



Developing Mathematical Model of Water Quality Dynamics using Indigenous Knowledge

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Linking Science and Indigenous Knowledge: Water Quality Trends in Calling Lakes (SK)

The project was supported by Health Canada within the National First Nations Environmental Contaminants Program and received the Recognition Award of the Regional Centre of Expertise (Saskatchewan, Canada)

Experts:

Chief Louis Taypotat – *Kahkewistahaw First Nation*

Elder Joseph Taypotat – *Kahkewistahaw First Nation*

Elder Caroline Wasacase – *Kahkewistahaw First Nation*

Elder Lionel Louison – *Kahkewistahaw First Nation*

Elder Evelyn Desnomie – *Peepeekisis First Nation*

Elder Elwood Pinay – *Peepeekisis First Nation*



Holistic Approach of Cognition

- Holism (from ὅλος holos, a Greek word meaning all, entire, total) is the idea that all the properties of a given system (physical, biological, chemical, social, economic, mental, linguistic, etc.) cannot be determined or explained by its component parts alone.
- A holistic approach means thinking about the whole picture with many parts. Any change to one part affects the whole system.
- **In medicine**, holistic refers to addressing the whole person, including their physical, mental, and emotional health, while taking social factors into consideration. Holistic medicine includes conventional and alternative treatments.
- John Muir ("Father of National Parks"), wrote "When we try to pick out anything by itself we find it hitched to everything else in the Universe"



Linking Science and Indigenous Knowledge: Water Quality Trends in Calling Lakes (SK)



From right to left:
Headman Lambert, Elders Elwood and Evelyn

Linking Science and Indigenous Knowledge: Water Quality Trends in Calling Lakes (SK)



From right to left:
Chief Louis, Councilor Josephine, Elders Joseph, Lionel and Caroline

Modeling of Water Quality Dynamics with Indigenous Perspectives



The Calling Lakes (Pasqua, Echo, Mission, and Katepwa Lakes)



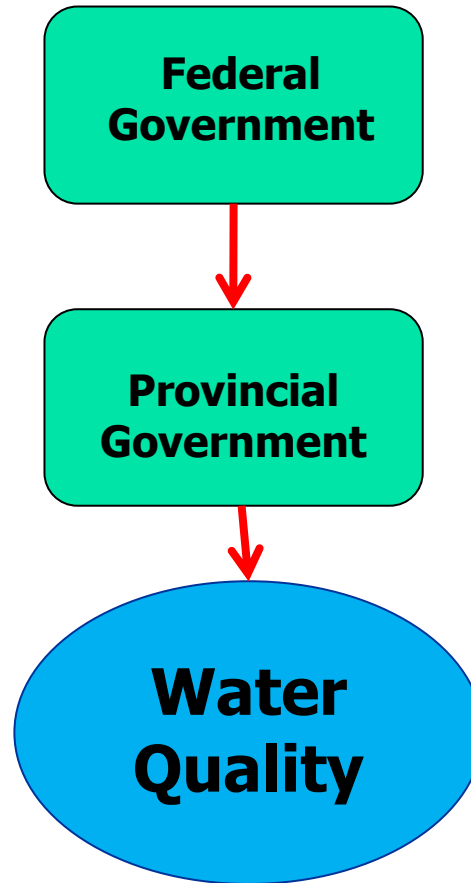
Calling Lakes



What is effected by water quality?



Who monitors the water quality?





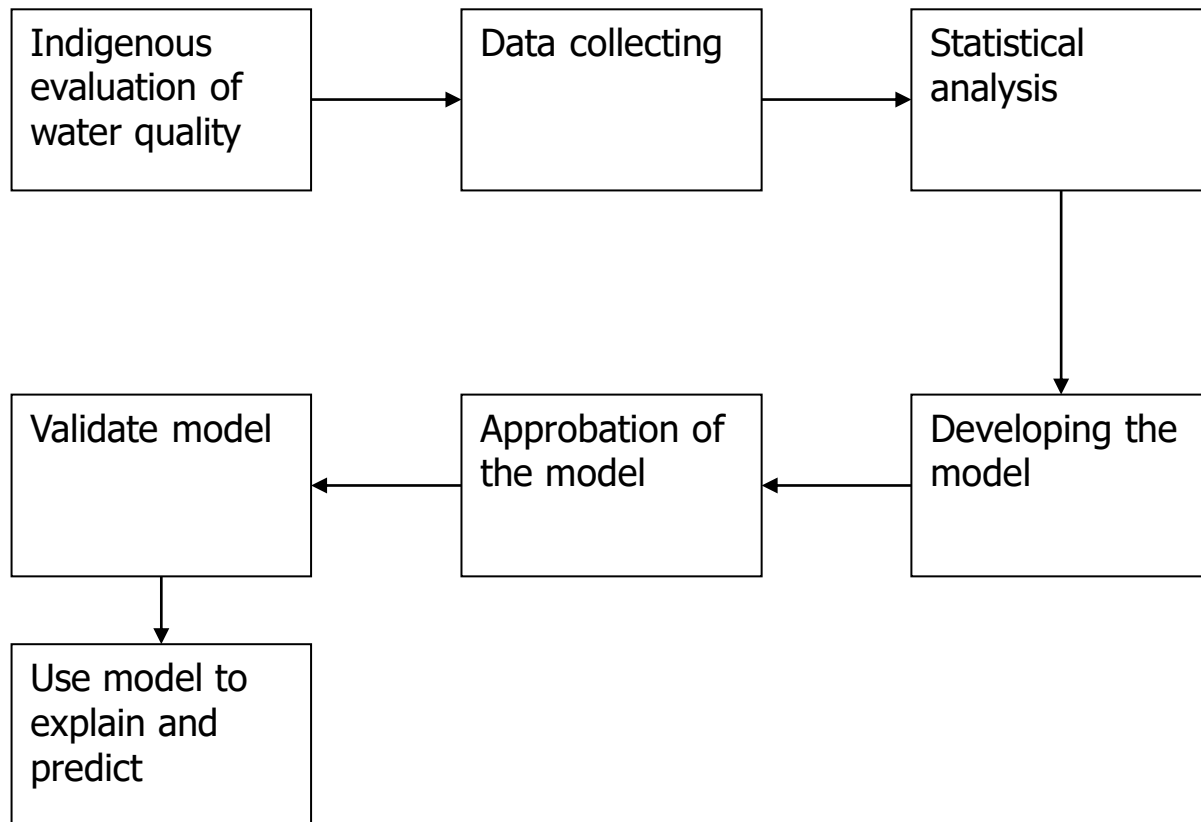
Ecosystem Evaluation. How to Evaluate Water Quality?

