



Delta progradation and lake infilling in the Peace-Athabasca Delta, Canada

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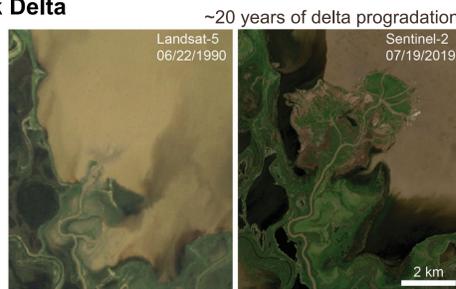
Background and Objectives

The Peace-Athabasca Delta (PAD)

- One of the largest inland deltas in the world, located in Alberta, Canada
- Complex hydrology with hundreds of small and shallow lakes, several large lakes and major rivers, distributary networks, and flow reversals
- Incredibly biodiverse region

Mamawi Lake and Mamawi Creek Delta

- Mamawi Lake is a key hydrologic connection in the center of the PAD
- Mamawi Creek Delta began forming in 1982
- Delta has already prograded ~3 km across the lake

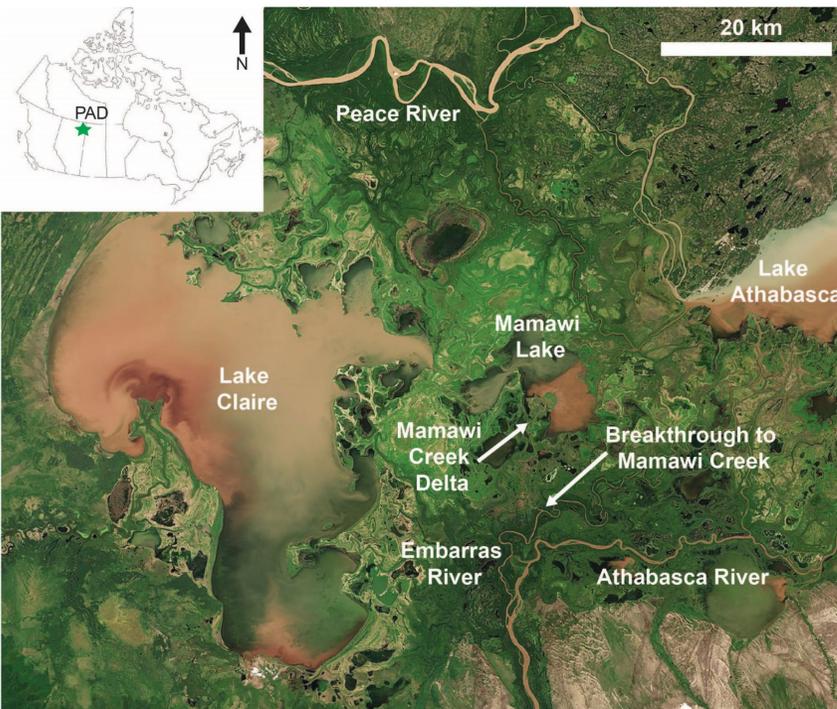


Recent Lake Shallowing

- Threat to delta sustainability, habitat, and navigability of the waterways
- Uncertain cause: Climate change, anthropogenic activity, natural variability?
- More research to date on changing hydrology than potential geomorphic influences on lake levels and storage

Objectives

- Develop a model (in Delft3D) of Mamawi Lake and delta that can acceptably simulate observed progradation rates
- Estimate potential timespans for lake infilling and loss of navigability



The Peace-Athabasca Delta (PAD) is in northeastern Alberta, Canada. Mamawi Lake is located at the center of the PAD and is primarily fed by Mamawi Creek. An avulsion on the Embarras River in 1982 reactivated Mamawi Creek, resulting in the growth and formation of the Mamawi Creek Delta.

Data and Proposed Methods

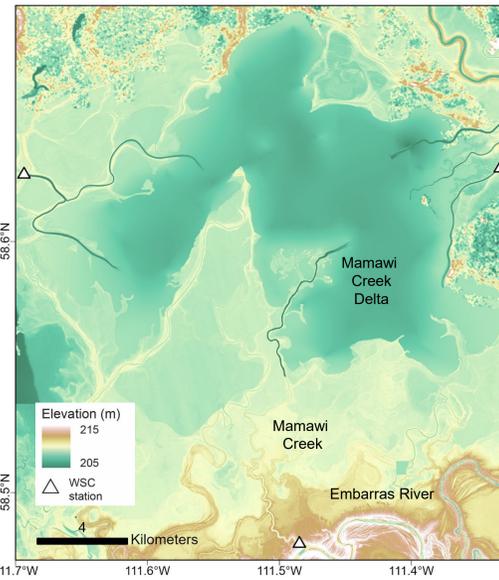
Stage 1: Historic Delta Progradation

SETUP

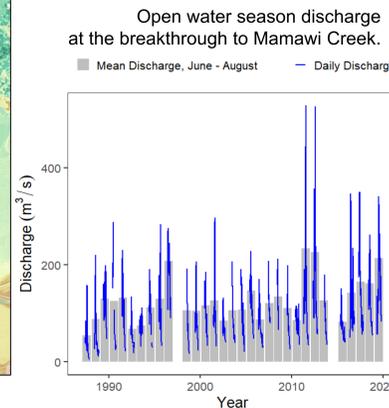
- *Timeframe:* 1987–present
- *Elevation:* Modify bathymetry to represent pre-delta conditions
- *Hydrologic boundaries:* Open water discharge on Mamawi Creek and water levels near Mamawi Lake from Water Survey Canada (WSC) stations
- *Sediment inputs:*
 1. Suspended sediment concentration (SSC) rating curve from WSC and existing field data
 2. Initial characteristics from WSC data and updated based on predicted delta form

