SEDIMENT REMEDIATION AND RESTORATION – A CANADIAN PERSPECTIVE

Randle Reef Sediment Remediation – Roger Santiago

Sydney Tar Ponds Remediation – Bruce Noble

Esquimalt Graving Dock Waterlot Remediation – Dan Berlin

Esquimalt Graving Dock Design Challenges – Dan Berlin

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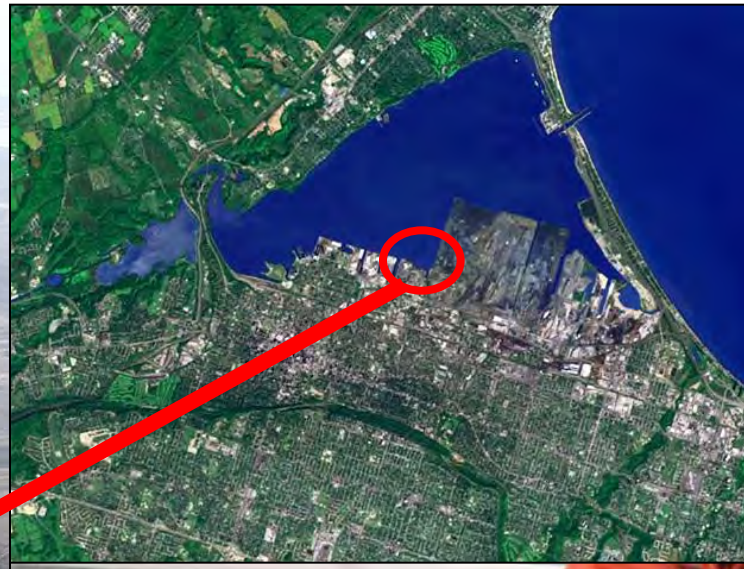
WODCON XXI
Randle Reef Sediment Remediation Project

Roger Santiago,
Head of Sediment Remediation Unit,
Great Lakes Areas of Concern
Environment and Climate Change Canada

June 15, 2016
Hyatt Regency Miami,
Miami, Florida
USA

Hamilton Harbour

Hamilton Harbour



Project Funding

Ontario Ministry of the Environment and Climate Change
$46.3M

Environment and Climate Change Canada
$46.3M

Local Funding Partners
$46.3M

$138.9M

Local Funding Partners:

1. U.S. Steel Canada
2. City of Hamilton
3. Hamilton Port Authority
4. City of Burlington
5. Region of Halton

Remedial Approach

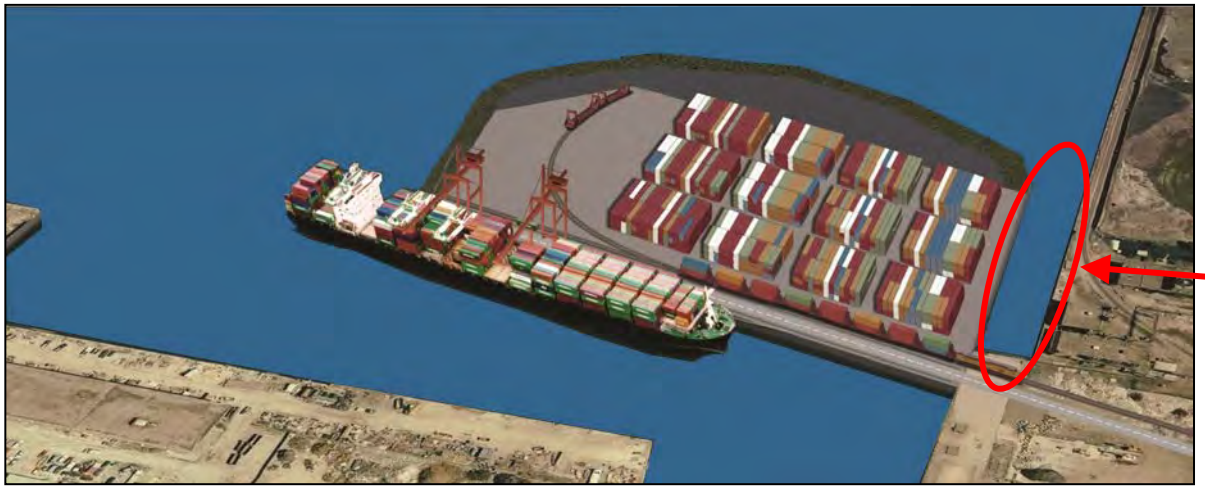
8 years to complete:

Dredging (hydraulic & mechanical)
Stage 2

Containment
Stage 1

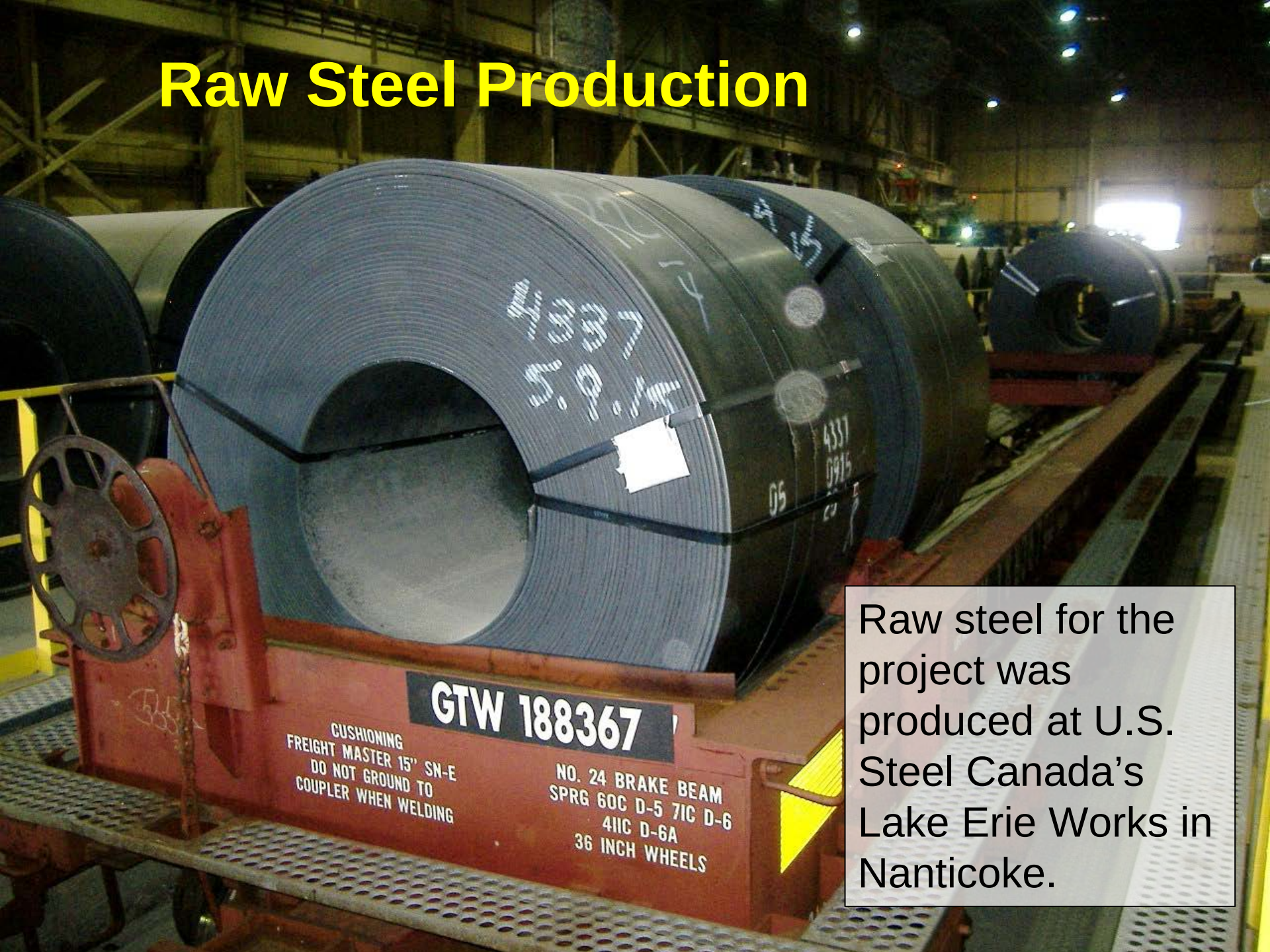
ECF Capping
Stage 3

Randle Reef Project Components



- Construct a 6.2 hectare Engineered Containment Facility (ECF) over the most highly contaminated sediment (140,000 m^3 *in-situ*);
- Using a combination of hydraulic and mechanical dredging, remove 445,000 m^3 and place within ECF;
- Thin Layer Capping of 105,000 m^3 of marginally contaminated sediment
- Cap U.S. Steel Intake/Outfall Channel sediments 5,000 m^3
- Cap ECF and construct a port facility.
- Total sediment management of **695,000 m^3**

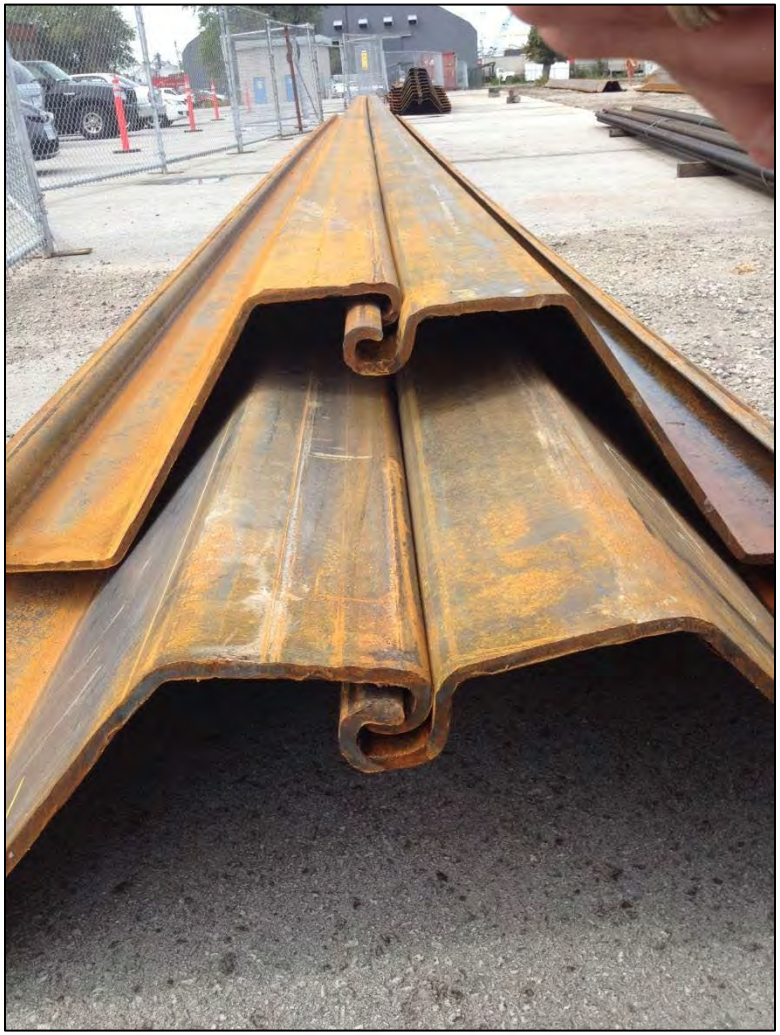
Raw Steel Production



Raw steel for the project was produced at U.S. Steel Canada's Lake Erie Works in Nanticoke.

Raw Steel Transportation

Steel Fabrication



- Sheet pile fabrication:
  - The length of the ECF face wall sheet pile required fabrication at a roll forming mill in Iuka, Mississippi.
  - ECF anchor wall sheet pile was fabricated at a roll forming mill in Cambridge, Ontario.

Steel Fabrication and Transport

Steel Fabrication and Transport

Fabricated steel sheet pile for the ECF face wall was produced in Iuka, Mississippi and shipped via river barge to Chicago.

