Agenda for February 15, 2018

Water news

Lecture: *Hydroelectricity*

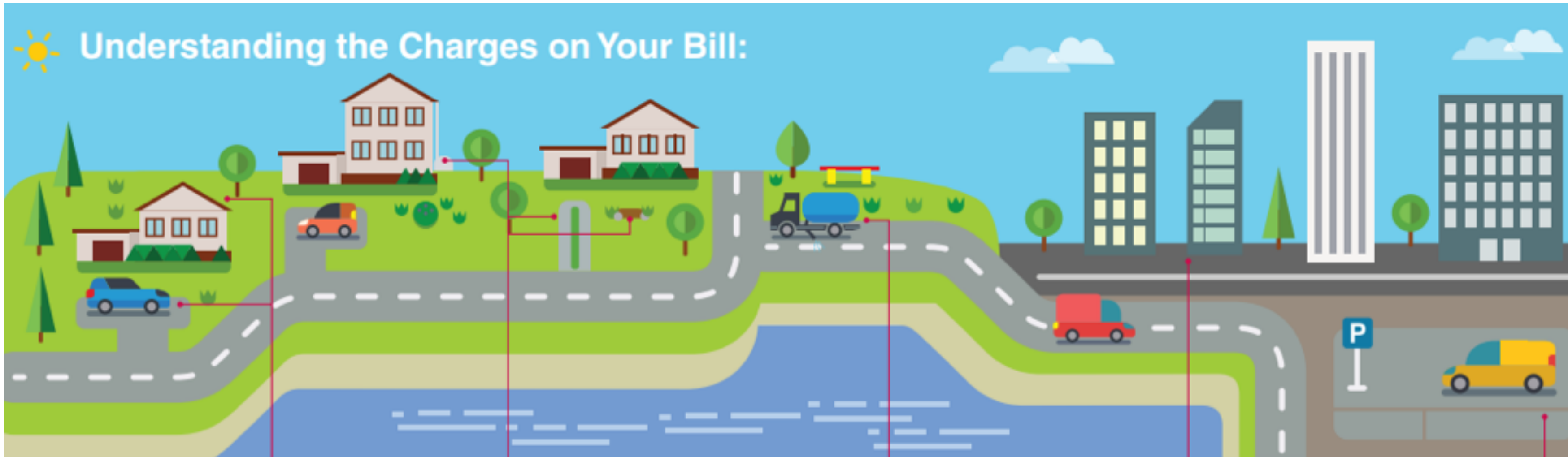
Water news

Cape Town

City of **Victoria** replaced its property-tax model with **stormwater-user fees** in 2016

Stormwater-user fees

- Victoria replaced its property-tax method in 2016
- Separate stormwater utility exclusively responsible for planning, financing, and operating the system
- Rates are based on: impervious surface area on property, street cleaning services and building type. Some properties with large parking lots pay an additional fixed fee to help clean stormwater before it leaves the property.
- Rewards program helps offset the cost of installing rainwater management technologies.



Impervious Area

Rainwater flows off these hard surfaces (e.g. roof or driveway) and is diverted into the stormwater management system.

These areas have been measured by building plans and mapping technology.

Rainwater Rewards Program

The new utility offers financial incentives for sustainable rainwater management, including rain gardens, cisterns and permeable (absorbent) paved areas.

Street Cleaning

Keeping our streets clean goes a long way to keeping pollutants out of our stormwater system. Rates are based on the frequency of street cleaning and street frontage length, measured by mapping technology.

Intensity Code

The impact a property has on the stormwater system, based on the property type assigned by BC Assessment.

Codes of Practice

A program to clean stormwater before it leaves the property, to preserve and protect our local waterways and ocean. Properties with 10 or more parking spaces and certain business or property uses are registered in this program.

Source: City of Victoria

Hydroelectricity

Hydropower was used in ancient times to grind grains, pump water and for irrigation. In the late 19th century, hydraulics were used to produce electrical power. The world's first hydroelectric process was developed in 1878 in England by William George Armstrong. It was used to power a single arc lamp in his art gallery. The first power station was at Niagara Falls which began producing electricity in 1881.

Hydroelectric Dams

The Aral Sea in 1964

Present extent of Aral Sea

Global Perspectives

- China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, about 17 percent of domestic electricity use.
- Paraguay obtains 100% of its electricity from hydroelectric dams
- Norway 98–99%
- Brazil, Canada, New Zealand, Austria, Switzerland, and Venezuela – majority of internal electric energy production
- 16 percent of global electricity generation.

http://www.amusingplanet.com/2013/10/7-ambitious-hydroelectric-power-projects.html

