

# Derivation of Water Quality Objectives During Dredging Operations - Randle Reef Sediment Remediation Project



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\*Toxicity Tests Conducted by **Trudy Watson-Leung**, Ontario Ministry of the Environment (MOE)



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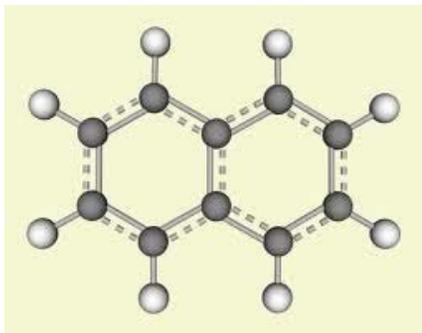
# Goal of this Study

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Examine  
**chemical** and **toxicological** effects resulting from a  
range of

## Total Suspended Solids (TSS)

concentrations (25, 50 and 75 mg/L).



### GOAL:

Determine

**Acceptable TSS level**

for dredging at a compliance point  
acceptable to the regulatory  
authorities

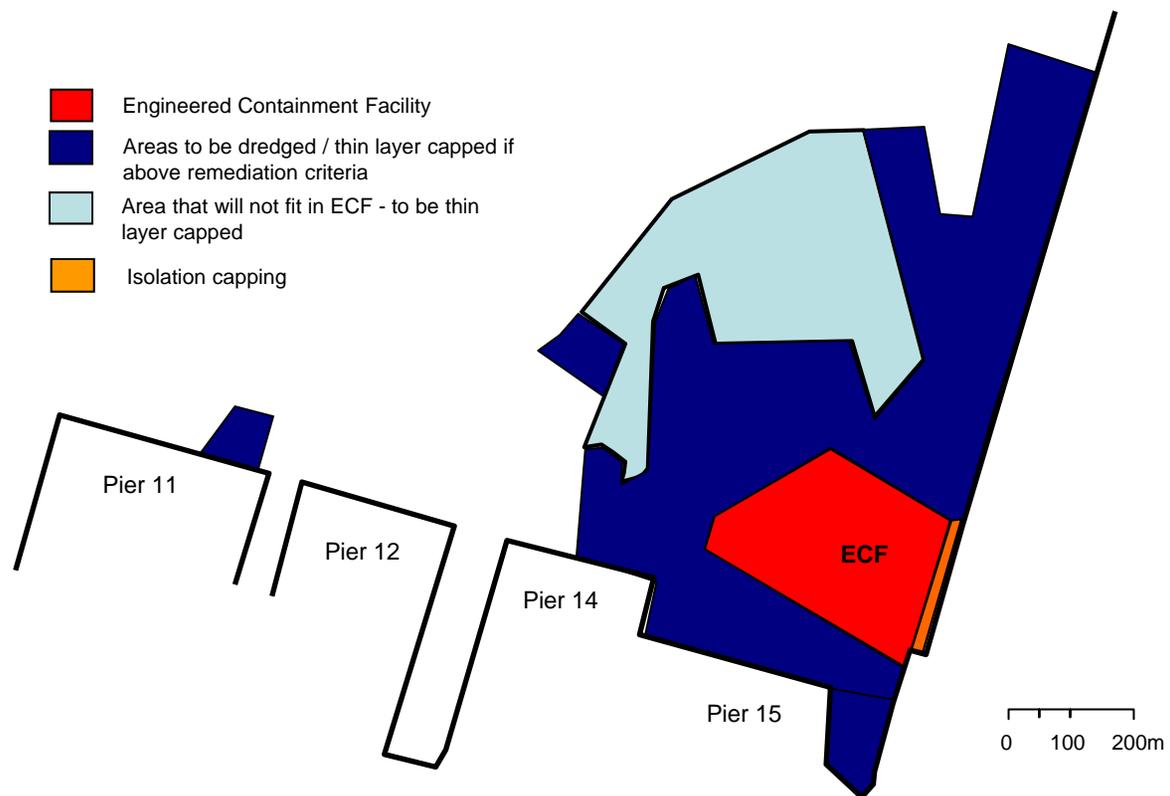


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# Remediation Plan



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# Previous Water Quality Limits

