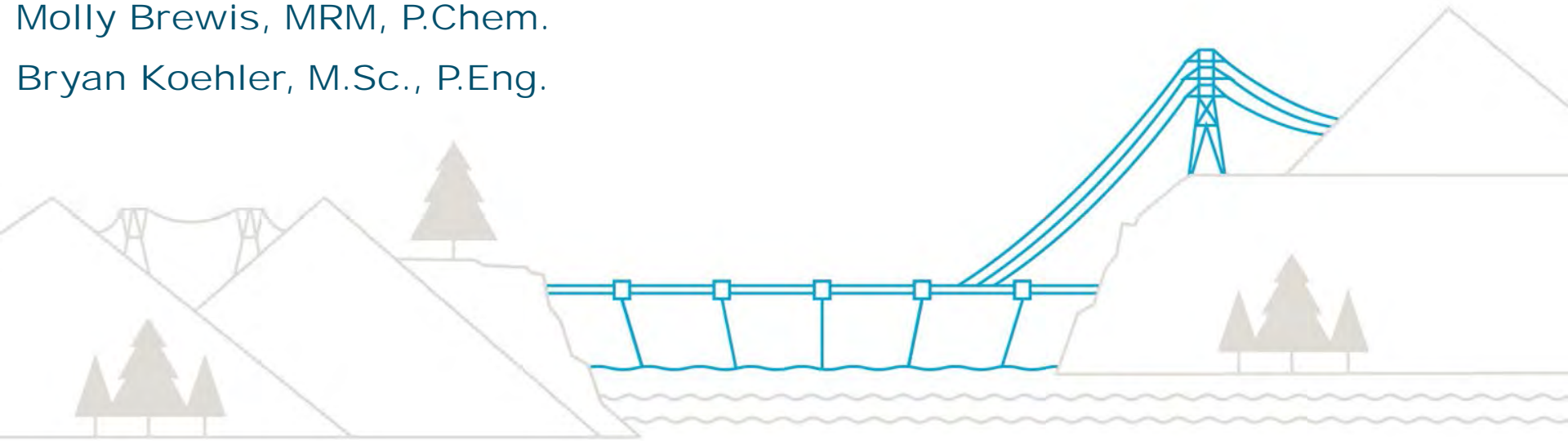


ML/ARD Challenges on the Site C Clean Energy Project

Molly Brewis, MRM, P.Chem.

Bryan Koehler, M.Sc., P.Eng.



4 December 2019

Site C is a Project of Unprecedented Scale for BC Hydro and our Province



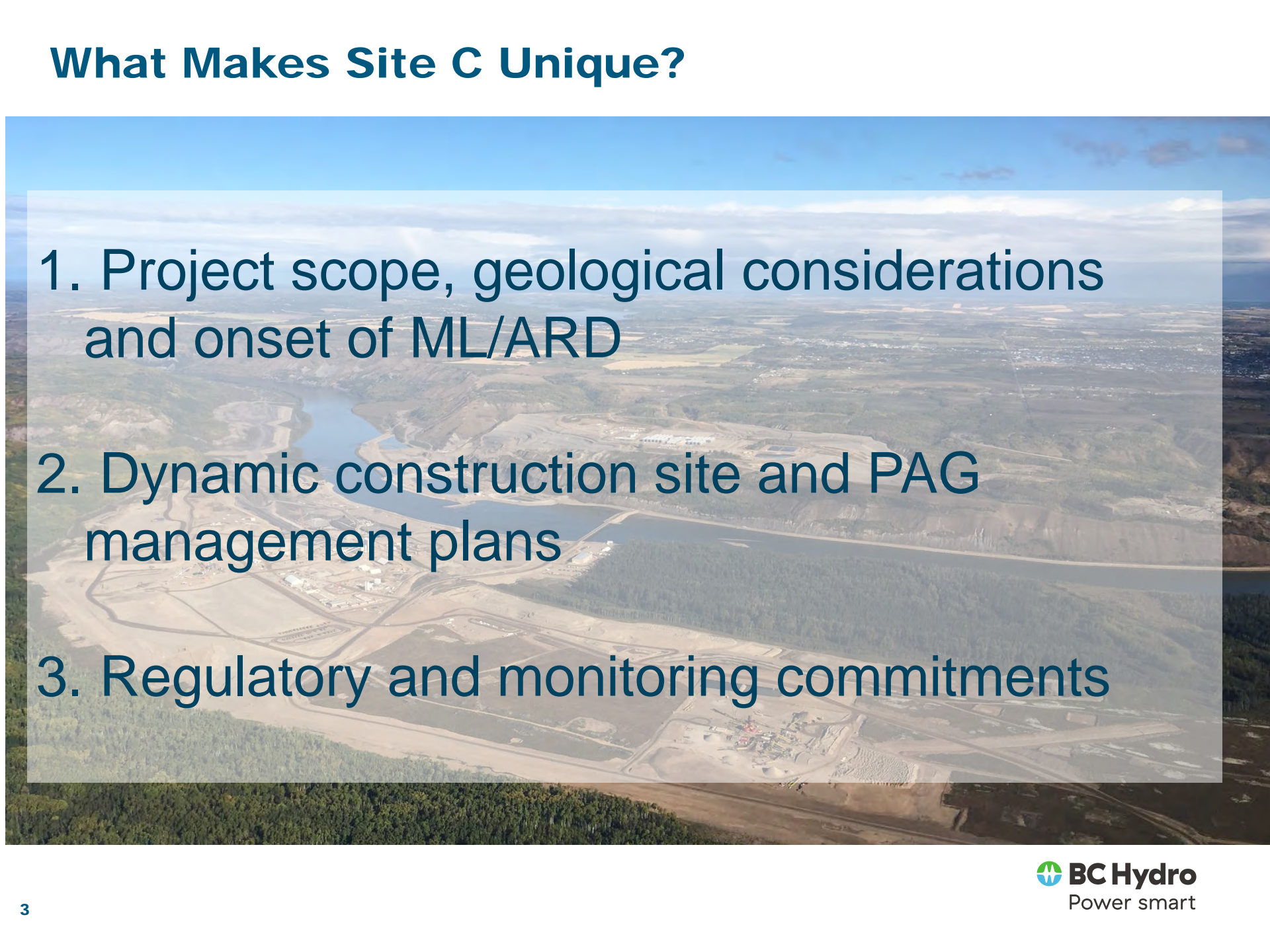
Site C, January 2019



Huckleberry Mine, August 2019

It bears many similarities, but also many differences, to a mining project.

What Makes Site C Unique?

- 
- An aerial photograph showing the construction of the Site C dam. The image captures a large reservoir, the dam structure under construction, and surrounding land with some vegetation and infrastructure. The sky is blue with some clouds.
1. Project scope, geological considerations and onset of ML/ARD
 2. Dynamic construction site and PAG management plans
 3. Regulatory and monitoring commitments



The Site C Project is not just a dam.

Project Scope

Dynamic
Construction

Regulatory &
Monitoring
Commitments

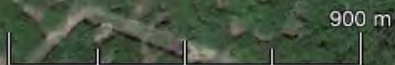




Construction Year 0

Image © 2019 Maxar Technologies
Image City of Fort St. John

Google Earth



2009

Imagery Date: 5/18/2015 56°13'04.69" N 120°57'04.66" W elev 0 m eye alt 4.28 km



Construction Year 1

Image © 2019 Maxar Technologies

Google Earth



Imagery Date: 4/25/2016 56°13'29.22" N 120°56'15.07" W elev 0 m eye alt 4.28 km



Construction Year 2

Image © 2019 Maxar Technologies

Google Earth



2009

Imagery Date: 9/22/2017 56°13'30.23" N 120°57'29.93" W elev 0 m eye alt 4.28 km



Construction Year 3

Image © 2019 Maxar Technologies

Google Earth



2009

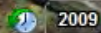
Imagery Date: 9/18/2018 56°13'42.57" N 120°57'30.79" W elev 0 m eye alt 4.28 km



