Utilizing Photogrammetry and LiDAR on Unmanned Aerial Vehicles for Quantification of Excavation and Backfill

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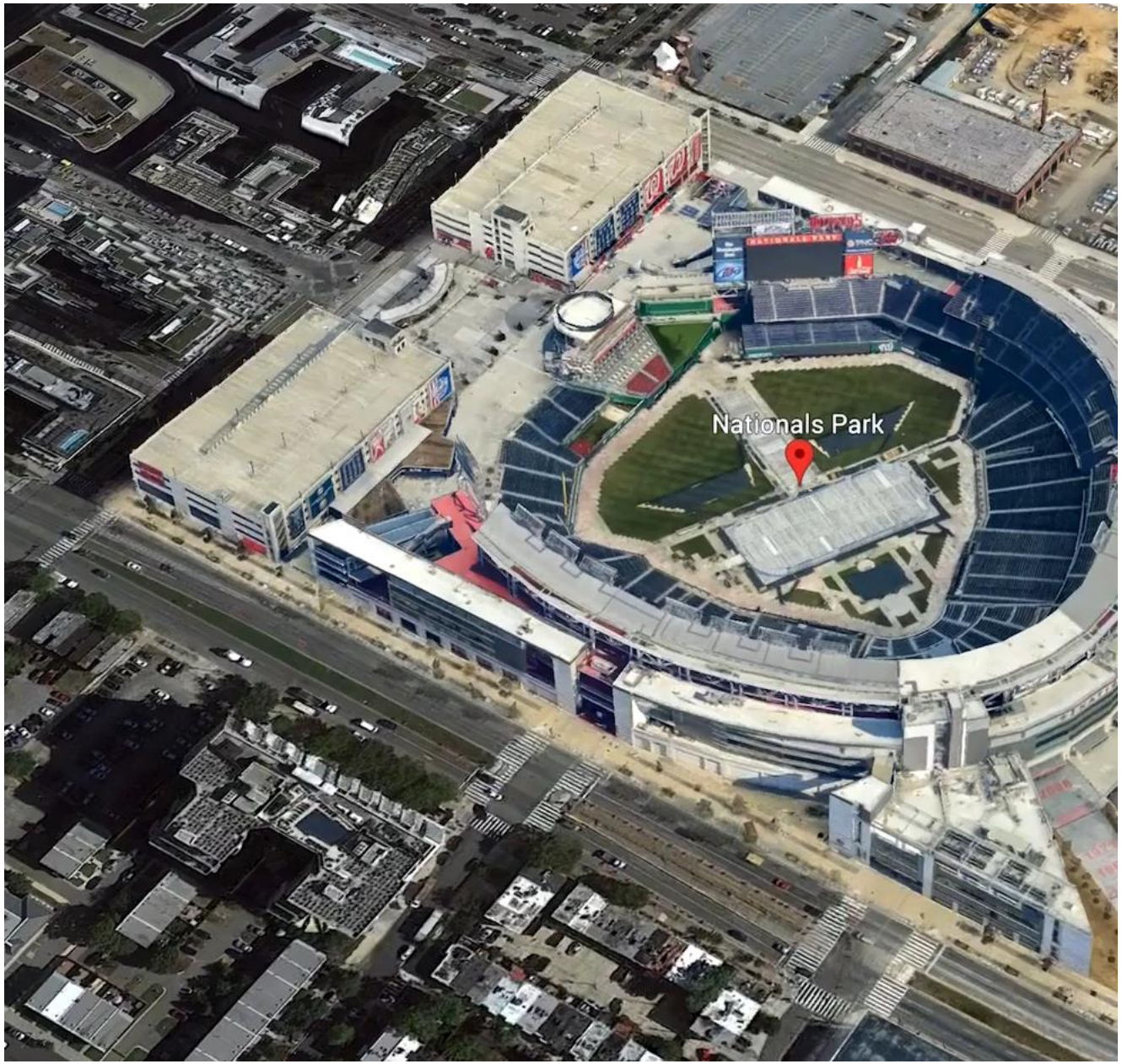

