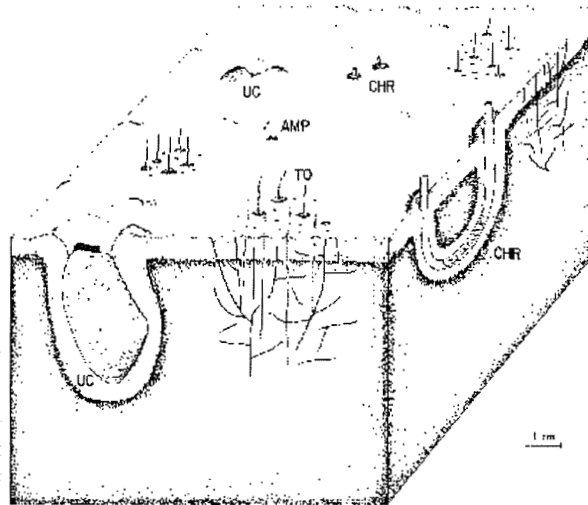
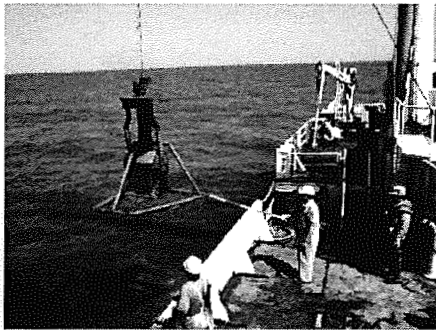


A Decision Making Framework for Sediment Assessment



Danielle Milani, Lee Grapentine, and
T. Reynoldson
National Water Research Institute
Environment Canada



Environment
Canada

Environnement
Canada



Underlying Philosophy

- Elevated concentrations of contaminants in sediments alone are not indications of ecological degradation.
- A recommendation of management action requires evidence of adverse biological effect on biota residing in the sediment or on biota that are affected by contaminants originating from the sediment.