- “Western type” evaluation
 - Reliable (+)
 - Quantitative (+)
 - Lab based (+ and -)
 - Not always available (-)

- Indigenous evaluation
 - Lab is not required (+)
 - Not always quantitative (-)
 - Based on many years of experience (+)



Modeling Chain





How to Create Indigenous Evaluation System?

- Work with experts (Elders)
 - Interview
 - Key questions (*parameters*)

- Work with community
 - Number of households
 - Age of community

- Questionnaires



Evaluation Parameters

1. How would you evaluate the taste of fish caught in your community water in comparison with our days?
2. How would you evaluate overall quality of water in your community in comparison with our days?
3. How would you evaluate the quality of birds hunted in your community in comparison with our days?
4. How would you evaluate the number of bird nests in the shore in comparison with our days?
5. How would you evaluate the level of chemicals of the water in your community in comparison with our days?
6. How often have your family members swim in the water in your community in comparison with our days?
7. How would you evaluate the transparency of the water in your community in comparison with our days?
8. How would the water quality in your community change in 5/10/15/20 years?



Evaluation Period

- Past
 - 30 years ago
 - 20 years ago
 - 10 years ago
 - 5 years ago

- Future
 - In 5 years
 - In 10 years
 - In 15 years
 - In 20 years



Evaluation Scale

- much better: +2
 - better: +1
 - about the same: 0
 - worse: -1
 - much worse: -2
- much more: +2
 - more: +1
 - about the same: 0
 - less: -1
 - much less: -2
- much more often: +2
 - more often: +1
 - about the same: 0
 - less often: -1
 - much less often: -2
- much more transparent: +2
 - more transparent: +1
 - about the same: 0
 - less transparent: -1
 - not transparent at all: -2



Digitizing the Answers (*Example*)

Example

- ***How would you evaluate the change of taste of fish caught in your community water in the past in comparison with modern day?***

$$\text{Averaged Mark} = \frac{\sum \text{Individual Mark} \times \text{Number of the Marks}}{\text{Number of Respondents}}$$

30 years ago	20 years ago	10 years ago	5 years ago
much better	much better	much better	much better
better	better	better	better
about the same	about the same	about the same	about the same
worse	worse	worse	worse
much worse	much worse	much worse	much worse



