Risk Management of Contaminated Sites

Atlantic CLRA Conference

November 8-9, 2016

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A Case Study

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Agenda

1. **Background to DFO Maritimes and Gulf Region Assessment Program**

2. **Ecological Risk Assessments (ERAs) at DFO sites**

3. **Validation Study**
   - I. Approach
   - II. Soil and soil invertebrates
   - III. Birds/Shrews
   - IV. **EPCs**

4. **Conclusions**

DFO Site Assessment Program

- **DFO owns over 1,000 properties in Maritimes and Gulf Region**
- **Prior to 2000, the extent of DFO's potential environmental liabilities was not quantified**
- **ESA program was initiated in fall of 2000, and has been ongoing annually, to respond to the need to quantify these potential liabilities**
  - Phase I/II/III ESAs
  - Human health SSCs in 2007
  - ERA program initiated in 2010
  - EcoRBRCs in 2012
- **The most ubiquitous concern present at the lightstations is lead-based paint resulting in trace metals (primarily lead) accumulating in soils**

DFO ERA Program

- **Standard approach (Template) of benchmark comparisons and food chain models to calculate Ecological Hazard Quotients (EHQs).**
- **Interpretation of risk, and need for remedial action, centered around EHQs >1**
- **Elevated EHQs (>1) are routinely predicted at sites ranging from larger light stations to small range lights.**
- **These EHQs are interpreted in light of field observations and assumed conservatisms and uncertainties in the food chain models, including:**
  - Positive bias in the soil EPC due to sampling design
  - Dietary/home range assumptions
  - Bioaccessibility
- **Remedial action has yet to be recommended based on the ERA results.**

Point Lepreau Light Station

- Maces Bay, Saint John County, NB
- Exceedances of the CCME SQG were most frequently encountered for lead.
- The highest soil metal concentrations are associated with the location of current or former buildings.
- EHQs >1 for American robin and masked shrew.

- Discounted based on bias in the soil EPC, limited area of impact, and bioaccessibility assumptions.
- No remedial action recommended.

DFO Validation Study Rationale

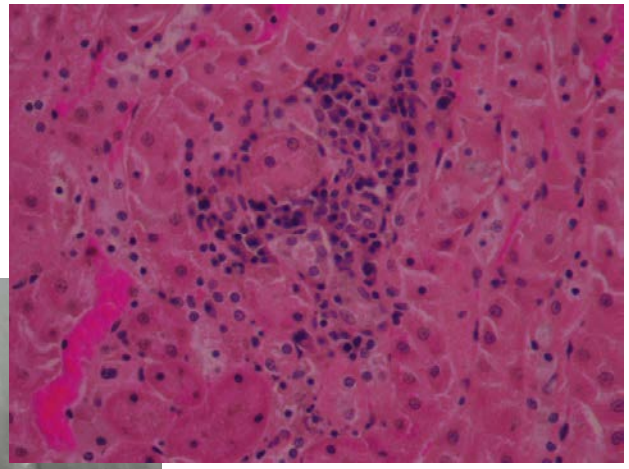
- **The field and laboratory results were used to validate three key uncertainties or sources of conservatism in the ERA model:**
  - Bias in the soil EPC due to sampling design.
  - Diet of small mammals and birds.
  - Comparison of measured blood lead and tissue lead to critical blood and tissue concentrations obtained from the scientific literature and to reference site concentrations.
- **The field results were used validate the conclusions from the previous ERA regarding potential exposures and risk and subsequently to verify the level of conservatism and the validity of the conclusions reached in the previous ERA with respect to the need for remedial action.**

DFO Validation Study Approach

- **Risk drivers in the ERAs are bird and mammal species that rely upon soil invertebrates, particularly earthworms, as a key component of their diet.**
- **Key components of the study included:**
  - Mist-netting of songbirds and collection of blood and feather samples for laboratory analysis of lead;

DFO Validation Study Approach
Key Components

- **Key components of the study included:**
  - Trapping and dissection of shrews and other small mammals for laboratory metals analysis whole body and liver, kidney, and femur
  - Weighing kidney samples and examining them for pathology (e.g., lesions)