Steel Fabrication and Transport

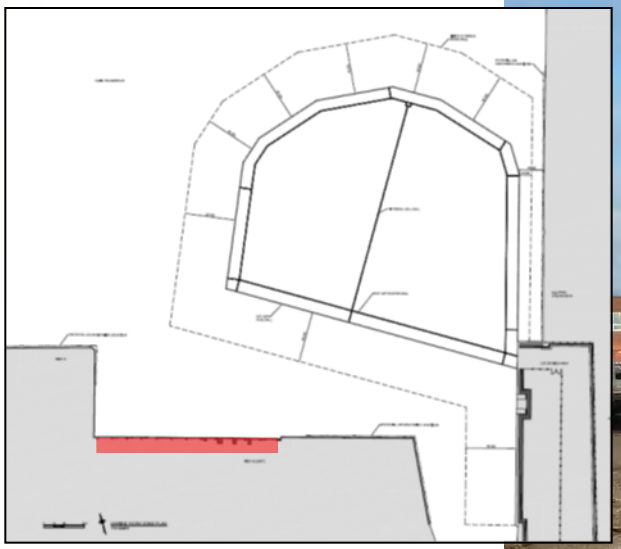
In Chicago the sheet pile will be transferred to a lake barge, McKeil's Lambert Spirit, for transport to Hamilton.

Steel Delivery

Delivery by barge from Mississippi

Delivery by truck from Cambridge

Stage 1: Pier 15 Reconstruction



Wall Reconstruction

Pier 15 Reconstruction

Photo Courtesy of Riggs Engineering

Photo Courtesy of Riggs Engineering

Pier 15 Reconstruction


Photo Courtesy of Riggs Engineering

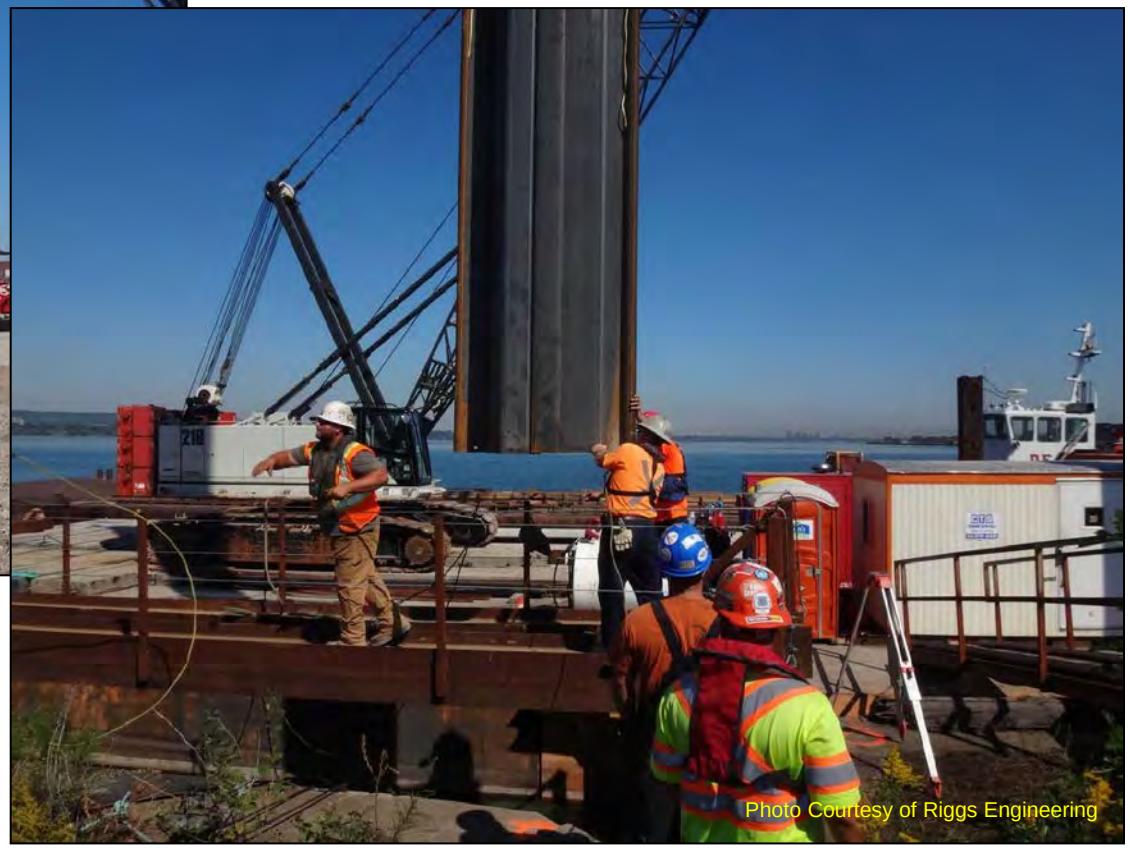


Photo Courtesy of Riggs Engineering

Pier 15 Reconstruction

Photo Courtesy of Riggs Engineering


Photo Courtesy of Riggs Engineering

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Pier 15 Reconstruction


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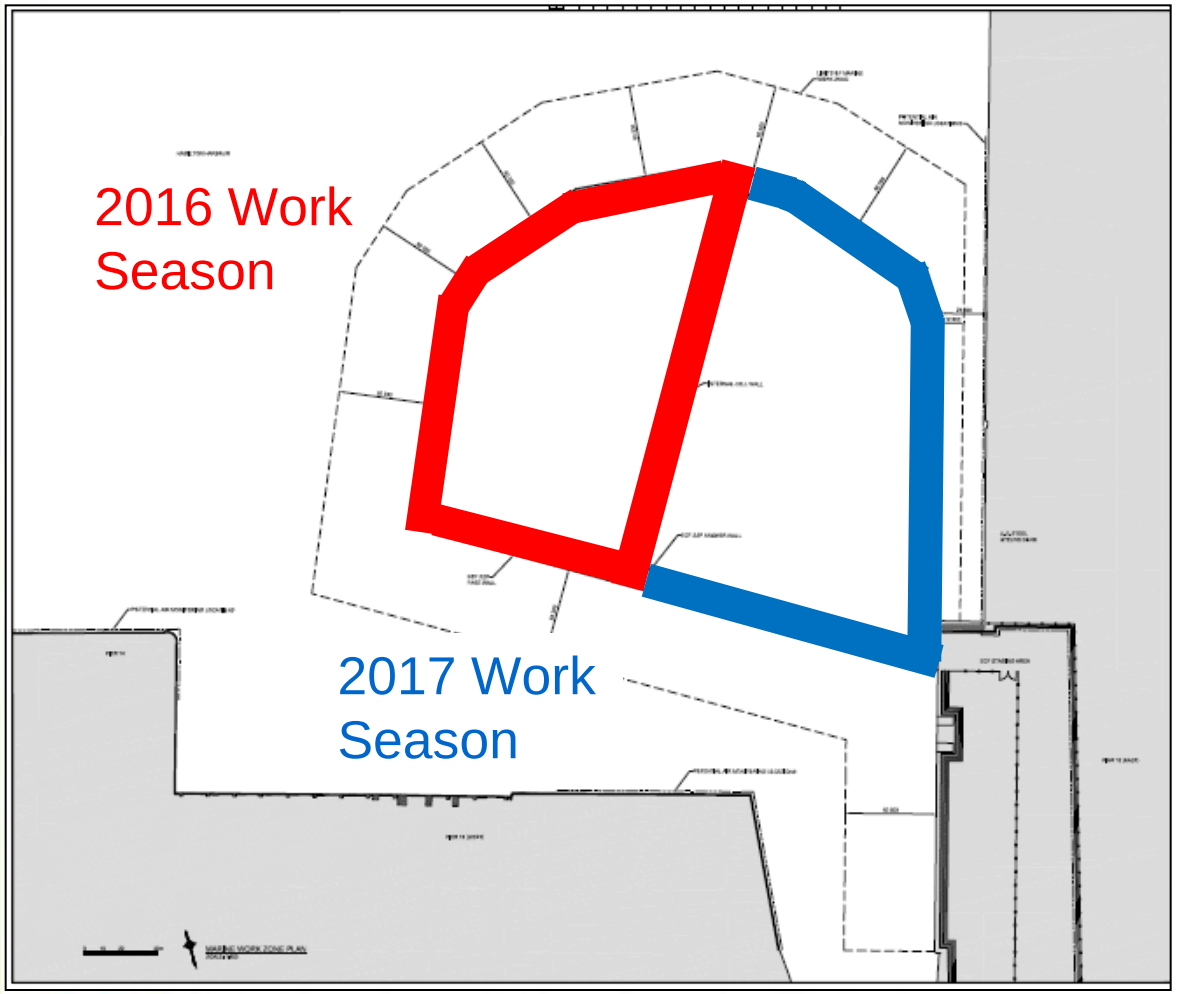
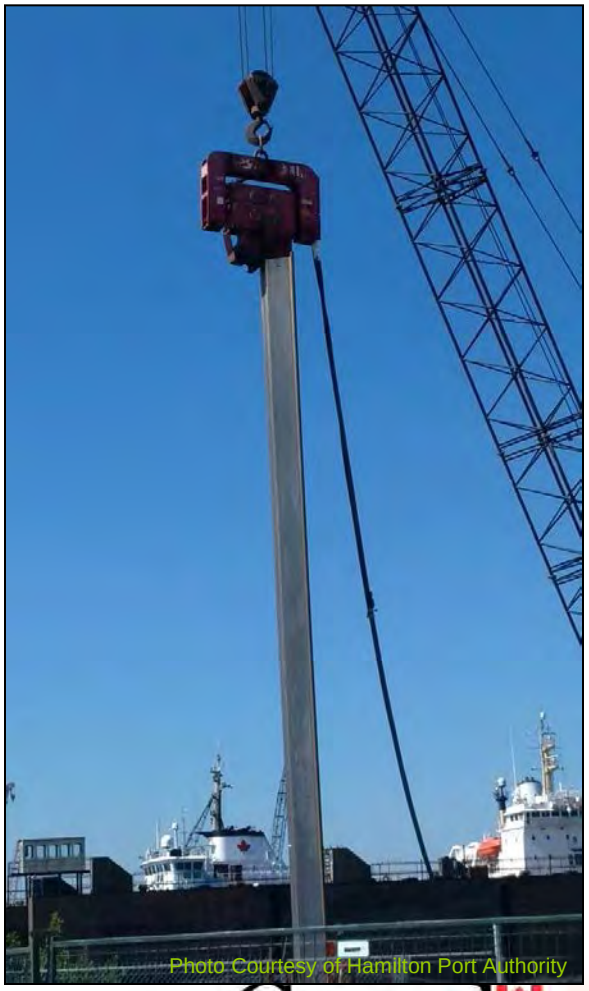
Stage 1 ECF Construction





