CIPP and Spray-On Liner Culvert Rehabilitation: A Review of Water Quality Impacts and Current Construction Specifications

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

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8:00 AM – 9:45 AM
Convention Center, 204A

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

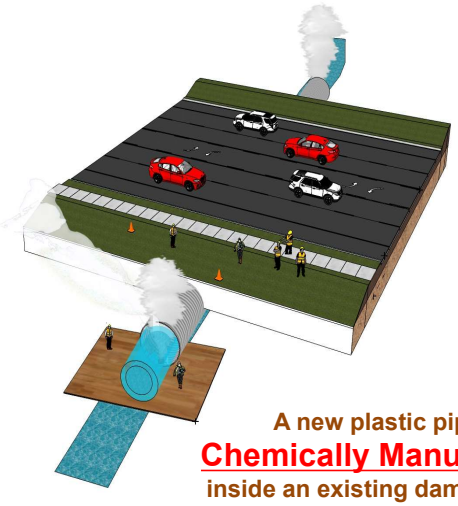
Fold-and-form pipe

Cured-in-place-pipe (CIPP)

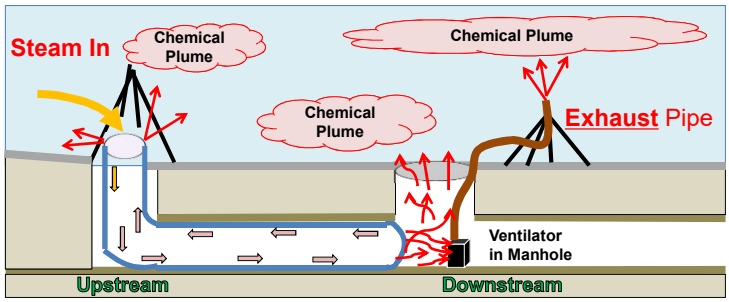
Spray-on lining

Chemically manufacture new liners in the field

CIPP is Used by DOTs for Storm Sewer Repairs



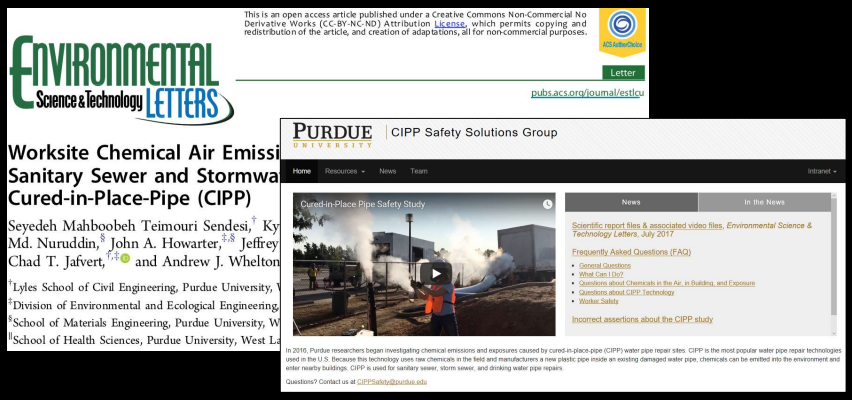
A new plastic pipe is
Chemically Manufactured
inside an existing damaged pipe



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)



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

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

You can access FREE CIPP worker and public safety resources

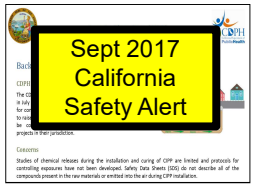
CIPP SAFETY STUDY WEBINAR (Oct 2017)
neha.http://neha.org/node/59333

To help local, state, and county health professionals better understand public health and occupational exposures with CIPP. Results of a July 2017 Purdue University CIPP safety study were presented as well as lessons learned from a NIOSH workplace Health Hazard Evaluation, and options for health officials, agencies, companies, and workers to gain technical assistance.

NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION

Promoting productive workplaces through safety and health research / NIOSH

PURDUE UNIVERSITY



Funded by the US National Science Foundation (www.nsf.gov)

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*

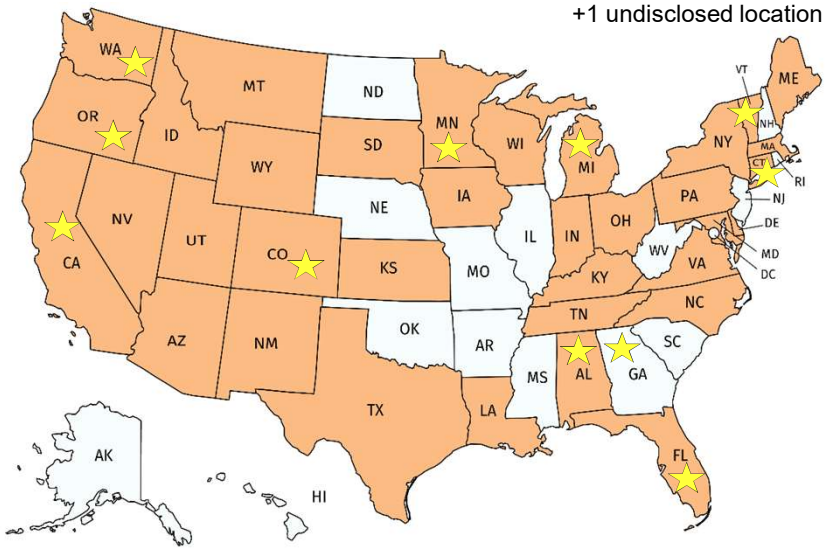
(2) Analyze CIPP water quality impacts

(3) Evaluate construction practices for 35 state DOT agencies

11 water contamination incidents were found in the US

+2 in Canada

+1 undisclosed location



Of the 14 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
  - 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	8
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