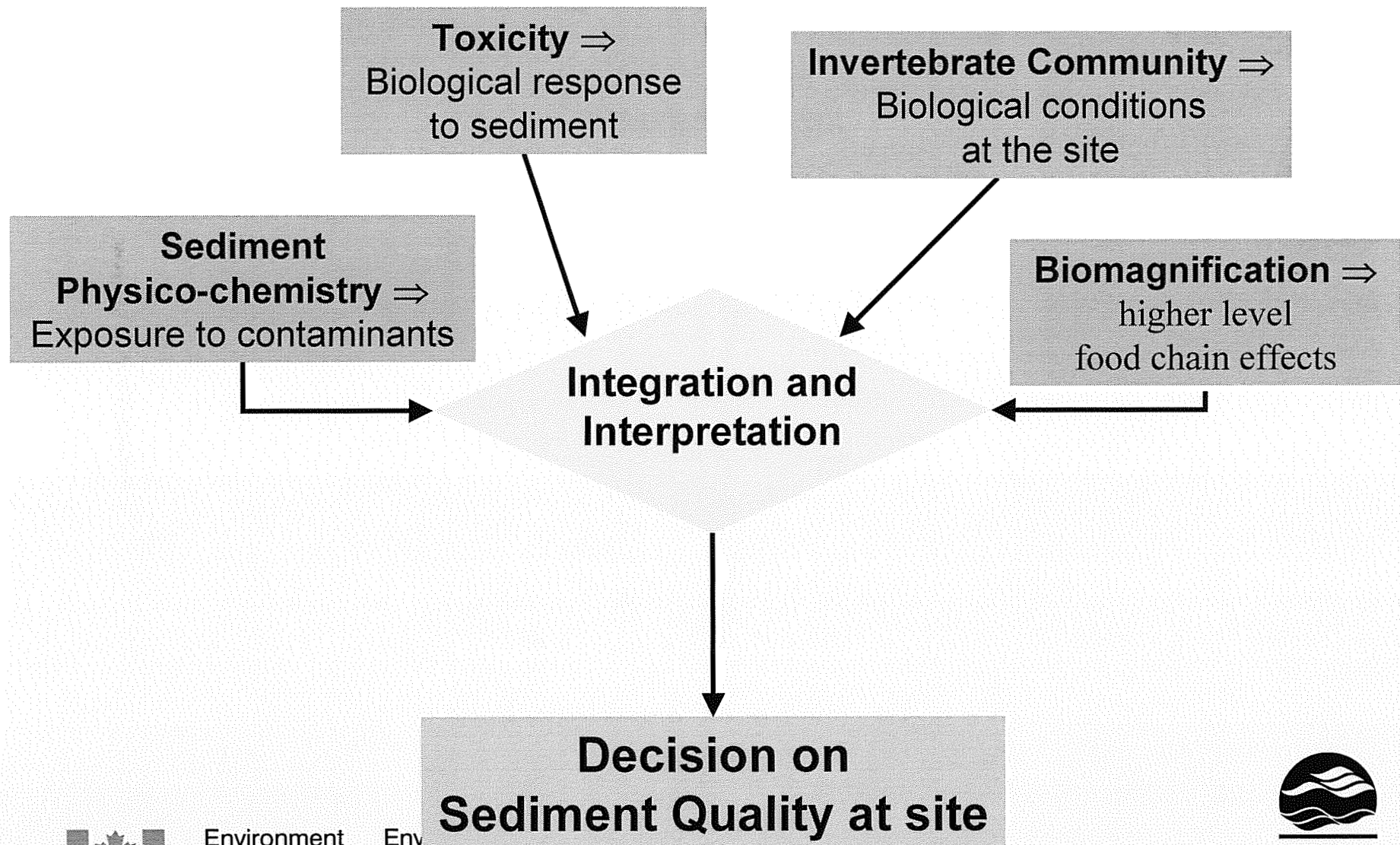


Environment
Canada

Environnement
Canada



Decision Making Elements



Environment
Canada

Env
Canada



Current Status

- Decision making framework based on four elements:
 - community structure – numeric criteria developed
 - toxicity – numeric criteria developed
 - chemistry – numeric criteria exist – how to integrate
 - biomagnification - numeric criteria proposed
- Method for integrating chemical data
- Consensus on biomagnification criteria
- Integrating across “elements”



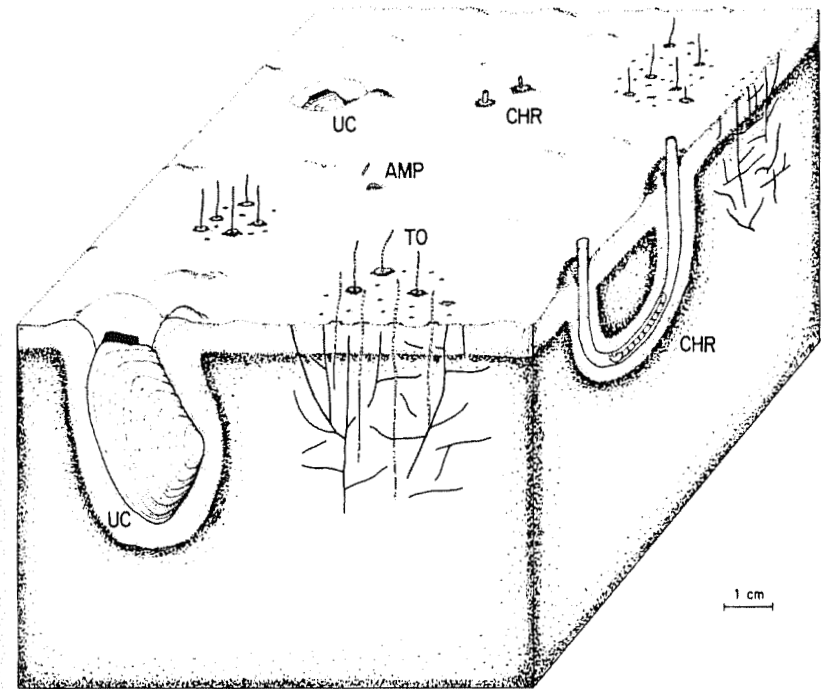
Environment
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: Community Structure

