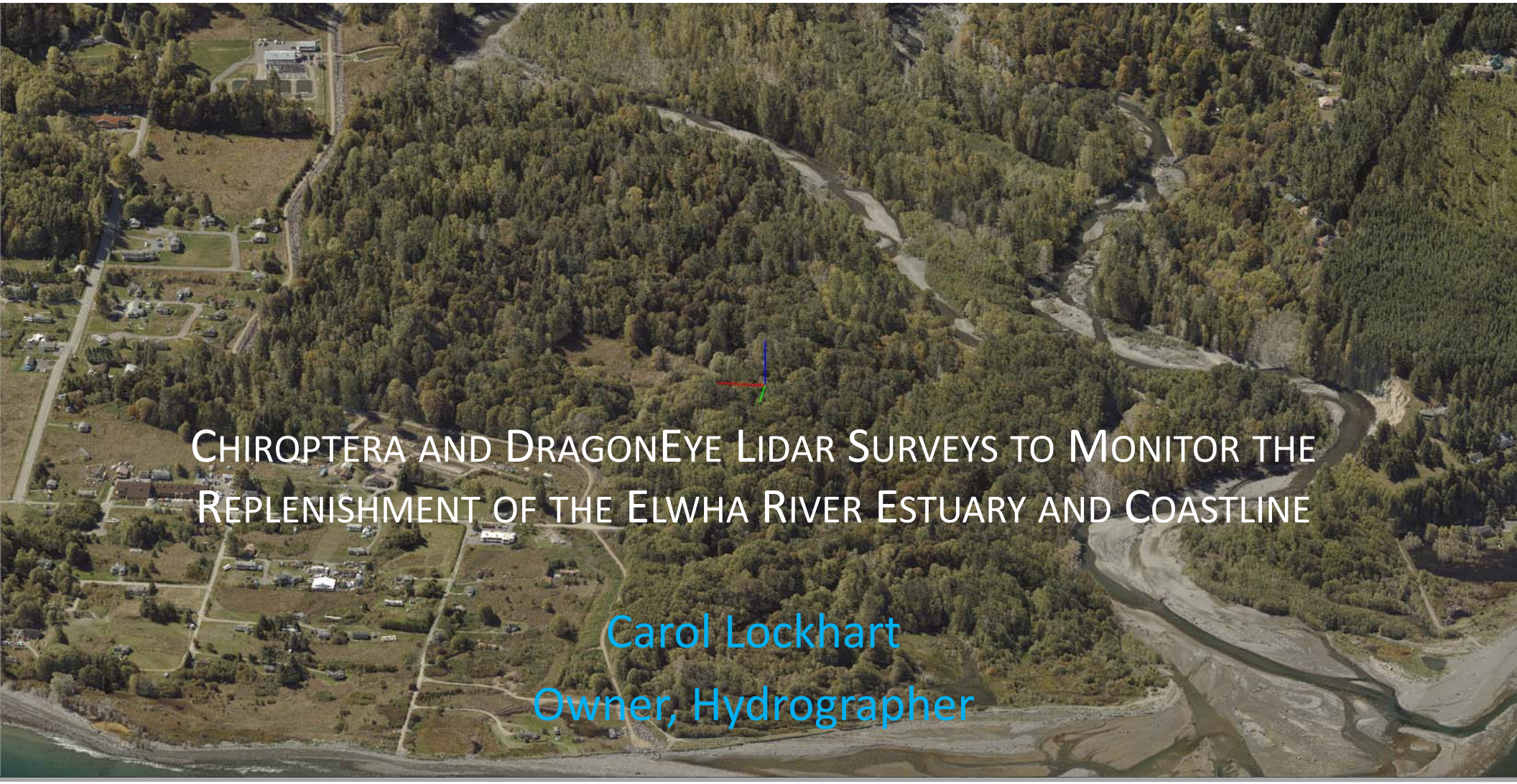


Chiroptera and DragonEye Lidar Surveys to Monitor the Replenishment of the Elwha River Estuary and Coastline

Carol Lockhart

Owner, Hydrographer

GEOMATICS DATA SOLUTIONS

June 15, 2016

THANKS TO

- US Geological Survey (USGS)
  - Tim Saultz & Jonathan Warrick, PhD
  - Conducted under Geospatial Product and Services (GPSC) contract
- Woolpert
  - John Gerhard

