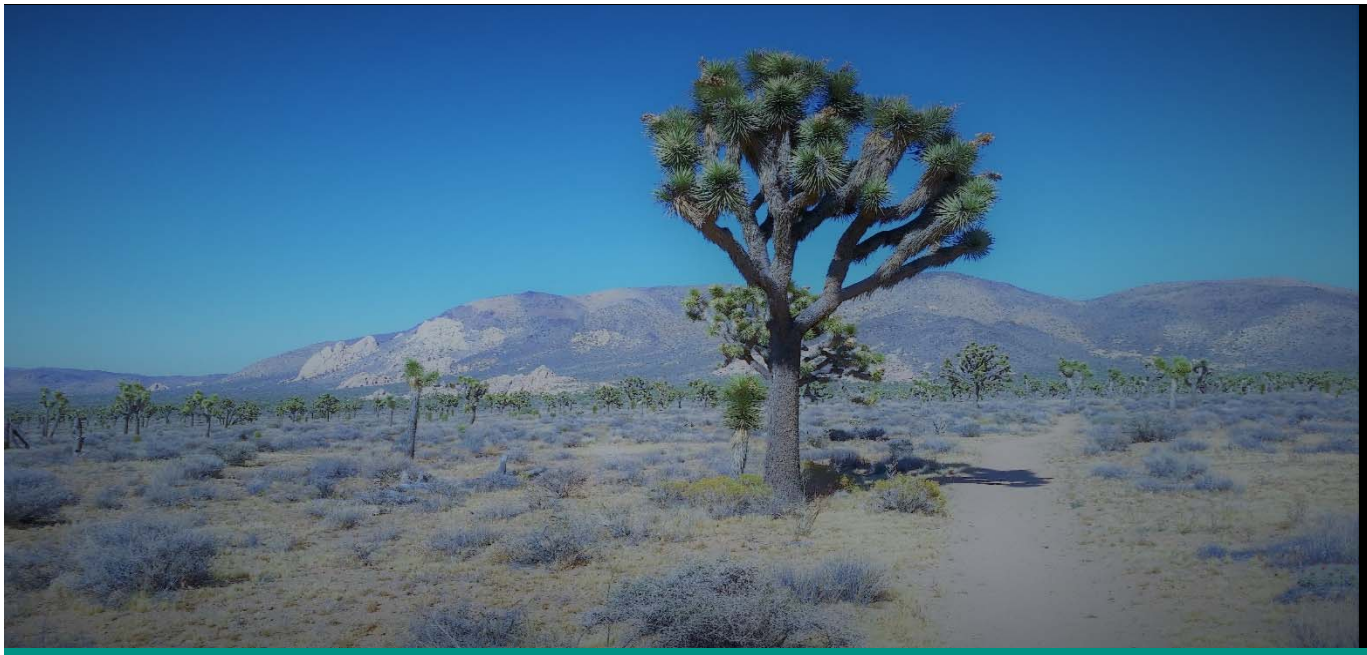

ISOTEC REMEDIATION TECHNOLOGIES

In-Situ Gasworks Remediation - Challenges and Innovations

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The 11th International Conference on Remediation of Chlorinated and Recalcitrant Compounds
Palm Springs, California
April 11, 2018

