Understanding and Reducing Impacts of Storm water Culvert Rehabilitation Technologies

June 21, 2018, LaPorte, IN

Kyungyeon Ra, Mahboobeh Teimouri,
Dr. John Howarter, Dr. Chad Jafvert, Dr.
Andrew Whelton, Purdue University

Bridget Donaldson,
Virginia Transportation Research Council

One part of a larger project

Paper DOI:
10.1002/awwa.1042

PURDUE
UNIVERSITY

Repair Needs for Storm Sewer Pipes & Culverts

> 12 million linear feet in place

> 1 million existing culverts require rehabilitation

Trenchless Technology can be Used to Repair Buried Assets

Slip lining

Spiral wound pipe

Close fit pipe

Thermoformed pipe

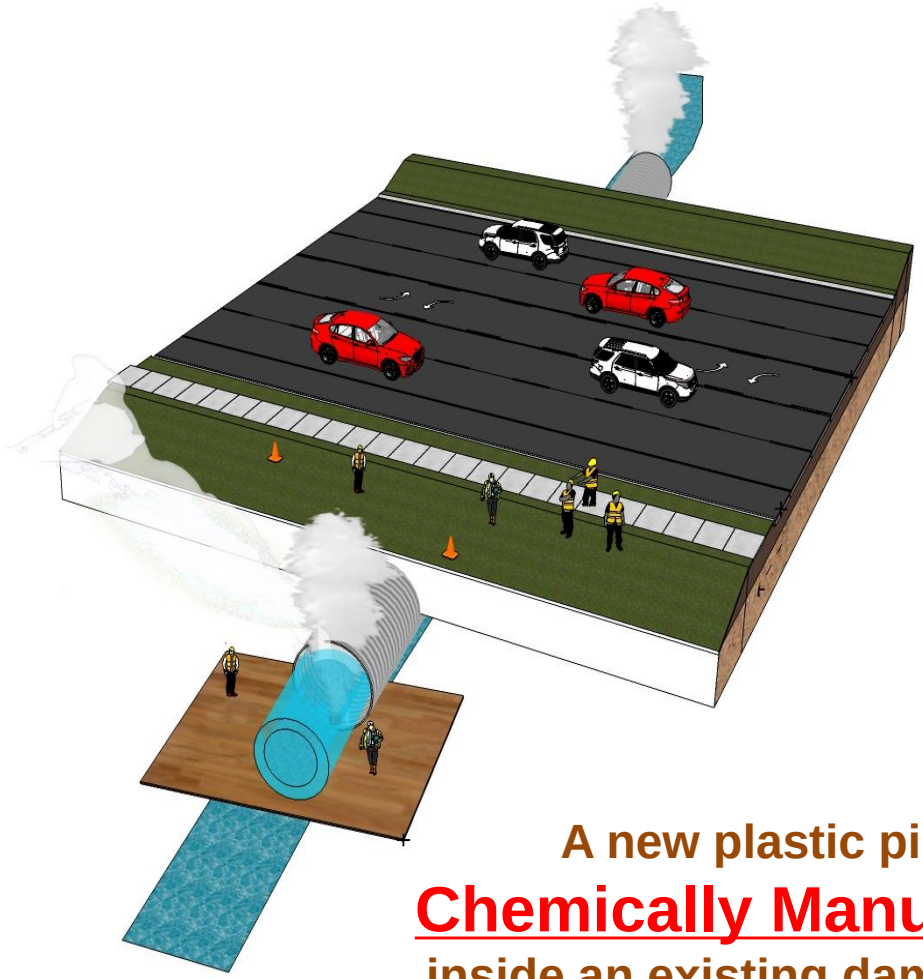
Fold-and-form pipe

Cured-in-place-pipe (CIPP)

