Environmental Remediation
Cement Solidification/Stabilization
After decades of improper waste management, an industrial location in Sydney Harbor became severely contaminated

- Throughout the 20th century, runoffs from coke ovens of the steel industry filled the estuary with a variety of coal-based contaminants and sludge, making this area a hazardous waste site.

- 800,000 metric tons of contaminated material needed to be treated due to the presence of pollutants like Polychlorinated Biphenyls (PCBs), raw sewage and benzene.
LafargeHolcim helped transform the Sydney Tar Ponds into a 250 acres park for public use

- In 2009, cleaning operations using Solidification/Stabilization (S/S) with cement began.
- The cleanup was completed in 2013, transforming the area into a Non-hazardous stabilized site, with 250 acres remediated.
- This is the largest brownfield redevelopment project in North America to date and transformed the area into the Open Hearth Park, a green space with a sports field, outdoor concert stage and a playground.
**Solidification / Stabilization with Cement**

**How it Works**

Depending of the type of contaminants, the material will need to be solidified and/or stabilized. This is achieved by mixing the soil with cementitious products.

**Organic Contaminants**
- Oil
- Solvents
- Raw Sewage
- Polychlorinated Biphenyls (PCBs)
- Benzene

**Heavy Metal Contaminants**
- Lead
- Mercury
- Cadmium
- Arsenic
- Chromium
- Zinc

**Solidification**
- Encapsulation of organic contaminants physically changing the properties of contaminated soil
- Reduces porosity, hydraulic conductivity and permeability of soil
- Reduces free liquid, solubility, leachability, mobility of contaminants and provides a stable base for additional engineered controls

**Stabilization**
- Converts heavy metals into non-hazardous forms
- Chemically changes soil and/or contaminants. The high pH converts heavy metals to hydroxides (insoluble and non-leachable)
- Changes soil physical character making it more amenable to solidification

**Cementitious products that can be used in Solidification/Stabilization**
- Type I/II - General-Use cement
- Type III and Type V cement
- Limestone cement
- Slag cement
- Cement Kiln Dust (CKD)
- Fly Ash
- Combination of any of the above
Solidification / Stabilization with Cement

Process and Equipment

The main objective of this process is to provide a good mixing of the contaminated soil with the liquefied cement that will ensure the solidification and/or stabilization of the impacted material.
Solidification / Stabilization is Considered a Viable Solution by EPA and its Advantages Include Traffic Reduction and Material Reutilization

**REDUCE**

- **95% reduction in truck traffic** on the roads around our towns and cities. For Example:

  - Traditional Solution: 60,000 m³ = \( 20 \text{ m}^3 / \text{truck} \times (3,000 + 3,000) = 6,000 \) trips
  - With S/S: 60,000 m³ = \( 40 \text{ MT} / \text{truck} \) = 290 trips

**REUSE**

- An **on-site** solution means material is treated and not relegated to outside landfills. Waste material becomes an engineered construction product.

**RETHINK**

- The U.S. Environmental Protection Agency (EPA) has identified S/S with cement as a *Best Demonstrated Available Technology* for *more than 50* Resource Conservation and Recovery Act (RCRA) listed wastes.

Less Traffic

Recycled Material

Proven
23% of EPA Source Control Sites Used Solidification / Stabilization
LH Follows a Rigorous Sampling, Preparation and Testing Process

Sampling and Preparation
- Each *individual* sample in the blocks is a composition of randomly extracted samples from fresh test pits on site.

Pre-engineering Testing
- Total organic carbon (TOC) of soil
- Compressive strengths 7/28 days
- Observed set time and workability
- Structural integrity test (SIT)
- Traditional synthetic precipitation leaching procedure (SPLP)
- SPLP extraction (on treated monolith)
- Proctor density curve & opt. moisture
- Gradation & in situ moisture content
- California bearing ratio (CBR)

Outgoing Material Testing
- Compressive strengths 7/28 days
- Structural integrity test (SIT)
- Traditional SPLP
Structural Integrity Test (SIT)

- U.S. EPA method 1310B
- Test method intent is to demonstrate treated soil will maintain structure in situ
- Relevant to treated soil that will be exposed only to acidified precipitation
- Core sample monolith tested using SPLP extraction
- Analytes tested are site specific
- Used successfully in compliance testing (e.g.: Sydney Tar Ponds, NS)
Impressive Reduction on Content of Hazardous Material

<table>
<thead>
<tr>
<th>Metals</th>
<th>Total Metals [μg/kg (ppb)]</th>
<th>SPLP SIT Sample [μg/L (ppb)]</th>
<th>5% Contempra</th>
<th>7% Contempra</th>
<th>9% Contempra</th>
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<tbody>
<tr>
<td>Antimony (Sb)</td>
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<td>Arsenic (As)</td>
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<td>Barium (Ba)</td>
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<td>Beryllium (Be)</td>
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<td>Boron Hot Water Extraction</td>
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<td>Boron (B)</td>
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<td>Cadmium (Cd)</td>
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<td>Chromium (Cr)</td>
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<td>Mercury (Hg)</td>
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<tr>
<td>Nickel (Ni)</td>
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<td>Thallium (Tl)</td>
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<td>Vanadium (V)</td>
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<td>Zinc (Zn)</td>
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*note: moisture content in 23% - 34% range
### Foundry Sand Before / After Adding CKD