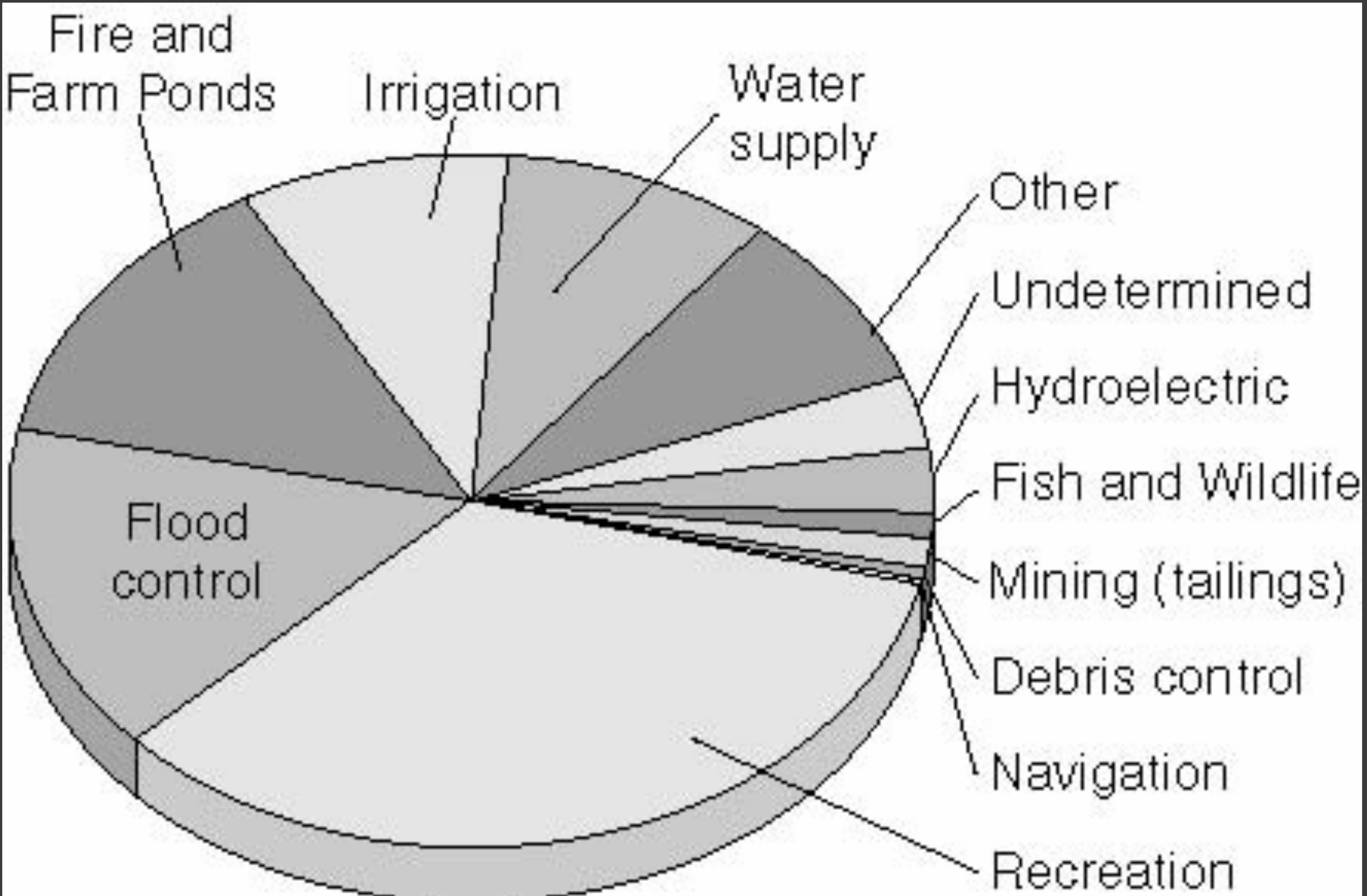
Dams: costs/benefits

Positive

- Economic growth
- Food production
- Flood management
- Recreation enhancement

Negative

- Loss of wildlife habitat
- Destruction of river corridors
- Displaced peoples
- Methyl mercury



