LECTURE 2_12:
FEB. 25, 2014

WATER

HUMAN INTERVENTIONS IN THE HYDROLOGICAL CYCLE

Text Reference: Dearden and Mitchell (2012), Ch. 11, pp. 374-383.

T. Randall, Lakehead University, WA 2014

Outline

From: Dearden and Mitchell (2012)

- Key components of the hydrological cycle
- Water diversions, with examples
  - {dams: WAC Bennett; Old Man River; La Grande; Columbia River; Revelstoke Dam}
  - {floodways: Winnipeg; Neebing-McIntyre}
  - {inter-basin transfers: Kemano; Nechako River}

- Canada
  - only 0.5% of the world's population
  - Home to almost 20% of the global stock of fresh water;
  - Only 7% of total flow of renewable water (Brazil and Russia have more)
  - 2nd amongst water consumers in the world

From: Dearden and Mitchell (2012)

Hydrological Cycle

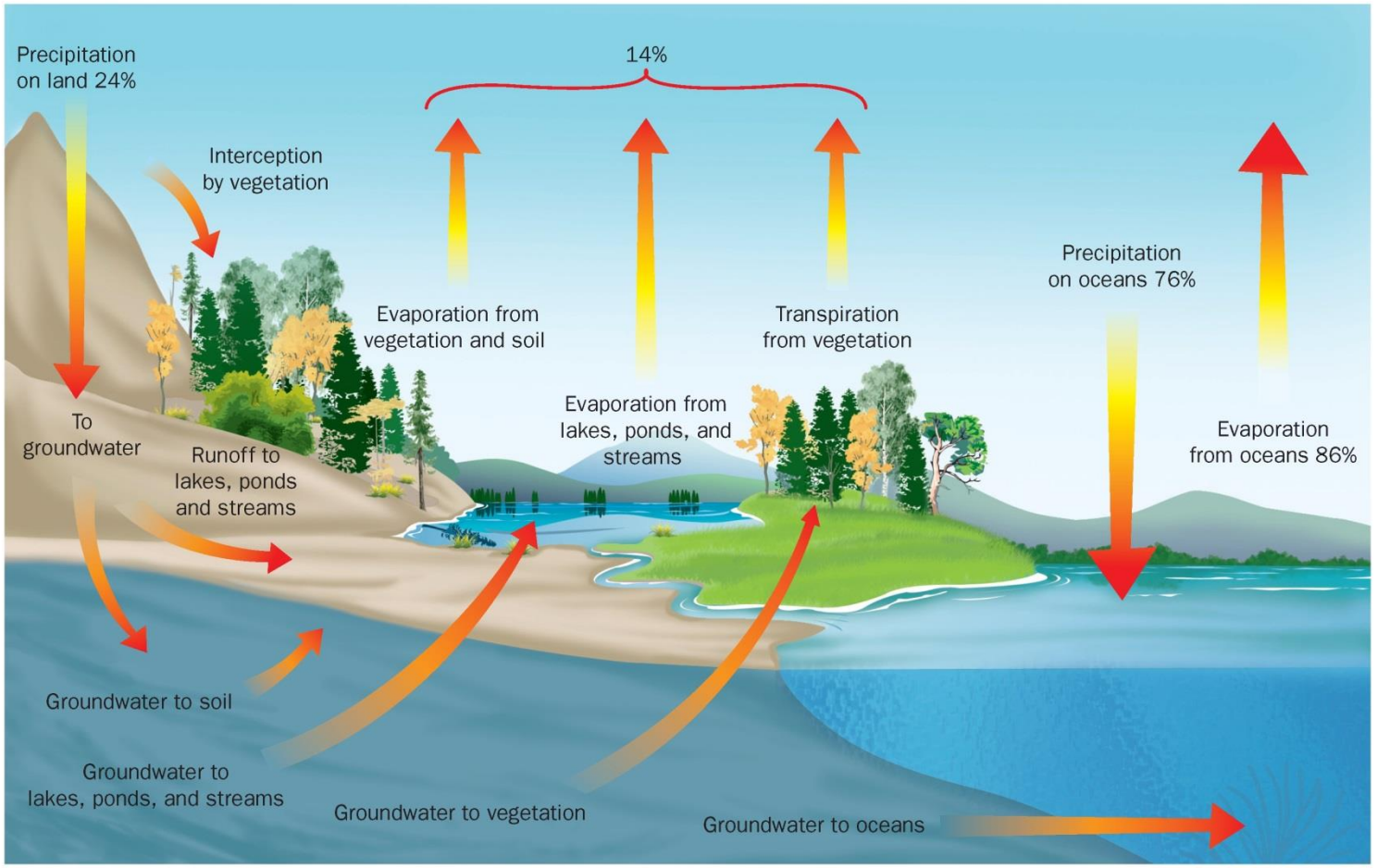


Figure 4.8 | The hydrological cycle. Water moves through the hydrological cycle as a liquid, as a vapour, and as snow.

From: Dearden and Mitchell (2012)

- About 12% of Canada is covered by lakes and rivers
- Various types of **wetlands,** hybrid aquatic and terrestrial systems, cover 14% of Canada
- Groundwater is a key source of water for rivers and lakes

From: Dearden and Mitchell (2012)

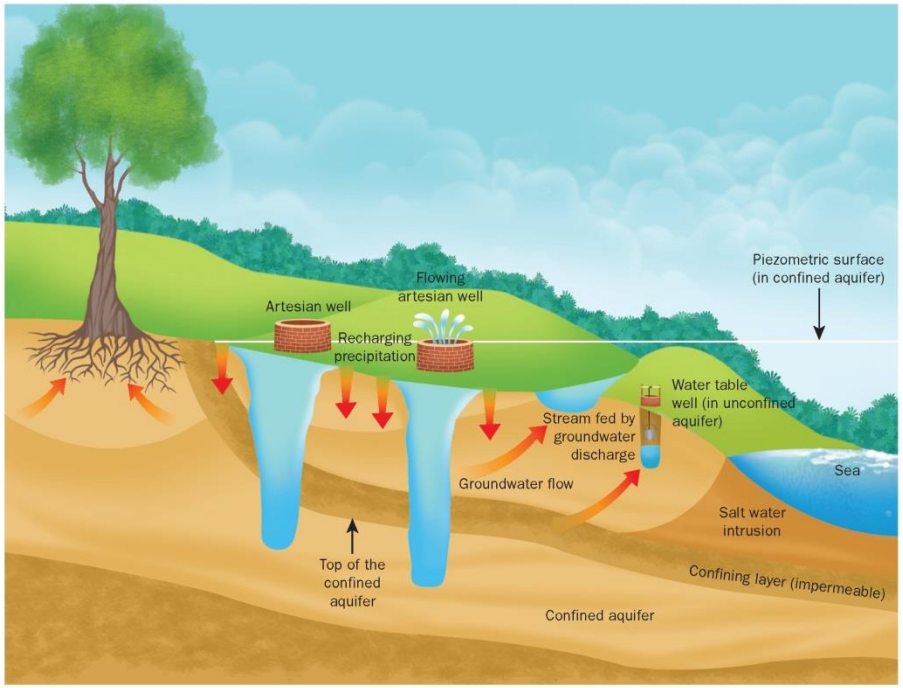
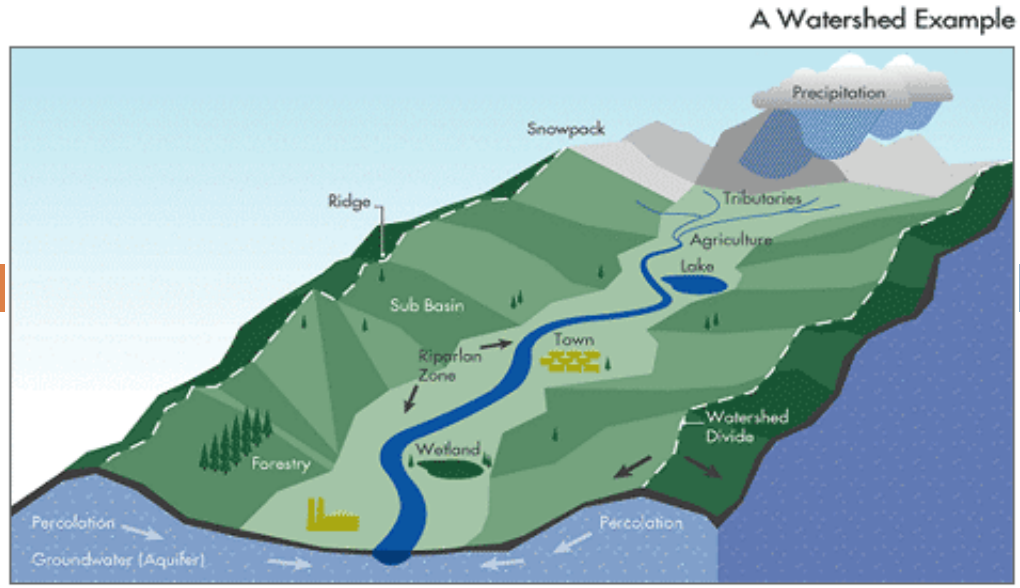


Figure 4.9 | Groundwater flow.