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- Initial version of the engineering specifications cited **50 NTUs above background** (a common limit used in the U.S.), however, no backup rationale was provided
- When pressed for clarification, specifications were altered then cited the CCME freshwater criteria, which is far too stringent for a dredging operation and not practical for a remediation project
- Hence the undertaking of elutriate testing to provide a defensible and site specific criteria

NTUs = Nephelometric turbidity units

CCME = Canadian Council for Ministers of the Environment



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# Previous Water Quality Limits

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- Traditionally, water quality impacts associated with dredging focused on physical impacts of SS (gills, eggs, behaviour, habitat etc)
- The negative effects associated with the physical aspects of suspended solids in the water column are diminished at Randle Reef (low level of fish presence and habitat due to degraded state)
- During dredging chemicals can be liberated to the water column or transformed to another form.
- In order to provide an alternative water quality criterion (in TSS), potential chemical and toxicological impacts of dredging Randle Reef contaminated sediment to the water column were examined.



# Elutriate Study

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- Determine the total and dissolved contaminant loadings associated with 25, 50 and 75 mg/L TSS
- Relate these to literature toxicity values
- Conduct toxicity testing on elutriate containing 25, 50 and 75 mg/L TSS
- Establish a “safe” TSS limit
- Provide recommendations to modify the specifications in regards to water quality during dredging operations