- use species composition
- animals inhabit “contaminated” sediment
- continual exposure



Environment
Canada

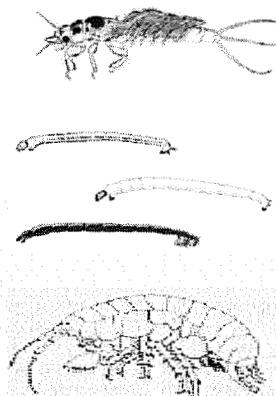
Environnement
Canada



Evaluation Within Lines of Evidence: Toxicity Tests

Survival and growth

- direct measure of effects
- confirm sediment as causative agent

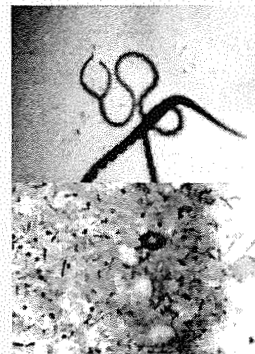


Hexagenia spp.
burrowing mayfly

Chironomus riparius
midge larvae

Hyalella azteca
scud

Survival and reproduction



Tubifex tubifex
aquatic worm

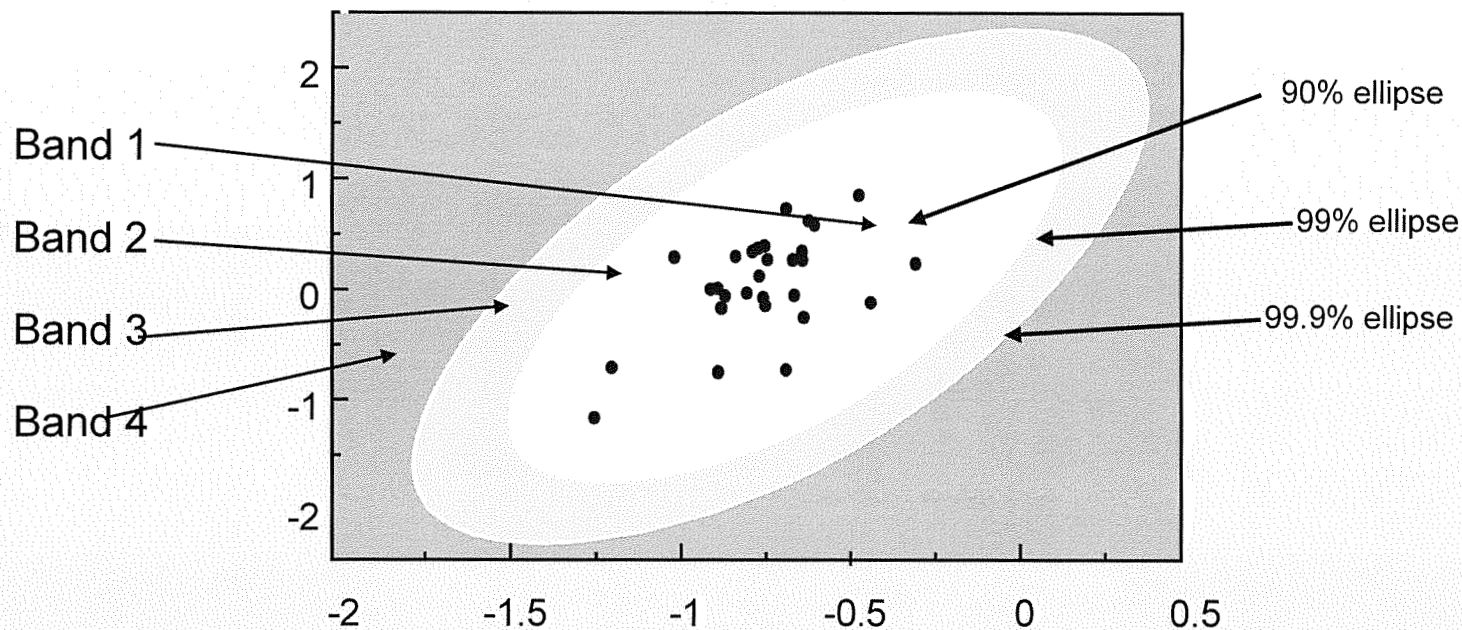


Environment
Canada

Environnement
Canada



Community and Toxicity: Comparison of reference vs. “exposed” sites



Environnement
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: Chemical Data

- Integrating information on chemical contamination -
what constitutes a “+” ?

Three methods are currently being evaluated:

Method 1:

— Sediment contaminant data from test and ref sites are ordinated (PCA) to yield 2 or 3 descriptors of sediment contamination. CL are produced for ref sites against which test sites are compared.



Environment
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: Chemical Data (cont'd)

Method 2:

- ___ Risk based sediment guidelines for individual contaminants are incorporated into a Hazard Quotient. The HQ are calculated as the individual ratios of sediment contaminant conc to a guideline value; individual HQs and the overall mean HQ are compared to the 95% CI for the reference sites.



Environment
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: Chemical Data (Cont'd)

Method 3:

___ Sediment Quality Index (modified from the Canadian water quality index) (CCME 2001)

Allows integration of individual measurements of sediment contamination based on:

- scope (# of variables that do not meet guideline objectives), and
- amplitude (the magnitude by which variables exceed guideline objectives).



Environment
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: *Potential* for Biomagnification

- Adopting biomagnification criteria
- Does not definitively quantify biomagnification
- Measurement of indigenous community tissue levels