Construction Year 4

Image © 2019 Maxar Technologies

Google Earth



Imagery Date: 9/17/2019 56°11'31.40" N 120°53'28.85" W elev 0 m eye alt 4.28 km

Site C Geology and ML/ARD

Shale bedrock and ARD/ML generating components

- Peace river region well-known for exposed shale faces which are heavily weathered and are known sources of MLARD
 - Shaftesbury formation – marine shale/mudstone/sandstone
- Risk of MLARD identified early during site selection/feasibility
- Multiphase approach to geochemical classification using industry standards and practices for testing/identification of MLARD risks



Site C Geology and ML/ARD

- Dam site MLARD/geochemical classification sampling:
 - 181 bedrock samples from 12 geologic units, 30 unconsolidated overburden samples
 - Static testing:
 - Acid-Base Accounting/elemental analysis
 - Kinetic testing:
 - Leachate extraction tests
 - Humidity Cells



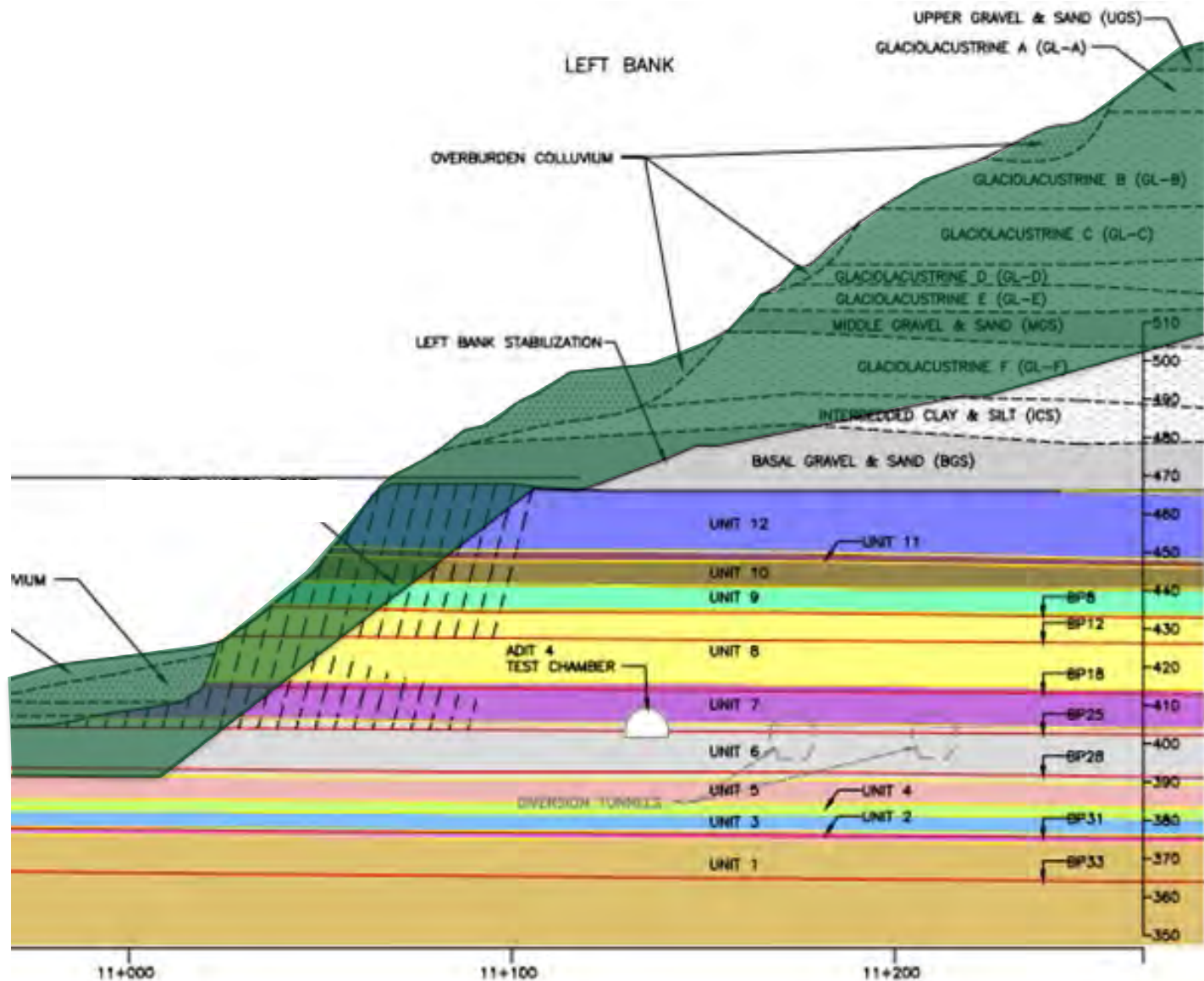
Site C Geology and ML/ARD

ML/ARD Onset

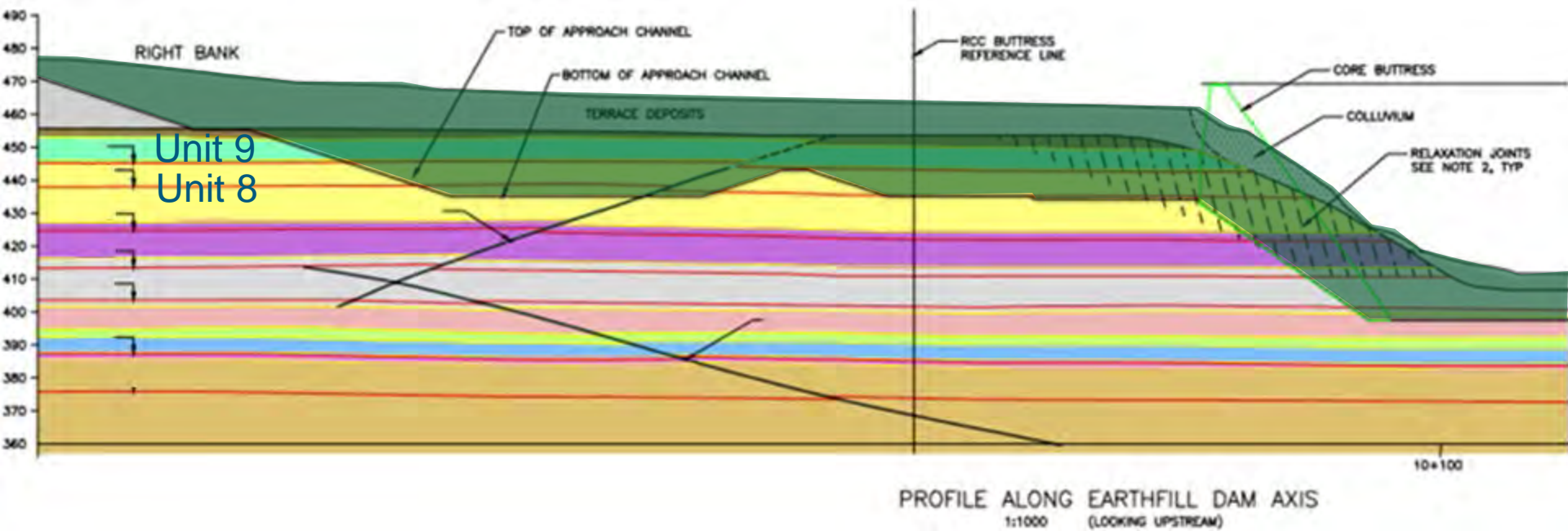
Unit	Criteria
PAG/AG	NPR<2
NPAG	NPR>2

Unit	NPR	Lag Time (years)	Total Vol. %
12	<0.3	0-1	5
11	0.6	0-1	2
10	0.3-0.5	0-1	10
9	0.03-0.9	0-1	50
8	0.04-0.09	0-1	30
7	0.1-1.7	2	5
6	0.05-1.6	9	1
5	0.05-1	3-10	
4	0.04-1.9	2	
3	1	1	
2	0.02-3.2	1	
1	0.1-1.6	3	

Site C Geology and ML/ARD



Site C Geology and ML/ARD



Site C Geology and ML/ARD

- PAG Mitigation strategy seeks to:
 - Minimize oxygen supply via diffusion or advection, water infiltration, and leaching
- PAG Mitigation through:
 - All PAG rock encapsulated with compacted overburden or colluvium materials to isolate from oxygen/water
 - Permanent submersion in reservoir following dam construction in “**Relocated Surplus Excavated Material**” (RSEM) areas



Construction is Dynamic.