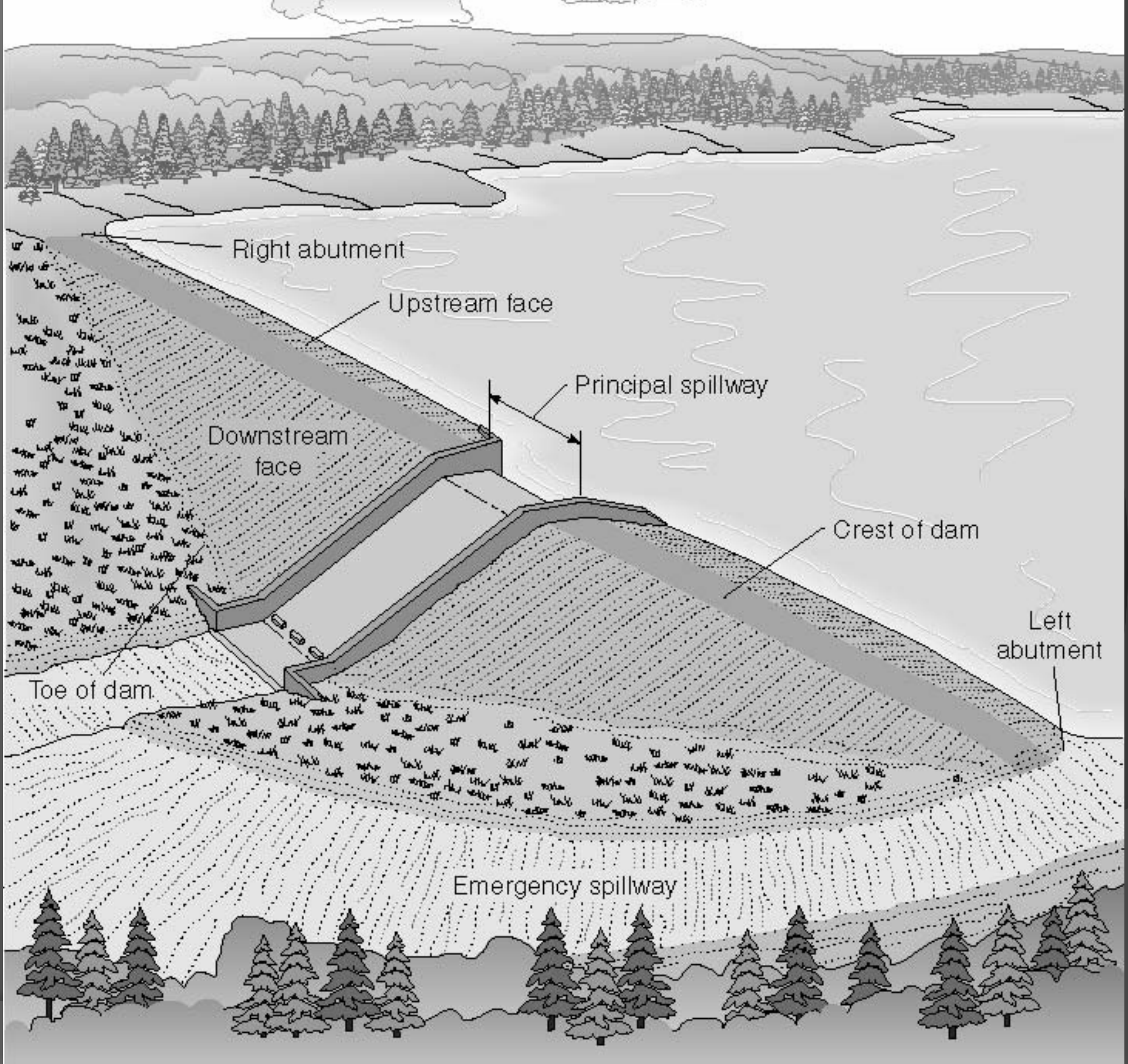
Fire and Farm Ponds
Irrigation
Water supply
Other
Undetermined
Hydroelectric
Fish and Wildlife
Mining (tailings)
Debris control
Navigation
Recreation
Flood control

TABLE 7.1 Primary Purposes of Dams in the United States, 2001

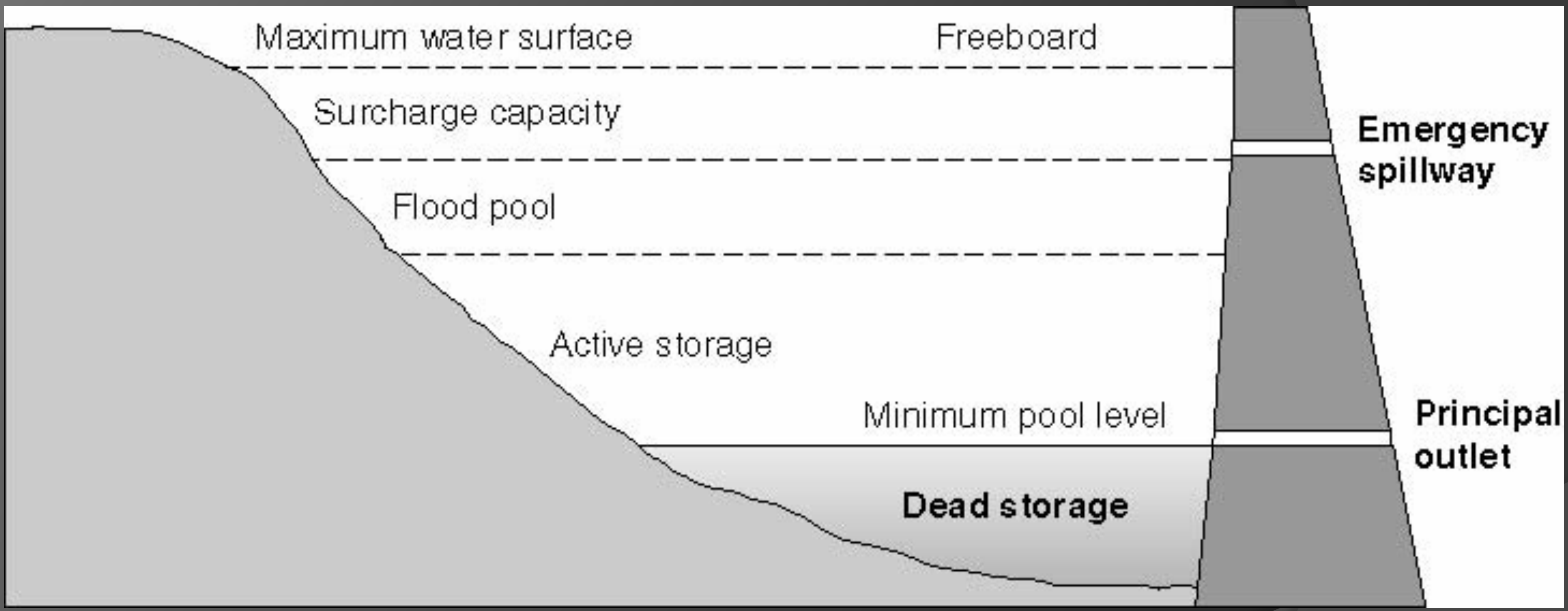
Primary Purpose	% of Total	Number of Dams
Recreation	33.8	26,152
Flood control	15.6	12,088
Fire and farm ponds	13.7	10,589
Irrigation	9.5	7,392
Water supply	9.4	7,297
Other	8.1	6,279
Undetermined	3.5	2,647
Hydroelectric	2.9	2,280
Fish and wildlife	1.4	1,046
Mining (tailings)	1.3	991
Debris control	0.5	396
Navigation	0.3	250
Total	100%	77,407

