Parkland
REFINING (B.C.) LTD.

SLR

AECOM

Passive Hydrocarbon Remediation in a Foreshore Marine Environment

Contaminated Sites Approved Professional Society
Fall Workshop
November 16, 2017

Parkland Fuel Corporation

Parkland Fuel Corporation recently acquired the following downstream business: refinery, gas stations, bulk plants, marine terminals.

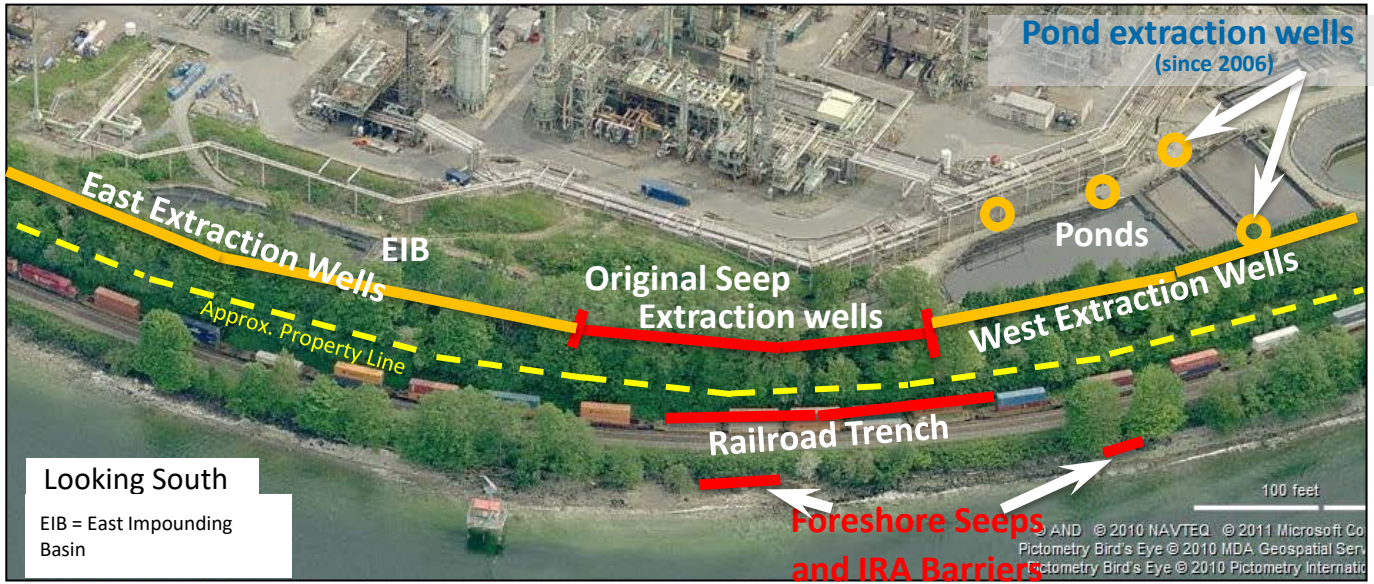
Parkland's values:

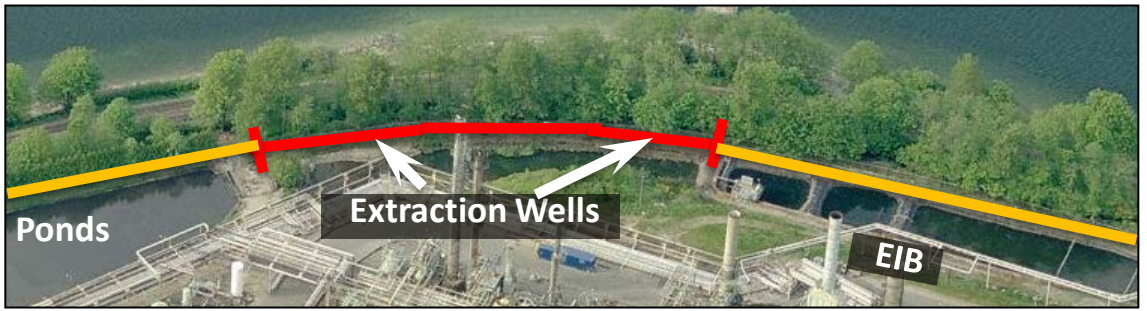
- Protecting the health and safety of individuals, communities, and eco-systems;
- Providing our customers with a reliable and dependable fuel supply;
- Delivering outstanding customer service; and
- Supporting the communities we operate in.

