VALUES ▪ SAFETY ▪ INTEGRITY ▪ EXCELLENCE ▪ PEOPLE AND CITIZENSHIP



Flow Forecasting at OPG

National Flow Forecasting Meeting
Vancouver, 21 February 2018

Kurt C. Kornelsen, Ph.D., C.D.
Senior Manager, Water Resources
Dam Safety and Water Resources

ONTARIO POWER GENERATION

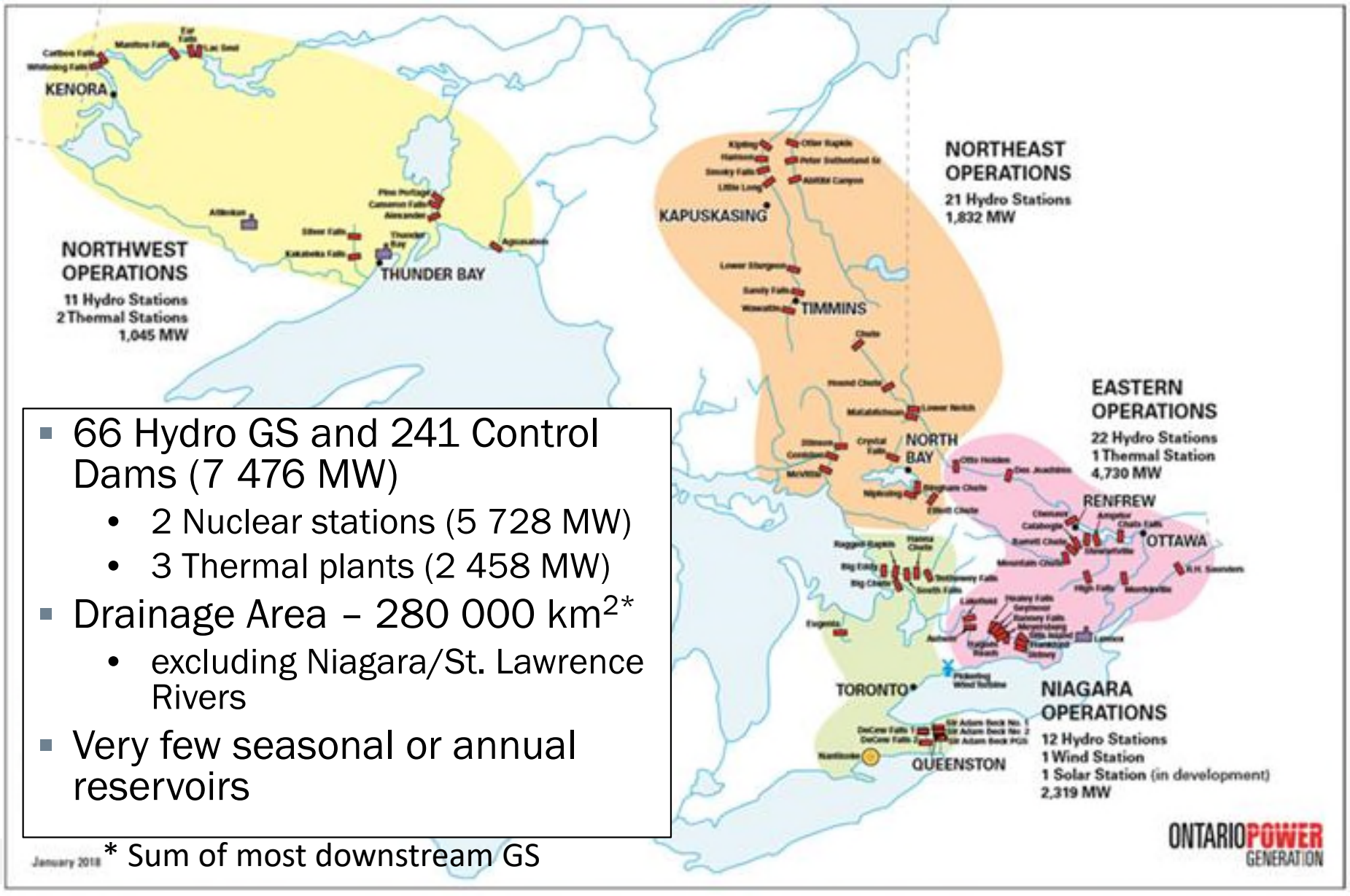


Agenda

- Current Practice
  - Data
  - Data Management
  - Models
- Now-steps
  - WISKI
  - Hydrological Prediction System
- Needs, Wants and Challenges