# Methods (Elutriate Chemistry)

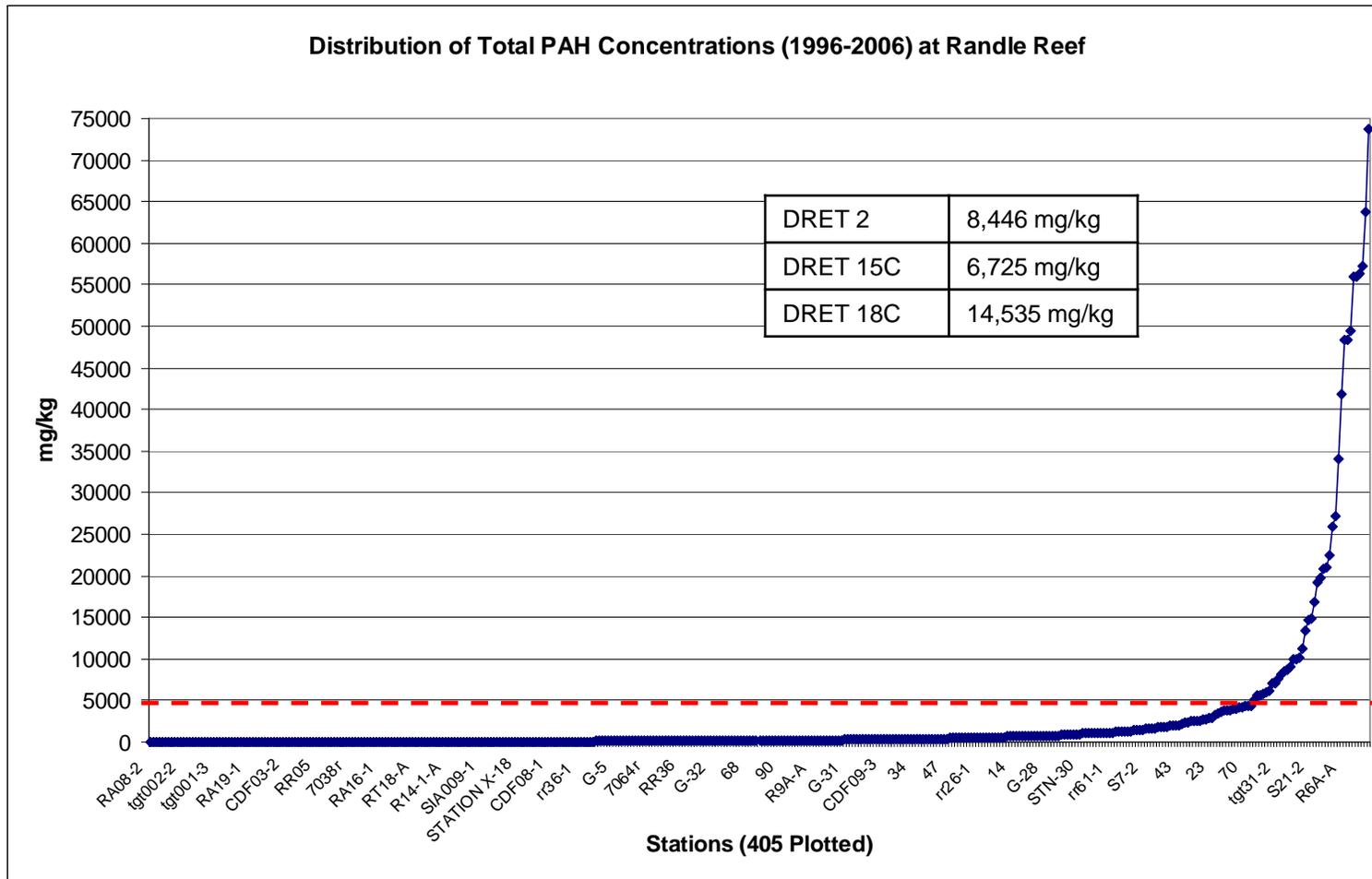


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# Methods (Elutriate Chemistry)



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# Methods (Elutriate Chemistry)



# Results (Elutriate Chemistry)

## Exceedences Metals (Dissolved)

APVs (MOE)	CCME / PWQOs
None	Marginal exceedences of zinc and copper on one sample (TSS 47 mg/L)

PWQO = Ontario provincial water quality objective



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# Results (Elutriate Chemistry)

## Exceedances of PAHs (Total)

APVs (MOE)	HC/EC (CEPA)
Numerous	(3) naphthalene, phenanthrene, indeno(1,2,3-c,d)pyrene). All from samples above 25 mg/L TSS

HC = Health Canada; CEPA = Canadian Environmental Protection Act priority substances list

## Exceedances of PAHs (Dissolved)

APVs (MOE)	HC/EC (CEPA)
4 exceedances of acenaphthylene 3 of these represent TSS >45 mg/L Final exceedence (TSS 25 mg/L) is marginal 0.149 vs 0.14 ug/L	Only naphthalene (for samples > 70 mg/L TSS)



# Results (Elutriate Chemistry)

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## Bottom Line:

Based on *chemistry* results and *literature based toxicity data*

**25 mg/L TSS would be a safe value**

for water quality objectives when monitoring dredging

## Next Tier:

What would actual toxicity tests find?



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# Methods (Elutriate Toxicity)

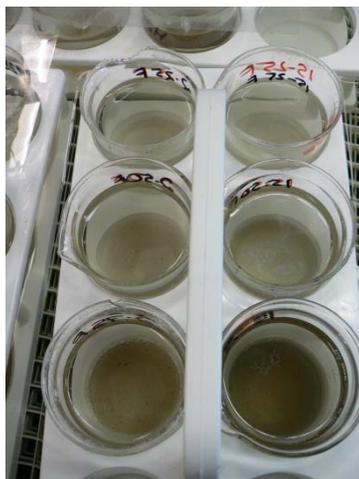


DRET solutions made in same manner as previous chemistry assessment

- site water, sediment, 15 min. mixing

Except...