Isolation Structure

A double steel sheetpile wall with sealed interlocks along the interior wall

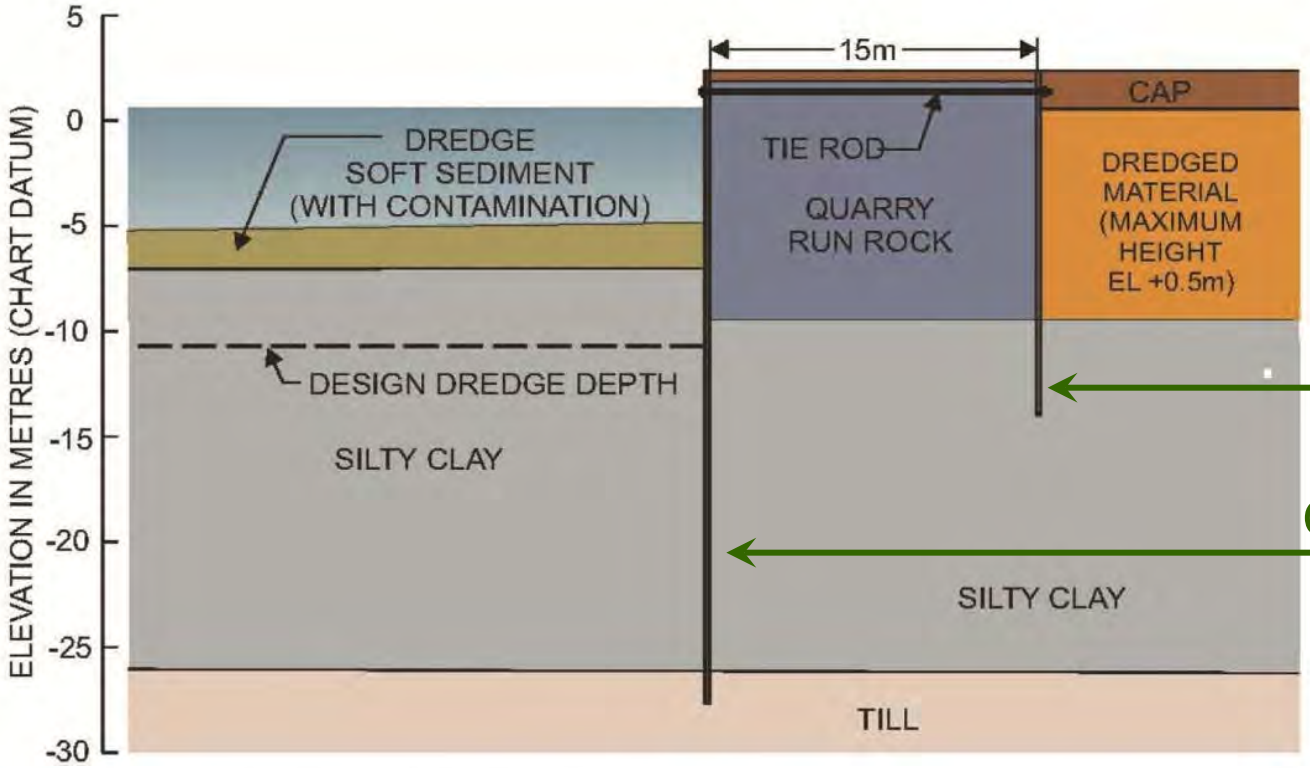


Photo Courtesy of Birmingham Foundation Solutions

Double Sheet Pile Wall Installation

Progression of Sheet Pile Installation

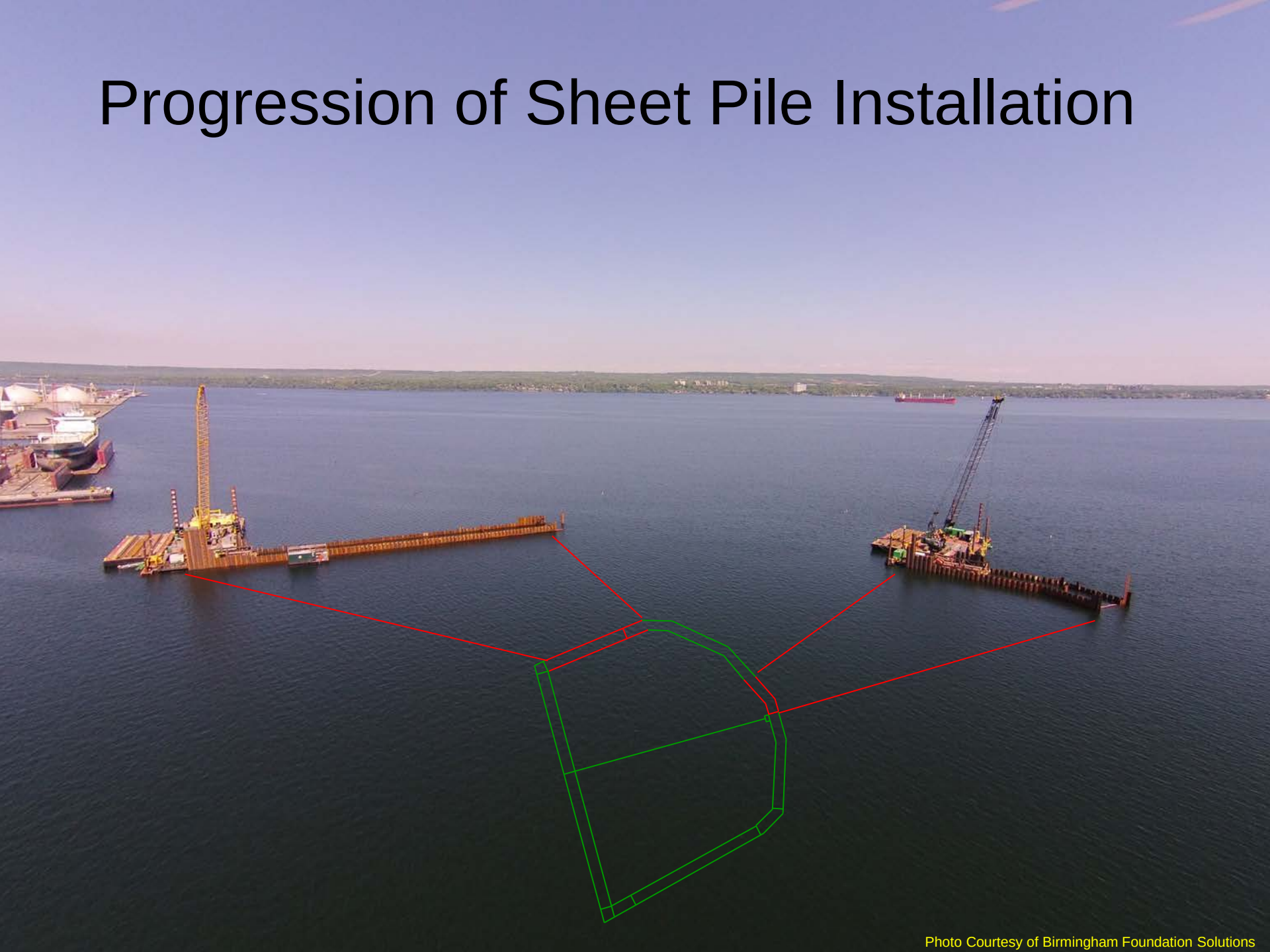
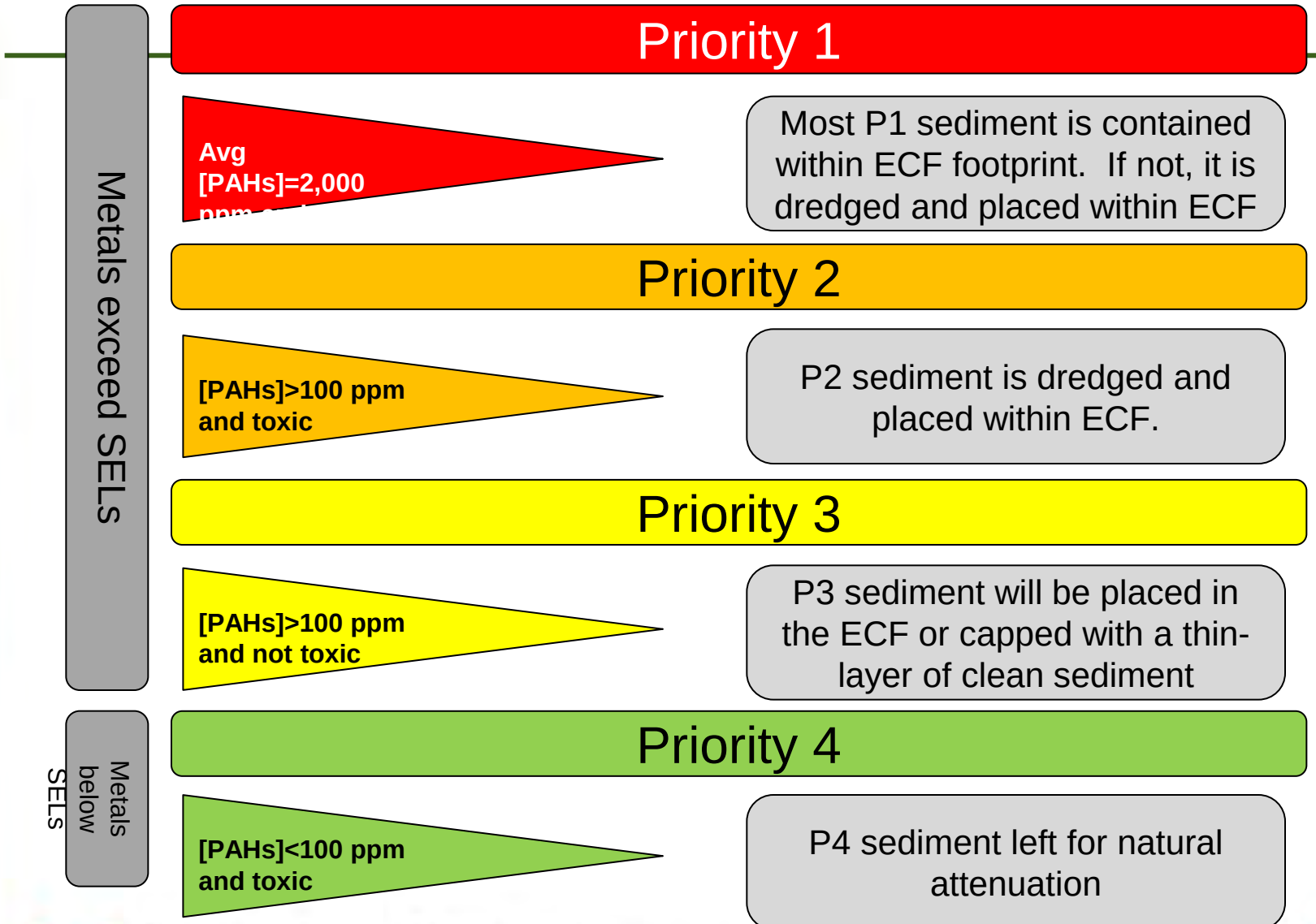
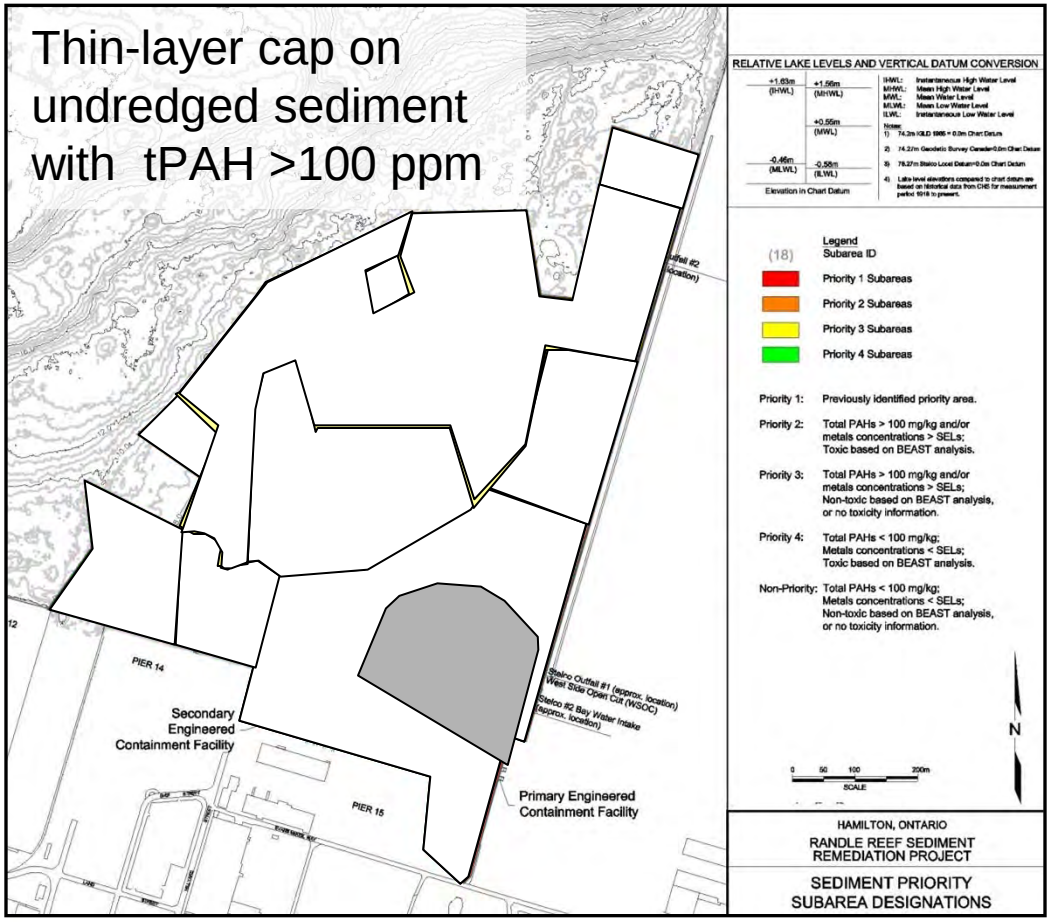


