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Where's the Waterline? The Case of the Disappearing Lake

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Summary

The McClelland Lake Wetland Complex (MLWC) is a vast and controversial Environmentally Significant Area in Alberta. Beneath the culturally and ecologically important MLWC lies enormous quantities of valuable bitumen ore. In 1996 Alberta banned mining within the MLWC. In 2002, the Province applied conditions on the Fort Hills Oil Sands Project affirming the rare lenticular patterned fen within the MLWC be protected. Understanding the surface hydrology, and groundwater-surface water interactions, of the MLWC is imperative to mining developments who wish to mine in the non-lenticular fen portion of the MLWC. Operational plans for the area require good understanding of the tolerance of the MLWC to surface water drawdown to mitigate effects to the MLWC. The public data record is a useful resource for scientists studying the historical changes that the hydrology of the MLWC has undergone over time. Of interest are the earliest air photos of the MLWC from 1950 and 1953. These images appear to show a dramatically drawn-down lake, since re-filled by natural bio-geoclimatic processes. This presentation explores the ambiguities of these puzzling images that draw surprise and fascination by the world's most prominent wetland scientists. The objectives are to provide new insights to the scientific community on these images and to promote the present value of historical air photo interpretation skills in modern scientific mysteries such as this "case of the disappearing lake."

Theory / Method / Workflow

The challenge posed is that in the 1950 and 1953 historical air photos, the lake appears to be 'half-empty', supposedly due to extensive warm and dry periods in that region of the boreal forest in the decades preceding it. Between 1953 and the next available air photo in 1967 (14 years), the lake had 're-filled' to present day water levels and there are affirming data that show the lake level has remained relatively static ever since, despite subsequent warm and dry periods, albeit not as severe as the early decades of the 20th century. Groundwater well records in the area during that time were scarce, and it is unclear whether groundwater discharge patterns can account for such a dramatic change in lake level between 1953 and 1967.

To complicate matters, the mosaic images developed by the Alberta air photo survey of 1949 to 1953, dyed McClelland Lake with black ink to a similar shoreline as depicted in modern aerial images, suggesting that the expert geographers of the day did not interpret the lake to be 'half-empty' as the 1950 image could be interpreted as.

In order to investigate alternate explanations for the ambiguities in the 1950 and 1953 air photos, the following investigation tactics were developed:

1. Creation of a timeline of historical images (including stereo pairs) from 1950 through to the beginning of the satellite image record (1972).

2. Creation of a timeline of historical satellite images (several images per calendar year), including the development of time-lapse videos from satellite images obtained through the USGS Landlook website and Google Earth.
3. Compilation and presentation of Historical Weather Data for Fort McMurray (1949 to present) from Environment Canada (2021)
4. Compilation and presentation of Bathymetry Data for McClelland Lake
    - L1 Station Monitoring Station Installed 1997
    - RAMP (2003) Report (2001 field monitoring)
    - Continuous readings 2017 to present (Station 07DA023) – Environment Canada (2021)
5. Review of Hydrology/Hydrogeology Reports in the Public Record for the Fort Hills Oil Sands Project (including True North 2001)
6. Creation of three-dimensional modelling and visualizations of the 1950 and 1953 stereo images in QGIS 3.16 and GRASS GIS 7.8, supplemented with publicly available digital elevation modelling data.
7. Delineation of the water's edge of McClelland Lake at various points in time, and estimating the change in water volume in the lake through correlation to the digital elevation model.

The weather and bathymetry data were synchronized with the historical images to make qualitative judgements about long-term trends of water-levels. These data were also used to estimate seasonal evaporative water loss from the lake using the Penman formula. Although McClelland Lake is about 90 km north of the Fort McMurray airport and local weather patterns would not be perfectly aligned, the elevation and regional topography is comparable. The Fort McMurray Airport data were considered to be a reasonable surrogate for evaluating historical trends in the absence of site-specific data.