Terminology:

- Watershed;
- Drainage Divide or Divide;
- Floodplain

Water Diversion

- **Dams**
  - (~900 large ones in Canada)
- **Inter-basin diversions**
  - (~60 large ones in Canada)

~333 (Quebec)

~149 (Ontario)

~131 (British Columbia)

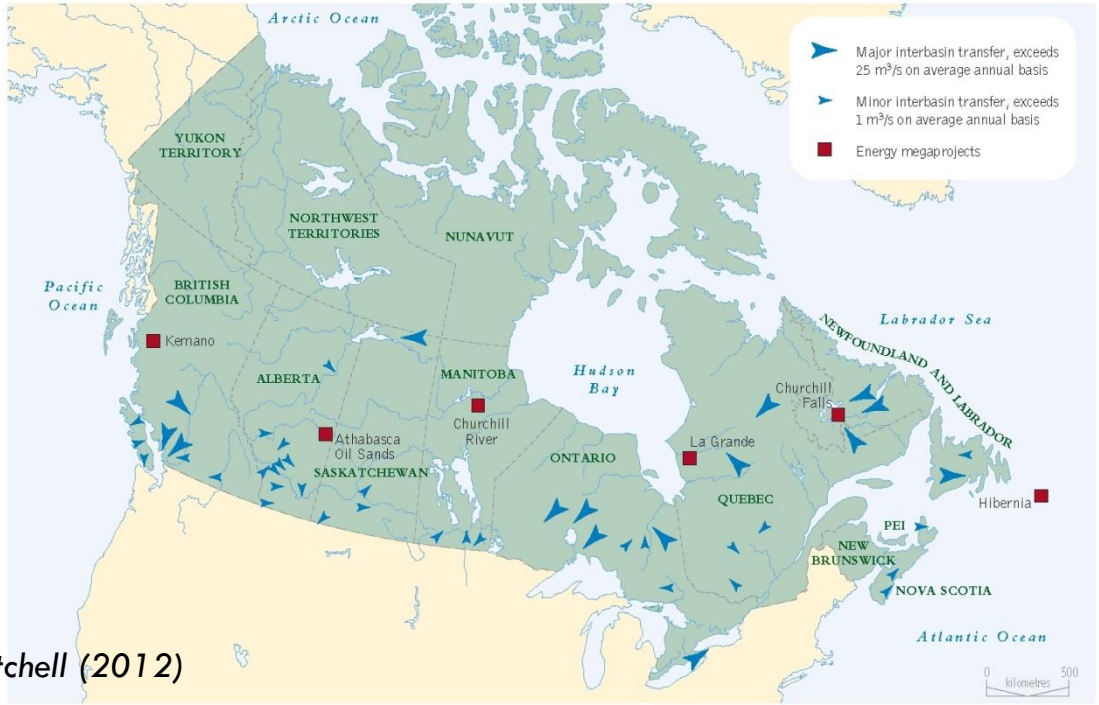


Figure 11.1 | Hydroelectric megaprojects in Canada. *Source: Adapted from Day and Quinn (1992: 16).*

From: Dearden and Mitchell (2012)

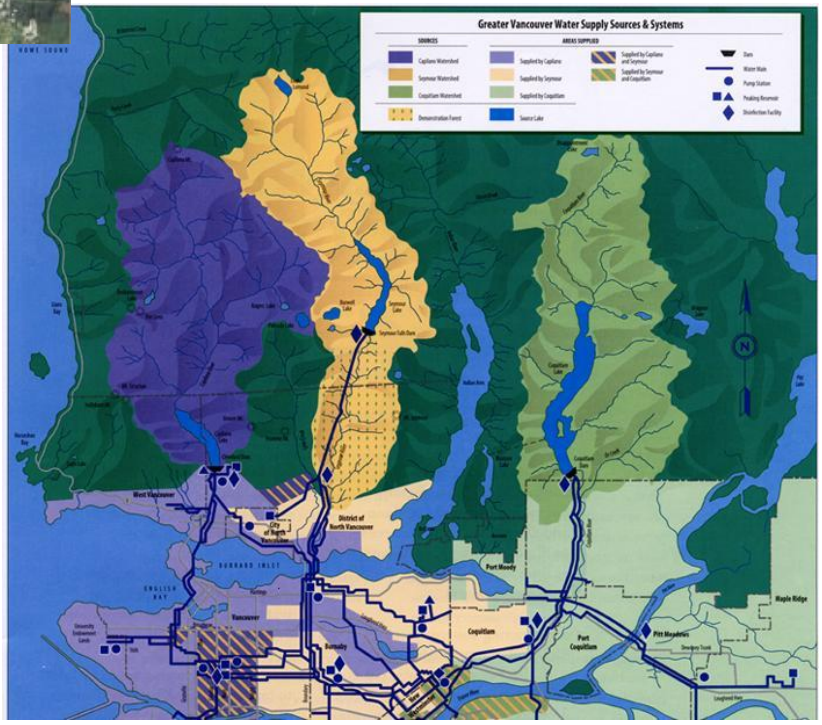
Reasons for Water Diversions (1)

- To increase community water supplies (for consumption, for irrigation … *less common in Canada than elsewhere*)
- e.g., Old Man R. dam (S. Alberta) (installed in 1992, response to droughts); Vancouver's three northshore watersheds

Old Man River dam.

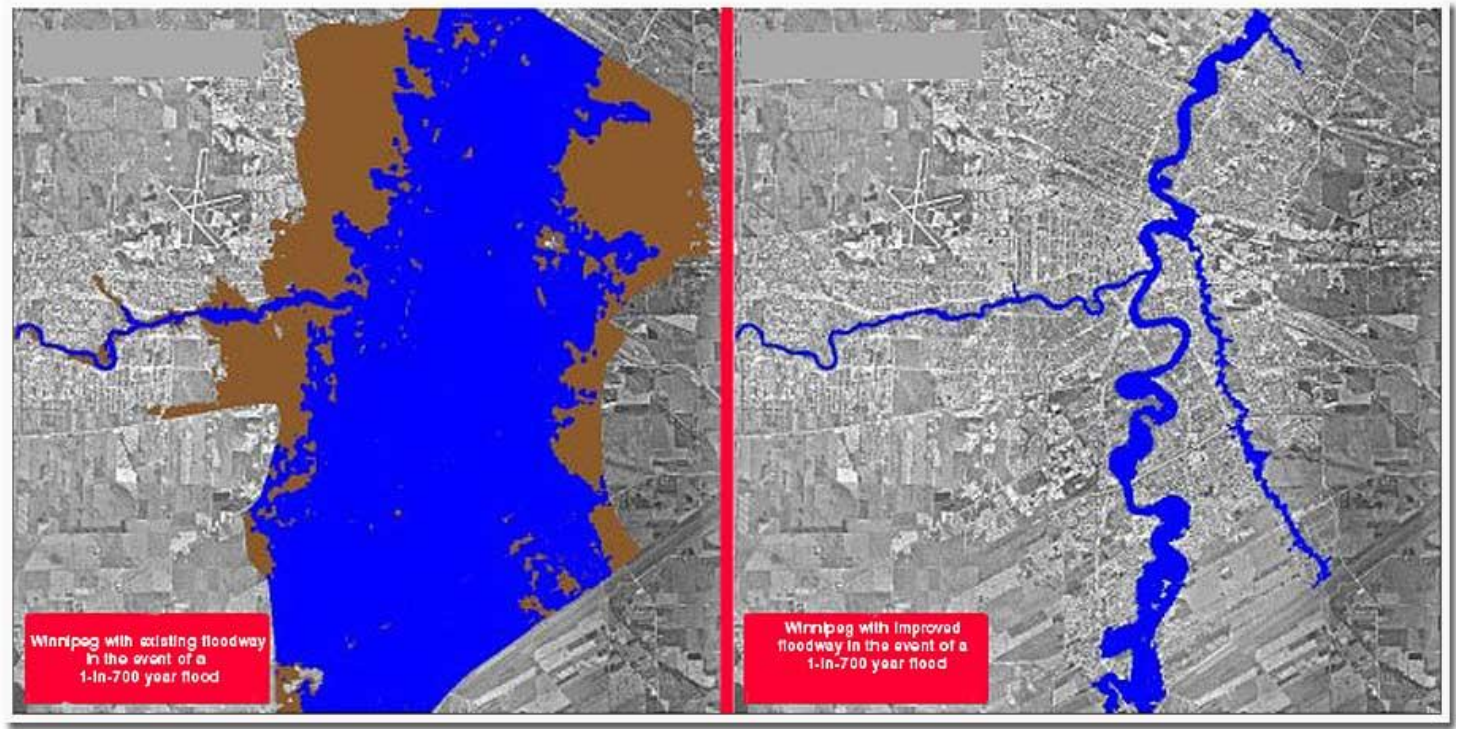
Capilano Reservoir


Capilano Watershed
Seymour Watershed
Coquitlam Watershed
Lower Seymour Conservation Reserve