Photo Courtesy of Birmingham Foundation Solutions

Approach to Remediate Sediment



Stage 2: Dredging/Capping Sequence

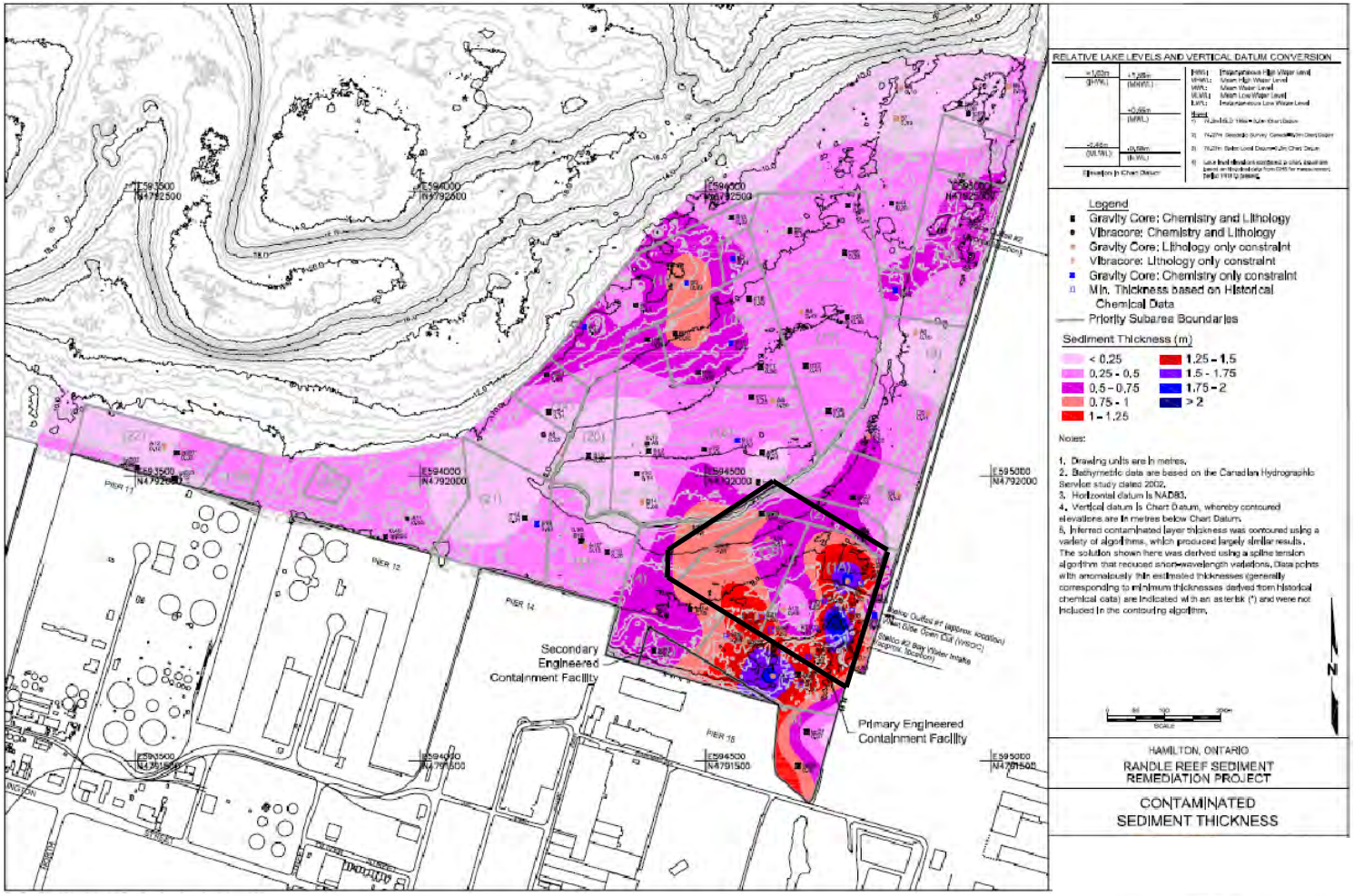


PAH Mass Distribution

Subarea	Priority Designation	Volume (m^3)	Average [Total PAHs] (ug/g)	Mass of PAHs for a Subarea (kg)	Percentage of PAHs in a Subarea Compared to the Site (%)	Cumulative Percentage of PAH (%)
1	1	130,000	6,340	1,318,720	72.3	72.3
2a (soft sediments)	1	23,412	367	13,744	0.8	73.1
2b (clay)	1	42,099	0	0	0.0	73.1
3	1	39,802	3,975	253,122	13.9	87.0
4	1	33,144	325	17,256	0.9	87.9
5	1	8,040	139	1,784	0.1	88.0
6	1	5,655	4,021	36,380	2.0	90.0
7	1	15,449	204	5,038	0.3	90.3
8	1	24,924	283	11,278	0.6	90.9
9	2	31,966	1,747	89,330	4.9	95.8
10	2	9,351	107	1,593	0.1	95.9
11	2	26,850	69	2,969	0.2	96.1
12	2	74,713	62	7,447	0.4	96.5
13	2	5,124	145	1,187	0.1	96.5
14	2	10,299	28	458	0.0	96.6
15	2	6,722	49	526	0.0	96.6
16	3	28,321	283	12,810	0.7	97.3
17	3	74,296	315	37,398	2.1	99.3
18	3	34,704	71	3,920	0.2	99.6
19	3	42,461	80	5,415	0.3	99.9
20	3	20,484	50	1,629	0.1	99.9
21	4	26,770	18	775	0.0	100.0
22	4	13,983	8	181	0.0	100.0
23	4	2,331	5	19	0.0	100.0
Total		730,899		1,822,978	100.0	

ECF Full

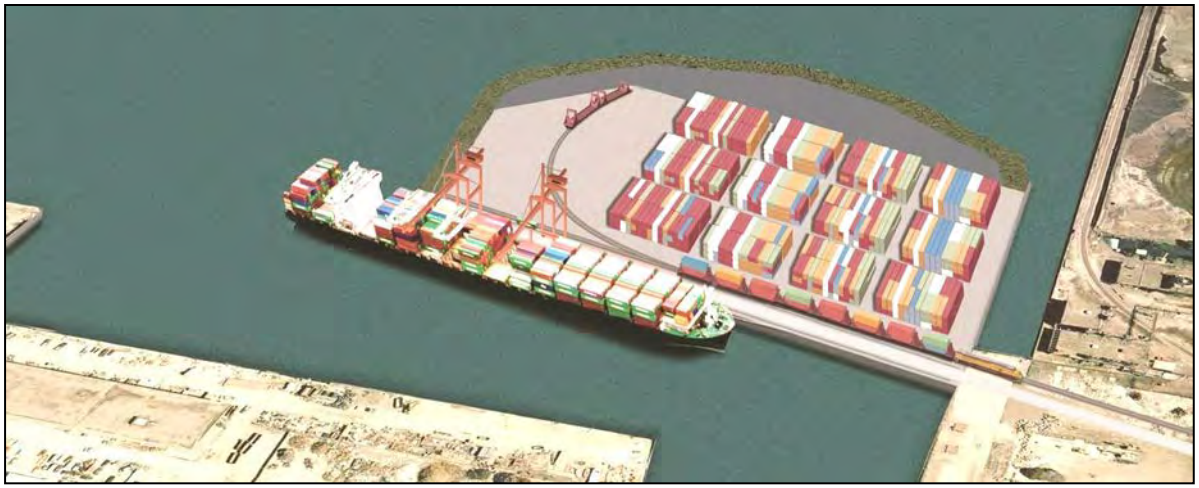
Sediment Thickness Layer



Dredging Design

➢Dredging Challenges:

- Dredging of firm clay;
- Volatile air emissions management;
- Finite capacity of the ECF;
- Dredging offsets from existing dock walls;
- Dredging prohibitive in one section due to existing infrastructure.



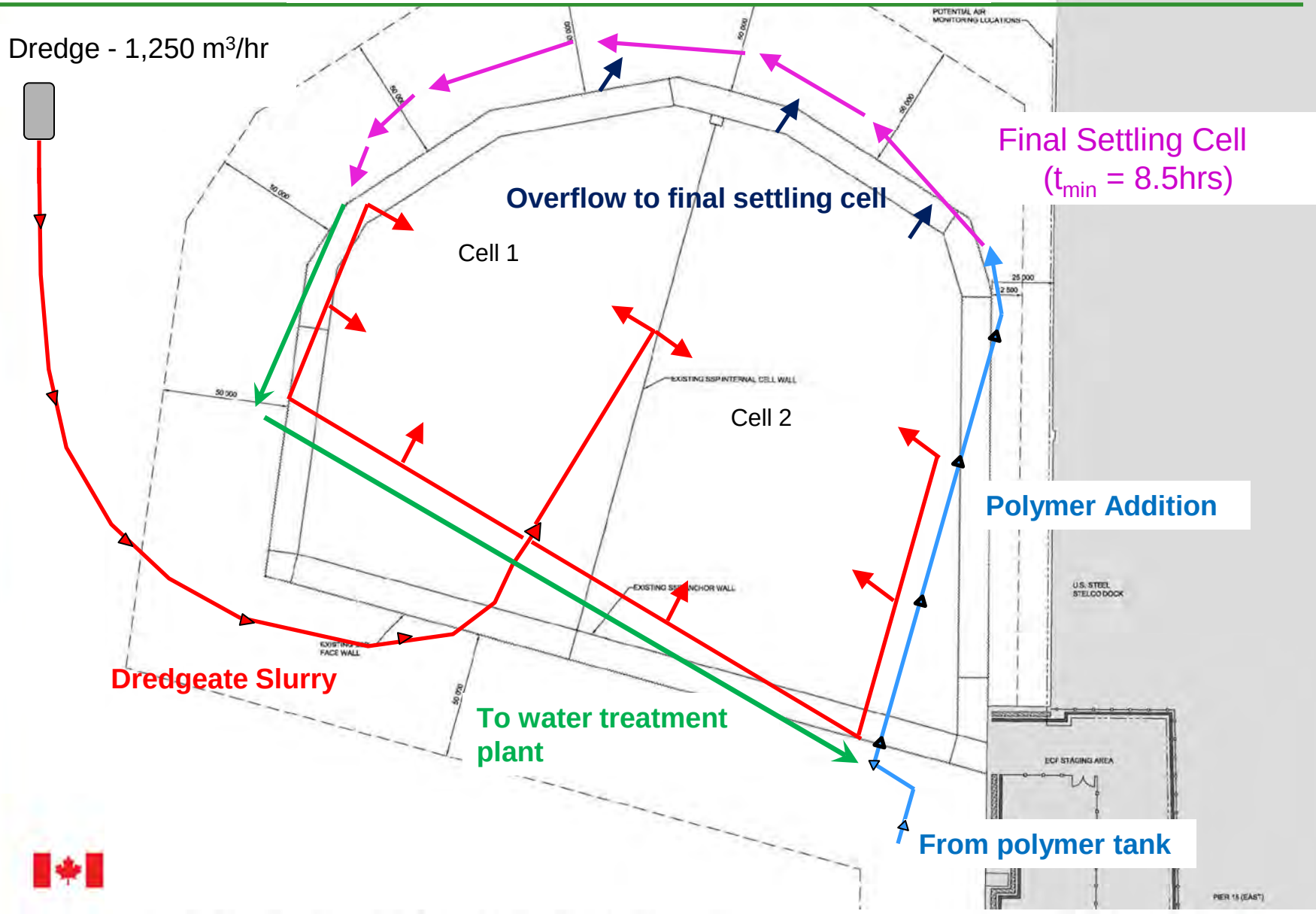
5 Phases of Dredging:

1. **Mechanical dredging** between the double sheet pile walls to remove contaminated sediments.
1. **Mechanical dredging** of clay from between the double sheet pile walls to accommodate the structural design.
1. **Hydraulic dredging** of contaminated sediments down to the underlying clay in Priority 1 and 2 areas.
1. **Hydraulic dredging** of contaminated sediments down to an established clean line in Priority 3 areas.
1. **Second pass dredging** in all dredged areas to address any remaining residual contamination.