OPG Overview



- 66 Hydro GS and 241 Control Dams (7 476 MW)
  - 2 Nuclear stations (5 728 MW)
  - 3 Thermal plants (2 458 MW)
- Drainage Area – 280 000 km^{2*}
  - excluding Niagara/St. Lawrence Rivers
- Very few seasonal or annual reservoirs

January 2018

* Sum of most downstream GS



Processes: Water Management

- Gauges and Inflow
- Weather Forecasts
- Water Management Strategy
- Daily Water Availability
  - Forebay Limits



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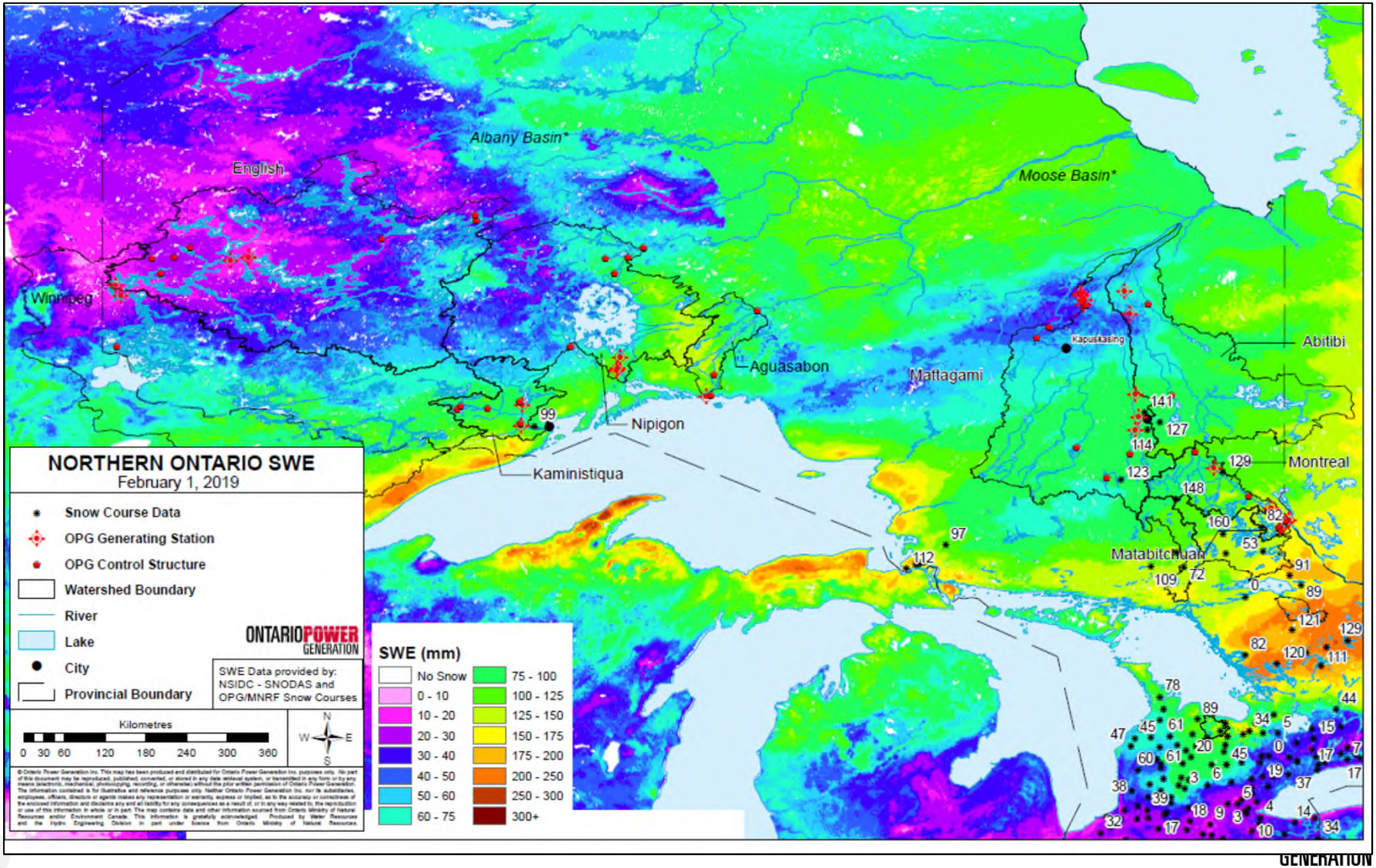