Compound detected at a CIPP site or found leaching from CIPP	EPA water testing method required or used by certain state DOTs		
	524.2 (CO)	8260B (CO, VT, VA)	8021B (NV)
Acetone	X	X	–
Acetophenone	–	–	–
Acrylate monomer (undisclosed)†	–	–	–
Benzaldehyde	–	–	–
Benzene	X	X	X
Benzoic acid	–	–	–
Benzyl alcohol	–	–	–
Bisphenol A (BPA)	–	–	–
2-Butanone (Methyl ethyl ketone)	X	X	–
Butyl benzyl phthalate (BBP)	–	–	–
tert-Butyl benzene	X	–	–
tert-Butyl alcohol	–	X	–
Butylated hydroxytoluene (BHT)	–	–	–
Chloroform	X	X	X
Dibutyl phthalate	–	–	–
Diethyl phthalate (DEP)	–	–	–
Di(2-ethylhexyl) phthalate (DEHP)	–	–	–
Dibutyl phthalate			
4-(1,1-dimethyl)cyclohexanol	–	–	–
4-(1,1-dimethyl)cyclohexanone	–	–	–
Ethylbenzene	X	X	X
3-Heptanol	–	–	–
Isopropylbenzene	X	X	–
Methylene chloride	X	X	X
Phenol	–	–	–
N-Propylbenzene	X	–	–
Styrene	X	X	X
1-Tetradecanol	–	–	–
4-tert-Butylcyclohexanol	–	–	–
4-tert-Butylcyclohexanone	–	–	–
Toluene	X	X	X
1,2,4-Trimethylbenzene	X	–	–
1,3,5-Trimethylbenzene	X	–	–
Tripropylene glycol diacrylate (TPGDA)	–	–	–
Vinylic monomer (undisclosed)	–	–	–
Xylene (total)	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.

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

Final Thoughts

- **CIPP** and **spray-on** linings are products chemically manufactured *in the field.*
  - 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.

Specification Recommendations for CIPP

1. **Wear** appropriate PPE (i.e., inhalation, dermal, eye protection)
2. **Submit** a POTW permit to the DOT 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 CIPP passes water quality tests
5. **Utilize** impermeable plastic sheets (i.e., 10 mil thick) immediately upstream and downstream of the pipe
6. **Prohibit** chemicals from exiting the pipe during the CIPP manufacturing process (collect gases, liquids, or solids)
7. **Rinse** the new CIPP after manufacture (collect liquids and solids)
8. **Prohibit** wastewater, rinse water, or condensate to be discharged to waterway unless written approval by state environmental agency
9. **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
10. **Capture** particles and shavings created during cutting the end of CIPP
11. **Report** accidental discharge, small or large, to state DOT and Environmental Regulatory officials immediately, so downstream water supplies, the environment, and population can be protected.

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.TheWheltonGroup.org

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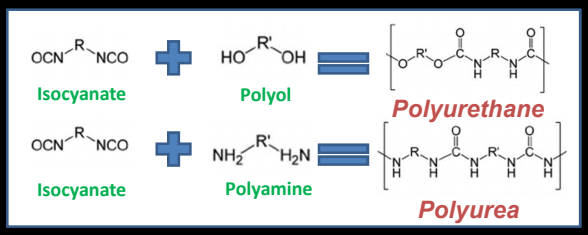
ADDITIONAL SLIDES

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	Polyurea Liner
↑ Water pH	↓ Water pH
↑ Alkalinity	↑ 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

Spray-On Liner Specification Recommendations

1. **Wear** appropriate PPE (i.e., inhalation, dermal, eye protection)
2. **Submit** a POTW permit to the DOT Engineer to verify pre-approval for POTW disposal of rinse water
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** curtains to prevent overspray
6. **Prohibit** chemicals from exiting the pipe during the CIPP manufacturing process
7. **Rinse** the new CIPP after manufacture (collect liquids and solids)
8. **Prohibit** rinse water discharge to waterway unless written approval by state environmental agency
9. **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
10. **Report** accidental discharge, small or large, to state DOT and Environmental Regulatory officials immediately, so downstream water supplies, the environment, and population can be protected.

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


Virginia Transportation Research Council

research report

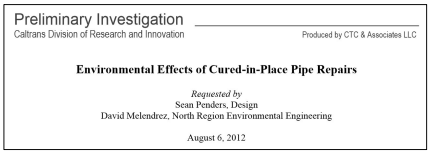
Understanding the Environmental Implications of Cured-in-Place Pipe Rehabilitation Technology

Donaldson & Baker (2008) http://www.virginiadot.org/vtrc/main/online_reports/pdf/08-r16.pdf


O'Reilly NYSDOT (2009)

Summary of Water Sampling CIPP for 4 Culverts

Background and Introduction


Preliminary Investigation

Caltrans Division of Research and Innovation

Produced by CTC & Associates LLC

Environmental Effects of Cured-in-Place Pipe Repairs

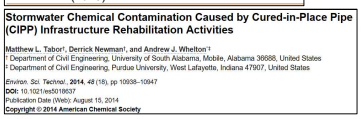
Requested by
Sean Penders, Design
David Melendrez, North Region Environmental Engineering

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
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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)