Digitizing the Answers (*Example*) *cont.*

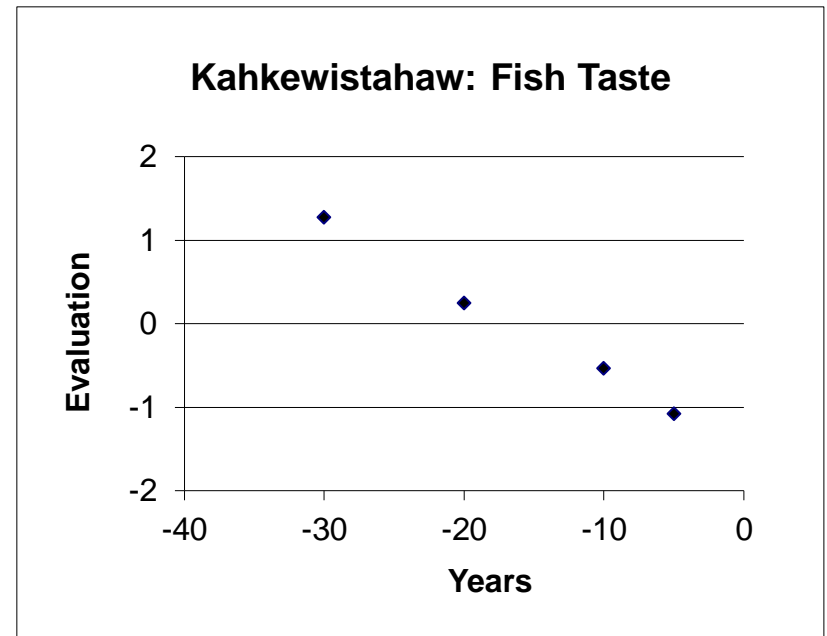
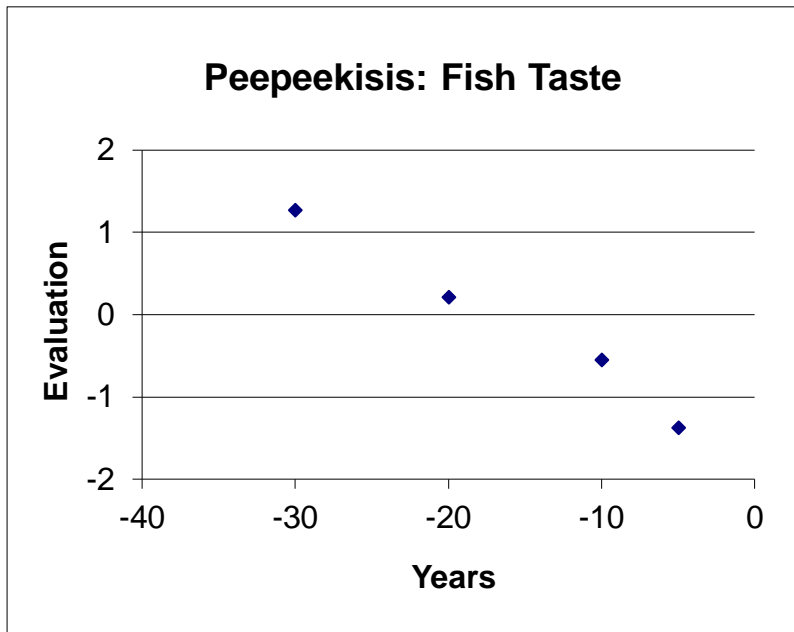
	# of respondents		
30 years	26		
much better	16	2	32
better	5	1	5
about the same	2	0	0
worse	2	-1	-2
much worse	1	-2	-2
			1.27

Average Mark

$$= \frac{2 \times 16 + 5 \times 1 + 2 \times 0 + 2 \times (-1) + 1 \times (-2)}{30} = +1.27$$

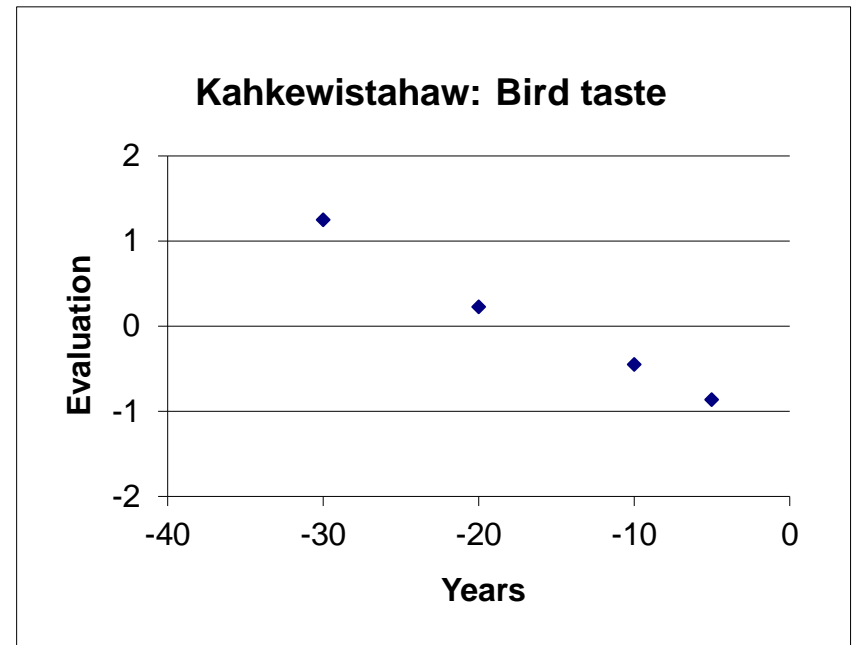
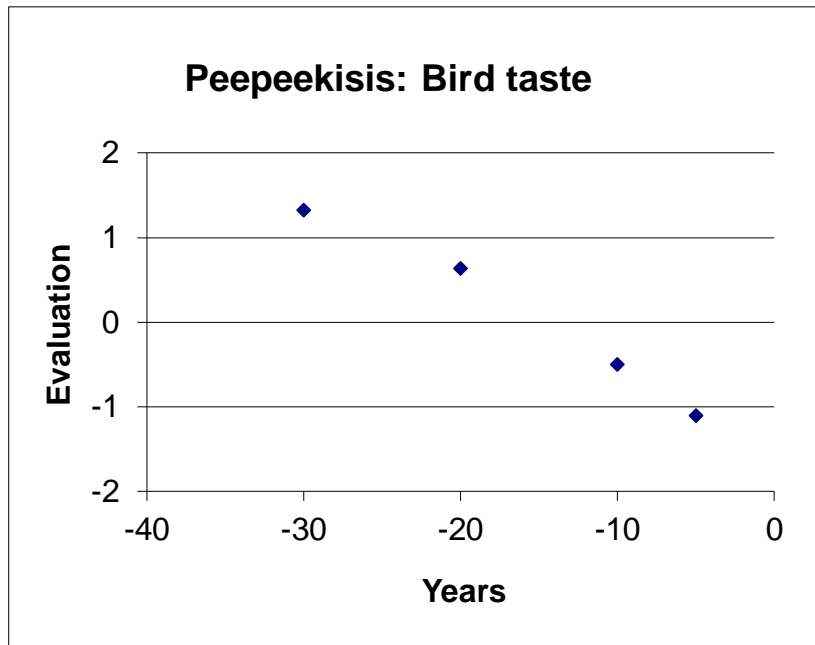