Weather Data Sources

- ECCC Forecast
- Websites (Intellicast, weather underground…)
- MNRF Weather Office
- ECCC Datamart
- NWS
- SNODAS
- Snow Surveys



SNODAS


NORTHERN ONTARIO SWE
February 1, 2019
Snow Course Data
OPG Generating Station
OPG Control Structure
Watershed Boundary
River
Lake
City
Provincial Boundary
ONTARIO POWER GENERATION
SWE Data provided by: NSIDC - SNODAS and OPG/MNRF Snow Courses
Kilometres
0 30 60 120 180 240 300 360
N
W E
S
SWE (mm)
No Snow
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 - 250
250 - 300
300+
Albany Basin*
Moose Basin*
English
Winnipeg
Aguasabon
Mattagami
Kapuskasing
Abitibi
Nipigon
Kaminstiqua
Montreal
Matabitchuan



ECCC Precip Data

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Daily Precip Summary
Precipitation Forecast
Water Resources

Scroll to: NEO | NWO | EO | CO

Show /Hide: Sub Basins | Regional | Global | All Ensem

2				Regional forecast issued:	Feb-21-2019	at	6:00	UTC	*Note: Regional Forecast is typically not issued at 0:00 hr											
3				Global Forecast Issues:	Feb-21-2019	at	0:00	UTC												
4				Ensemble Forecast Issued:	Feb-21-2019	at	0:00	UTC												
5	**Operations Group**	**Basin**	**Sub-Basin**	**Forecast**	T + 1 day		T + 2 days		T + 3 days		T + 4 days		T + 5 days		T + 6 days		T + 7 days		T + 8 days		T + 9 day	
6					21-Feb-19		22-Feb-19		23-Feb-19		24-Feb-19		25-Feb-19		26-Feb-19		27-Feb-19		28-Feb-19		1-Mar-1	
162			***Basin Average Precip***	Global	5.8		0.1		3.3		16.3		2.6		0.2		- -		- -		- -	
163				Ensemble -90%	3.9		0.0		0.3		7.8		0.5		0.0		0.0		0.0		0.0	
164				Ensemble -75%	4.2		0.0		0.6		13.6		1.1		0.1		0.1		0.2		0.2	
165				**Ensemble -50%**	**5.0**		**0.1**		**1.5**		**15.9**		**1.9**		**0.1**		**0.2**		**0.4**		**0.4**	
166				Ensemble -25%	5.6		0.1		2.5		20.1		2.6		0.3		0.8		1.1		1.1	
167				Ensemble -10%	6.2		0.2		3.1		23.2		4.3		0.5		1.7		2.2		1.8	
168			**Upstream of Lower Notch GS to Latchford**	Regional*	1.3		0.2		- -		- -		- -		- -		- -		- -		- -	
169				Global	5.4		0.1		1.4		13.0		3.6		0.3		- -		- -		- -	
170				Ensemble -90%	3.7		0.0		0.0		9.7		0.4		0.1		0.0		0.0		0.0	
171				Ensemble -75%	4.7		0.0		0.1		12.9		1.4		0.1		0.2		0.1		0.1	
172				**Ensemble -50%**	**5.6**		**0.0**		**0.2**		**17.2**		**1.8**		**0.2**		**0.4**		**0.2**		**0.3**	
173				Ensemble -25%	6.2		0.1		0.5		21.9		2.4		0.4		1.4		0.7		1.0	
174				Ensemble -10%	6.6		0.2		1.6		24.4		3.2		1.7		4.8		3.2		3.2	

Summary - Precip | Regional (Precip) | Global (Precip) | Ensemble (Precip) | Regional (Temp) | Global (Temp) | Ensemble (Temp) | Raw-E ...

