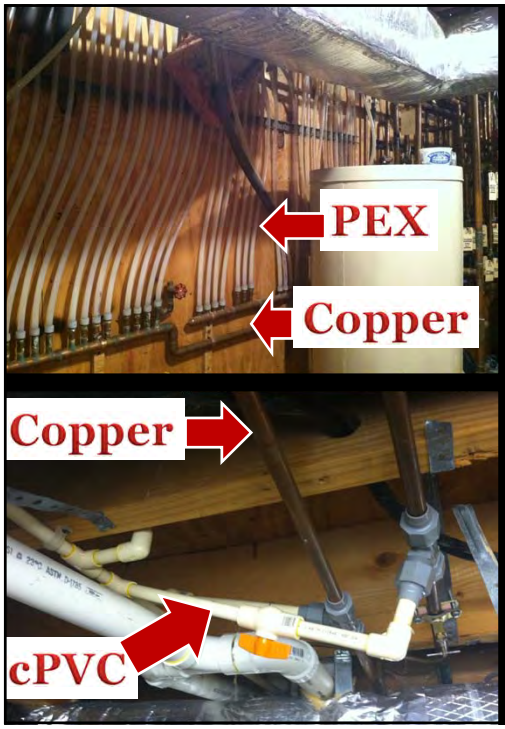
County Manager Jennifer Sayre said West Virginia American Water Co. told county officials some of the bulk containers might have been filled at the Charleston treatment plant.

"We received complaint calls about an odor when people went to use the bulk containers," Sayre said.

She said the county has conflicting information on where the tankers were filled and that only when county officials called the water company were they told that some might have

Yes,
we are using
bottled water
in our food
preparations.

WV Clean Water Hub
Can you offer clean water?
Do you need clean water?
Please post to this page!
Now
4,000+
Strong!
WV Clean Water Hub
Liked
Following
Message
ICE MOUNTAIN



Plumbing Systems Were Complex (plastics, metals, glass, hot, cold, tanks …)

Residents started reporting blueish crystals in their water during flushing

Downey. 2014.

Oxygen	58%
Aluminum	18%
Carbon	17%
Zinc	1.4%
Phosphorous	1.4%
Fluorine	1.0%
Chromium $^{+6}$	**0.8%**
Calcium	0.2%
Copper	0.1%

NOT SAND

NO SILICA

Whelton et al. 2014. Downey et al. 2014

OUR MODIFIED FLUSHING RECOMMENDATIONS

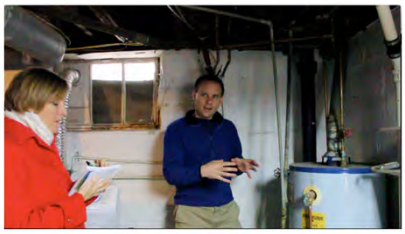
Shutoff hot water heater and allow to cool before flushing
Flush 1 room at a time
Use fans and open *all* windows (and doors) to expel contaminated air
Flush, not once, but multiple times

WEST VIRGINIA WATER CRISIS

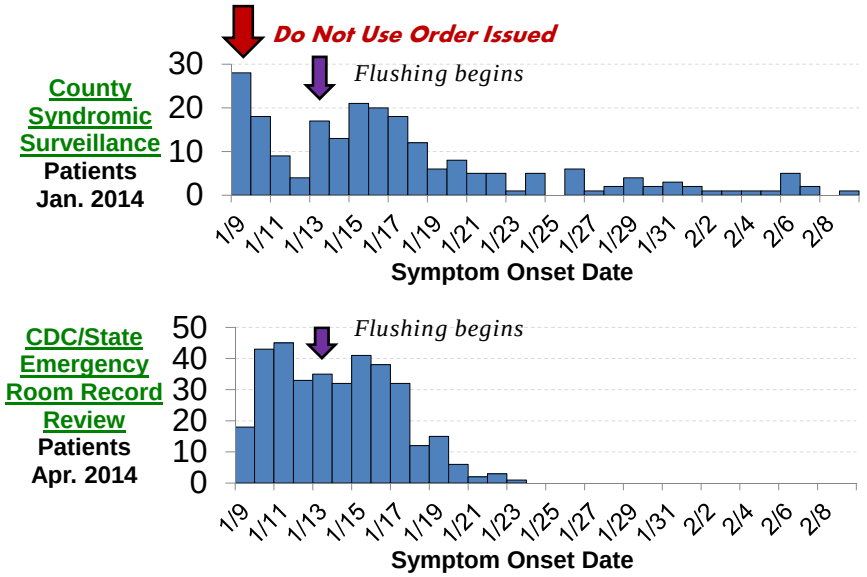
Krista Bryson

WEST VIRGINIA WATER CRISIS: EXCLUSIVE *CRUCIAL* INFORMATION ABOUT FLUSHING

YOUR QUESTIONS ANSWERED: FLUSHING RECOMMENDATIONS, WATER AND WATER SYSTEMS SAFETY, AND HEALTH CONCERNS



Medical Data Showed Residents Became Ill When Plumbing System Flushing was Recommended