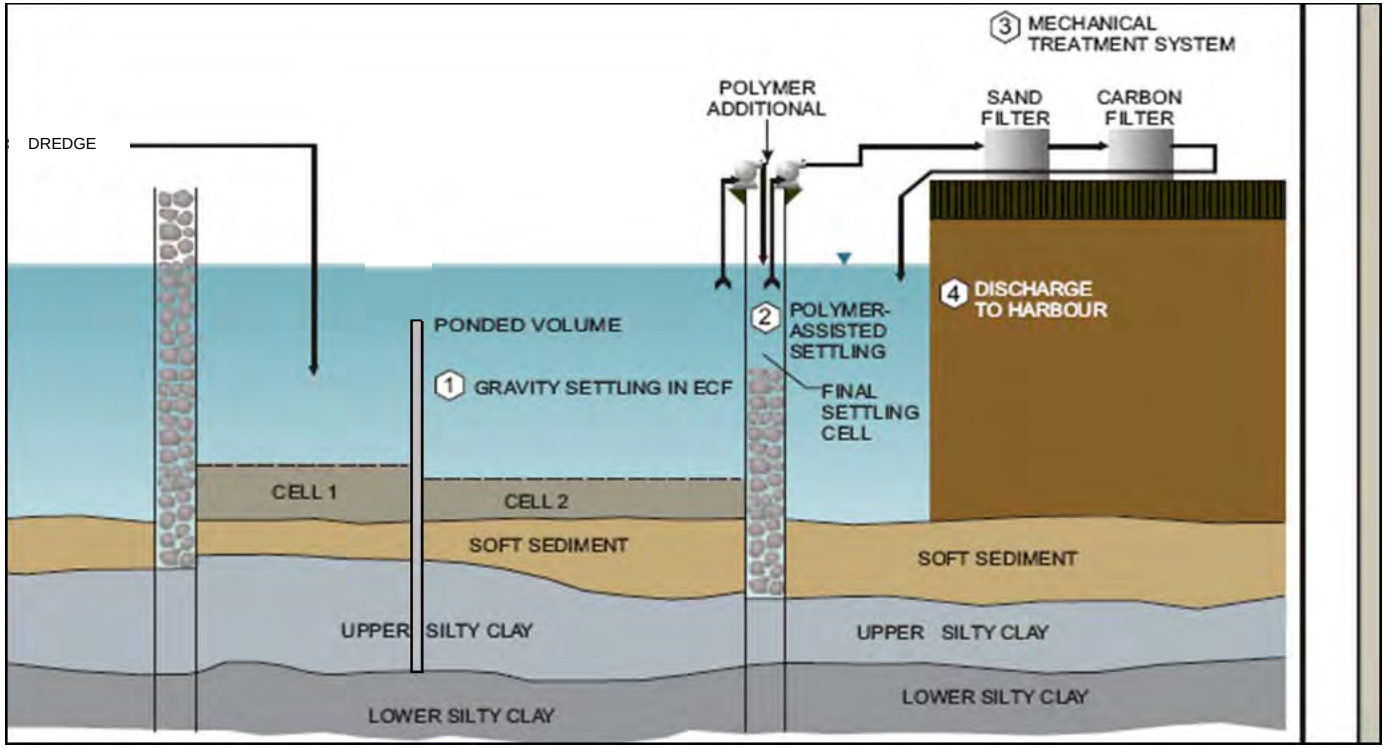
Stage 2: Thin Layer Backfill/Capping

- Place a thin-layer cover of sand to backfill areas with PAH concentrations at or above 100 ppm
  a) Thin-layer cap will be between 8 & 16 cm in thickness and
  b) Capping is proposed to occur in two separate lifts of approximately 8 cm.

Dredgeate Management



Production Dredging – Dredgeate Management

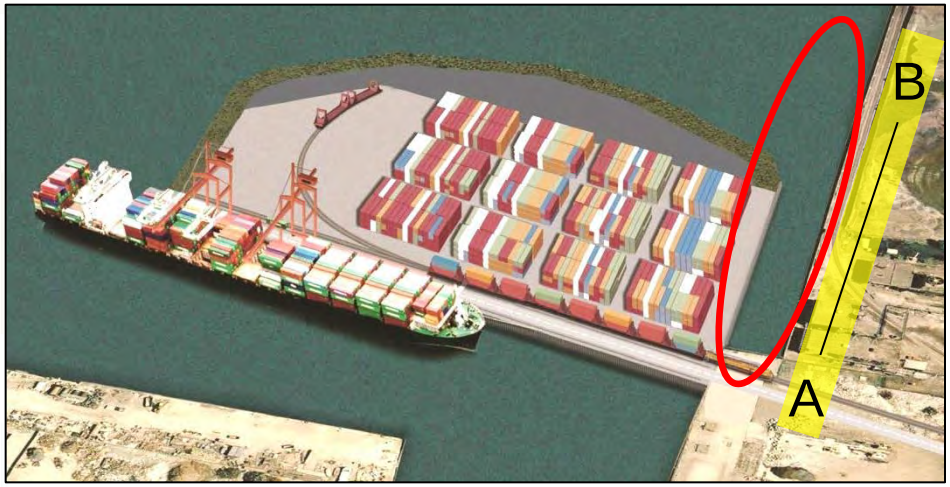


1. Gravity settling of decant water within the ECF
2. Polymer-assisted settling in a final settling cell (area between the walls)
3. Additional treatment using sand filtration and (GAC) adsorption
4. Discharge to Hamilton Harbour

Water Treatment

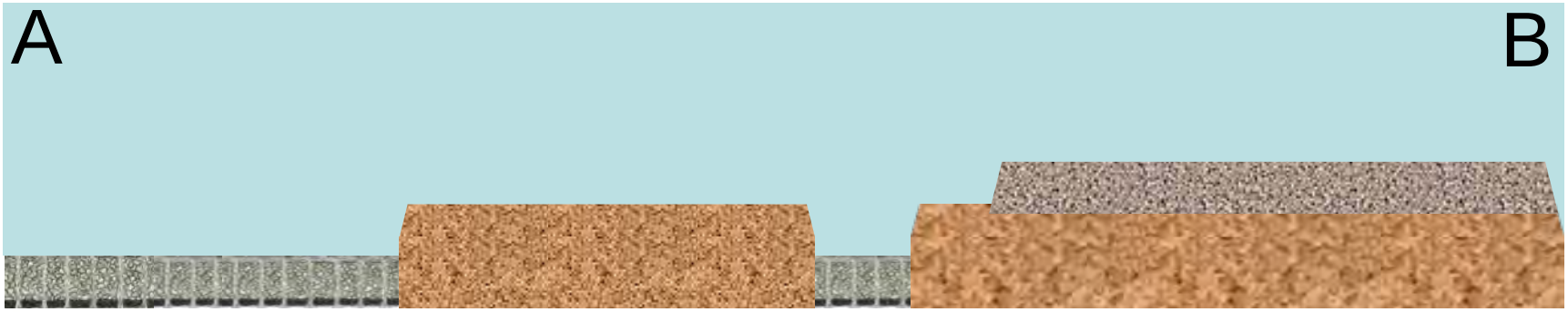
- Water will be treated through a series of filters prior to discharge into Hamilton Harbour

Isolation Cap Design



US Steel Channel

Accommodates intakes and dock wall stability concerns



Reactive Core Mat

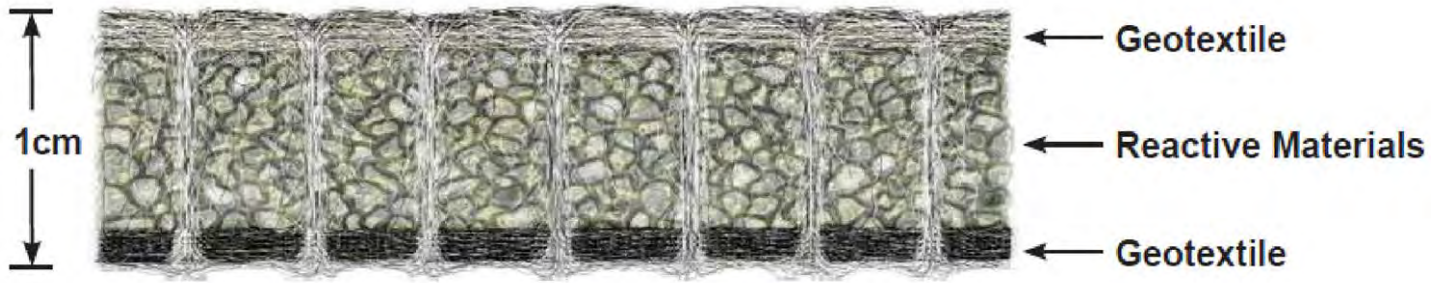
Amended Sand Cap

Amended Sand Cap with Armour Stone

U.S. Steel Channel Capping

Striker Bay Duluth, MN

- Reactive Core Mats in inflow/outfall areas
- Significantly thinner than traditional cap

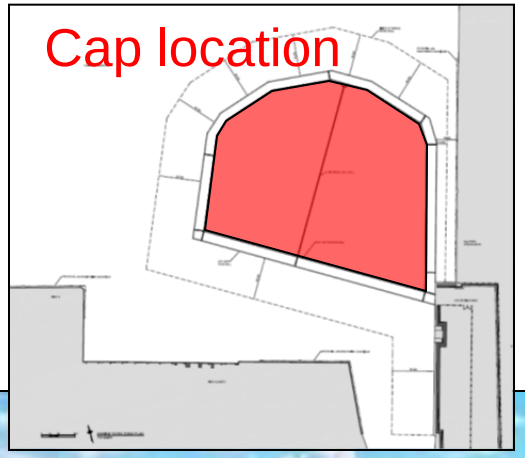


Stage 3: Installation of ECF Cap

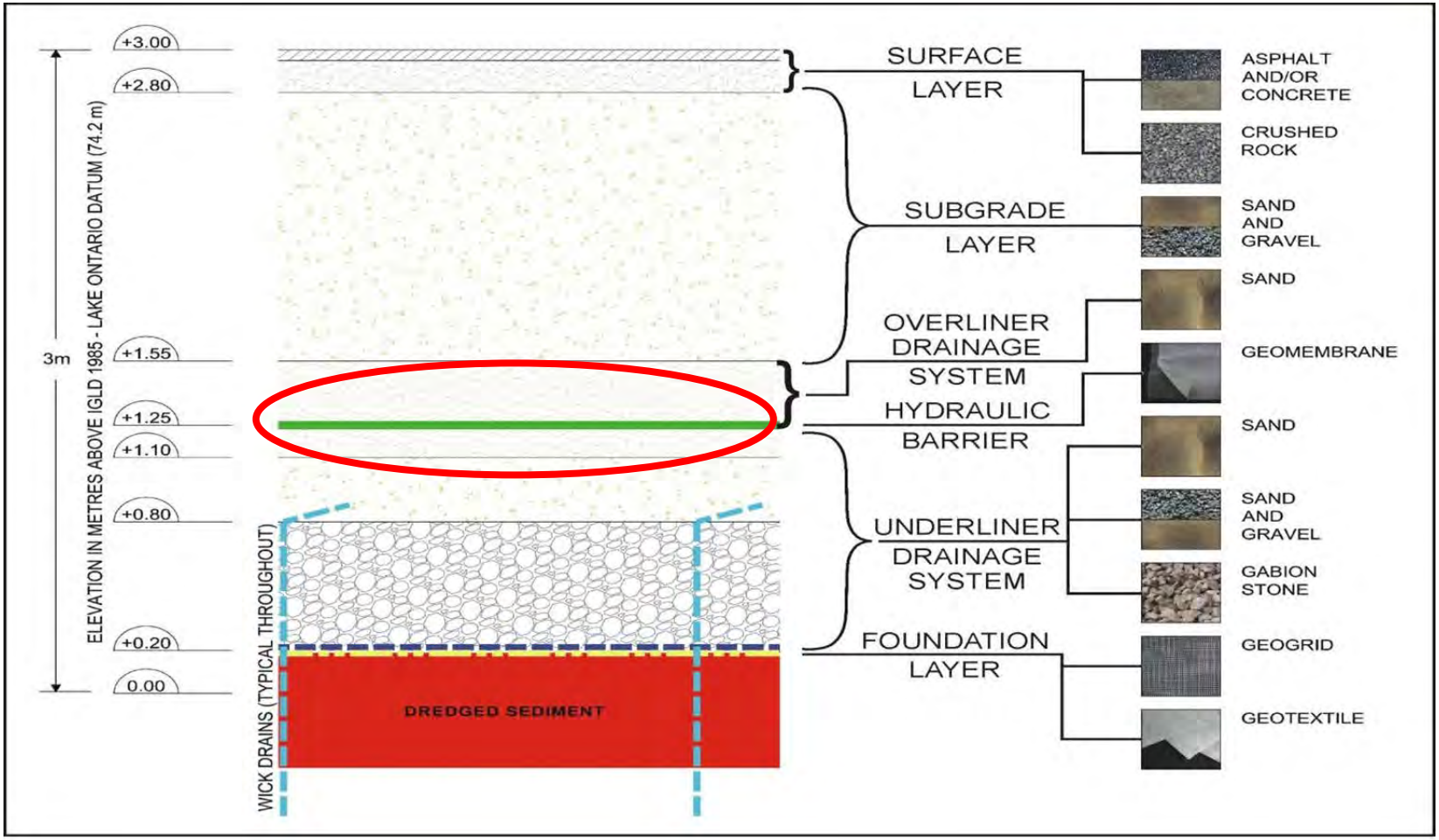
- The ECF capping system will consist of several layers:

  1. Foundation layer
  2. Underliner drainage system
  3. Hydraulic barrier layer
  4. Overliner drainage system
  5. Paved surface
  6. Stormwater management systems

- Cap thickness ~3m

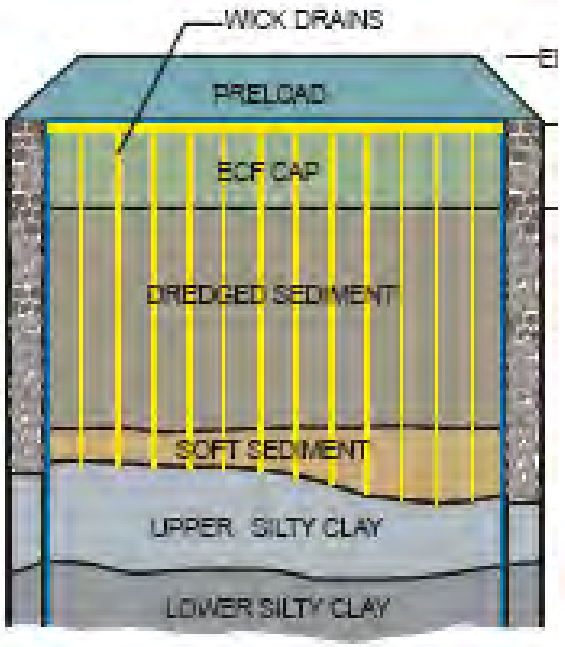


Randle Reef ECF Cap – Multiple Layers



Installation of ECF Cap

- A ‘preload’ of 400,000 tonnes will be placed on the cap;
- Wick drains will be used to increase the rate of consolidation and shorten the necessary ‘preload’ duration;
- Approximately 11,500 wick drains will be installed (4’’x 1.5’’x 33’);
- It is anticipated that the “preload” will be in place for approx. 1 year and then removed.



