Dams on the Athabasca River: assessing trade-offs of regulated flows as an option for water management

Dammed Rivers Conference
Saskatoon
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Scope

- Surface water quantity in the Athabasca River main stem, and the major tributaries
- Implications changes in streamflow may have on certain quality parameters (i.e., temperature and dissolved oxygen)
- Implications of basin landscape and climatic change on streamflow
Hydrology, climate and landscape...

Streamflow is low during the cold winter months, peaks during the spring due to snowmelt, and tapers off into the fall as the winter snowpack becomes depleted.

The Athabasca River is supplemented during the late summer by glacier melt.

~58% of the Athabasca River streamflow by area occurs upstream of Hinton, ~38% occurs upstream of Jasper.

Drains ~165,000 km²
Covers ~25% of Alberta
4 natural regions:
• Rocky Mountain
• Foothills
• Boreal Forest
• Canadian Shield
Human activity: Many land uses throughout the basin

- Agriculture – largest overall land use by area
- Forestry – distributed through the basin within FMA boundaries
- Oil & gas development – largest area footprint in the lower basin
- Roads, seismic, power, rail – highest density and pressure in upper basin
- Traditional uses – throughout the basin
ARB: A massive, diverse, complex basin
Thank you to our participants
Water challenges facing the ARB

- Maintaining or improving ecosystem health
- **Providing water supply certainty for development**
- Minimizing the effect of the development footprint on basin hydrology
- **Ensuring sufficient flow for navigation**
- Limiting damage from floods or extreme events
- Maintaining or improving the health of the Peace-Athabasca Delta
- **Addressing concerns around Indigenous rights**
- Accessing water-related data and knowledge in the basin
- Maintaining or improving water quality
- **Understanding the renewable energy potential of the basin**
Goal: ARB Roadmap for sustainable water management

A Roadmap is:
• a set of strategies with practical actions
• developed by an inclusive basin-wide working group using collaborative modelling and dialogue
• a recommended or potential path toward sustainable water management in a basin
• intended to inform future planning and management efforts as they relate to water

• Screens and sorts strategies; does not prioritize projects
• Identifies gaps and recommends next steps; does not layout an Implementation Plan
• Reflective of collaborative findings; not Consultation or a decision making body
• A guiding document; not a basin Plan
Collaborative process to develop the ARB Roadmap

<table>
<thead>
<tr>
<th>Understand the current state of the basin</th>
<th>Define the problem or improvement</th>
<th>Identify &amp; refine potential strategies</th>
<th>Assess &amp; sort which are the better strategies</th>
<th>Combine the better strategies to fix / improve</th>
<th>Recommend what should be done next</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>WG expertise &amp; AIRM</em></td>
<td><em>Working list of issues</em></td>
<td><em>Working list of opportunities</em></td>
<td><em>AIRM &amp; PMs</em></td>
<td><em>Roadmap</em></td>
<td><em>Next steps</em></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Working Group meetings</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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</table>
Fact base: Athabasca Integrated River Model (AIRM)

Input: opportunities (changes in demand/water use, flow targets, infrastructure changes, land use and landscape change, changes in climate, etc.) and expertise.

Output: future daily precipitation and air temperature

Outputs: changes in landscape composition from various scenarios

Outputs: changes to streamflow based on changes to climate and landscape, changes in snowpack, soil moisture, etc.

Outputs: Changes to streamflow and performance measures that show effects of strategies on the system
What can be looked at in the model...
What can be looked at in the model...

Operational changes to existing infrastructure

Investment in new water infrastructure

Investment in natural infrastructure

Demand management

Planning and preparedness

Policy and practices
### Performance Measures used to explore opportunities....