Temporal Dynamics

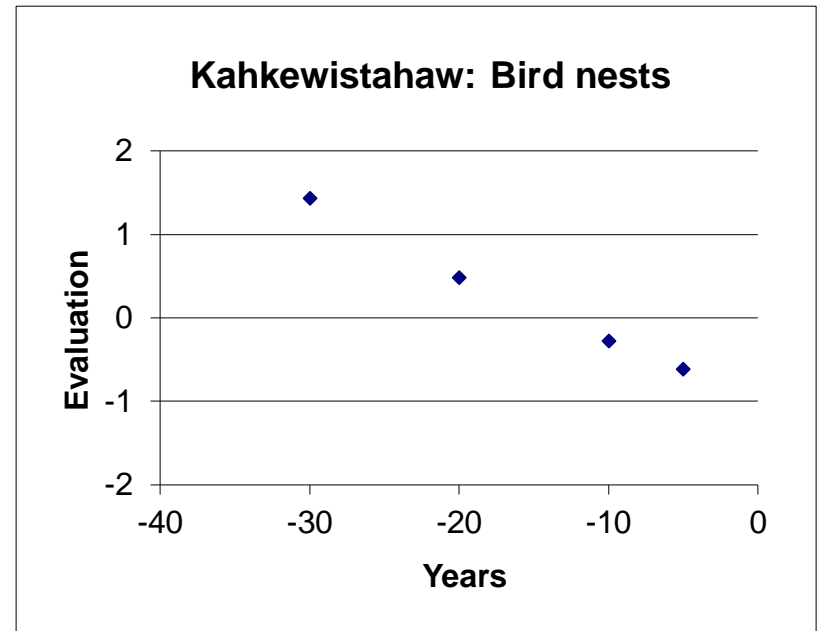
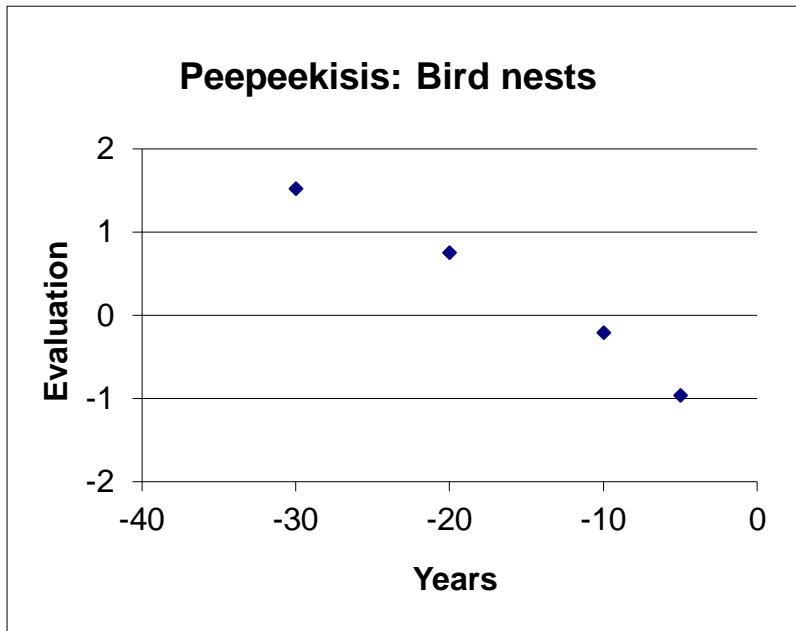




