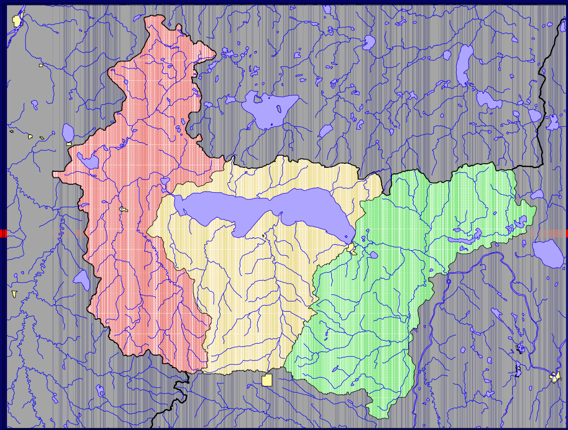

Hydrology of the Lesser Slave Watershed

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Evaluation and Reporting Section (Water Assessment)
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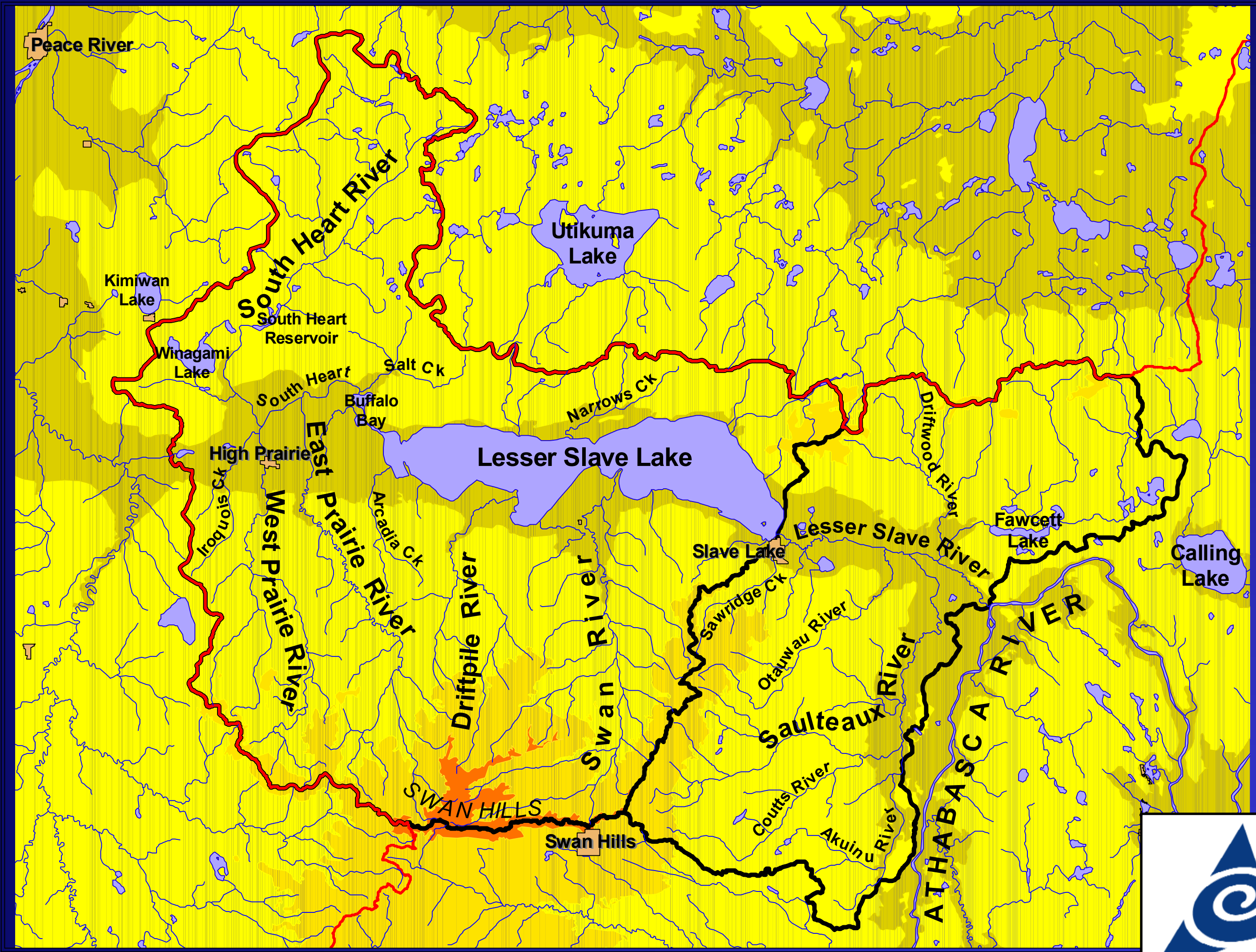
Introduction

