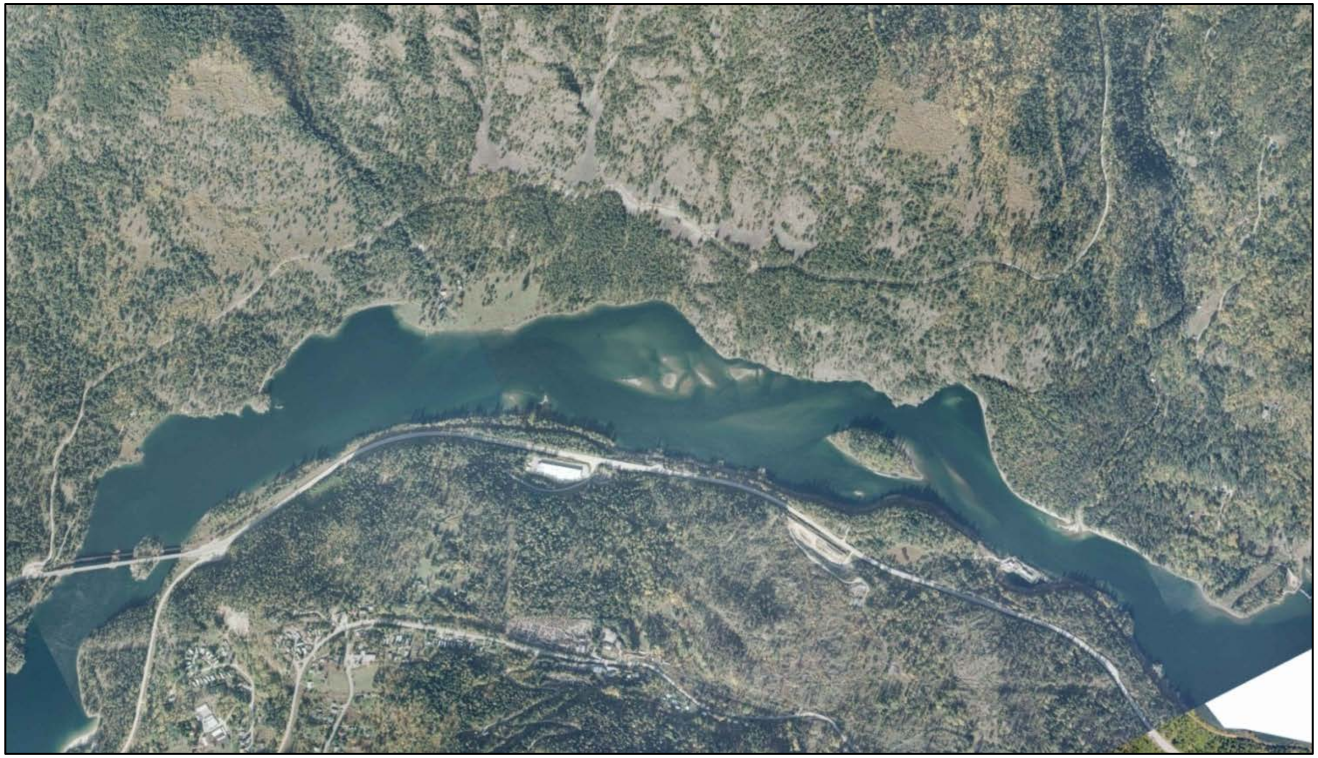
GROHMAN NARROWS CHANNEL IMPROVEMENT PROJECT

12 Sept 2013

BC hydro

FOR GENERATIONS

BACKGROUND AND PROJECT DRIVERS



- Grohman Narrows is a natural hydraulic constriction on the Kootenay River, ~3 km downstream of Nelson
- The constriction is primarily due to a naturally high river bed elevation through the reach
- The river narrows to an approximate width of 175 m at the upstream end of the reach
- Bed elevation through the reach varies between approximately El. 520 m (1706 ft) and El. 530 m (1739 ft).

BACKGROUND AND PROJECT DRIVERS

- The effects of the Grohman Narrows constriction include:
  - Higher peak flood levels on Kootenay Lake
  - Reduced ability to release water from Kootenay Lake, especially from March to June, to fully utilize the storage flexibility of the lake
  - Reduced head and generation at Corra Linn and Kootenay Canal and increased spill at Corra Linn and all of the downstream Kootenay River dams
  - Less operating flexibility at Kootenay Canal, Corra Linn, and the downstream Kootenay River plants
- Channel improvements at Grohman Narrows would improve all these effects
- In response to local government and community concerns, BC Hydro initiated the project to explore potential improvements to Grohman Narrows in late 2012

PROJECT AREA

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PREVIOUS EXCAVATION EFFORTS

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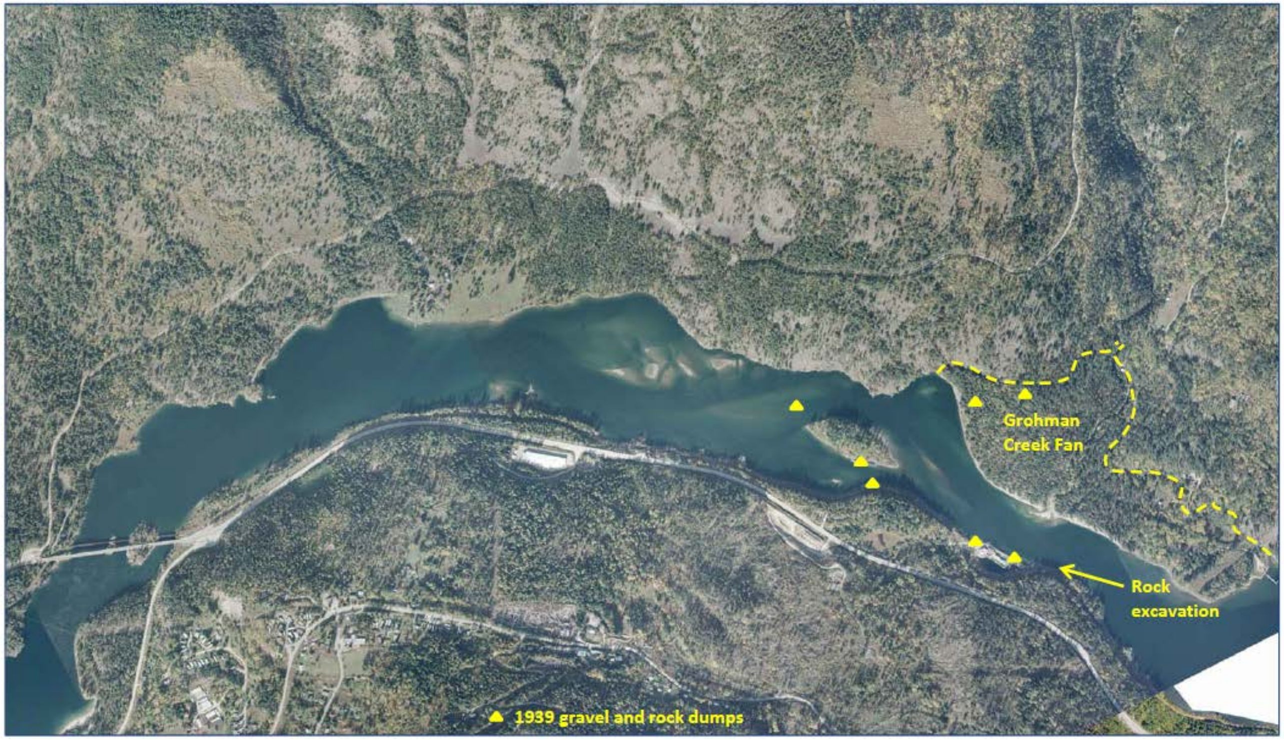
- The benefits of channel improvements in the Grohman Narrows have been recognized since the 1890's.

- **1890:**
  - An estimated 18,000 cubic yards of blasted rock, boulder and gravel removed from the riverbed

- **1931:**
  - Approximately 350,000 m^3 of rock and 200,000 m^3 of boulders and gravel
  - Material removed from six locations between Corra Linn Dam and Grohman Narrows

- **Further improvements in 1939:**
  - Approximately 14,000 m^3 of rock from the left bank of the river opposite Grohman Creek
  - 256,000 m^3 of boulders and gravel from the Grohman Creek fan and from either side of the wooded island in the Narrows

1939 DREDGING



Dredging in progress

Temporary railway across the streambed surface to facilitate dredging

Deposited excavated material

KEY CONSIDERATIONS

- **Engineering**
  - Evaluate project benefits
  - Estimate amount of excavation material
  - Assess composition of excavated material
  - Evaluate channel stability

- **Environmental**
  - Establish environmental requirements during construction
  - Confirm timing and duration of construction season
  - Assess effects on fish and wildlife during construction
  - Assess long-term effects on fish and wildlife
  - Assess effects on archeology resources
  - Plan to avoid environmental and archeological impacts

KEY CONSIDERATIONS

- **Regulatory / Permitting**
  - Compliance with IJC Order
  - BC Water Act Section 9 Approval Process
  - Determine applicability of Federal Fisheries and Environmental Assessment Act
  - Columbia River Treaty issues
  - International River Improvement Act requirements
  - Crown Land permits

- **Stakeholder Consultation**
  - Stakeholder Consultation and Communications Plan

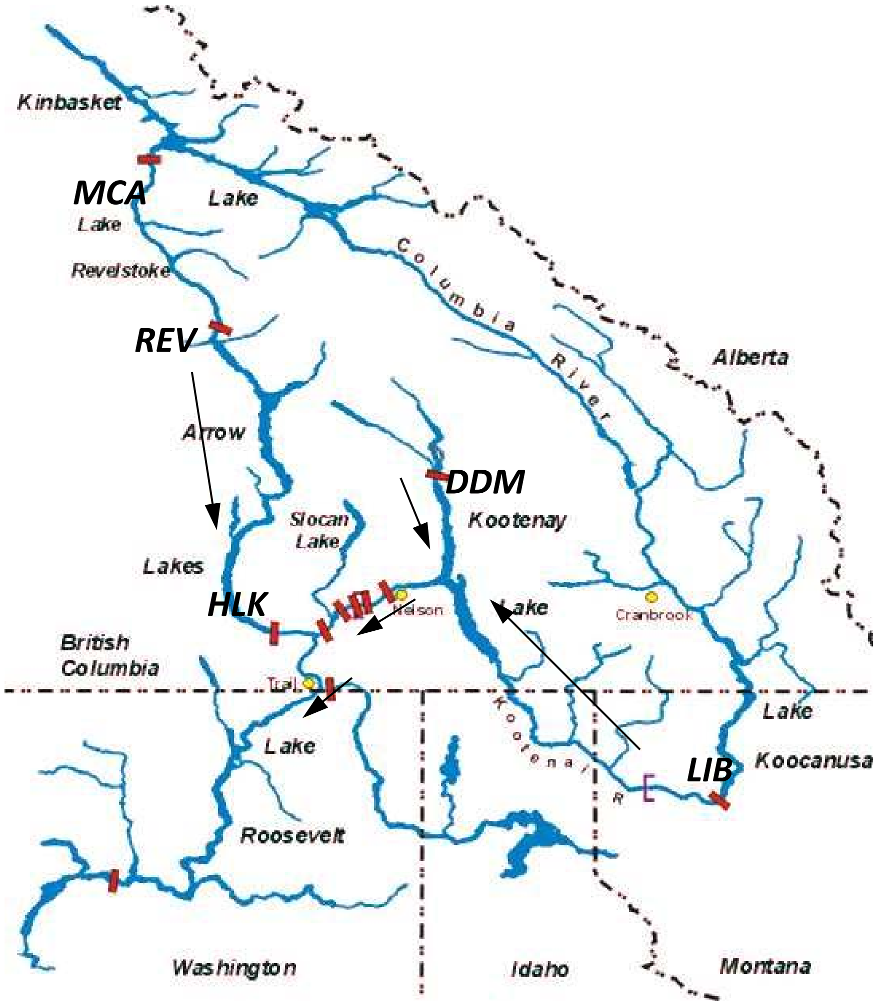
- **First Nations Consultation**

PROJECT TIMELINES AND NEXT STEPS

- The first phase of the project is now underway and will run until October 2013
  - Evaluation of the potential costs and benefits of the project
  - Feasibility of moving ahead with channel improvements

- The next phase, if undertaken, would involve additional investigations and planning for the potential improvements
  - Could take up to two years
  - A decision regarding whether or not to proceed could be made at that time

2012 OPERATIONS: COLUMBIA/KOOTENAY SYSTEM



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2012 WEATHER & INFLOW SUMMARY