Project Scope

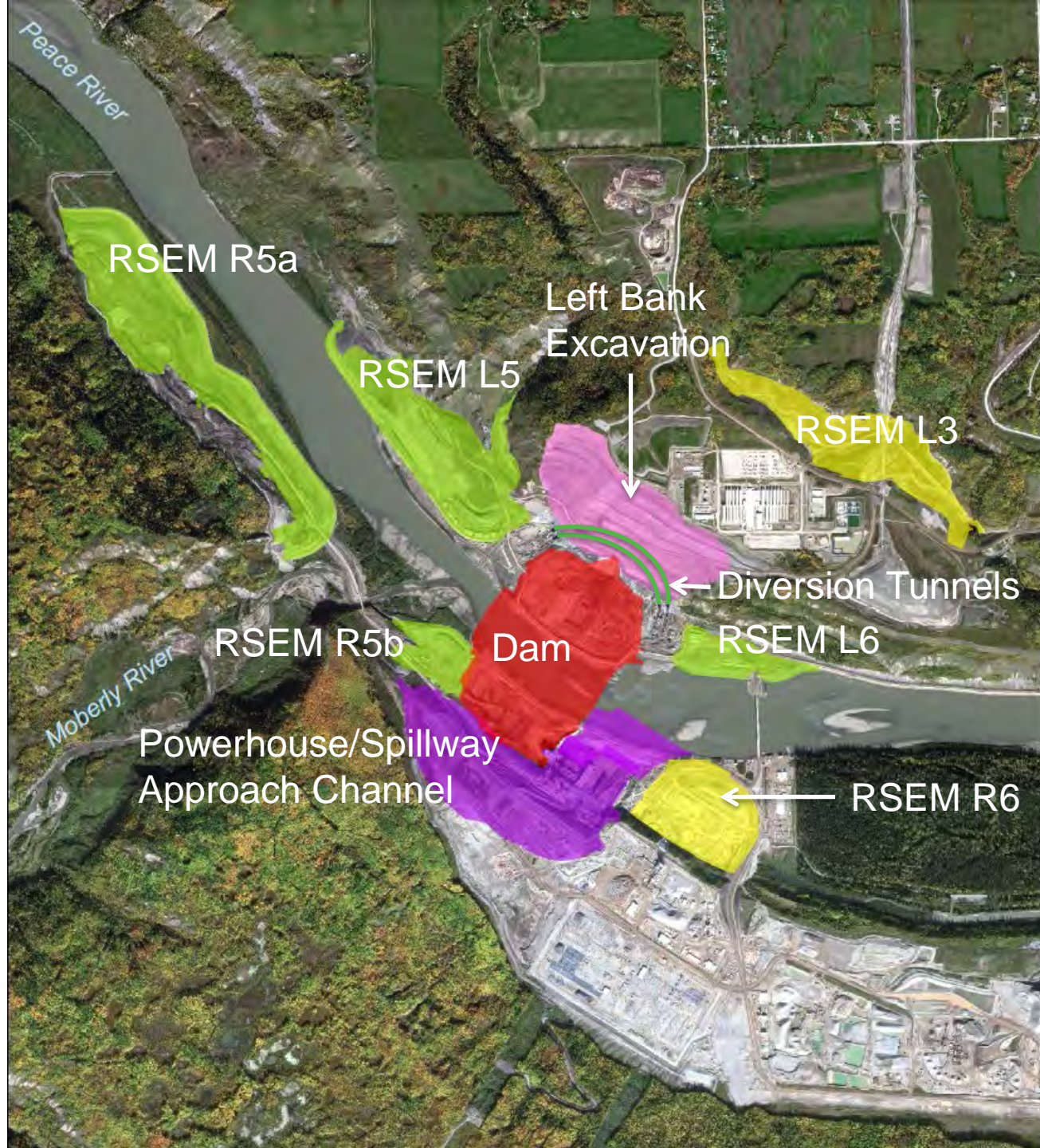
Dynamic
Construction

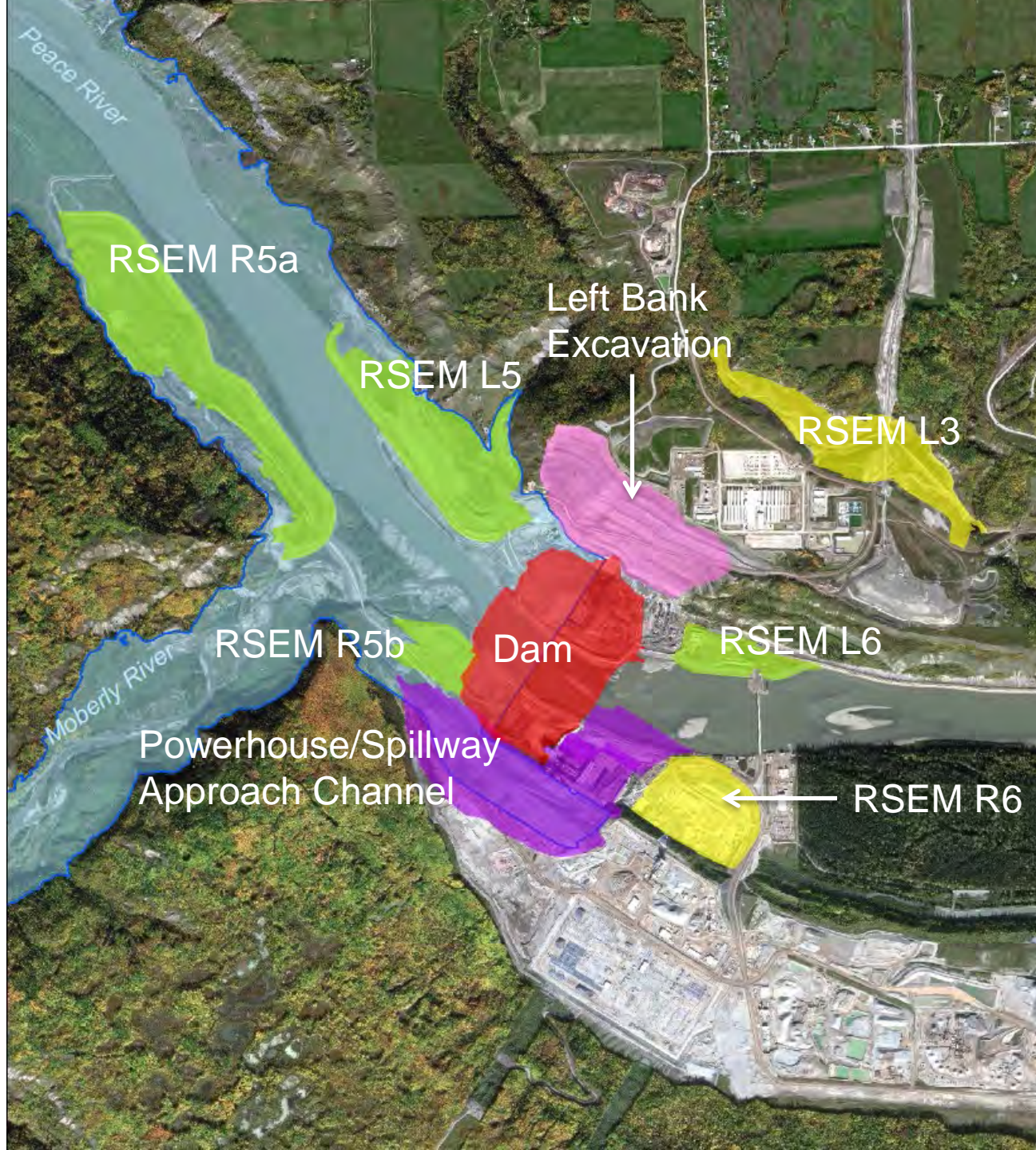
Regulatory &
Monitoring
Commitments

PAG Management and Changing Work Areas

- Unlike at a mine site with designated work area and disposal area and interconnected infrastructure, Site C work area is changing on a daily basis
- What may be a laydown one week may be an active excavation the next
- All excavated material is relocated surplus material, and is not for beneficial re-use



