

Where we are Today: Cured in Place Pipe Lining (CIPP) Chemical Emissions and Safety

Andrew J. Whelton, Ph.D.

Lyles School of Civil Engineering
Environmental & Ecological Engineering
awhelton@purdue.edu



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Indianapolis, IN USA

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Cured-in-Place Pipe Safety Study

News In the News

DOT Lining Study (Surface and Storm Water Quality)

- [Scientific file](#), *Journal of the American Water Works Association*, May 2018
- [Frequently Asked Questions \(FAQ\)](#)

NSF Rapid CIPP Study (Worker, Public Safety, and Chemical Air Emissions)

- [Scientific report files & associated video files](#), *Environmental Science & Technology Letters*, July 2017
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[Incorrect assertions about the NSF Rapid CIPP study](#)

In 2016, Purdue researchers began investigating chemical emissions and exposures caused by cured-in-place-pipe (CIPP) water pipe repair sites. CIPP is the most popular water pipe repair technologies used in the U.S. Because this technology uses raw chemicals in the field and manufactures a new plastic pipe inside an existing damaged water pipe, chemicals can be emitted into the environment and enter nearby buildings. CIPP is used for sanitary sewer, storm sewer, and drinking water pipe repairs.

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Sanitary Sewer and Storm Sewer Infrastructure Repairs

