Environmental Effects Monitoring in Sydney Harbour During Remediation of One of Canada’s Most Polluted Sites: A Review and Lessons Learned

Tony Walker, PhD, EP
Overview

- Why Conduct Environmental Effects Monitoring (EEM)?
- Implementation of Marine EEM Program (MEEMP)
- Review of MEEMP Findings
- Changes to MEEMP
- Lessons Learned
Monitoring Effects of Remediation

- Environmental Impact Statement (EIS) & Joint Review Panel (JRP) concluded
  - “Remediation unlikely to cause significant negative environmental impacts with implementation of appropriate mitigation”

- EEM program designed to
  - Determine effectiveness of mitigation
  - Verify effects predictions made in EIS
  - Designed to assess positive / negative changes potentially attributed to remediation

- EEM program reviewed by key federal & provincial departments
  - GW monitoring
  - SW monitoring
  - Marine EEM Program (MEEMP)

- Continuous improvements made to MEEMP
  - Lessons learned
Marine EEM Program

- **Water Quality (WQ)**
  - 24h auto sampler
  - Water grabs (surface & near bottom)

- **Mussel Tissue**

- **Sediment Quality**
  - Sediment Chemistry (grabs & traps)

- **Crab Hepatopancreas Tissue**

- **Benthic Community**
  - Inter-tidal (5 transects using quadrats)
  - Sub-tidal (sieve analysis for benthic invertebrates)

Detection of changes

- **Short term**

- **Long term**
Marine EEM Sampling

- **Spatial & temporal sampling**
- **Stations - 9**
  - Area 1 – Near-field
  - Area 2 – Mid-field
  - Area 3 – Far-field/reference
  - Area 4 – Sydney River Estuary
- **Sampling**
  - 2009 baseline
  - 2010 1st yr remediation
  - 2011 2nd yr remediation
  - 2012 3rd yr remediation
- **Changes to MEEMP**
  - Added 2 more stations
Monthly 24h auto-seawater composites
Monthly water grabs (surface & near bottom) at all harbour stations
Parameters
- Total Suspended Solids (TSS)
- Total Organic Carbon (TOC)
- General chemistry
- PAHs & PCBs
- Metals
USEPA 95% upper confidence limits (UCL95) calculated for site specific baseline WQ data
WQ: TSS 24H Auto

- Highest [TSS] observed during baseline
- Peaks correlated to rainfall events NOT remediation
- Overall [TSS] low close to reportable detection limits, RDLs (2 mg/L)
Some regulators requested termination of WQ monitoring program because of lack of detections of many parameters.
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Non Detect Problems: WQ
Non Detect Problems: WQ

- **Non detects**
  - Many WQ parameters <RDLs
  - <RDLs make determination of *positive* or *negative* temporal changes difficult

- **Some metals had increased RDL values up to 10x**
  - Cu = 2, 4, 10, 20 µg/L

- **Different approaches for using non detect data**
  - Common approach uses $\frac{1}{2}$RDL value as substitution
  - Robust method - assumes normal distribution of data
  - Replace <RDL value with zero - biased low
  - Replace <RDL value *actual RDL* - biased high

- **US EPA UCL95 includes WQ data with <RDLs**

- **Changes to MEEMP**
  - Used *actual RDL value* to be overly conservative
  - Argued for *continuance of WQ monitoring* to detect potential contaminant releases
Sediment Quality: PAHs

- Significant increase in PAHs in Yr 1
  - Some agencies called for termination of remediation after 1st year (Premature?)

- Subsequent monitoring showed a continued decrease in PAHs
  - Not significantly different from baseline
  - Within predicted ranges reported by Smith et al. (2009)

- EIS prediction of no significant environmental impacts in SH confirmed?
Sediment Quality: Pb

- Little spatial / temporal variation
- Within predicted [Pb] ranges reported by Smith et al. (2009)
- Highest [Pb] measured at 1-2 & Coal 2
### Sediment Quality: Metals

#### Little apparent temporal variation

- Some metals may show subtle decreases (e.g., Hg, Pb & Zn)?
- EIS prediction of no significant environmental impacts in SH confirmed?
Heavy Metal(s) Lives On!
Sediment Quality: Grainsize

Year 1: >75% Silt/Clay
Changes in composition likely due to harbour dredging – now similar to baseline

Year 2: <30% Silt/Clay
Dramatic changes in composition possibly from uncovering event(s)

Year 3: >75% Silt/Clay

Baseline: >60% Silt/Clay

Highly dynamic
Sediment Quality: Sediment Traps

- **Low sedimentation rates**
  - 0.4 – 0.8 cm/yr
- **Limited material for**
  - Sediment chemical analysis
  - Amphipod toxicity testing
- **Changes to MEEMP**
  - Sediment traps discontinued
  - Some triplicate sampling to assess intra-station variation
  - Grabs and DFO gravity SLO-CORER compared
In situ Mussels