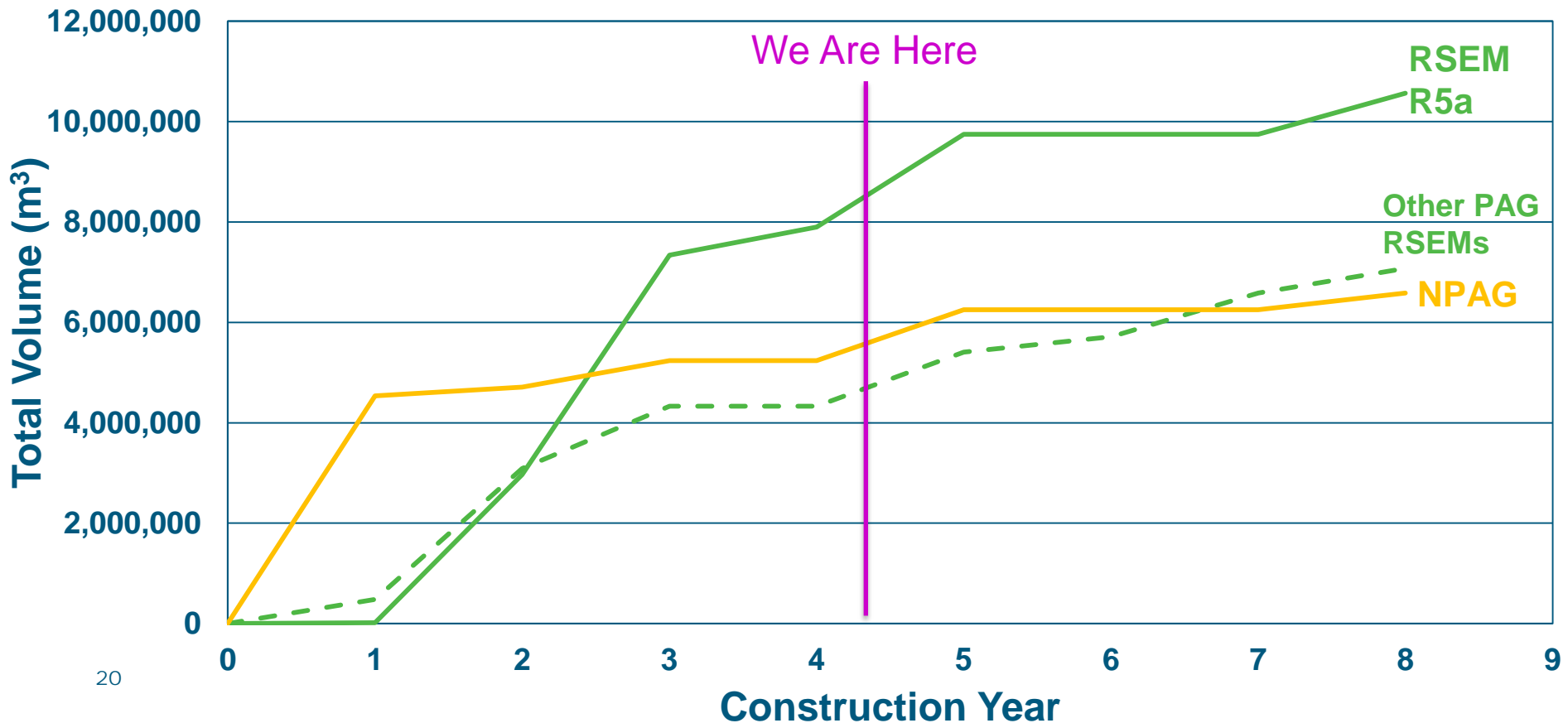




Managing Dynamic Construction

PAG Excavation Schedule

- Total excavated:
 - PAG ~40 million tonnes (18,000,000 m³)
 - NPAG ~18 million tonnes (7,000,000 m³)



Managing Dynamic Construction

ARD/ML Mitigation – Operational Sampling

- Active material management to ensure RSEM capacity not exceeded
- Ongoing sampling program throughout construction and excavation to manage PAG rock and guide deposition locations

Facility	Sample Frequency	Sample Distribution	Analysis
Active Excavation	NA	1/5,000m ³	Rinse pH, ABA, metals
RSEM Construction	1 event per month exposure	1/0.2 ha	Rinse pH

Managing Dynamic Construction

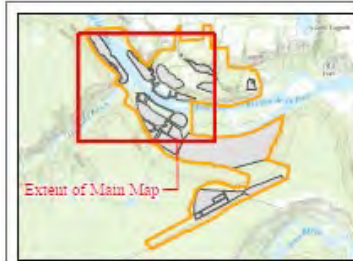
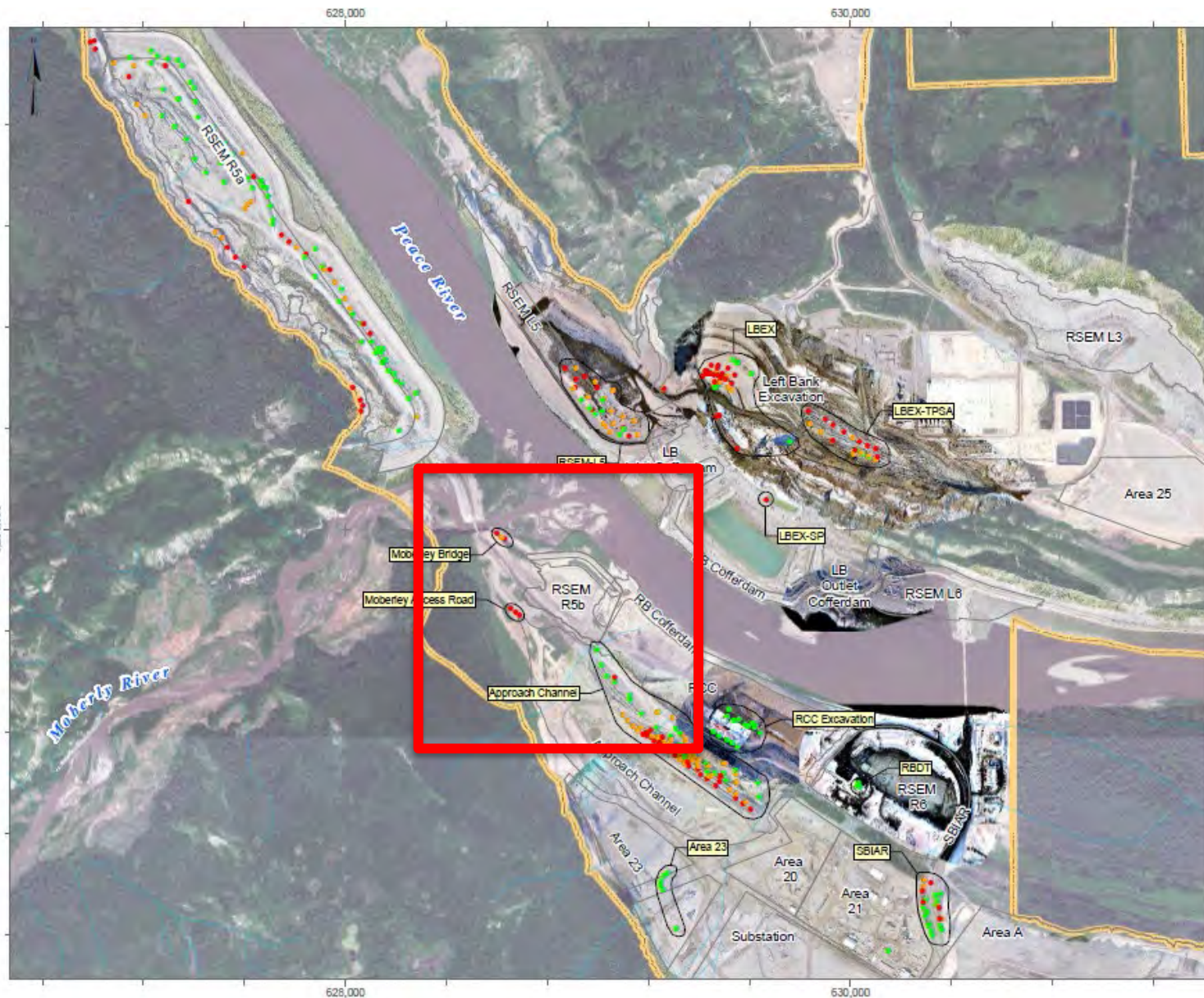
Surface Water Management Infrastructure