- Application of local food chain based biomagnification factor
- Comparison to CCME tissue guidelines for:
 - human consumption, protection of aquatic life



Environment
Canada

Environnement
Canada



Evaluation Within Lines of Evidence: *Potential* for Biomagnification (cont'd)

Proposed decision making criteria:

- pass (“-”): No sig. elevation of contaminants in tissues of inverts from test sites relative to ref. sites, and the predicted contaminant conc. in predators are not above the CCME protective values.
- fail (“+”): A sig. elevation of contaminants, and above the CCME protective values.



Environment
Canada

Environnement
Canada



Decision Framework

- Integrating the Multiple Elements among the 4 lines of evidence.
- Rules summarized in tabular form
- 16 combinations of either pass (-) or fail (+) outcomes for the individual elements
- For each scenario, description of current status, interpretation and management recommendation.



Environment
Canada

Environnement
Canada



Decision Framework

Interpretation - 4 categories:

- *Category 1* - sediments do not pose a risk.
- *Category 2* - there are adverse effects that require risk management evaluation (RME).
- *Category 3* - there is a need for both RME and further investigations - equivocal results.
- *Category 4* - there is no immediate need for RME, but further investigation is needed.



Environment
Canada

Environnement
Canada



Sediment Decision Making Framework (Category 1)

<i>Scenario</i>	<i>Chemistry</i>	<i>Toxicity</i>	<i>Community</i>	<i>Bionagnostic</i>	<i>Description of Current Status (surficial sediment)</i>	<i>Interpretation (followed by an assessment of site stability and subsurface contamination)</i>	<i>Management Recommendation</i>
1	-	-	-	-	Measured sed. contaminants not elevated above thresholds. No evidence of adverse biological effects.	Sediments do not pose a risk	Risk management action not required.
2	+	-	-	-	Contaminants in sediment at elevated concentrations above thresholds, but not toxic; no evidence of adverse biological effects	Contaminants do not present a risk.	Risk management evaluation not required.