Ready

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Data Management

- Energy and Resource Information System (ERIS)
  - Custom built database
  - Water data from operators, GOES other operators*
  - Y2K solution being upgrade to Microsoft

- WISKI Water Record Accounting (WRA)
  - SCADA
  - GOES
  - Other Operators
  - Datamart
  - Network of networks???



Market Operations

Operating Strategy Plans

Outages/Tests

Market Information

Portfolio Management Centre

Offers to the Market

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State of Practice

- Water Managers responsible for flow forecasts and directing water operations
- Daily flow limit and target forebay elevations established
- PMC bidding short term dispatch
- Heavy reliance on Excel based tools and manual input
- Forecasts tend towards long term median



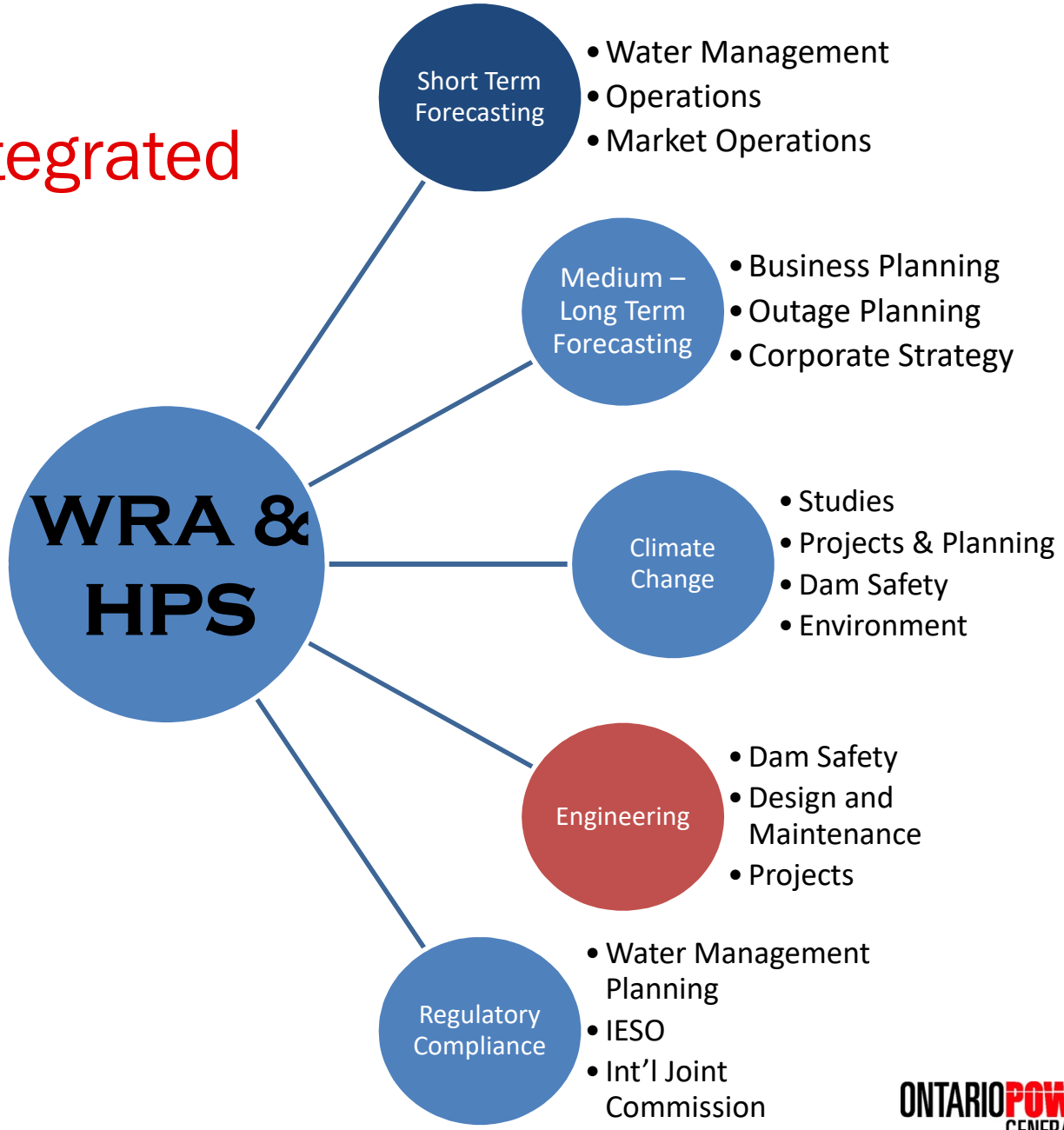
Models

- 2 WATFLOOD models in Mattagami & Madawaska
  - Pre-run non-interactive
  - Madawaska – NRCan – Scripts
  - Mattagami – 4DM on Webserver
- WATFLOOD (LWCB)
- HQ Model + HEC-ResSIM (Ottawa R.)
- Other models (Niagara and St. Lawrence)



Horizontally Integrated

- **Shared**
  - Architecture
  - Models
  - Platform
- **Variety and Flexibility**



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Table 1: Model Decision Matrix

Consideration	Weight	Justification
Model Physics: Processes represented in the model and relevance to OPG	3	Important for determining accurate model flow and the ability to get the correct model response for the correct reason
Data Requirements: Is the data and configuration data readily available	1	Most data is readily available from ECCC or NOAA but some models have greater requirements
Speed/Efficiency: Can the model run quickly or in parallel	2	An important feature for ensemble prediction and conducting ad-hoc analysis for operations
Ensemble Predictions: Can the model be run numerous times in a short time span to support multiple weather forecasts	2	The ability to see the consistency of a long-term forecast is important for decision making.
Available Support: Is technical support available including outsourcing calibration	2	The goal is to develop in-house expertise, but some opportunity should be available for outside work
Water Management: Does the model support water management operations (i.e. dams and reservoir rules)	3	This ties with model physics. Water management is important from an OPG perspective.
Portability: Can the model be used in a variety of watersheds or for multiple purposes.	3	OPG watersheds cover a range of physical conditions and it is important that a model can represent all OPG watersheds; potential model application beyond forecasting e.g. climate change studies
Ease of Use: Can the model be easily used or configured by trained staff	2	An easy to use model is important, but this could be augmented by connection to other systems.
Potential for Improvement[1]: Flexibility in providing model improvements to meet OPG needs	2	The ability to have the developer add new methods could benefit OPG simulations



Water Manager Needs/Wants

- Ability to run model themselves and tune local conditions
- Lake and reservoir routing critical for OPG
- Ease of manipulation
- Access to forecast record*
- Forecaster involvement
- Data poor in the north!