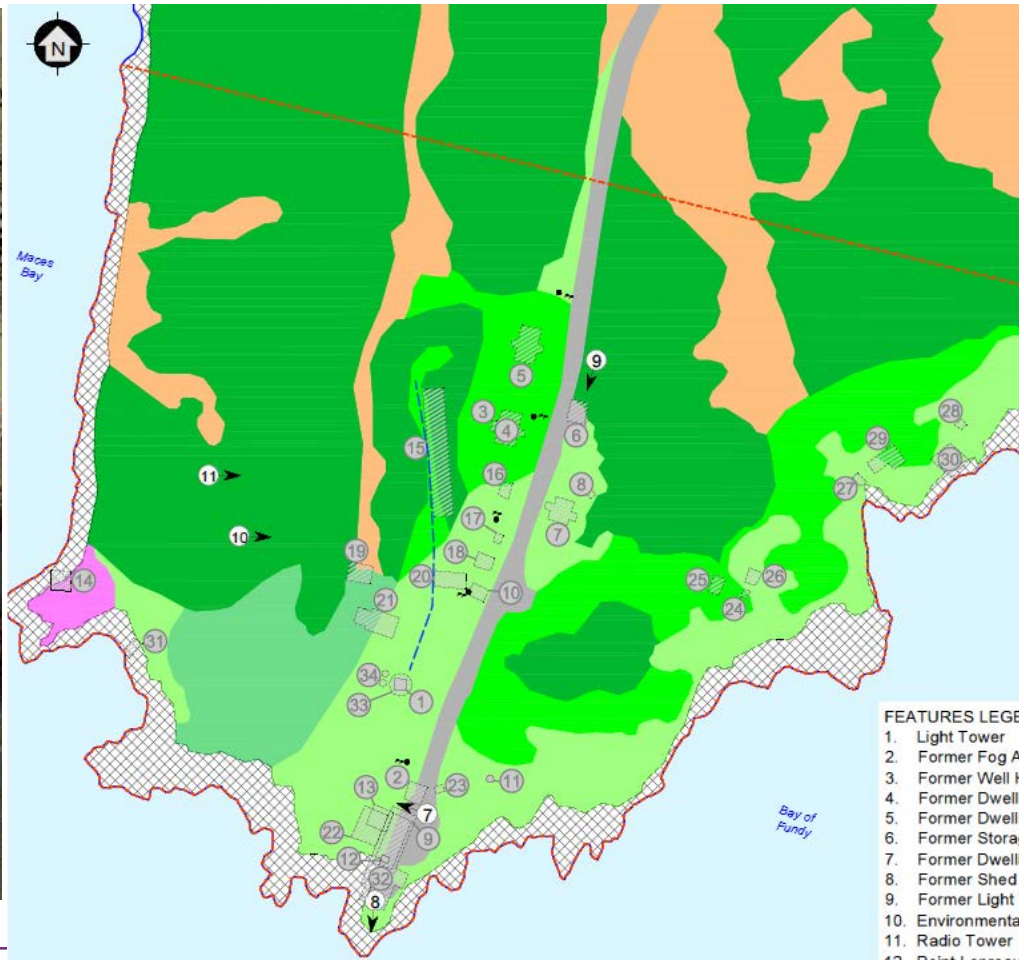


DFO Validation Study Approach
Key Components

- Collection of soil invertebrates including earthworms, slugs, and grasshoppers for laboratory analysis of metals;

DFO Validation Study Approach
Key Components

- Habitat surveys and field observations on foraging preferences.