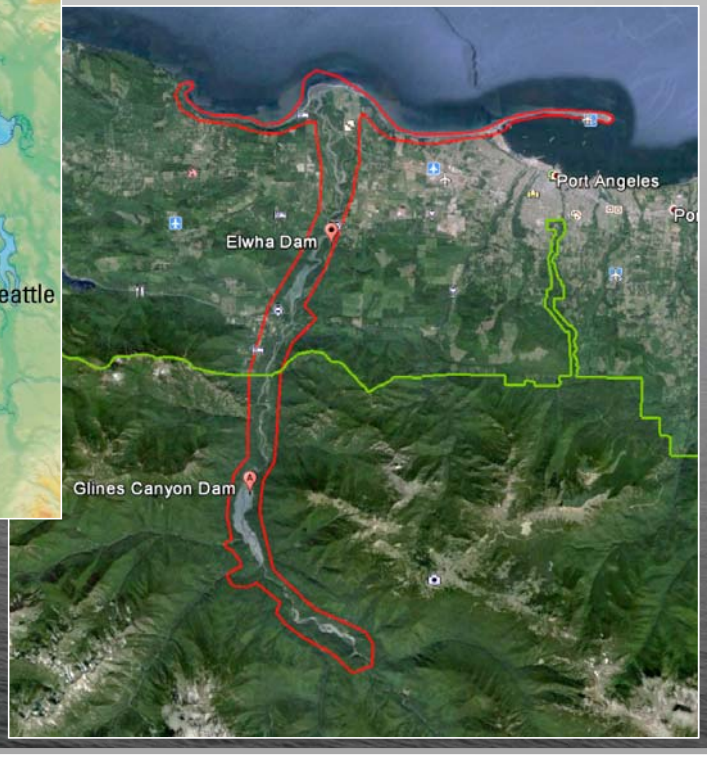
INTRODUCTION

- 2015 and 2016 Lidar Surveys of Elwha River

- Monitor the replenishment of the Elwha River Estuary and the surrounding coastline after the largest dam removal project in US history

- 2015 topo-bathy lidar survey
- 2016 topo only lidar survey

PROJECT LOCATION



Elwha River Dam History

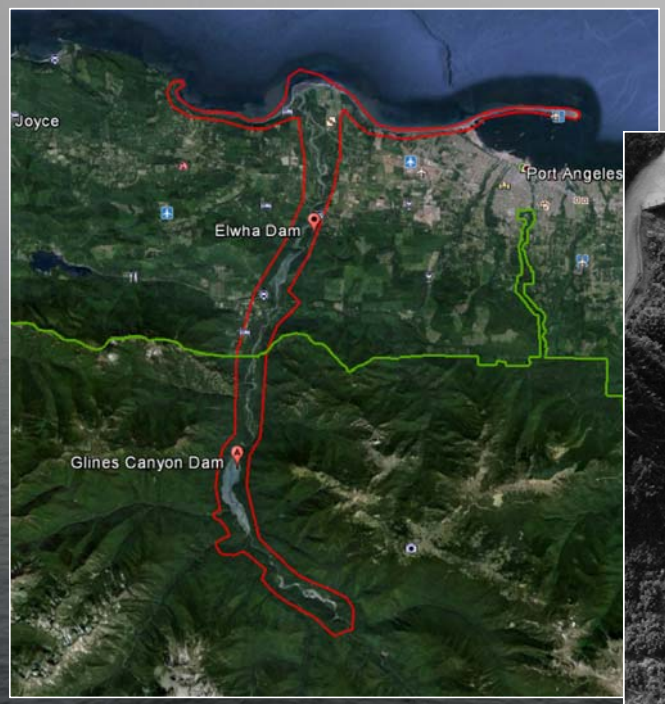
- Elwha Dam built 1910-1913 to power Port Angeles pulp mill
- Glines Canyon Dam operational in 1927 – increased demand from industry