Whelton et al. 2014. ES&T.

Former Resident Charleston, West Va.

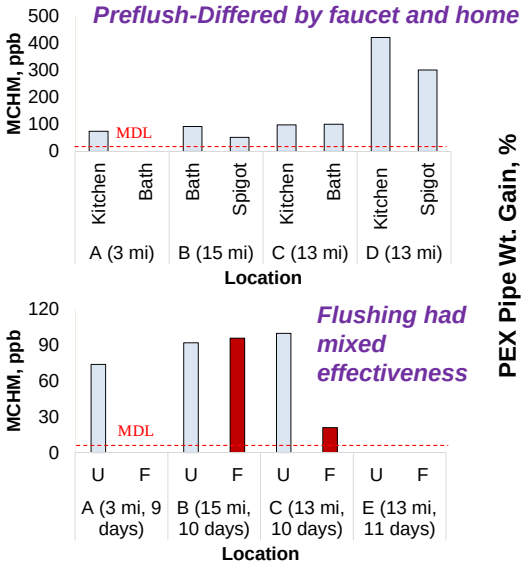
Flushed her premise plumbing 3x per guidance

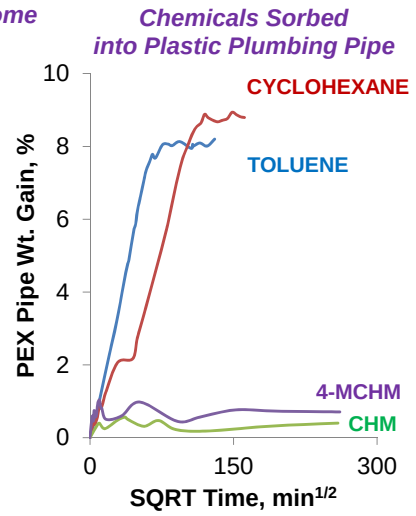
Diagnosed with adult onset asthma after flushing her house

Inmates in Charleston's Jails were Impacted

"…They could drink the sweet-tasting water that might make them sick or deal with the inevitable drain of severe dehydration." - ThinkProgress

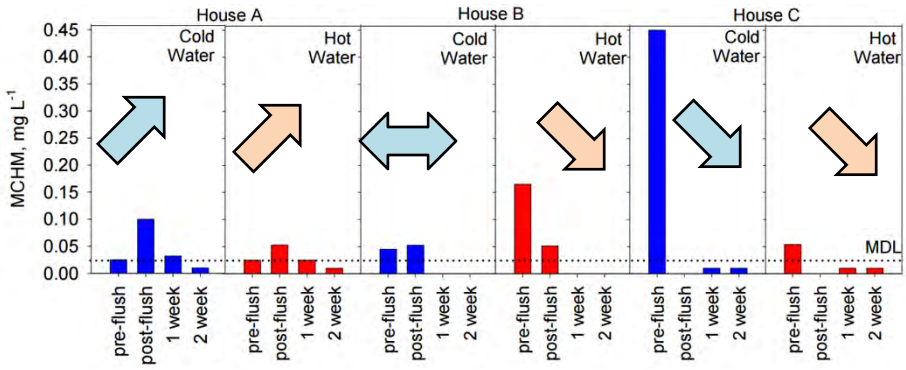
By Conducting Rapid In-Home Tests We Were Able to Understand Resident Experiences and Exposures





Whelton et al. 2014. ES&T.