Foreshore Seep

- Discovered on April 21, 2010 and immediately reported to PEP
  - Mixed NAPL hydrocarbon seeps observed in an area adjacent to the railroad and on the foreshore below the refinery.
- **Emergency response**
  - Foreshore - Refinery responded immediately with soaker pads and booms to mitigate the effects of the NAPL seeps.
  - Area near Railroad – passing excavator was hailed to dig a collection ditch – pads and vacuum truck applied

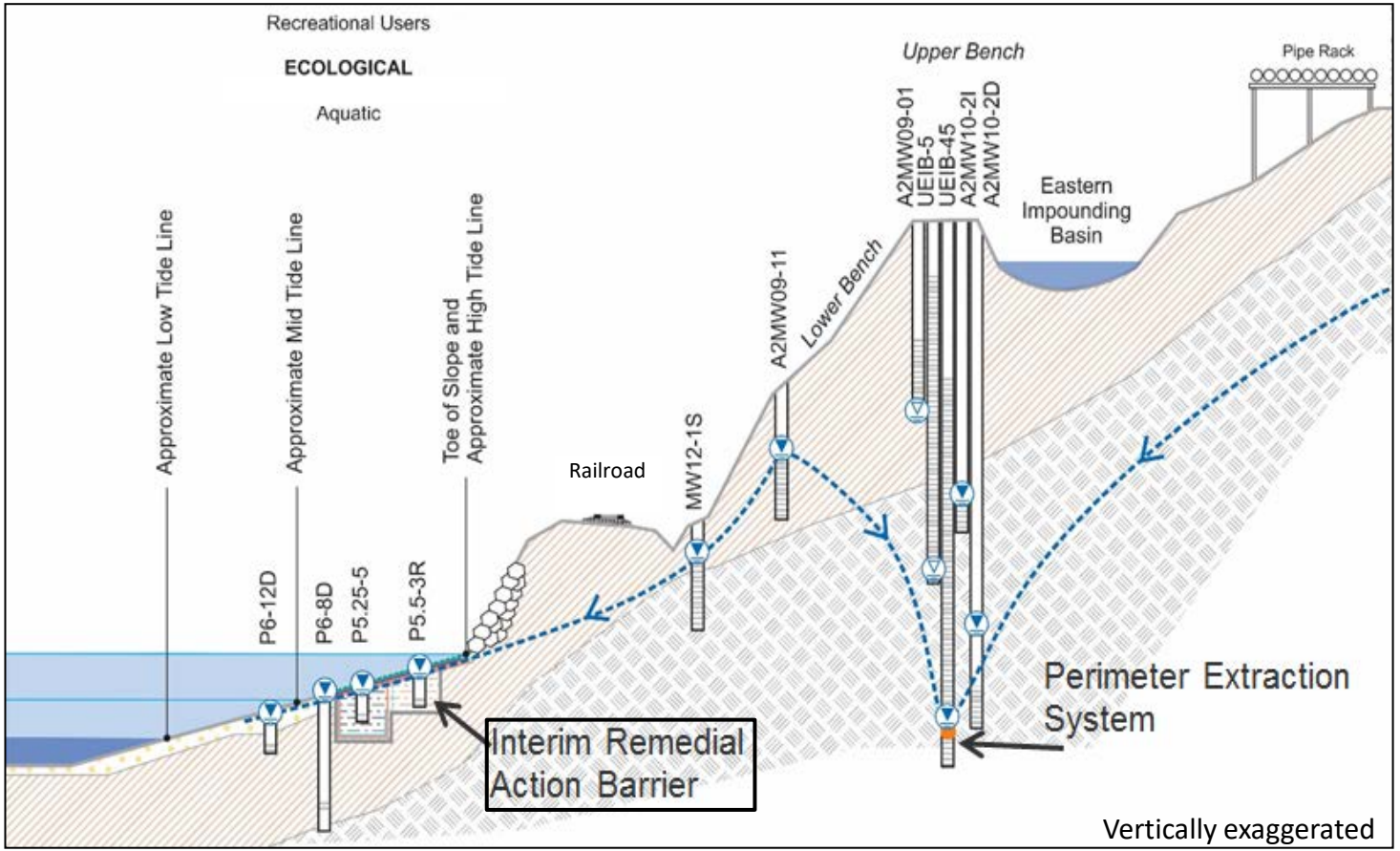
Project Area and Upland Perimeter Extraction System