- No pit/pond! Managing storm events and groundwater seeps?
 - Use of lined and unlined ditches/retention ponds on-site, temporary sumps, active water management
- RSEM Sediment Ponds
- Mobile Water Treatment Plant for high-risk PAG contact water



Managing Dynamic Construction

Water Treatment Requirements



Legend

Rinse pH

- <5.5
- 5.5-7
- >7

0 250 500 750 Meters 1:15,000

DATE SAVED: Mar 09, 2018 REVIEWED: NM

DRAWN BY: AL VERSION: 1

CLIENT:



PROJECT:

Site C Clean Energy Project
ARD/ML 2017 Annual Report

TITLE:

Rinse pH Sampling Locations

PROJECT#: A416

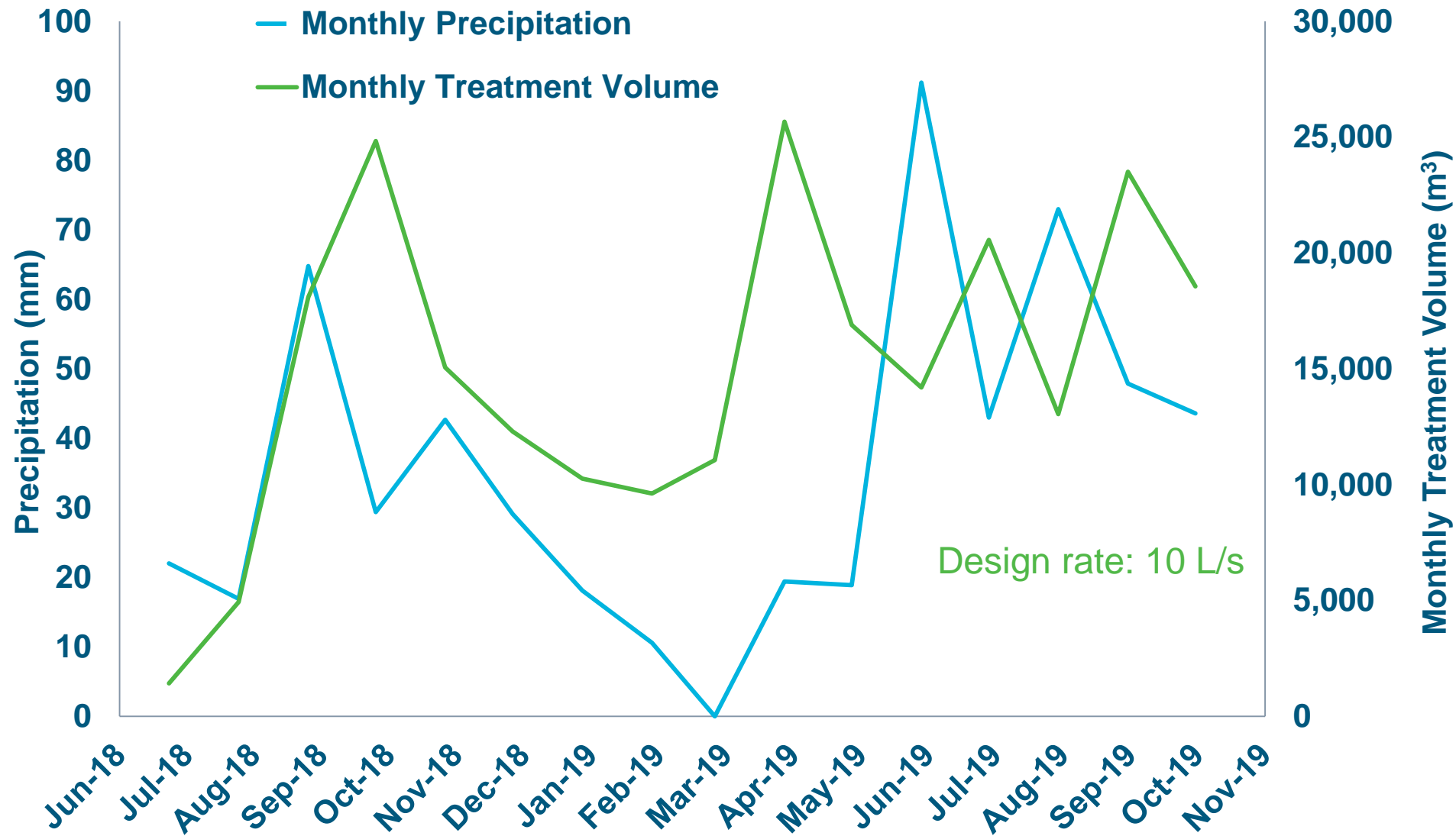
FIGURE: 2.4-1

Managing Dynamic Construction

Mobile Water Treatment Facility (MWTF)



Water Treatment

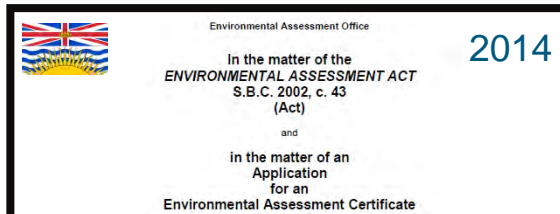


The Regulatory Oversight & Water Quality Monitoring Requirements are Unique.