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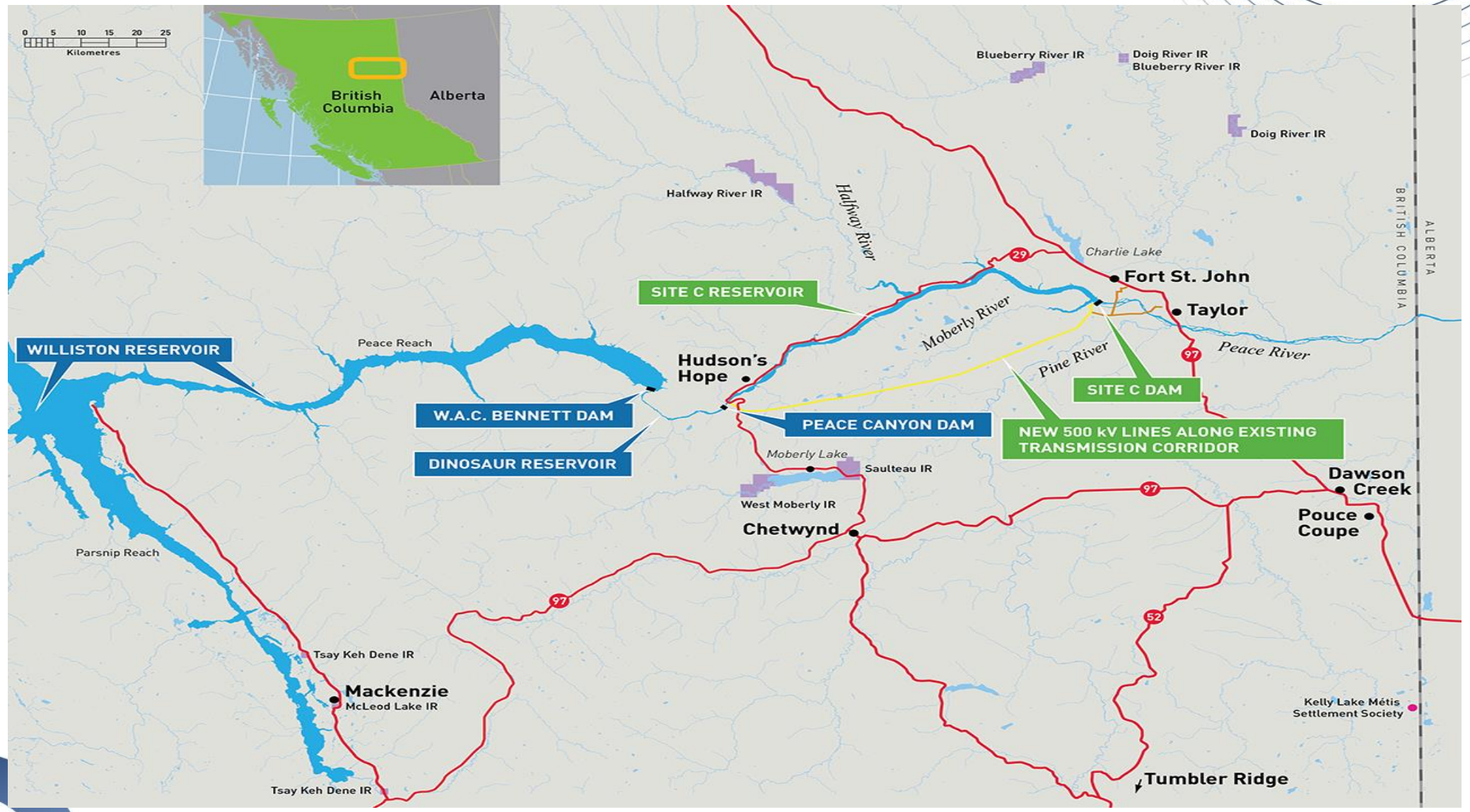

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PROJECT LOCATION

- Site Chosen
  - Access to nearby aggregate sources
  - Take advantage of the local geological condition

- The Earth Filled Dam
  - Huge amount of excavation to get down to bedrock
  - Structural Fill to build the EFD

PROJECT REPORTING

- BC Hydro is a Provincial Crown Corporation
  - The Government wanted oversight of this provincially funded project
  - Accurate and timely reporting
  - Verification of contractors progress payments
  - We helped drive the contractors schedule to completion

PROJECT STATS

- Project Site is 2200 Ha's – the same size as nearby Fort St John, BC.
  - Generate 1100 Mega Watts of Hydroelectric Power.
  - Consists of six 183 MW Turbine Generators.

- The Earth filled Dam (EFD)
  - 1050 meters in length and raises 60 meters above the river
  - 15.2M m3 of material was placed to create the EFD

- The Dam and Core Buttress
  - 1.7M m3 of RCC Concrete
  - 1.1M m3 of Structural Concrete

WHAT IS A DRONE?

A Drone is an Unmanned Aerial Vehicle

UAV/Drone — We use a variety on site but mainly use the Quantum Trinity F90+ on the Excavation and Backfills due to the area we need to cover.