Environment
Canada

Environnement
Canada



Sediment Decision Making Framework (Category 2)

<i>Scenario</i>	<i>Chemistry</i>	<i>Toxicity</i>	<i>Community</i>	<i>Biomagnific</i>	<i>Description of Current Status (surficial sediment)</i>	<i>Interpretation (followed by an assessment of site stability and subsurface contamination)</i>	<i>Management Recommendation)</i>
5	-	-	-	+	Potential for risk at higher trophic levels but source(s) unclear.	Biomagnification risk. Conduct assessment to verify lack of contaminant availability from sed., and id source and implications. Investigate potential shift in food web dynamics.	Risk management evaluation required.
16	+	+	+	+	Elevated sed, contamination above thresholds likely causing adverse biol. Effects and biomagnification..	Sufficient evidence for unacceptable risk from sediment contamination.	Risk management evaluation required.



Environment
Canada

Environnement
Canada



Sediment Decision Making Framework (Category 3)

<i>Scenario</i>	<i>Chemistry</i>	<i>Toxicity</i>	<i>Community</i>	<i>Biomagnific</i>	<i>Description of Current Status (surficial sediment)</i>	<i>Interpretation (followed by an assessment of site stability and subsurface contamination)</i>	<i>Management Recommendation)</i>
8	-	-	+	+	Evidence of either increased biological bioavailability or non-sediment contaminant related stress (e.g. biotic or physical differences, water column conditions, unknown habitat factors); potential for risk at higher trophic levels but source(s) unclear.	Sediments currently may not pose a risk, but biomagnification occurring. Examine sources and pathways of concern. Investigate potential shift in food web dynamics (e.g. due to <i>Dreissena</i> invasion). Must confirm that sediment is not the source of contamination.	Risk management evaluation required for biomagnification. Determine cause(s) for benthic alteration on a priority basis. Reassess, then take management action as required.



Environment
Canada

Environnement
Canada



Sediment Decision Making Framework (Category 4)

<i>Scenario</i>	<i>Chemistry</i>	<i>Toxicity</i>	<i>Community</i>	<i>Biomagnific</i>	<i>Description of Current Status (surficial sediment)</i>	<i>Interpretation (followed by an assessment of site stability and subsurface contamination)</i>	<i>Management Recommendation)</i>
3	-	+	-	-	Measured sed. contaminants not elevated above thresholds. Lab toxicity but no evidence of benthic community alteration; no biomagnification.	Potential for adverse effects. Consider comprehensive analyses of contaminants in lab and field biota for evidence of contaminant exposure and uptake.	No immediate need for risk management evaluation. Determine cause(s) of toxicity; monitor for change in status of benthic populations.
9	+	-	+	-	Benthic community alteration may be due to sediment contaminants or other stressors; no toxicity, or effects may be too chronic/long term for detection by toxicity tests; no biomagnification.	Adverse effects occurring but cause(s) unknown.	Risk management evaluation required. Determine cause(s) for benthic alteration on a priority basis. Reassess, then take management action as required; monitor for further alteration.



Environment
Canada

Environnement
Canada



Strength of Response

- Incorporating quantitative information into each line of evidence i.e., from +/- to - / +++++
- Individual elements can be ranked (i.e. score of 1 (unaltered or non toxic) to 4 (very altered or toxic).
- Provides more information to managers to aid in decision options.



Environment
Canada

Environnement
Canada



Decision Framework

Management Recommendations:

- natural recovery
- source control
- in situ treatment
- removal of sediment
- restriction of access to area
- fish consumption guidelines