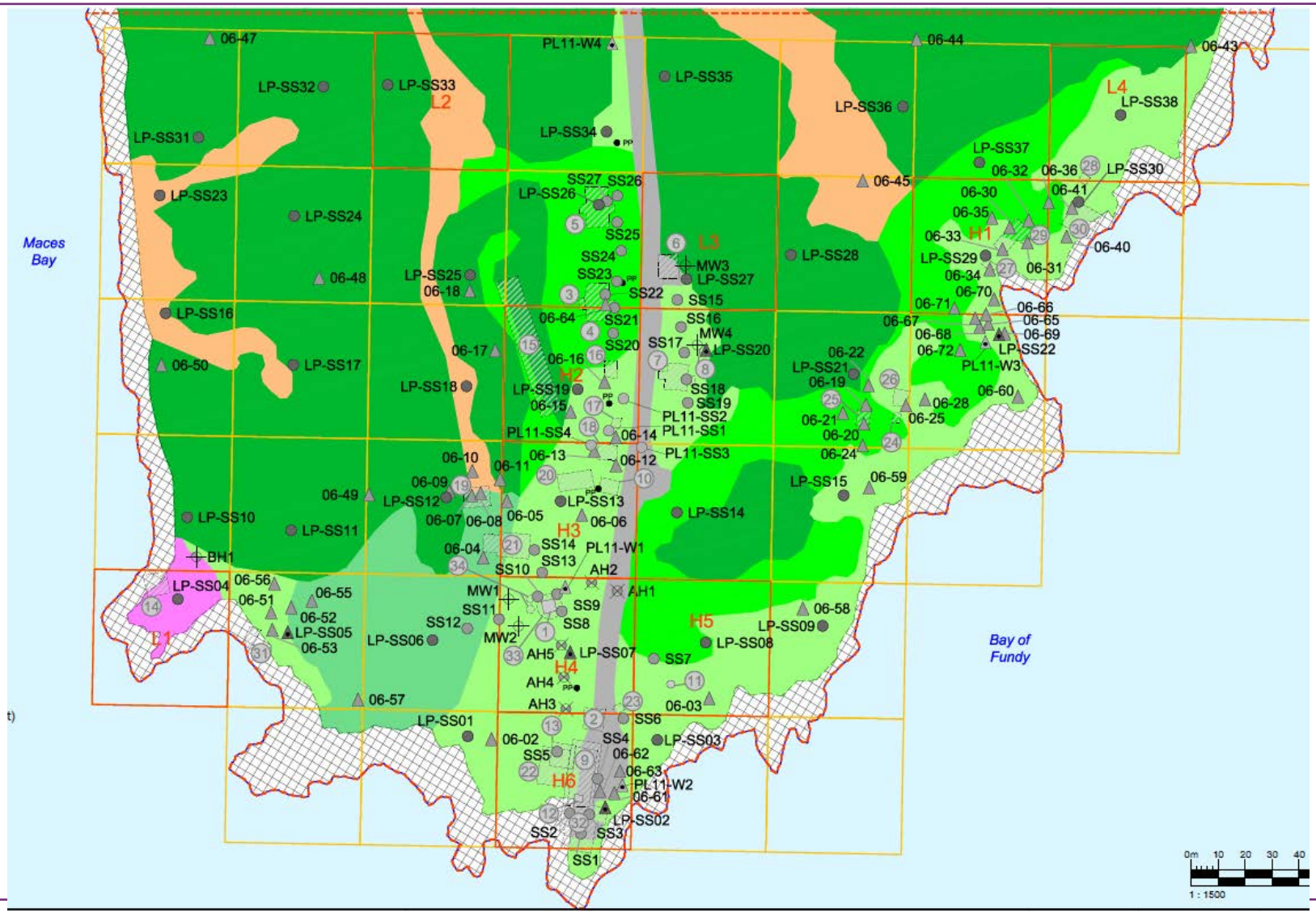


DFO Validation Study Approach
EPC Study

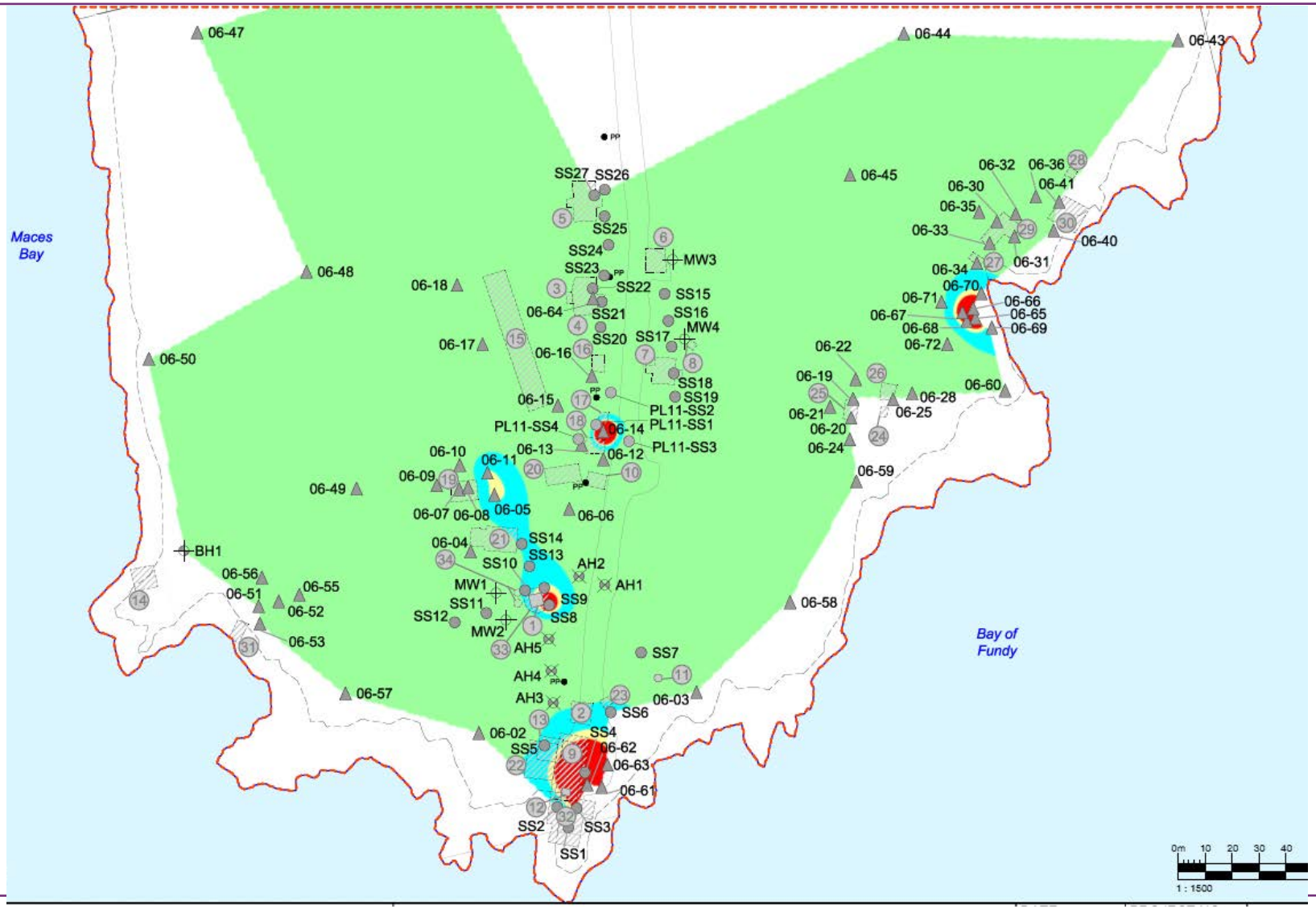
- **Grid-based soil sampling to investigate effect on exposure point concentration (EPC) calculations**
- **The following methods were investigated for comparing and contrasting the derivation and use of EPCs in HHRAs and ERAs, based on those typically utilized within the Template at DFO sites. These methods are:**

  - Deriving a site-wide EPC based on ESA (targeted) data;
  - Deriving a site-wide EPC based on grid (systematic) data;
  - Statistically stratifying the soil data based on concentration;
  - Deriving an EPC for each habitat area;
  - Deriving a site-wide EPC based on the combined targeted and grid data.