- Basic Watershed Information
  - Key Features and Major Tributaries
  - Drainage Areas
- Basic Hydrologic Data
  - Lake Characteristics
  - Runoff, Precipitation and Evaporation
- Basic Lake Water Balance
  - Amounts and Sources

Introduction

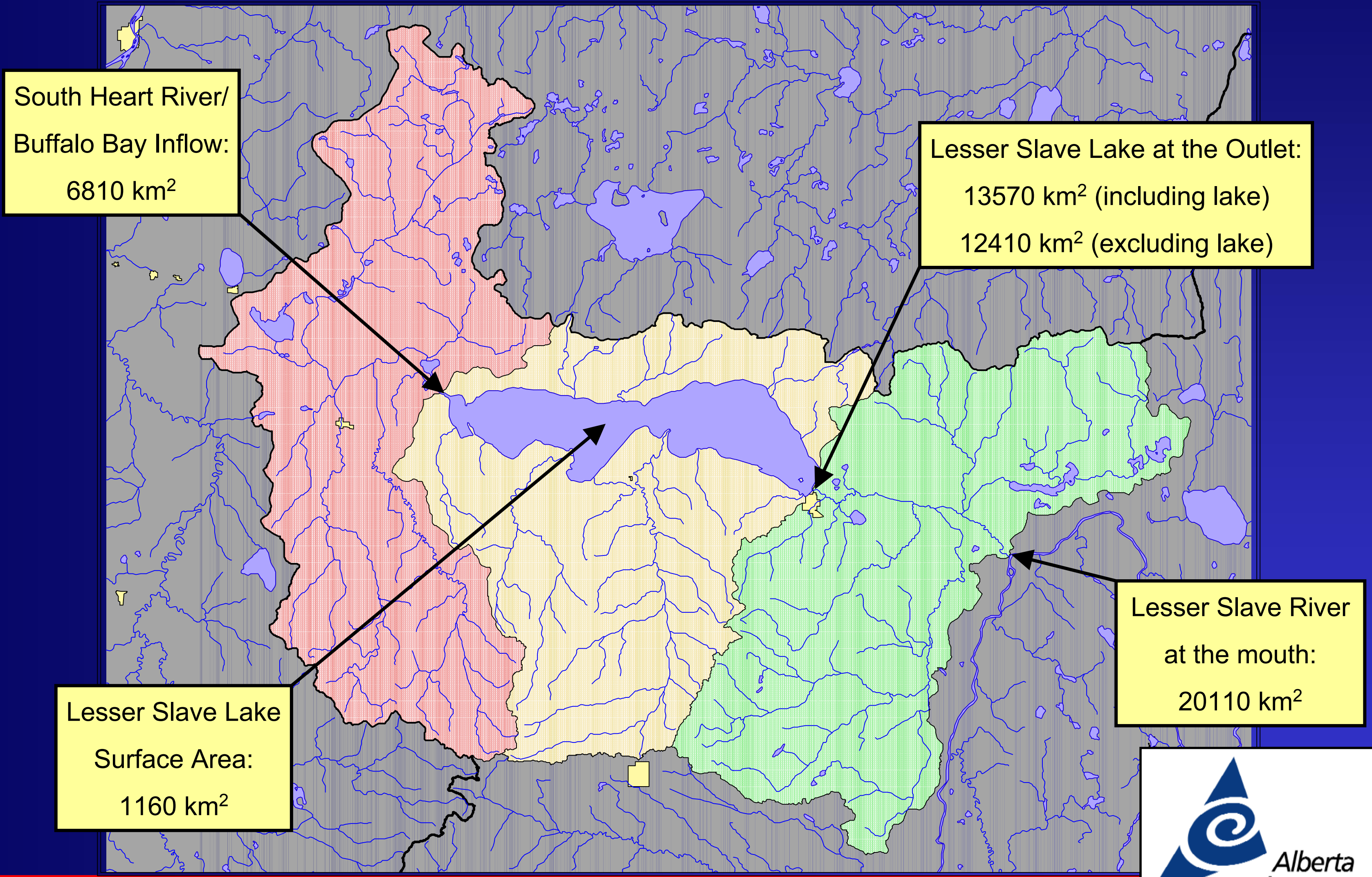
- Significance of relative catchment size
- Why do levels seem to fluctuate so much?
- Lake level regulation project
  - Purpose
  - Performance
- Modelling
- Alternative management options
  - Realities
  - Considerations and tradeoffs