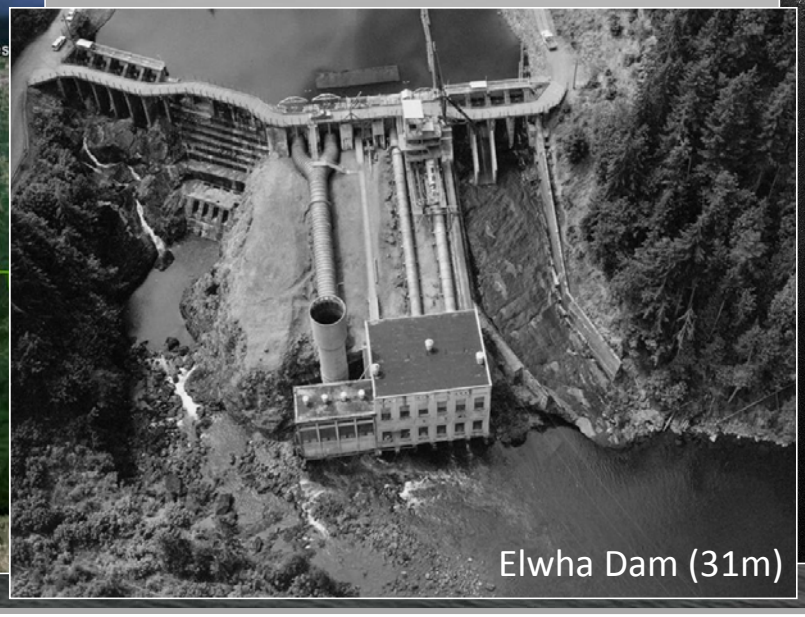
- Blocked migration of salmon
- Disrupted flow of sediment and wood downstream
- Flooded the historic homelands & cultural sites of Lower Elwha Klallam Tribe.

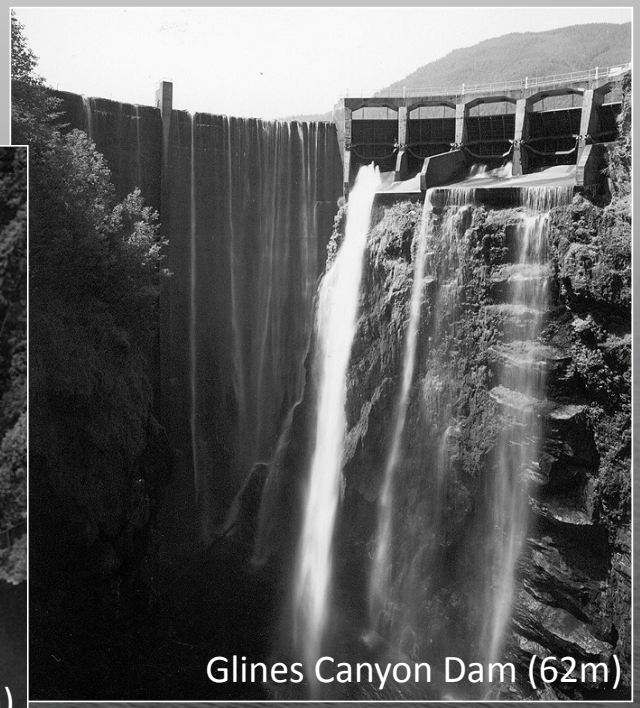
- 1992 - Elwha River Ecosystem and Fisheries Restoration Act
  - Remove dams to restore the altered ecosystem
  - Largest dam removal project in US history

Elwha River Dam Removal Project

- Removal of Elwha and Glines Canyon Dams began September 2011
- Elwha completed in 6 months. Glines Canyon completed August 2014




Elwha Dam (31m)