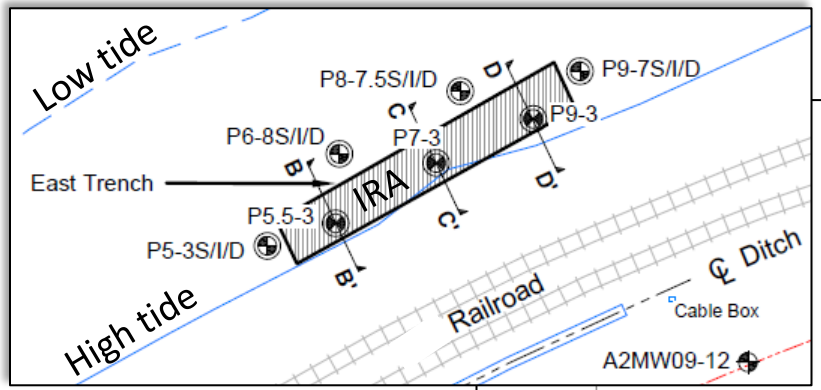
Looking North

Cross Section and Key Limiting Site Conditions



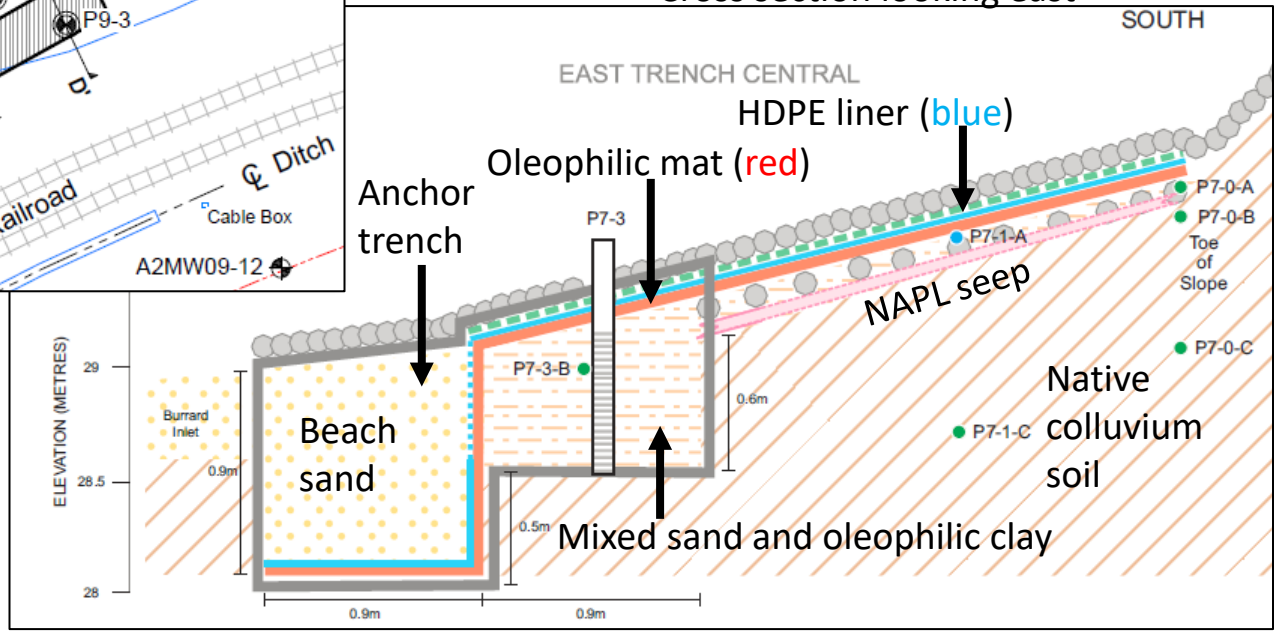
Interim Remedial Action (IRA) Barrier

- The first passive remedial system, installed in the spring of 2011, was designed to absorb oil using oleophilic clay and sand in a trench, and oleophilic clay in a geotextile mat