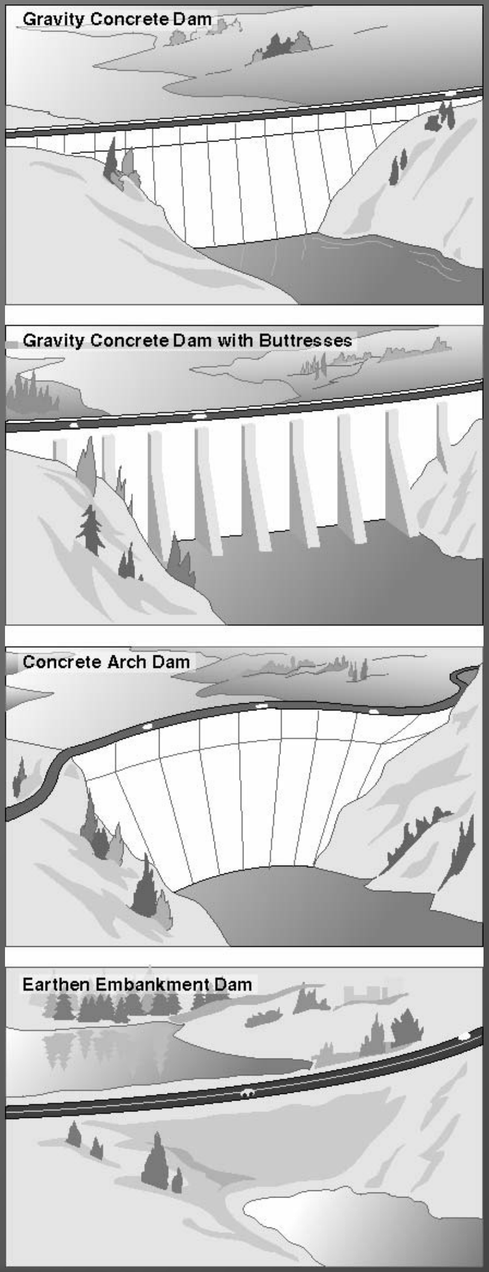
Source: U.S. National Inventory of Dams, U.S. Army Corps of Engineers, January 2001.