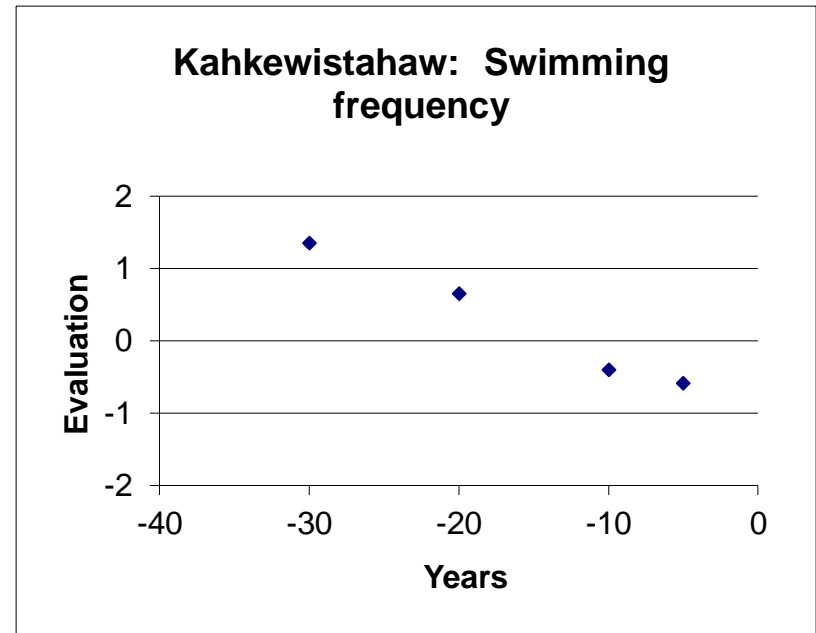
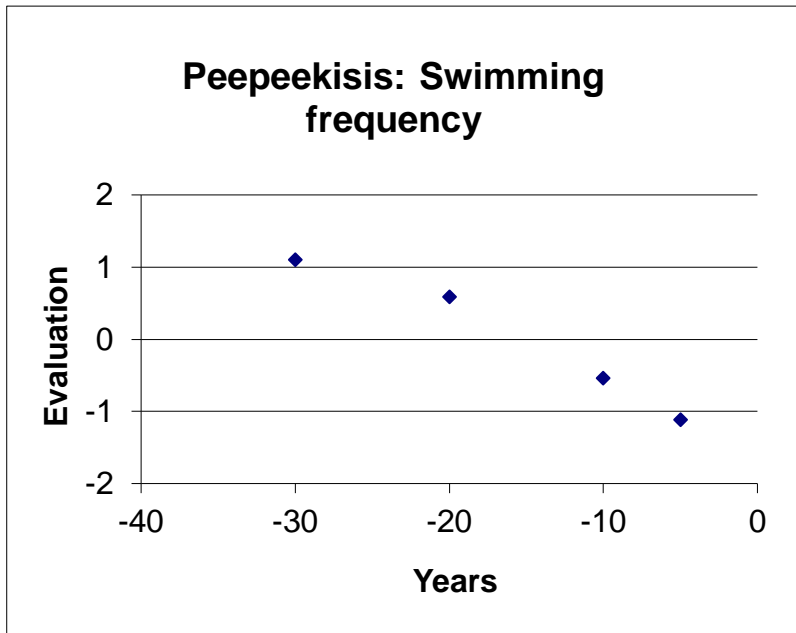
Temporal Dynamics