- Range
- Flight Time
- Payload Capacity
- Payload Choices
  - D2M Camera
  - LiDAR

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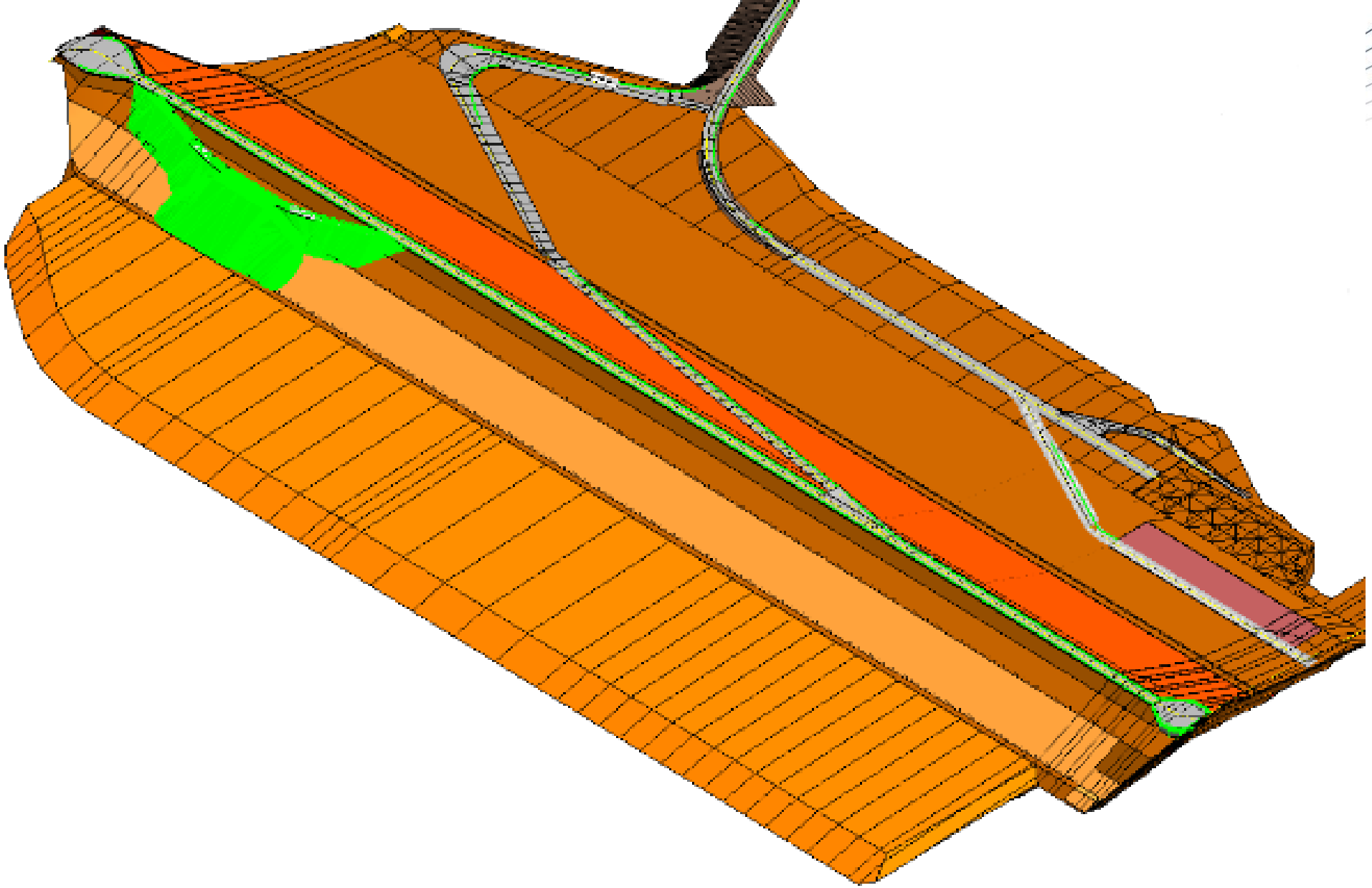
DEFINITIONS

Photogrammetry	Photogrammetry is the art and science of extracting 3D information from photographs. The process involves taking overlapping photographs of an object, structure, or space, and converting them into 2D or 3D digital models.
LiDAR	Stands for Light Detection and Ranging A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the ground.
Point Cloud	A discreet set of data points in space that represent a 3D shape or surface. Each point has its own set of Cartesian Coordinates

HOW DID WE START

Quantification of Excavations and Backfill

- The EFD was designed as a surface in Civil 3D
  - The complexity did not allow us to properly track progress
  - A Revit Model was created
  - Broke it into 110,000 blocks



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HOW DID WE START

Quantification of Excavations and Backfill

- The blocks were various sized each with its own Metadata
  - Location (Stationing and Elevation)
  - Material and Thickness as per design specification
  - 17 different types of aggregates are tracked

EXCAVATION AND BACKFILL

- Seasonal limitations on backfill
  - ~ 1 Year of Excavation after River Diversion (October 2020)
    - 2020 October to August 2021
  - 3 Seasons of Construction
    - 2021 August to October
    - 2022 April to October
    - 2023 April to August

PROGRESS INFORMATION SOURCES

- Daily Shift Reports on Progress
  - Contractor Reports
  - Construction Officers
  - Resident Engineers / Quality Inspectors / NDE Reports

- How did we quantify it?
  - Drones
  - Updated our tracking sheet of the 110,000 blocks

FLIGHT CHALLENGES

- Verification of the weekly progress

- Drones Flights
  - With wind and weather conditions were limitations.
  - Three (3) planned flights for weekly coverage.
    - One to substantiate the weekly progress
    - The other two as spares (future posterity)
  - Flights (25-90 minutes) to collect the data