<table>
<thead>
<tr>
<th>Performance Measure (PM)</th>
<th>Associated water challenge</th>
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<tbody>
<tr>
<td>Change in seasonal system shortages (m³/s)</td>
<td>Provide water supply certainty for municipalities and development</td>
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<td>Change in seasonal streamflow as a percentage of naturalized streamflow</td>
<td>Minimize the effect of development footprint on basin hydrology</td>
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<td>Change in walleye recruitment reduction</td>
<td>Maintain or improve ecosystem health</td>
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<td>Change in annual instream flow needs violations</td>
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<tr>
<td>Change in number of days over 1:100 flood thresholds</td>
<td>Limit damage from floods</td>
</tr>
<tr>
<td>Change in number of days meeting Aboriginal Extreme Flow</td>
<td>Ensure sufficient flow for navigation</td>
</tr>
</tbody>
</table>

PMs are proxies to show whether the strategies were having their intended impact and no unintended consequences.
Strategies for sustainable water management in the ARB

1. **Effluent reuse**: Enable reuse of industrial or municipal effluent to reduce reliance on freshwater

2. **Water conservation**: Continue to achieve water conservation and efficiency improvements as communities develop

3. **On-stream storage**: Explore new on-stream multi-purpose storage options

4. **Off-stream storage**: Develop new and existing off-stream storage sites to meet multiple basin water management objectives

5. **Existing infrastructure**: Alter existing water storage infrastructure and operations to meet multiple basin water management objectives

6. **Environmental flows**: Establish instream flow needs or similar targets for all tributaries in the basin as a precautionary water management measure

7. **Navigational flows**: Implement minimum flows to improve navigation in the lower Athabasca basin

8. **Land conservation**: Increase the quantity and improve the condition of conserved and restored land across the basin

9. **Forestry practices**: Support practices in Forest Management Agreements that minimize hydrologic change

10. **Wetlands**: Avoid further wetland loss and functional impairment and promote more wetland restoration, education, and best management practices focused on minimizing impacts

11. **Linear connectivity**: Reclaim or deactivate linear features and reduce future linear disturbances in watersheds

12. **Extraction industry reclamation**: Continue to set and meet high standards of reclamation of extraction footprint to maintain or improve hydrological functions in a watershed

***Numbering does not indicate priority or ranking of the strategies***
Strategy overview: On-stream storage

Explore new on-stream multi-purpose storage options

Overview:
Explore on-stream storage options within the ARB, which would serve multiple purposes, including but not limited to:

- Storage for flow augmentation to meet downstream minimum flows e.g., flows for aquatic health, riparian health, and/or navigation
- Water supply for licensed demands
- Flood mitigation
- Hydropower generation as a renewable energy source

What’s already happening with this strategy:

- A report completed in 2010 for AUC by Hatch identified a number of potential hydropower sites in Alberta, with 17 potential sites identified in the ARB
- Alberta’s Climate Leadership Plan established aggressive targets for renewable energy
- Applications have been made for two on-stream run-of-river hydropower sites on the mainstem of the Athabasca River; the two proposed sites are the Pelican Renewable Generating Station Project and Sundog Renewable Generating Station Project upstream of Fort McMurray
Strategy overview: On-stream storage

How it was simulated in the model

The following model runs were simulated in AIRM to explore the effects of on-stream storage at different locations in the basin:

- On-stream tributary facility - McLeod site
  - This reservoir would have a maximum storage of 694,000 dam$^3$ and would operate to meet downstream flows for navigation and IFN flows on the McLeod River. The reservoir would only release water when it is needed for these purposes. The McLeod reservoir could also be simulated to operate for hydropower purposes only.

- On-stream mainstem facility - Mirror site
  - This reservoir would have a maximum storage of 1,899,600 dam$^3$ and would operate for low flow augmentation and hydropower production. The Mirror reservoir could also be simulated to operate for hydropower purposes only.