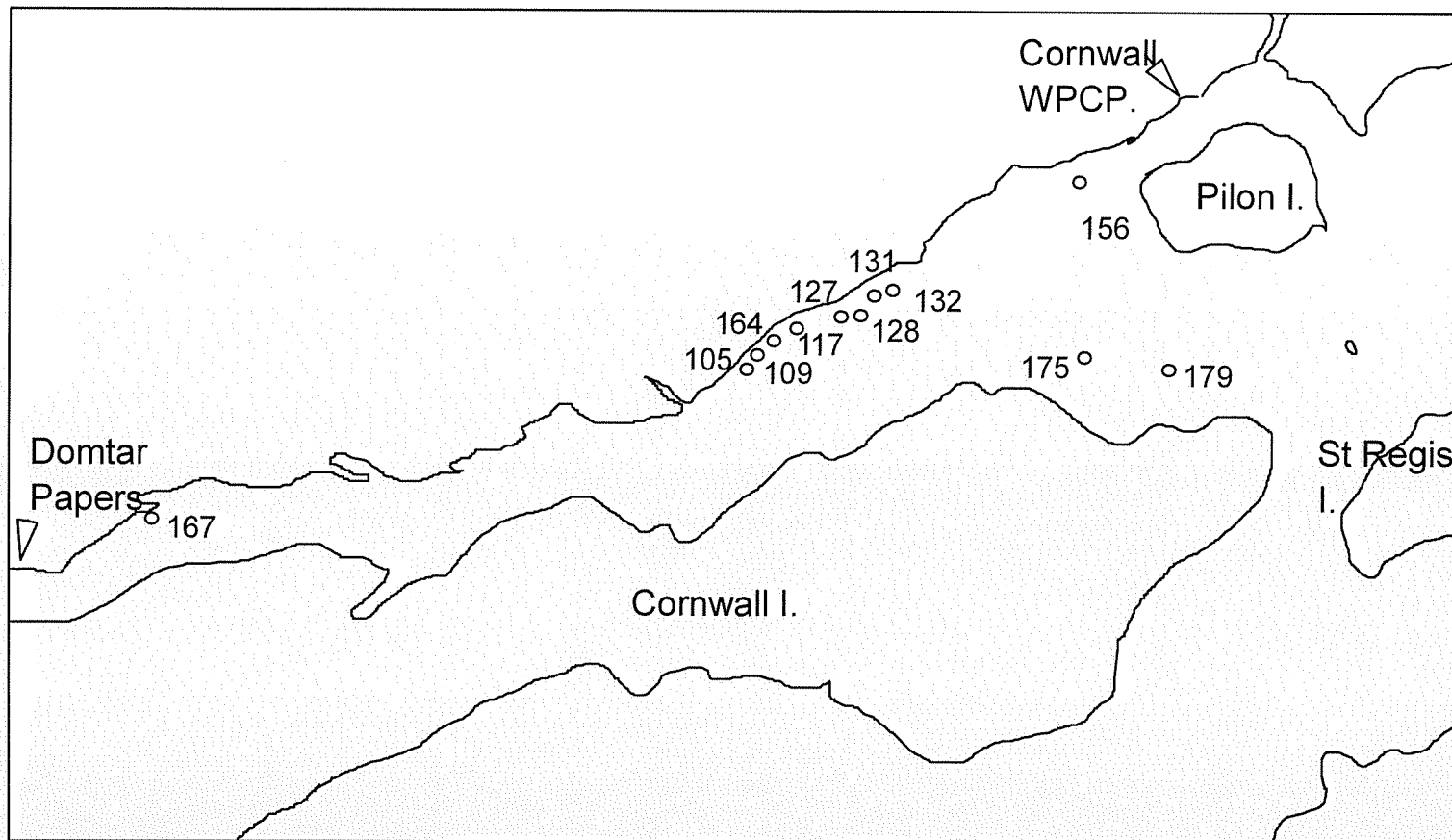


Environment
Canada

Environnement
Canada



Case Study: Cornwall, Ontario



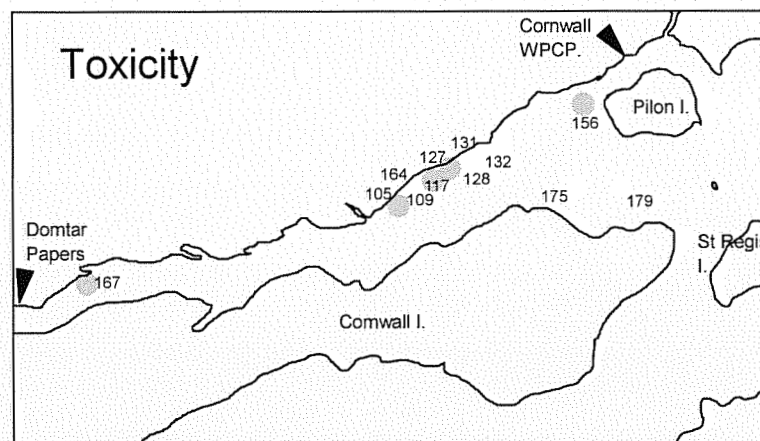
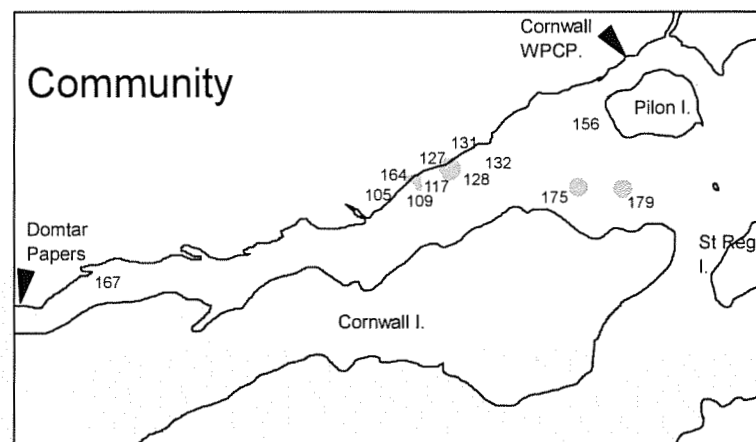
Environnement
Canada

Environnement
Canada



Summary of Sediment Quality at Cornwall

Assessment of sediment quality at 12 Cornwall sites in 1997



equal to reference

● possibly different (>90%)

● different (>99%)

● very different >99.9%)

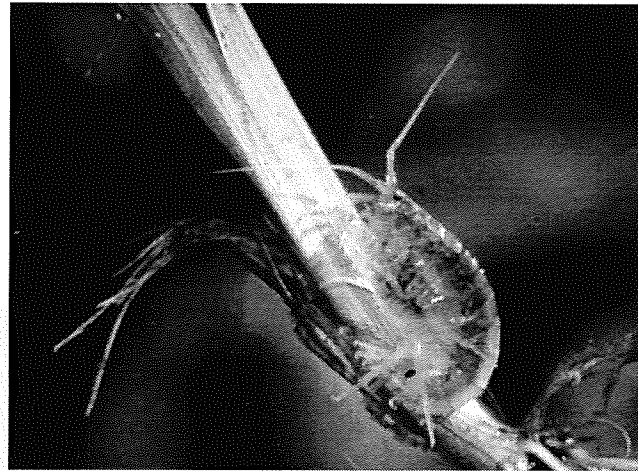


Environment
Canada

Environnement
Canada



Fourth Decision Making Element



Environment
Canada

Environnement
Canada



Possible Outcomes for Cornwall Category 1 or 2 ?

Scenario	Chemistry	Toxicity	Community	Biomagnific	Description of Current Status (surficial sediment)	Interpretation (followed by an assessment of site stability and subsurface contamination)	Management Recommendation
2	+	-	-	-	Contaminants in sediment at elevated concentrations above thresholds, but not toxic; no evidence of adverse biological effects.	Contaminants do not pose as risk	Risk management evaluation not required.
10	+	-	-	+	Potential for risk at higher trophic levels related to sediment contamination above thresholds.	Unacceptable risk of biomagnification	Risk management evaluation for biomagnification.