Lesser Slave Watershed
Key Features



Lesser Slave Watershed

Basin & Sub-basin Areas



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Key Parameters

- Lake Area:
  - At 575.50 m elevation: 1,115 km^2
  - At 576.61 m elevation: 1,160 km^2
  - At 578.26 m elevation: 1,255 km^2
- Lake Volume:
  - At 575.50 m elevation: 11,950 million m^3
  - At 576.61 m elevation: 13,200 million m^3
  - At 578.26 m elevation: 14,570 million m^3

575.50 m = outlet weir crest elevation
576.61 m = elevation at time of bathemetric survey
578.26 m = 1:100 year flood elevation (weir in place)

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Key Parameters

Mean annual precipitation:

~470 mm (18.5”)

Mean annual lake evaporation:

~610 mm (24.0”)

So, average net evaporative loss to lake:

~140 mm (5.5”)

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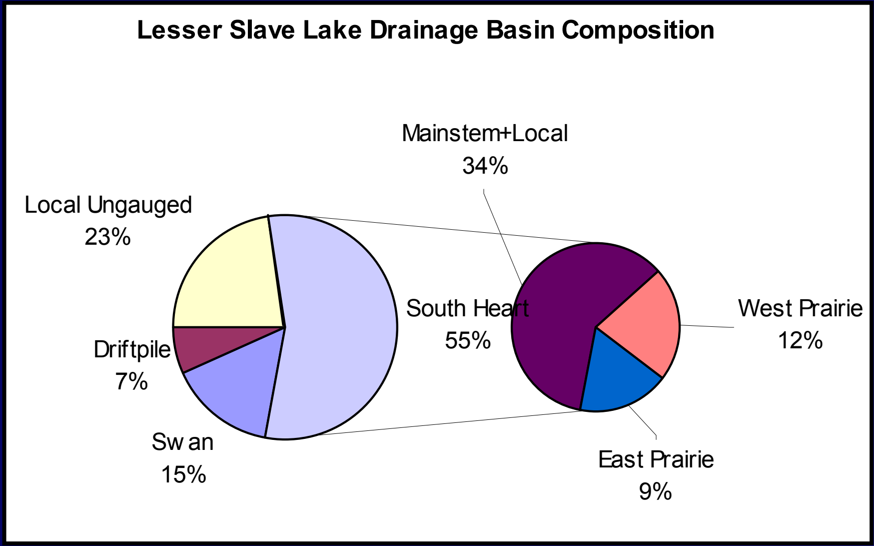
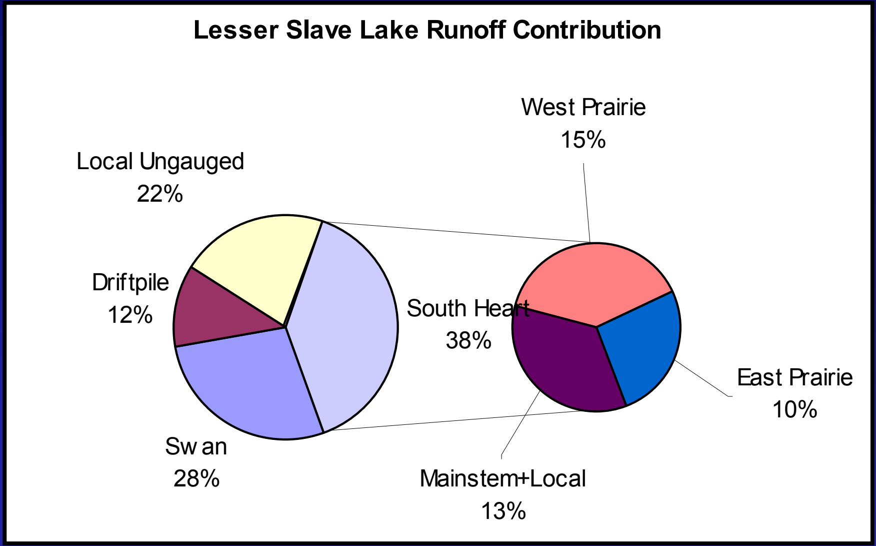
Mean Annual Runoff Sources





The South Heart basin comprises a majority (55%) of the lake catchment area, but contributes only 38% of total runoff. Basins that primarily drain from the Swan Hills are much higher yielding.

Both the Swan and Driftpile Rivers contribute almost twice as much runoff volume to the lake as compared to their relative watershed sizes.