PRINCIPAL PARTS OF A DAM

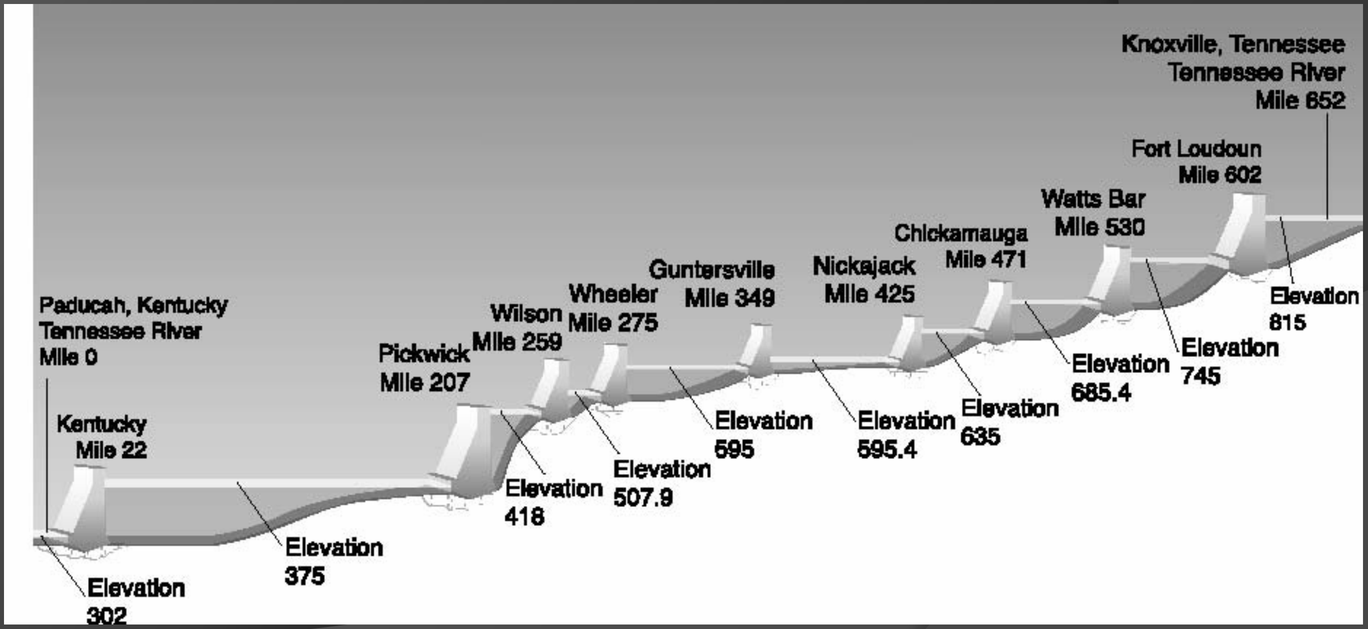


CLASSIFICATION OF PRINCIPAL STORAGE ZONES IN A CROSS SECTION OF A MULTI-PURPOSE RESERVOUR

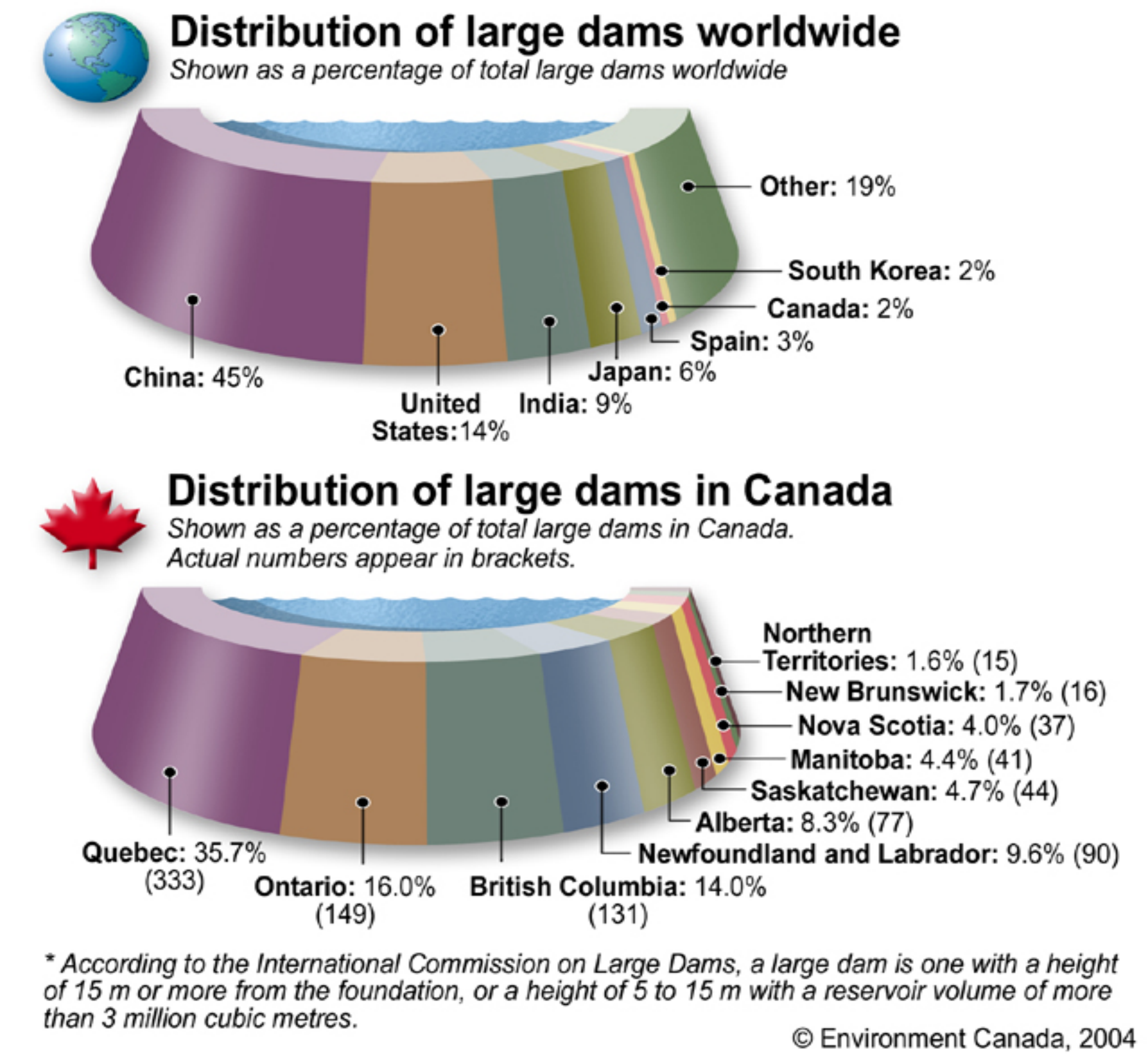




River dams (locks, levees) form a staircase of reservoirs that stretch the entire length of the Tennessee River



Global Overview of Dam Location



In 2000 there were over 45,000 "large dams" world wide.

Half of the world's existing large dams are built strictly for irrigation, while the remainder are build for hydro generation, water supply and flood control.

Powering the world with water

In 2000, one-third of the world's countries relied on hydropower for more than half their electricity supply and large dams generated 19% of electricity overall. About 70% of hydroelectric power generation potential has already been tapped in the developed world; only about 10% in the developing world.