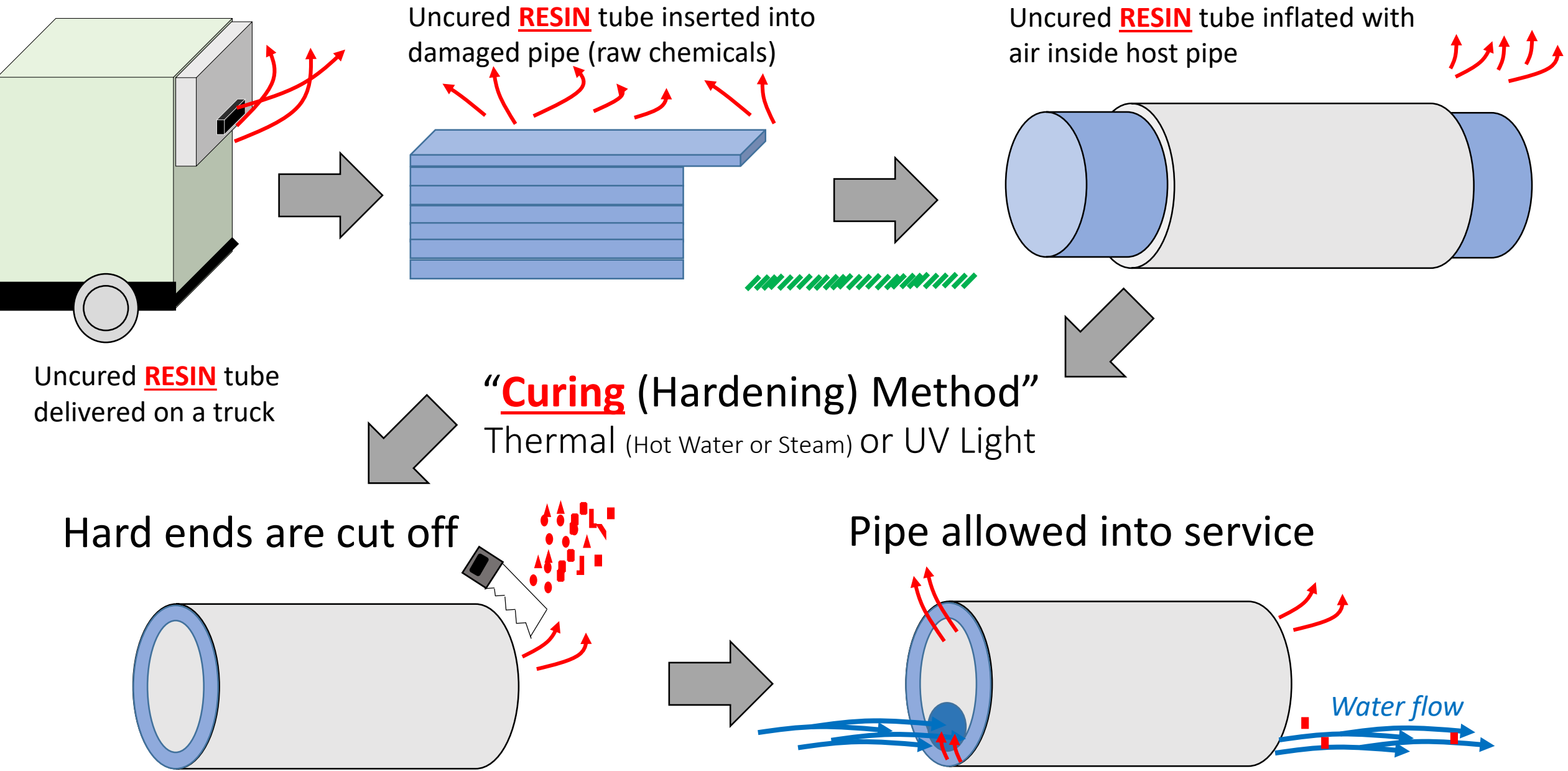


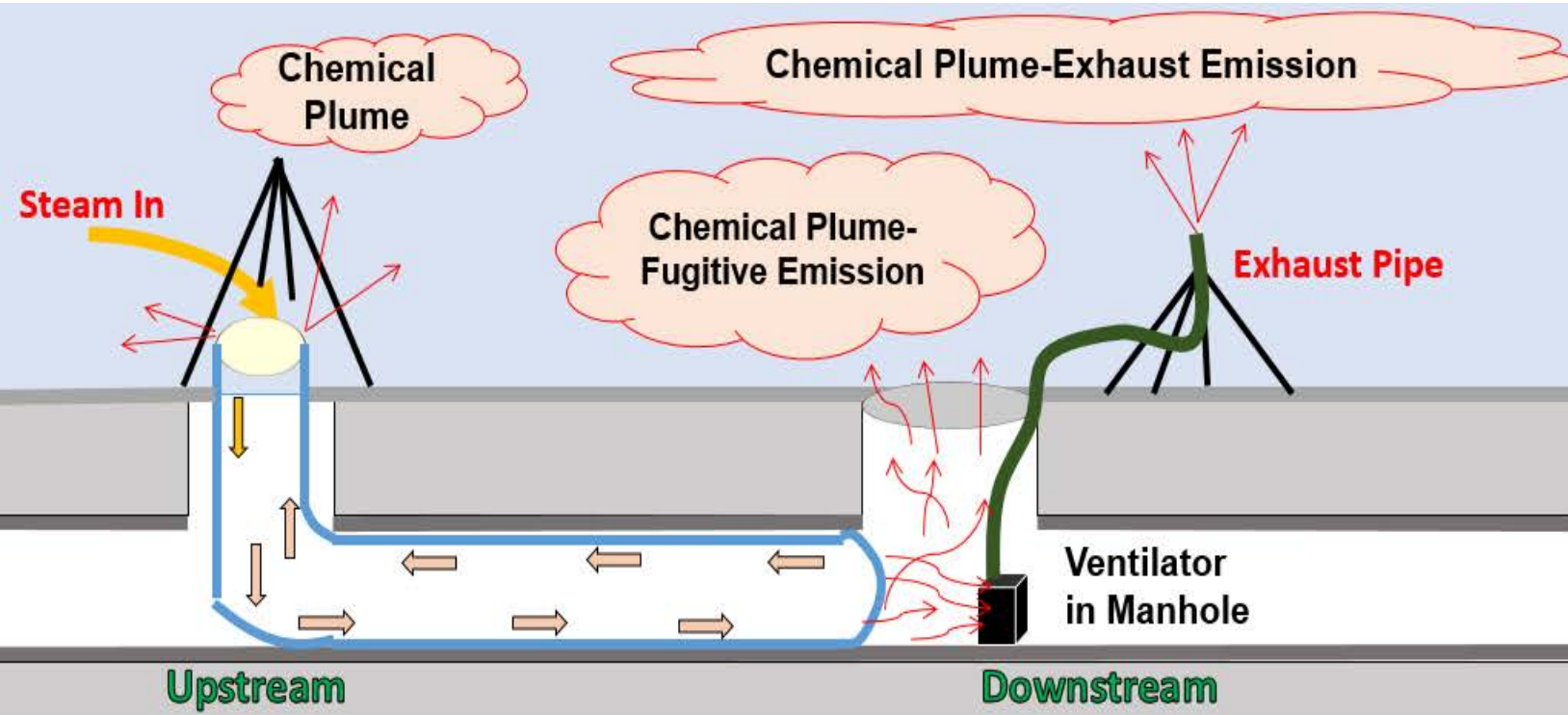
Millions of feet of culverts require repair
~ 1.3 million feet of sewer pipe repairs needed
> 7 million feet of drinking water pipe repairs needed