Greater Vancouver Water Supply Sources & Systems
SOURCES
AREAS SUPPLIED
Capilano Watershed
Seymour Watershed
Coquitlam Watershed
Demonstration Forest
Supplied by Capilano
Supplied by Seymour
Supplied by Coquitlam
Source Lake
Supplied by Capilano and Seymour
Supplied by Seymour and Coquitlam
Dam
Water Main
Pump Station
Peaking Reservoir
Disinfection Facility
West Vancouver
District of North Vancouver
City of North Vancouver
Vancouver
Burnaby
Port Moody
Coquitlam
Port Coquitlam
Pitt Meadows
Maple Ridge

Reasons for Water Diversions (2)

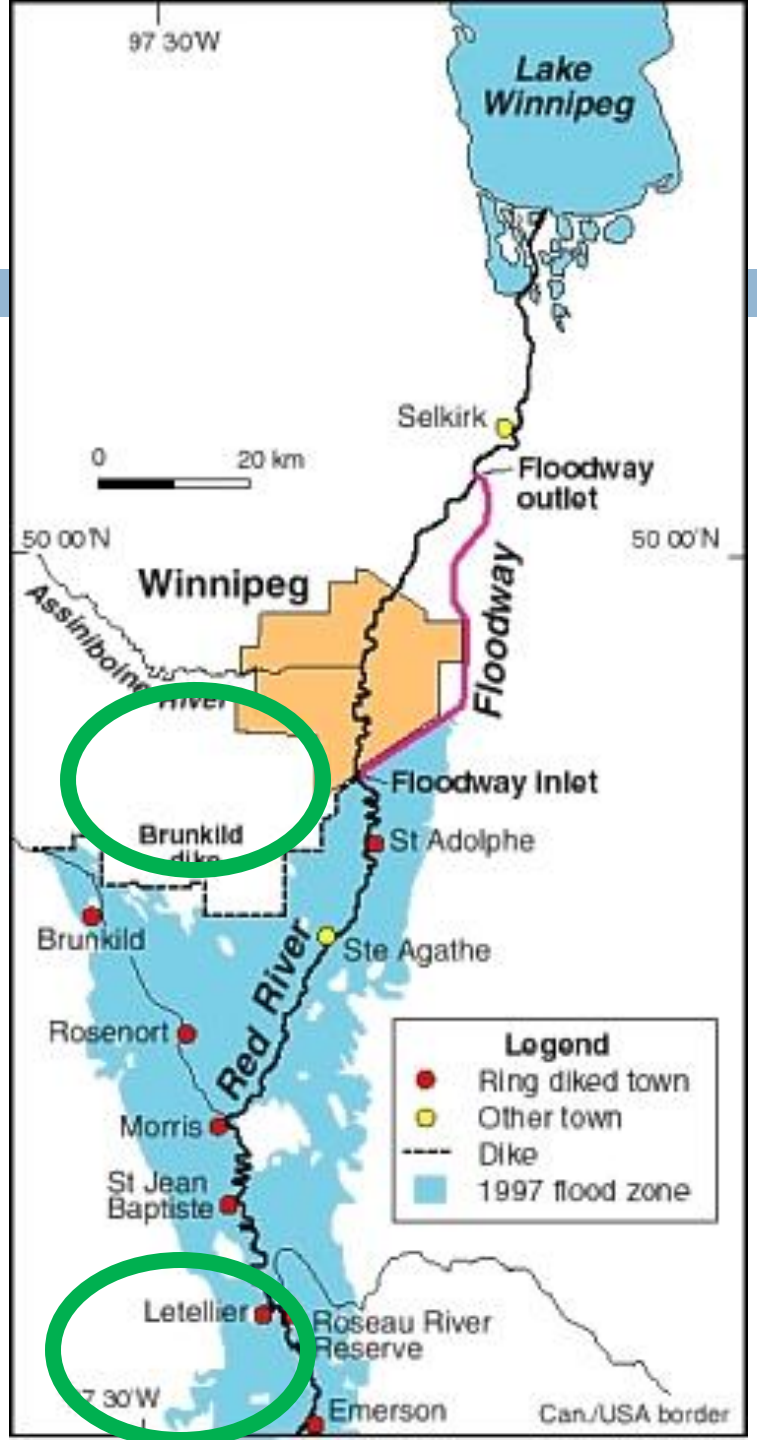
- To protect communities/intrastructure (flood protection)
- e.g. Winnipeg Floodway (shown during 1997 floods)



Potential impact of 700 year flood on Winnipeg without the floodway (left). *Source:* Natural Resources Canada

Red River Floodway

- Significantly abated the 1996 and 1997 flood events



Winnipeg spillway – inlet; in operation during 1997 flood

Extensive flooding near Roseau River Reserve

Neebing River Spillway (Thunder Bay)

- Completed in 1982
- To carry floodwaters from Neebing R. to Neebing-McIntyre Diversion
- Dam at Lake Tamblyn part of "catchment control measures"
- To protect Intercity area