- We found the imagery from the Photogrammetry better use than the LiDAR

THE PROCESS

- Flight is done
  - Data collected and downloaded

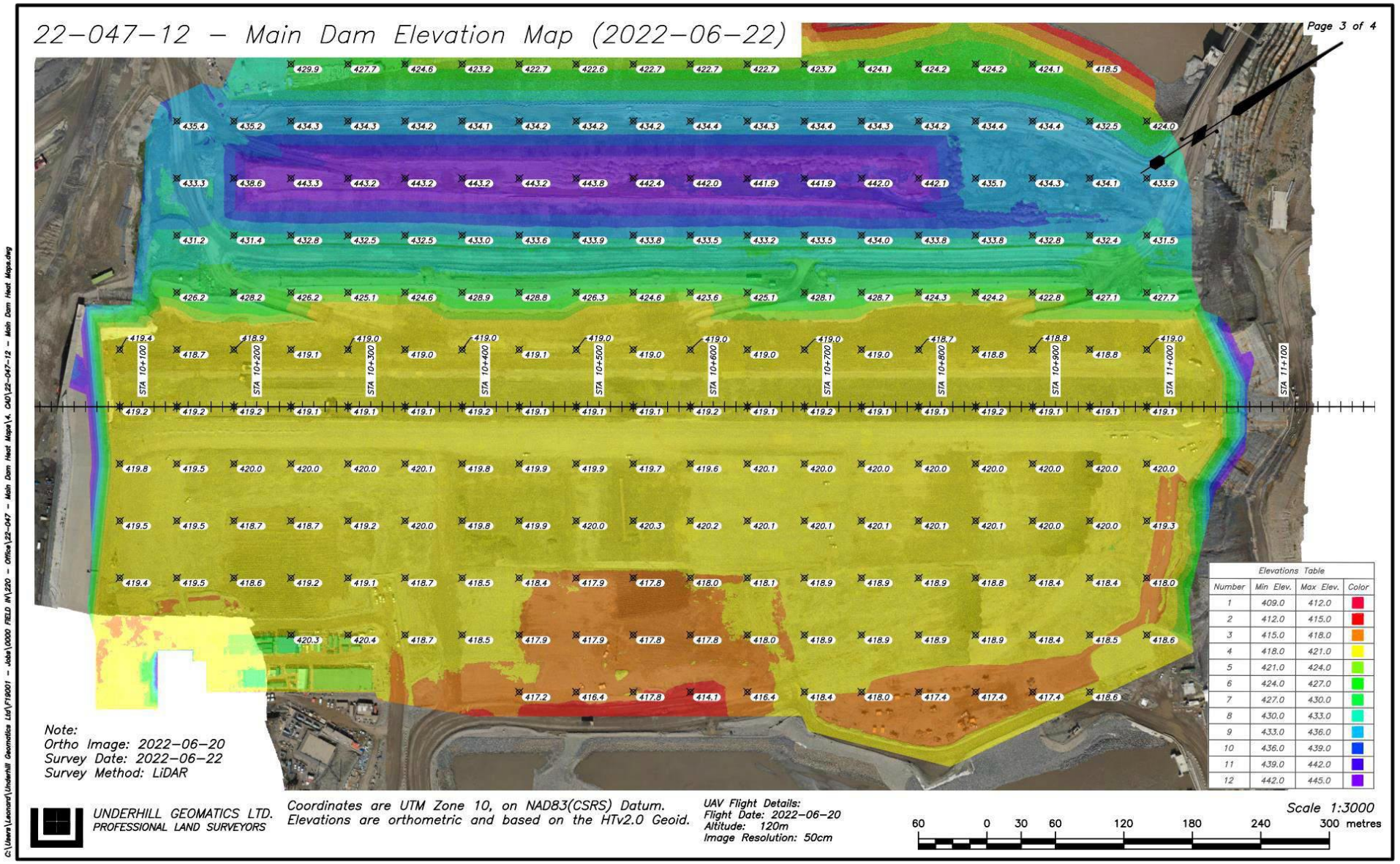
- Using special software the data is correct and aligned to known GPS coordinates
  - Agisoft Metashape (Photogrammetry)
  - Yellowscan CloudStaion (LiDAR)

- Two versions created
  - Full Point Cloud
  - Digital Terrain Model (DTM) - Corrected

THE DELIVERABLES

- The Digital Terrain Model (DTM) is used to compare against last weeks surface
  - The changes in the surface elevations creates the Volume
  - Shows elevation of the current construction