The weather data allowed for scrutiny of various ambiguities that are apparent in the 1950 and 1953 image, such as evaluating the probability that surface ice and/or biofilms may be present, and to what extent emergent/submergent/free-floating vegetation may be obscuring the water's edge. Lastly, the weather and seasonality data were used to provide insights into the possibility that subsurface algal blooms may be creating variable scattering or absorption of light when compared to recent full-colour images that have been modified to resemble the saturation/exposure/contrast of the cameras used for the 1950 and 1953 images.

Results, Observations, Conclusions

At the time of preparation of this abstract, the study is underway, however observations and results are preliminary. Conclusions have not yet been drawn. It is anticipated that the results and conclusions of this investigation will be ready for presentation at geoconvention 2021.

Novel/Additive Information

In two-dimensions and black and white, even a discerning eye can make errors of judgement in the interpretation of water's edge and where exposed vs. submerged sediment occurs in large, shallow waterbodies. Where the historical record of air photos is of importance to making

operational and regulatory decisions that may (or may not) impact large and sensitive ecosystems, the application of the precautionary principle is imperative. In these instances, resources in the form of professional scrutiny by experienced biophysical scientists and geographers are necessary to examine the multitude of ambiguities that the historical air photo record may present. It is through these examinations that professional practitioners are able to protect the public interest on matters of environmental protection while at the same time protecting proponents from judgements that might expose them to regulatory risks or financial liabilities associated with unintended environmental harm.

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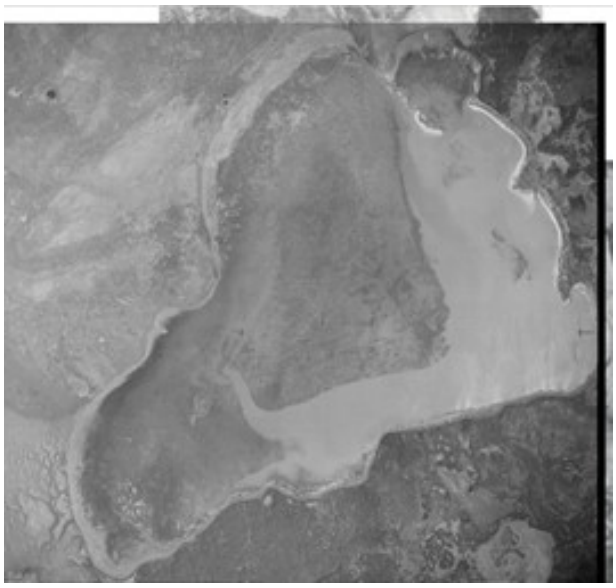

Figure 1 – McClelland Lake (1950 air photo)

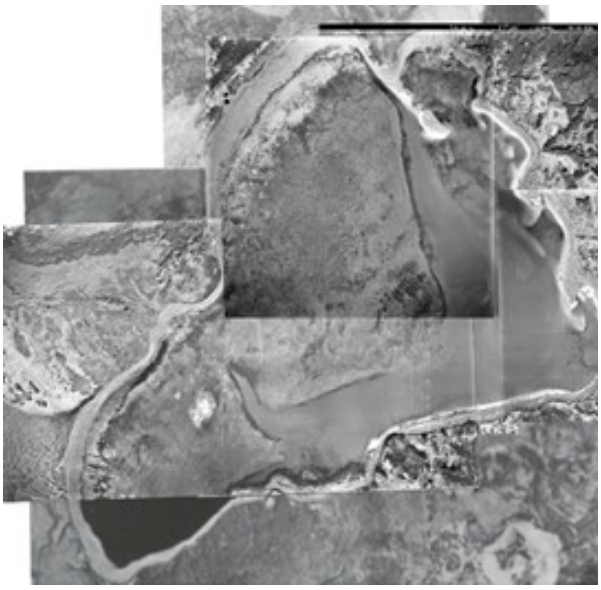

Figure 2 – McClelland Lake (1953 air photo mosaic)

Figure 3 – McClelland Lake (1986 Google Earth image)

Figure 4 – McClelland Lake (2005 Google Earth image)