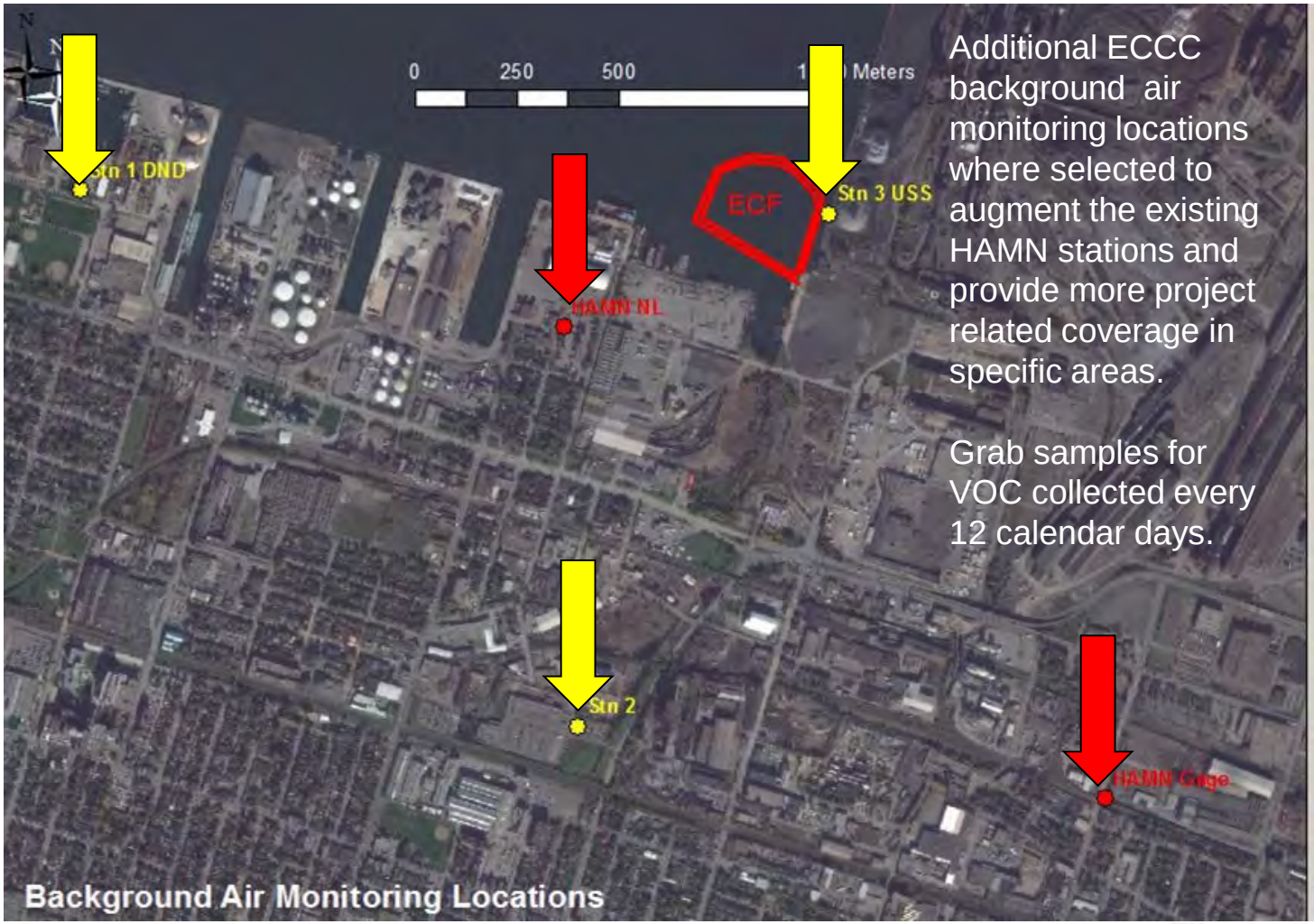
Randle Reef Sediment Remediation Project

Monitoring Programs

Randle Reef Air Monitoring Programs

- **Background Air Monitoring:** This has been conducted in 2014 and 2015 by Environment Canada to establish an accurate account of current air quality conditions around the Randle Reef site. Background air monitoring will continue on thorough implementation of the project.
- **Project Air Monitoring:** This will take place during project activities and will be conducted by the project air specialist. Both constant real time monitoring and periodic grab samples are included.
- **Contractor Health and Safety Monitoring:** The construction contractor will monitor air quality within the confines of the work area to ensure the safety of workers on the site.
- **Odour Monitoring:** This will be conducted by the project air specialist. Baseline odours will be established. Complaints will trigger odour and air quality sampling.

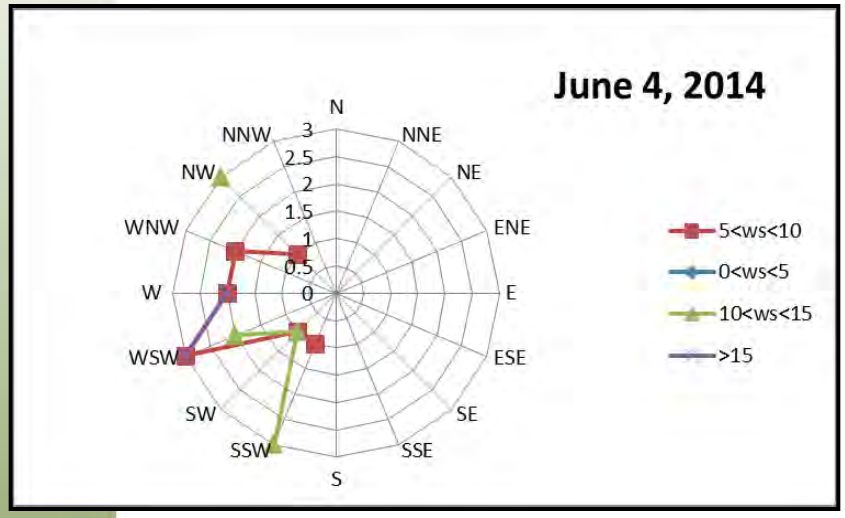
Background Air Monitoring



Additional ECCC background air monitoring locations where selected to augment the existing HAMN stations and provide more project related coverage in specific areas.

Grab samples for VOC collected every 12 calendar days.

Background Air Monitoring



Sample location	EC 1, DND	EC 2, Ham		EC 3, USS	AAQC
Canister ID	EPS 800	EPS 805	EPS 561	EPS 764	
Sample Volume (mL)	500	500	500	500	
Benzene	1.59	0.30	0.46	0.37	2.3
Toluene	4.57	1.02	1.45	1.63	2,000*
Ethyl benzene	2.07	0.32	0.66	0.22	1,000
m,p-Xylene	3.52	1.14	1.58	0.61	730
o-Xylene	2.70	0.40	0.90	0.26	
Naphthalene	0.46	0.17	0.21	0.16	22.5

Mitigation Measures

Mechanical dredging during Stage 1 is limited to a 12 hour shift. Further mitigation measures will be implemented if required, these could include:

- altered work activities such as changing locations, changing tasks or slowing work until conditions change.
- odour/emission suppressors, such as foams, if required.
- Stopping work until conditions change.

Odour Monitoring

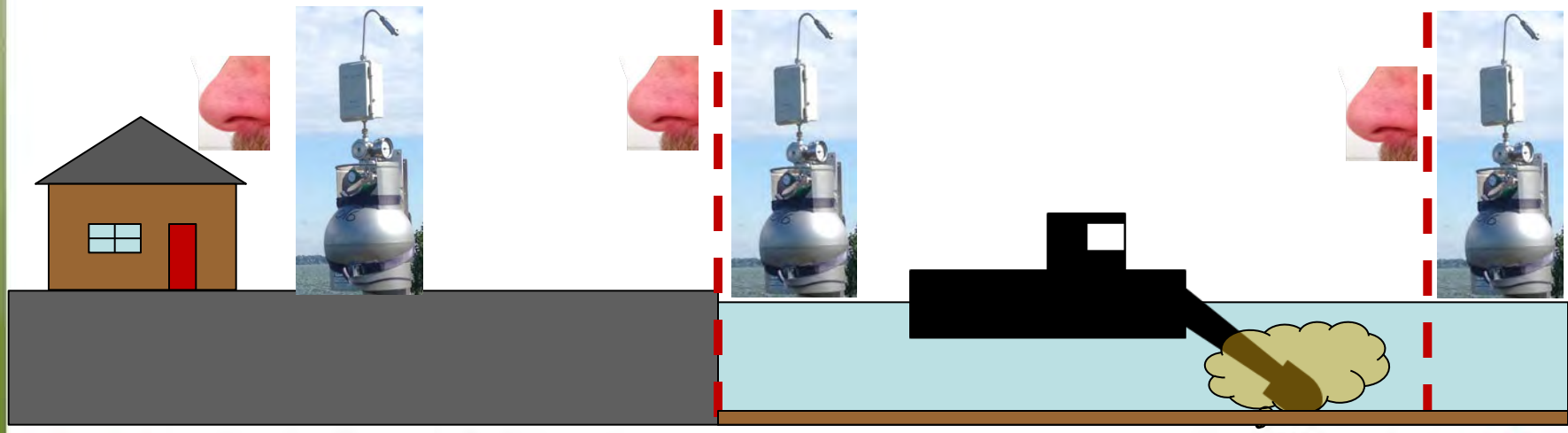
- If an odor complaint is received both **odour samples** and **air samples** (for chemical analysis) would be collected at three locations.

Wind direction

#1 at the receptor where the complaint was noted.