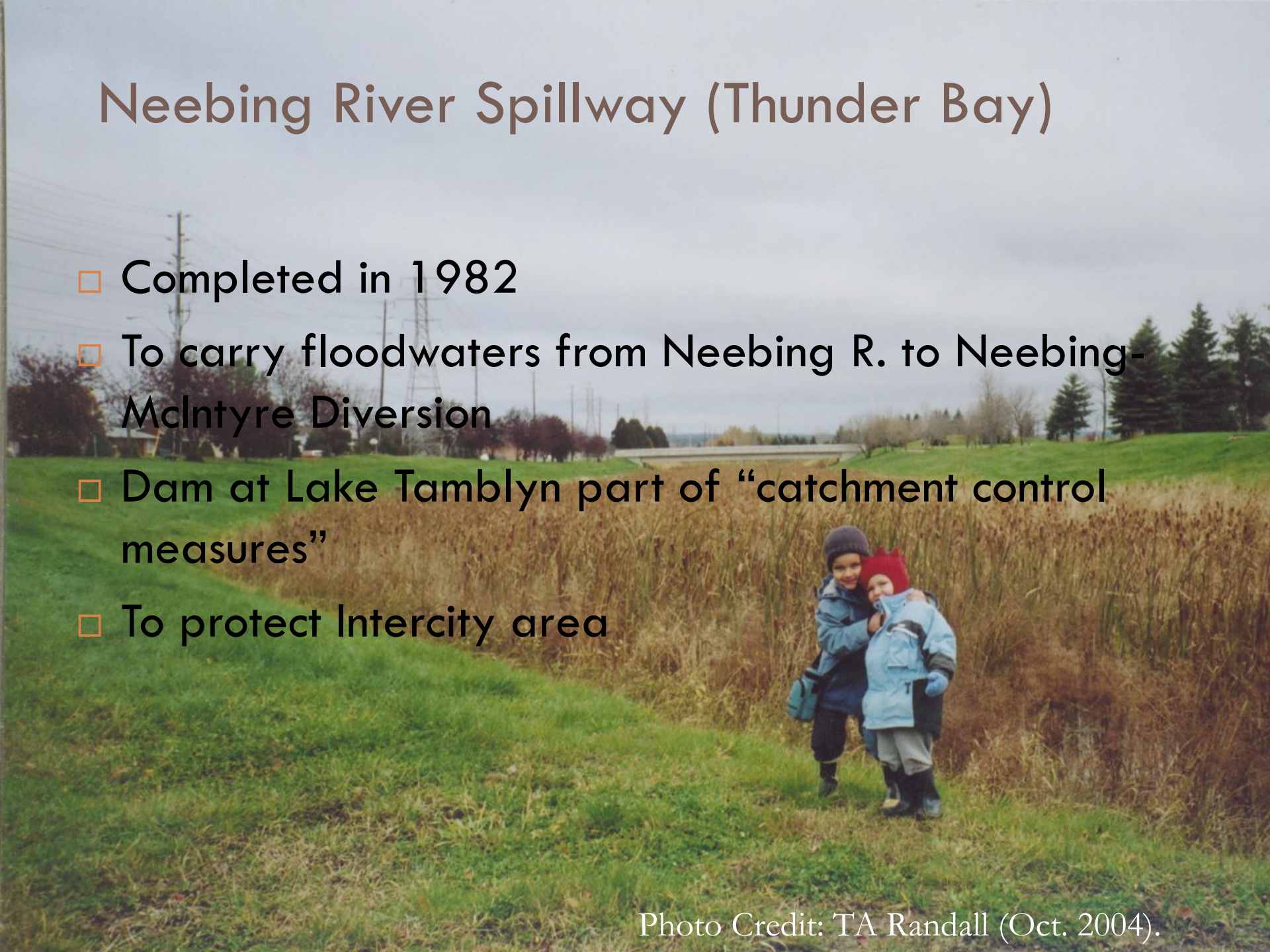
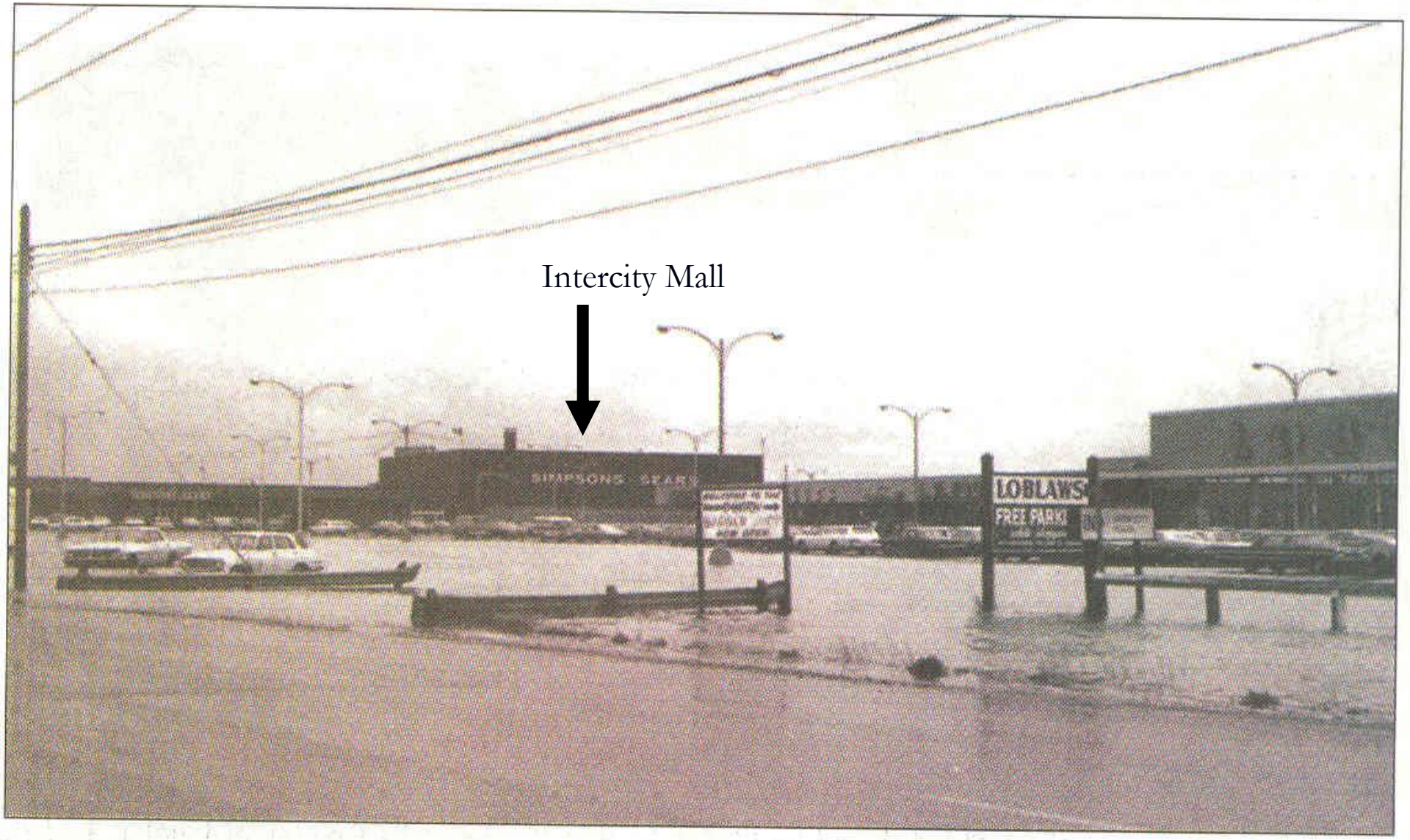
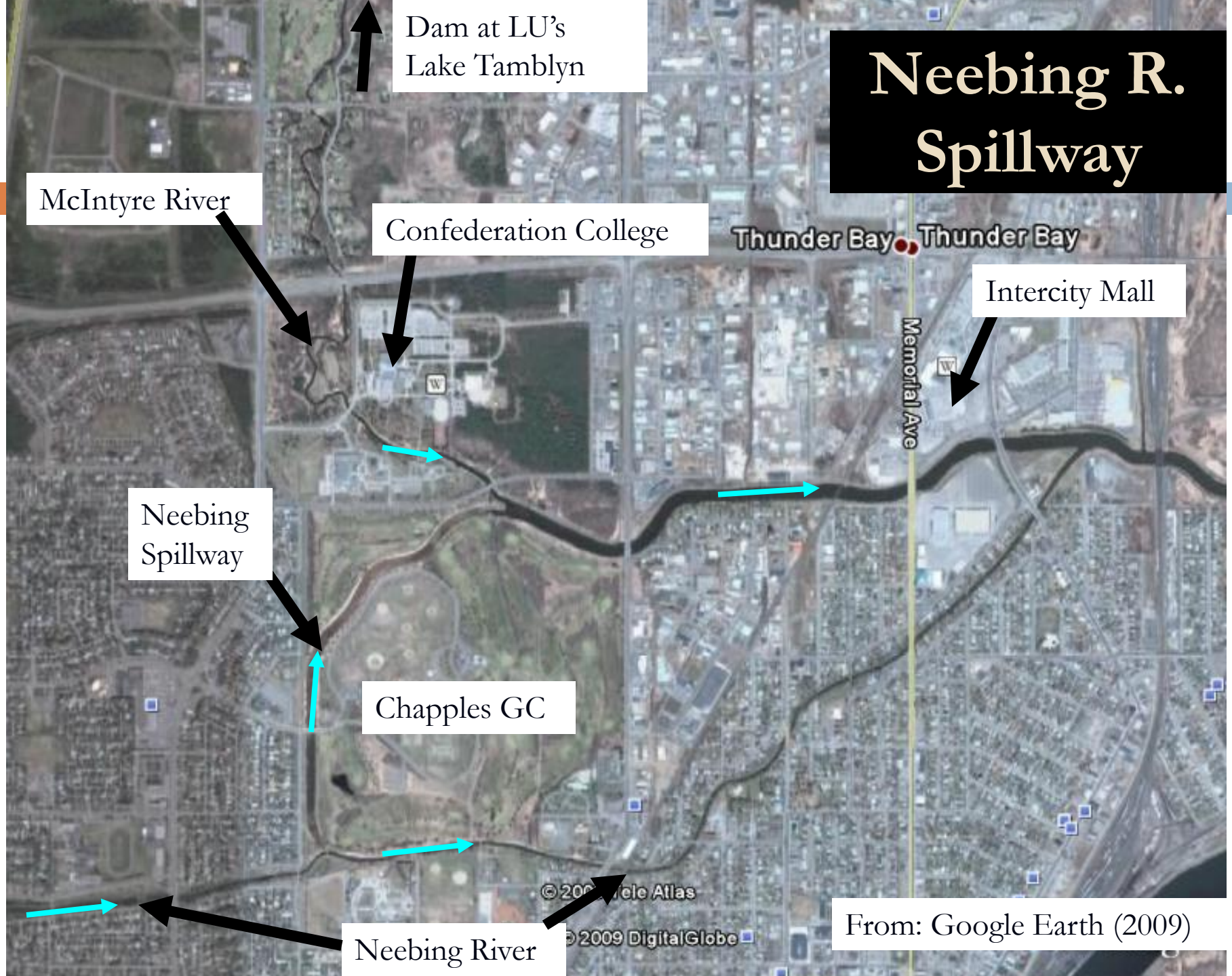


Photo Credit: TA Randall (Oct. 2004).