Spray-on lining

Chemically manufacture new liners in the field

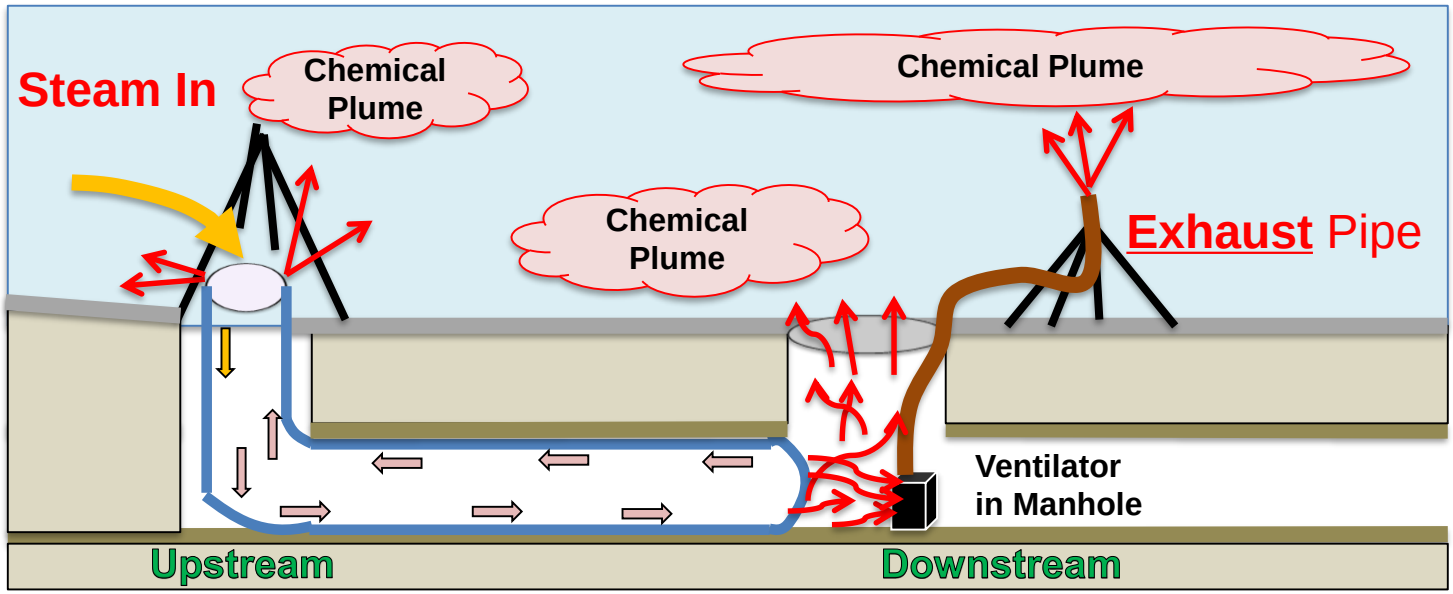
CIPP is Used by DOTs for Storm Sewer Repairs



A new plastic pipe is

Chemically Manufactured

inside an existing damaged pipe



Example of steam CIPP for storm sewer

1. Curing facilitated by hot water, steam or UV light
2. Various resins (Styrene vs. Nonstyrene based)
3. Different contractors that manufacture similar “types” of CIPP can have different setups and processes
4. Styrene is only one of many chemicals used
5. *New chemicals can be created* during CIPP manufacture

2016 RAPID Response Study funded by the National Science Foundation (www.NSF.gov)

ACS AuthorChoice

Environmental Science & Technology Letters

Letter

pubs.acs.org/journal/estlcu

Worksite Chemical Air Emissions and Sanitary Sewer and Stormwater Pipe Cured-in-Place-Pipe (CIPP)

Seyedeh Mahboobeh Teimouri Sendesi,[†] Kyungyeon Ra,[‡] Md. Nuruddin,[§] John A. Howarter,[‡,§] Jeffrey P. Youngblood, Chad T. Jafvert,[†,‡] and Andrew J. Whelton*,[†,‡]

[†]Lyles School of Civil Engineering, Purdue University, West Lafayette, In
[‡]Division of Environmental and Ecological Engineering, Purdue Universi
[§]School of Materials Engineering, Purdue University, West Lafayette, Ind
[∥]School of Health Sciences, Purdue University, West Lafayette, Indiana 4

PURDUE UNIVERSITY | CIPP Safety Solutions Group

Home | Resources | News | Team

Incorrect assertions about the 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 manufacturers 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.