  - Shows where it was placed
    - Changes in elevation
    - “Heat” map



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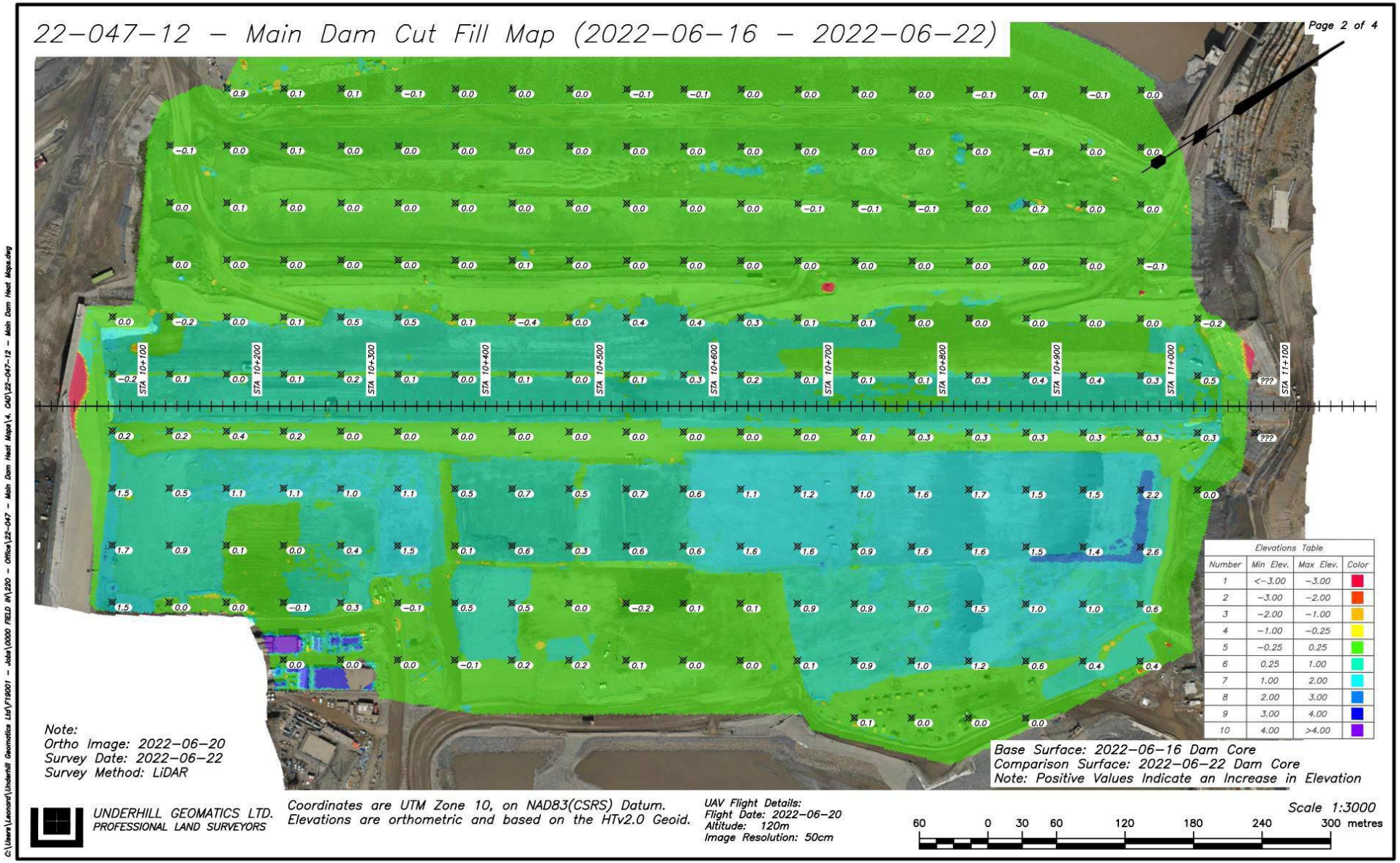