The Project Site

Former Millers Point Gasworks, Hickson Rd, Barangaroo, Sydney, Australia

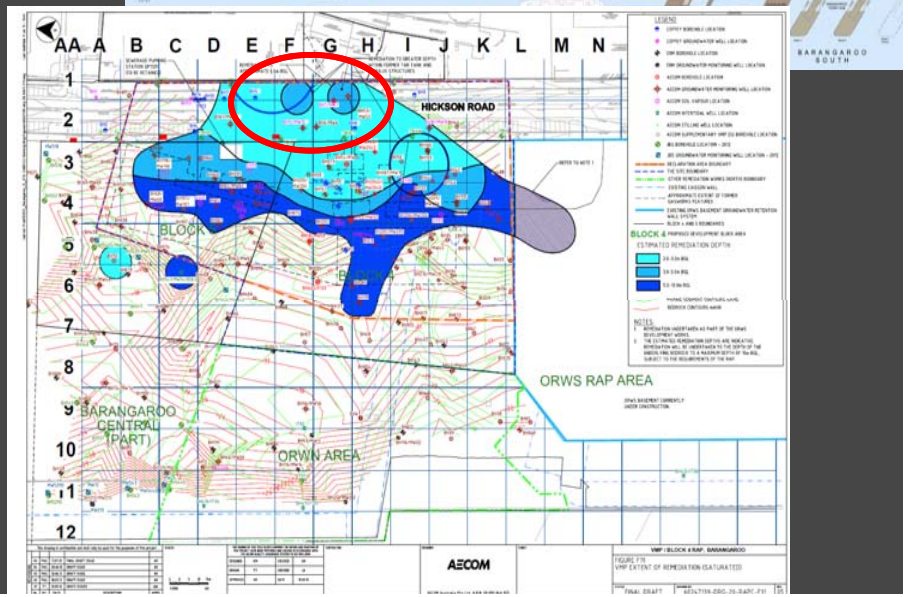
- Gasworks operated between 1841 to 1921
- Site located between Darling Harbour and Circular Quay, beneath Hickson Rd
- Within a busy CBD Streetscape with subsurface utilities
- Part of Barangaroo precinct development (total value approximately AU$6 billion)

The Project Site

Source: Barangaroo Delivery Authority

The Project Site

- In 2009 the NSW EPA declared part of Barangaroo a Remediation Site
- The Declaration is related to Separate Phase Gasworks Waste and Tar (SPGWT)
- In 2013 a Remedial Action Plan (RAP) was prepared for the Declared Area



In-Situ Chemical Remediation Overview

Remediation Method

1. Baseline sampling (groundwater, soil)
2. Install Injection & Extraction Wells for chemical flushing
3. Injection of chemicals (surfactant & solvent)
4. Removal of liquid and vapour contamination through Multiphase and Soil Vapor Extraction
5. Disposal of extracted liquid waste
6. Destruction of contamination through chemical oxidation
7. Post treatment sampling and validation analysis

Remediation Goals

The remediation goals (as defined in the RAP)

- Removal of SPGWT to the extent practicable
- Remediation of soil and groundwater concentrations exceeding the relevant SSTC to the extent practicable, and
- Removal/remediation of contaminated soil such that the contaminant mass is reduced, on average, by **90%** (calculated based on the estimated mass of naphthalene and TPH C_{10}-C_{14})

Project Background

The project was structured as:

- **Pilot Trial** to trial the in situ remediation on one buried structure (Southern Tar Tank)
- **Full scale** works (all structures) would follow if Stage 2B was successful

"Stage 2" – Removal of SPGWT (qualitative assessment)

"Stage 2A" – Removal of SPGWT & reduction of contaminant mass by **25%** (calculated by estimated mass of naphthalene and TPH C_{10}-C_{14})

"Stage 2B" – Removal of SPGWT & reduction of contaminant mass by **90%** (calculated by estimated mass of naphthalene and TPH C_{10}-C_{14})

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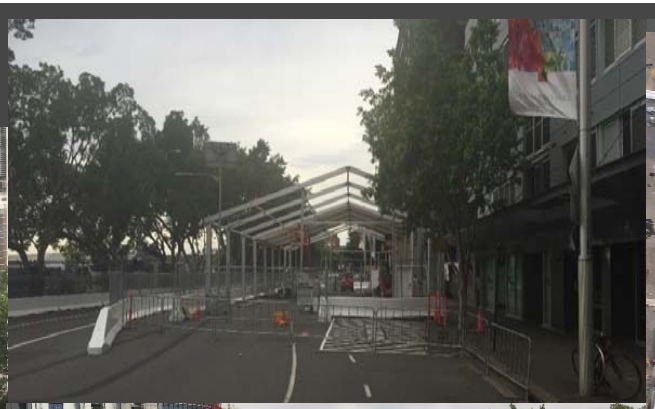
Site Specific Challenges - CBD Streetscape



Site Specific Challenges – Chemical Choice

A whole range of chemicals for flushing and oxidation

- Surfactants?
- Solvents?
- Oxidants?
- Which ones are best?