...a time before there was a Neebing - McIntyre Floodway?

From: Lakehead Region Conservation Authority (2005)


Dam at LU's
Lake Tamblyn
Neebing R.
Spillway
McIntyre River
Confederation College
Thunder Bay
Thunder Bay
Intercity Mall
Memorial Ave
Neebing
Spillway
Chapples GC
Neebing River
From: Google Earth (2009)

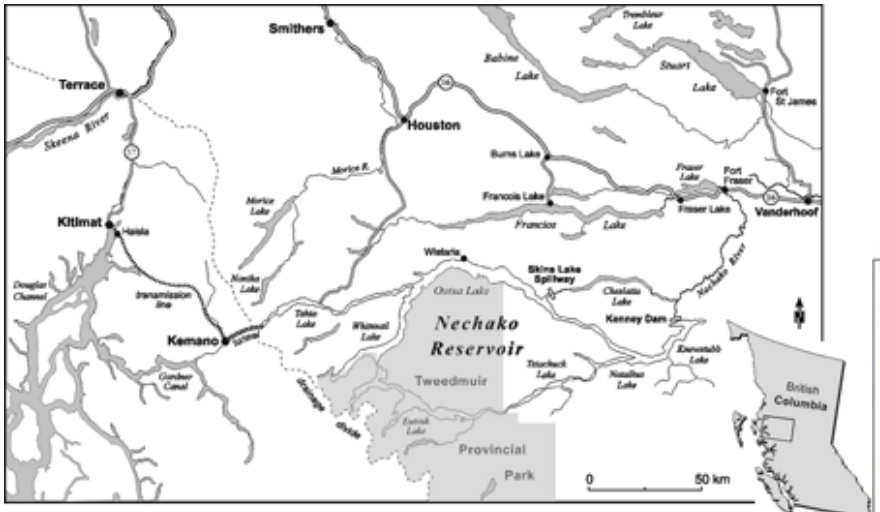
Reasons for Water Diversions (3)

- To augment/increase river capacity (for shipping, for moving goods downriver)
- e.g., small dams on Ottawa river to move logs to sawmills

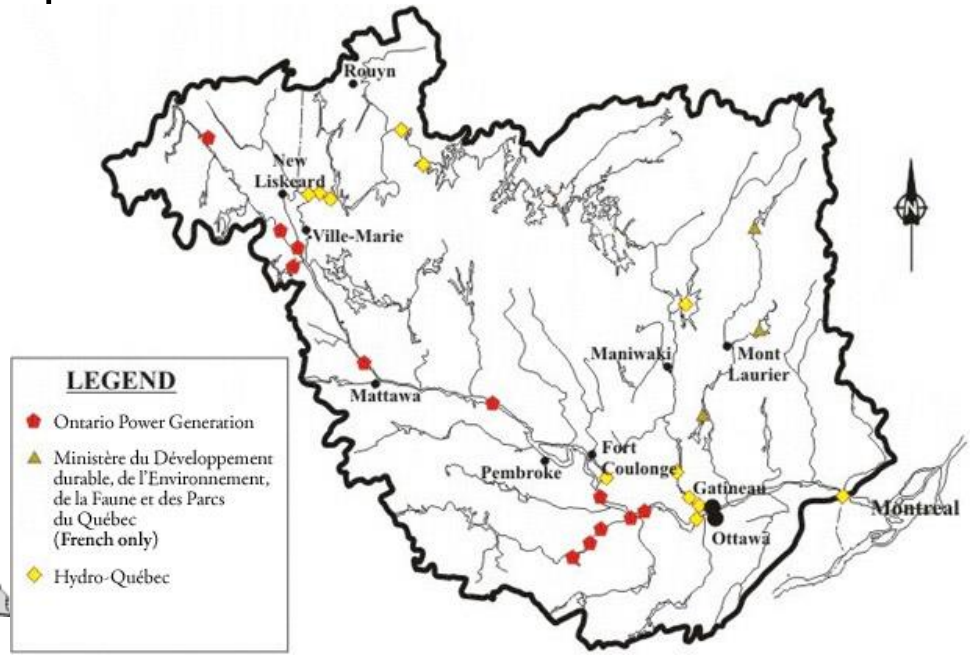
Timber rafts at Parliament Hill (in 1882)

Reasons for Water Diversions (4)

- To concentrate/consolidate water flows (for hydroelectric generation purposes)
- Canada a global leader in diversions for these purposes
- e.gs., Columbia River Treaty; James Bay Project; Churchill Falls; Gardner Dam, SK; Kemano Completion



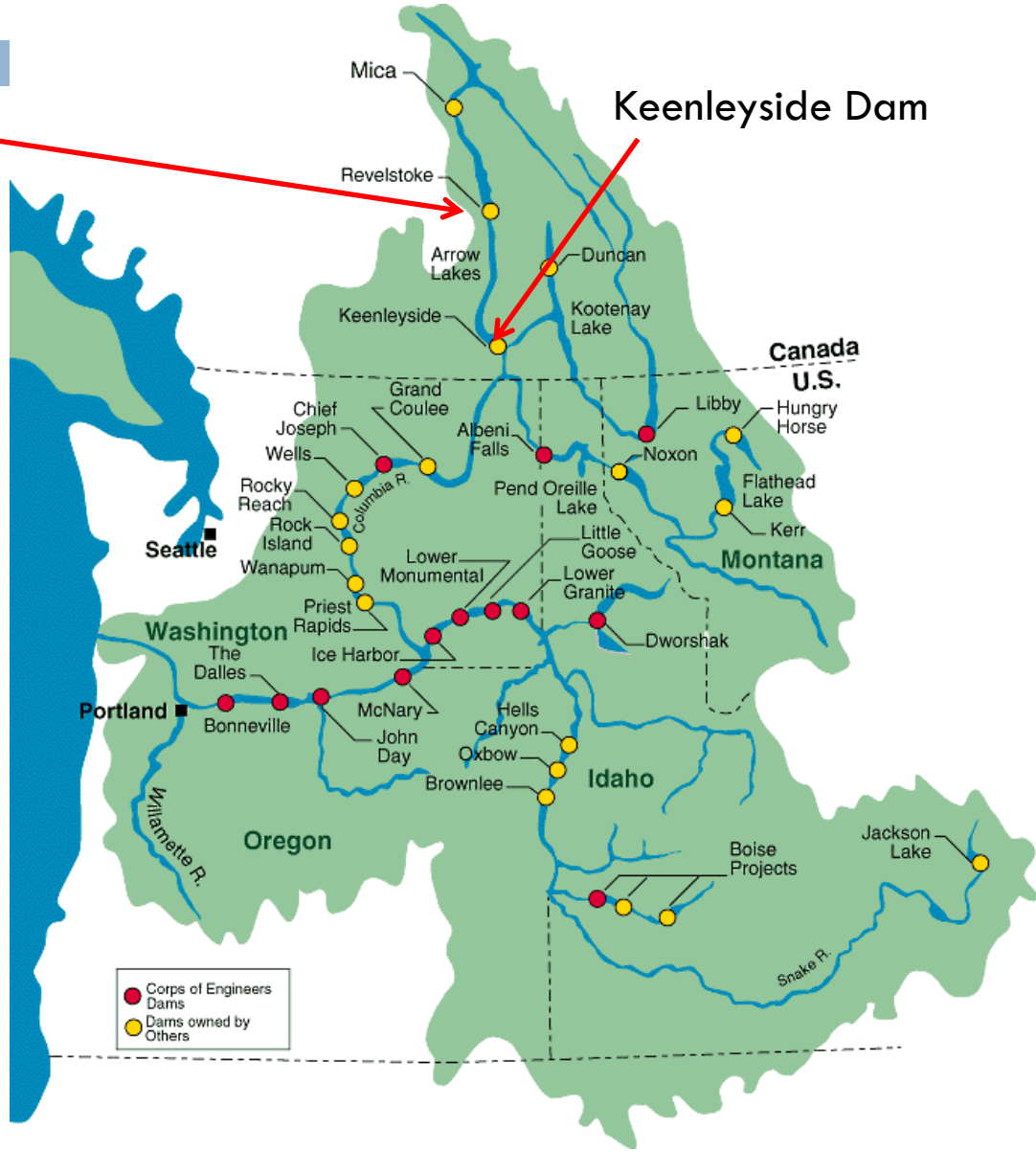
Kemano diversion (Nechako R. → Fraser R.)



