Limiting CIPP and Spray-On Liner Culvert Rehabilitation Water Quality Impacts and Construction Specifications

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One part of a larger project
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
Worksite Chemical Air Emissions from Sanitary Sewer and Stormwater Cured-in-Place-Pipe (CIPP)

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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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>No documents provided or no CIPP use</td>
<td>9</td>
</tr>
<tr>
<td><strong>Before Construction</strong></td>
<td></td>
</tr>
<tr>
<td>Show POTW permit to the Engineer</td>
<td>4</td>
</tr>
<tr>
<td>Install impermeable liner up and downstream</td>
<td>4</td>
</tr>
<tr>
<td>Conduct water testing at the site</td>
<td>4</td>
</tr>
<tr>
<td><strong>Before Reinstating Flow</strong></td>
<td></td>
</tr>
<tr>
<td>Rinse new liner with clean water, capture, and dispose</td>
<td>5</td>
</tr>
<tr>
<td>Prohibit return to service before a minimum unspecified time period</td>
<td>4</td>
</tr>
<tr>
<td>Prohibit culvert return to service before a minimum time period (2, 4, or 7 days)</td>
<td>3</td>
</tr>
<tr>
<td><strong>General Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>Capture and dispose of compounds, water, and condensate</td>
<td>10</td>
</tr>
<tr>
<td>Conduct water testing at the site</td>
<td>4</td>
</tr>
<tr>
<td>Contractor is responsible for reporting any water quality alterations</td>
<td>3</td>
</tr>
<tr>
<td>Compound Name</td>
<td>Compound Class</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>CAR, EDC, HAP</td>
</tr>
<tr>
<td>2-Butanone (Methyl ethyl ketone)</td>
<td>CAR, HAP</td>
</tr>
<tr>
<td>tert-Butyl alcohol</td>
<td></td>
</tr>
<tr>
<td>tert-Butyl benzene</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>CAR, HAP</td>
</tr>
<tr>
<td>o-Chlorotoluene</td>
<td></td>
</tr>
<tr>
<td>Diallyl phthalate (DAP)</td>
<td>EDC</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>EDC, HAP</td>
</tr>
<tr>
<td>Isopropylbenzene</td>
<td></td>
</tr>
<tr>
<td>p-Isopropyltoluene</td>
<td></td>
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<tr>
<td>Methylene chloride</td>
<td></td>
</tr>
<tr>
<td>N-Propylbenzene</td>
<td>EDC</td>
</tr>
<tr>
<td>Styrene</td>
<td>CAR, EDC, HAP</td>
</tr>
<tr>
<td>Toluene</td>
<td>HAP</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>CAR</td>
</tr>
<tr>
<td>1,3,5-Trimethylbenzene</td>
<td>CAR</td>
</tr>
<tr>
<td>Xylene (total)</td>
<td>EDC, HAP</td>
</tr>
</tbody>
</table>

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

**Diagram:**

- **Isocyanate**
- **Polyol**
- **Polyurethane**
- **Polyurea**
- **Polyol**
- **Polyamine**

**Images:**

- Before
- Polyurea After
- Cement Mortar
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.
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

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 (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.
The contents of this presentation reflect the views of the authors and do not necessarily reflect the official views or policies of the sponsoring organizations. This presentation does not constitute a standard, specification, or regulation.
Thank You

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

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VA (lead), CA, KS, NC, NY, OH

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Want more information? Please visit
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