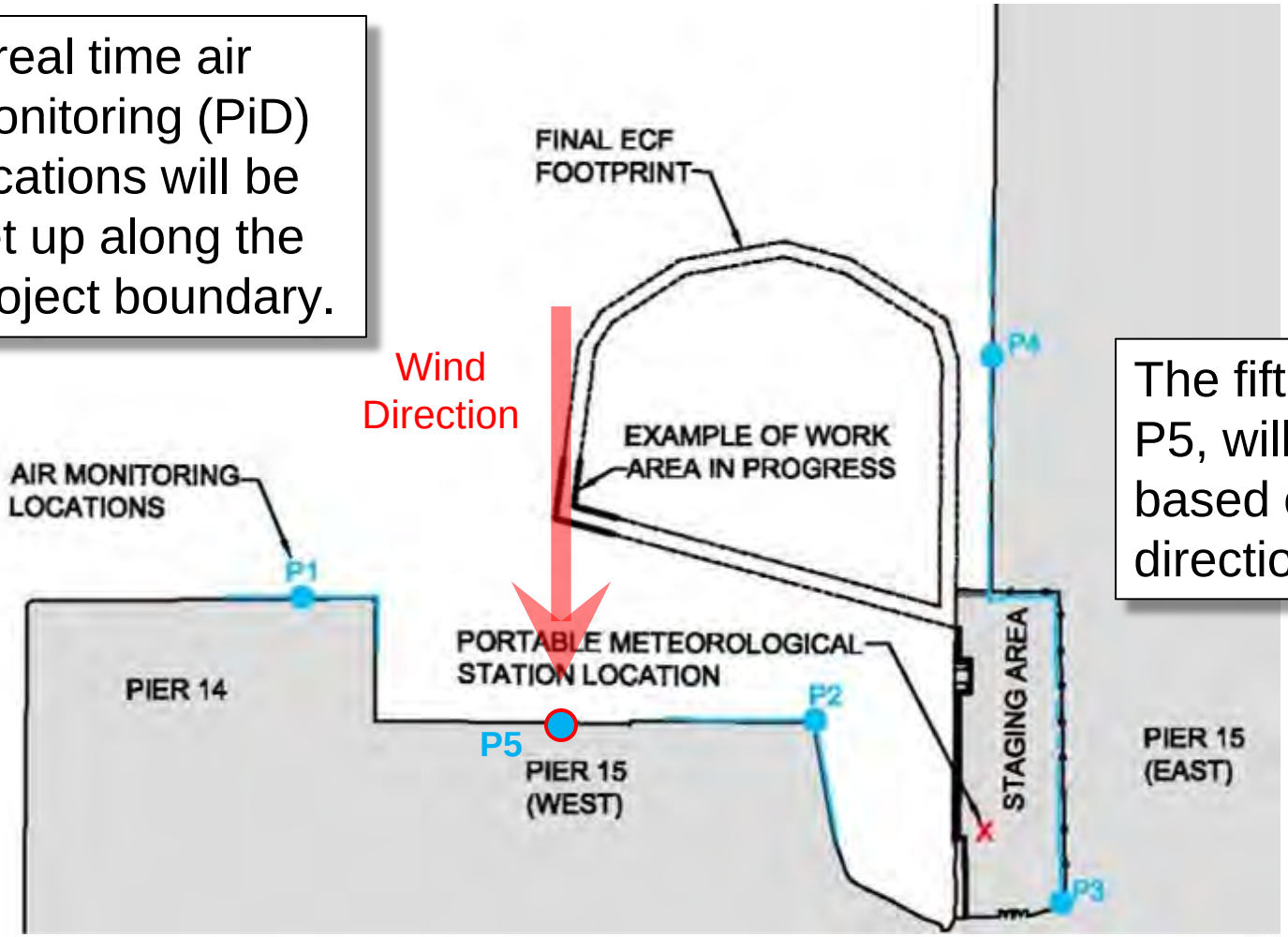
#2 at the site boundary between receptor and project activity.

#3 at the site boundary upwind of the project activity.



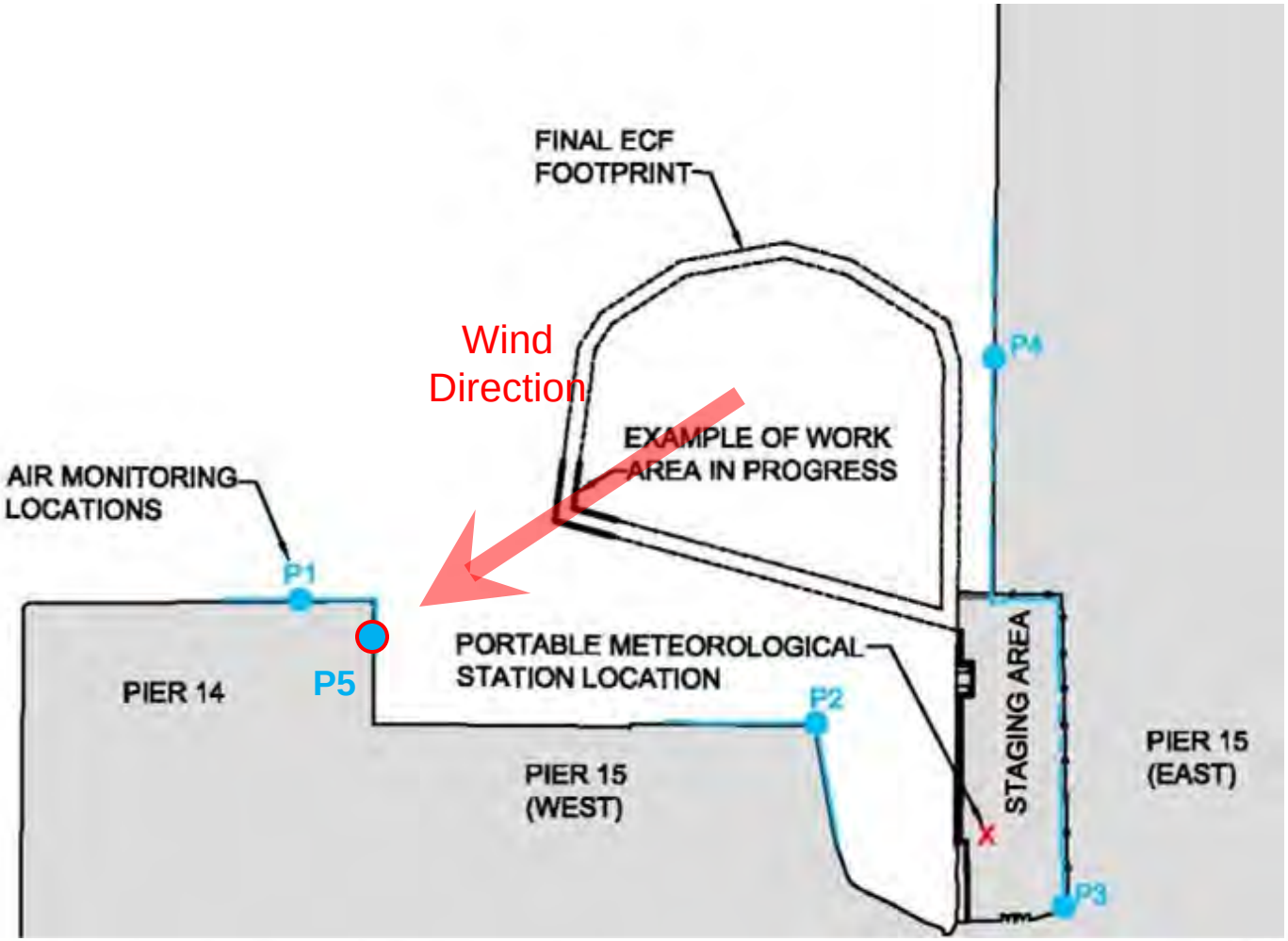
Air Monitoring Program

5 real time air monitoring (PiD) locations will be set up along the project boundary.

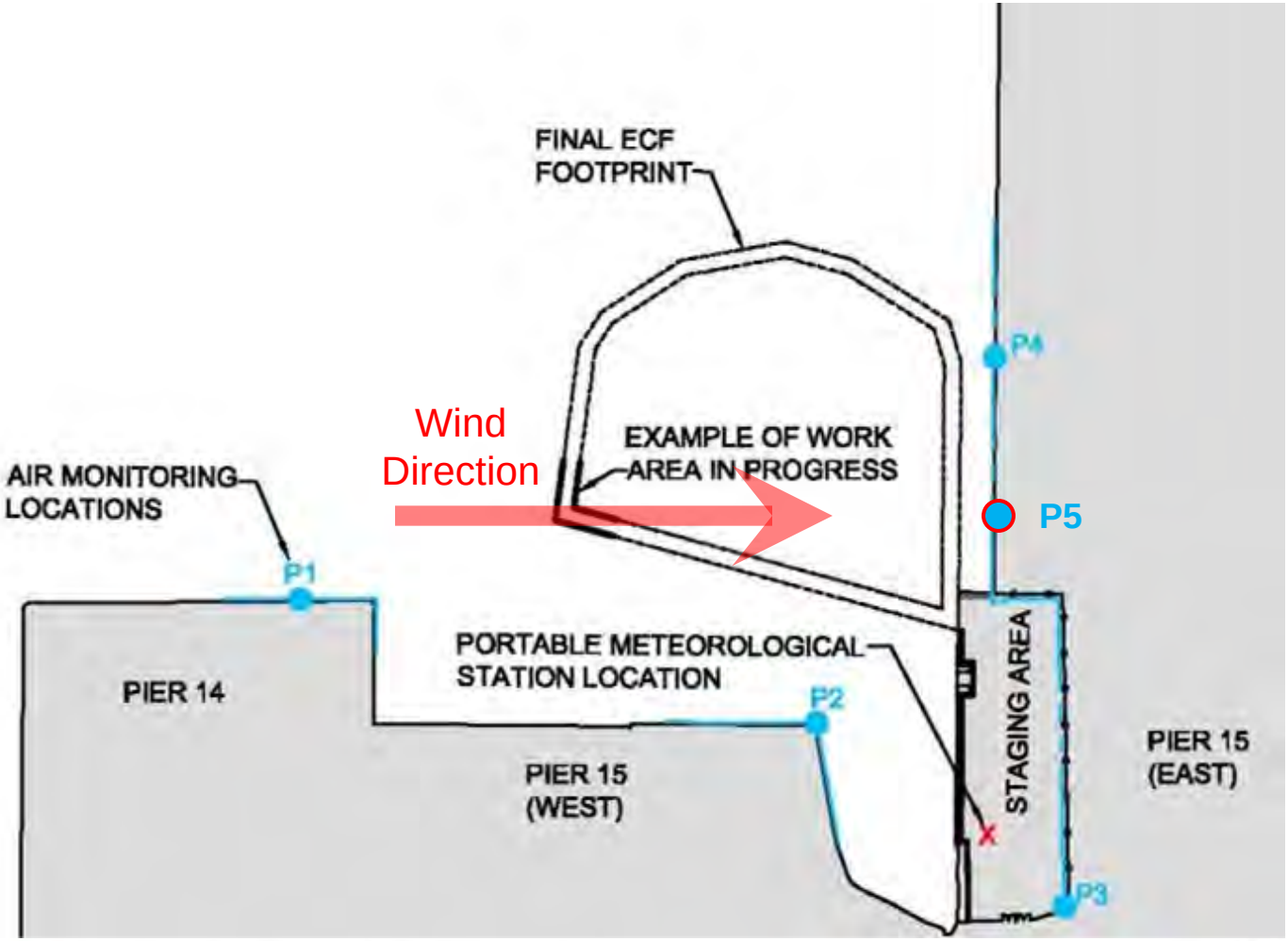


The fifth location P5, will shift based on wind direction.

Air Monitoring Program



Air Monitoring Program



Sediment Verification Sampling

Once the depths are confirmed, sediment is sampled in order to verify the new sediment surface meets the 100 ppm total PAH clean-up criteria. Sample results will determine the next step:

- Verifying the area meets criteria.
- Identifying residuals are present to be capped.
- Identifying the need for further dredging.

Site Specific Criteria

TSS is required to be no more than 25 mg/L above background levels, 100 m from in-water work

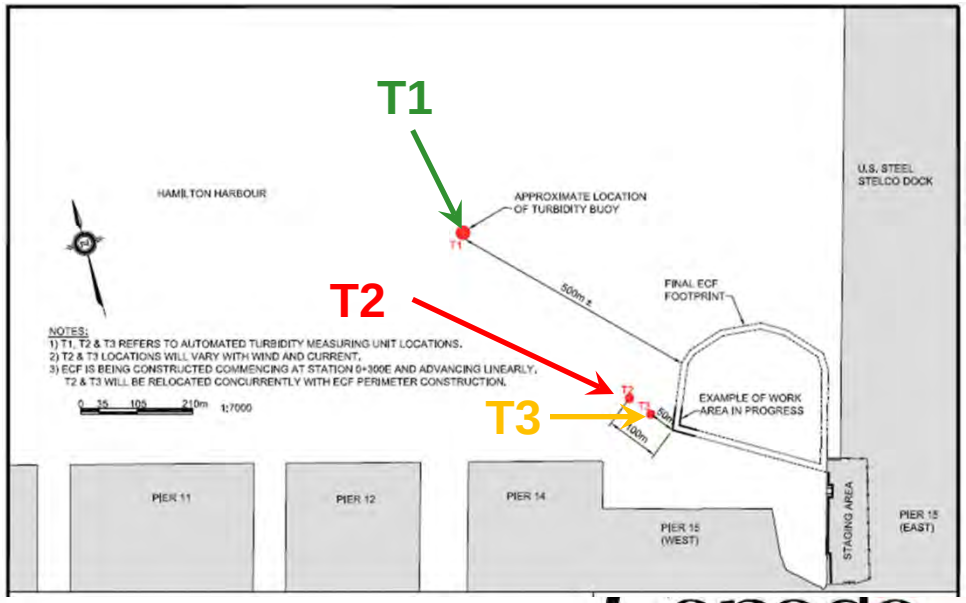
- Site specific TSS-Turbidity relationship indicates 2 mg/L TSS is equivalent to 1 NTU