WORK PLAN

- Leverage optical remote sensing record (Landsat 4-8 and Sentinel-2) to constrain unknown and variable model inputs (i.e., sediment characteristics)
- Iteratively compare modeled and observed delta growth and form (i.e., number of channels, delta length, delta area, and progradation rate)
- Update sediment characteristics in the model to improve agreement between model predictions and observed delta growth over time



Elevation and bathymetry data over Mamawi Creek, delta, and lake (Bergeron et al., 2020; Siles et al., 2020). Planned 2022 fieldwork will collect additional bathymetry in Mamawi Creek and delta channels.



Implications and Future Work

- First attempt to quantify future navigability in the PAD
- Estimated lake infill rates will complement hydrology-focused studies on lake level declines
- June–July 2022: Model development with Dr. Doug Edmonds at Indiana University, supported by CUAHSI
- July–August 2022: Fieldwork in the PAD to collect additional bathymetry and validation data



Mamawi Creek Delta in June 2014 (K. Timoney)

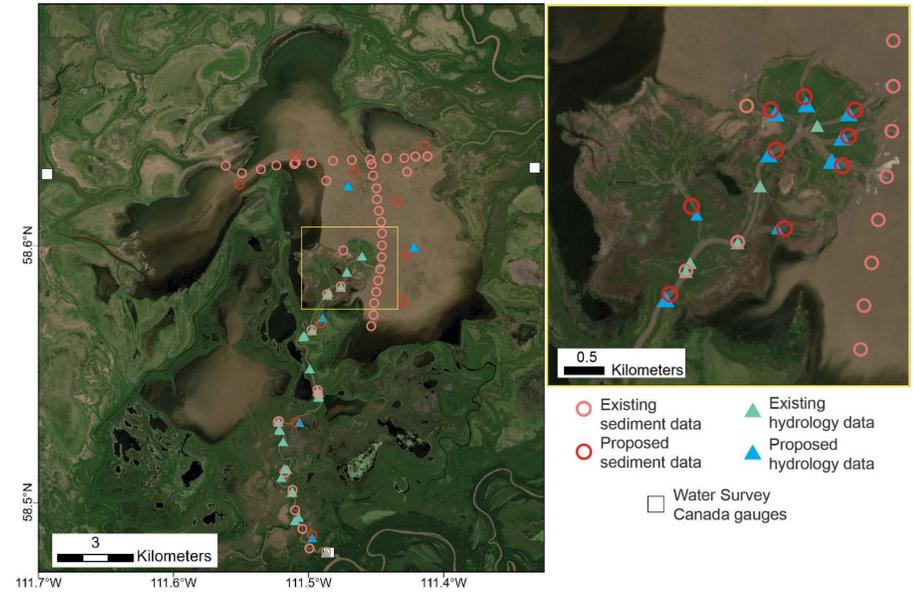
Stage 2: Predicting Delta Growth

SETUP

- *Timeframe:* Present–2120
- *Elevation:* Modify bathymetry to include other delta channels (fieldwork in summer 2022)
- *Hydrologic boundaries:*
 1. Mean discharge and water levels (1987–present)
 2. Discharge and water levels adjusted with climate change predictions (Dibike et al., 2018)
- *Sediment inputs:*
 1. Updated SSC rating curve based on Dibike et al. (2018)
 2. Characteristics determined during Stage 1

WORK PLAN

- Calibration: Measurements of summer lake levels, Mamawi Creek discharge, and SSC from previous field campaigns, 2006–2019
- Validation: Fieldwork in summer 2022 to collect additional water levels, discharge, and SSC data
- Sensitivity analysis to find an optimal morphological acceleration factor (MORFAC)
- ~100 year simulations to determine when and where Mamawi Lake will become unnavigable



Existing and planned field measurements of discharge, water levels, and SSC over Mamawi Lake, creek, and delta. Data from previous campaigns span 2006–2019 (Pavelsky and Smith, 2009; Long and Pavelsky, 2013; Harlan et al., 2021). Planned measurements for summer 2022 will focus on intra-delta flow and sediment partitioning.

Acknowledgements and References

Members of the Mikisew Cree First Nation, the Athabasca Chipewyan First Nation, and the Fort Chipewyan Métis Association live in the Peace-Athabasca Delta, their ancestral and current lands. This work is being conducted at the University of North Carolina at Chapel Hill, which sits on the lands of the Occaneechi, Shakori, Eno, and Sissipahaw peoples.

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Bergeron et al. (2020), *Hydrology and Earth System Sciences* 24. Dibike et al. (2018), *River Research and Applications* 34. Harlan et al. (2021), *Water Resources Research* 57. Long and Pavelsky (2013), *Remote Sensing of Environment* 129. Pavelsky and Smith (2009), *Water Resources Research* 45. Siles et al. (2020), *Remote Sensing of Environment* 236.