- site 15 and 18 sediments combined, mixing at 300 rpm



## Acute Toxicity Tests Conducted on:

Water-column:

*Daphnia magna* and fathead minnow

Sediment-water interface:

*Hyalella azteca*, *Chironomus dilutus*



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# Methods (Elutriate Toxicity)

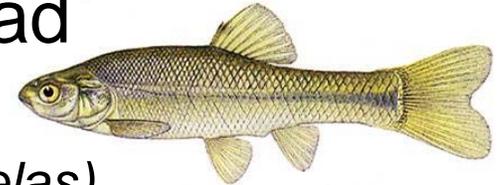
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## USACE\* recommended species:

*Daphnia magna*



juvenile fathead minnow  
(*Pimephales promelas*)

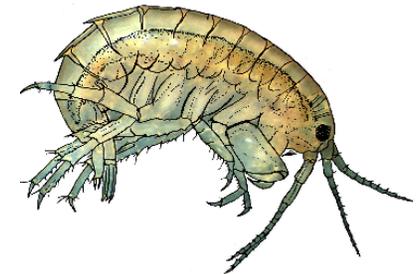


## Species adapted :

*Chironomus dilutus*



*Hyalella azteca*



\* United States Army Corps of Engineers



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# Methods (Elutriate Toxicity)

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## Water-Column Species Test Details:

(These are USACE recommended benchmark species)

48-hr EC *Daphnia magna* survival

96-h USEPA fathead minnow survival with elutriate refresh on day 2

## Sediment-water Interface Species Test Details:

96-hr EC *Hyalella azteca* survival in water-only with gauze

10-day *Chironomus dilutus* survival and growth with silica sand substrate and elutriate refresh on day 5