- On-stream mainstem downstream facility - Grand Rapids site
  - This reservoir would have a maximum storage of 407,000 dam$^3$ and would operate to meet the following objectives in priority order: 1) meet downstream ecosystem flows, 2) meet navigational flow requirements, 3) reduce shortages, and 4) maximize hydropower. The Grand Rapids reservoir could also be simulated to operate for hydropower purposes only.
Strategy overview: On-stream storage

Mirror:
- Operate for low flow augmentation (min flow of 170 cms at Ft. Mac to meet SWQMF in stress conditions)

McLeod:
- Meet the AXF for navigation
- Meet the IFN on the McLeod

Grand Rapids:
- Meet downstream ecosystem flows
- Meet AXF for navigation
- Reduce shortages by meeting SWQMF
- Maximize hydropower

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### Key modelling results and discussion: On-stream storage tributary (multipurpose storage)

<table>
<thead>
<tr>
<th>Period and Location</th>
<th>Dry - McLeod</th>
<th>Historic - McLeod</th>
<th>Wet - McLeod</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Change in number of days meeting Aboriginal Extreme Flow. Challenge: Ensure sufficient flow for navigation</strong></td>
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<tr>
<td>Annual - below Firebag confluence</td>
<td>43.0 Days</td>
<td>59.0 Days</td>
<td>0.0 Days</td>
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<tr>
<td><strong>Change in number of days over 1:100 flood thresholds. Challenge: Limit damage from floods</strong></td>
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<tr>
<td>Annual - Athabasca River at Athabasca</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - McLeod River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Athabasca upstream of Whitecourt</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Athabasca River at Hinton</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Lesser Slave River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
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<tr>
<td>Annual - Pembina River at Sangudo</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
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<tr>
<td>Annual - Ft. McMurray</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>-2.0 Days</td>
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<tr>
<td><strong>Change in annual instream flow needs violations. Challenge: Maintain or improve ecosystem health</strong></td>
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<tr>
<td>Annual - Mouth of the Lac La Biche River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Mouth of the McLeod River</td>
<td>-1904.0 Days</td>
<td>-1701.0 Days</td>
<td>-1640.0 Days</td>
</tr>
<tr>
<td>Annual - Mouth of the Clearwater River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
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<tr>
<td>Annual - Mouth of the Lesser Slave River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Mouth of the Pembina River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
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<tr>
<td><strong>Change in walleye recruitment reduction. Challenge: Maintain or improve ecosystem health</strong></td>
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<td></td>
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<tr>
<td>Annual - below Ft. McMurray</td>
<td>0.38%</td>
<td>2.54%</td>
<td>0.05%</td>
</tr>
<tr>
<td><strong>Change in seasonal streamflow as a percentage of naturalized streamflow. Challenge: Minimize the effect of development footprint on basin hydrology</strong></td>
<td></td>
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</tr>
<tr>
<td>Summer - at the Mouth</td>
<td>0.26%</td>
<td>0.37%</td>
<td>0.68%</td>
</tr>
<tr>
<td>Spring - at the Mouth</td>
<td>1.16%</td>
<td>1.10%</td>
<td>0.77%</td>
</tr>
<tr>
<td>Fall - at the Mouth</td>
<td>0.25%</td>
<td>0.66%</td>
<td>0.56%</td>
</tr>
<tr>
<td>Winter - at the Mouth</td>
<td>0.35%</td>
<td>0.32%</td>
<td>0.65%</td>
</tr>
<tr>
<td><strong>Change in seasonal system shortages (m3/s). Challenge: Provide water supply certainty for municipalities and development</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Spring - whole system</td>
<td>-0.01 m3/s</td>
<td>-0.0 m3/s</td>
<td>0.0 m3/s</td>
</tr>
<tr>
<td>Winter - whole system</td>
<td>-0.0 m3/s</td>
<td>0.0 m3/s</td>
<td>-0.01 m3/s</td>
</tr>
<tr>
<td>Fall - whole system</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
</tr>
<tr>
<td>Summer - whole system</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
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<tr>
<td>Change in number of days meeting Aboriginal Extreme Flow. <strong>Challenge: Ensure sufficient flow for navigation</strong></td>
<td>1.0 Days</td>
<td>1.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - below Firebag confluence</td>
<td>1.0 Days</td>
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<td>0.0 Days</td>
</tr>
<tr>
<td>Change in number of days over 1:100 flood thresholds. <strong>Challenge: Limit damage from floods</strong></td>
<td>0.0 Days</td>
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<tr>
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<td>0.0 Days</td>
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<tr>
<td>Annual - Ft. McMurray</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td><strong>-1.0 Days</strong></td>
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<tr>
<td>Change in annual instream flow needs violations. <strong>Challenge: Maintain or improve ecosystem health</strong></td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Mouth of the Lac La Biche River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - Mouth of the McLeod River</td>
<td><strong>15.0 Days</strong></td>
<td><strong>-7.0 Days</strong></td>
<td><strong>32.0 Days</strong></td>
</tr>
<tr>
<td>Annual - Mouth of the Clearwater River</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
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<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Annual - below Ft. McMurray</td>
<td><strong>6.67%</strong></td>
<td><strong>13.75%</strong></td>
<td><strong>6.67%</strong></td>
</tr>
<tr>
<td>Change in seasonal streamflow as a percentage of naturalized streamflow. <strong>Challenge: Minimize the effect of development footprint on basin hydrology</strong></td>
<td>0.0 Days</td>
<td>0.0 Days</td>
<td>0.0 Days</td>
</tr>
<tr>
<td>Summer - at the Mouth</td>
<td><strong>-0.77%</strong></td>
<td><strong>-0.69%</strong></td>
<td><strong>-0.55%</strong></td>
</tr>
<tr>
<td>Spring - at the Mouth</td>
<td>1.11%</td>
<td>0.99%</td>
<td>0.61%</td>
</tr>
<tr>
<td>Fall - at the Mouth</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Winter - at the Mouth</td>
<td>0.00%</td>
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<td>Change in seasonal system shortages (m3/s). <strong>Challenge: Provide water supply certainty for municipalities and development</strong></td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
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<tr>
<td>Spring - whole system</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
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<tr>
<td>Winter - whole system</td>
<td>0.0 m3/s</td>
<td>0.0 m3/s</td>
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<tr>
<td>Fall - whole system</td>
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Benefits and tradeoffs: On-stream storage