Plan view

Cross section looking east



Oleophilic Mat

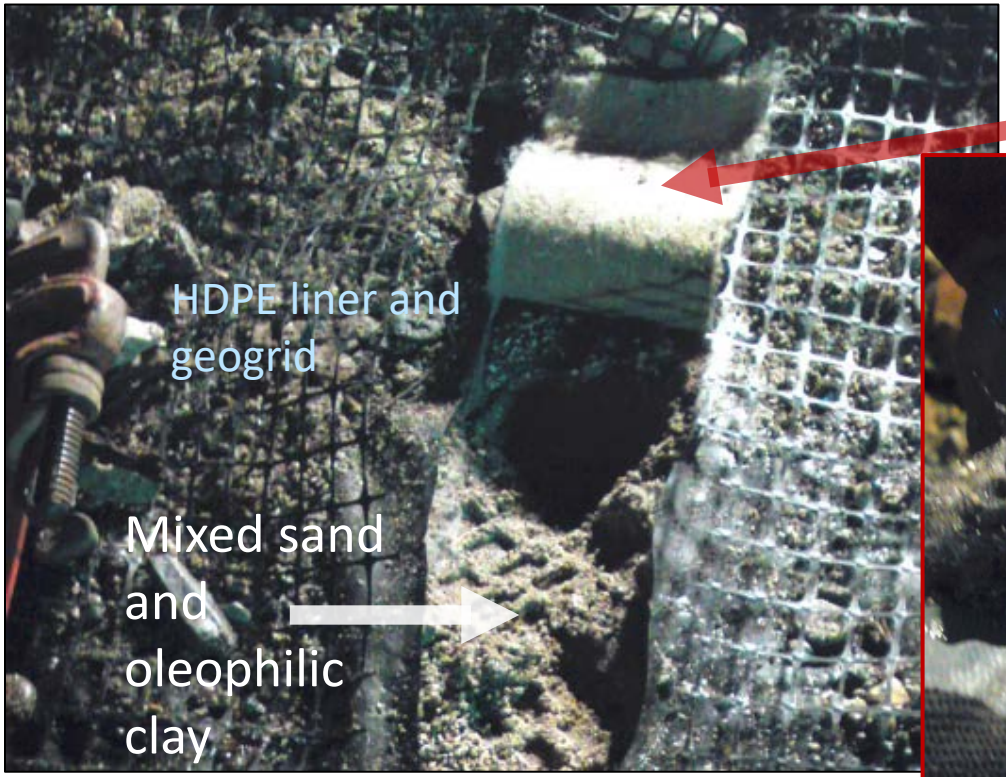
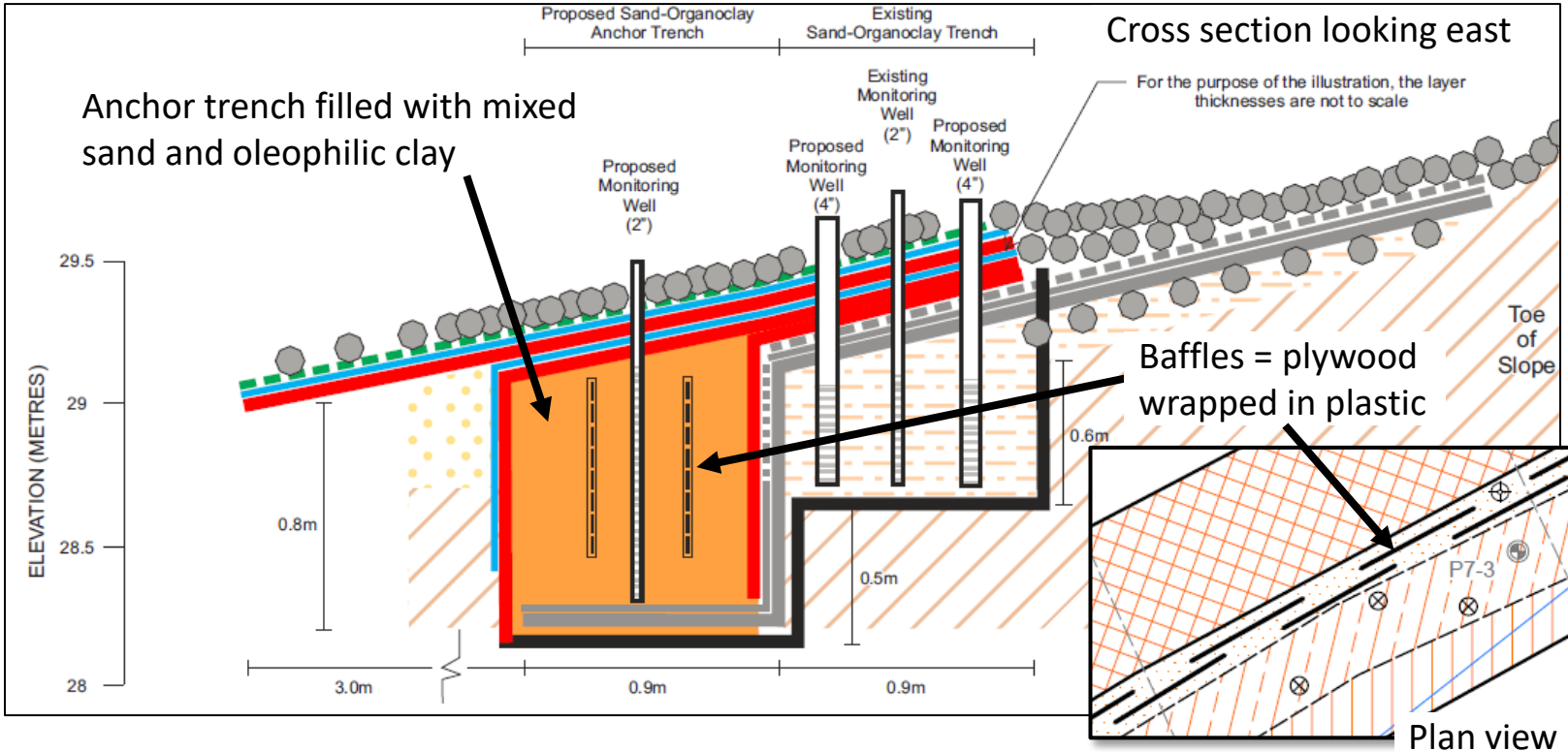