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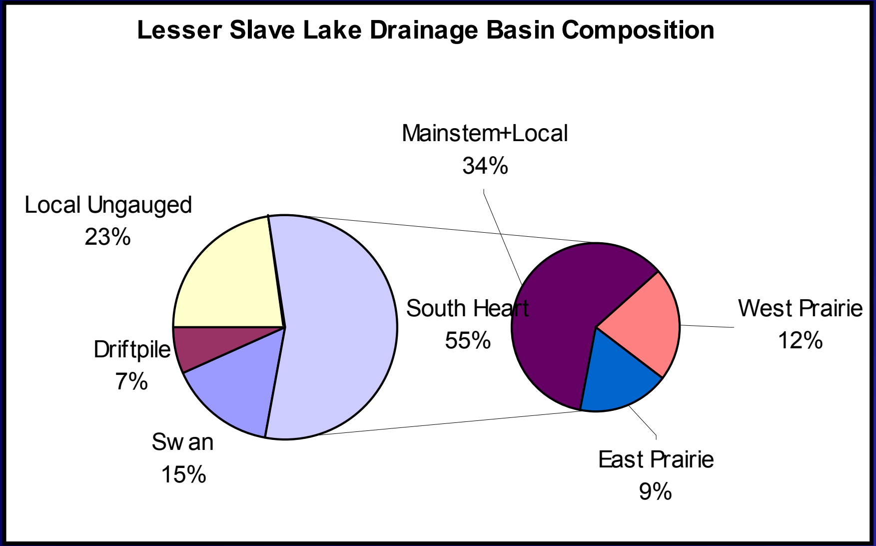
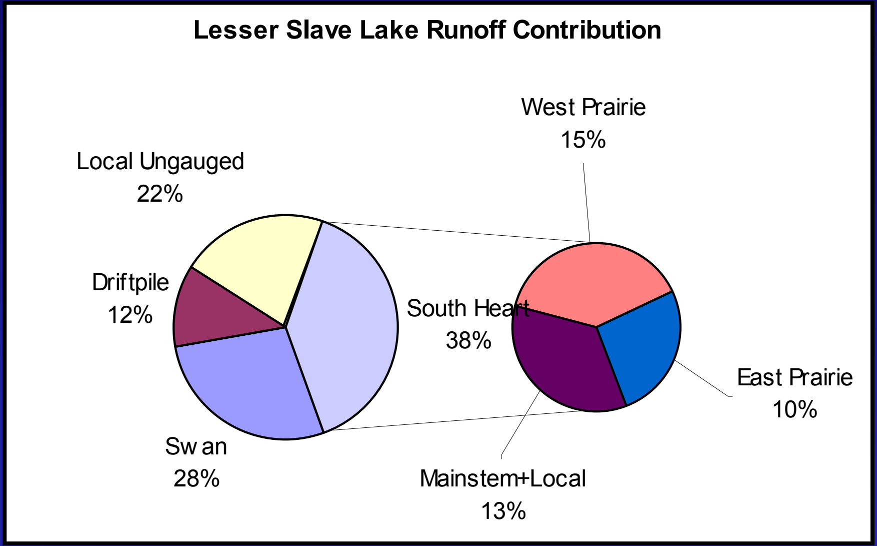
Mean Annual Runoff Sources

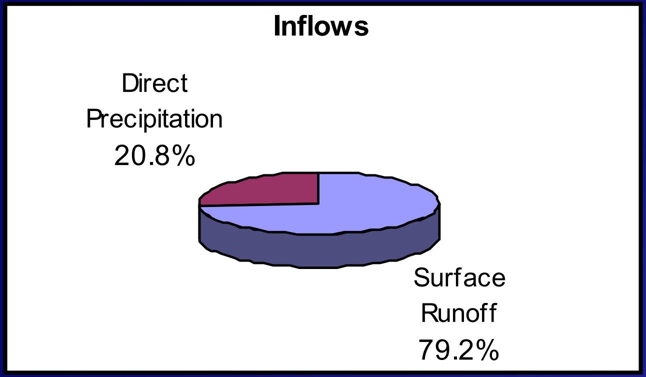


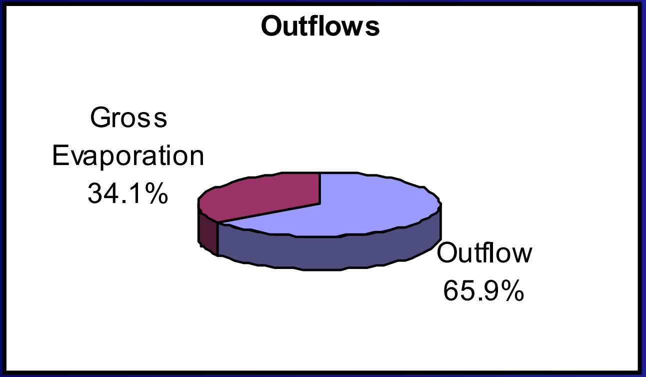


The East and West Prairie Rivers, which are part of the South Heart watershed but originate in the Swan Hills, contribute 65% of runoff to the South Heart but make up only 39% of the drainage area.

Conversely, the area upstream of South Heart Reservoir generates about 7% of total natural lake inflow, but makes up about 17% of the drainage area.