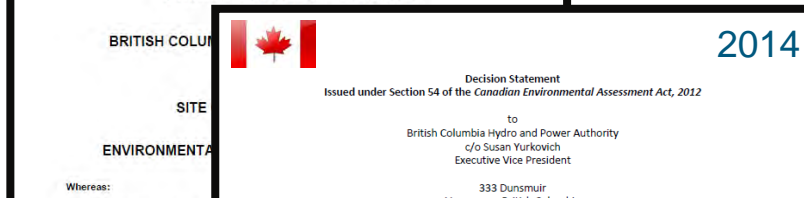
Project Scope

Dynamic
Construction

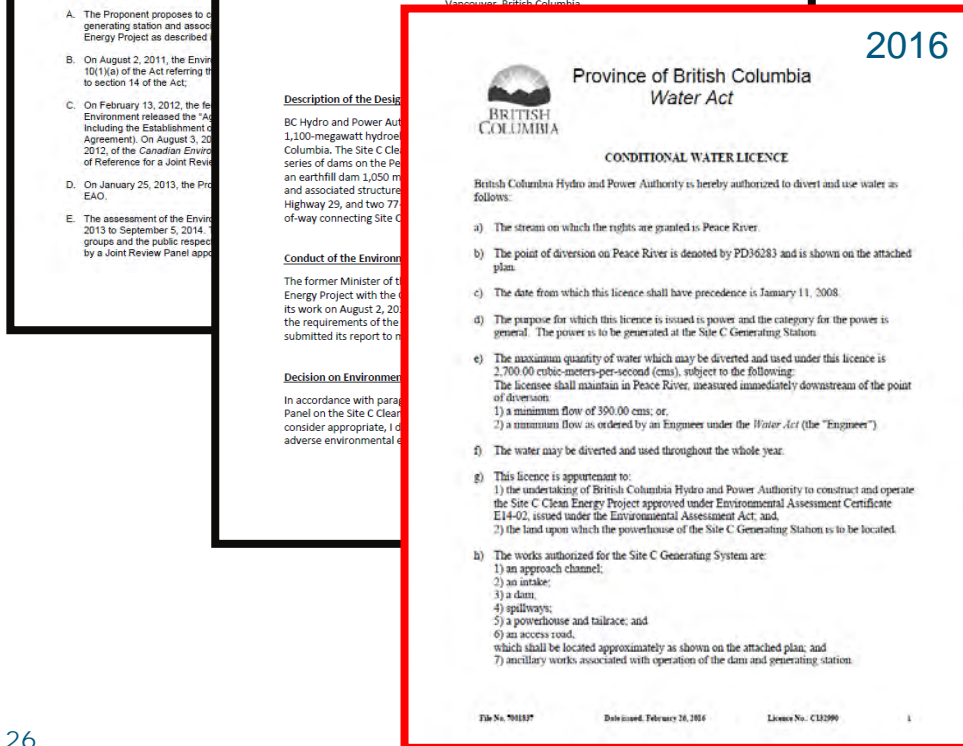
Regulatory &
Monitoring
Commitments



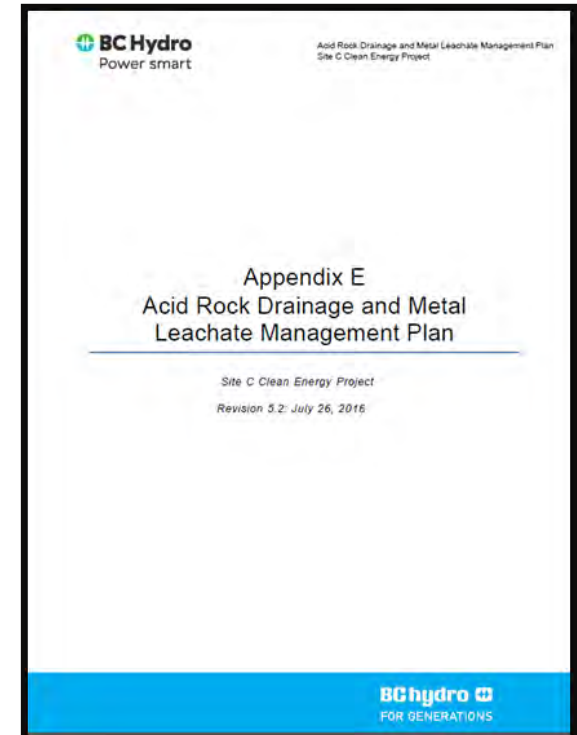
2014



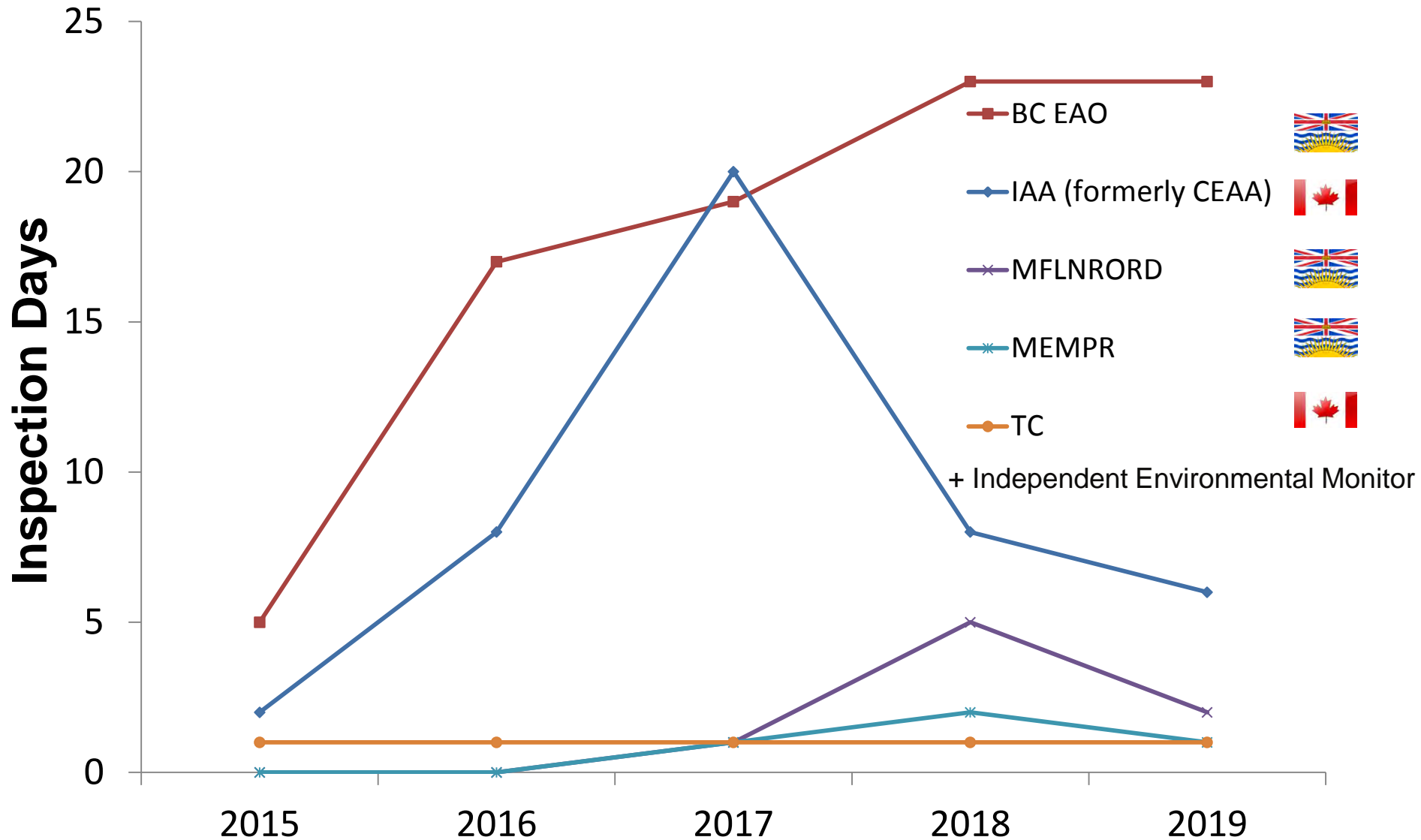
2014



2016



Regulatory Inspection Effort



Regulatory and Water Quality Monitoring

Project-specific Discharge Limits

Parameter	End of Pipe Discharge Limit (mg/L)	Peace River Initial Dilution Zone (IDZ) Limits
Cadmium	0.00029	BC WQG
Cobalt	0.55	BC WQG
Copper	0.011	BC WQG (or RPD 20% if Peace River > BC WQG)
Zinc	0.033	BC WQG
TSS	BC WQG	BC WQG
pH	6.0 – 9.0	BC WQG
All other variables	n/a	BC WQG