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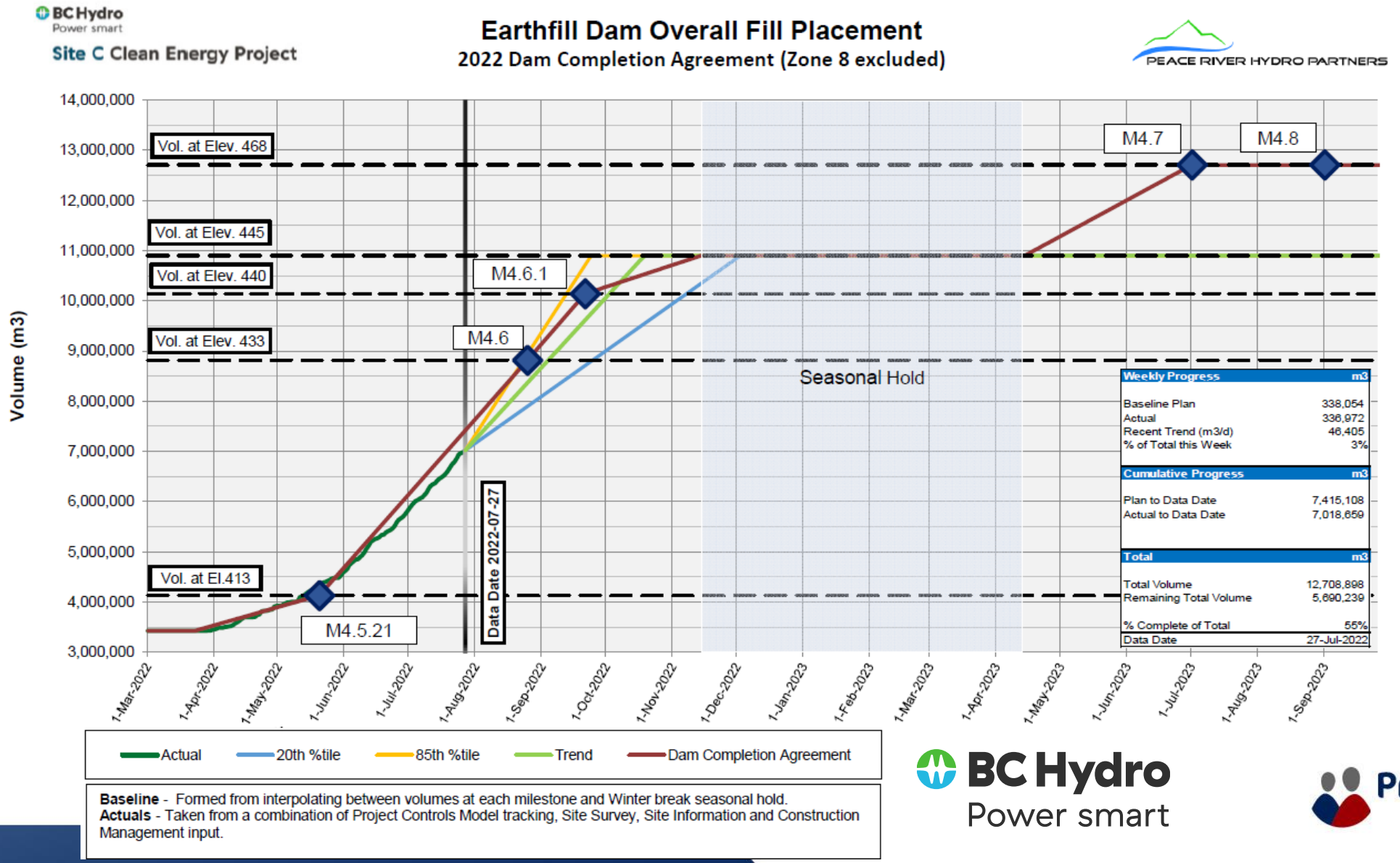
OUTPUT FROM MODEL TRACKING

Zone Type	Total Volume up to Elev. 468 (m3)	Total Placed Volume (m3)	2022 Dam Agreement Volume - Combined (m3)	Placed Volume 2022 (m3)	Weekly Volume (m3)	Total Completion	2022 Completion
Zone 1	2,043,299	1,091,884	1,950,120	353,800	21,876	53%	19%
Zone 1a	156,248	49,453		22,995	1,605	32%	
Zone 1b	35,793	31,353		2,332	141	88%	
Zone 2a	608,842	197,792	1,072,995	67,521	4,526	32%	18%
Zone 2b	401,985	127,525		45,456	3,074	32%	
Zone 2c	391,656	340,515		77,447	437	87%	
Zone 3	7,697,062	3,378,751	7,857,828	1,219,967	116,311	44%	17%
Zone 3c	1,197,800	137,300		137,300	25,884	11%	
Sub-total	**12,532,685**	**5,354,573**	**10,880,943**	**1,926,818**	**173,854**	**43%**	**18%**
Zone 8	1,913,122	1,913,122	1,913,122	686,184	0	100%	36%
Total	**14,445,807**	**7,267,695**	**12,794,065**	**2,613,002**	**173,854**	**50%**	**20%**

2022 PROGRESS CURVE



Baseline - Formed from interpolating between volumes at each milestone and Winter break seasonal hold.
Actuals - Taken from a combination of Project Controls Model tracking, Site Survey, Site Information and Construction Management input.