Photo of cutout (during subsequent investigation)

Oleophilic mat

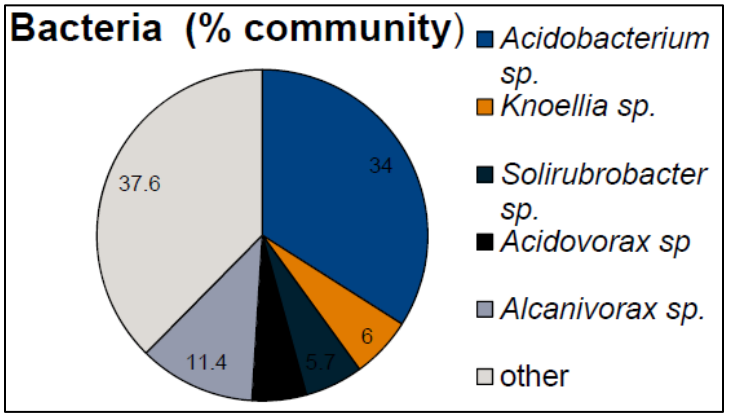
IRA Refurbishment

Groundwater channeling / preferred pathways through the oleophilic clay required us to install more sand-organoclay mixture, and to introduce baffles, in March 2012



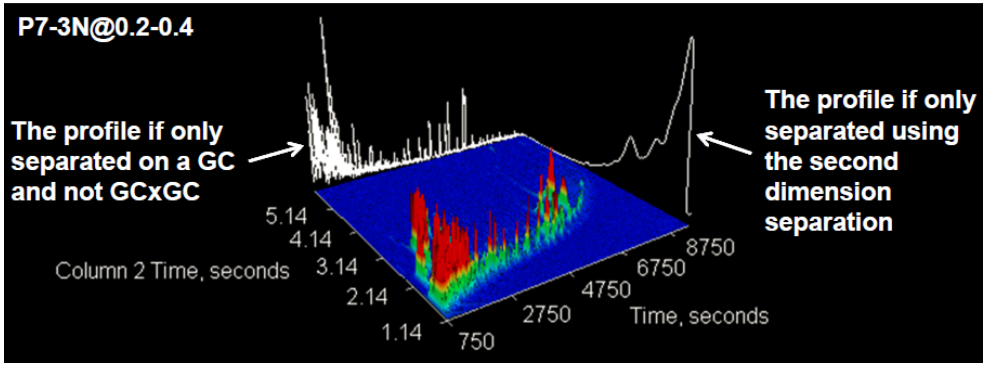
IRA NAPL Mobility and Hydrocarbon Degradation Assessment