Power generation in Ottawa River watershed

Columbia River Treaty (Can-US)

Revelstoke Dam, completed 1984 but NOT part of Columbia River Treaty dams



http://www.nwd-wc.usace.army.mil/report/colmap.htm

Columbia River Treaty (Can-US)

- Agreement 1964, re development and operation of dams in the upper Columbia basin for purposes of flood control and power generation;
- 4 dams constructed under this treaty (3 in Canada, 1 in US);
- The Canadian treaty dams (except the Mica) were initially for water storage and discharge regulation only;
- Canada is compensated financially for providing these storage and floor control benefits to downstream states;
- Treaty has no expiration, however at 60 years (in 2024), either country can terminate most provisions given a full 10 years notice (…. Currently both governments are reviewing as 2014 is this advanced 10 years)

Columbia River Treaty (Can-US)

- Advantages
  - Economic benefits to both BC and Pacific NW states (including but not limited to employment);
  - Flood control
- Disadvantages
  - Social impacts: community and home relocations; loss of culturally significant First Nations landscapes (including burial grounds) of the Sinixt people who occupied the Columbia Valley;
  - Environmental impacts: during both construction and operation phases; "loss of natural river behaviour" (e.g., smoothing of annual hydrograph – lower peak flows, higher winter 'low' flows) (reduced peak levels by 10's of metres); impacts on fish habitat (water temperature, sedimentation) and fish migration;

Hugh Keenleyside Dam, completed in 1968

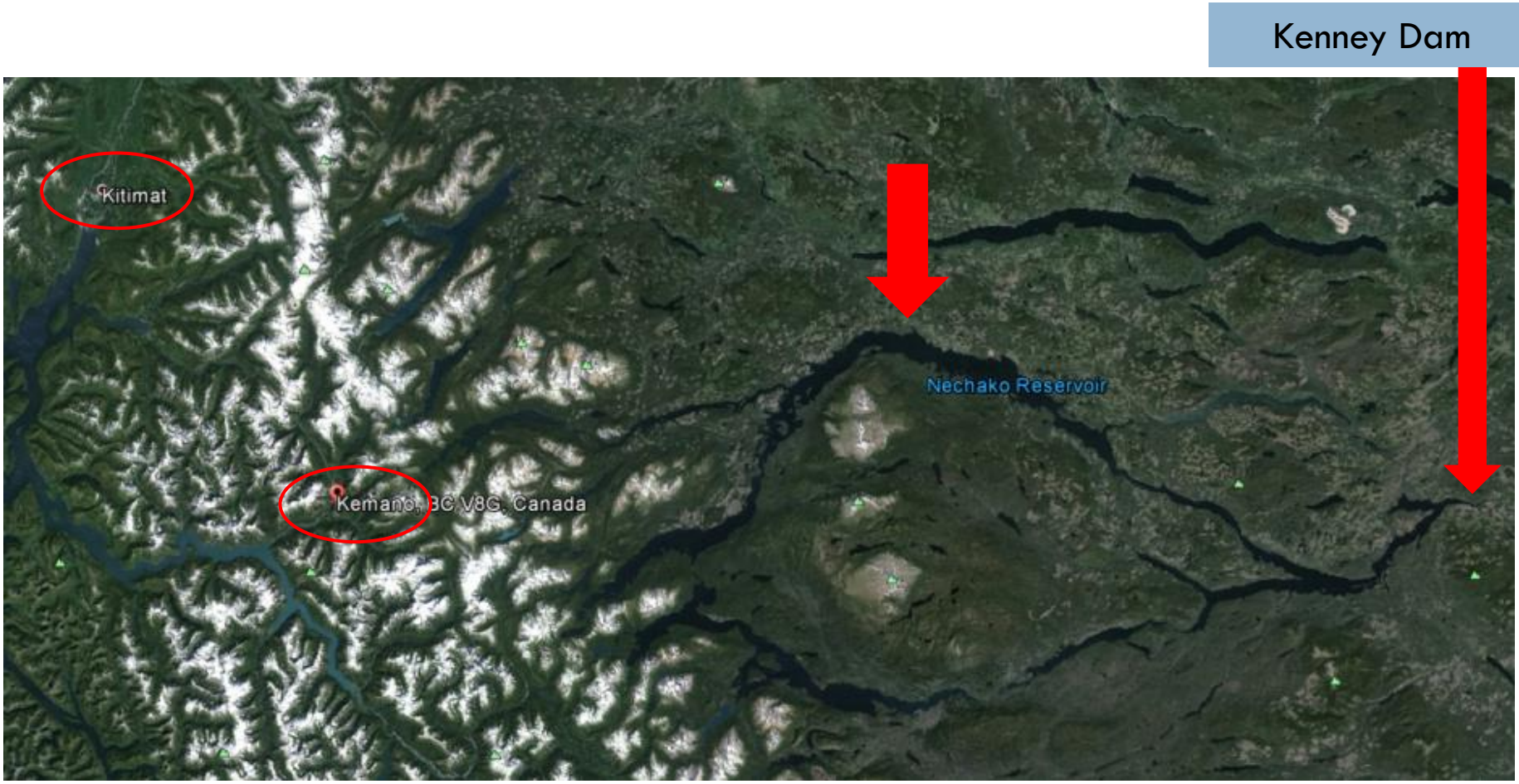
Hugh Keenleyside Dam and Arrow Lakes Reservoir
Interactive Pre- and Post-Dam Image: Burton

Other images viewable at:
http://www.cbt.org/crt/resources-PreAndPostImages.html

Kitimat-Kemano Project

- 1948: BC Gov't invited Alcan to consider building aluminum smelter on BC Coast;
- Dec. 1950: BC Govt granted Alcan license to divert water from Nechako and Ninika watersheds to feed turbines at Kemano hydro-station;
- First Nations situated on reserves on Lake Cheslatta (which would be inundated by the rising Nechako Reservoir) were relocated – with very little notice – April 1952;
- Kenney Dam completed in Oct 1952

Nechako Reservoir – Ootsa Lake



Source: Google Earth 2014

- Flows in upper Nechako dropped to 25% of normal for 4 years after dam completion (to fill reservoir)
- Chinook salmon run all but destroyed during this period
- 1957: Smelter at Kitimat in full operation, powered by "Kemano 1"
- Late 1970's interest in Kemano 2 ("Kemano Completion Project") – has been subject of much debate during 1980s-1990s at times being approved by Fed Govt (e.g., exempted from an Environmental Assessment in 1991 by Mulrooney Govt); it has yet to be built
- Kemano plant is now largely automated, with the community of Kemano formally closed in 2000;
- Dislocated FN still active ….

Cheslatta aboriginals seek Kenney Dam water licence

An aboriginal band in north-central B.C. has moved toward harnessing the power of a hydro-electric dam that flooded their territory and imprinted images of floating coffins into their history.

Sixty-two years after the Kenney Dam flooded the traditional territory of the Cheslatta Carrier Nation, destroying hunting, fishing and living areas and drying up parts of the Nechako River, the Prince George-area nation plans to profit from the structure built without their consultation to power the Rio Tinto Alcan smelter in Kitimat.

Source: The Globe and Mail, Monday September, 30, 2013

James Bay Project

From: Dearden and Mitchell (2012)