Questions? Contact us at CIPPSafety@purdue.edu

Visit http://CIPPSafety.org or https://engineering.purdue.edu/CIPPSafety

- ✓ FAQs
- ✓ Links to studies
- ✓ Links to resources

Pooled Fund Project - *Contaminant Release from Storm Water Culvert Rehabilitation Technologies: Understanding Implications to the Environment and Long-Term Material Integrity*

Task 1

To better understand existing CIPP construction practices and past chemical contamination incidents focused on storm sewer

Objectives

(1) Compile and review CIPP-related surface water contamination incidents: *incident = outside a research study*

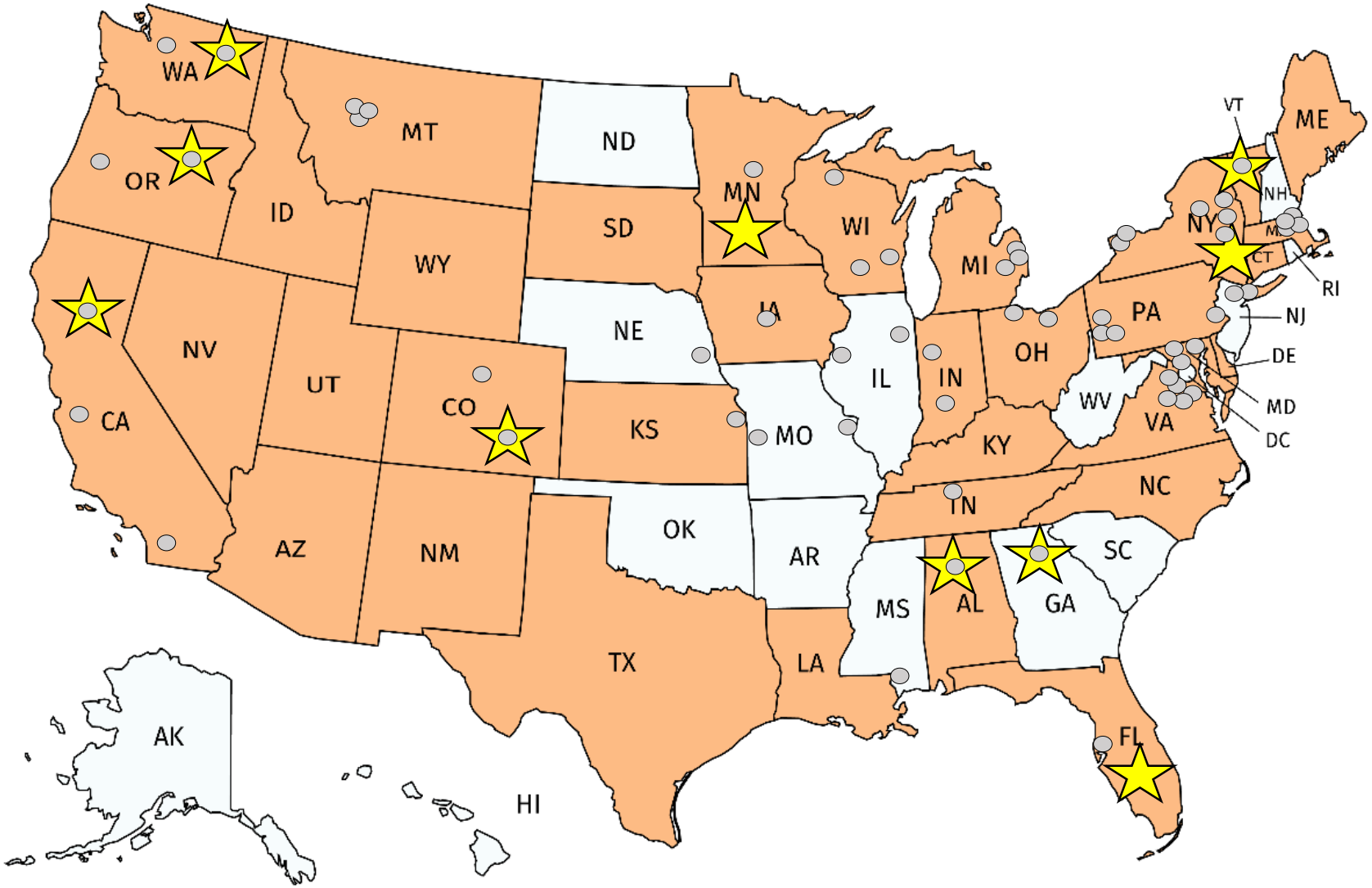
(2) Analyze CIPP water quality impacts

(3) Evaluate construction practices for 35 state DOT agencies

10 water contamination incidents were found in the US

+2 in Canada

+1 undisclosed location



Of the 13 water contamination incidents...

- **Alabama (2010):** National Response Center
  - 70,000 gallons of CIPP wastewater released to a dry creek bed
  - Styrene concentration in the creek water (143 mg/L), contaminated nearby drinking water well (4 mg/L)
- **Colorado (2011):** DOT, Department of Public Health and Environment
  - Chemicals entered surface water and downstream drinking water
  - Maximum styrene level detected in water (18 mg/L) and 14 mg/kg in soil
  - Variety of other chemicals present associated with CIPP
- **Vermont (2013):** DOT, Vermont Department of Environmental Conservation
  - Maximum styrene level in the Creek the day of installation was reported as 5,160 mg/L (Information reported by VTDEC)
  - Styrene level decreased over the two month monitoring period, but other compounds were detected: acetone, 1,2,4-TMB, 1,3,4-TMB, *tert*-butanol