- NAPL no longer observed in wells in the IRA after Sept 2011; pump tests in 2014 were unable to induce NAPL flow
- Based on monitoring and sampling completed between 2012 and 2016, dissolved phase concentrations were above risk-based targets in water inside the IRA, but below such targets in downgradient wells
- DNA/RNA analysis showed presence of degrading organisms



IRA NAPL Mobility and Hydrocarbon Degradation Assessment (cont.)

- GC-GC/MS Analysis of PHCs – showed increase in oxidized PHCs
- Sulfate was present. Dissolved oxygen was periodically present from tidal mixing
- Multiple lines of evidence to support biodegradation within the barrier



- The IRA barrier succeeded in its objective of capturing NAPL and also degraded dissolved phase contamination

IRA Limitations

- The IRAs were installed as interim measures and had the following drawbacks:
  - Permeability difficulties led to preferred pathways
  - Limited ability to withstand erosion
  - Limited capacity to assess upgradient porewater concentrations
  - Not designed to treat sheens
  - Not specifically designed to treat dissolved phase contamination

Next Steps

- Next step was to design and install a final, permanent remedy. Remedial options explored.
- To that end a human health and ecological risk assessment was completed by SLR in 2012
- SLR also developed risk-based management targets for the site. Based on the risk-based targets, the remedial driver for the site was LEPHw

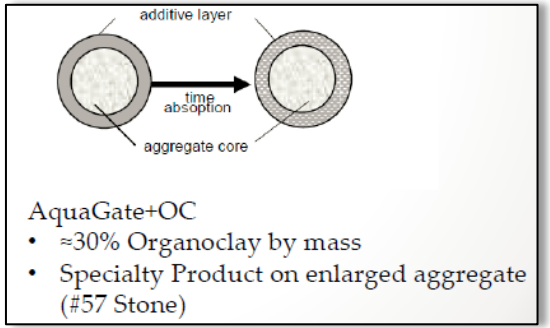
Objectives of a Foreshore Seep Final Remedy

- Last 30 years
- Treat NAPL
- Treat dissolved phase impacts, notably LEPHw
- Resist erosion
- Maintain permeability
- Install monitoring wells up slope, cross gradient, within and down slope of the system
- Have flexibility to adjust to higher than expected levels of contamination
- Sustainable, passive system with low energy or maintenance requirements

Remediation System Outline

- Removal of existing IRA Barriers (and associated impacted sediments)
- Subsurface cells to treat NAPL and dissolved phase petroleum hydrocarbons
- Infrastructure to allow contingency addition of Enhanced Bioremediation amendments
- Sheen Prevention (Oleophilic Bio Barrier)
- Embankments to protect subsurface components

Remedial System Conceptual Design



Rip-Rap Embankment

Piping to Deliver Nutrients or Electron Acceptors, or Extract PHCs or NAPL (if needed)

Impermeable Sheeting

Rail Lines

Sand/Organoclay in Rip-Rap

Porewater Elevation at High Tide

Sand + AquaGate/ Organoclay Treatment Cell

OBB Anchor (Cobbles)