Temporal Dynamics



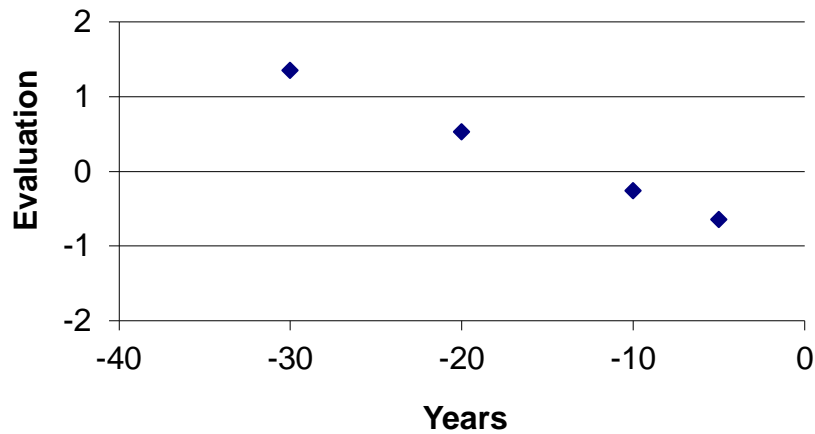
Temporal Dynamics



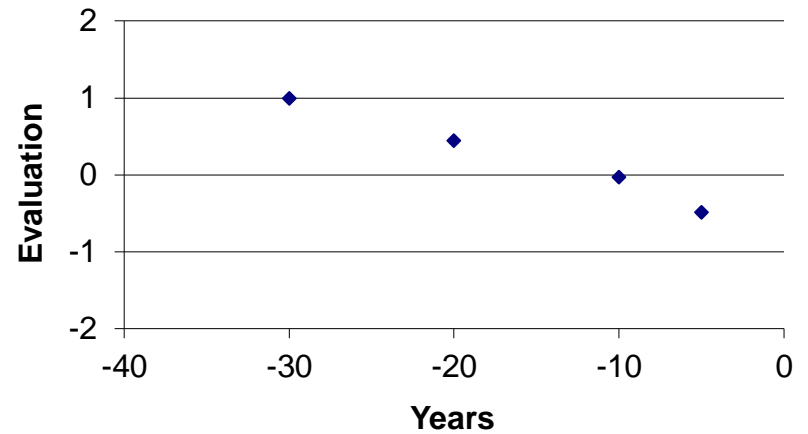


Temporal Dynamics

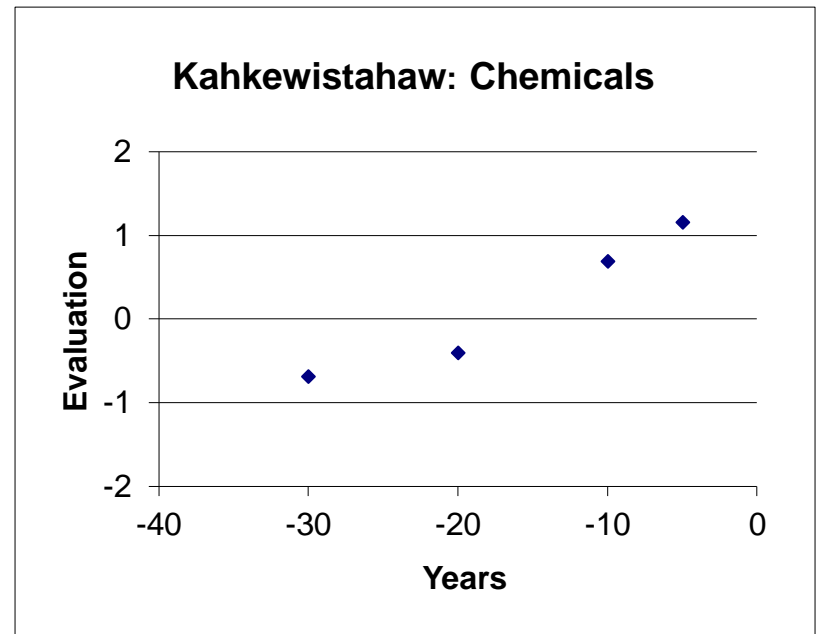
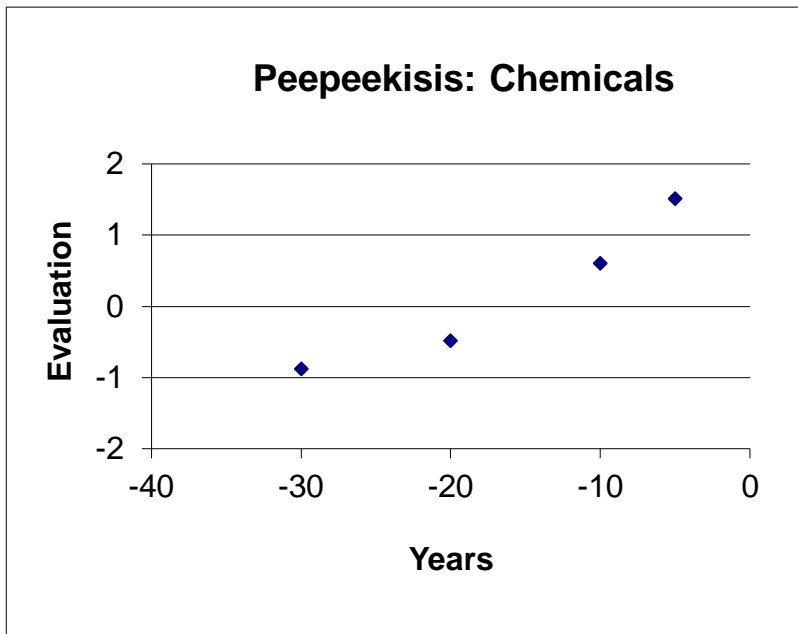
Peepeekisis: Transparency