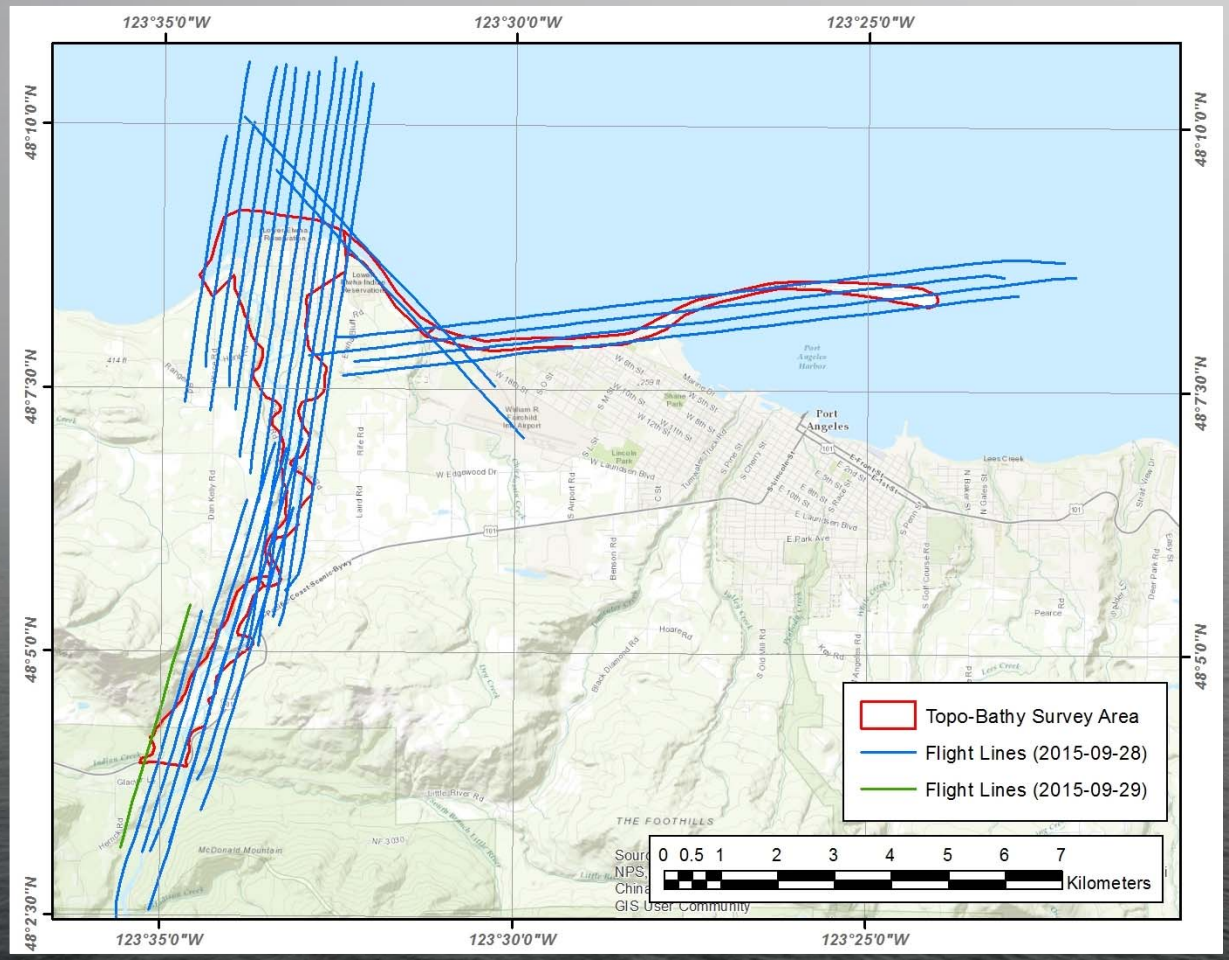

Glines Canyon Dam (62m)

Two Part Survey

- Chiroptera II, with RCD30 4-band imagery (Topo-bathy)
  - 28-29 September, 2015
- Dual-Head DragonEye, with RCD30 4-band imagery (Topo Only)
  - 29 March, 2016