Lake Mean Annual Water Balance





Surface Runoff = 1,532 million m^3

Direct Precipitation = 545 million m^3

Gross Lake Evaporation = 708 million m^3

Outflow = 1,369 million m^3
(equivalent to 43.4 m^3/s mean annual discharge to the Lesser Slave River)

Net lake evaporation = 162 million m^3 (evaporation from lake surface LESS direct precipitation on lake.

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Relative Catchment Size

- Lake Catchment Area to Lake Surface Area Ratio = 10.7: 1
  - Surface runoff from 10.7 km^2 of land area supports each square km of lake surface area
  - Surface runoff from the catchment offsets the lake's net evaporation deficit

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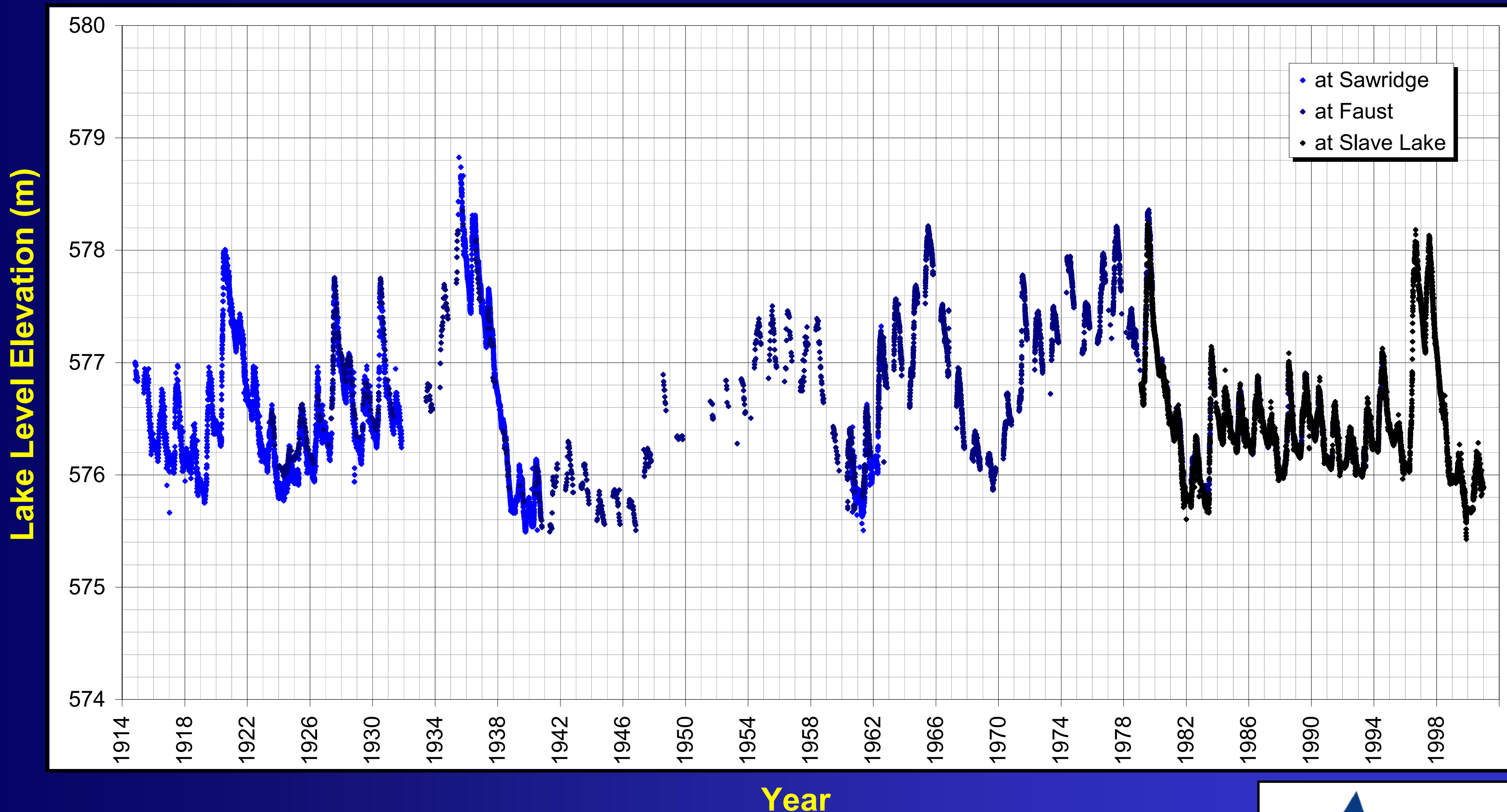
Relative Catchment Size

- The higher the catchment to lake ratio, the more sustainable the lake becomes:
  - Lake levels tend to fluctuate above the lake's outlet elevation (rather than cycling above and below) – outflow is more consistent
  - Less susceptible to long-term climate fluctuations (extended dry or wet periods)
  - Dry years tend to show up primarily as reduced outflow, rather than drastically reduced levels

Lesser Slave Lake

Recorded Lake Levels



Data published by Water Survey of Canada (from stations 07BK010, 07BJ002, 07BJ006)

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Why do levels fluctuate so much?