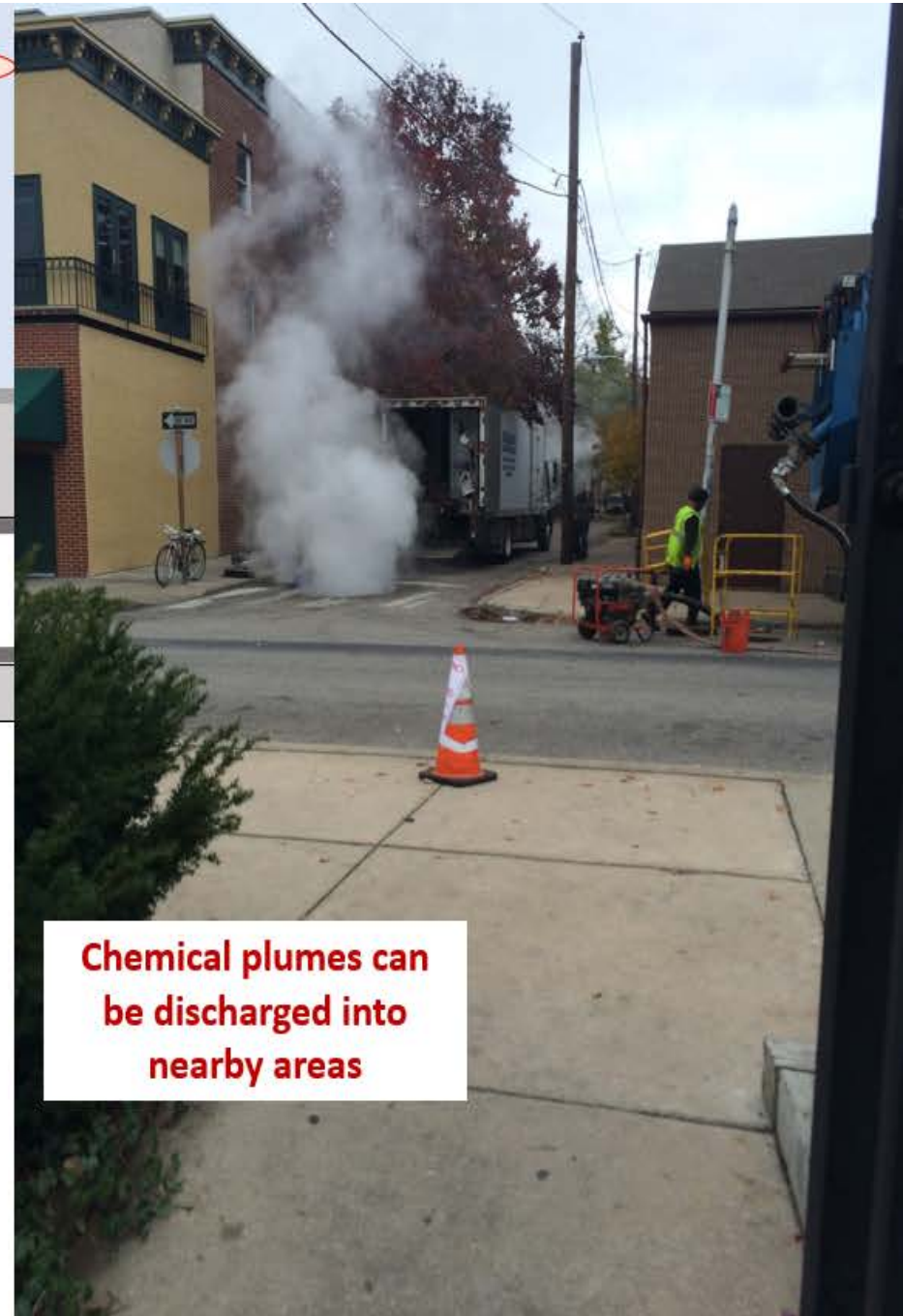
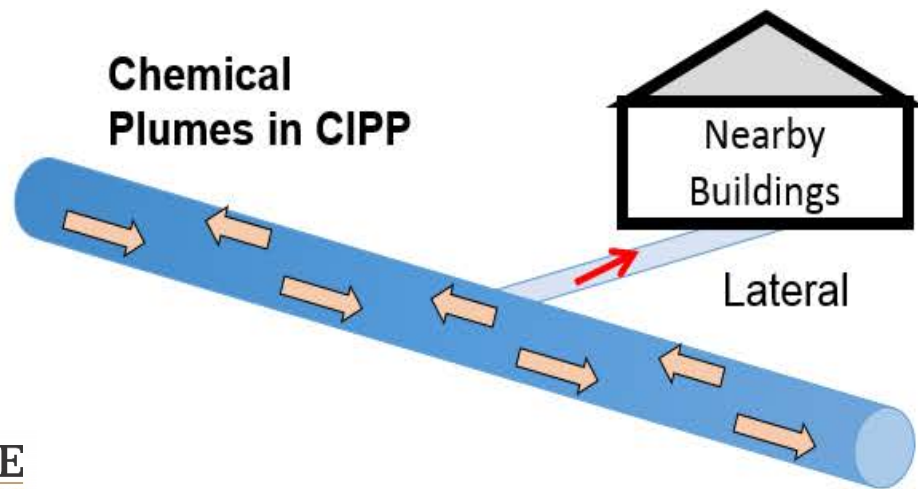
Mechanical pipe failures can be catastrophic
(traffic disruption, public safety)