Styrene: 0.1 mg/L (EPA); 2.5 mg/L (VDOT), 1.0 mg/L (VTDOT), 0.005 mg/L (NYSDOT)
Other chemicals found in contaminated water, not just styrene

In summary….few CIPPs have been examined

- 7 total studies: VDOT, CALTRANS, NYSDOT
- Total CIPPs monitored: 18 steam, 4 hot water, 3 UV
- Styrene, a common ingredient for some CIPPs, found often
  - Reported in waterway: Up to 77 mg/L
  - Detectable in water: 88 days
  - In curing water: Up to 250 mg/L
  - Found leaching from a non-styrene based CIPP
- Other compounds detected at UV- and steam-CIPP sites
  - Vinylic monomer exceeded toxicity threshold for up to 120 days; Other chemicals found: acetone, benzene, chloroform, isopropyl benzene, *tert*-butyl alcohol, methylene chloride, methyl ethyl ketone, *n*-propyl benzene, toluene, xylenes, 1,2,4-TMB, 1,3,5-TMB
  - Steam-CIPP condensate contains high chemical concentrations

For the 32 states who responded, CIPP construction specifications and requirements differed quite a bit

Requirement	States
No documents provided or no CIPP use	9
Before Construction	
Show POTW permit to the Engineer	4
Install impermeable liner up and downstream	4
Conduct water testing at the site	4
Before Reinstating Flow	
Rinse new liner with clean water, capture, and dispose	5
Prohibit return to service before a minimum unspecified time period	4
Prohibit culvert return to service before a minimum time period (2, 4, or 7 days)	3
General Requirements	
Capture and dispose of compounds, water, and condensate	10
Conduct water testing at the site	4
Contractor is responsible for reporting any water quality alterations	3

California had the most explicit requirements and included a plastic coating 20 ft long and 10 mils (250 μm) thick to contain resin before liner installation.