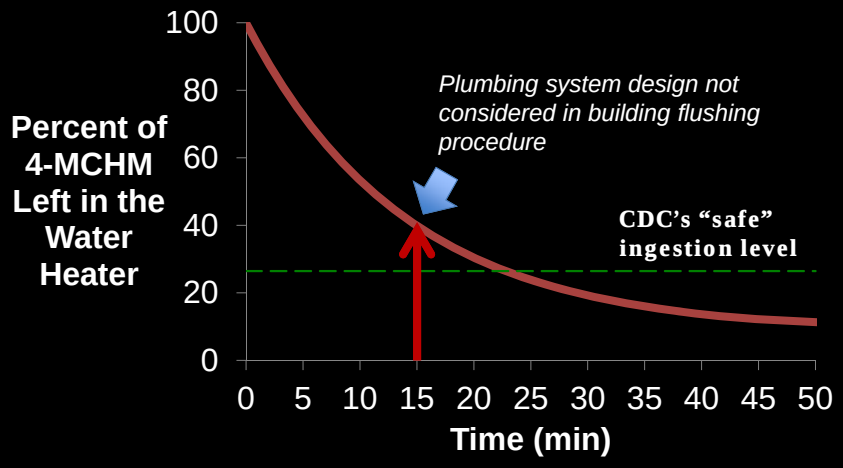
Others Found Residential Flushing Had Mixed Effectiveness



Weidhass et al. 2015. Presented at the WV Taskforce Symposium. Morgantown, WV.

"…after you have flushed each hot water faucet for 15 minutes, your water heater will be safe for use."

- West Virginia American Water, 2014

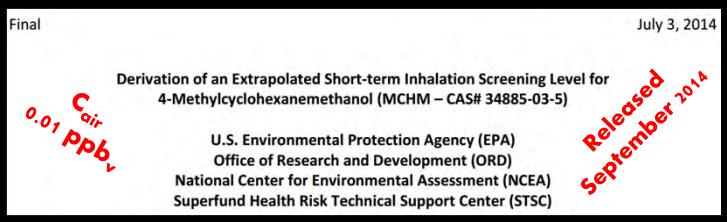


32

Casteloes et al. 2015. ES: WR&T.

"…if the water is at nondetectable levels for MCHM, it is safe to drink, bathe in and clean with, and this would include for pregnant women."

- CDC, late Feb 2014


Final

July 3, 2014

Derivation of an Extrapolated Short-term Inhalation Screening Level for 4-Methylcyclohexanemethanol (MCHM – CAS# 34885-03-5)

U.S. Environmental Protection Agency (EPA)
Office of Research and Development (ORD)
National Center for Environmental Assessment (NCEA)
Superfund Health Risk Technical Support Center (STSC)

C_{air} 0.01 ppb_v

Released September 2014

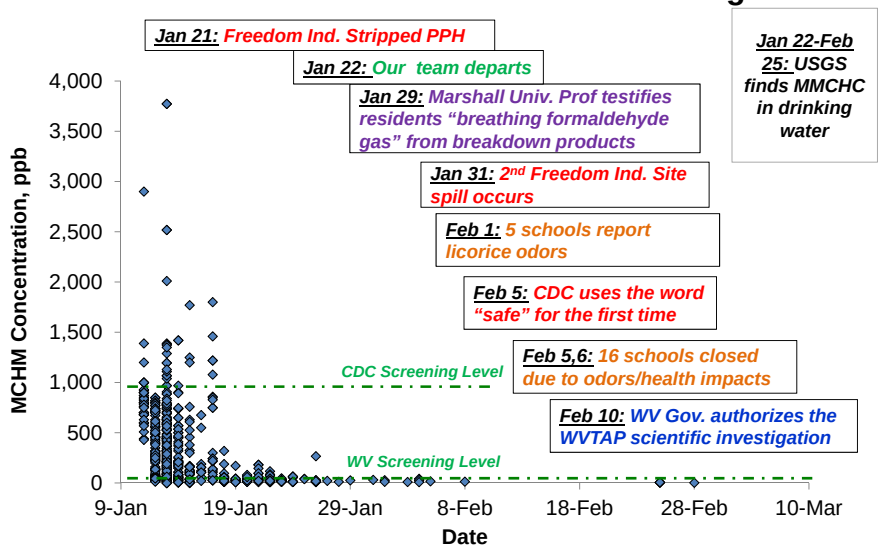
Our NEW data: Kitchen, Bathroom, Half-bath

- Opening 1 or multiple windows insufficient to prevent indoor air MCHM concentration exceedances for small spaces
- Future solutions: Mechanical ventilation, Protective wear, Building evacuation