Water Quality Monitoring

Background, Source Locations, Discharge Points, Receiving Waters

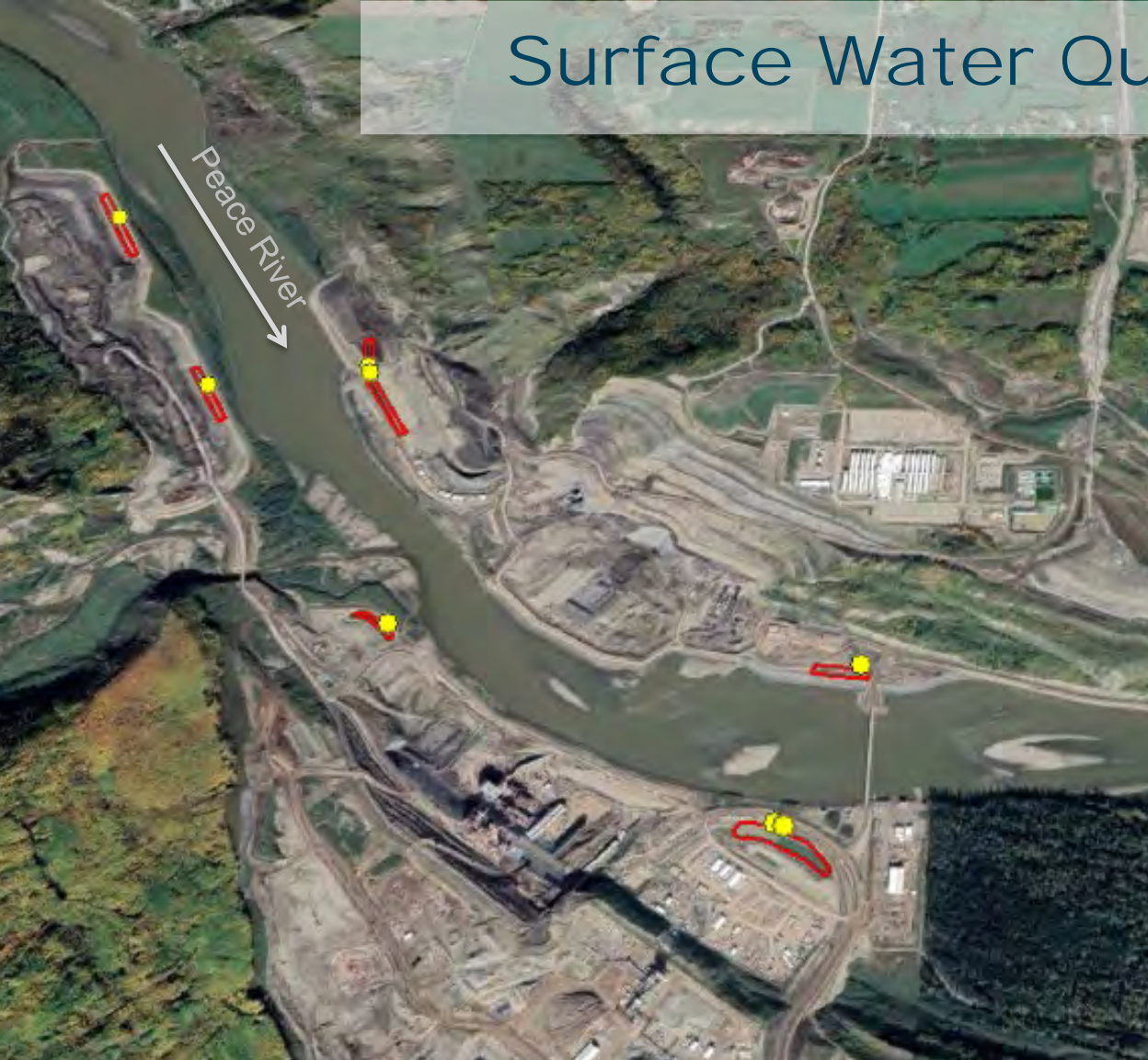


Surface Water Quality Monitoring



5 PAG-contact sediment ponds that discharge to the receiving environment

Surface Water Quality Monitoring



Sediment pond monitoring

In situ: pH, EC, turbidity, flow rate (for metals loading) → continuous

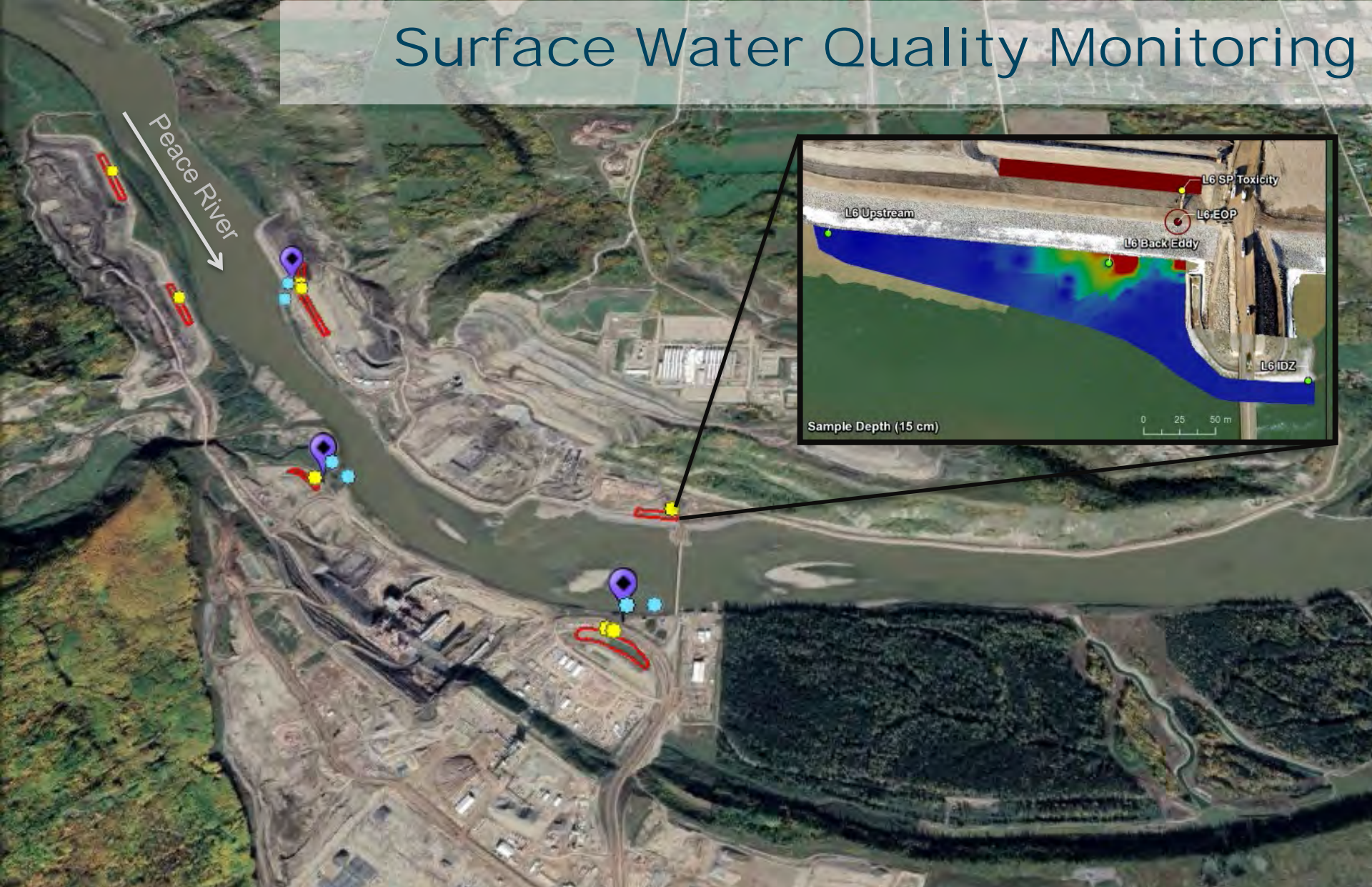
Laboratory: physical parameters, metals, major ions → daily

Toxicity: 96 hr rainbow trout LC50 → bimonthly

Since Fall 2016:

- 2152 unique samples collected at EOP for lab analysis
- ~99% compliance for EOP metals