The world's largest hydroelectric plants

Numbers indicate megawatts of installed generating capacity

1. Three Gorges	China	**18 200 MW**
2. Itaipu	Brazil/Paraguay	**12 600**
3. Grand Coulee	United States	**10 100**
4. Guri	Venezuela	**10 100**
5. Tucuruii	Brazil	**7 500**
6. Sayano-Shushensk	Russia	**6 400**
7. Krasnoyarsk	Russia	**6 100**
8. Corpus-Posadas	Argentina/Paraguay	**6 000**
9. La Grande 2	Canada	**5 300***
10. Churchill Falls	Canada	**5 200**

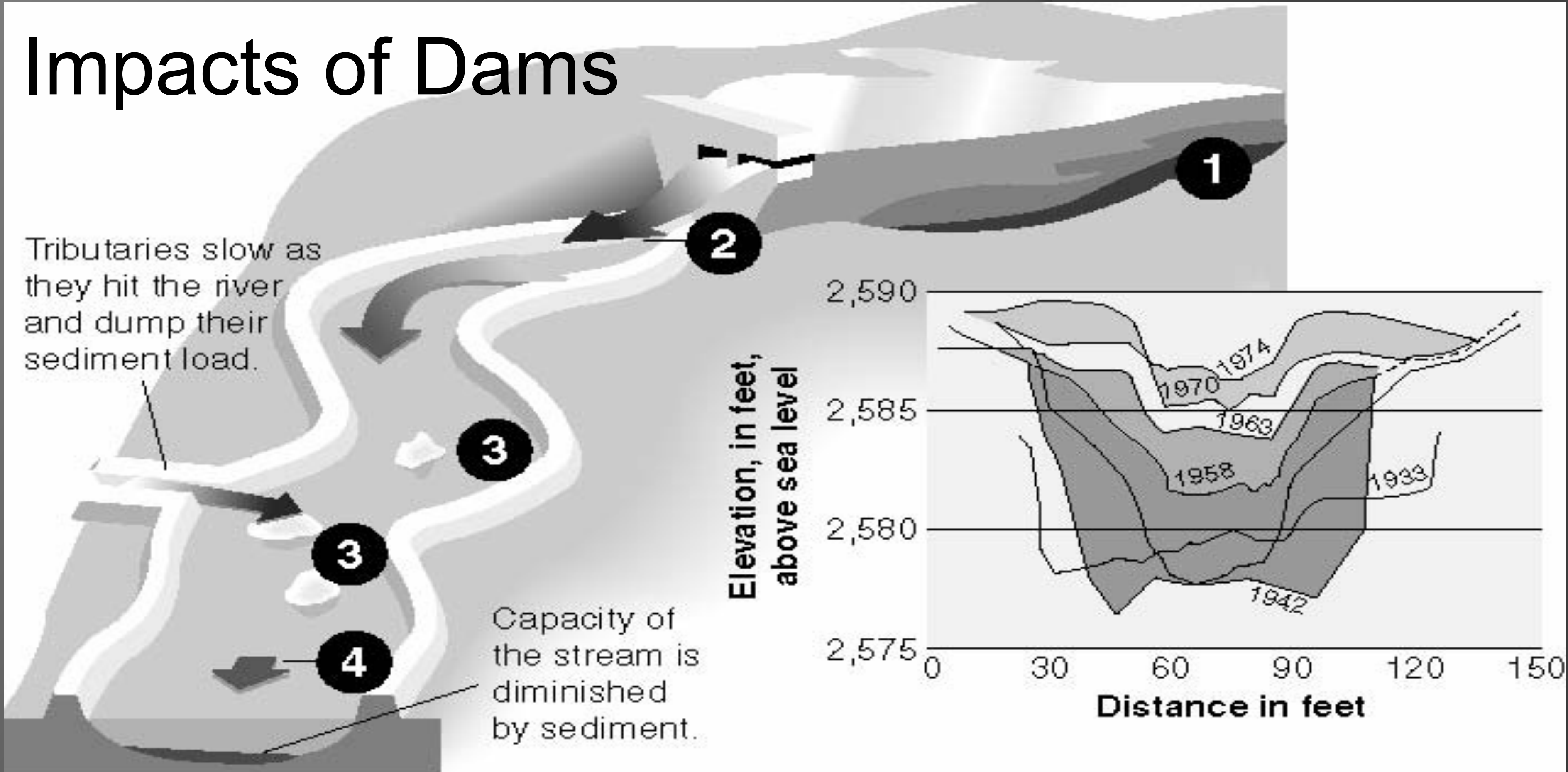
** The combined output of all eight dams at James Bay is 15 237 MW*

How much electricity is that?

La Grande 2 on James Bay, Canada's largest hydroelectric plant, produces enough hydro to constantly light a 60-watt light bulb for more than 10 000 years.**

*** Assuming the plant is run at maximum capacity around the clock.*

Impacts of Dams



- Dams change behaviour of rivers- sediment load settles behind a dam.
- Downstream, water released through outlet pipes causes channel erosion.
- Farther downstream, the opposite can occur with silt forming islands and sandbars.