**Benefits**

- There are potentially large benefits to the basin from on-stream dams and reservoirs; the nature of the benefits would depend on what objectives the storage facility is built and operated to meet.
- On-stream storage would allow for storage of water at high flow times and releases at low flow times, therefore potentially helping to meet navigational flows more often, reducing shortages to licenced demands, and reducing IFN violations (if storage were on the major tributaries).
- Flow stabilization or augmentation may offer potential for managing ice-jamming.
- On-stream storage could result in fewer flood days through communities under wet conditions by capturing and storing peak flows.

**Trade-offs**

- The potential benefits from on-stream storage would result from the facility changing the natural flow regime of the river; such changes can introduce significant trade-offs.
- A major trade-off is the potential impact on fisheries; as modelled, this strategy has negative impacts on walleye recruitment during the summer fry period (as walleye rely on naturalized summer flows for recruitment).
- On-stream storage could have impacts on other environmental factors and traditional communities, for example, inhibiting fish passage, altering riparian health, and changing the natural sedimentation of the river.
- On-stream storage may have negative effects on Indigenous communities, land uses and sites.
- Other cultural and recreational uses of the river, such as canoeing, may be negatively impacted by this strategy; however, in some instances these same uses have seen benefits from flow augmentation from storage.
Implementation: On-stream storage

Challenges
• Large on-stream storage infrastructure projects are extremely costly to develop, build and operate
• A wide range of environmental concerns will need to be identified and addressed for an on-stream storage project to proceed, e.g. flows to the Peace-Athabasca Delta, sediment transport, fish migration, and ice-jamming; these should be managed through federal and provincial environmental assessment and mitigation measures

Actions
• Develop basin purposes for any potential on-stream storage facility; should a project be advanced, it would meet basin objectives in addition to energy generation
• Perform site selection, project feasibility and environmental assessments in the context of defined basin purposes
• Align with best practice guidelines through upfront engagement and consultation, and conduct them in accordance with federal and provincial regulations

Screening assessment
• This strategy was identified as being least promising to having some promise
• The strategy was considered to have low feasibility (contingent on site selection, feasibility studies, EAs, adequate engagement, and adequate financial support), with high potential benefit, but also high tradeoffs
Strategies across the watershed

- Wetlands
- Extraction Industry Reclamation
- Navigational Flows
- Water Conservation
- Land Conservation
- On-stream Storage
- Off-stream Storage
- Existing Infrastructure
- Environmental Flows
- Effluent Reuse
- Forestry Practices
- Linear Connectivity
Draft recommendations for sustainable water management in the ARB

1. **Maintain or improve the natural hydrological functions of the watershed**
   ... to protect water supply, water quality, and watershed health
   ... by embedding hydrological priorities in land use planning and enforcement at the regional, sub-regional and local scales.