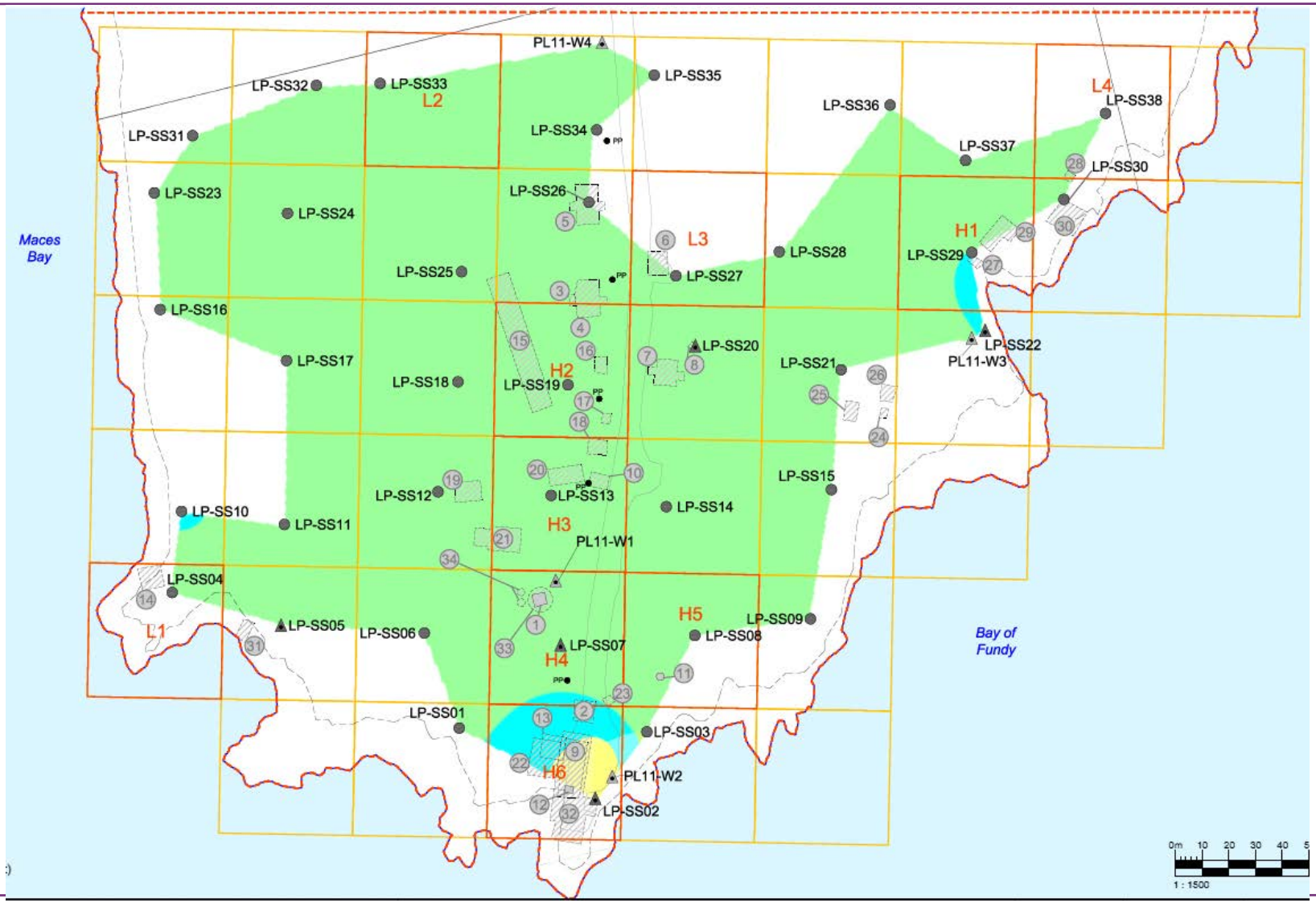
Point Lepreau Light Station
(Sampling Locations and Habitat)