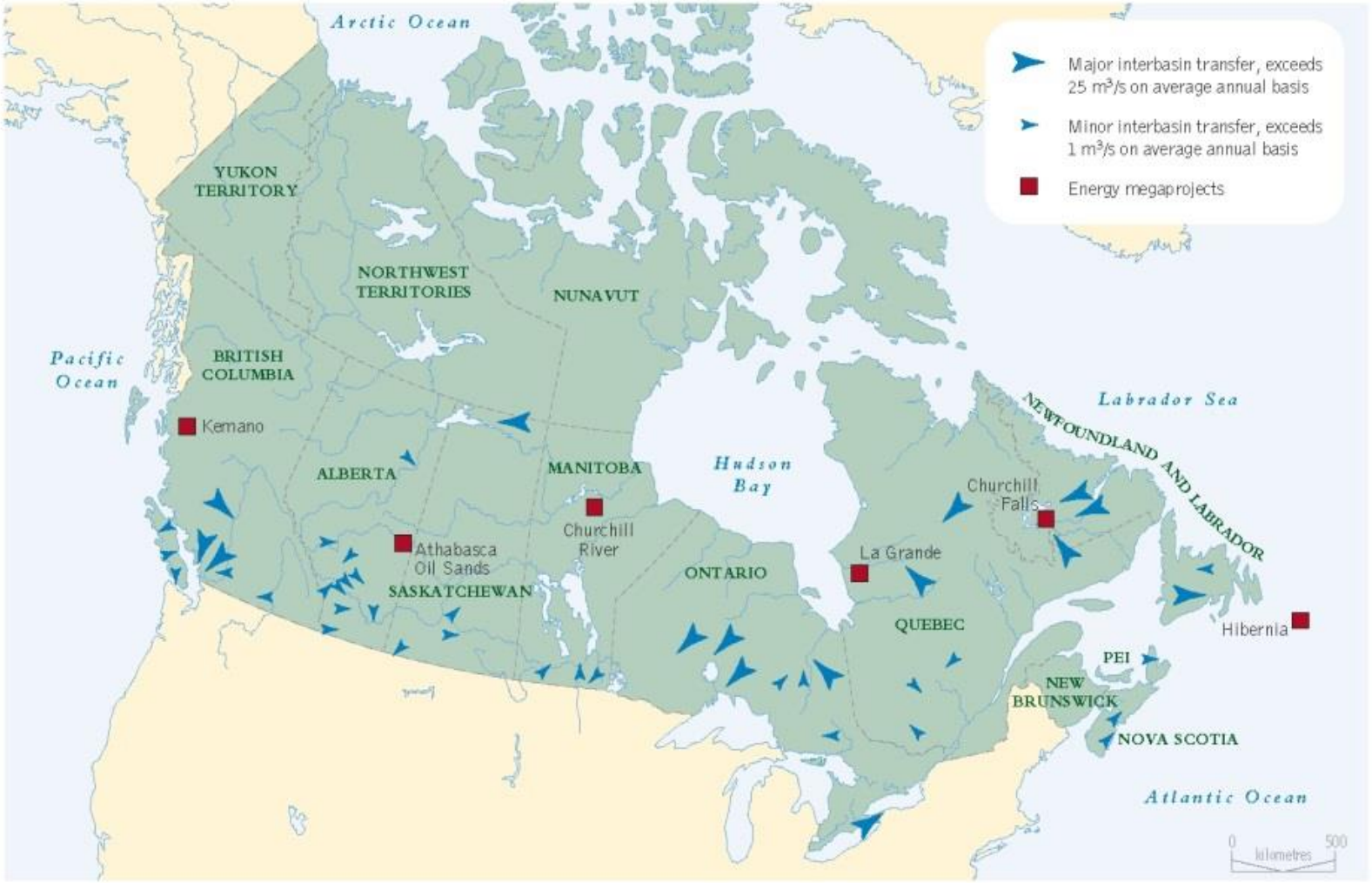


Figure 11.1 | Hydroelectric megaprojects in Canada. *Source: Adapted from Day and Quinn (1992: 16).*

La Grande River (James Bay Pr. Phase I)

- Part of hydro development originally proposed in 1971 to satisfy future electricity needs in Quebec;
- Phase I: La Grande River
  - Flow to this basin doubled via diversions from adjacent watersheds;
  - LG2, 3 and 4 constructed; LG1 deferred to Phase II;
  - Phase I completed in 1986
- Phase II: announced 1985
  - Energy for export to US;
  - Energy (low cost) to attract energy-intensive industries to PQ

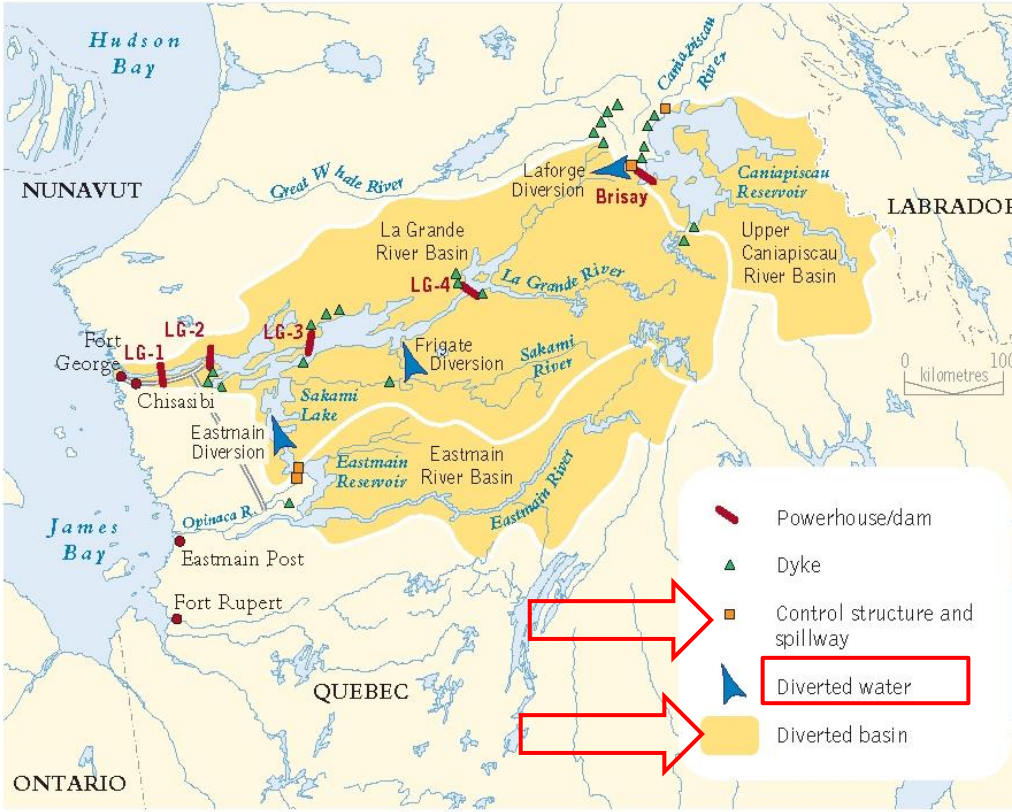


Figure 11.2 | La Grande River hydroelectric development project, Phase 1. *Source: D and Quinn (1992: 134).*

From: Dearden and Mitchell (2012)

James Bay Pr. Phase II (Great Whale Project)

- Like Phase I, continues to encroach on traditional territory of >10,000 Cree and Inuit;
- Encompasses an area ~size of France
- An agreement was reached "James Bay and Northern Quebec Agreement" in 1975 – between govts and these First Nations (the first 'modern' land claims agreement)
- Agreement included provisions for: 1) land rights; 2) a process to deal with future hydro developments