OUTDOOR PLASTIC (CIPP) MANUFACTURING SITES, CHEMICALS ARE CREATED





Chemical Plumes Generated by CIPP can Escape the Pipe Being Repaired



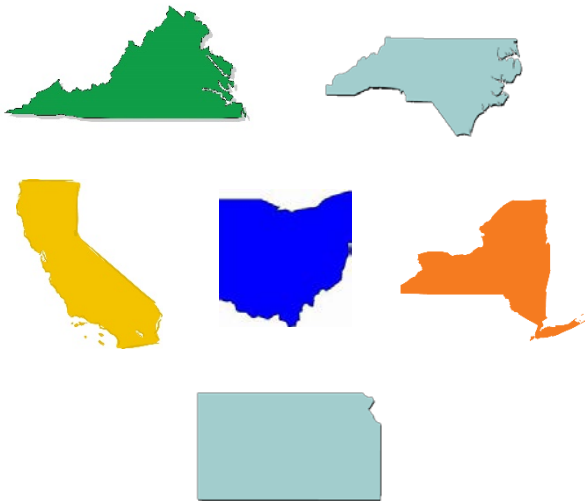
Chemical plumes can be discharged into nearby areas

Contaminant Release from Storm Water Culvert Rehabilitation Technologies: Understanding Implications to the Environment and Long-Term Material Integrity, 2016-2019

Goal: To enable DOT informed decisions with regard to culvert polymer in-situ lining method selection and specification development.

Objectives: (1) The scope of the problem across DOTs; (2) The effectiveness of existing construction specifications at minimizing contaminant release from rehabilitated culverts; and (3) The degree to which the structural integrity and longevity of rehabilitated culverts are compromised by chemical leaching.

Our Partners



1. Critical Review: Spray-on lining chemical release
2. Critical Review: CIPP lining chemical release
3. Feedback from 32 DOTs about in-situ lining practices
4. Thermal-CIPPs: Field- and Bench-scale studies
5. UV-CIPPs: Field- and Bench-scale studies
6. Recommendations for lining jobs and future work



Investigating ClPP safety was not an initial focus of our work, but became a priority when we discovered problems

Here are a Few of the Now Debunked Safety Claims

“Styrene vapor of at most few ppm” - **False**

“is not a human health risk” - **False**

“is safe for people and animals” - **False**

“it is harmless steam” - **False**

“no hazardous conditions posed” - **False**

“don’t be alarmed” - **?**

“some people are offended by this odor and are fearful of it; even though the concentrations they smell present no harm”

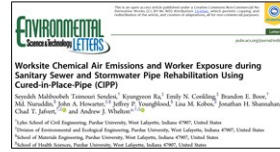
– **If you smell something it may in fact be harmful.**



Reported Chemical Exposures in 29 States & AUS, CAN, UK

More than 100 Chemical Exposure Incidents have been Reported in and Outside the US

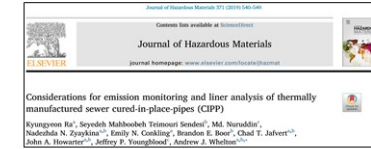
Our 2017 study



Alexandria, Virginia
Antigo, Wisconsin
Arlington, Virginia
Baltimore, Maryland
Bellevue, Washington
Bethlehem, New York
Boston, Massachusetts
Botany Village, New Jersey
Brooklyn, New York
Cambridge, Massachusetts
Cheektowaga, New York
Clear Creek, Colorado
Des Moines, Iowa
Fayetteville, New York
Good Hope, Illinois
Helena, Montana
Kensington, Maryland
Lincoln, Nebraska
Lorain County, Ohio
Madison, Wisconsin

Milwaukee, Wisconsin
Nashville, Tennessee
North Tonawanda, New York
Philadelphia, Pennsylvania
Picayune, Mississippi
Pittsburgh, Pennsylvania
Port Huron, Michigan
Prairie Village, Kansas
Rensselaer, New York
Saint Louis, Missouri
Saint Petersburg, Florida
Saugus, Massachusetts
Snellville, Georgia
Southfield, Michigan
West Lafayette, Indiana
Willamette River, Oregon
Williams Co. Village, Ohio
Worcester, Massachusetts
Unidentified, Illinois
Unidentified, Minnesota