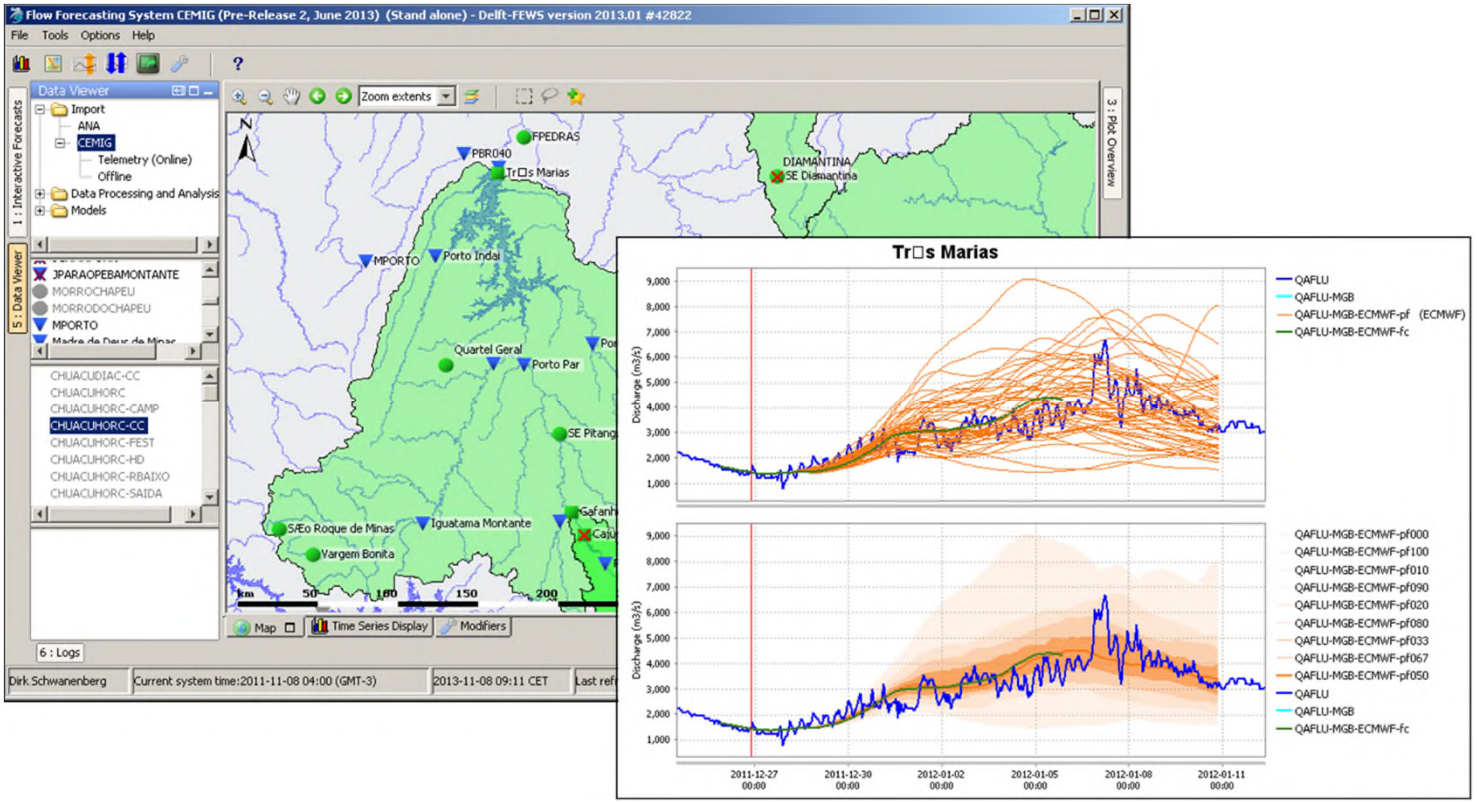
Architecture

- KISTERS WISKI (Water Record Accounting)
  - Archive
  - Quality Control
  - Statistical Analysis
  - Real-time data
  - Download
  - Visualization
- Delft-FEWS (Hydrological Prediction System)
  - Forecasting
  - Modelling
  - Visualization
  - Training



Delft FEWS

- Flexible, scalable, expandable data handling and modelling platform



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Status

- WISKI Implementation finalized Q3 2019
- Delft-FEWS prototype – 2019
- Delft-FEWS full implemention – 2019-2021
  - Pending business case approval





- Separate runoff and routing models
- Greater integration of water management in model
- Testing data-assimilation dual state-parameter updating for reservoir calibration

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Needs and Challenges

- Networks of Networks (for real)
- Plans and Sharing with ECCC
- Other operators
- Usable data formats & standards of practice
- Snow product