Kahkewistahaw: Transparency



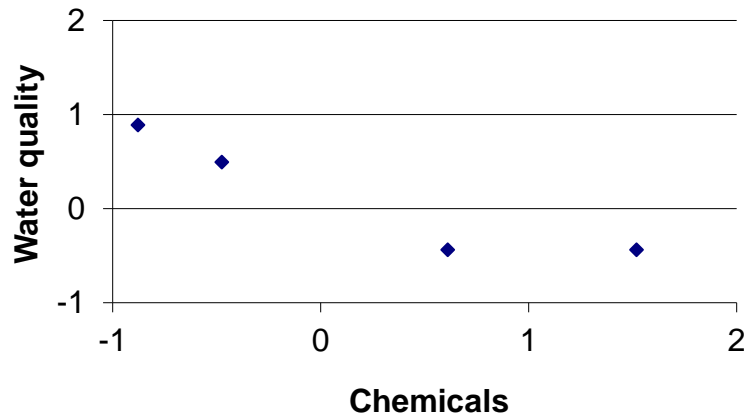
Temporal Dynamics



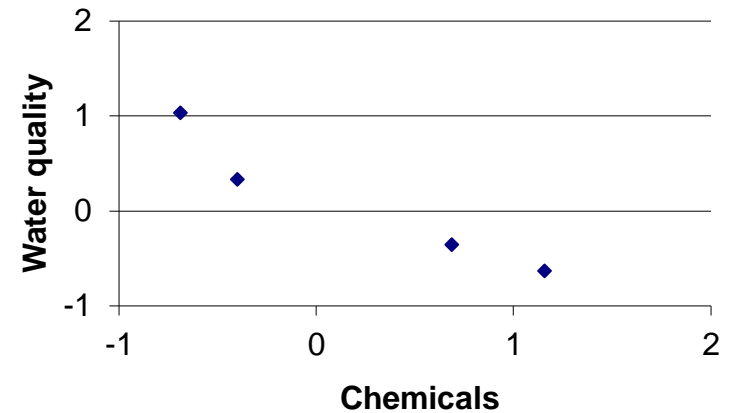


Phase Diagram

**Peepekisis:
Water quality vs. Chemicals**



**Kahkewistahaw:
Water quality vs. Chemicals**





Statistical Analysis

Peepeekisis Water Survey Analysis

Q2. & Q8. combined

95.6% of the variation in the evaluation of water quality in the past and future combined is explained by the variation in the year.

Q2. & Q8. separate

Q2.- 94.6% of the variation in the evaluation of water quality of the past is explained by the year that you are evaluating.

Q8.- 99.5% of the variation in the evaluation of water quality in the future is explained by the year that you are evaluating.

Q5.

99.9% of the variation in the evaluation of chemicals in the water is explained by the year that you are evaluating.

Kahkewistahaw Water Survey Analysis

Q2. & Q8. combined

98.7% of the variation in the evaluation of water quality in the past and future combined is explained by the variation in the year.

Q2. & Q8. separate

Q2.- 99.96% of the variation in the evaluation of water quality of the past is explained by the year that you are evaluating.

Q8.- 95.8% of the variation in the evaluation of water quality in the future is explained by the year that you are evaluating.

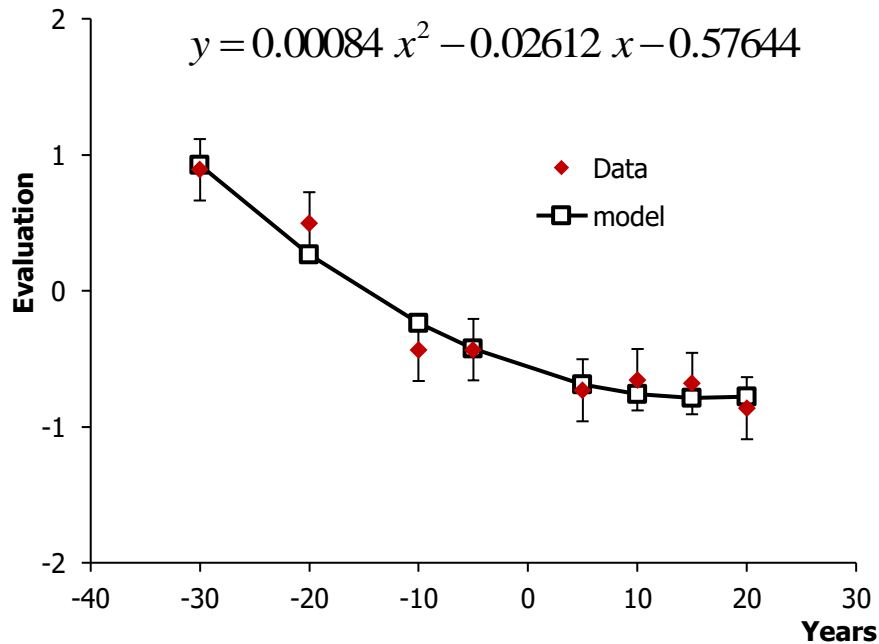
Q5.

99.0% of the variation in the evaluation of chemicals in the water is explained by the year that you are evaluating.