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<tr>
<th>Parameter (PPM)</th>
<th>Lagoon 1</th>
<th>Lagoon 2</th>
<th>Lagoon 1 - 10%</th>
<th>Lagoon 1 - 15%</th>
<th>Lagoon 2 - 10%</th>
<th>Lagoon 2 - 15%</th>
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<tr>
<td>Antimony</td>
<td>&lt;1.6</td>
<td>&lt;1.6</td>
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<td>0.05</td>
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<tr>
<td>Arsenic</td>
<td>6.80</td>
<td>9.00</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
<td>&lt;0.010</td>
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<tr>
<td>Barium</td>
<td>201.00</td>
<td>182.00</td>
<td>0.83</td>
<td>0.72</td>
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<td>Beryllium</td>
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<td>1.30</td>
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<td>&lt;0.010</td>
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<td>Cadmium</td>
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<td>14.50</td>
<td>0.07</td>
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<td>Chromium</td>
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<td>Cobalt</td>
<td>5.70</td>
<td>6.00</td>
<td>0.04</td>
<td>0.03</td>
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<tr>
<td>Copper</td>
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<td>Iron</td>
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<td>38,200.00</td>
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<td>Lead</td>
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<td>483.00</td>
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<td>Molybdenium</td>
<td>6.70</td>
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<td>0.04</td>
<td>0.05</td>
<td>&lt;0.020</td>
<td>0.03</td>
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<tr>
<td>Nickel</td>
<td>40.80</td>
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<td>Selenium</td>
<td>0.80</td>
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<td>0.01</td>
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<td>&lt;0.010</td>
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<tr>
<td>Silver</td>
<td>0.90</td>
<td>4.00</td>
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<td>Strontium</td>
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<td>Titanium</td>
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<td>&lt;0.050</td>
<td>&lt;0.050</td>
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<tr>
<td>Vanadium</td>
<td>11.50</td>
<td>36.00</td>
<td>&lt;0.020</td>
<td>0.02</td>
<td>&lt;0.020</td>
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<tr>
<td>Zinc</td>
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<td>12.30</td>
<td>7.18</td>
<td>81.40</td>
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<td>pH</td>
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<td>n/a</td>
<td>10.90</td>
<td>11.90</td>
<td>9.84</td>
<td>10.50</td>
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</tbody>
</table>
Success Stories
Sydney Tar Ponds Clean Up

Site: Tar Ponds, Sydney, NS
Date: 2007 - 2013

Challenges:
• 800,000 tons of material needing to be excavated
• Cooling pond sludge from coke ovens
• Over 3.8 tons of PCBs, raw sewage and benzene

Requirements:
• Minimal dust, unconfined compressive strengths and permeability specs
• Future site uses: park, walking trails, sports fields, and wetlands

Project / Application:
• Contractors: GHD; Nordlys Environmental and Van Zutphen Construction / Material Supplier: Lafarge
• Remediate ~100-hectare (250 acres) surface area
• In situ treatment, stabilization and solidification of soil/sludge, filling ponds

Benefits to Customer:
• Site stabilized and hazardous chemicals immobilized
• Canada’s largest S/S project, converted to parkland
• Avoided most widely used method of destroying PCBs via incineration
Success Stories
Recycle Barrel Facility

**Site:** Lansing, MI

**Date:** March 2012

**Challenges:**
- 10,000 tons of material of lead-contaminated soil; 1,900-8,000 mg/Kg total Pb
- 10-150 ug/L in TCLP extraction
- Proximity to commercial and residential properties

**Requirements:**
- Stabilize lead in soil to less than 5 mg/L in a TCLP extraction

**Project / Application:**
- *Contractor:* CRA (GHD) / *Material Supplier:* Lafarge
- In situ treatment and removal off-site due to economical cost advantage
- Soil remediation using 1,000 tons of CKD

**Benefits to Customer:**
- Reduced cost due to in situ treatment before removal
- Dramatic reduction in landfill cost; non-haz vs hazardous
- Project resulted in 50% savings vs original budget of dig and haul
Success Stories
Former Chemical Facility

**Site:** Bay City, MI
**Date:** Summer 2013

**Challenges:**
- 40,000 tons of impacted soil
- Former chemical manufacturing plant
- Hazardous heavy metals, PAHs and other organics

**Requirements:**
- Remediated site required passing environmental assessment for TCLP
- Portland Cement to solidify and immobilize organic fraction
- CKD to stabilize heavy metals (originally Portland was specified)

**Project / Application:**
- *Contractor:* Job Site Services / *Material Supplier:* Lafarge
- Remediate 40,000 ton of impacted soil and sludge in a series of drainage ditches
- In situ remediation and treated soil left in place

**Benefits to Customer:**
- No off-site landfilling
- Project resulted in 50% cost-savings vs. original budget of dig and haul
Questions?

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