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Case Study –Peaks & Water



Lower Notch Generating Station

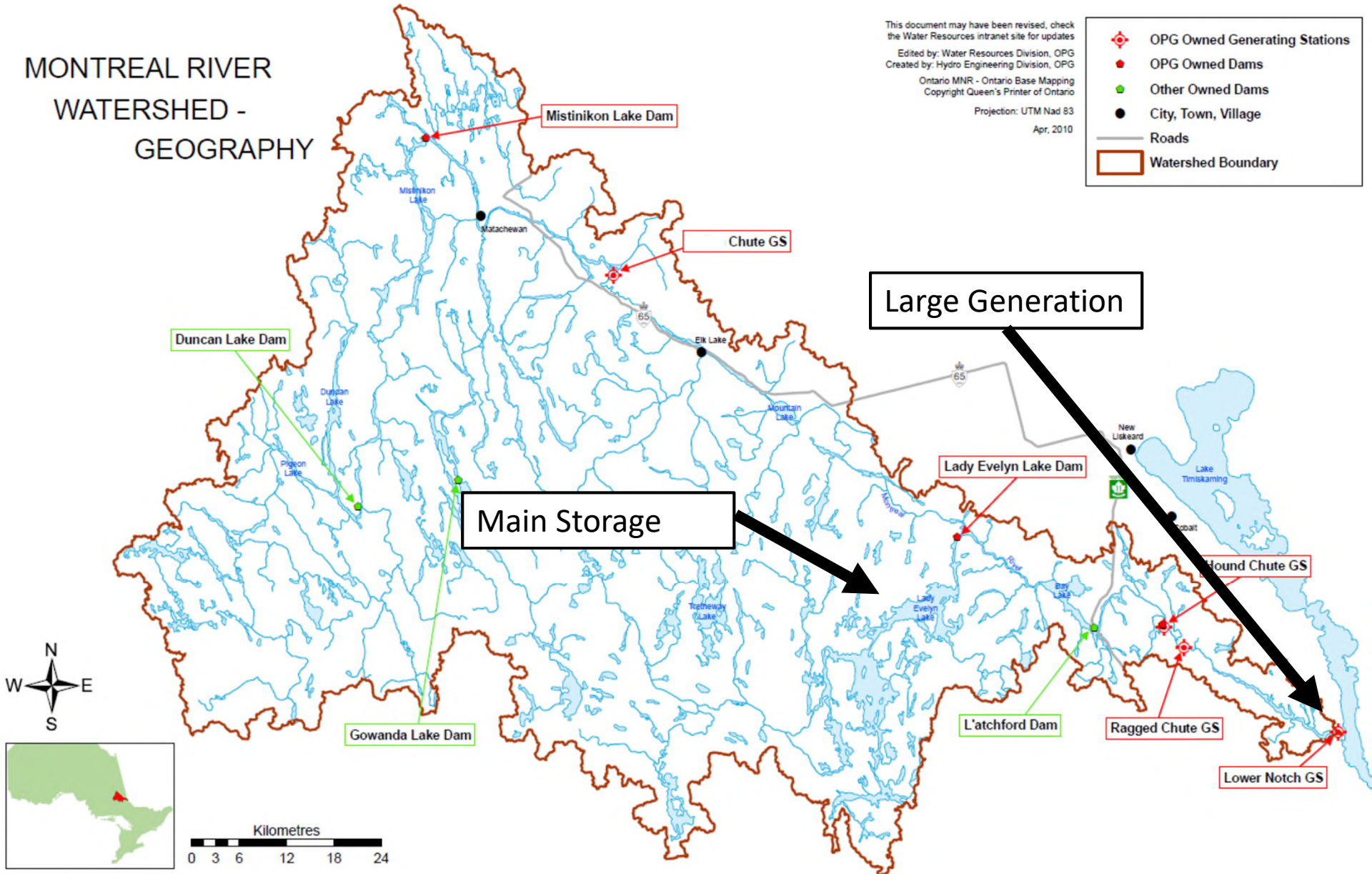
Montreal River

274 MW Capacity

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Montreal River Map





Case Study II –Peaks & Water

- Peaking plant but limited storage
- Time release from Lady Evelyn need to maintain WMP limit so outflow available depends on inflow when opportunities arise
- Requires timing of operation to make water available for peaks and market opportunities
- Most water must be used or wasted
- Close integration to time market and water availability

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