33

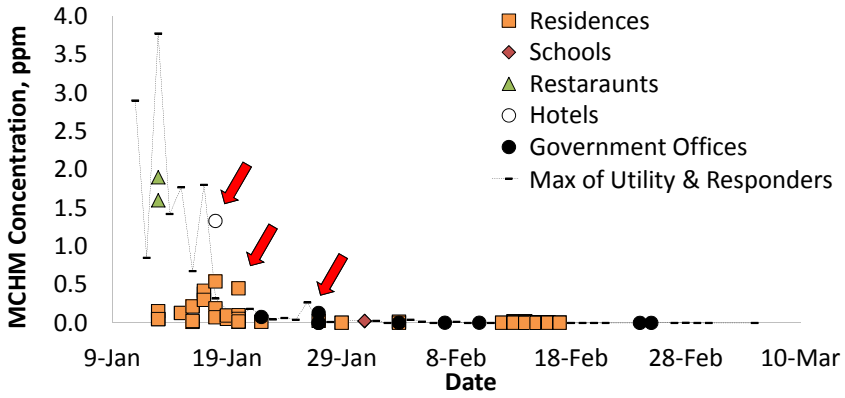
Omur-Ozbek et al. 2015. In Prep.

The Water Company Flushed its Distribution System and the National Guard Flushed Government Buildings



34

Responder Water Distribution Data Sometimes Did Not Match In-Home Concentrations



>2,500 responder water distribution water samples vs. much fewer samples from 38 buildings
Neither distribution sampling or building sampling was statistically designed

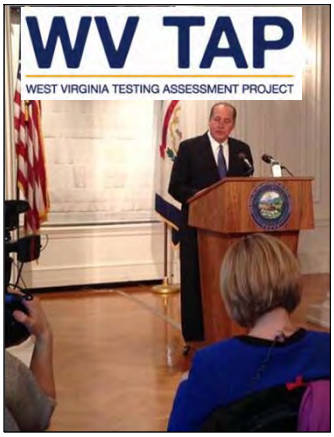
McMillan et al. 2015

"Dr. Tierney, Is the Water Safe to Drink?"

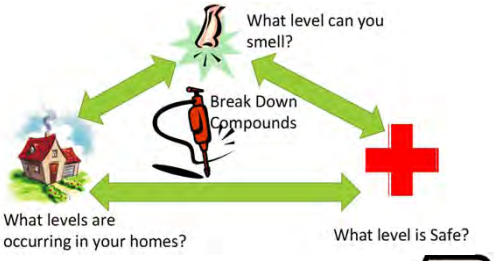
February 10, 42 days after the spill

"That's, in a way, is a difficult thing to say…"

WVTAP was Authorized because of Unexplained Illnesses, Chemical Levels, and Odors



Team:
Jeffrey Rosen, CEC
Andrew Whelton, Ph.D.
Michael McGuire, Ph.D., McGuire, Inc.
Jennifer Clancy, Ph.D., CEC
Tim Clancy, CEC
Tim Bartrand, Ph.D., CEC
Andy Eaton, Ph.D., Eurofins
Craig Adams, Ph.D., Utah State University
Jacqueline Patterson, TERA
Michael Dourson, Ph.D., TERA
Patricia Nance, TERA
And the Expert Health Effects Panel

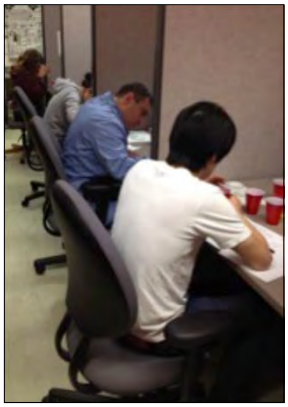


38

Rosen et al. 2014. JAWWA.

Contaminated Tap Water Had an *Licorice Odor* when MCHM was Present Below 1 ppb

Results	Expert Panel (Mar 16)	Consumer Panel (Mar 31)
Number of panelists	9	60
Threshold Concentration (OTC)	**< 0.15**	**0.55**
Recognition Concentration (ORC)	2.2	7.4
Objection Concentration (OOC) based on degree of liking	4.0	7.7
Objection Concentration (OOC) based on objection/complaint	4.0	8.8



People smell the water

4-MCHM MDL of 2 ppb … referred to as "non-detect"… but *licorice odor* present!