\* USACE = United States Army Corps of Engineers

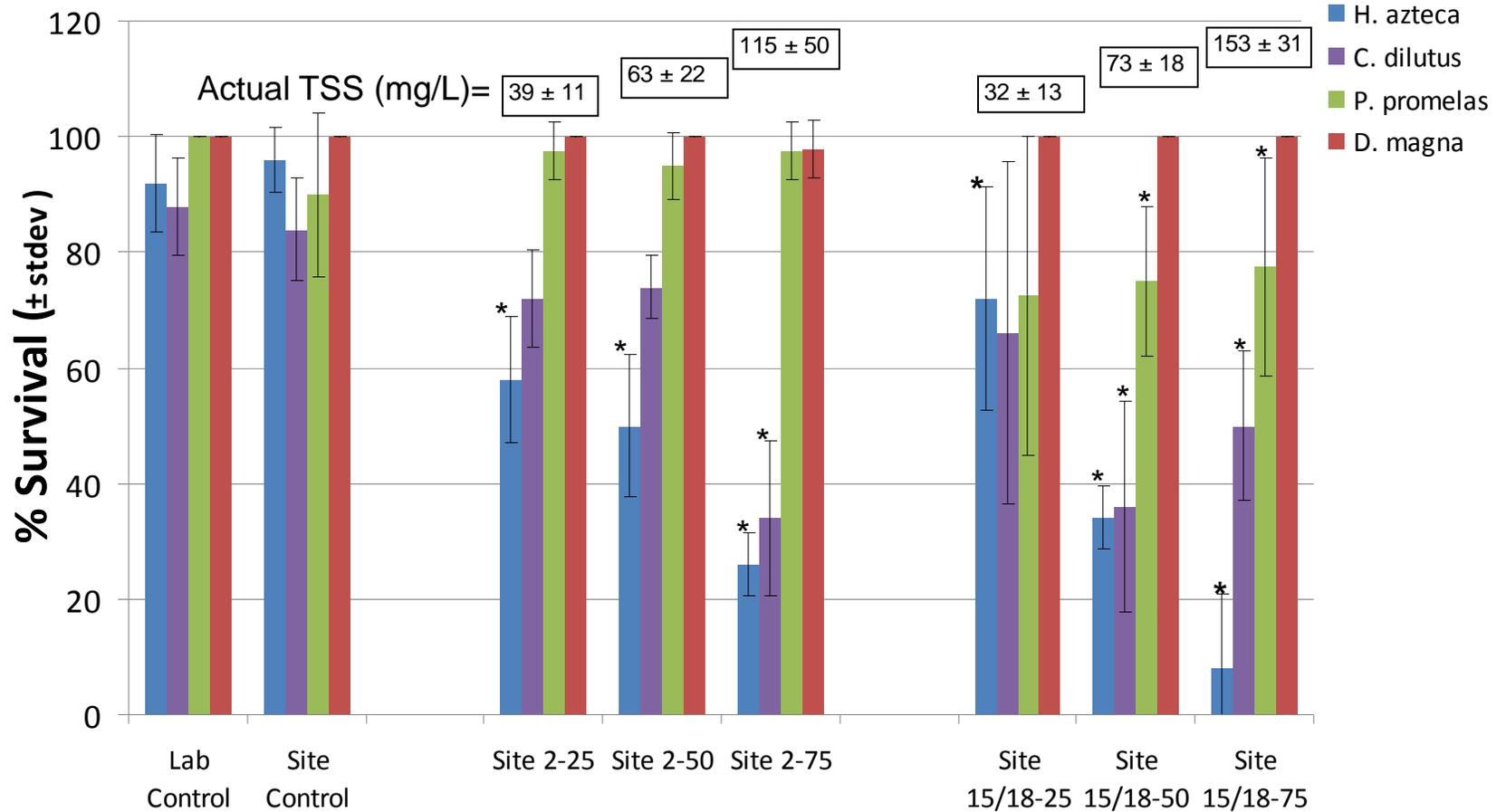


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# Results (All Species Elutriate Toxicity)



# Results (Other Sub-lethal Effects?)

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Lab Control



Site Water



Elutriate Exposed



Note: Oil droplets under carapace and empty guts in DRET



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# Discussion

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- *D. magna* appeared to consume the sediment particles
- *H. azteca*, while not a water-column species, were significantly affected at 25 mg/L

**Are these tests protective?**

**What are the longer term sub-lethal effects in a project of this scale?**



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# Discussion

**“The toxicity data collected from this study needs to be placed into the context of dredging”**

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- Dredging is detrimental to infaunal benthic invertebrates.
- The most relevant species reside in the water column and can not escape.
- Focusing on relevant species (impacted by the dredge plume), = no significant mortality to *Daphnia*. For fathead minnow, while the Fisher’s exact test indicated some differences, when variability is taken into account, significant effects are doubtful. There are no significant differences between the 25, 50 and 75 mg/L treatments for the species relevant to dredging.
- Short-term acute toxicity test results for fathead minnow and the *Daphnia* indicate no significant toxicity to exposure to up to 75 mg/L TSS.



# Discussion

“A TSS value resulting from the dredging of Randle Reef sediments of up to 75 mg/L can be supported”

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This conclusion is conservative for the following reasons:

- Testing utilized sediment that was of the most contaminated in Randle Reef. During actual dredging the elutriate created would be expected to be of lower chemical loading most of the time.
- While many PAH compounds in the total fraction exceed the APV, filtered fractions exceeded only acenaphthylene by a marginal amount. The filtered fraction is more representative of pathways experienced during dredging
- Although the highest targeted TSS was 75 mg/L, water column organism bioassays with TSS concentrations as high as 177 mg/L were tested with no significant effect.
- Populations in the field may be adapted to higher contaminant loadings than laboratory reared populations.



# Discussion

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- EC will recommend that the chosen criterion will be above a floating background level.
- Chemical loading associated with background TSS in the Randle Reef Area is negligible.
- MNR okay with TSS being above 100 mg/L from a “physical” standpoint due to the poor / degraded habitat at the site and the long term benefit
- A 75 mg/L level would only be supported by EC if associated with a time limitation

MNR = Ontario Ministry of Natural Resources



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# Discussion

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In order not to encourage “aggressive” dredging EC recommending:

- ***25 mg/L above a floating background value, 100 m from the in-water work, when background levels are less than or equal to 75 mg/L. In any cases where background TSS exceeds 75 mg/L, the maximum allowable TSS will be 100 mg/L.***



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# Acknowledgments

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- Christina Jaskot (Environment Canada) for assistance with sample filtering
- Environment Canada Technical Operations for assistance with sample collection.