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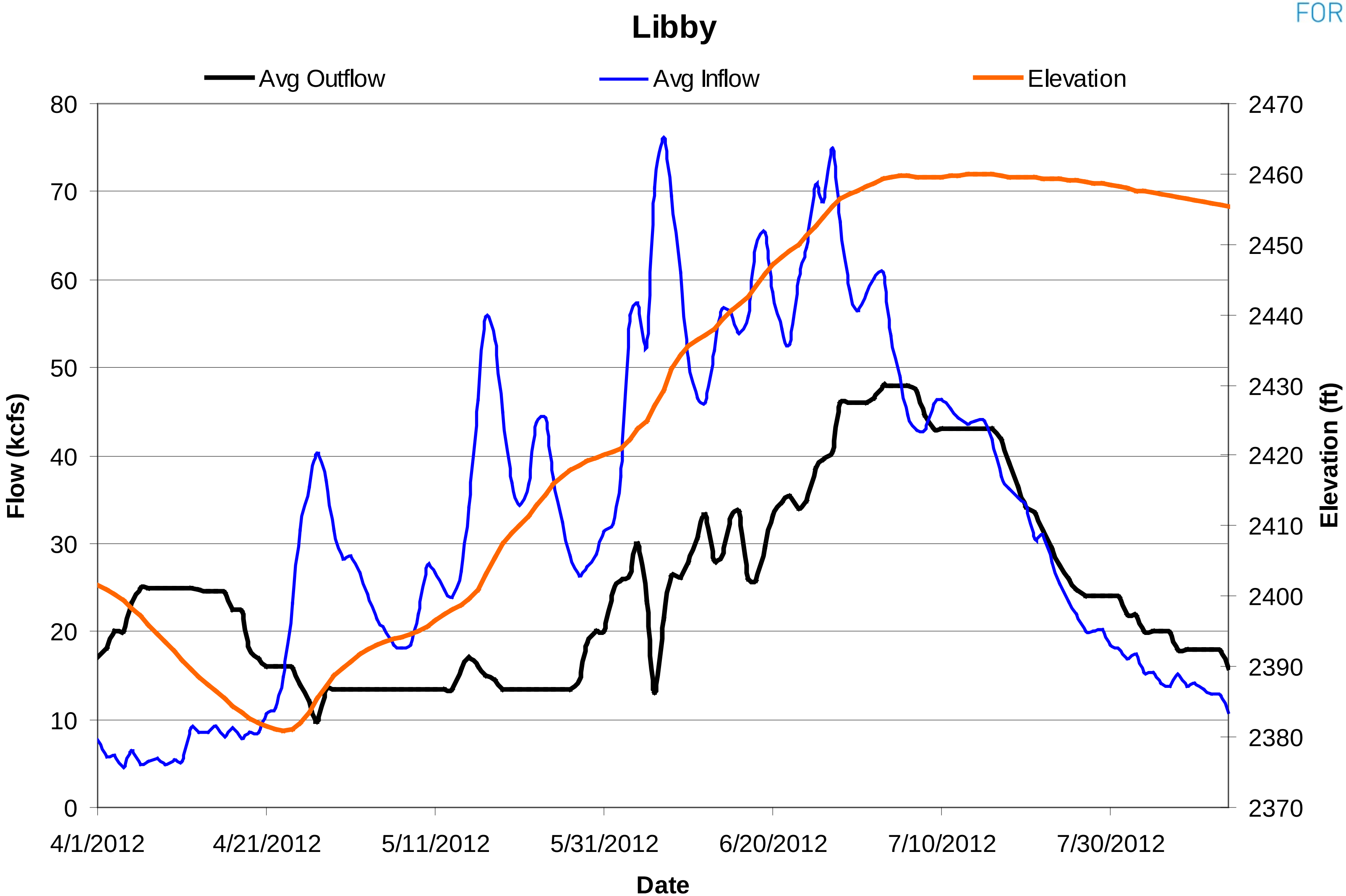
- 1 May snowpack in the Columbia/Kootenay region:
  - Above normal, but not extreme
- June & much of July: unprecedented rainfall in the basin
- Rainfall in June 2012:
  - 2 to 5 times the normal amounts across the upper Columbia & Kootenay basins
  - Wettest month <u>ever</u> at Castlegar Airport & other stations
- Inflows for Feb-July 2012:

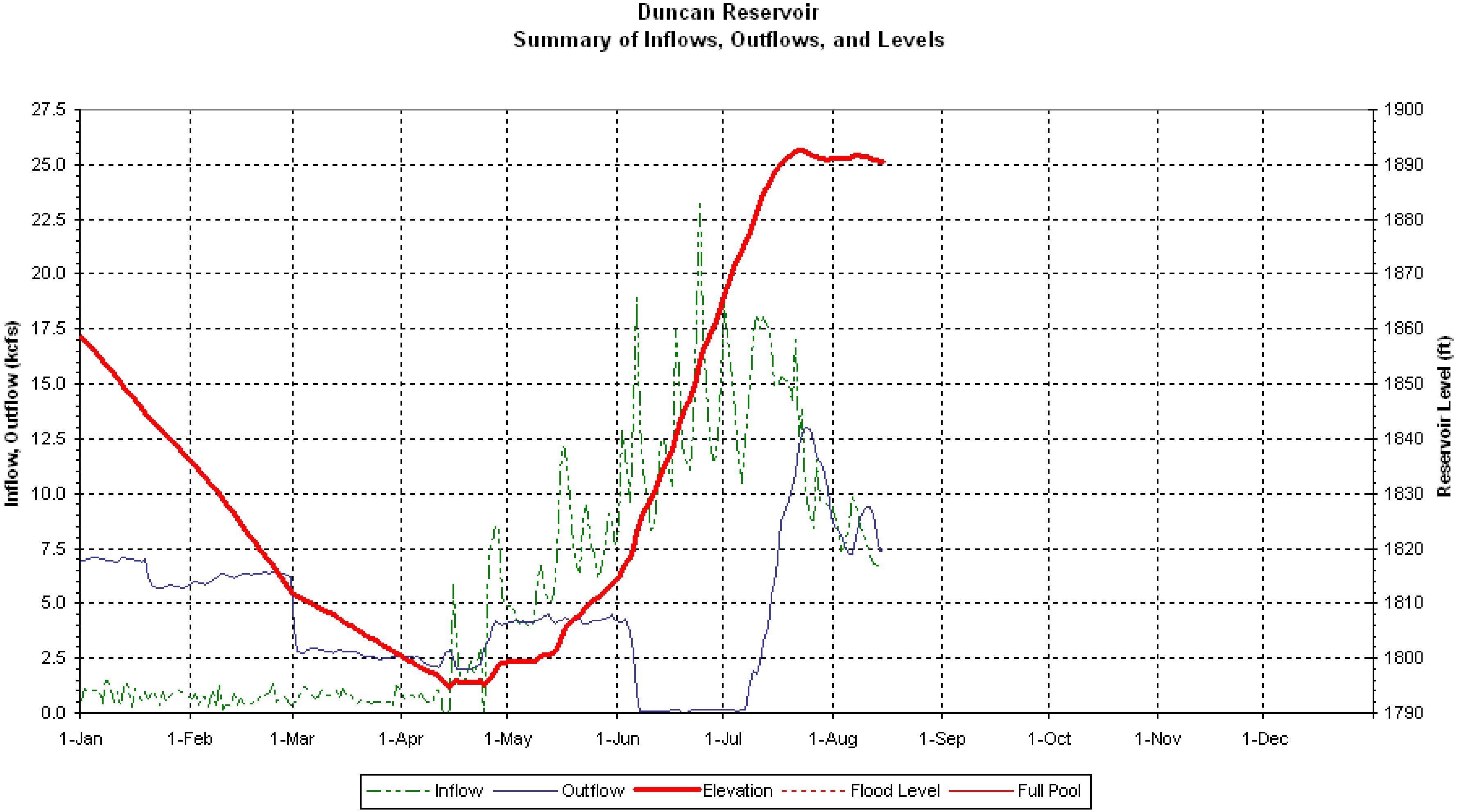
Basin	Rank	% of Average
Mica	1st of 40 yrs	136%
Revelstoke	1st of 28 yrs	130%
Arrow	3rd of 42 yrs	127%
Duncan	1st of 40 yrs	130%
Kootenay Lake	4th of 44 yrs	142%

LIBBY DAM OPERATIONS - 2012



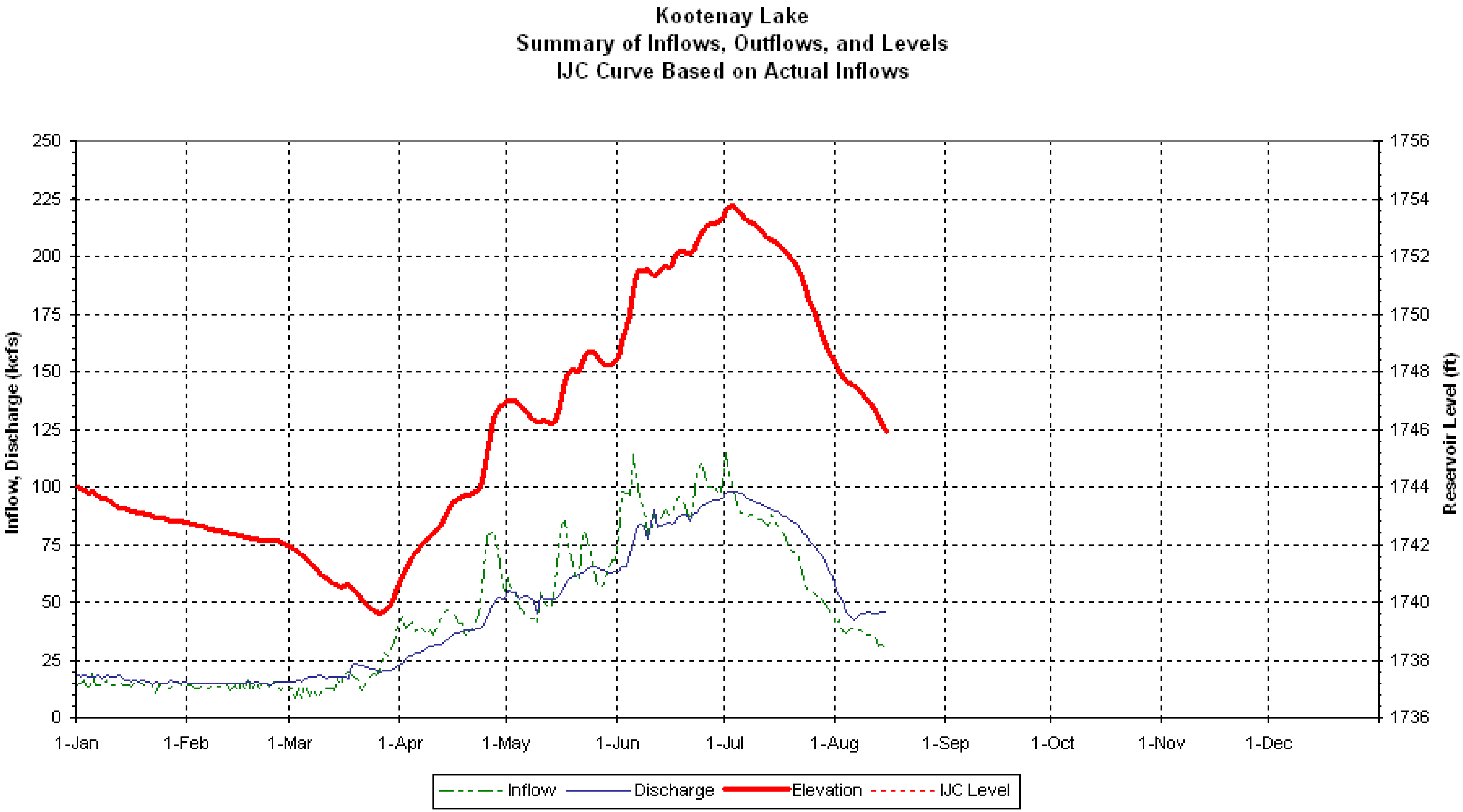
- Surcharge allowed Libby to maintain a lower discharge, reducing downstream flooding
- Reservoir level was above normal full pool for 23 days
- Peak Libby discharge of 48 kcfs occurred in early July.
- River level at Bonners Ferry peaked at 1766.6 ft, 2.6 ft above flood stage.

DUNCAN DAM OPERATIONS - 2012

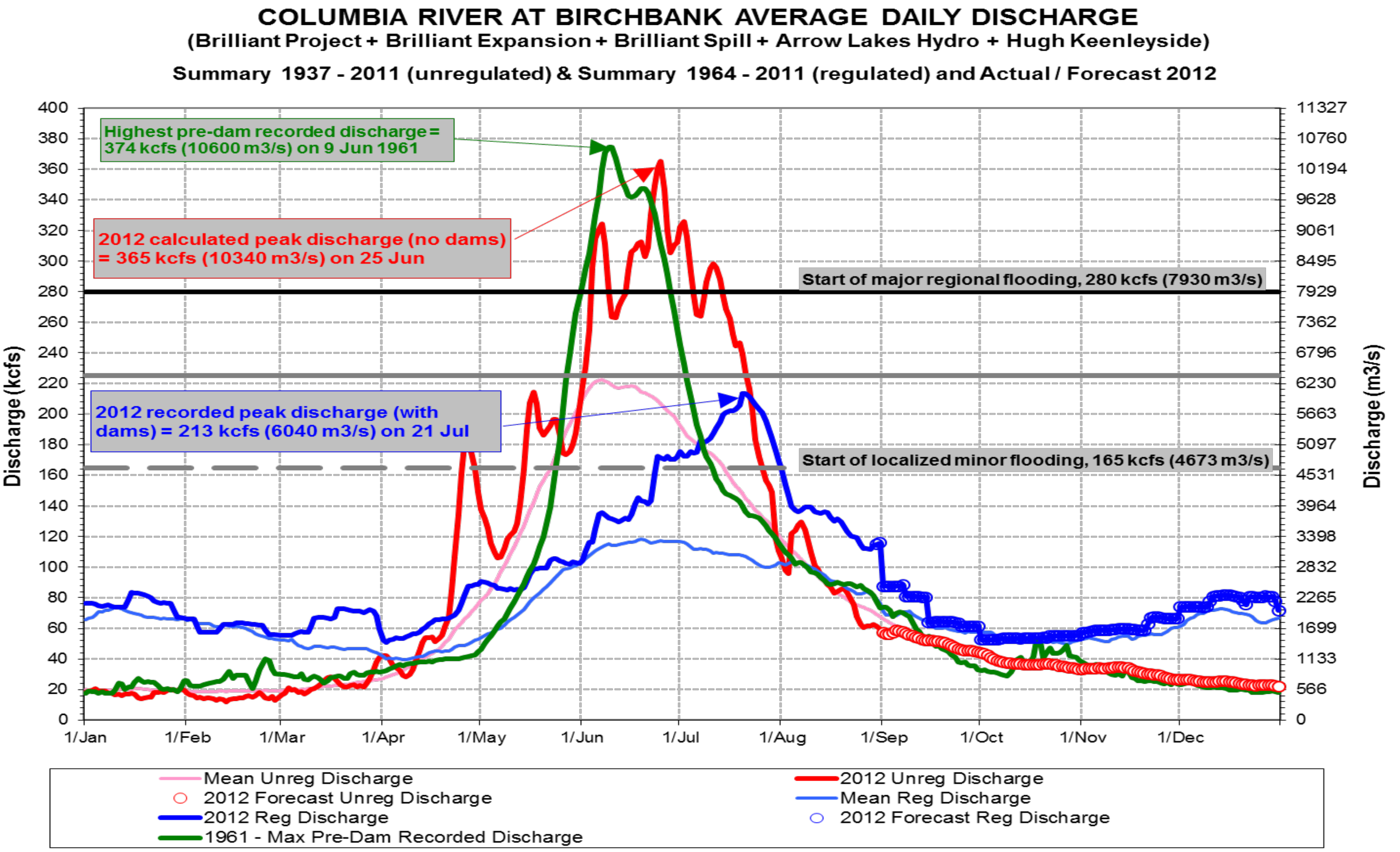


- Reservoir drafted to near empty in late April … then refilled during May-July
- Discharge reduced to minimum during June & early July to reduce inflow into Kootenay Lake
- After Kootenay Lake level peaked, Duncan discharge increased to manage refill of Duncan Reservoir
- Duncan Reservoir surcharged by ~ 1 ft (0.3 m) to reduce peak discharge & downstream flooding