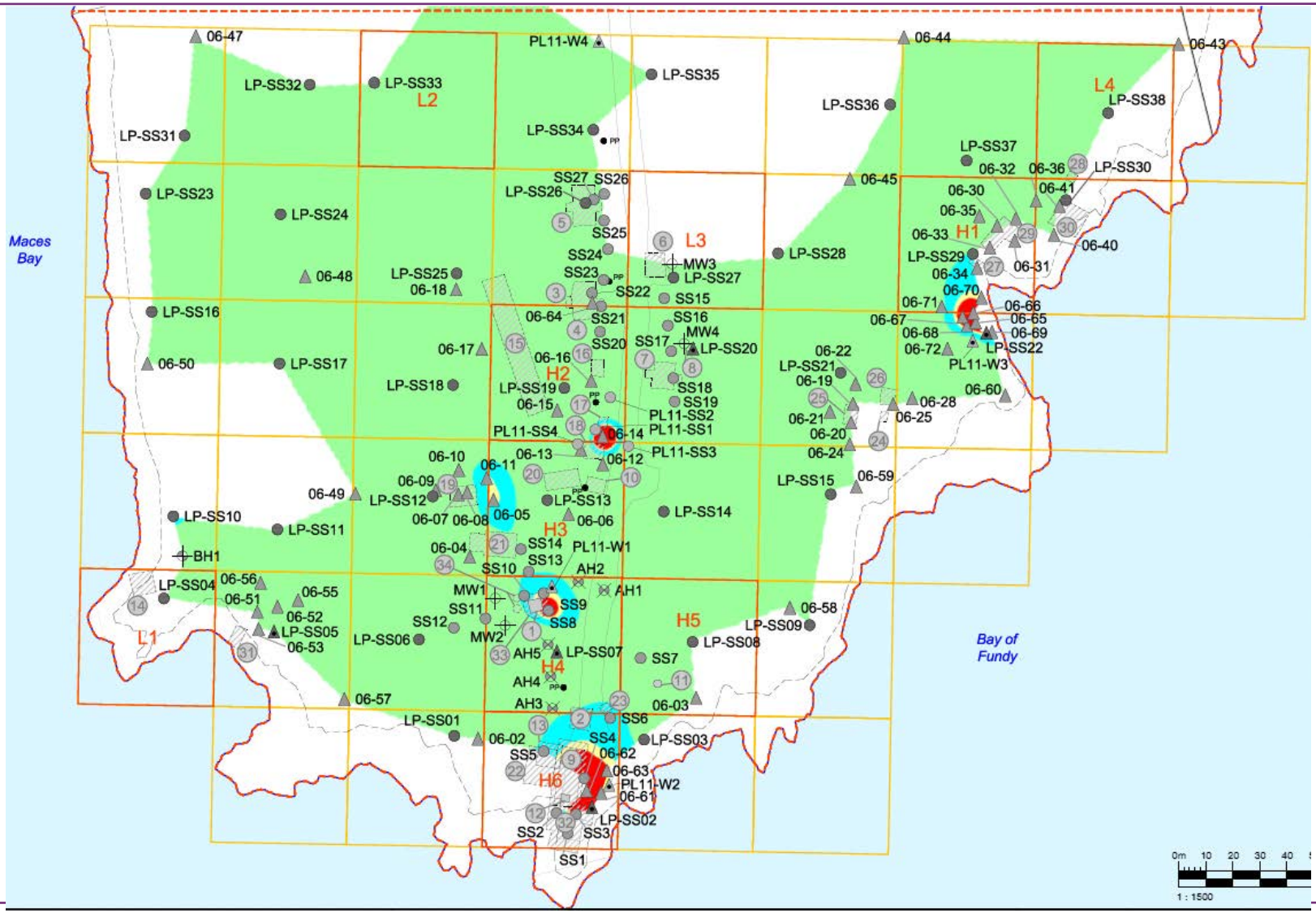
Point Lepreau Light Station
(ESA [targeted] soil sampling – 2011)