- The large catchment of Lesser Slave Lake is good for long-term sustainability, but can also cause significant fluctuations arising from extreme runoff events
- Inflows and outflows dominate the water balance in general
- Inflow rates can far exceed normal outflow capacity, resulting in a rapid lake response

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Why do levels fluctuate so much?

- Example: 60 mm (2.4”) of rain falls in the Swan Hills in 24 hours (~1:5 year rain intensity). Only half runs off…
  - Contributing drainage ~5400 km^2
  - Effective runoff is 30 mm, say over one week
  - 30 mm x 5400 km^2 = 162 million m^3
- 162 million m^3 in one week:
  - Equivalent to an average weekly inflow of 268 m^3/s
  - OR, assuming no outflow: 162 million m^3 / 1160 km^2 = 140 mm rise in lake level (5.5”)

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Why do levels fluctuate so much?

- What about recent low years?
  - Comes back to the dominance of surface runoff on lake water balance inflows
  - Surface runoff is a large component AND is also much more variable than precipitation (highs and lows are more extreme)
    - For example, West Prairie River:
      - Highest runoff year (1996): 342 mm
      - Lowest runoff year (1998): 32 mm
      - Average: 125 mm

Why do levels fluctuate so much?

- What about recent low years?
  - Similar patterns (record high runoff to record lows, in only a few years) observed in all gauged tributaries to Lesser Slave Lake, and throughout northern Alberta
  - The rapid decline in levels since 1997 is a direct result of the very low runoff levels in contributing watersheds
  - Low runoff trend continues
    - 1998-2001 all significantly below average

Purpose of Regulation Project (1984)

- To reduce the severity, both in frequency and duration, of the relatively common flooding of low-lying areas around the lake
- Project consisted of fixed-crest weir outlet structure plus a series of river cutoffs downstream to improve the conveyance capacity out of the lake at high flows