- Commercial blue mussels deployed & analyzed for
  - PAHs, PCBs, As, Cd, Cu, Hg, Pb, Zn & Lipids
  - Condition Index

- Most PAHs <RDLs
  - Except fluoranthene & pyrene

- [PCB] <RDLs in baseline, yrs 1 & 3
  - Some detections in yr 2

- [Metals] showed little spatial variation

- EIS prediction of no significant environmental impacts in SH confirmed?
In situ Mussels: Challenges

- Invasive tunicates covered frames
- Missing frames
  - Suspect stealing of buoys & shackles
- Massive dredging project
  - Between Oct 2011-Jan 2012 ~4.2 million m³ of dredged sediment used for infilling in a confined disposal facility (CDF) for proposed container terminal
- Changes to MEEMP
  - Chemistry measured prior to deployment
  - Condition Index discontinued – inconclusive
  - Mussel monitoring temporarily suspended during dredging
  - Station 2-2 permanently lost
Crab Tissue

- **Adult male rock crabs** collected each July (102-130 mm)
- **DFO scientific crab licenses** obtained prior to collection
- **Triplicate crab traps**, baited with mackerel, deployed at each station & retrieved 2d later
- Crabs (6-13) from triplicate traps **pooled** to obtain min. wt required for **composite hepatopancreas tissue** analysis
- Hepatopancreas tissue from live crabs analyzed for
  - PAHs, PCBs, As, Cd, Cu, Hg, Pb & Zn
Crab Tissue: PAHs & PCBs

- **[PAHs]**
  - Mostly <RDL (0.05 µg g⁻¹)

- **[PCBs]**
  - Significantly higher in yr 1
  - Potential decrease in yr 2 & 3
  - Below CFIA guidelines (2 µg/g) in yr 3

- EIS prediction of no significant environmental impacts in SH confirmed?
Crab Tissue: Metals

- **Highest** concs of As, Cd & Cu measured at reference stations

- No pattern of elevated [metals] in crabs close to remediation

- [Metals] showed some temporal variability, but **not directly related to remediation**

- EIS prediction of no significant environmental impacts in SH confirmed?
Crab Tissue: Challenges

- **Occasional by-catch**
  - Invasive green crabs
  - American lobster
- **Sometimes no crabs caught**
- **Massive dredging project**
  - Infill for CDF for new container terminal (2011-2012)
- **Other traps lost or stolen**
- **Changes to MEEMP**
  - Station 2-2 permanently lost
Benthic Community Assessment

- **Composition & distribution**
  - Yr 1 & 2 similar to baseline & earlier study by Stewart et al. (2002)

- **Total animal abundance**
  - Significantly higher since baseline
  - Positive changes since baseline

- **Community differences**
  - Driven more by organic enrichment rather than contaminant concentrations

- **Changes to MEEMP**
  - Discontinued after 3 seasons - *inconclusive*
Intertidal Communities

- Intertidal transects established at baseline
- HW & LW quadrats assessed on transects for
  - Algal species & cover
  - Faunal species & abundance
- Remediation results similar to baseline
  - Dominated by *Fucus* sp. algal cover
  - Faunal species dominated by periwinkles & barnacles
- Species diversity higher with increasing distance from STP site
- Changes to MEEMP
  - Discontinued after 2 seasons - *inconclusive*
## Contaminants in Various Media

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→ = Stable  
↓ = Decreasing  
↑ = Potentially increasing  
nd = Not detected

Summary

- **EEM in SH did not detect substantial contaminant releases**
  - Many parameters decreased despite ongoing remediation

- **[PAHs] in sediments increased during yr 1, but now decreasing**
  - Results within predicted ‘natural recovery’ ranges reported by Smith et al. (2009)

- Dredging may have had positive environmental effect on Sydney Harbour

- Detection of these changes attests to effectiveness of EEM programs

- EIS prediction of no significant environmental impacts in SH confirmed?
Lessons Learned

- Calls for termination of remediation by regulators after 1 yr was premature
- Several years of baseline data required to properly understand range of natural inter-annual variation
- Some EEM components removed only after several years of inconclusive data
- Cumulative impacts from other industrial activities / weather events should be considered during large-scale remediation projects
- Some agencies requested reduction in MEEMP to reduce costs, but collecting a range of multimedia helps build stronger evidence of potential effects
- Longer term monitoring of fewer multimedia to assess long-term performance of S/S remediation over decadal timeframes
- EEM programs can also become important research studies
Thank You

In this Issue:
- Saskatchewan Proposed Amendment to the Wildlife Habitat Protection Act
- Water Supply is Putting Canadian Health & Economy at Risk
- Arctic at Risk from Global Warming Study
- N.W.T. Proposes New Bathurst Caribou Plan
- CSEB Meeting Fall 2010