Our 2019 study



Andersen, Indiana
Aurora, Colorado
Austin, Texas
Alexandria, Virginia
Arlington, Virginia
Arlington, Kentucky
Barnet, Vermont
Bend, Oregon
Bolivar, Missouri
Bronxville, New York
Burlington, Kentucky
Charlotte, North Carolina
Chattanooga, Tennessee
Columbia, Missouri
Darlington, Wisconsin
Dublin, California
Effingham, Illinois
Falls Church, Virginia
Hattiesburg, Mississippi
Honolulu, Hawaii

Lees Summit, Missouri
Midland, Michigan
Milwaukee, Wisconsin
North Attleboro, Massachusetts
Nyack, New York
New York City, New York
Richmond, Virginia
Salem, Virginia
Sarasota, Florida
Saint Louis Park, Minnesota
Saint Paul, Minnesota
San Diego, California
South Heights, Pennsylvania
South Pasadena, California
Tampa, Florida
Terra Haute, Indiana
Vancouver, Washington
Weymouth, Massachusetts
Whitesboro, New York

2005,
The Netherlands
public health
agency (RIVM)
finds styrene in
sewer air
unchanged 0.6
miles downstream

2012,
Consultant: CIPP
chemicals
traveled
"kilometers from
the worksite"
aboveground

2017,
Worksite safety
study shows white
chemical plume at
steam-CIPP sites is
not steam, Worker
and public safety
upgrades needed

2017,
22-yr old CIPP
worker dies on
worksite,
investigation finds
chemical exposure
a contributing
factor

2019,
NIOSH finds
styrene
exposure limit
exceeded at a
CIPP worksite.
Advice
provided.

2019,
Field study shows
100+ air
contamination
incidents, 100+
chemicals found,
Worker and
public safety
upgrades needed

2005,
US ATSDR finds
that CIPP office
building
contaminated
caused a
'public health
hazard'

2006,
The Netherlands
RIVM recommends
all sites have air
monitoring and a
fan installed to
expel chemicals for
at least 24h after
CIPP installation

2017,
California
Department of
Public Health
issues 1st
statewide CIPP
Safety Alert

2017,
California
Department of
Public Health
issues 2nd
statewide CIPP
safety warning

2018,
Environmental
impact critical
review shows a
history of CIPP
associated water
contamination,
spec upgrades
needed

2018,
Environmental
impact field
study shows
CIPP water
contamination,
spec upgrades
needed

2019,
Toxicology study
indicates
potential for
human health
effects. Should
consider not just
styrene and long-
term impacts like
cancer.

2017, Worksite Chemical Air Emissions and Worker Exposure during Sanitary Sewer and Stormwater Pipe Rehabilitation Using Cured-in-Place-Pipe (CIPP)

Field Sites:
5 thermal CIPPs
in California

- Styrene and nonstyrene resins examined
- Some of the findings
 - Material SDSs did not list all the chemicals being released
 - More than styrene was found in the resin and released into the air and water
 - Raw resin being handled without gloves
 - Workers sitting in chemical plumes without respiratory or dermal protection
 - Styrene was released into air and water by a non-styrene CIPP

Until more info available (1) minimize dermal and inhalation exposures, (2) monitor emissions, (3) use appropriate PPE, (4) capture emissions and confirm this by monitoring.



This is a Multiphase Chemical Mixture, NOT Steam
(particulates, droplets, partially cured resin, etc.)

Critical Review: Surface Water and Stormwater Quality Impacts of Cured-In-Place Pipe Repairs

Specs from 32 DOTs, past field and lab studies, industry inspector training course and literature

- Findings

- 26 states had CIPP specs, 14 water incidents confirmed, 59 air incidents
- Often due to contractor materials (i.e., release of wastewater, uncured resin, condensate, or other materials) and lack of effective oversight.
- More than styrene was released, chemicals found were much higher than what industry claimed
- CIPP wastewater negatively impacted wastewater treatment plants. Some banned wastewater or set styrene limits of <2 mg/L (US), 0.4 mg/L (Germany)
- Recommendations (paper contains all + final DOT report)