KOOTENAY LAKE OPERATIONS - 2012



- From March through July, FortisBC & BC Hydro discharged maximum possible out of Kootenay Lake, limited only by the Grohman Narrows channel restriction.
- Kootenay Lake level peaked at 1753.8 feet → highest level since 1974
- With no surcharge of Libby Reservoir, the Kootenay Lake peak level would have been 0.3 ft (0.1 m) higher
- Without Libby & Duncan, the Kootenay Lake peak level would have been 6.6 feet (2 m) higher



COLUMBIA RIVER AT BIRCHBANK AVERAGE DAILY DISCHARGE
(Brilliant Project + Brilliant Expansion + Brilliant Spill + Arrow Lakes Hydro + Hugh Keenleyside)
Summary 1937 - 2011 (unregulated) & Summary 1964 - 2011 (regulated) and Actual / Forecast 2012
Highest pre-dam recorded discharge = 374 kcfs (10600 m3/s) on 9 Jun 1961
2012 calculated peak discharge (no dams) = 365 kcfs (10340 m3/s) on 25 Jun
Start of major regional flooding, 280 kcfs (7930 m3/s)
2012 recorded peak discharge (with dams) = 213 kcfs (6040 m3/s) on 21 Jul
Start of localized minor flooding, 165 kcfs (4673 m3/s)
Discharge (kcfs)
Discharge (m3/s)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
0
566
1133
1699
2265
2832
3398
3964
4531
5097
5663
6230
6796
7362
7929
8495
9061
9628
10194
10760
11327
1/Jan
1/Feb
1/Mar
1/Apr
1/May
1/Jun
1/Jul
1/Aug
1/Sep
1/Oct
1/Nov
1/Dec
Mean Unreg Discharge
2012 Forecast Unreg Discharge
2012 Reg Discharge
1961 - Max Pre-Dam Recorded Discharge
2012 Unreg Discharge
Mean Reg Discharge
2012 Forecast Reg Discharge

2012 OPERATIONS SUMMARY

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- Mica, Arrow, Duncan, Libby – reservoirs were refilled above their normal full pool levels (by up to 1.3 ft) to help manage downstream flood impacts.
  - Reservoir surcharge → trade-off between downstream flood impacts & upstream reservoir impacts.
- Mica, Duncan, Libby – highest-ever reservoir levels.
- Arrow – highest reservoir level since 1990.
- Kootenay Lake – highest lake level since 1974.
- Mica, Revelstoke – spilled water for the first time since 1997.
- Columbia River at Revelstoke – highest flow since 1991.
- Columbia River at Trail – highest flow since 1972 (pre Mica dam).

2012 OPERATIONS SUMMARY (CONT.)

BC hydro FOR GENERATIONS

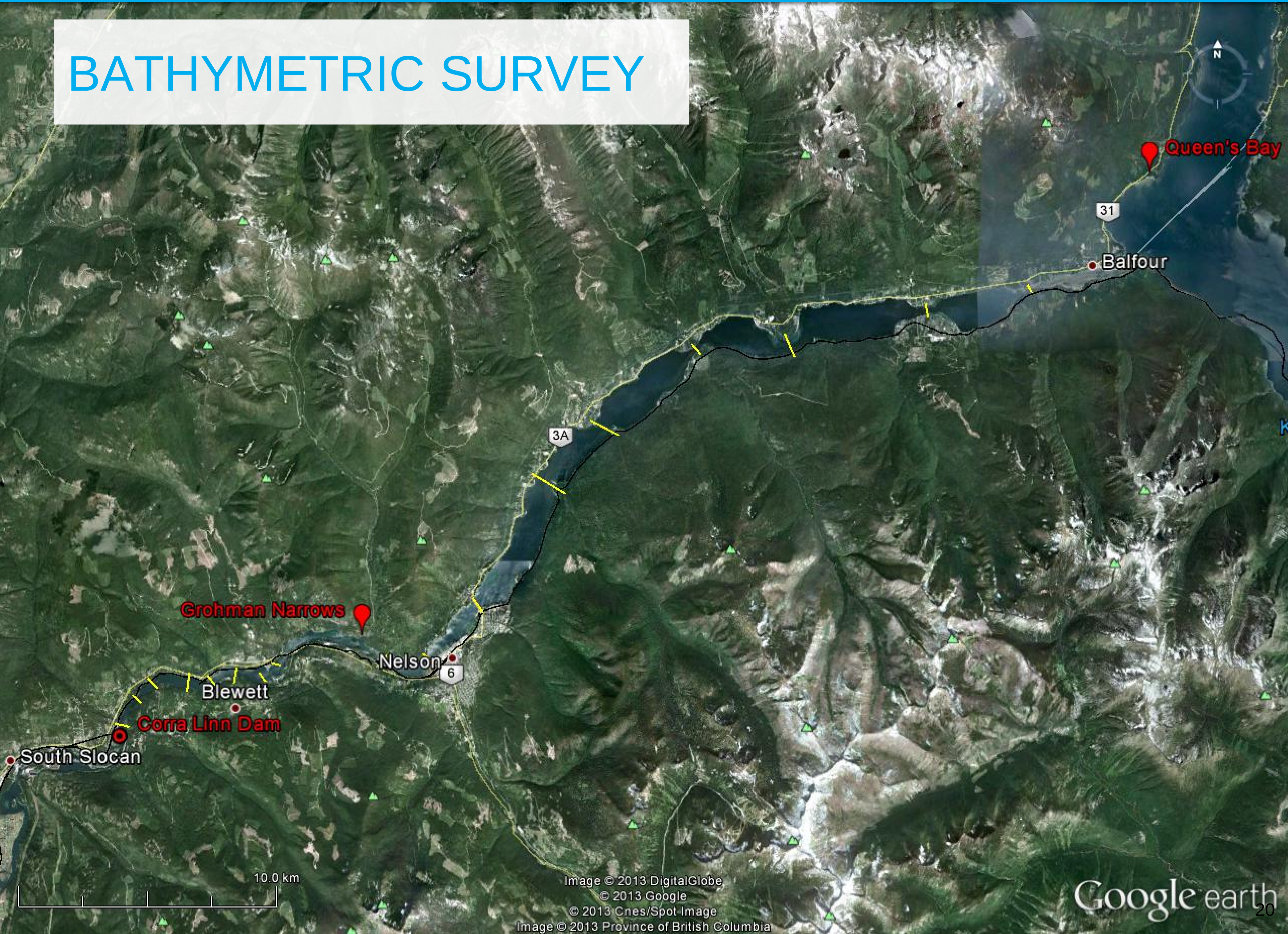
- Prior to, & during, the record-setting inflows of June-July 2012, BC Hydro and its partners operated the reservoirs with flood management as the highest priority.
- All of the Columbia/Kootenay reservoirs have multiple purposes. These many interests (flood control, fisheries, recreation, energy, etc.) must be balanced subject to domestic laws and other requirements.
- Upstream reservoir operations significantly reduced downstream flood peak flows.
- Without the Treaty dams in place, damage to property would have been much greater and more widespread:
    - Peak Kootenay Lake level would have been 6.6 ft higher.
    - Peak Columbia River flow at Trail would have been about 70% higher, similar to the level of flood flows in 1948 & 1961.

HYDRAULIC STUDIES AND GEOTECHNICAL STUDY RESULTS TO-DATE

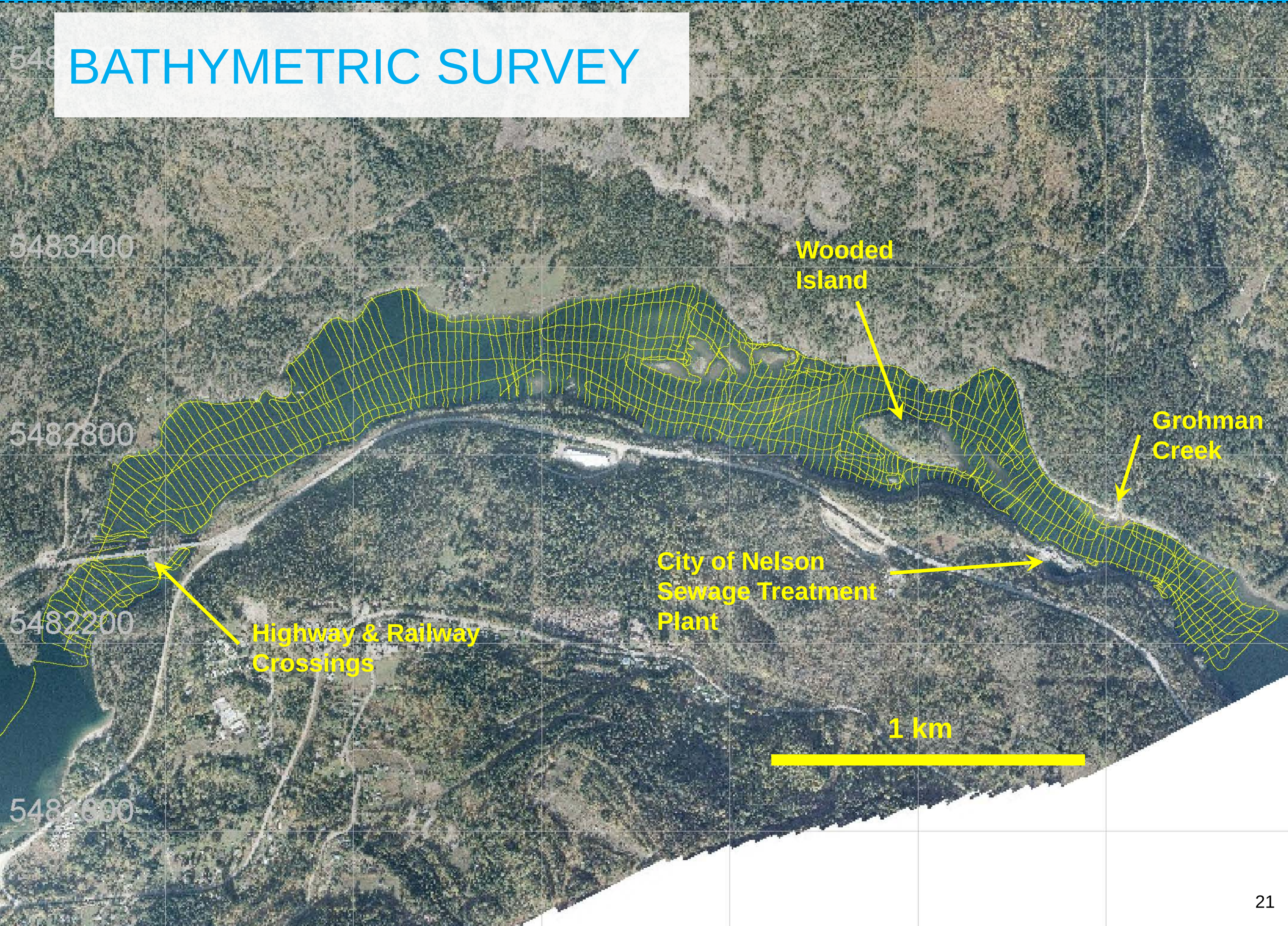
BATHYMETRIC SURVEY

- Boat based survey to map the elevation of the river bed
- Completed in October 2012
- Centreline survey of the West Arm from Queen's Bay to Corra Linn Dam (approximately 50 km)
- 24 cross sections surveyed at select locations
- Detailed survey through, and in the vicinity of, the Grohman Narrows reach (approximately 5 km)