Specified CIPP waste handling requirements

Number of States	Direct quotes
8	Not specified requirements
6	"…remove and properly dispose of waste"
3	"…debris of culvert should be disposed of in accordance with state and local environmental regulations."
1	"…follow the rules and regulations for discharge of waste."
1	"…a compound, process water, or condensate used during the installation or curing operation shall be contained, removed from the site and disposed of in a manner approved by the Engineer."

Compound Name	Compound Class	EPA water testing method required or used by certain state DOTs		
		524.2 (CO)	8260 (CO, VA, VT)	8021B (NV)
Acetone[θ‡§Δ¶ρ]		x	x	.
Benzene[θΔ¶]	CAR, EDC, HAP	x	x	x
2-Butanone (Methyl ethyl ketone)[¶]	CAR, HAP	x	x	.
tert-Butyl alcohol[§]		.	x	.
tert-Butyl benzene[ρ]		x	x	x
Chloroform[¶θρ]	CAR, HAP	x	x	x
o-Chlorotoluene[θ]		x	x	x
Diallyl phthalate (DAP)[Φ]	EDC	.	.	.
Ethylbenzene[θ‡]	EDC, HAP	x	x	x
Isopropylbenzene[‡θ§Δ¶Ψ]		x	x	x
p-Isopropyltoluene[θ]		x	x	x
Methylene chloride[¶Ψ]	CAR	x	x	x
N-Propylbenzene[‡§Δ¶Ψ]	EDC	x	x	x
Styrene[¥†‡§θ¶Δρ*]	CAR, EDC, HAP	x	x	x
Toluene[θΔ]	HAP	x	x	x
1,2,4-Trimethylbenzene[θ‡§Δ¶Ψρ]	CAR	x	x	x
1,3,5-Trimethylbenzene[θ‡§Δ¶Ψρ]	CAR	x	x	x
Xylene (total)[Δ]	EDC, HAP	x	x	x

4 states required water testing for CIPP installations (CO, NV, VA, VT)

But methods used differed.

Some methods not capable of detecting CIPP related compounds.

Specification Recommendations

1. **Wear** appropriate personal protective equipment (PPE)
2. **Submit** a POTW permit to the Agency Engineer to verify pre-approval for POTW disposal of rinse water, wastewater, and/or condensate
3. **Conduct** real-time and grab sample air monitoring
4. **Divert** water flow until “acceptable degree of cure” established and new liner passes water quality tests
5. **Utilize** impermeable plastic sheets (i.e., 10 mil thick) immediately upstream and downstream of the pipe
6. **Utilize** curtains to prevent overspray for spray-on liner
7. **Prohibit** chemicals from exiting the pipe during the CIPP manufacturing process (collect gases, liquids, or solids)
8. **Rinse** the new liner after manufacture and collect liquids and solids
9. **Prohibit** wastewater, rinse water, or condensate to be discharged to waterway unless written approval by state environmental agency
10. **Conduct** water testing before and after installation - compare to standards/specs (use tests capable of detecting all chemicals of concern) - Any exceedance triggers additional testing
11. **Capture** particles and shavings created during cutting the end of liner
12. **Report** accidental discharge, small or large, to state transportation agency and environmental regulatory officials immediately, so downstream water supplies, the environment, and population can be protected.