39

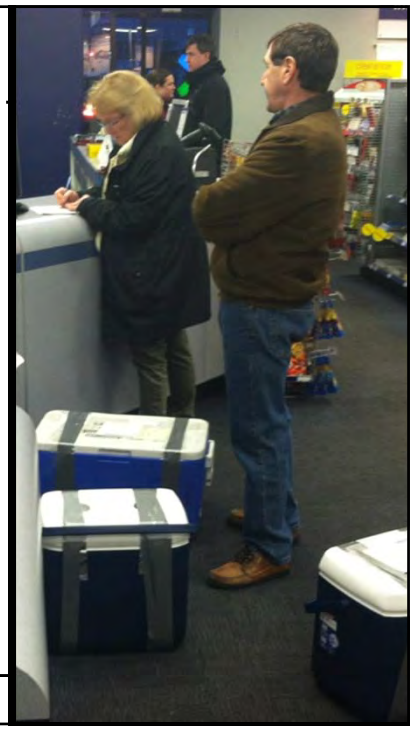
30 Days After the Spill: We Investigated Ten Homes in the Affected Counties

Interviewed residents and examined plumbing systems

Characterized tap water quality
4-MCHM, PPH, TOC
MDLs were 0.38 ppb, much lower than State and utility
Odor, FAC, pH, temp.

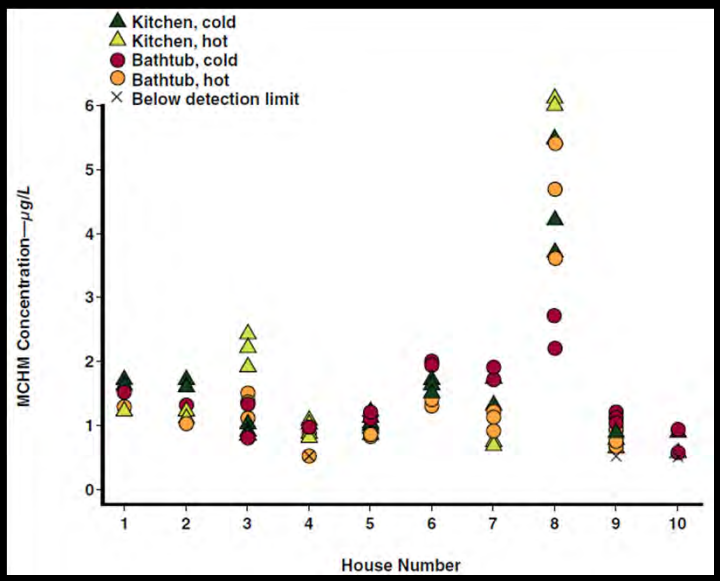
Four conditions per house
Kitchen hot and cold
Bathroom hot and cold

Split sampled to two commercial laboratories
90 samples per home



40

We Found 4-MCHM in *All* 10 Homes



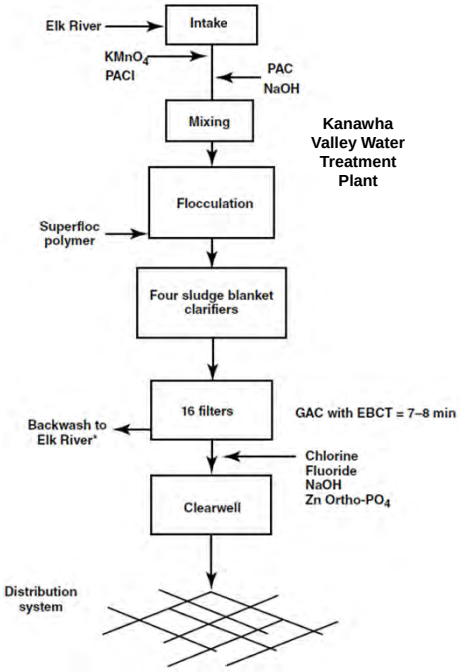
March 2014: We then discovered the water plant filters were bleeding 4-MCHM into the tap water (≤0.61 ppb)

We were Concerned About Breakdown Products

- **Drinking water odor not consistent with pure 4-MCHM**
- **Contaminated water underwent treatment**

Our Approach:

1. Batch oxidation studies $KMnO_4$ and FAC on products and odor
   - Neither affected 4-MCHM or odor levels
2. GC/MS analysis of spilled solvent
   - Nothing unexpected found
3. GC/MS analysis of solvent in tap water for 10 homes



42

An International Health Effects Expert Panel was Convened

WV TAP

EXPERT PANEL

Dr. Michael Dourson, TERA, Cincinnati, **Ohio USA**

Dr. Shai Ezra, Israel National Water Co. Ltd, **Tel Aviv, Israel**

Dr. Paul Rumsby, Nat. Centre for Environ. Tox. at WRc plc, **Blagrove, United Kingdom**