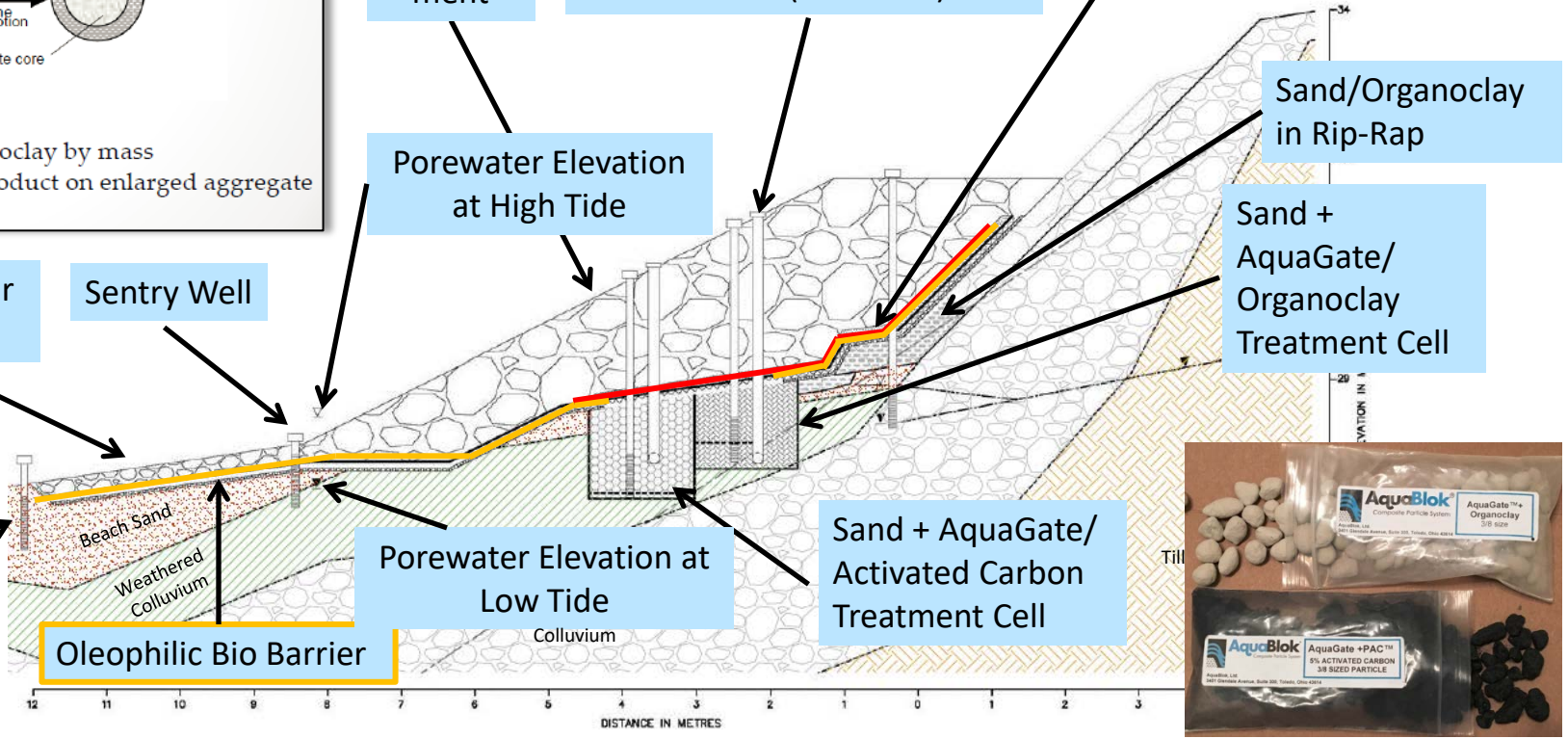
Sentry Well

Compliance Well

Oleophilic Bio Barrier

Porewater Elevation at Low Tide

Sand + AquaGate/ Activated Carbon Treatment Cell



Artist’s Rendition (Low Tide)

Treatability Study and Trench Materials

- Laboratory bench-scale study required to:
  - test ability of AquaGate + Powdered Activated Carbon (AG+PAC) to treat LEPHw, and
  - to determine sand mix to obtain optimal permeability.
- Porewater samples taken from impacted upgradient groundwater monitoring wells at refinery.