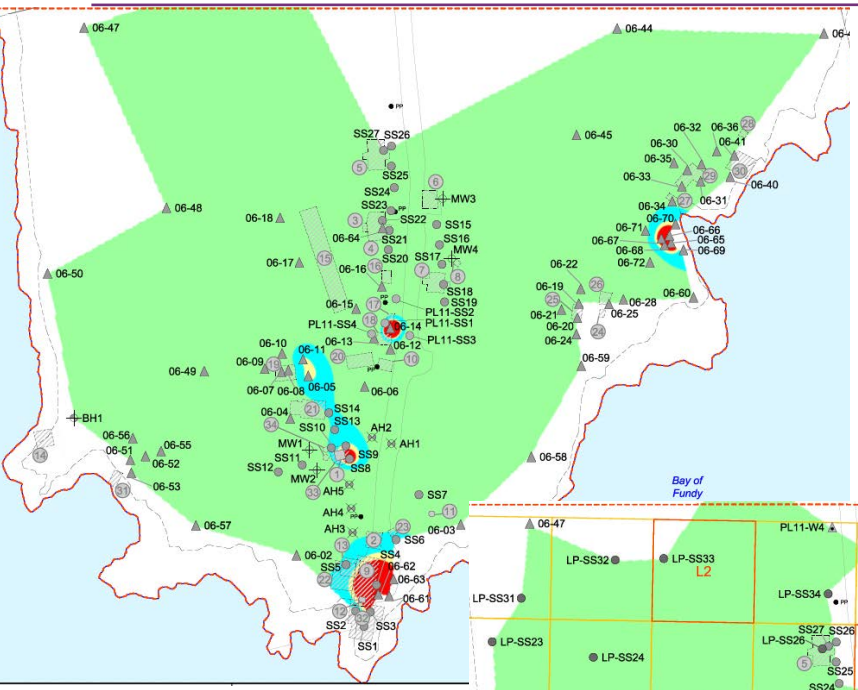
Point Lepreau Light Station
(Grid [systemic] sampling – 2015)