BATHYMETRIC SURVEY

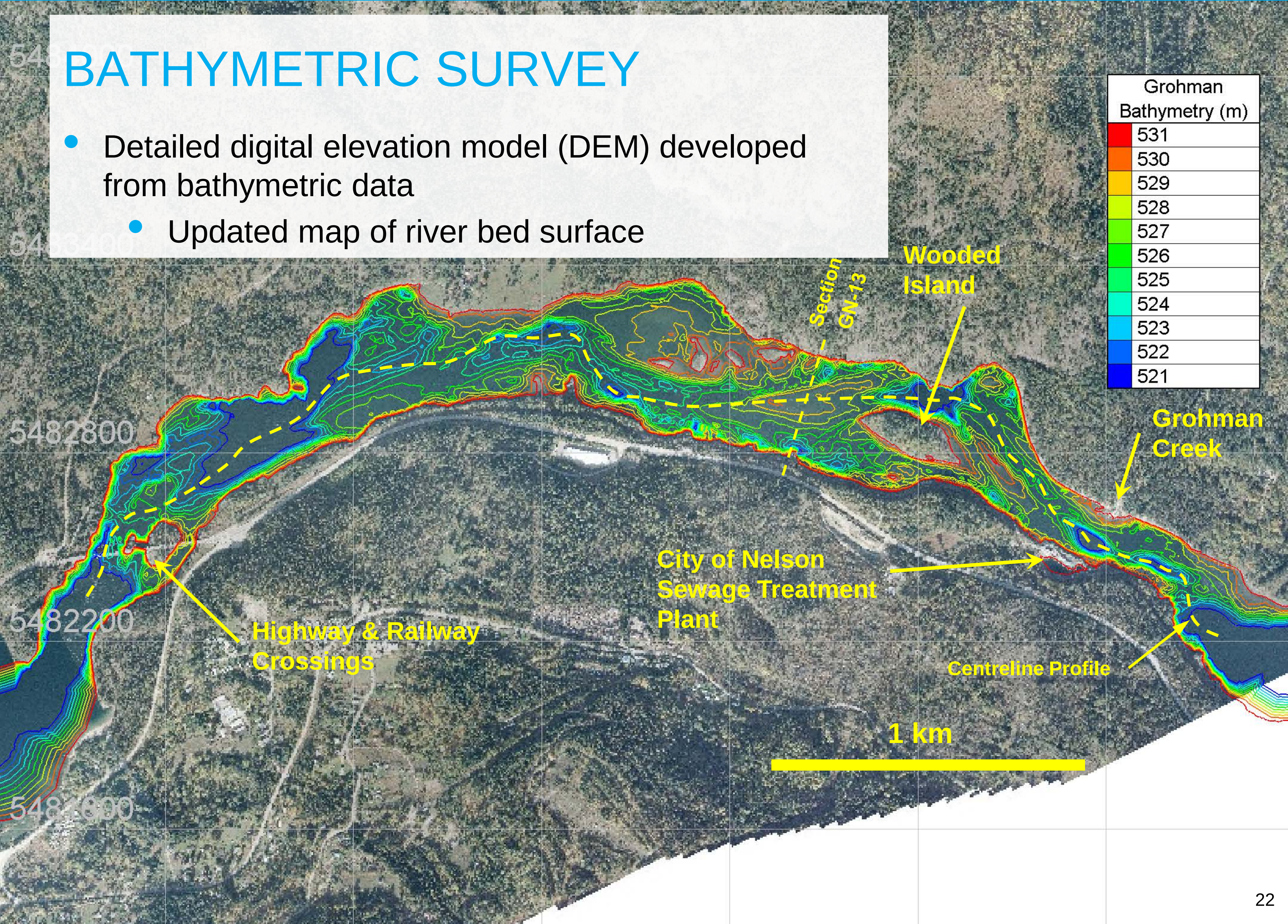


BATHYMETRIC SURVEY



BATHYMETRIC SURVEY

- Detailed digital elevation model (DEM) developed from bathymetric data
  - Updated map of river bed surface



BATHYMETRIC SURVEY

BC hydro
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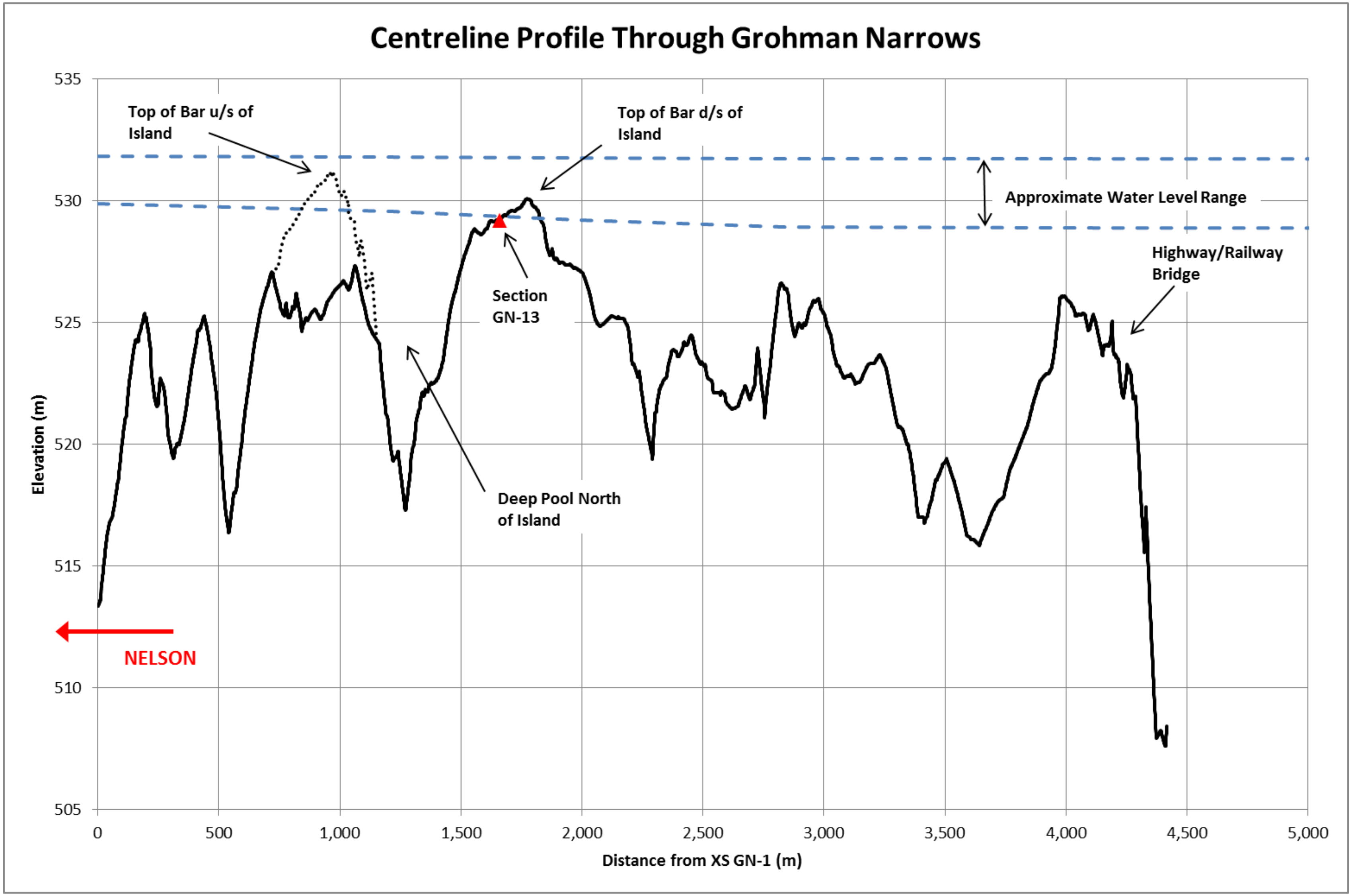
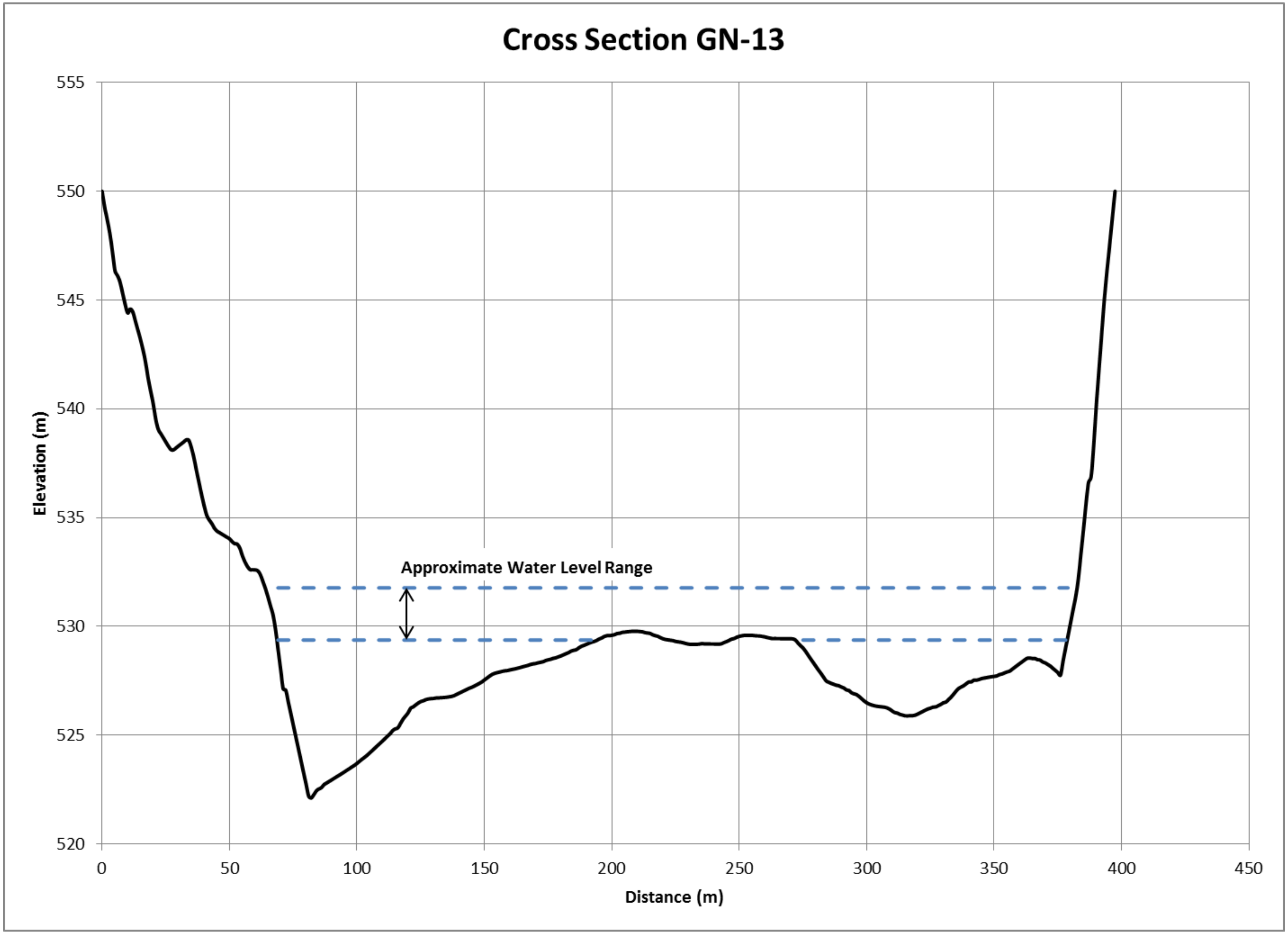