Dr. Stephen Roberts, Univ. Florida, **Florida USA**

Dr. James Jacobus, Minnesota Dept. Health, **Minnesota USA**

CHARGE QUESTIONS AND CONSTRAINTS

1. Given data now available, what would be appropriate screening levels for MCHM, PPH, and DiPPH in drinking water?
2. What additional data, analyses, or studies might reduce uncertainty and provide greater confidence?
3. How should the presence of multiple chemicals in the release to the Elk River be considered?
4. Are the screening values protective for all potential routes of exposures (i.e., ingestion, dermal and inhalation)?
5. Identify additional scientific issues or questions that the panel should discuss.

43

The Expert Panel Established Different "Safe" Drinking Water Limits than CDC

WV TAP

Compound & Assumption	WV TAP March 2014	CDC January 2014
4-MCHM	120	1,000
PPH	850	1,200
DiPPH	250	1,200
Duration	28 days	14 days
Most sensitive population	Formula fed infant	1 year old child
Exposure routes	Ingestion, inhalation, dermal	Assumed ingestion most conservative

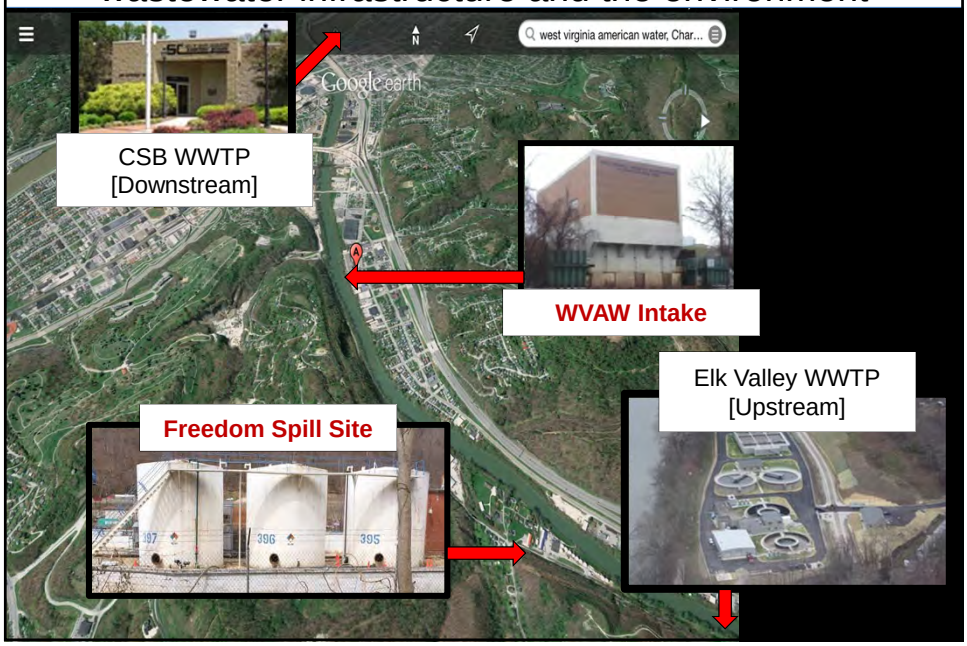
Caveats:

Very limited toxicity data; No chronic studies

Residents were exposed for at least 2.5 months

MMCHC found in the tap water by USGS, no limit established by anyone

Flush water discharged to wastewater infrastructure and the environment



300,000 people flushing their plumbing systems across 9 counties

Charleston Sanitary Board WWTP
14 MGD
24,600 customers
300 miles collection lines
88 pumping stations, 408 manholes

- 1' Clarifiers
- High Purity O_2
- Digestion
- 2' Clarifiers
- UV disinfection

Kanawha River (downstream)

Elk Valley WWTP
5 MGD
4800 customers
69 pumping stations

- Aeration
- Clarifiers
- Chlorination/ Dechlorination

Elk River (upstream)

Limited information exists on the impact of contaminated water on WWTPs and environment