Review of water quality impacts of spray-on liners

Task 2

Better understand existing spray-on liner construction practices and past chemical contamination incidents

(Cement Mortar, Polyurethane, Polyurea, Epoxy)

Objectives

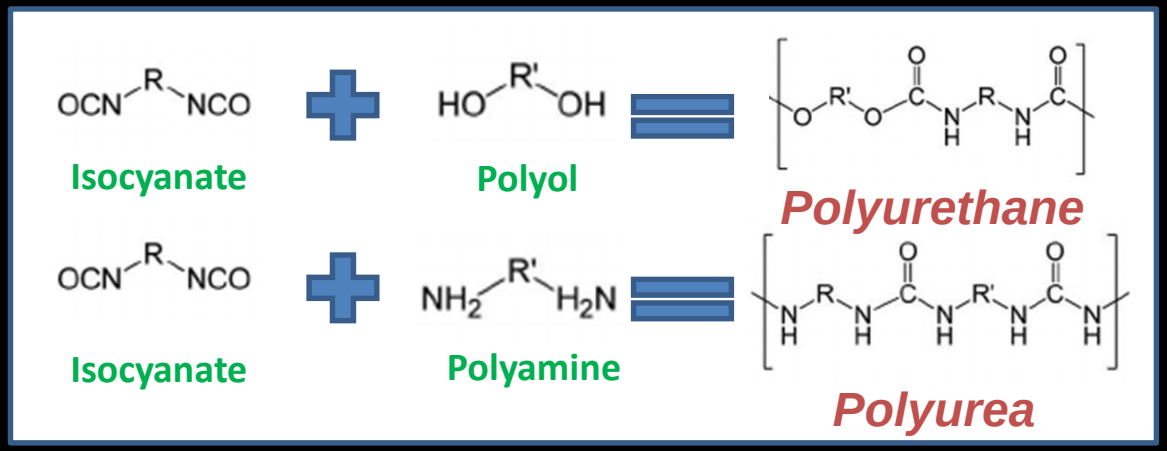
(1) Compile and review spray-on lining related surface water contamination incidents from publicly reported data

(2) Review lab- and field-scale studies

(3) Evaluate current construction practices for spray-on liners as reported by 35 DOT agencies

Results available on the posted presentation

Spray on lining technologies ALSO chemically manufacture the product at the asset repair site



0 water contamination incidents found…*but*

- Spray-on lining technology seems to be used less frequently than CIPP and there are differences in chemicals and installation practices
- Practically no information found for chemicals used, created, emitted, their fate and their toxicity at storm sewer repair sites
- Only 2 field studies found for a cementitious and polyurea liner: No impacts found in field for parameters monitored, in lab changes were found

Cementitious Liner

↑ Water pH
↑ Alkalinity

Polyurea Liner

↓ Water pH
↑ Chemical oxygen demand (COD)
↑ Total organic carbon (TOC)
↑ Total nitrogen (TN)

Only 3 of 32 DOTs provided documents. Most stated they had no formal or statewide specification.

- Spray-on linings:
  - Cement mortar (2 states)
  - Polyurethane (1 state)
  - Epoxy (1 state)
  - Polyurea (1 state)
- 1 of the 3 states detailed some monitoring requirements, these included
  - During install, curtains to prevent overspray
  - After install, water rinsing until water pH less than 9 especially for cementitious lining
  - Before and after install, water sampling for diphenyl diisocyanate (MDI), methylenedianiline (MDA), total cyanide, COD, and TN for polyurea

Contact Us for the Spray-On Lining Specification Recommendations

Very few sanctioned lab- and field-scale water quality impact studies have been conducted

Virginia Transportation Research Council

research report

Understanding the Environmental Implications of Cured-in-Place Pipe Rehabilitation Technology

http://www.virginiadot.org/vtrc/main/online_reports/pdf/08-r16.pdf

Donaldson & Baker (2008)

Summary of Water Sampling CIPP for 4 Culverts

O'Reilly NYSDOT (2009)

Background and Introduction

Preliminary Investigation

Caltrans Division of Research and Innovation

Produced by CTC & Associates LLC

Environmental Effects of Cured-in-Place Pipe Repairs

Requested by
Sean Penders, Design
David Melendrez, North Region Environmental Engineering

August 6, 2012

Water Quality Implications of Culvert Repair Options: Vinyl Ester Based and Ultraviolet Cured-in-Place Pipe Liners

http://www.virginiadot.org/vtrc/main/online_reports/pdf/13-r2.pdf

Donaldson (2013)