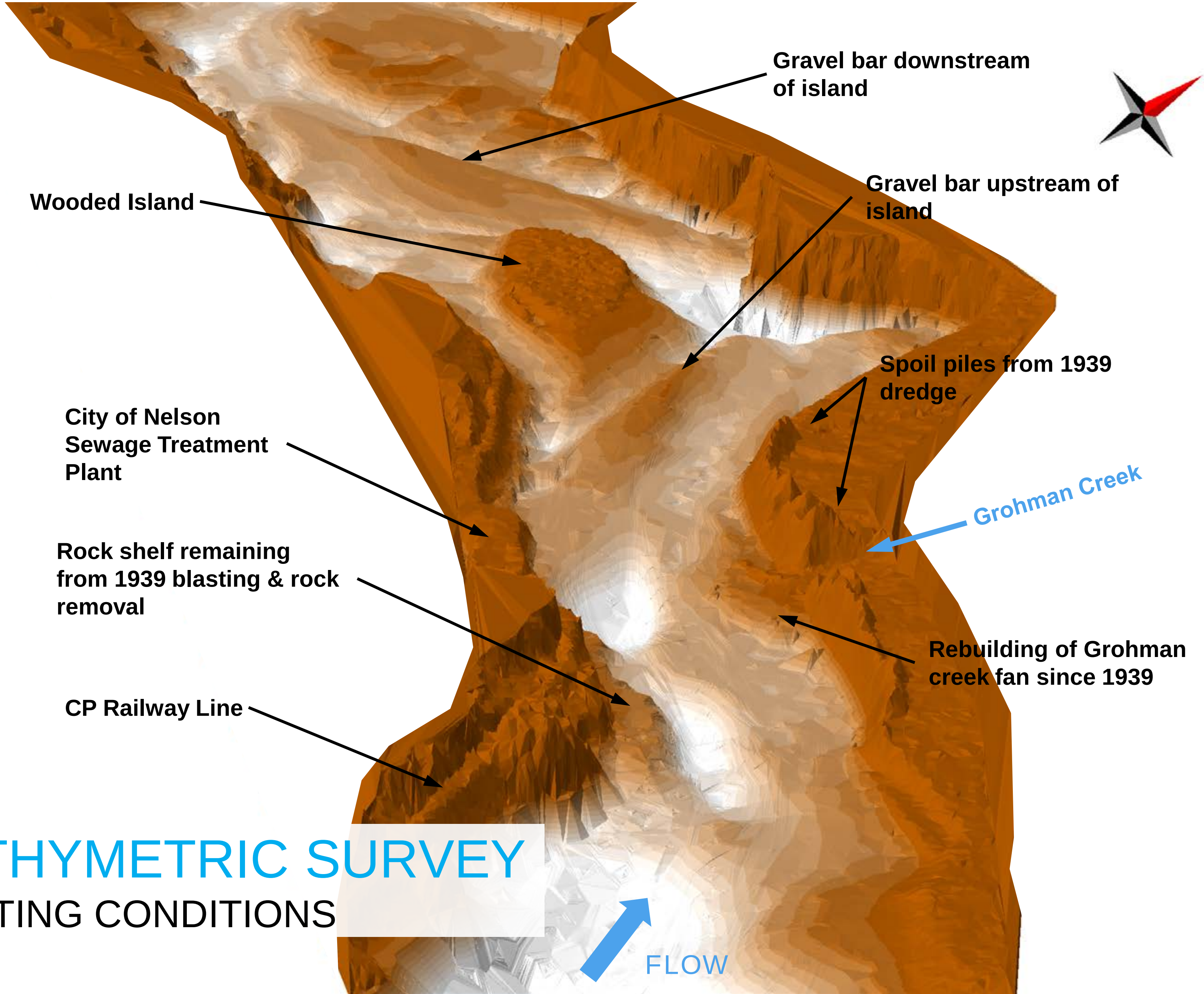
BATHYMETRIC SURVEY

BC hydro
FOR GENERATIONS



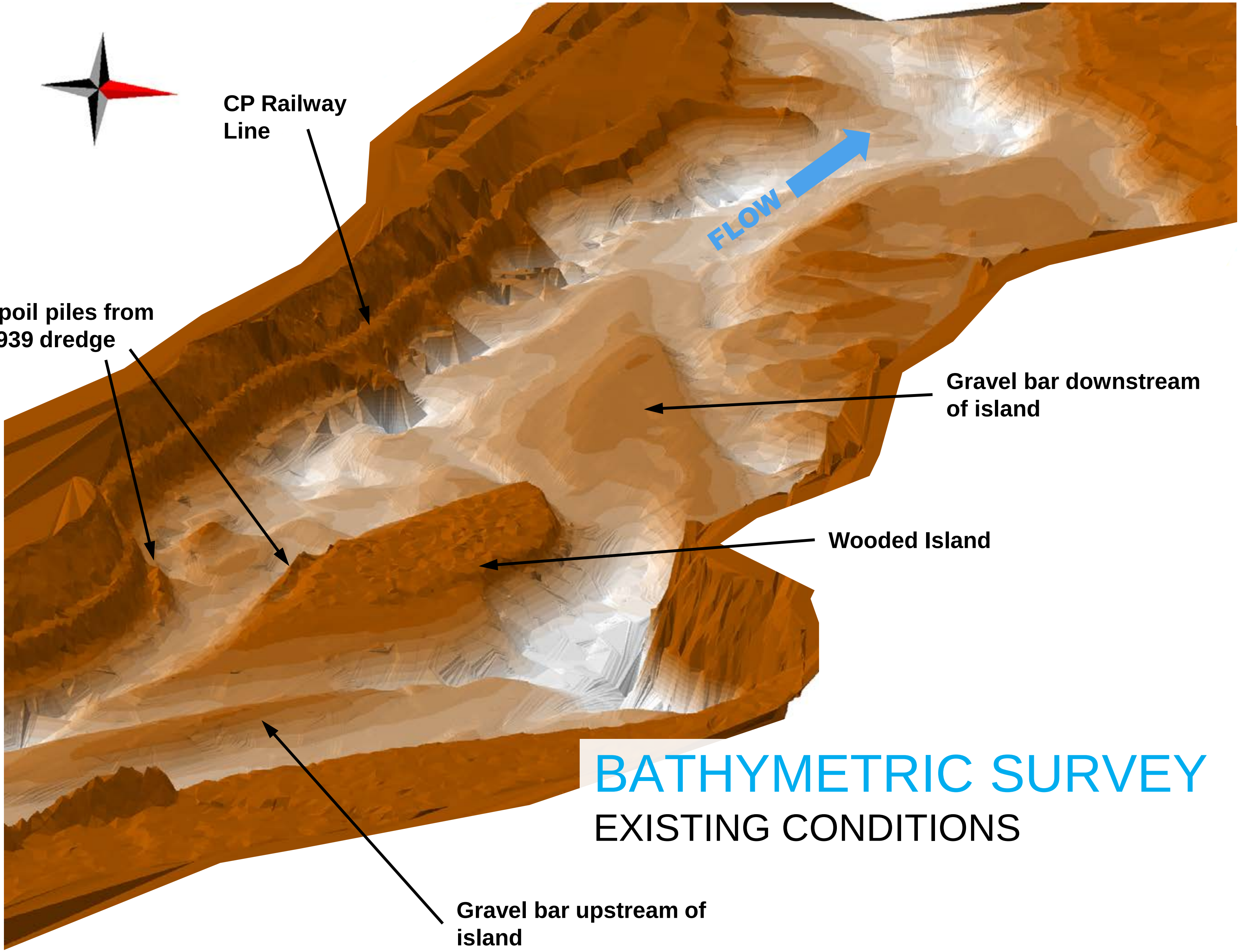
BATHYMETRIC SURVEY

EXISTING CONDITIONS



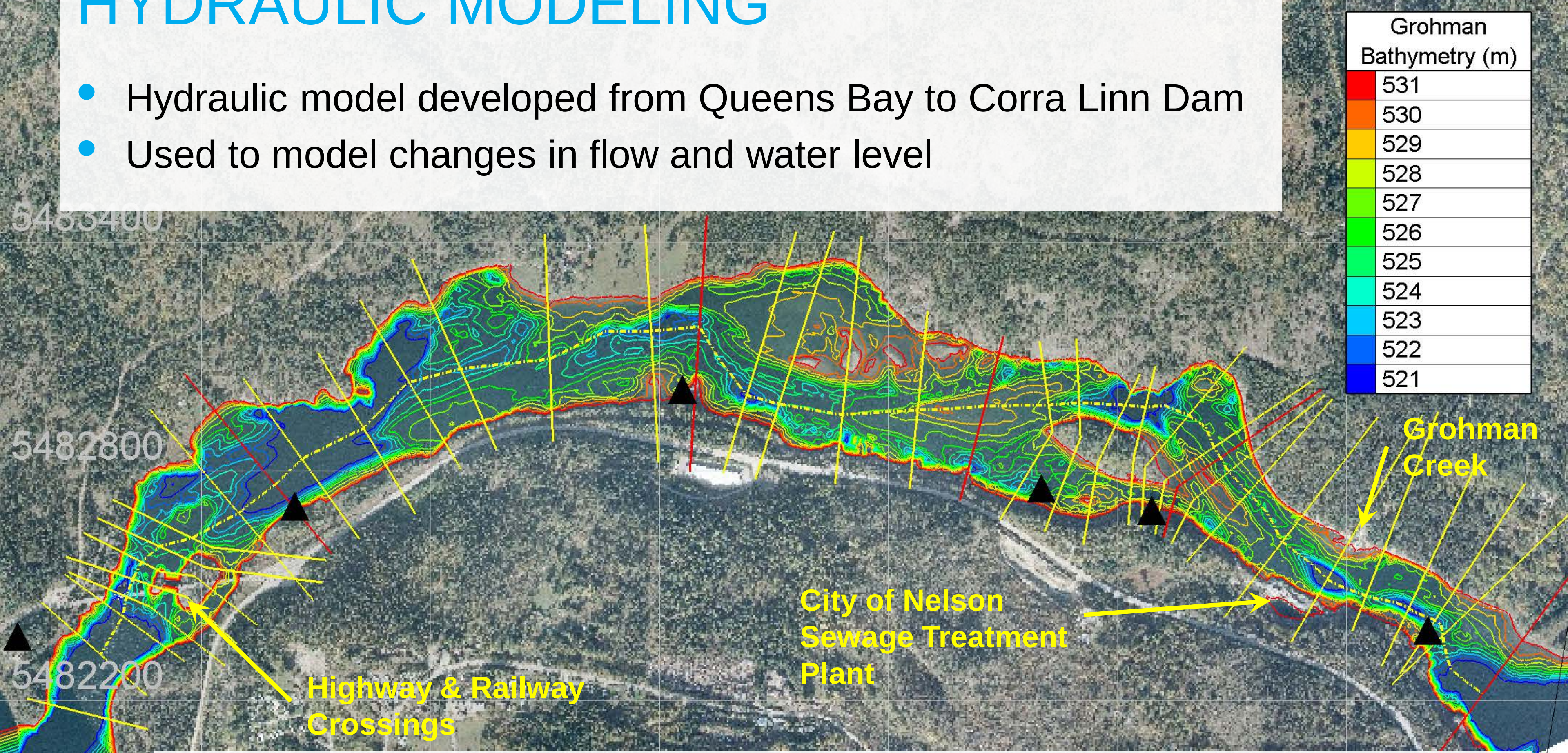
BATHYMETRIC SURVEY

EXISTING CONDITIONS



HYDRAULIC MODELING

- Hydraulic model developed from Queens Bay to Corra Linn Dam
- Used to model changes in flow and water level



- 104 cross sections - 31 through detailed Grohman Narrows reach
- Calibrated to historical gauge data at Corra Linn, Nelson and Queens Bay
- Additional limited historical (1940's) gauge data available along Grohman Reach
- Advanced model also under development to further refine analyses