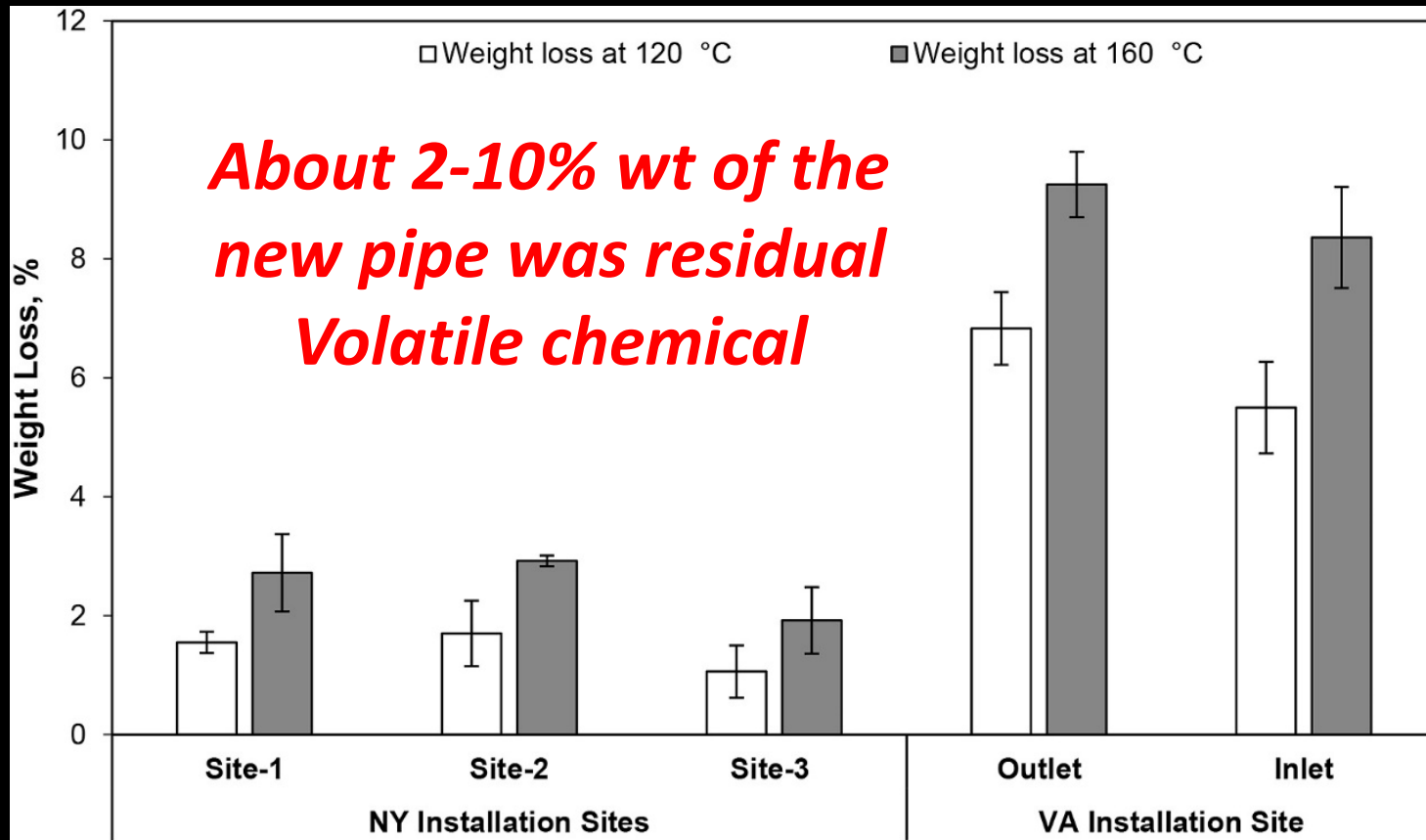
Industry standards, training, and textbooks *all need to be upgraded to limit health and environmental repercussions of using lining technologies*

- ❑ Construction Inspectors course lacks training about water quality impacts, methods to detect them or evidence-based practices to avoid them
- ❑ Industry Styrene Resin Handling Document (old versions and 2018) have numerous incorrect statements, that guidance may prompt Clean Water Act violations and greater safety risks to workers and the public
 - 11 years ago New York State DOT noted some similar questions about information contained in that document*

Outdoor manufacture of UV-Cured plastic linings for storm water culvert repair: Chemical emissions and residual

Field Sites:
4 UV CIPPs in
New York and
Virginia

- A Few of the Field Observations
 - Glide sheet can limit raw chemical contact with ground
 - Encapsulation may limit raw chemical release
 - Particulates with chemical residual released during cutting
 - Workers may contaminate water/soil with resin on gloves, boots, etc.
- A Few of the Laboratory Observations
 - All chemicals of environmental concern not disclosed on MSDS
 - Particulates loaded with leachable chemicals
 - Magnitude of residual in the new CIPPs differs a lot
 - CIPPs contain residual that can leach out post-installation