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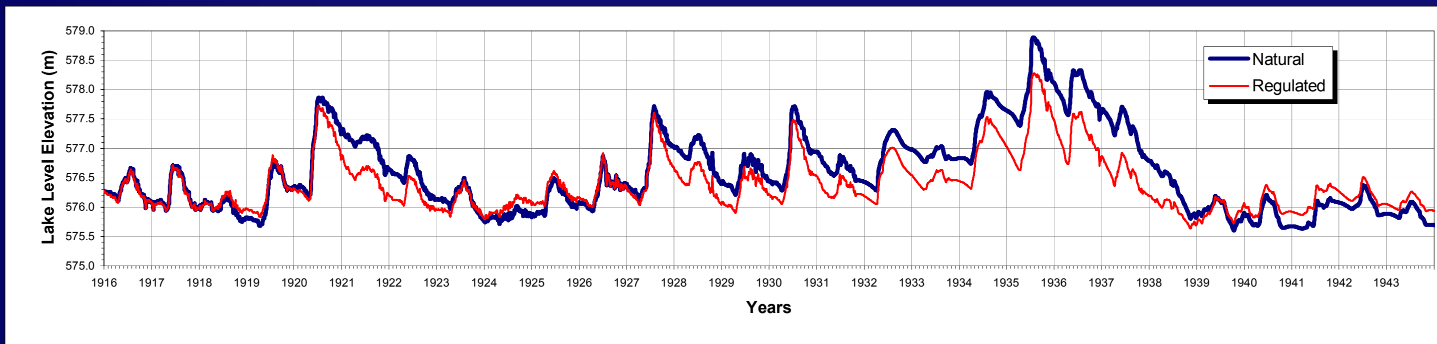
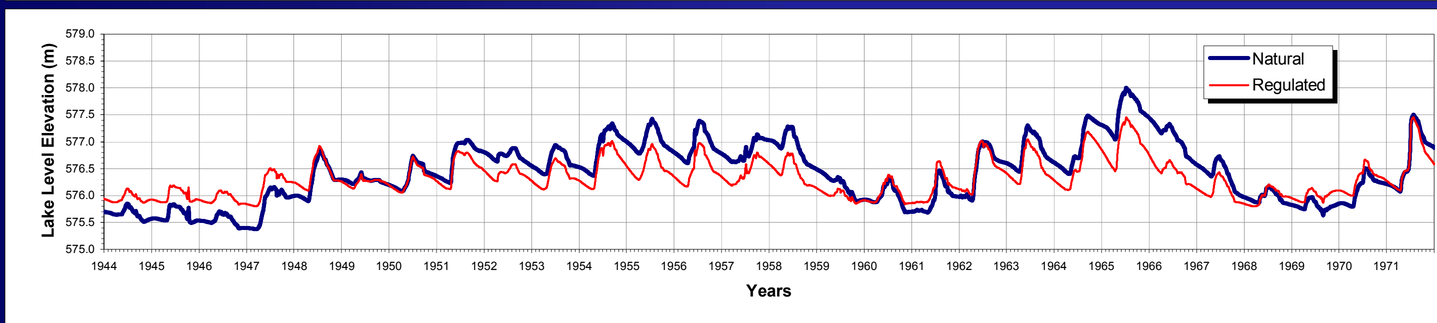
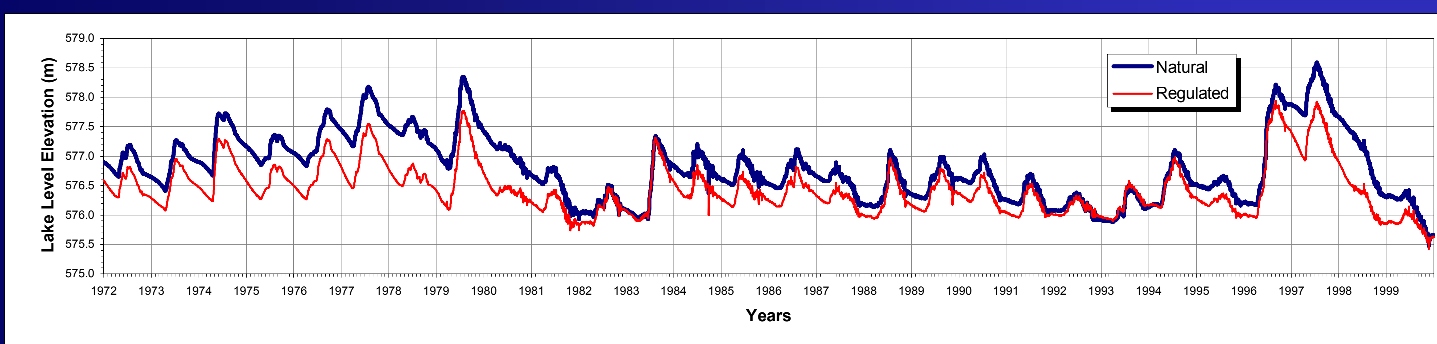
Lesser Slave Lake Modelling

Natural vs. Regulated Scenarios







Data from modelling - completed for the initial Regulation Study, and updated for the recent Sustainability Review.