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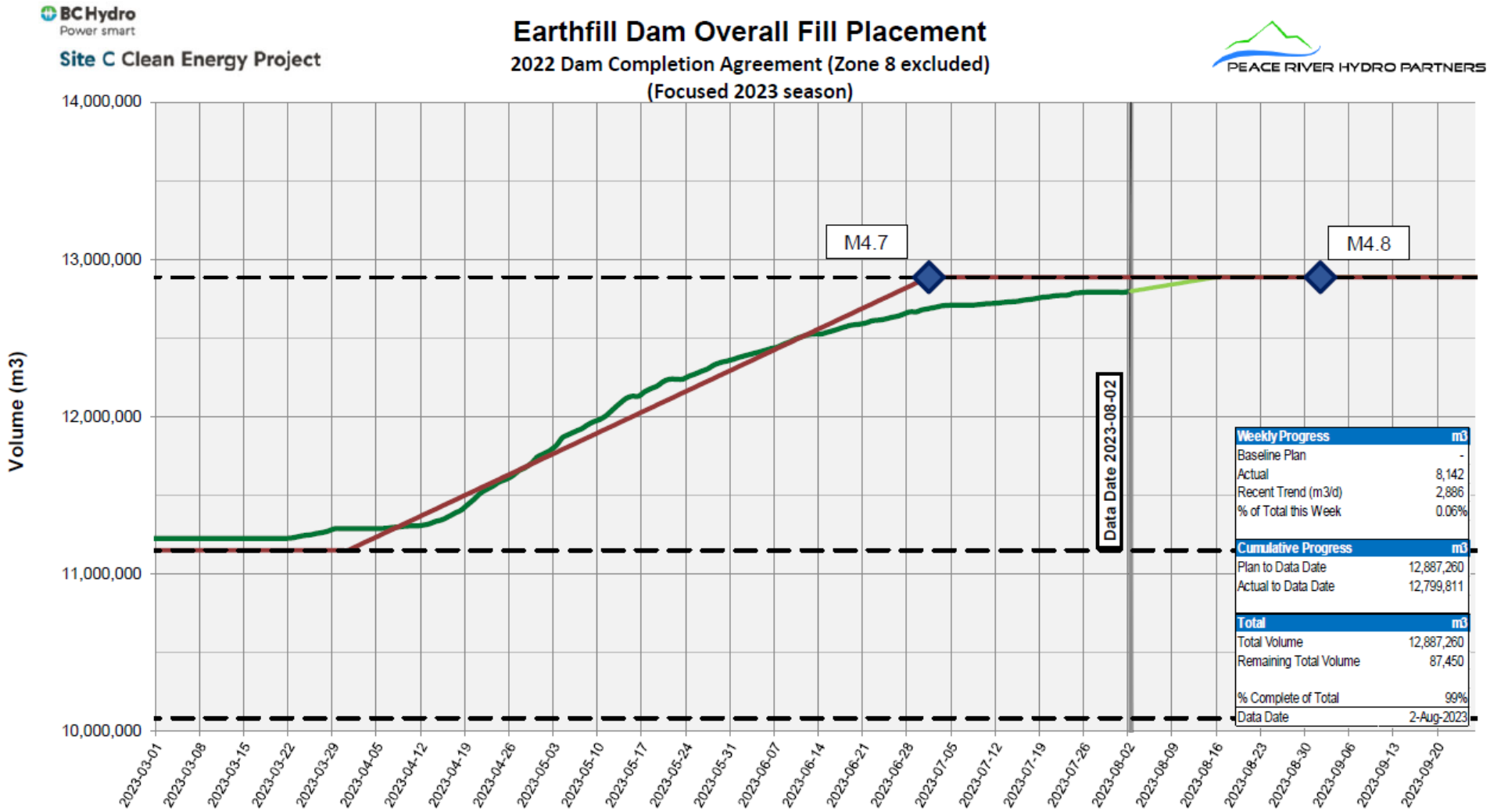
Zone Type	Total Volume up to Elev. 468 (m3)	Total Placed Volume (m3)	2022 Dam Agreement Volume - Combines (M3)	Placed Volume 2022 (m3)	Weekly Volume (m3)	Total Completion	2022 Completion
Zone 1	1,982,101	1,734,560		1,057,662	0	88%	
Zone 1a	156,478	119,489		93,271	0	76%	
Zone 1b	35,607	34,851		6,031	0	98%	
Zone 1c	9,985	0		0	0	0%	
Zone 1 Total	**2,184,171**	**1,888,900**	**1,888,872**	**1,156,964**	**0**	**86%**	**100%**
Zone 2a	609,297	422,011		283,163	0	69%	
Zone 2b	412,461	263,508		181,338	0	64%	
zone 2c	391,688	391,201		90,626	0	100%	
Zone 2 Total	**1,413,446**	**1,076,720**	**1,076,720**	**555,127**	**0**	**76%**	**100%**
Zone 3	7,485,714	6,862,453		4,703,669	30,614	92%	
Zone 3a	22,993	0		0	0	0%	
Zone 3b	40,218	1,146		1,146	0	3%	
Zone 3c	1,405,641	1,405,561		1,405,561	0	100%	
Zone 3f	5,504	0		0	0	0%	
Zone 3 Total	**8,960,070**	**8,269,160**	**8,174,298**	**6,110,376**	**30,614**	**92%**	**101%**
Zone 5	34,112	7,538	3,310	7,538	0	22%	228%
Zone 5 Total	**34,112**	**7,538**	**3,310**	**7,538**	**0**		**228%**
Zone 6b	26,359	14,882		14,882	0	56%	
Zone 6c	10,500	0		0	0	0%	
Zone 6e	32,625	170		170	0	1%	
Zone 6 Total	**69,484**	**15,052**	**6,616**	**15,052**	**0**	**22%**	**228%**
Sub-total	**12,661,283**	**11,257,370**	**11,149,816**	**7,845,057**	**30,614**	**89%**	101%
Zone 8	2,571,449	2,216,918	2,571,449	989,543	0	86%	38%
Total	**15,232,732**	**13,474,288**	**13,721,265**	**8,834,600**	**30,614**	**88%**	98%