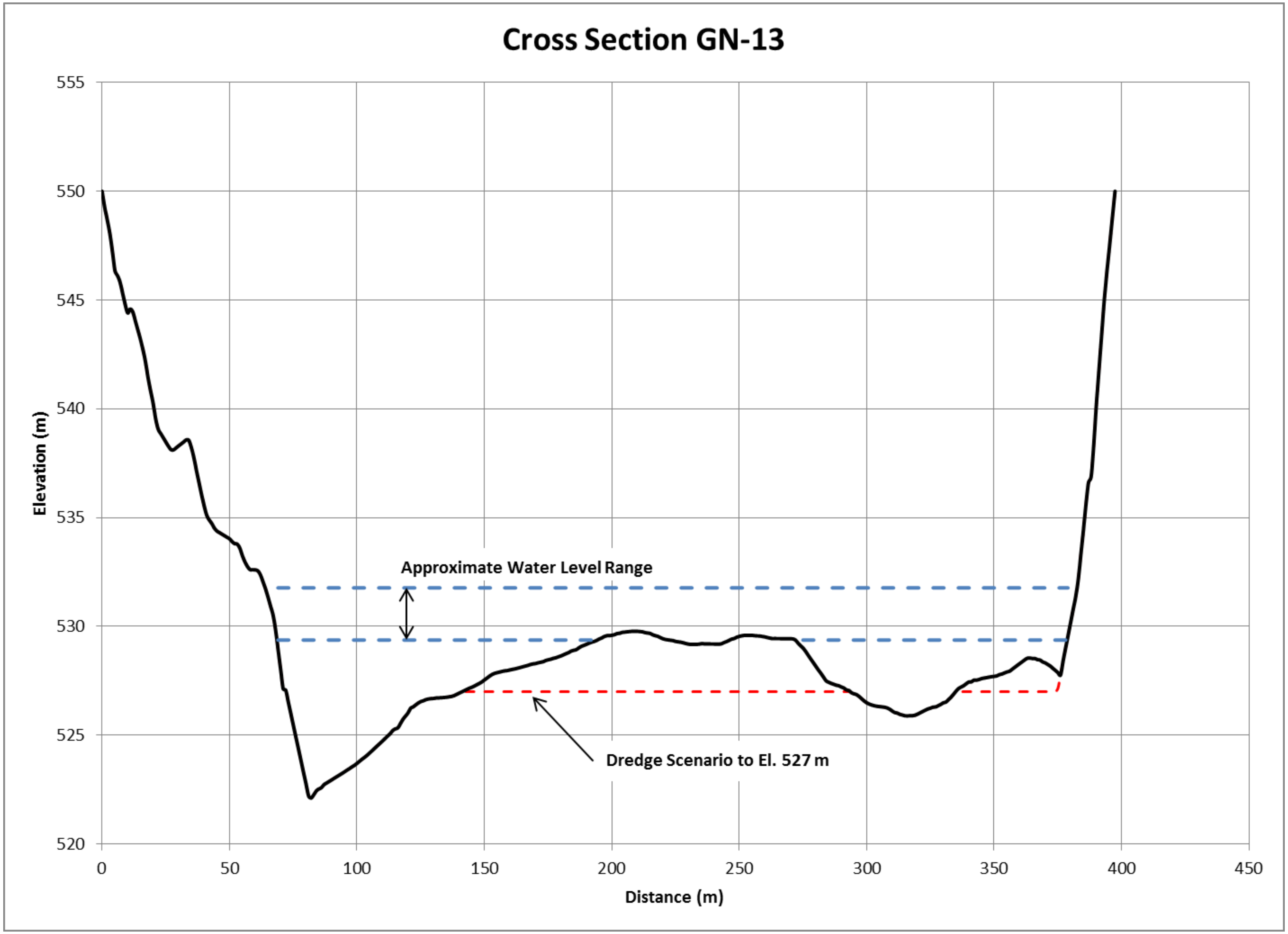
HYDRAULIC MODELING

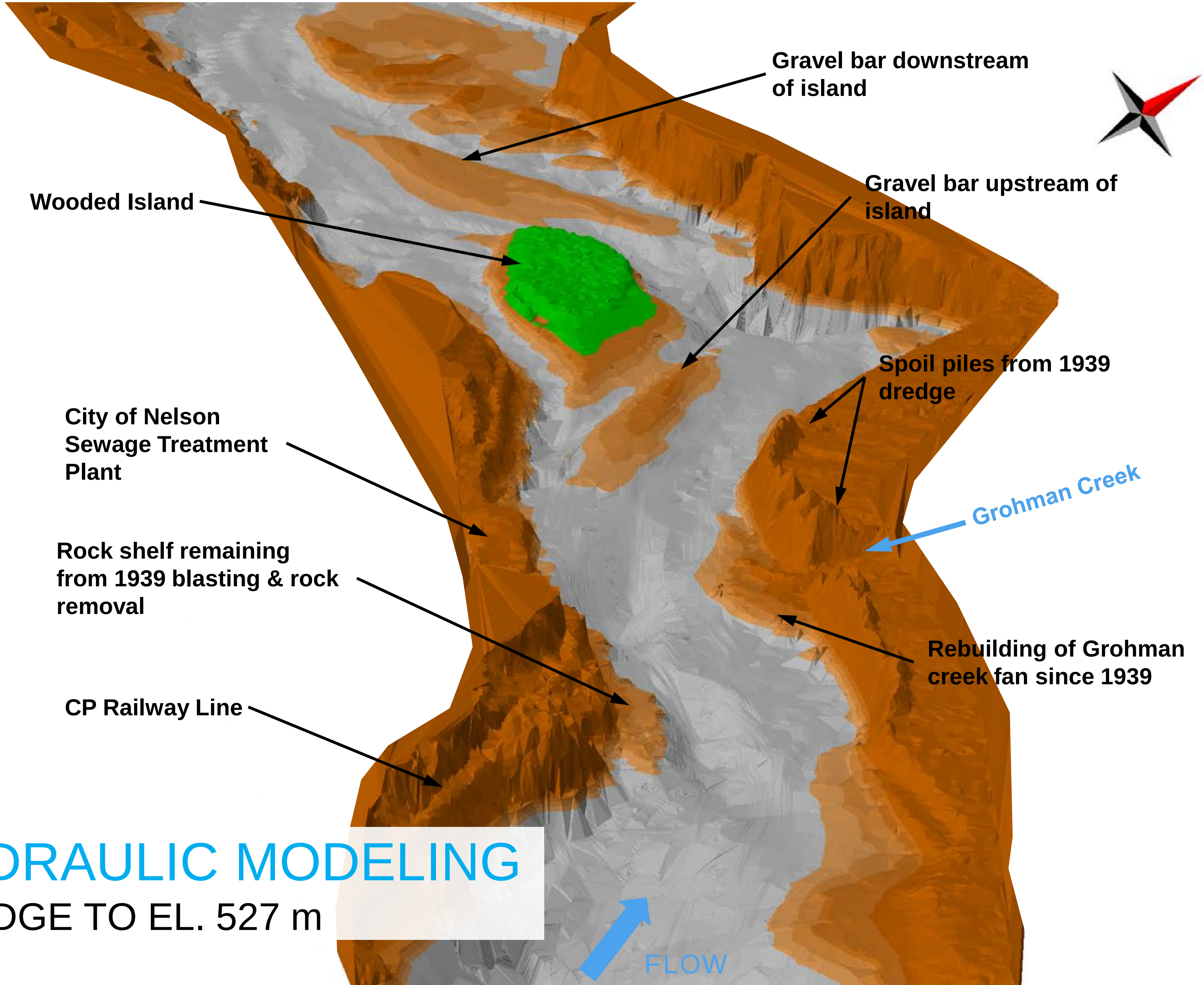
BC hydro FOR GENERATIONS

- Compare various improvement scenarios with existing conditions
- Preliminary ***sensitivity*** scenarios examined include dredge to bed elevations of 526 m (1726 ft) and 527 m (1729 ft), within approximately 2 km long reach from start of Narrows
  - Approximate volume of material in the range of 600,000 m^3 (785,000 yd^3)
  - Volume mostly in bars upstream and downstream of wooded island
  - Balance between benefits realized (flood peak reduction, improved operations, energy benefits) and amount/cost of dredging
    - Need to optimize dredge extents and locations
  - Consideration of environmental effects of different dredge levels and locations

HYDRAULIC MODELING

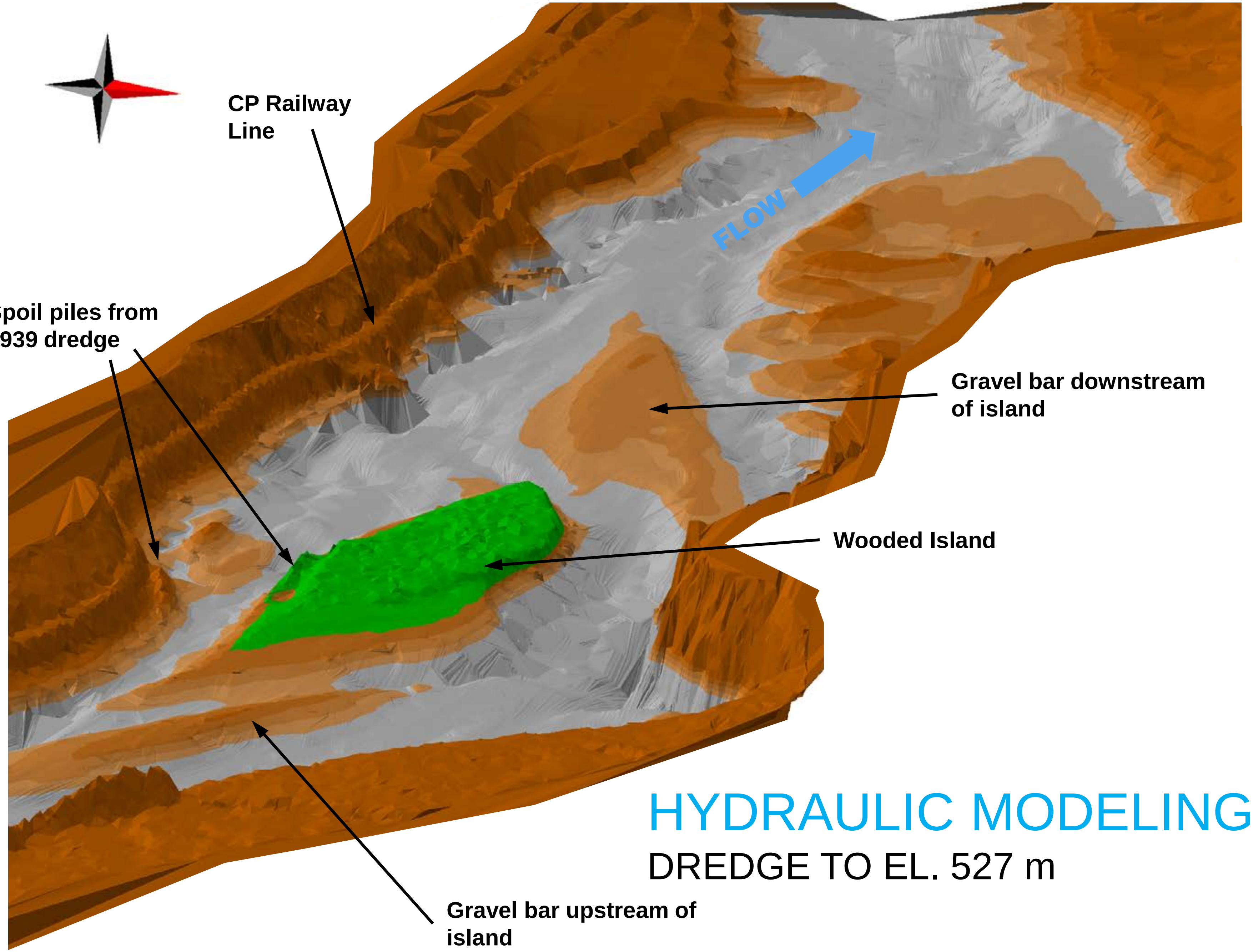
BC hydro FOR GENERATIONS





HYDRAULIC MODELING

DREDGE TO EL. 527 m



HYDRAULIC MODELING

DREDGE TO EL. 527 m

HYDRAULIC MODELING

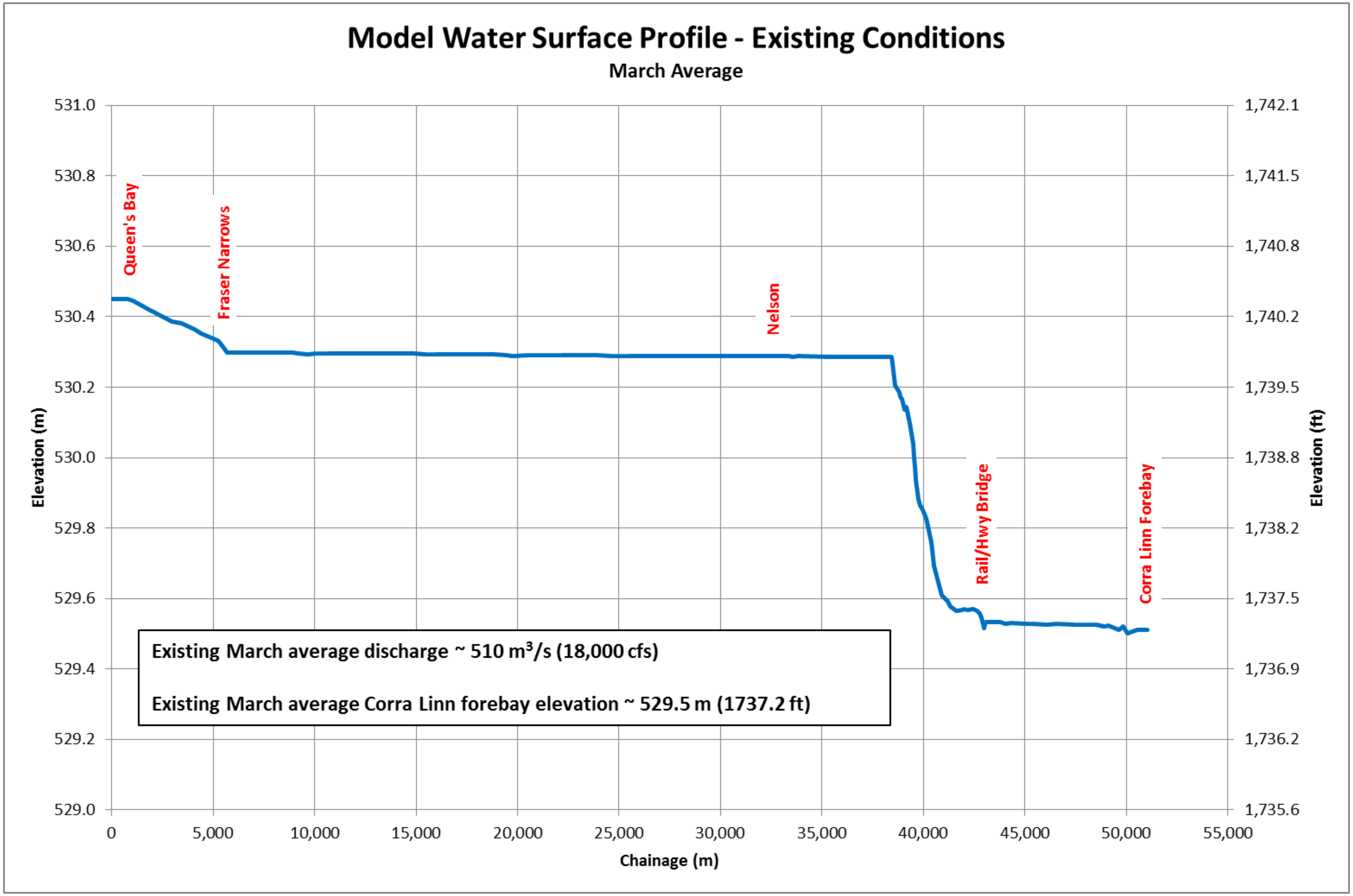
BC hydro FOR GENERATIONS

PRELIMINARY RESULTS AND OBSERVATIONS (SENSITIVITY SCENARIOS)

- For average conditions and existing operating regimes:
    - Reduction in peak flood levels in the range of ~ 0.5 - 0.8 m (1.5 - 2.5 ft)
        - Also reduction in number of years and duration of time at higher lake levels
    - Range of potential discharge capacity increase ~ 90 - 350 m^3/s (3,000 - 12,000 cfs), or ~ 10 - 50%
        - Highest potential discharge capacity increases (in terms of flow rate) during the March – July period
    - Range of potential increased generation in the order of 1 - 1.5 % per year (includes BCH Kootenay Canal plant, 4 Fortis BC River Plants and CPC Brilliant Dam)