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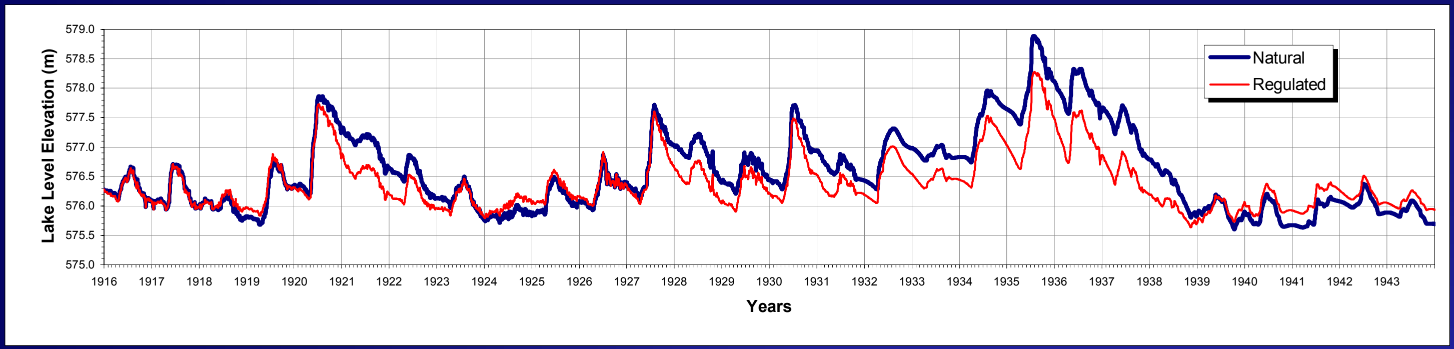
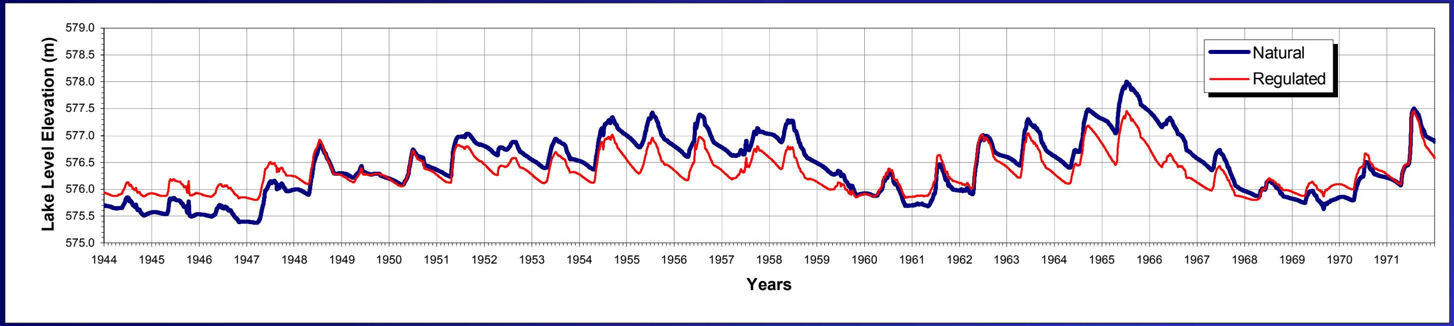
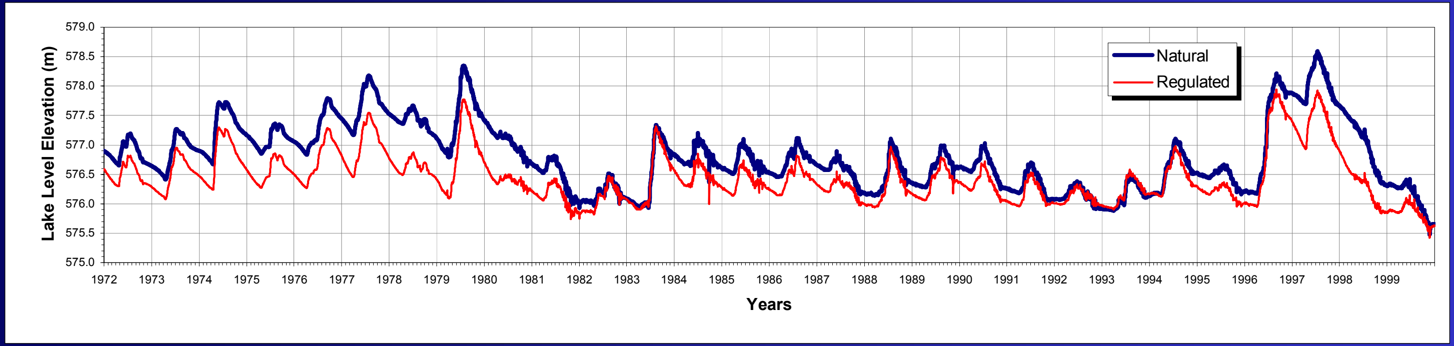
Lesser Slave Lake Modelling
Natural vs. Regulated Scenarios







All indications are that the objectives of the Project have been achieved. Flood levels have been reduced while low levels have been maintained or enhanced.

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How the Modeling Works

Fundamental Water Balance Equation:

Inflow = Outflow +/- Change in Storage

Inflow = Precipitation, Surface Runoff, (Groundwater)

Change in Storage = Change in Lake Levels

Outflow = Evaporation,Outflow,(Groundwater)

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How the Modeling Works

- We know Outflow (river outflows) and Change in Storage (recorded lake levels, plus an elevation-storage curve)
- We can then back-calculate the Net Inflow (the net sum of all other inputs) to the lake
- We change the outlet condition to a new rating curve and run the model forward, showing the resulting impact on lake levels and outflow

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What about storage?

- If sill were increased, what about the available "storage" in the lake? Consider:
  - Lake volume at median lake level (regulated case) of 576.30 m is about 12,680 million m^3
    - Volume to reach 578.26 m (1:100 level): 1,890 million m^3
    - Mean annual inflow from runoff: 1,532 million m^3
- So, if the lake could be considered a reservoir, it only has about one year of "freeboard"
  - Where to "store" the water that could sustain over extended dry periods becomes a critical question, as it is impossible to predict whether the following years will be average or wet

Tradeoffs to Consider

- By itself, increasing sill elevation will increase the average level of the lake
  - Flood risk will increase
- Operable structure could refine lake level management but is a limited solution
  - Still have to ensure reasonable “storage” capacity would be available (minimize flooding potential)
  - Who will build/maintain/operate ($$$)
  - Downstream interests, or liability (low flows or floods)
- Value of natural variability to ecosystem

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