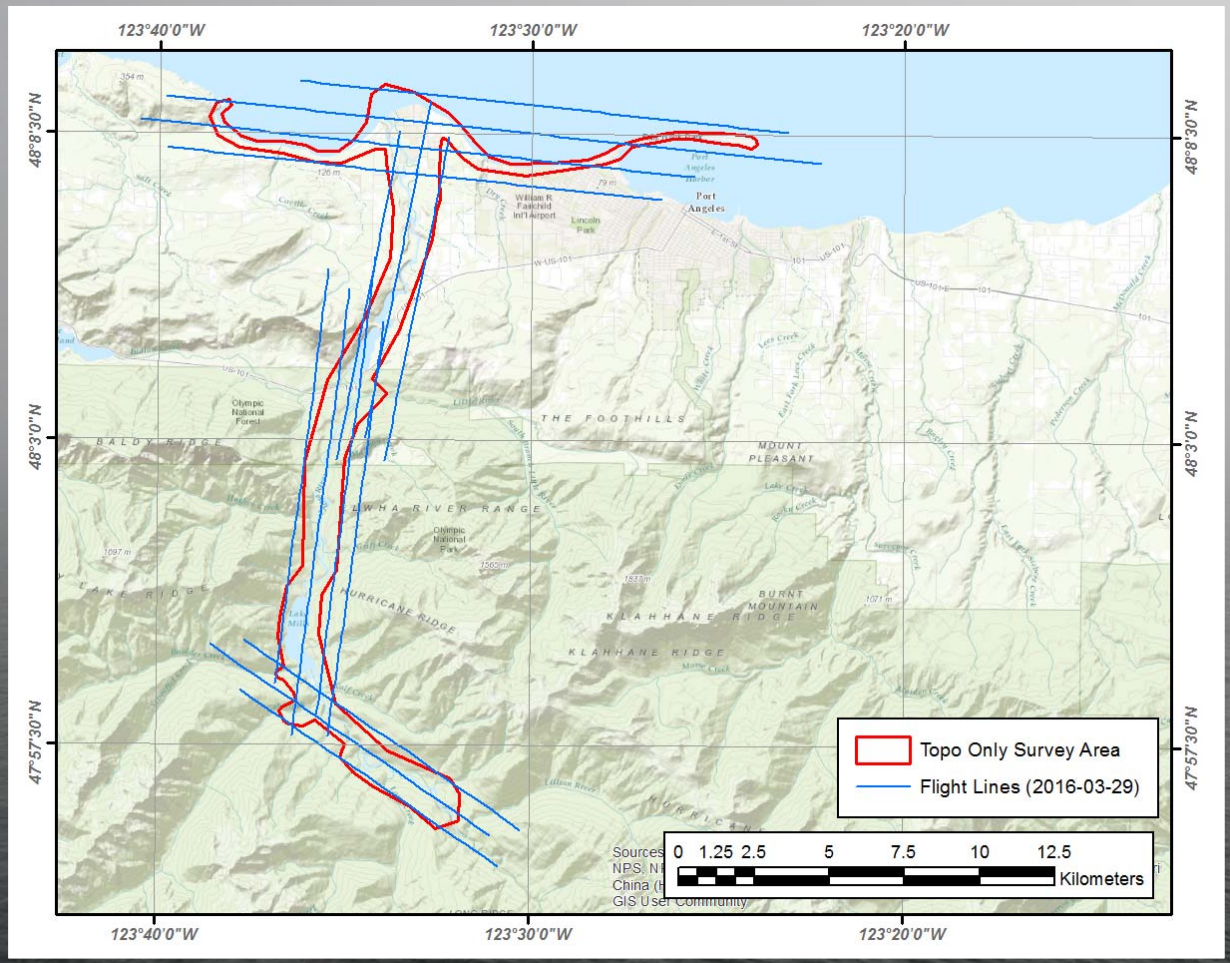
Settings	Topo-Bathy	Topo Only
Topo PRF (kHz)	300	320
Topo Points per m^2	11	3.3
Bathy PRF (kHz)	35	-
Bathy Points per m^2	1.29	-
Swath Width (m)	280	1050
Flight Line Sidelap (%)	15	15
Altitude (m)	400	1500
Survey Speed (knots)	125	125

Topo-Bathy Survey Area



- 27 Flight Lines
- 9.68km^2 (3.73 miles^2)
- Single GNSS base station at Port Angeles Airport