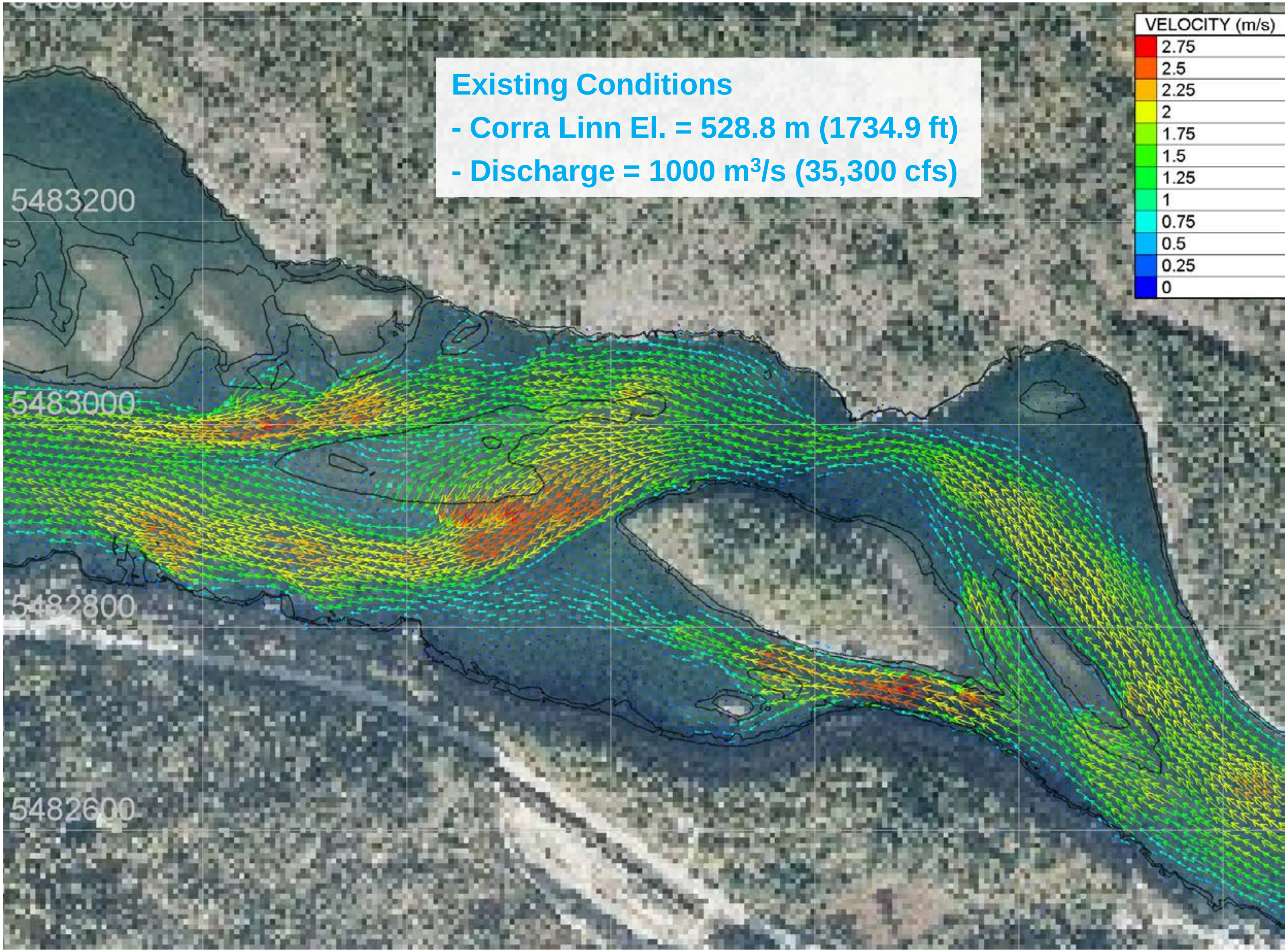
HYDRAULIC MODELING

SAMPLE MODEL OUTPUT



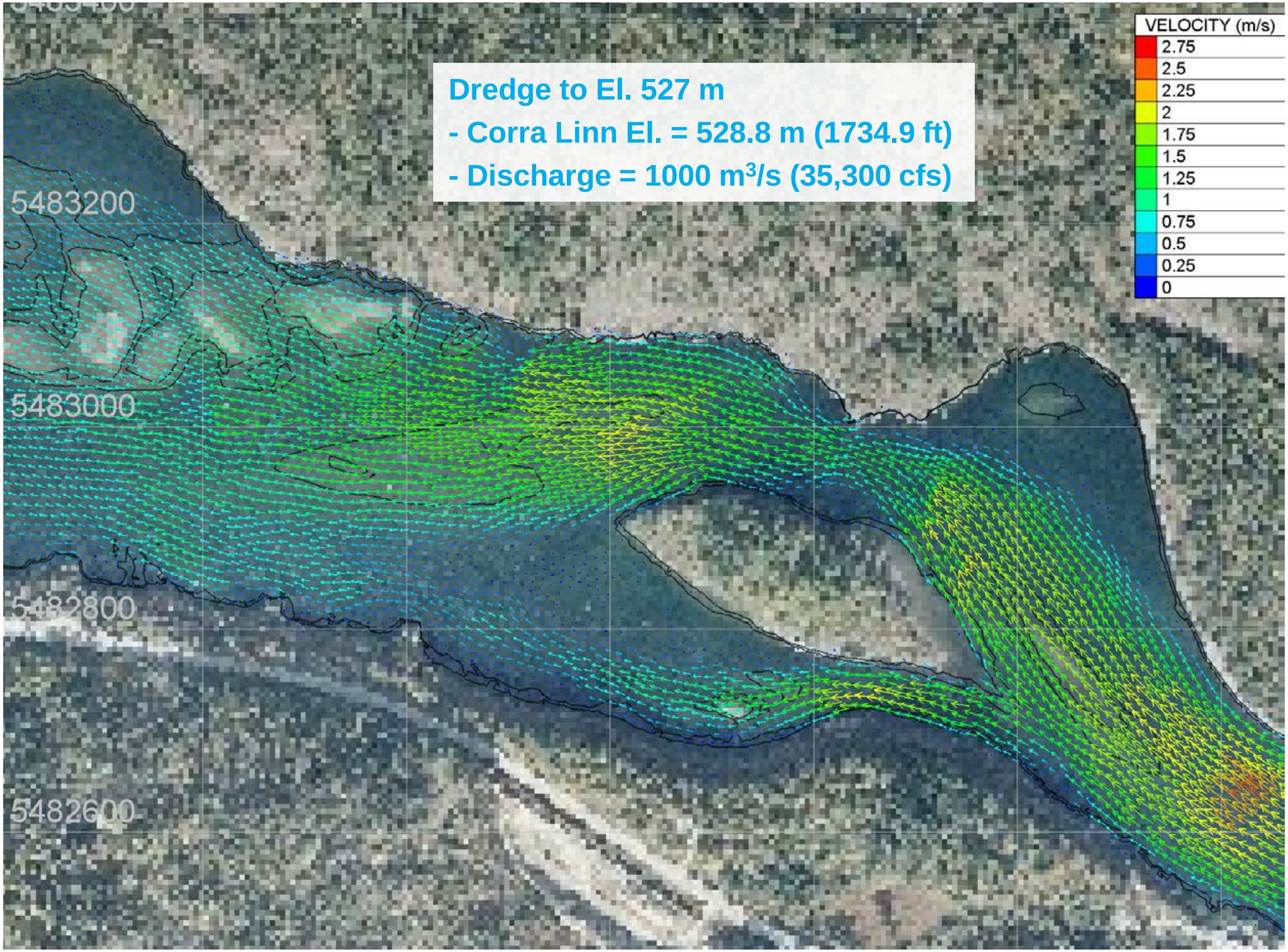
HYDRAULIC MODELING

SAMPLE MODEL OUTPUT



HYDRAULIC MODELING

SAMPLE MODEL OUTPUT



HYDRAULIC MODELING

- Potential Operating implications:
  - Control of Kootenay Lake outflows/elevations remains with Corra Linn Dam for a longer period of time
  - In forecasted low freshet inflow years, could operate with higher Corra Linn forebay elevation during this period (i.e. spring water levels downstream of Grohman Narrows not as low as current operations)
  - In forecasted high freshet inflow years, can take advantage of additional flow capacity before freshet starts and during freshet rise to maximize outflow and reduce peak Kootenay Lake elevations upstream of Grohman Narrows
  - Very little change to lake elevations upstream and downstream of Grohman Narrows outside of freshet period (i.e. late summer, fall, and winter)
- Review of full Kootenay system operating regimes would be required to optimize the added flexibility of an improved Grohman Narrows and assess seasonal effects

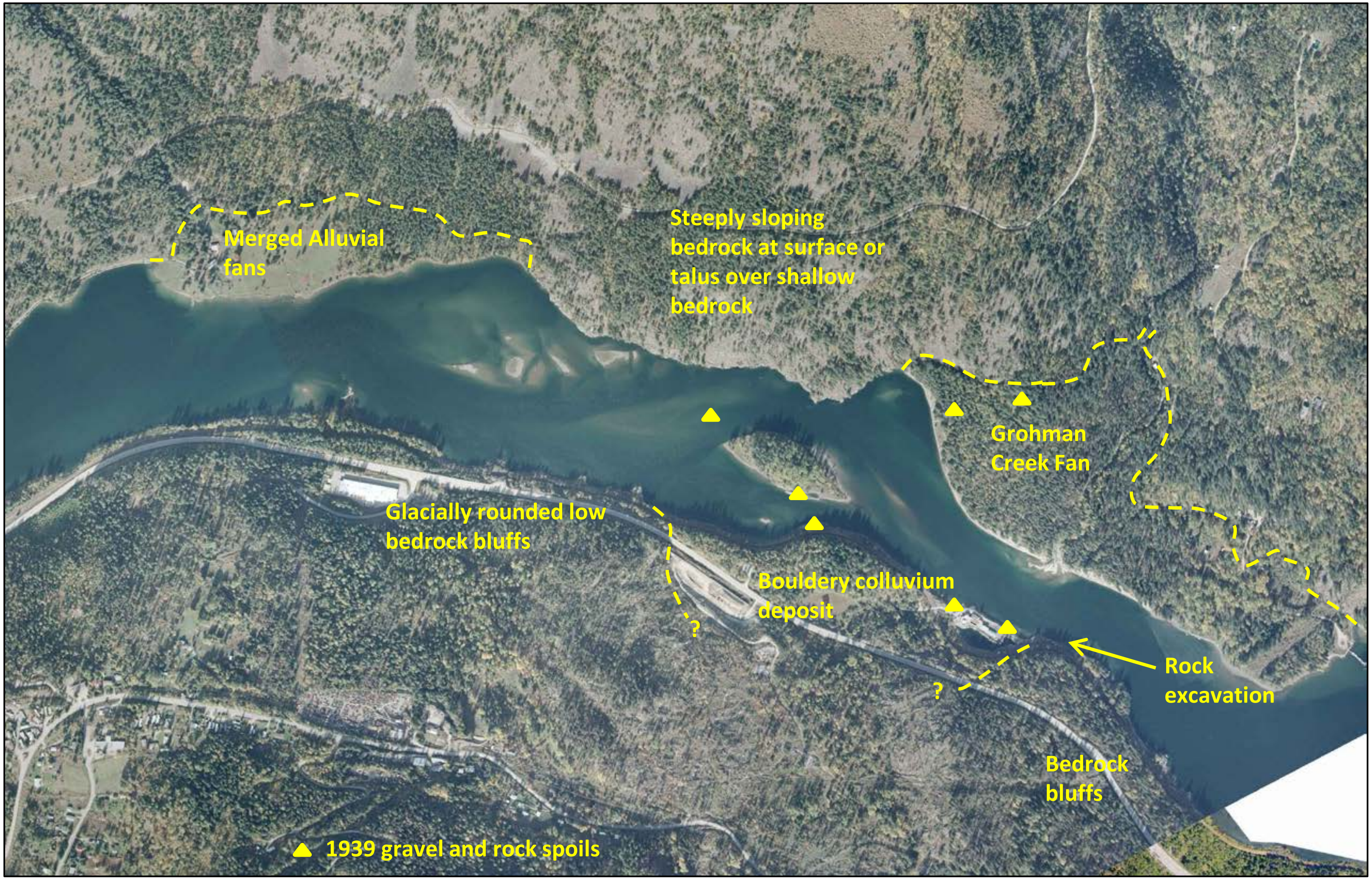
HYDRAULIC MODELING

- Additional Feasibility Study hydrotechnical engineering work:
  - Use of models to refine and optimize potential dredge volume and location, to maximize benefits and minimize cost
  - Assess longer term impacts of dredging on bed elevations and potential for sediment infilling
  - Refine project benefit estimates

GEOTECHNICAL STUDIES

BC hydro FOR GENERATIONS

GEOLOGICAL OVERVIEW



GEOTECHNICAL STUDIES

GEOLOGICAL OVERVIEW

GEOTECHNICAL STUDIES

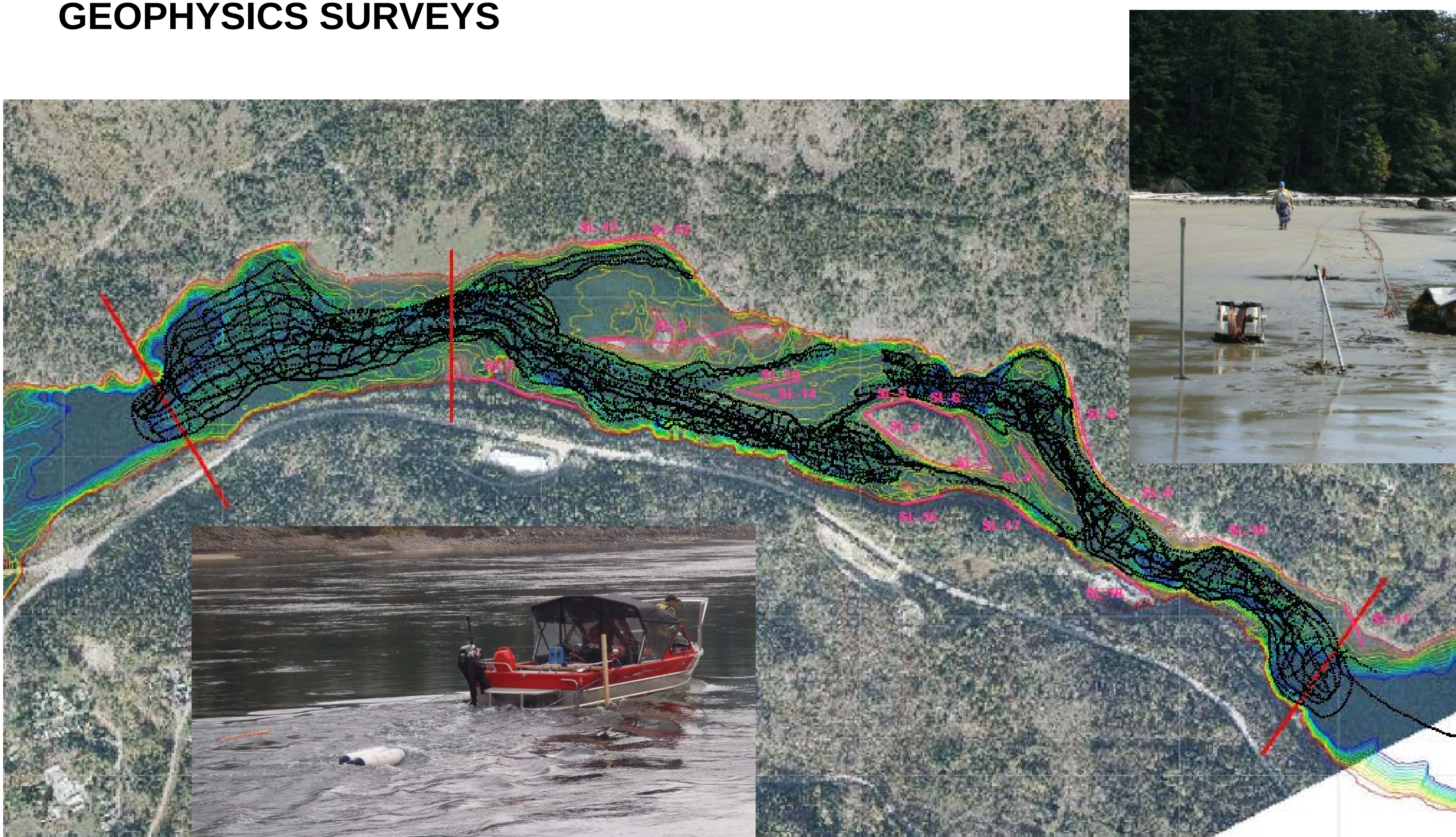
GEOPHYSICS SURVEYS

- Completed in March, 2013
- Overwater acoustic profiling and side-scan sonar survey
  - 3 km reach of Grohman Narrows
- Shoreline based seismic refraction surveying
  - 18 separate seismic profile lines
  - 2,645 m of seismic refraction data recorded