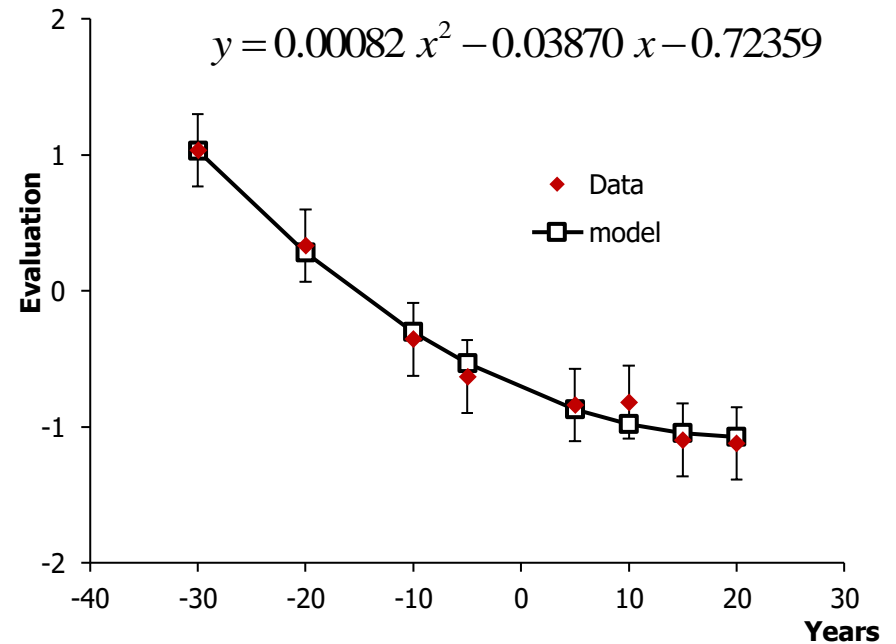


Polynomial Model

Peepeekisis Water Quality



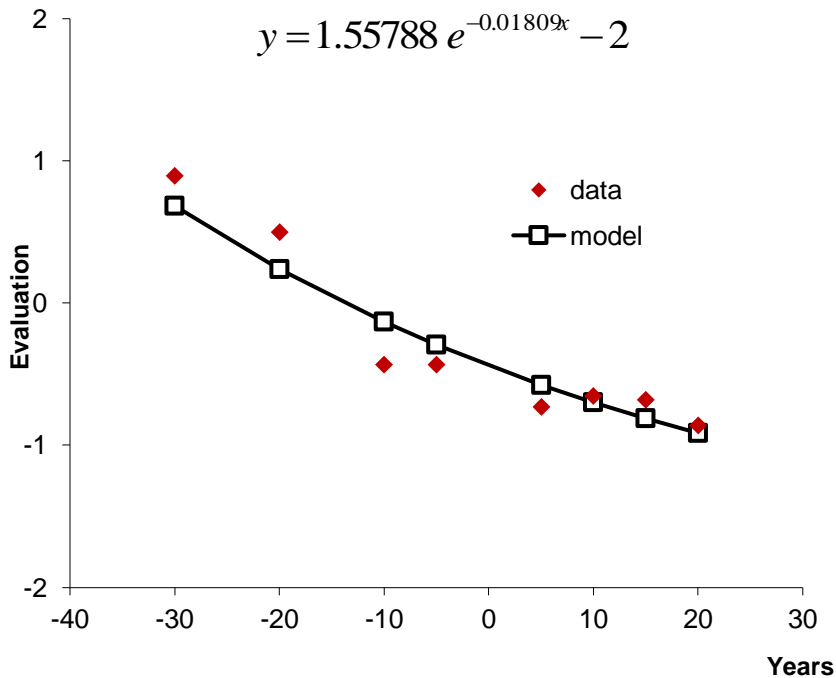
Kahkewistahaw Water Quality



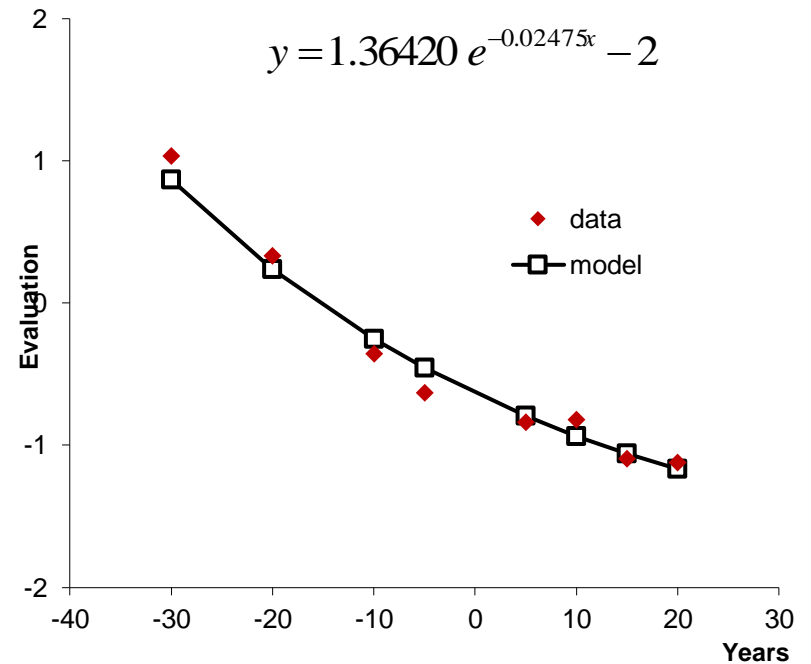


Exponential Model

Peepeekisis Water Quality



Kahkewistahaw Water Quality





Possible Scenarios

Polynomial Model

The community water is expected to reach the lowest level of quality in 16 (Peepeekisis) – 24 (Kahkewistahaw) years. Then due to water treatment activities some improvement in the water quality may be evident.

Exponential Model

The community water quality will decrease exponentially in spite of water treatment activities until it reaches natural saturation.

How to monitor the water quality?