Surface Water Quality Monitoring

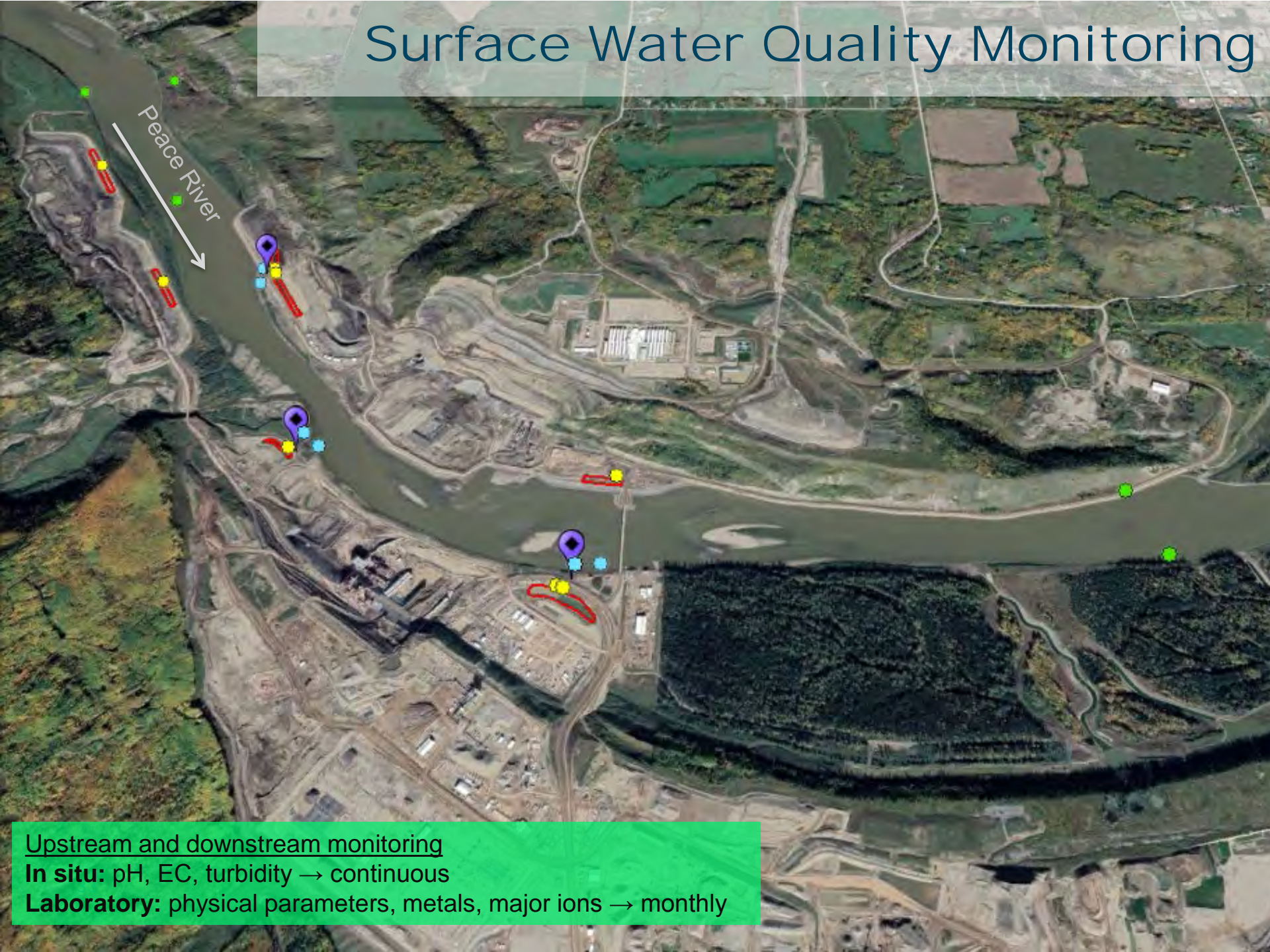


Discharge monitoring (upstream and IDZ)

In situ: pH, EC, turbidity → monthly, twice annual 5-in-30 (low and high flows)

Laboratory: physical parameters, metals, major ions → monthly, twice annual 5-in-30 (low and high flows)

Surface Water Quality Monitoring



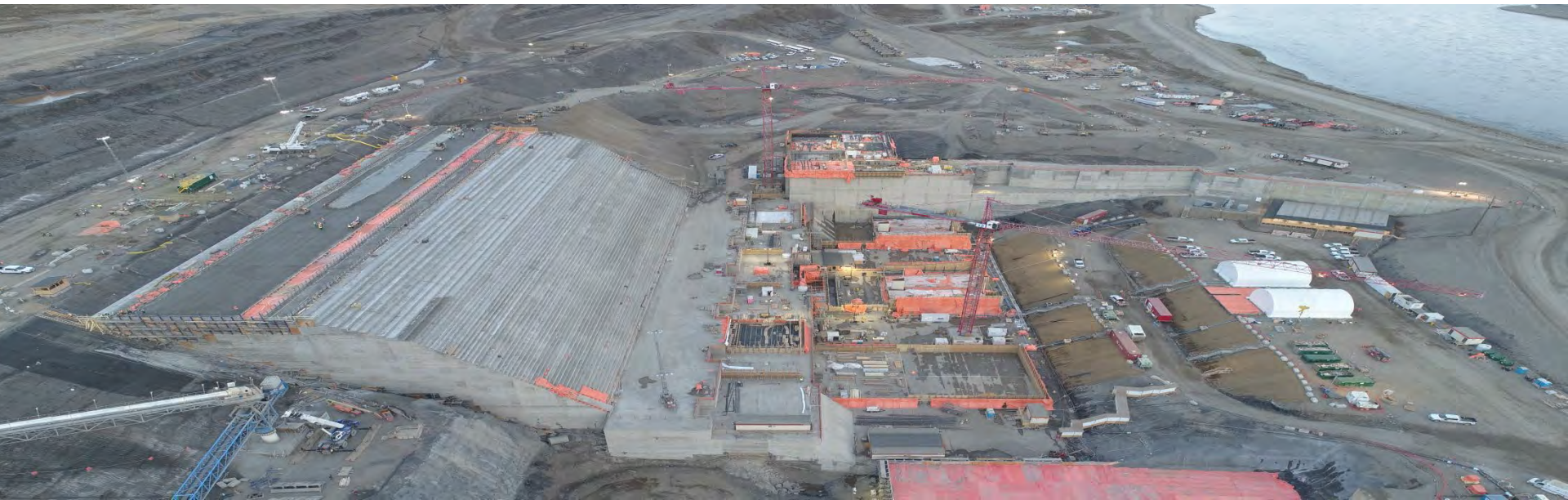
Upstream and downstream monitoring

In situ: pH, EC, turbidity → continuous

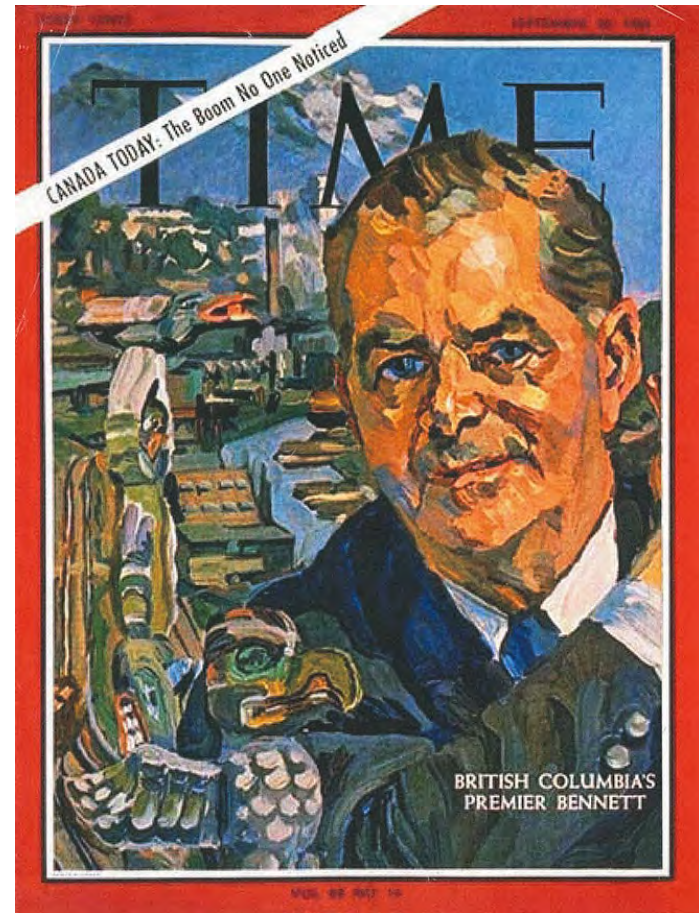
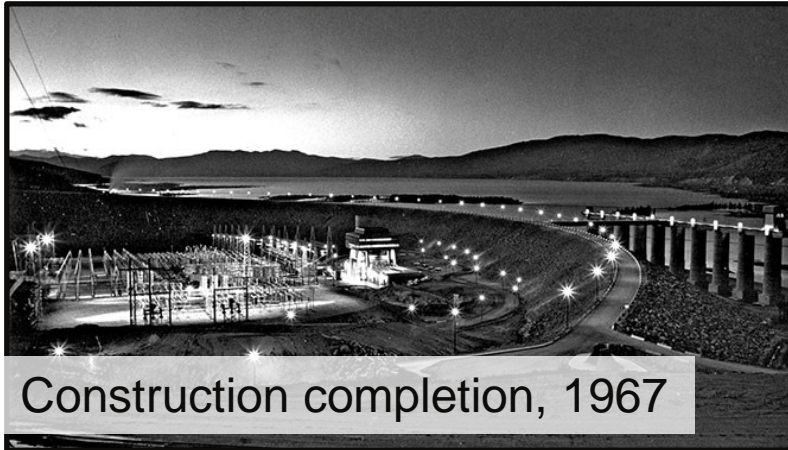
Laboratory: physical parameters, metals, major ions → monthly

Site C is Unique because...

1. Project scope, geological considerations and onset of ML/ARD
2. Dynamic construction site and PAG management plans
3. Regulatory and monitoring commitments



Site C is a Project of Unprecedented Scale for BC Hydro and our Province



The 50+ year legacy of the WAC Bennett Dam

Acknowledgements



Thank You

www.sitecproject.com