Site Specific Challenges - Wider Barangaroo

Hickson Rd contains vast majority of existing contamination

↓

The completion of other Barangaroo development is dependent upon successful Hickson Rd remediation

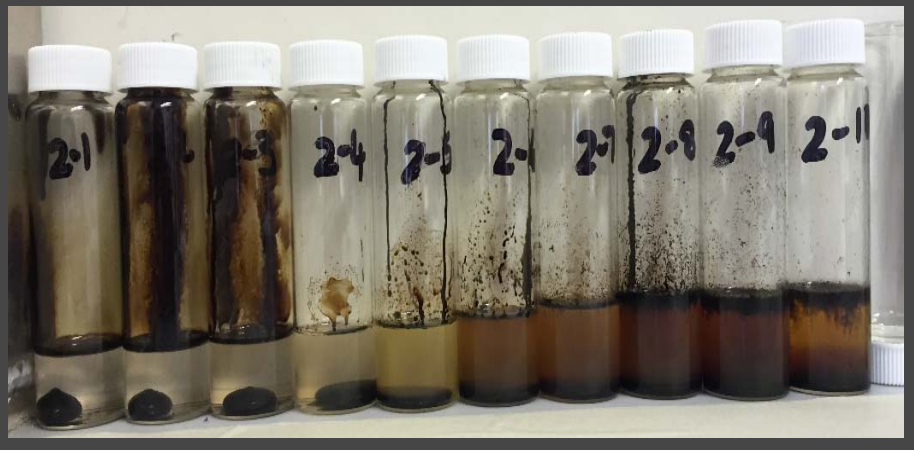
↓

The remediation method for Hickson Rd must provide certainty in remediation

Innovations – Choice of Chemical

Team undertook bench scale lab trials to test both surfactants and co-solvents

- Trials observed the effect of chemicals on the viscosity of the tar and its ability to mobilize NAPL
- Tested both surfactant and solvents separately and in combination
- Surfactant chosen was a non-ionic alkyl polyglucoside
- Solvent chosen was an ether-based reagent



Innovations – System Design

- Injection and extraction well designs included both deep and full depth screens
- Air sparging
- Increased chemical residence time
- Program design necessarily included flexibility!

Results Summary / Project Success

In-Situ Soil Sample Results

Baseline Soil Results	TPH C_{10}-C_{14} (mg/kg)		Naphthalene (mg/kg)	
	Mean	95% UCL	Mean	95% UCL
Upper Material (0.5 m to 2.1 mbgl) (total 16 samples)	504	1 915	152	521
Lower Material (2.1 to approximately 5.5 mbgl) (total 24 samples)	22,565	29,092	5,856	7,381
All samples (total 40 samples)	13,741	26,217	3,574	6,600

Baseline to Stage 2 (qualitative assessment)	TPH C_{10}-C_{14} (% change)		Naphthalene SVOC (% change)		Combined (TPH C_{10}-C_{14} and Naphthalene) Change (%)
	Mean	95% UCL	Mean	95% UCL	Mean
Upper Material (0.5 m to 2.1 mbgl) (total 10 samples)	148%	-45%	168%	86%	154%
Lower Material (2.1 to 5.5 mbgl) (total 15 samples)	-42%	-39%	0%	51%	-34%
All samples (total 25 samples)	-40%	-	2%	-	-32%

Baseline to Stage 2A (target 25% reduction)	TPH C_{10}-C_{14} (% change)		Naphthalene SVOC (% change)		Combined (TPH C_{10}-C_{14} and Naphthalene) Change (%)
	Mean	95% UCL	Mean	95% UCL	Mean
Upper Material (0.5 m to 2.1 mbgl) (total 16 samples)	609%	231%	384%	550%	557%
Lower Material (2.1 to 5.5 mbgl) (total 24 samples)	5%	2%	-22%	-20%	0%
All samples (total 40 samples)	14%	-	-15%	-	+8%