Stormwater Chemical Contamination Caused by Cured-in-Place Pipe (CIPP) Infrastructure Rehabilitation Activities

Matthew L. Tabor†, Derrick Newman†, and Andrew J. Whelton*‡
† Department of Civil Engineering, University of South Alabama, Mobile, Alabama 36688, United States
‡ Department of Civil Engineering, Purdue University, West Lafayette, Indiana 47907, United States

Environ. Sci. Technol., **2014**, *48* (18), pp 10938–10947
DOI: 10.1021/es5018637
Publication Date (Web): August 15, 2014

Standardized Test Method to Quantify Environmental Impacts of Stormwater Pipe Rehabilitation Materials

Whelton et al. (2015)

http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r11.pdf

---

FINAL REPORT

February 2017

Prepared for
California Department of Transportation

by CSUS

WATER QUALITY OF FLOW THROUGH CURED-IN-PLACE PIPE (CIPP)

Final Thoughts

- **CIPP** and **spray-on** linings are products chemically manufactured *in the field.*
  - MSDS does not tell what chemicals can be released and exceed state water quality standards.
  - They are not installed like other materials. Raw chemicals and other hazards are used *in the field.*
  - They can present different and sometimes additional risks of chemical release compared to other rehabilitation technologies.

- Some CIPP related incidents have **contaminated drinking water supplies**, prompted **emergency responses**, **contaminated drinking water**, caused **fish kills**.

- Incidents found may be outlier events or they may represent the risks inherent of typical installations.

FREE DOWNLOAD at

https://awwa.onlinelibrary.wiley.com/doi/epdf/10.1002/awwa.1042

Peer Reviewed

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

KYUNGYEON RA,[1] SEYEDEH MAHBOOBEH TEIMOURI SENDESI,[2] JOHN A. HOWARTER,[3] CHAD T. JAFVERT,[1,2] BRIDGET M. DONALDSON,[4] AND ANDREW J. WHELTON[1,2]

[1]Division of Environmental and Ecological Engineering, Purdue University, West Lafayette, Ind.
[2]Lyles School of Civil Engineering, Purdue University, West Lafayette, Ind.
[3]School of Materials Engineering and Division of Environmental and Ecological Engineering, Purdue University, West Lafayette, Ind.
[4]Research Division, Virginia Transportation Research Council, Charlottesville, Va.

Cured-in-place pipe (CIPP) technology has been used to rehabilitate sanitary sewer, storm sewer, and drinking water pipes. However, utilities, regulators, and health officials have raised environmental, occupational, and public health concerns regarding chemical emissions into air and water. To better understand emissions into water, available literature was reviewed. Water contamination has been documented in 10 states and Canada because of the release of uncured resin, solvents, manufacturing byproducts, and wastes during and after construction. Odor, fish kill, and drinking water contamination incidents have been reported. The few field- and bench-scale studies available show that a variety of volatile organic compounds and semivolatile organic compounds have been released into water and contamination was detected for several months. CIPP waste was acutely toxic to aquatic organisms. Chemical release is likely influenced by formulation, installation, and environmental conditions. CIPP installation and inspection recommendations were suggested. Studies are needed to develop evidence-based construction and monitoring practices to minimize risks.

Keywords: *cured-in-place pipe, leaching, plastic pipe, rehabilitation*

Thank You

Additional specification recommendations and guidance from this Pooled Fund Project will be released. Ongoing work pertains to CIPP longevity and chemical release.

Pooled Fund Partners:
VA (lead), CA, KS, NC, NY, OH

Project Leader
Bridget Donaldson, VTRC
Bridget.Donaldson@VDOT.Virginia.gov

Kyungyeon Ra
Purdue University
kra@purdue.edu

Andrew Whelton, Ph.D.
Purdue University
awhelton@purdue.edu

Want more information? Please visit
http://www.CIPPSafety.org