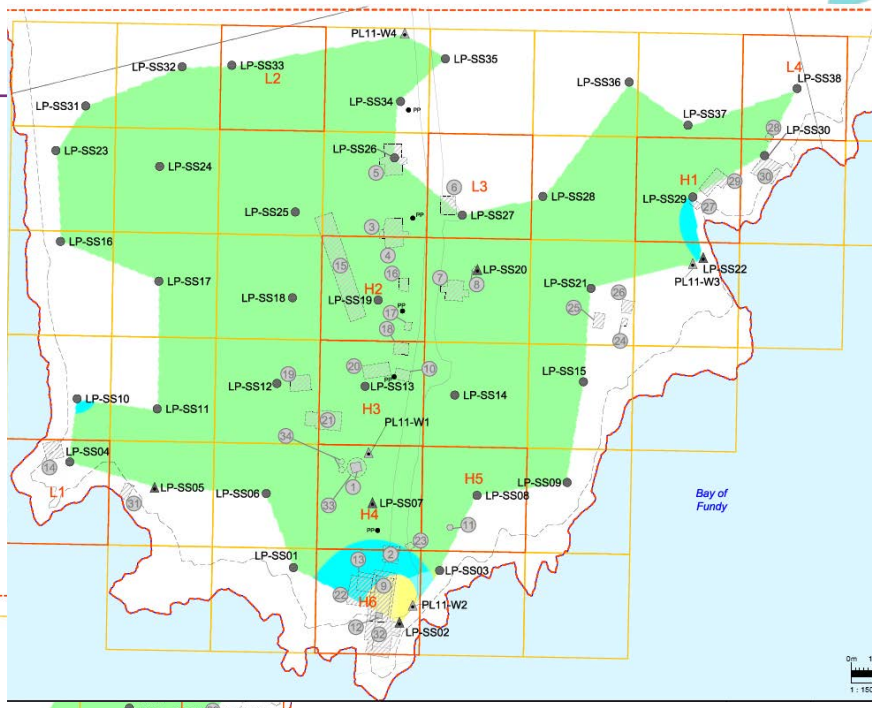


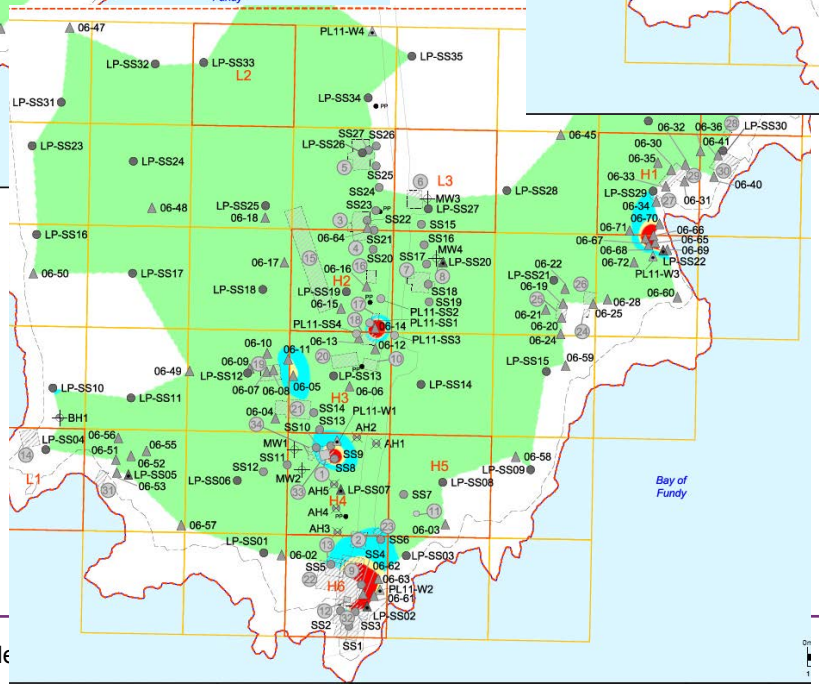
Point Lepreau Light Station
(ESA and Grid Sampling Combined)



Point Lepreau Light Station
(Comparison)







EPC Study Findings

- **Range of soil lead EPCs (ProUCL)**
  - ESA (Targeted)
    - 4,795 mg/kg [2,787 to 8,926 mg/kg]
  - Grid
    - 513.9 mg/kg [328.5 to 886.9 mg/kg]
  - Soil Clusters
    - Unable to calculate
  - Habitat
    - 6,397 mg/kg for field habitat and 413.4 mg/kg for spruce forest
  - ESA + Grid
    - 3,340 mg/kg [1,958 to 6,161 mg/kg]

EPC Study Findings

- **Significant uncertainty and range in possible soil EPCs**
  - This value drives the food chain model and over-estimation here causes a knock–on effect in all risk estimates.

- **It is essential to note the differences in methodology between the HHRA and ERA.**
  - HHRA SSTLs not dependent on EPC
  - ERA EHQs dependent on EPC

Conclusions

- **There appears to be no "one-size-fits-all" EPC calculation method that is broadly applicable to all DFO sites**
- **Professional judgment must be used to determine what method(s) might best capture exposure at the site from the perspective of ecological and human health.**
- **To this end, the EPC should:**
  - relate to ecological and human health protection goals;
  - reflect human and ecological exposure potential rather than concentration differences;
  - provide a reasonable yet protective risk prediction (must not underestimate risk);
  - be easily and universally reproducible across all DFO sites; and
  - ideally be equally applicable to the HHRA and the ERA.

Conclusions

How each proposed method meets these goals is summarized in the matrix below:

	Protection Goal	Exposure Potential	Protective	Universal	HH + ERA
ESA + Grid	✓	✓	✓	✓	✓
ESA	✓ (HH)	✓ (HH)	✓	✓	×
Grid	✓ (Eco)	✓ (Eco)	×	✓	×
Habitat Unit	×	✓ (Eco)	✓ (Eco)	✓	×
Statistical Clustering	×	×	✓	×	×

Conclusions

- Use of soil data from investigations designed to characterize contaminant sources (e.g., the light tower) are likely to bias significantly ERA results high.
- Food chain models based solely on earthworm uptake and ingestion will significantly overestimate contaminant uptake in an invertivore diet.
- ERAs conducted at DFO light stations in Maritimes and Gulf Region have likely overestimated potential risks.
- Biological effects to avian receptors at lightstation sites are unlikely.
- Biological effects to insectivorous small mammals are uncertain
  - Lead accumulation in kidney and femur
  - No morphological effects
  - No qualitative difference in abundance

Thank you!

Acknowledgments:

AmecFW
Peter Morrison
Dan Michaud
Jody Berry
David Rae

PWGSC
Heather McCleave