Topo Only Survey Area



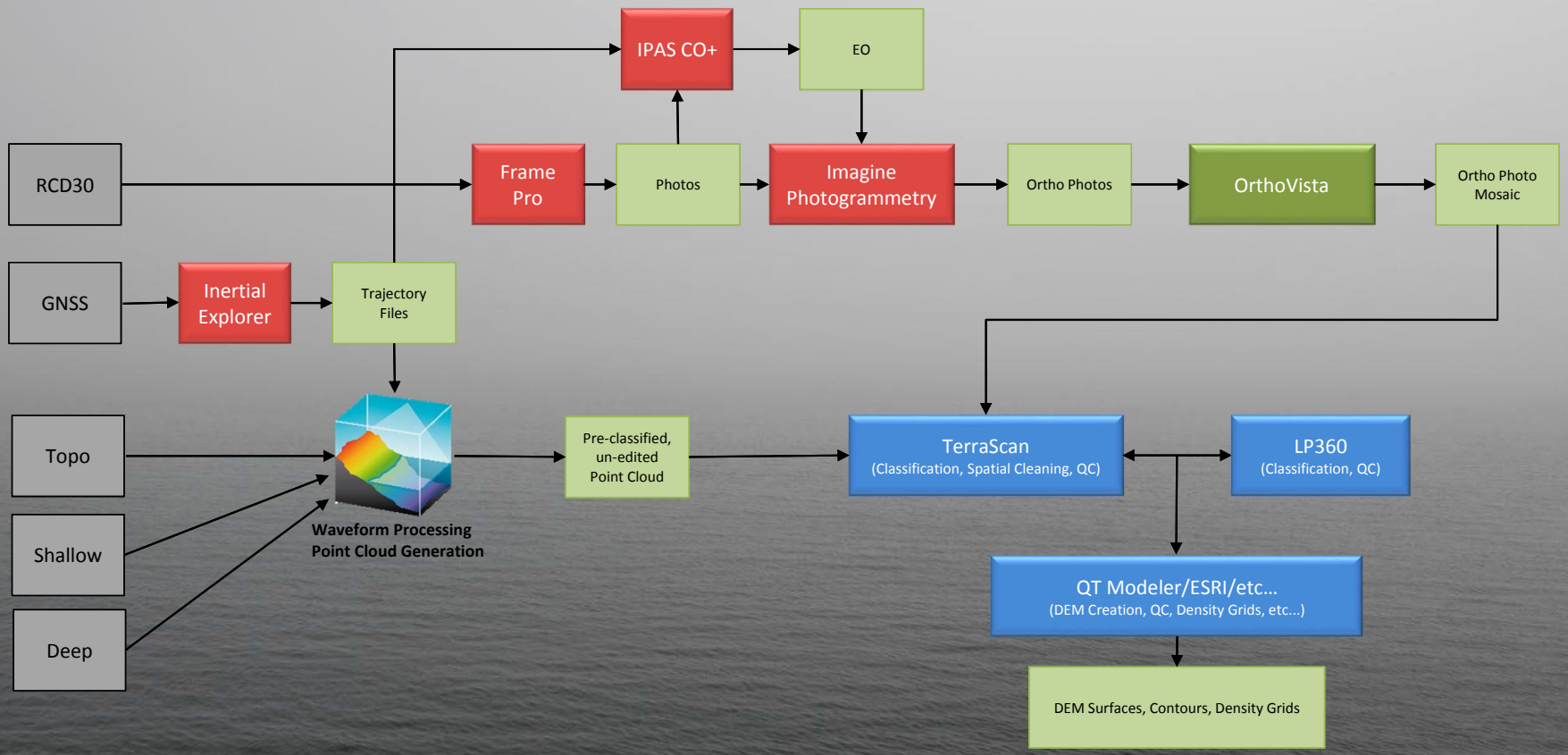
- 14 Flight Lines
- 44.9km^2 (17.34 miles^2)
- Single GNSS base station at Port Angeles Airport