Pinch of salt = 148 mg

Pinch of CIPP dust = 100 mg caused 4-16 mg/L styrene in water in 48 hr



Li et al. 2018. Outdoor manufacture of UV-Cured plastic linings for storm water culvert repair: Chemical emissions and residual. *Env. Pollution*. <https://doi.org/10.1016/j.envpol.2018.10.080>

Considerations for emission monitoring and liner analysis of thermally manufactured sewer cured-in-place-pipes (CIPP)

Field Sites:
5 thermal CIPPs
in California

- A Few of the Field Observations
 - Multi-phase mixture: Solids, liquids, gases emitted into air
(The plume is NOT steam)
 - More than styrene released into air, styrene released from nonstyrene install
 - Particulates released during cutting
 - Real-time PID devices 10- to 1000-fold different than actual styrene level
- A Few of the Laboratory Observations
 - All chemicals of environmental concern not disclosed on the material SDS
 - Contractors cross-contaminated non-styrene CIPP with styrene
 - Magnitude of residual differs across CIPPs
- CIPPs contain residual that can leach out post-installation

In vitro toxicity assessment of emitted materials collected during the manufacture of water pipe plastic linings

Lisa Kobos, Seyedeh Mahboobeh Teimouri Sendesi, Andrew J. Whelton, Brandon E. Boor, John A. Howarter, and Jonathan Shannahan

<https://www.tandfonline.com/doi/full/10.1080/08958378.2019.1621966>



Human Toxicology Study Conclusions

- CIPP emissions likely should not be regulated based on styrene alone and exposure assessments of worksites would benefit from more comprehensive evaluation of emission components
 - Benzaldehyde, Benzoic Acid, Phenol, 1-Tetracecanol were all highest in Site 4 emissions
- Efforts should be made to adequately inform workers and the public regarding emissions as there is a potential for toxicity following inhalation exposure
- Exposures should be minimized and the proper personal protective equipment utilized
- Alterations in operational procedures should further be investigated to mitigate emissions and to understand potential adverse health effects
- Based on our findings future studies should examine cytotoxicity and cell injury, immune responses, fibrosis, and cancer as these were pathways determined to be modified significantly in representative pulmonary cells following exposure

Solvable problems exist for this innovative technology.

Emissions and exposures can present acute and chronic human health risks and environmental hazards.



August 2019 in Carlisle, PA

1 of the top 10 trout streams in the US

Fish kill (200+) associated with CIPP contractors

Styrene found, temperature not high

NOV issued to city; Criminal/law enforcement, and environmental enforcement investigations remain open


For Everyone: Learn More at www.CIPPSafety.org

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What Do We Know? What Can be Done?

- All CIPP practices emit chemicals into the air (steam, hot water, and UV)
- Chemical release occurs during setup, manufacture, and from new CIPPs after contractors leave site
- More chemicals than styrene are emitted into air and water
- A non-styrene CIPP emitted styrene into the air and water
- Steam-CIPP emitted solids, liquids, and gases into the air
- Chemical plumes are sometimes NOT visible, can travel 0.5+ miles
- Environmental, contractor conditions influence the size of the “hot zone”

Setback distances, site physical access controls needed

Dermal and inhalation protections needed

New CIPPs will emit chemicals into the air; Do not enter without testing

Emissions should be captured and disposed. Monitoring should confirm capture, not document how bad the exposure was that could have been prevented.

Ground protection, water testing, limiting emissions and particulates during cutting

And more...

You should reach out to NIOSH for advice and –*FREE*– (\$0.00) onsite testing.

Health Hazard Evaluations help workers learn what health hazards are present at their workplace and recommends ways to reduce hazards and prevent work-related illness.