Results

- AG+PAC treated dissolved phase to below the LEPHw Risk-Based Management Target of 300 µg/L.
- AquaGate + Organoclay (AG+OC) can absorb NAPL and found to also treat (absorb) LEPHw

Sheen Treatment

- Oleophilic Bio Barrier (OBB) is a plastic geogrid encapsulated by fabric
- Allows gas to pass through while capturing any associated hydrocarbon sheen

Final Remedy Installation – July-October 2017

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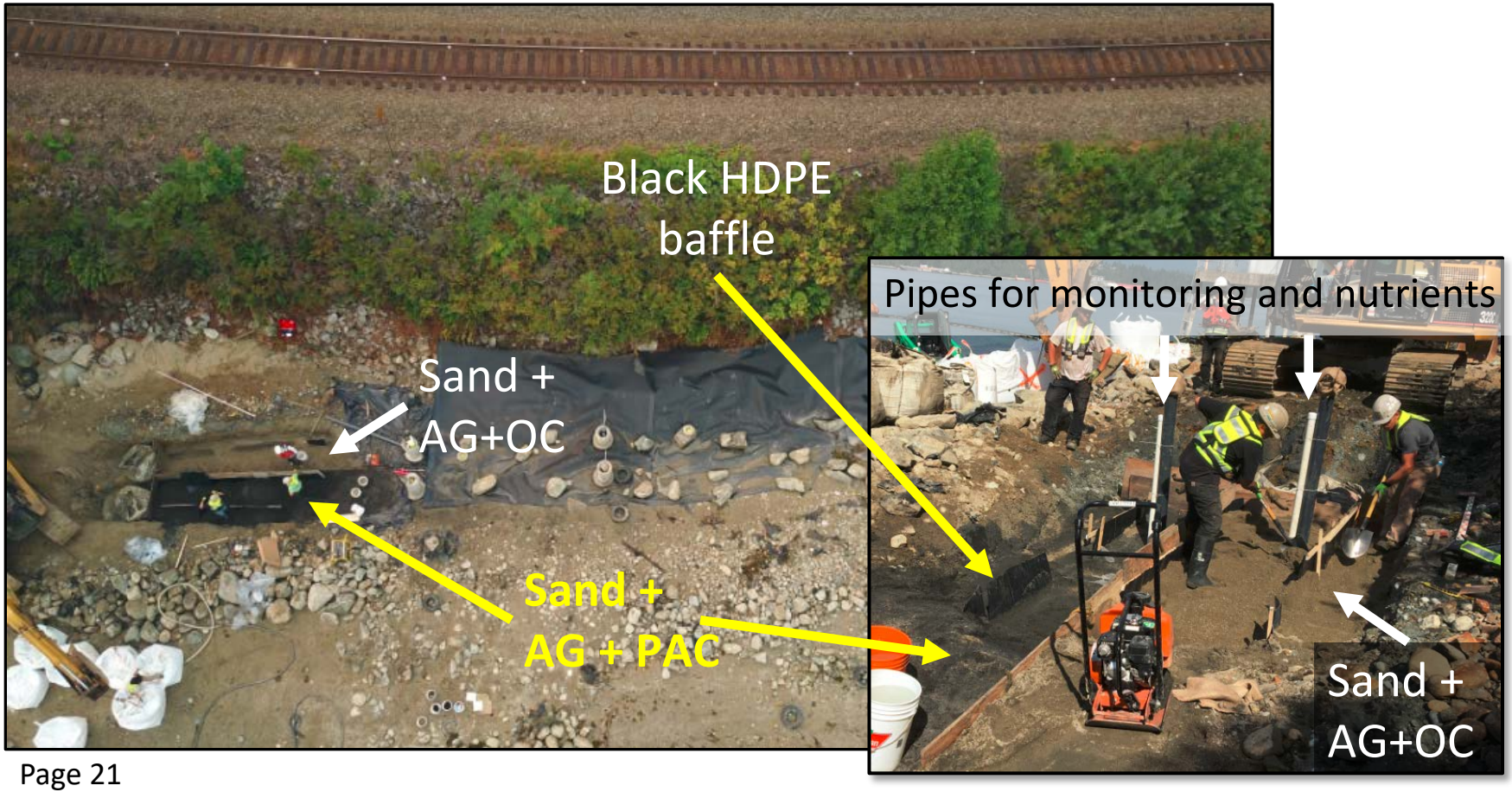
Excavating IRA trench contaminated material

- Dark grey colour is due to anoxic conditions, not NAPL.
- Hydrocarbon odours were low to moderate.

Final Remedy Installation – July-October 2017



Final Remedy Installation – July-October 2017

Acknowledgements

7 year collaborative effort:
Burnaby Refinery
AECOM
SLR Consulting (Canada)

THANK YOU!

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