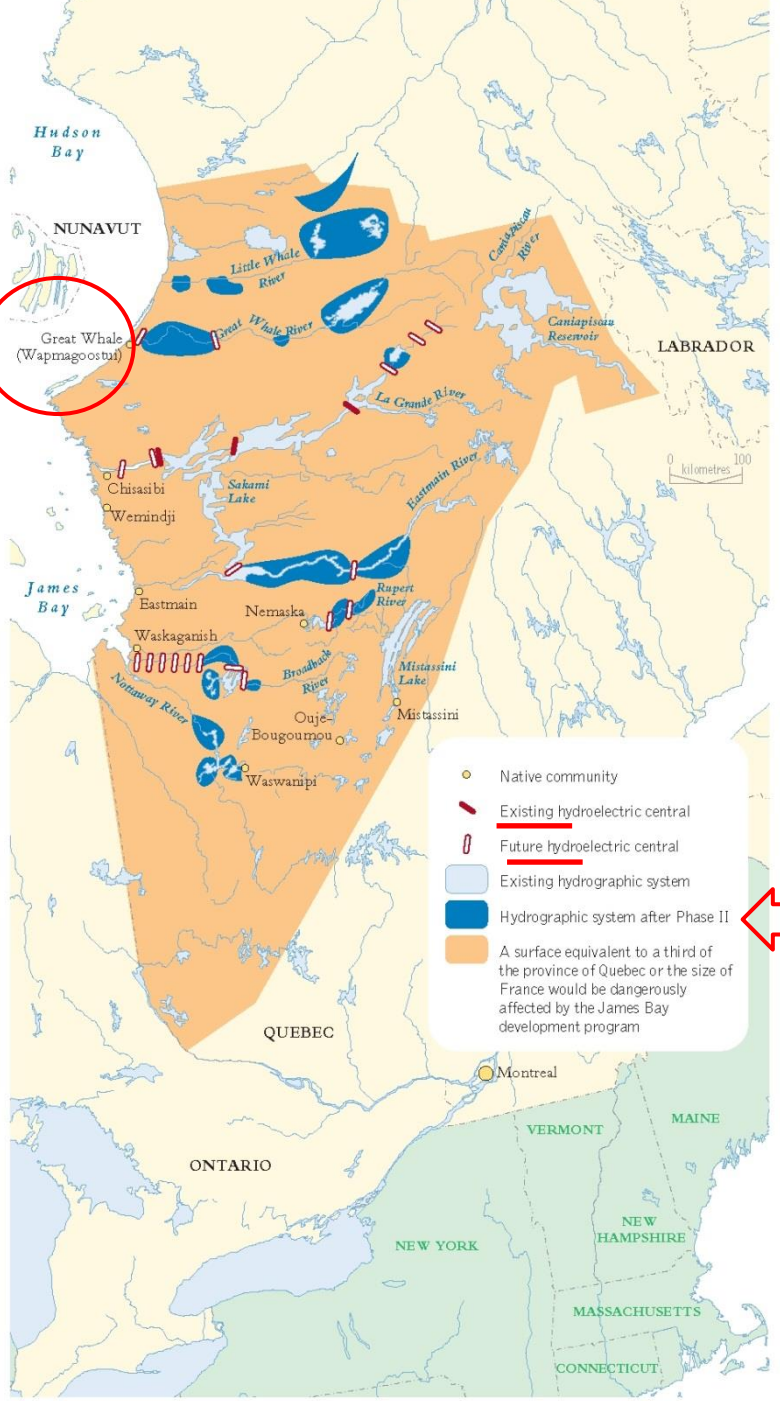


Figure 11.3 | The Great Whale project. *Source: Diamond (1990: 32).*

Need for adaptive management approach …

- … reinforced by concerns / issues raised during construction period and in years following construction:
- **During Construction:**
  - Relocation of Ft George to new site at Chisasibi;
  - Quality of drinking water at new community;
  - Problems maintaining traditional hunting activities (affected due to access road construction, altered patterns of ice breakup by release of 'warm' water from reservoirs)
- **Following Construction:**
  - Very high levels of Mercury in fish caught in reservoirs or connecting rivers;

- No environmental assessment had predicted the appearance of Hg in reservoir fish;
- Monitoring ongoing for both fish and higher consumers (e.g., Cree populations);
- Some improvements (i.e., drop in Hg levels in Cree) but these may be due to change in diet rather than change in concentrations in fish species they used to consume; (from studies in late 1990s')

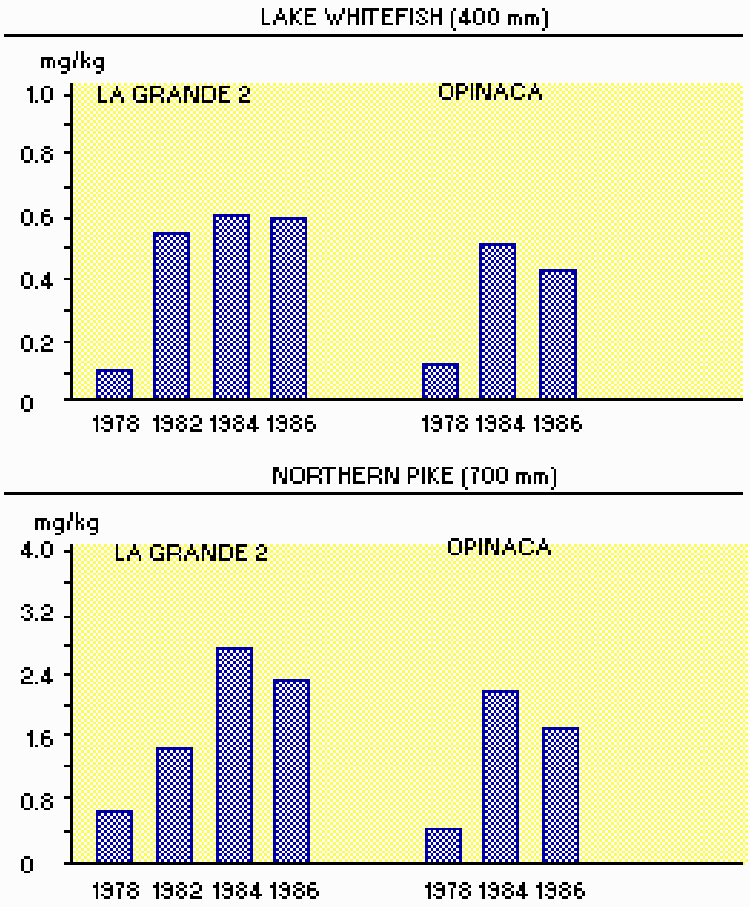
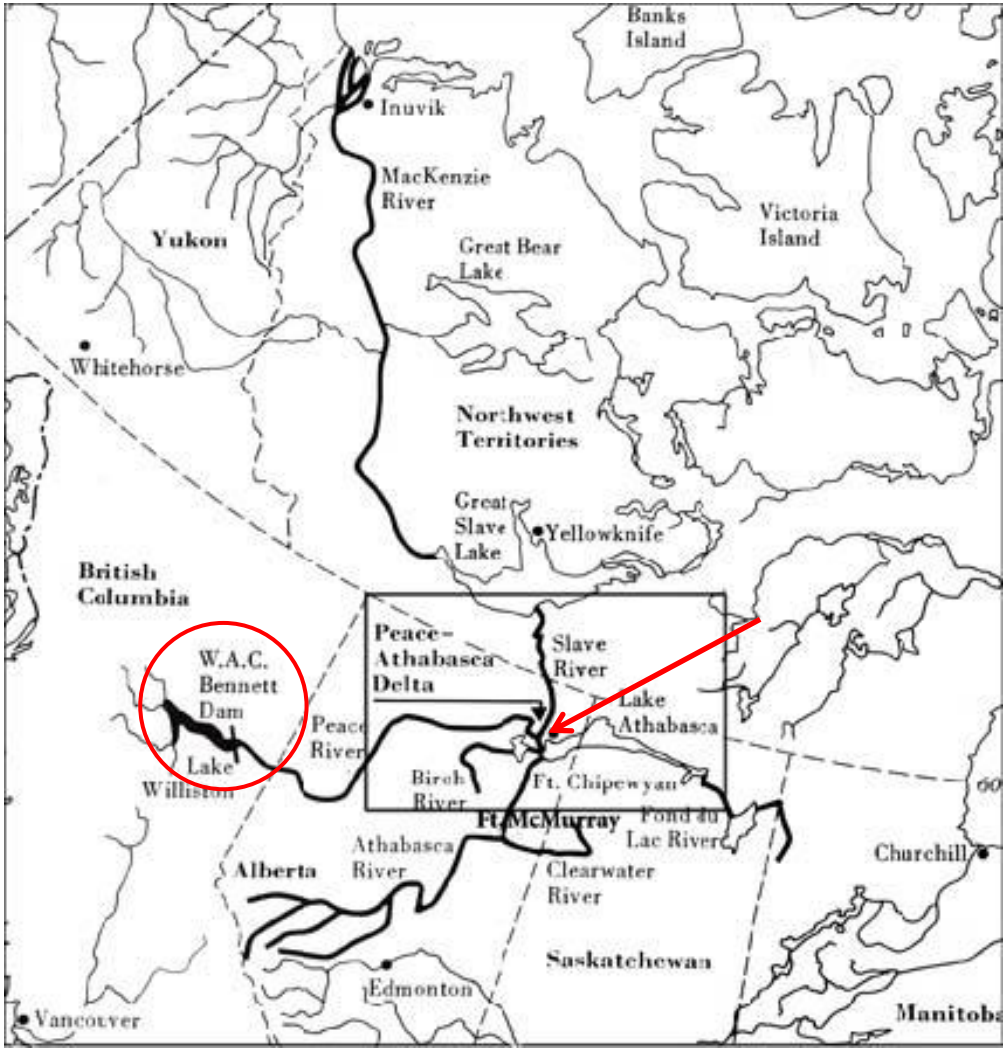


Fig. NAM-28-12 Average mercury levels [mg kg^{-1}] in the flesh of lake whitefish and northern pike in the La Grande 2 and Opinaca Reservoirs (11).

Fig. NAM-28-12
(11) Average mercury levels [mg kg-1] in the flesh of lake whitefish and northern pike in the La Grande 2 and Opinaca Reservoirs.

http://wldb.ilec.or.jp/data/databook_html/nam/nam-28.html

WAC Bennett Dam, Peace River, BC



- Built in 1967
- Created Lake Williston
- Significant downstream on river hydrology (magnitude and timing of discharge) and on riverine habits (especially the Peace-Athabasca delta) and the loss of 'regular flooding' in that ecosystem

Looking Ahead to the next lectures

Thursday: "The Evolution of Development" (Dan Duckert, PhD candidate, Lakehead University Faculty of Natural Resources Management)

Tuesday: "Water Quality and Water Security"

Read ahead (Chpt. 11, Water, pp. 383 → 397)

References

- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {Chapter 11: 'Water'}