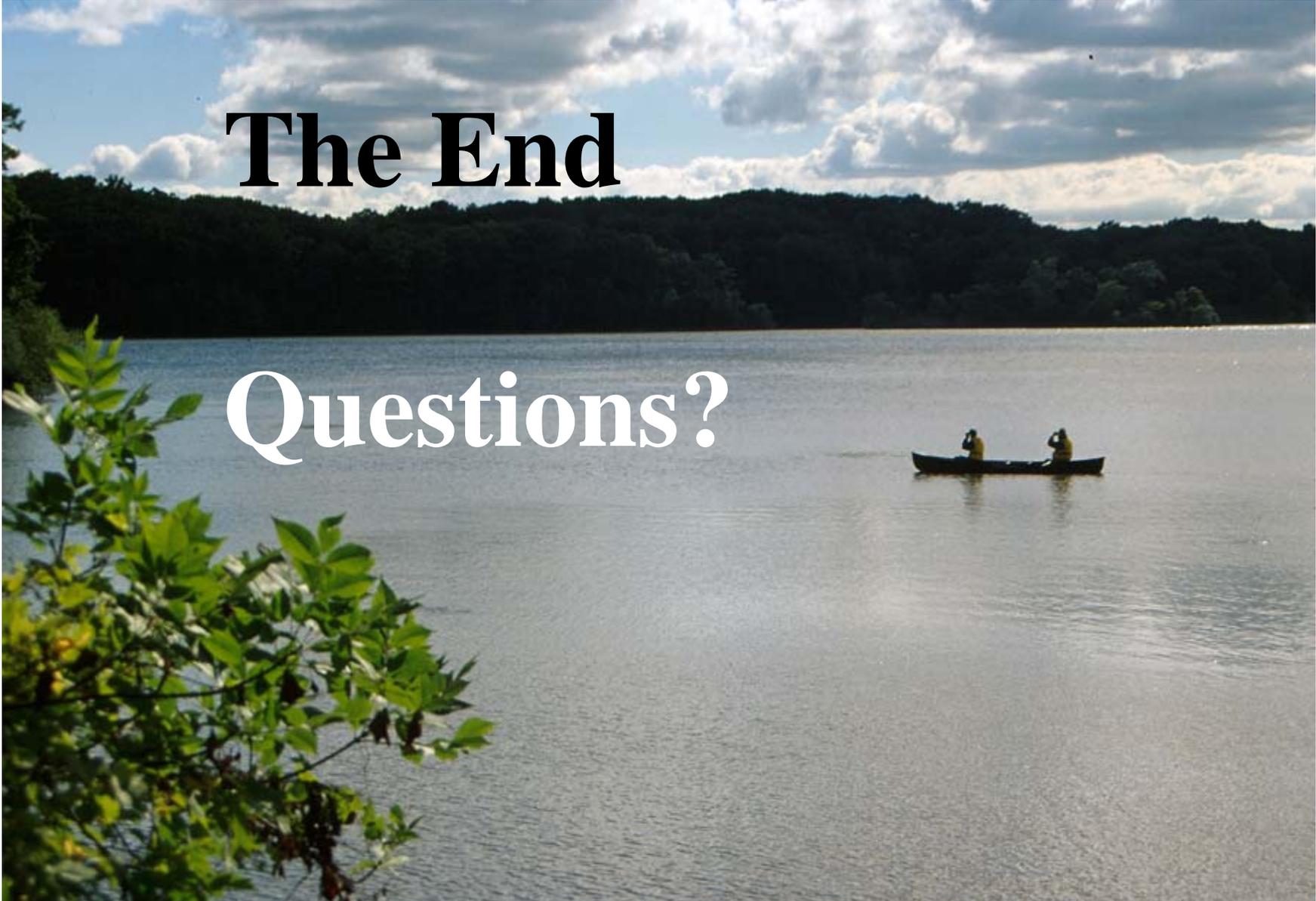
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# The End

# Questions?



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