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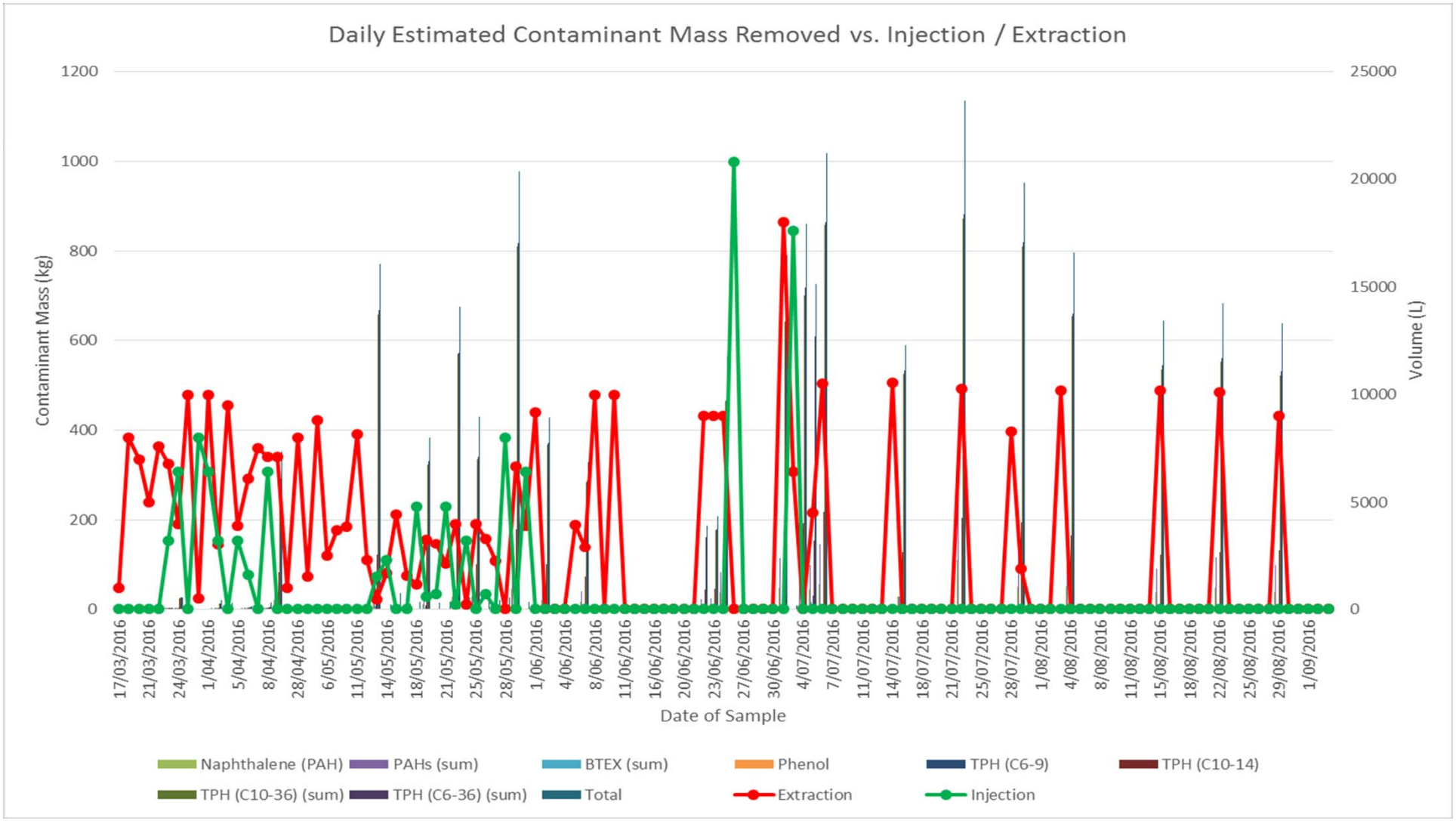
Results Summary

Ex-Situ Contaminant Mass Removal

- Based on extracted waste volume estimates and laboratory analysis of DNAPL, LNAPL and water phases
- Estimated Contaminant Mass reduction = 17%
- Removal rates increased substantially (both per day and per hour of MPE operation) throughout Stages 2 and 2A


Daily Estimated Contaminant Mass Removed vs. Injection / Extraction
Contaminant Mass (kg)
Volume (L)
Date of Sample
Naphthalene (PAH)
PAHs (sum)
BTEX (sum)
Phenol
TPH (C6-9)
TPH (C10-14)
TPH (C10-36) (sum)
TPH (C6-36) (sum)
Total
Extraction
Injection