GEOTECHNICAL STUDIES

BC hydro FOR GENERATIONS

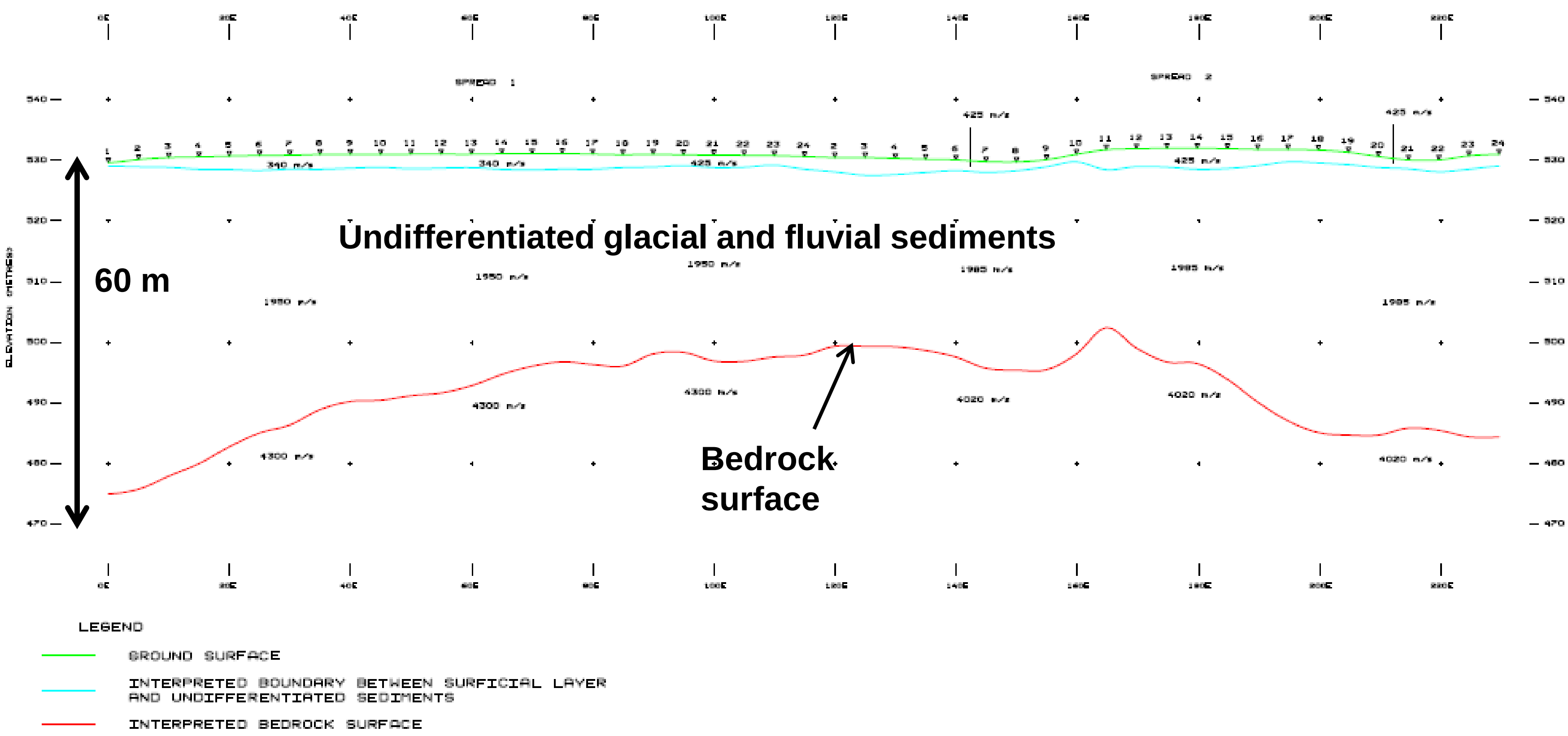
GEOPHYSICS SURVEYS



GEOPHYSICS RESULTS

EXAMPLE SEISMIC REFRACTION PROFILE

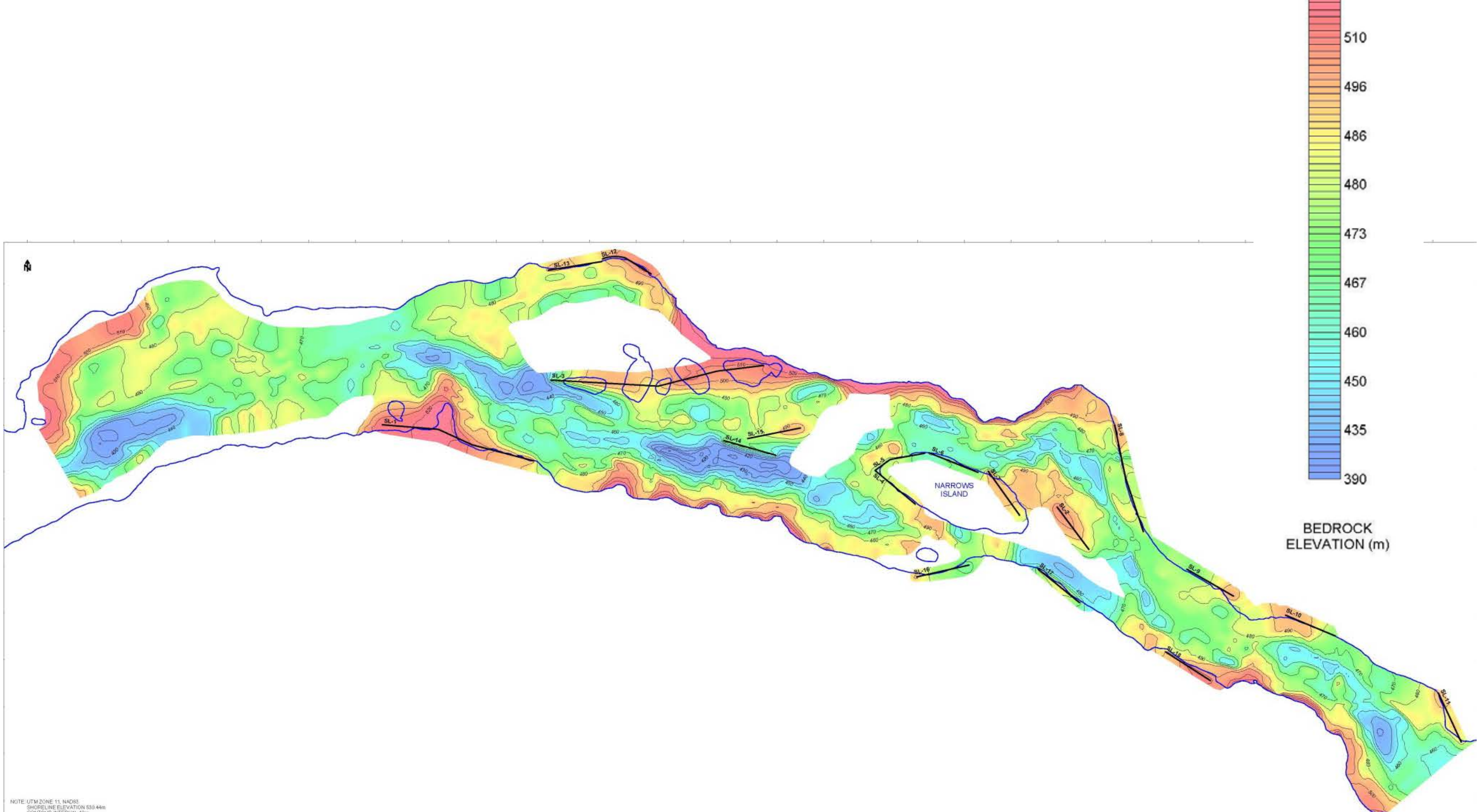
SL-3A on mid channel bar downstream of wooded island



GEOTECHNICAL STUDIES

BC hydro FOR GENERATIONS

INTERPRETED BEDROCK ELEVATION CONTOURS



GEOTECHNICAL STUDIES

Geotechnical Studies – Preliminary Observations:

- Bedrock is relatively deep across most of the Grohman Narrows area and would not influence dredging operations
- Some bedrock exposed at shorelines
- Surficial bed materials generally consist of well graded mix of sand, rounded gravels and cobbles
- Some evidence of larger boulder material, especially along south bank

HYDRAULIC MODELING

- Updates since the June 2013 Public Meeting:
  - Optimizing of dredge location and extent
    - 3 scenarios developed (low, medium and high dredge volume = 200,000 m^3, 400,000 m^3 and 600,000 m^3)
    - Most benefit realized from dredging the two bars u/s and d/s of wooded island and the area at Grohman Creek outlet (see figure next slide)
    - Low scenario dredge these areas to El. 527 m (1729 ft), medium to El. 526 m (1725.7 ft) and high to same as medium, but also dredge additional material from right bank bar complex d/s of island
  - Cost estimates under development for these scenarios
    - Biggest factor influencing costs is material spoiling
    - Other major factor is available construction duration (fisheries, operational, seasonal constraints)

HYDRAULIC MODELING

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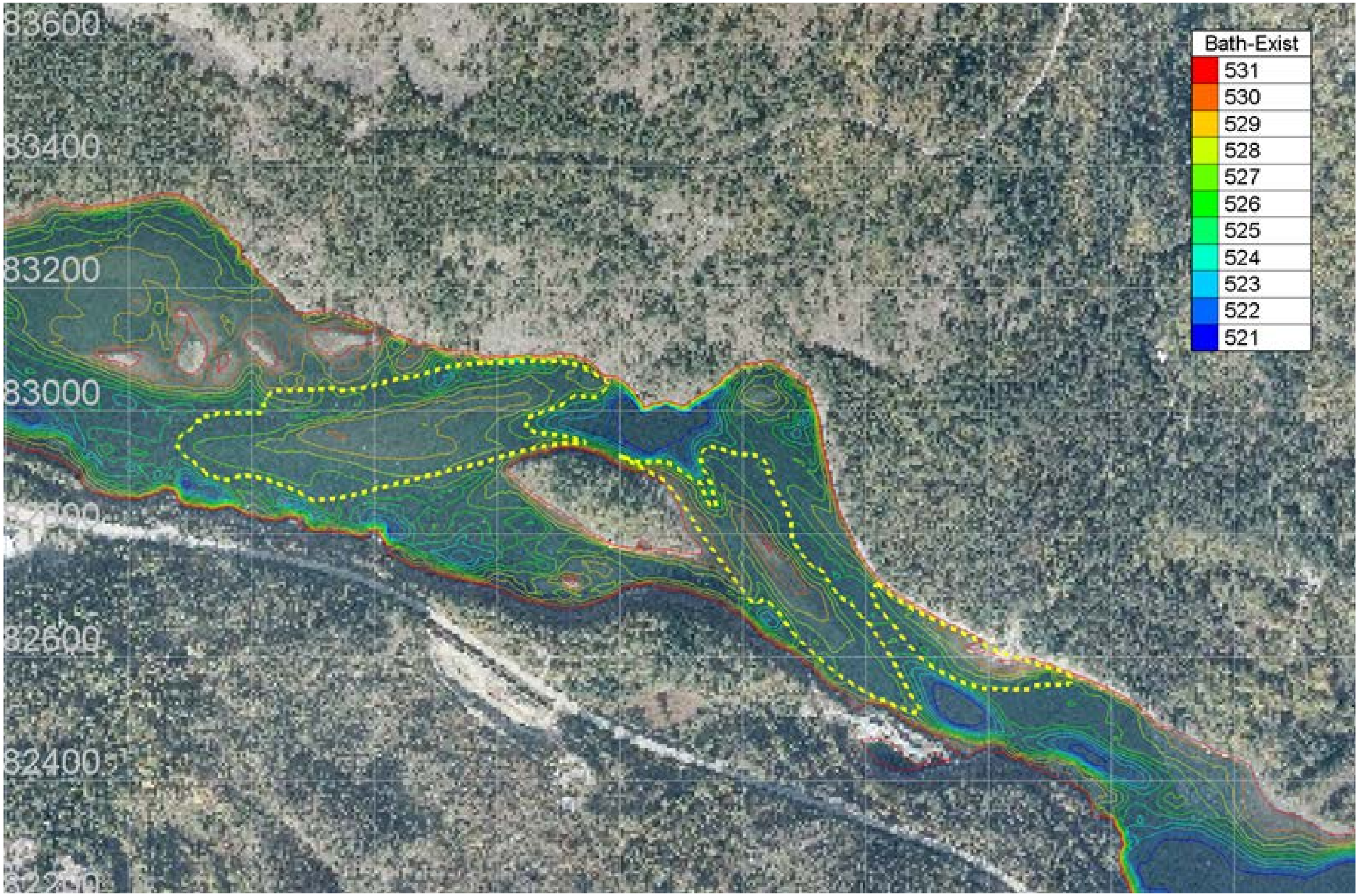
Main Dredge Areas:



HYDRAULIC MODELING

BC hydro FOR GENERATIONS

- Energy and flood reduction benefits being finalized for these scenarios
  - Up to 80 GWh per year energy benefit
  - Flood reduction in the order of 2 ft
  - Depends on final dredge volume

- Overview geomorphic analysis completed
  - Only significant source of sediment input to the Grohman reach is from Grohman Creek
  - Some minor change in bed elevations since 1939 dredge, but no significant infilling observed
  - Most changes would occur immediately following dredging as bed adjusts (self-armours) to stable level

- Preliminary examination of operational impacts
  - No significant impacts in late summer, fall or winter to existing lake levels (Corra Linn remains control)
  - Reduced KLK elevation in spring in high freshet years to allow further drawdown and reduced flood peak and duration (see next slide)

HYDRAULIC MODELING

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