2. **Establish environmental flow needs for the Athabasca River and all tributaries**
   ... to clarify flows needed for watershed health and volumes available for use
   ... by calculating and publicly communicating reach specific IFNs or similar.

3. **Reduce water navigation limitations in the lower basin**
   ... to maintain traditional access and activities
   ... by recognizing that further minimum flow targets are unlikely to provide navigational flows and, instead, by employing a suite of alternative methods.

4. **Increase the adaptive capacity of the basin**
   ... to be more resilient to climate change impacts on water supply while meeting multiple basin needs
   ... by investigating multi-purpose infrastructure to manage the flow regimes of the Athabasca River and major tributaries.

5. **Continue to develop the means to share and apply Traditional Knowledge**
   ... to lend the experience and expertise of Indigenous Peoples to formal sustainable water management in the basin
   ... by developing and enabling meaningful processes that support the UNDRIP and TRC mandates

6. **Address the most critical gaps in water data, processes, policy, and knowledge**
   ... to better inform sustainable water management
   ... by prioritizing and closing gaps most critical to the ARB
How might rapidly melting glaciers impact long term water supply in the ARB?

**Commonly held perceptions:** Glaciers worldwide are melting faster now than historically due to warmer air temperatures from climate change. We expect the glaciers in the Athabasca River Basin are similarly retreating therefore we expect that we will run out of glacier water supply at some point soon.

**Learning from this project:**

Glaciers provide an important late-season source of water for the Athabasca River

Future changes in climate are likely to result in higher glacial contribution to streamflow over the medium term (next 50 years or so) from higher ice melt

Over the long-term (in the next 100 years), glaciers will contribute less and less to streamflow in the Athabasca as glacier ice recedes substantially.
Can shutting off water licence withdrawals improve navigation on the Athabasca River?

**Commonly held perceptions:** Industrial water withdrawals are high. If they are shutoff, higher flows would substantially help navigation in the lower basin.

**Learning from this project:** SWQMF supports minimum flow targets in the Lower Athabasca by limiting total oil sands withdrawals to 4.4 m$^3$/s during low flow periods (<87 m$^3$/s at Fort McMurray). 2010 ‘As Long as the River Flows’ report suggested 400 m$^3$/s minimum extreme flow (AXF) and ~1,600 m$^3$/s ideal flow (ABF) to support Aboriginal navigation and access in the lower basin.

- Modelled targeting 400 m$^3$/s downstream of the Firebag River, between April 16 and October 28 by shorting any upstream licences
- Results showed generally increased flow during the open water season but not by very much
- The 400 m$^3$/s target remained often not met

Potential alternatives to a minimum flow might include:
- Construction of instream structures to increase water depth in specific locations
- Construction of a dam and reservoir upstream to store and release water for navigation
- Better understanding of navigation channels and their changes through time; may lead to suggestions for channel management including targeted dredging
- Investment in alternate transportation; water craft, road navigation
Looking at the bigger picture for the Slave Basin
Thank you!

Thank you to our funders:

Thank you to those who have contributed by sharing invaluable perspectives, including:

- First Nations and Métis communities
- Federal and Provincial Governments and related agencies
- Municipalities, Counties and Districts
- Watershed Planning and Advisory Councils (WPACs)
- Environmental non-government organizations (ENGOs)
- Industry (coal, agriculture, oil and gas, forestry, oil sands, utility companies)

All meeting and project materials are posted on the ARB Initiative website (visit www.albertawatersmart.com or Google “ARB Initiative”)

www.albertawatersmart.com
Water: the key to our sustainable future

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