A total of 13 grab samples were collected from the CSB WWTP by West Va. DEP

MDL = 6 ppb

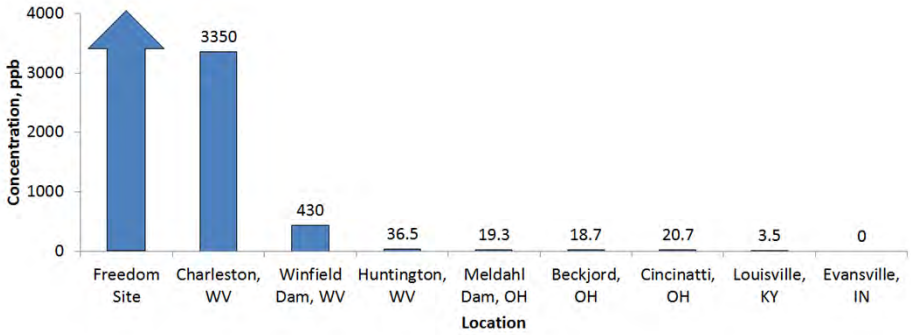
Date	In	Out
Jan 13	No data	No data
Jan 14	Non-detect	Non-detect
Jan 15	est. 0.87 ppb	est. 0.58 ppb
Jan 16	No data	No data
Jan 17	No data	No data
Jan 18	No data	No data

Citizens and businesses organized to protect water supplies
Maya Nye, People Concerned About Chemical Safety

Senate Bill 373, The Water Resources Protection Act
March 2014

Multiple tanks leaking before January 9, 2014
Chemical Safety Board, 2014

Communities 700 Miles Downstream were Impacted by the Spill



- ❑ Huntington WV: 4-MCHM finished water level = 9 ppb
- ❑ Numerous communities downstream
  - Shut their intakes
  - Conducted odor monitoring of their raw and drinking waters

Novy et al. 2015. In Prep.

TANK 396 RELEASE
FREEDOM INDUSTRIES FACILITY
CHARLESTON, WEST VIRGINIA

Prepared For:

FREEDOM INDUSTRIES, INC.
1015 BARLOW DRIVE
P.O. BOX 713
CHARLESTON, WEST VIRGINIA 25311

Prepared By:

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
4000 TRIANGLE LANE, SUITE 200
EXPORT, PENNSYLVANIA 15632

CEC Project 140-256

April 8, 2014

"At the end of the day, there can be no risk. We just can't have it."

November 13, 2014
Sec. Randy Huffman, WV DEP

Spill site STORM WATER:
4-MCHM: 76 – 190 mg/L
PPH: 1.6 – 95 mg/L

Spill site GROUND WATER:
4-MCHM: 0 – 0.014 mg/L
PPH: 0 – 0.022 mg/L

SOIL:
Contamination found as deep as 20 ft depth
4-MCHM: Up to 15,000 mg/kg
PPH: Up to 9,000 mg/kg

Other Chemicals Found:
4-methyl cyclohexanecarboxylic acid (MCHCA)
4-methyl methyl ester, cyclohexanecarboxylic acid (MMCHCA)
1-hydroxymethyl-2-methyl-1-cyclohexane (HMC)

Novy et al. 2015. In Prep.

The 2014 Crude MCHM was *More Toxic* than what the Eastman Chemical Co. Found in 1998

Result	1998 Crude MCHM - Eastman			2014 Crude MCHM - Our Work	
	Tox Report (1998)	MSDS (2005)	MSDS (2011)	Eastman Procedure	USEPA Protocol 600/8-87/011
EC_{50}, ppm	98.1 (86.4, 111.3)	98.1	98.1	56.7 ± 5.0 (42.8, 78.0)	50.8 ± 11.6 (36.4, 74.6)
NOEC, ppm	50	40	40	6.25	< 6.25

In 2014, Eastman noted that the MSDS 40 NOEC was a typo
95% Confidence intervals determined

Novy et al. 2014. In Prep.

Compound	Organism	End Point	Toxicity Response Detected?
Tank 396 from Spill Site	*Yeast*	Cytotoxicity	In progress
	Human lung cells	Cytotoxicity	In progress
	D. Magna	EC50, NOEC	In progress
	C. Dubia	EC50, NOEC	Acutely toxic
	Red-horse sucker fish	Developmental	In progress