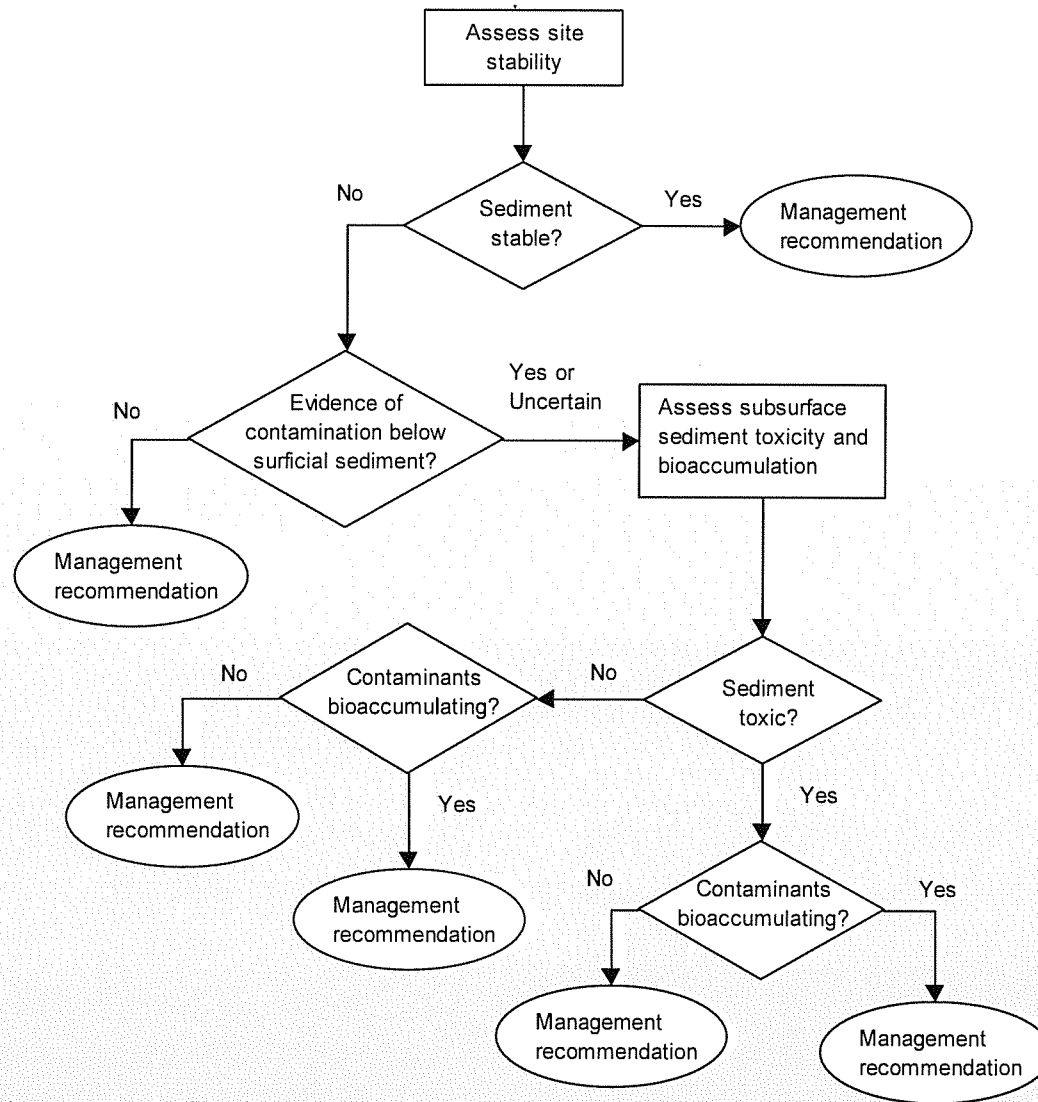


Environment
Canada

Environnement
Canada



Other Issues:



Environment
Canada

Environnement
Canada



Conclusions

- Rule-based process integrating 4 essential lines of evidence.
- Critical elements in making sediment management decisions include exposure, effect, weight of evidence, and risk.
- Transparent as possible from data collection to evaluation within lines of evidence, to integration and interpretation.



Environment
Canada

Environnement
Canada



Acknowledgement

Workshop participants consisting of group of expert scientists from academia, government, and consulting (US and Canada)



Environment
Canada

Environnement
Canada