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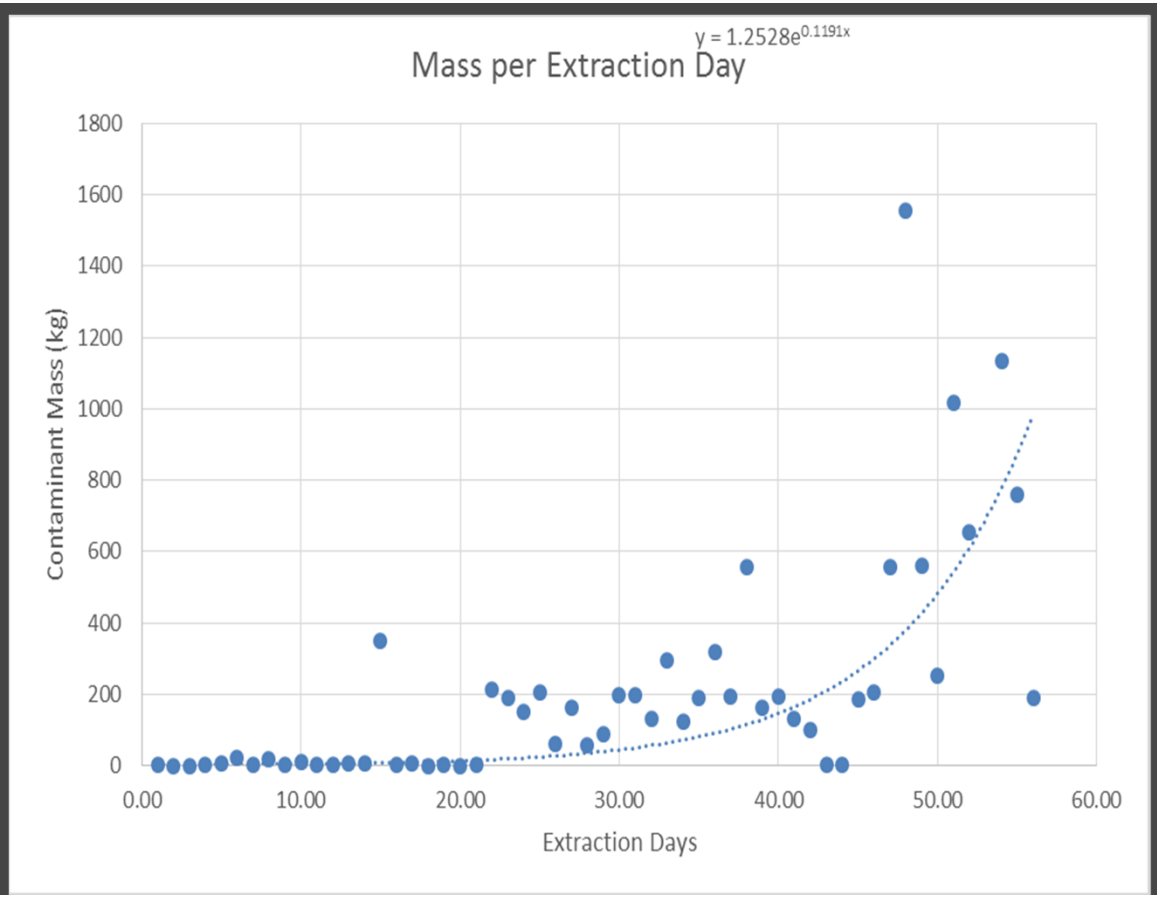
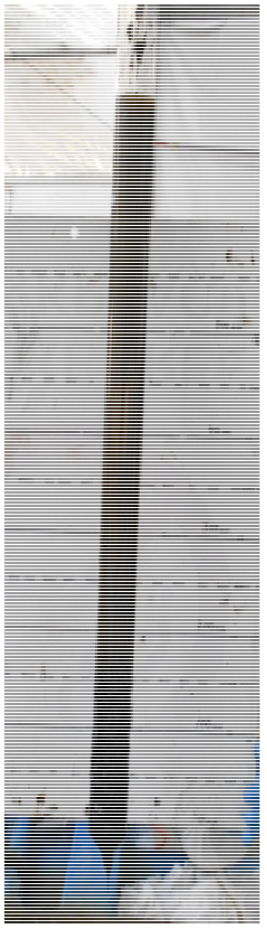
Results Summary - cont.