2023 PROGRESS CURVE



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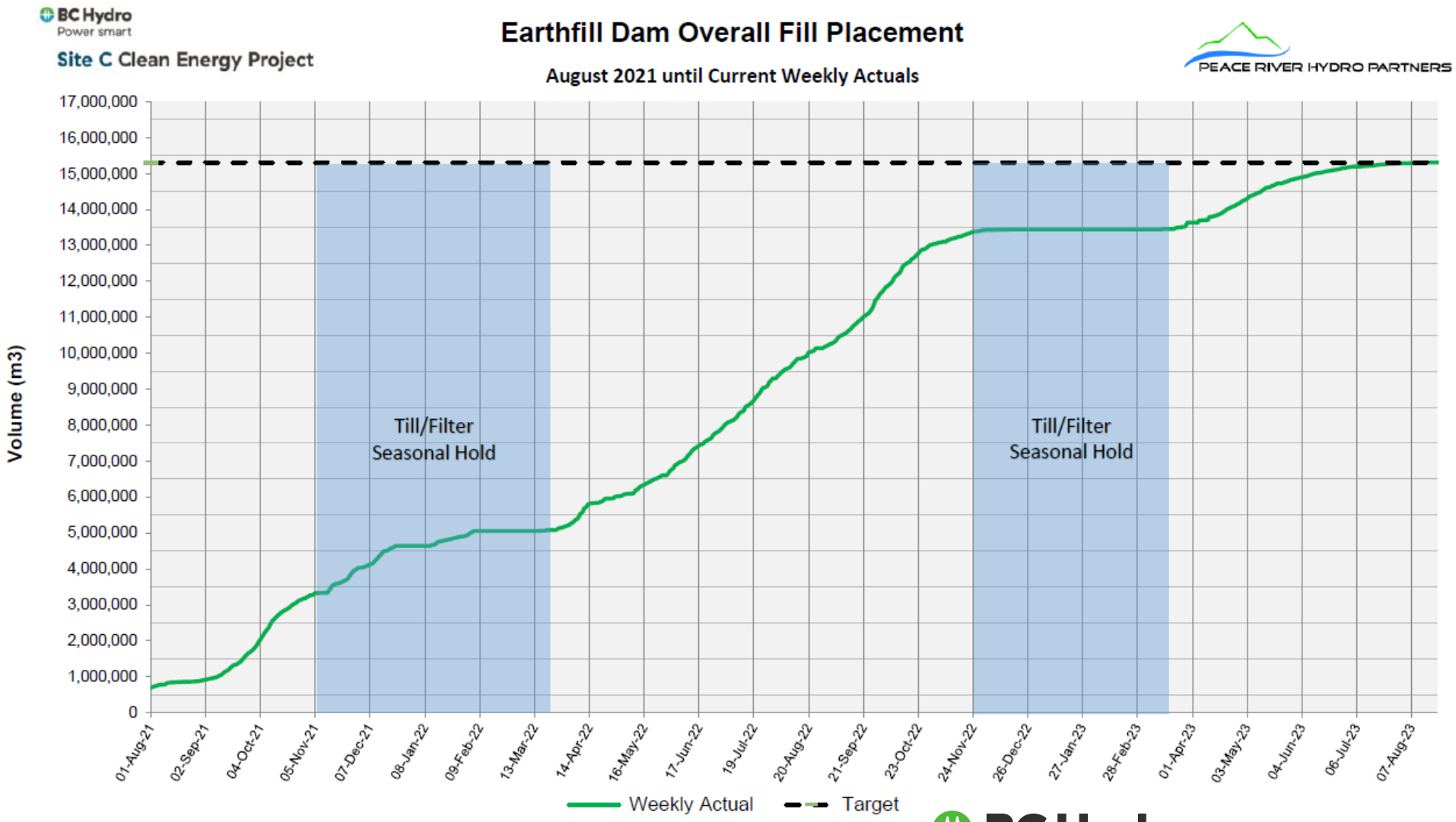
OVERALL PROGRESS CURVE



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OTHER USES

- Quantification of Stockpiles
  - Materials on the ground; delivered to site
- Extent of Excavations
  - Tracking excavations
- Royalties on materials
  - paid to Government for non BC Hydro owned properties

OTHER USES

- The Point Clouds
- Engineering
- Used in a Digital Twin
- Being used by Environmental
- Security
- Construction Management & Project Management
- Regulatory

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QUESTIONS?

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THANK YOU

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