Compound	Organism	End Point	Toxicity Response Detected?
Crude MCHM	*D. Magna*	EC50, NOEC	More acutely toxic in 2014 than 1998
	C. Dubia	EC50, NOEC	Acutely toxic
	Fathead minnow	LC50, NOEC	Acutely toxic
Pure 4-MCHM	Structure Activity Relationships	Potential toxicity	Dermal irritant
	Yeast	Cytotoxicity	DNA damage; Metabolites more toxic
	Human lung cells	Cytotoxicity	DNA damage; Metabolites more toxic
	Xenopus	Developmental	CNS defects, growth cessation
	Danio rerio	Developmental	Neurotoxic
DMCHC	*E.coli/Salmonella*	Mutagenicity	DNA damage
	Danio rerio	Developmental	Embryonic malformations
1,4-CHDM	*E. Coli, S. typhimurium*	Mutagenicity	DNA damage
PPH	*D. Magna*	EC50	Acutely toxic
	Fathead minnow	EC50	Acutely toxic
DiPPH	*C. Crangon*	EC50	Acutely toxic
	P. Putida	EC10	Acutely toxic
	S. Capricornutum	EC50	Acutely toxic
	D. Magna	LC50, NOEC	Acutely toxic
	Fathead minnow	LC50	Acutely toxic

Novy et al. 2014. In Prep.

Animal Toxicity Testing Results

Compound	Organism	End Point	Toxicity Response Detected?
Tank 396 from Spill Site		*Not a single test*	

Entirety of Animal Data

Crude MCHM vs. Pure 4-MCHM vs. PPH

Rat, Rabbit, Guinea pig, Mouse

Acute toxicity only, Up to 28 days

Dermal, oral, eye exposures

LD50, NOAEL, kidney and liver responses

Novy et al. 2014. In Prep.

Re·sil·ience

\ri-’zil-yen(t)s\

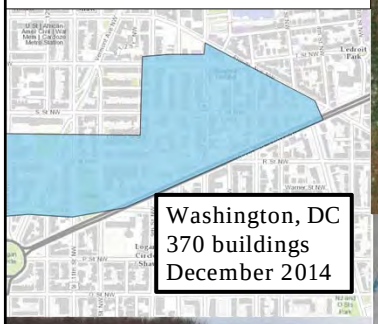
The ability to recover from or adjust easily to misfortune or change

Water Contamination

Asset Failure

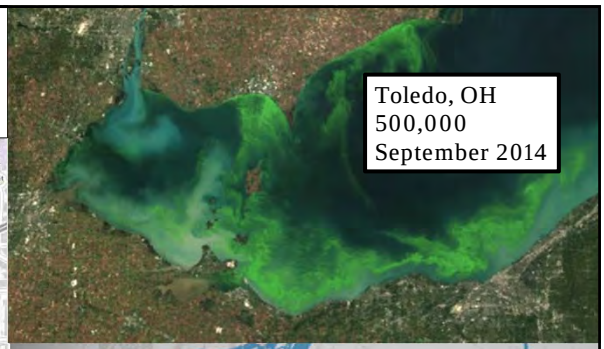
New Regulations

The Frequency of Water Supply Contamination Incidents is Increasing

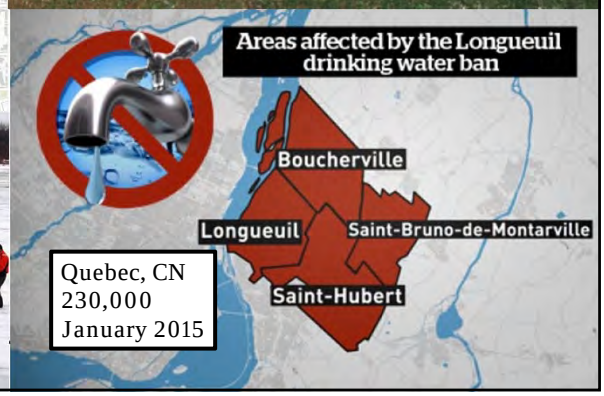


Washington, DC
370 buildings
December 2014

Glendive, MT
5,500
January 2015



Toledo, OH
500,000
September 2014



Quebec, CN
230,000
January 2015

PURDUE UNIVERSITY

Water Infrastructure Testing & Evaluation (T&E) Facility

Recreate field conditions, Evaluate system design and contamination scenarios, Explore material-contaminant interactions, Challenge decontamination aide effectiveness

NSPE Engineer's CREED:

Hold paramount the safety, health, and welfare of the public.

What I have Learned:

- Empathy, empathy, empathy
- Most people try to do the right thing
- Take *initiative* when your expertise can help others
- Provide decision makers *scientifically relevant* data
- *Point out* questionable data, statements, and unknowns
- *Do not wait* for someone else to help you

Think Resilience.

www.WheltonGroup.org