Hydroelectricity

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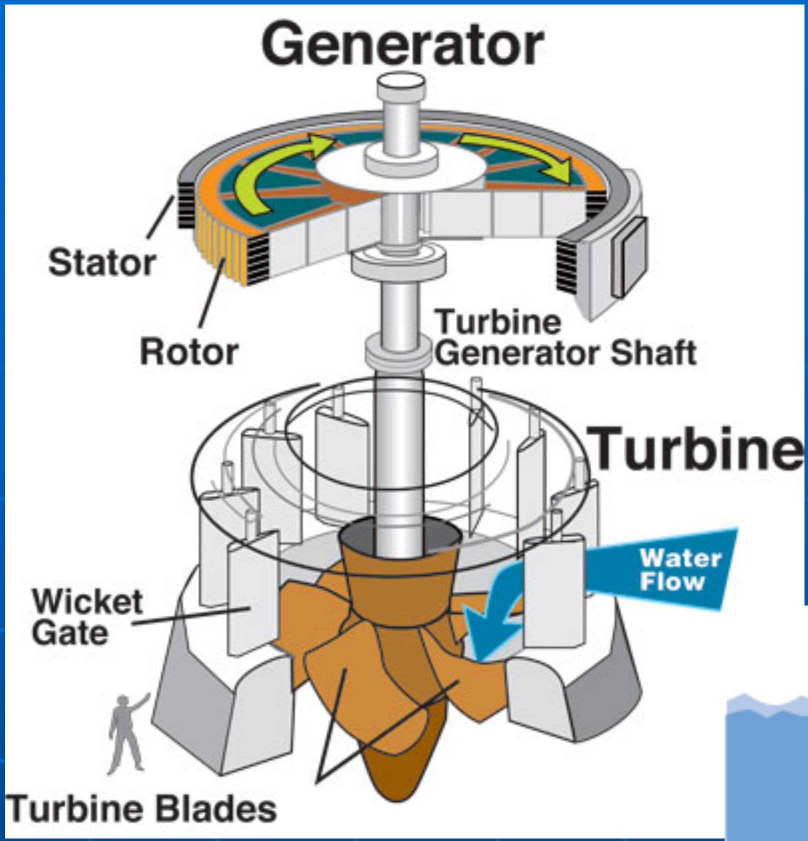
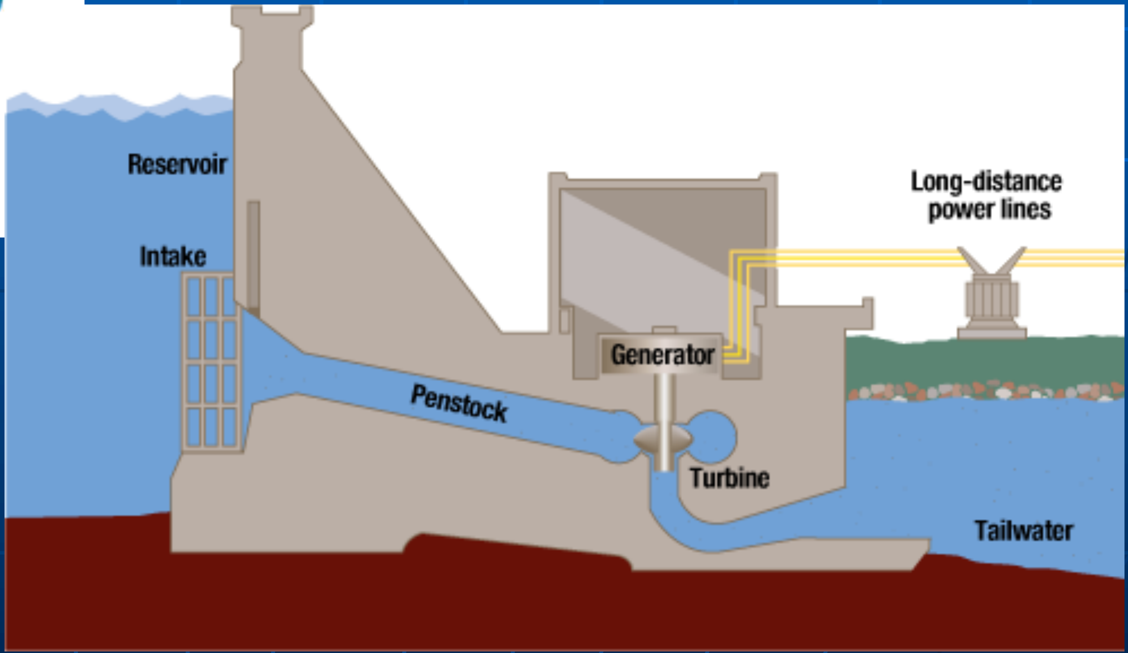
Hydro-Electric Development in Canada:

Past / Recent / Potential

Electricity Production at a Hydroelectric Plant



height x
flow x
density of water x
acceleration (gravity)=
ELECTRICITY PRODUCED



Kakabeka Falls

Hydroelectric power production:

P = ρhrgk where,

- **P is the electric power in watts**
- **ρ is the density of water (~1000 kg/m³)**
- **h is the height in metres**
- **r is the flow rate in cubic metres/second**
- **g is the acceleration from gravity of 9.8 m/s^2**
- **k is the efficiency** (coefficient of efficiency from 0 to 1. Efficiency is often near 1 with larger, modern turbines.)