Pre-injection

Post 1st injection

Post multiple injections & extractions



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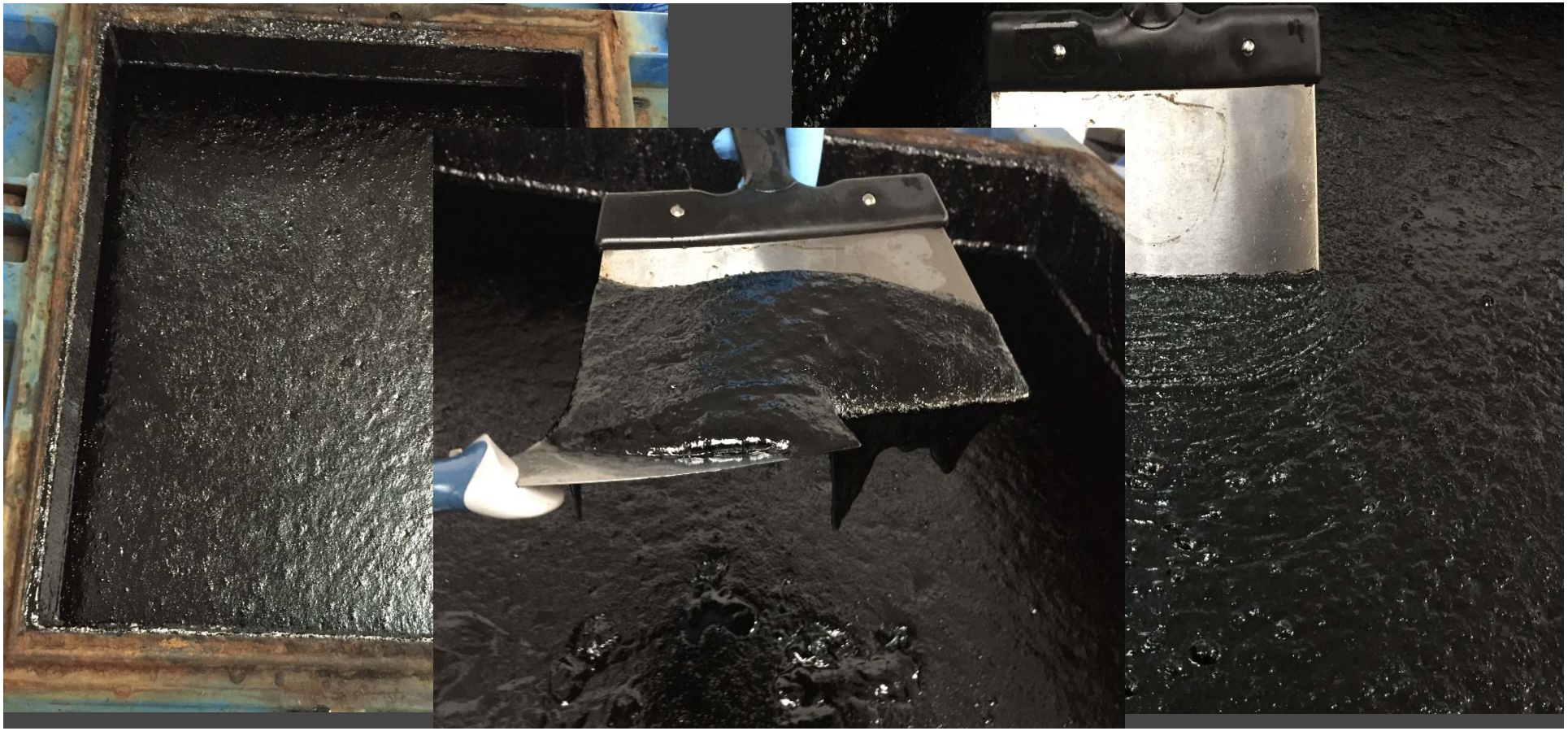
LNAPL on Surface of Extracted Liquid



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DNAPL Collected from Base of Tank

Results Summary - cont.

Remediation Achievements

- Ex-situ Contaminant Mass extraction results continued to increased with time
- Contaminant Mass continued to be extracted well after final injection event
- ~15 tons Contaminant Mass removed

In-Situ vs. Ex-Situ Remediation

In-Situ – Pros

- Reduced exposure to hazardous substances
- Reduced impact to surrounding community
- Ability to reach inaccessible/ tight areas

In-Situ – Cons

- Typically longer duration
- Quantitative assessment issues
- Likely require pilot trial or treatability study
- Proof of success may be challenging

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However…

Pilot trial was discontinued as stipulated remedial goals were not achieved for Stage 2A

Tar continued to be removed by the multiphase extraction system for > 12 months

Current approach is to jet grout the remaining mass in the tar holder


ISOTEC
REMEDIATION
TECHNOLOGIES
Thank You
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WARNING
cameras
are in constant
operation on site.