∴ Site specific criteria is equivalent to:

Turbidity is required to be no more than 12 NTUs above background levels, 100 m from in-water work

Sampling Overview

- 4 sets of sampling equipment:
  - T1 – provides continuous **background** turbidity monitoring
  - T2 – provides continuous **compliance** turbidity monitoring
  - T3 – provides continuous **sentinel** point turbidity monitoring
  - T4 – provides periodic monitoring at any location



Daily Background Criterion

Turbidity is required to be no more than 12 NTUs above background levels, 100 m from in-water work

- Criterion provided daily by site engineer
- may be previous weeks average or discrete sample – depending on site conditions each day

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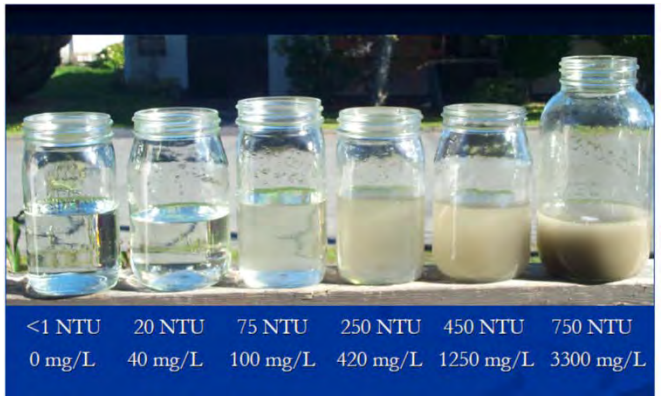
- In rare case where background TSS exceeds 60 mg/L (30 NTUs), the maximum allowable cumulative TSS will be 85 mg/L (42 NTUs)
- Average background turbidity in harbour ranges between 1 and 8 NTUs

Maximum Allowable Turbidity – Summary

Turbidity Measurements Above Background Levels



50 NTUs

Maximum Allowable if Background >30 NTUs

42 NTUs

25 NTUs

Maximum (T2)

18 NTUs

Action Trigger (T3)

13 NTUs

Background (T1)

8 NTUs

6 NTUs

0 NTUs

7 NTUs Root Cause Investigation Initiated – Work Altered

12 NTUs Work Stops

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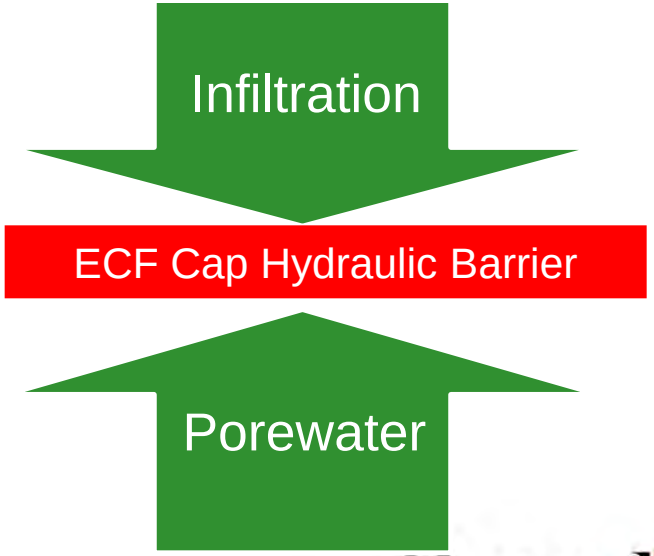
Post-Remediation Monitoring

- Isolation cap
- Thin layer backfill
- Perimeter monitoring wells

- Overliner drainage
- Underliner drainage



ECF Long Term Monitoring

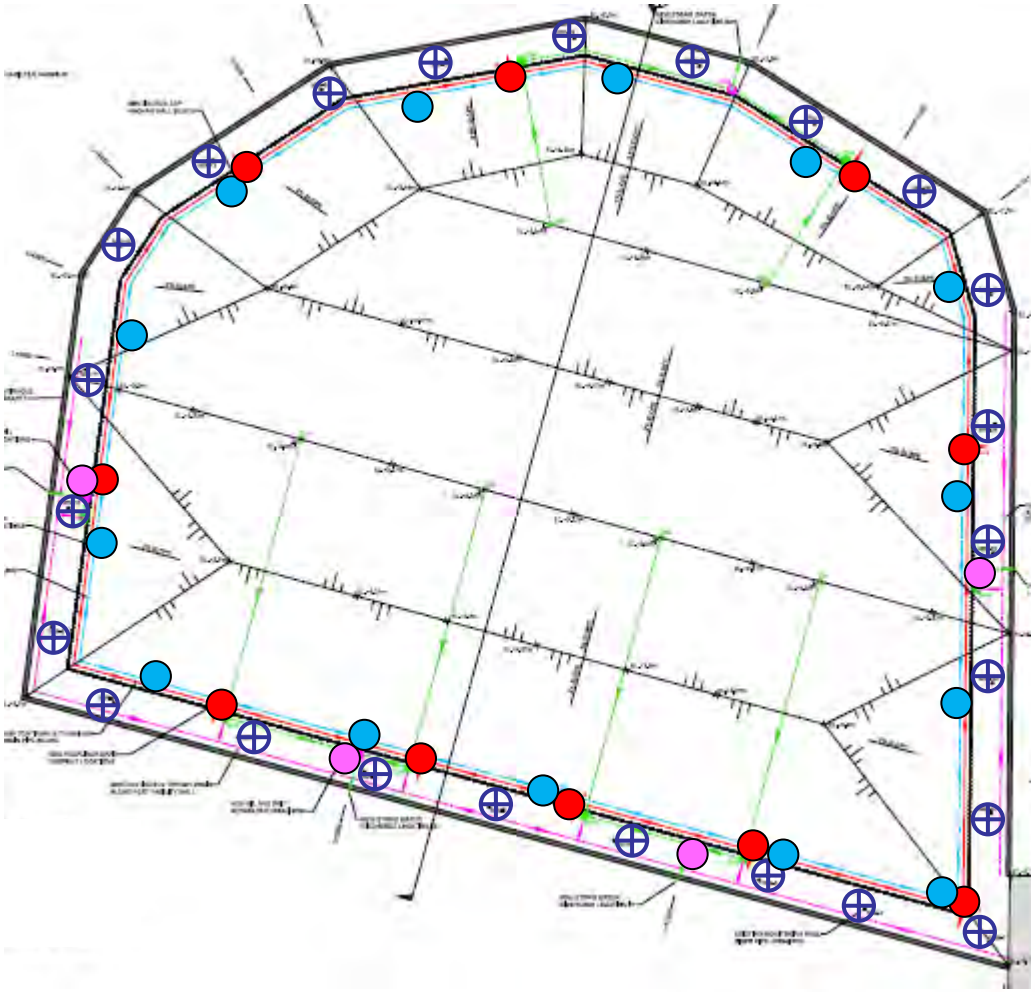
Sampling Locations

⊕ Monitoring wells outside sealed wall

● Overliner pipes from above the FML barrier

● Underliner pipes from below FML barrier

● Oil and grit separators for surface water



Assessing the Effectiveness of the Randle Reef Clean Up

- PAH concentrations & profiles in suspended sediments.
- Sediment toxicity & benthic invertebrate community structure.
- Larval & embryo deformities in fish exposed to PAHs.
- Wild fish health endpoints.
- Tumours & external abnormalities in wild fish.

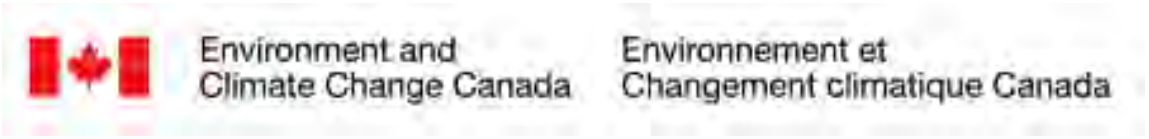
Construction Schedule

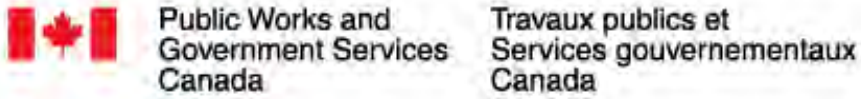
Stage 1
- ECF Construction
- 2015 to 2017

Stage 2
- Dredging
- 2018 to 2019

Stage 3
- Capping & Consolidation
- 2019 to 2022

Acknowledgements





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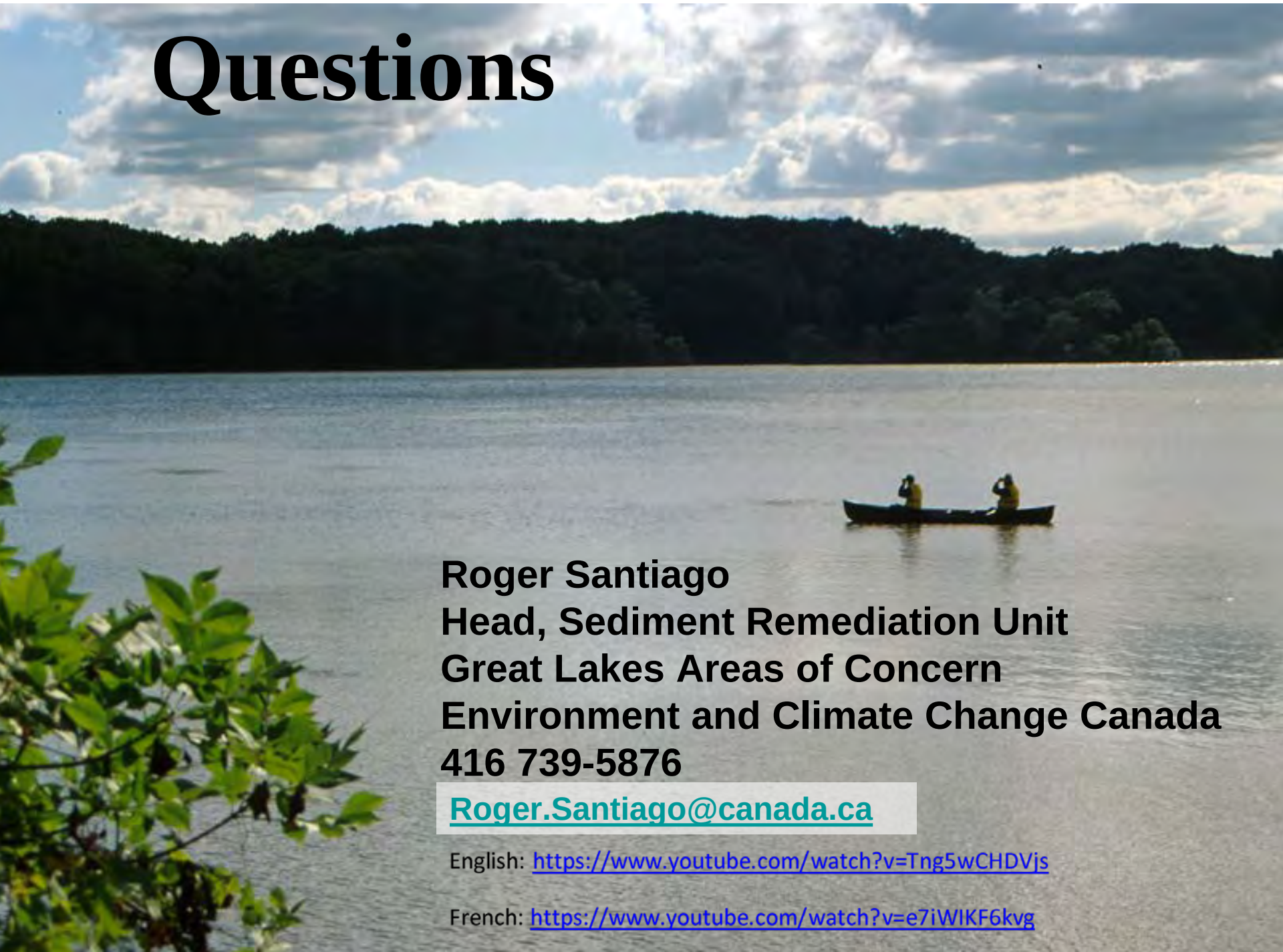
Canada

Questions



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English: https://www.youtube.com/watch?v=Tng5wCHDVjs

French: https://www.youtube.com/watch?v=e7iWIKF6kvg