Example: Kakabeka Falls

P = ρhrgk

= $(1000\ kg/m^3 \times 58\ m \times 31\ m^3/s \times 10\ m/s^2 \times 1)$

= 17,980,000 watts

= 17.98 MW

Effects of Dams

Dams change the character of rivers:

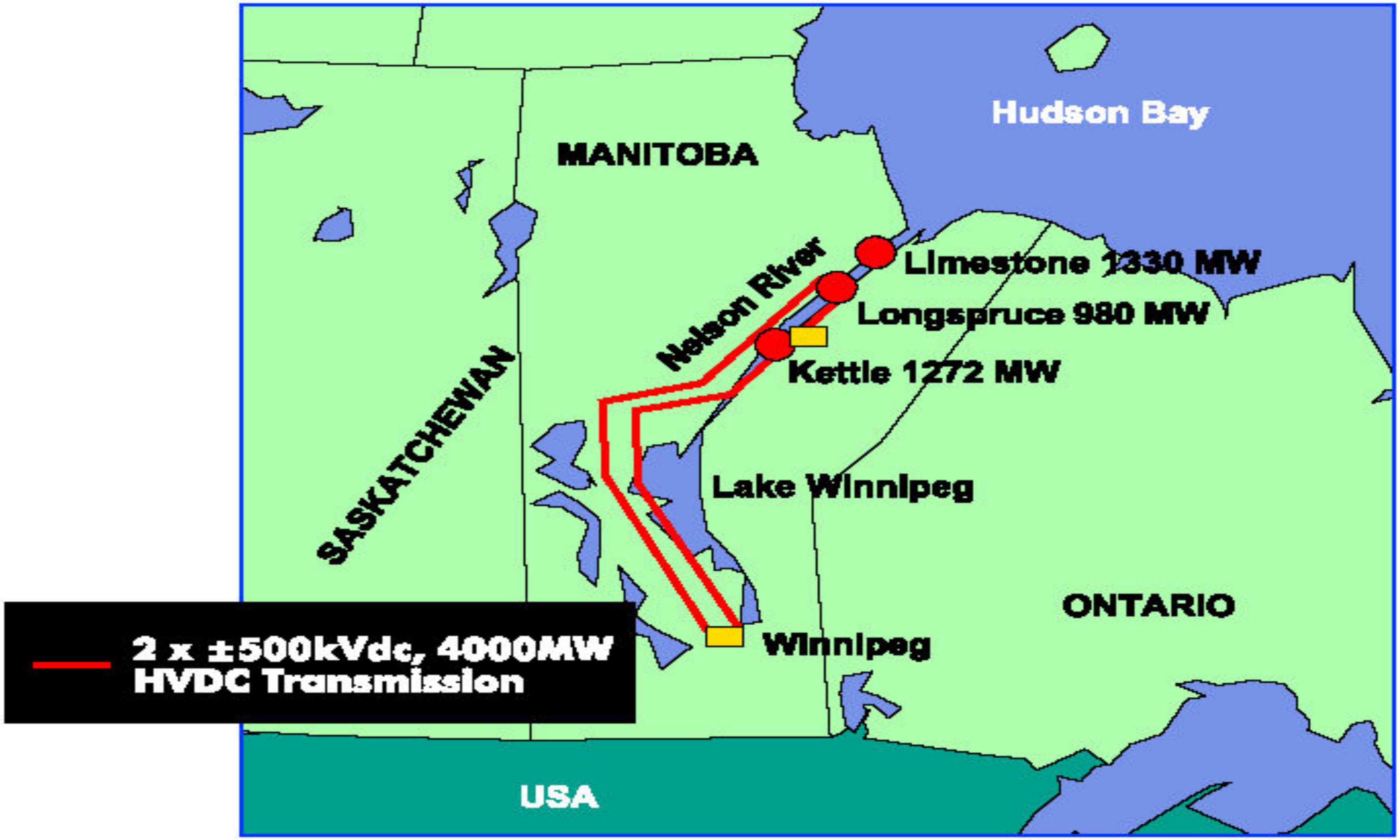
- Reservoir water temperature
- Bottom of reservoir is colder
- Barriers to migration
- Water can be uniform or erratic (habitat change)
- Generally low in dissolved oxygen
- Water flow and quantity variations harmful to downstream aquatic wildlife
- Sediment build-up in reservoir
- Removal of dams difficult (removing small dams in the United States a new management technique).

Clean Energy Transfer Initiative

Details and Routes

- Via Winnipeg and Thunder Bay
- Direct to Thunder Bay
- Direct to Timmins
- Hudson Bay to Timmins

Nelson River Transmission Lines



MANITOBA
KENORA
Red Lake
Kenora
Dryden
RAINY RIVER
Fort Frances
Atikokan
Thunder Bay
THUNDER BAY
Nipigon
Marathon
Hearst
Kapuskasing
Moosonee
COCHRANE
Cochrane
Timmins
Wawa
TEMISKAMING
SUDBURY
New Liskeard
ALGOMA
Sudbury
North Bay
Sault Ste. Marie
MANITOULIN
NIP
U.S.A.

Thursday agenda