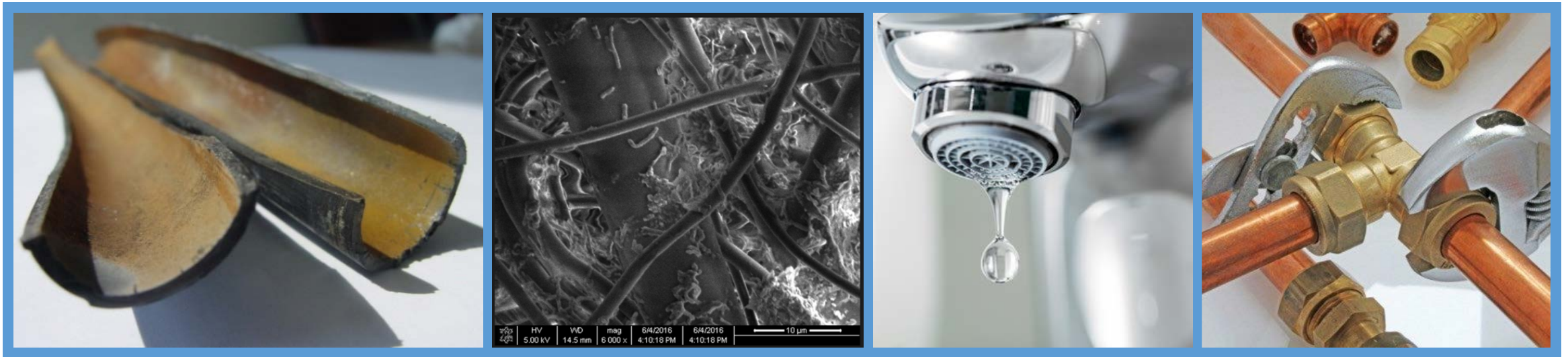
Dr. Ryan LeBouf, CIH (igu6@cdc.gov)

Dr. Rachel Bailey (feu2@cdc.gov)

Purdue Recommendations for CIPP Construction Specs coming soon.



Ongoing Plumbing Safety Study: Right Sizing Tomorrow's Water Systems for Efficiency, Sustainability, & Public Health



Andrew Whelton, Jade Mitchell, Joan Rose, Juneseok Lee, Pouyan Nejadhashemi, Erin Dreelin,
Tiong Gim Aw, Amisha Shah, Matt Syal, Maryam Salehi

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SJSU SAN JOSÉ STATE
UNIVERSITY


MANHATTAN
COLLEGE


Tulane
University

THE UNIVERSITY OF
MEMPHIS

Activities	Year 1 (2017)				Year 2 (2018)				Year 3 (2019)				Year 4 (2020)				Year 5 (2021)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Obj 1. Water Conservation Trends																				
Review & Info. Syn.																				
Workshop																				
Obj 2. Effect of Flow on Water Quality																				
Residential – 1 year chem/micro																				
Residential –Pathogen exposure																				
Residential – Water Age/HRT																				
Residential – Hydraulics																				
Residential – Fixture prediction																				
Residential – Rainwater switch																				
Residential – Integrative Hydro-WQ model																				
LEED School Bldg – chem/micro																				
LEED School Bldg – Pathogens																				
LEED School Bldg – Pathogen exposure																				
LEED Univ Bldgs – chem/micro																				
LEED Office Bldg - TBD																				
Experiment – GIP/PEX plumbing																				
Experiment – Metal depo																				
Experiment – Building TTHMs																				
Experiment – Biofilm 1																				
Experiment – Biofilm 2																				
Experiment – TBD																				
Int. Hydro-Fate WDS/Prem Mdl																				
Risk Models with bldg. model																				
Obj 3. DST Development																				
Development																				
Workshop																				
Upgrade																				



Not all efforts shown; 20+ studies ongoing

Single Family Home: Water at Service Line \neq Water at the Tap

	Service Line	Cold Water Lines	Hot Water Lines	MCL ¹ SDWR ²
Water pH	7.65 –(7.73)– 7.81	7.43 –(8.17)– 9.24	7.35 –(8.18)– 9.01	6.5-8.5 ²
Total Chlorine (mg/L)	BDL –(0.7)– 1.6	BDL –(0.1)– 0.8	BDL –(0.3)– 1.7	State Dependent
Temperature (C)	11.5 –(18.0)– 23.8	19.1 –(22.1)– 27.4	17.2 –(22.3)– 27.9	N/A
TTHM (µg/L)	0.00 –(1.64)– 9.62	1.91 –(16.79)– 41.88	3.42 –(19.91)– 39.20	80 ¹
TOC (mg/L)	0.32 –(0.41)– 1.05	0.40 –(3.92)– 46.7	0.49 –(0.94)– 4.71	N/A
Calcium (mg/L)	36.79 –(84.62)– 100.47	0.13 –(1.68)– 77.29	0.50 –(1.53)– 14.19	N/A
Iron (µg/L)	ND –(11.5)– 40.3	ND –(12.2)– 132	2.0 –(7.1)– 16.3	300 ²

Service line chlorine levels varied significantly during the day and throughout the week.

Questions?

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awhelton@purdue.edu

Learn More at www.CIPPSafety.org

Learn More at www.PlumbingSafety.org

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Federal Highway Administration TP (3)339 Pooled Fund Study (VA, CA, KS, OH, NC, NY)

Public donations through crowd funding

Purdue University Lyles School of Civil Engineering

NIOSH-University of Illinois at Chicago Center

Many people at Purdue University contributed to these results and recommendations