System Calibration

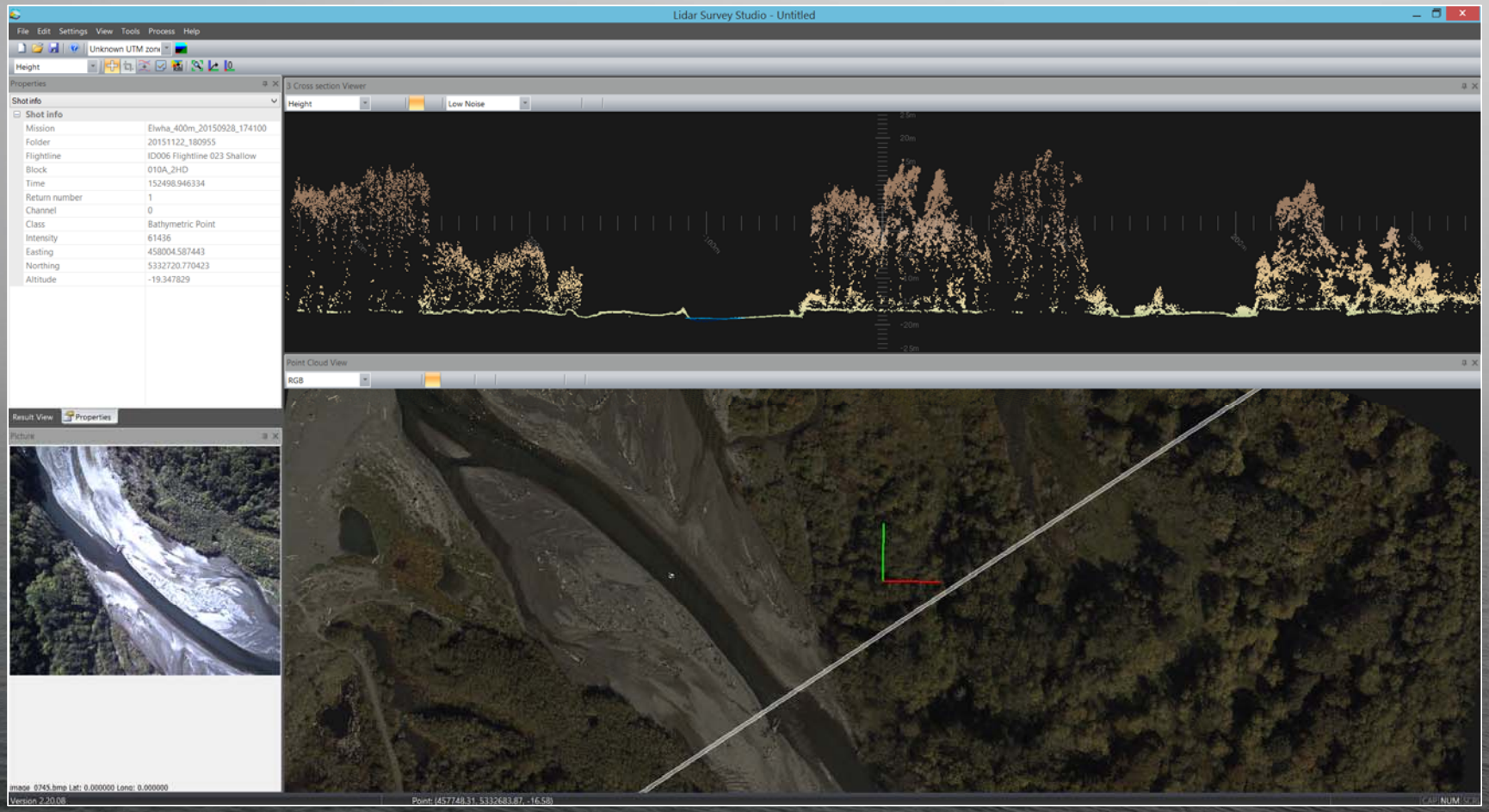
- Scappoose Airport, OR (SPB) – 150 nautical miles south of project
- GDS acquired > 20 000 PPK ground truth points

		Topo-Bathy (Sept 2015)					Topo Only (March 2016)					
Test		Topo			Bathy		Topo Laser 1			Topo Laser 2		
		1000m	500m	400m	500m	400m	1500m	1000m	500m	1500m	1000m	500m
Front to Back Scan Comparison	Average Error (m)	0.0192	0.0124	**0.0078**	0.0230	**0.0165**	**0.0274**	0.0333	0.0233	**0.0249**	0.0240	0.0099
	Std. Dev. of Error	0.0050	0.0032	0.0014	0.0026	0.0026	0.0042	0.0122	0.0043	0.0026	0.0106	0.0031
Comparison to Ground Truth	Average dZ (m)	-0.0209	-0.0027	**-0.0019**	0.0061	**0.0085**	**0.0195**	-0.0070	-0.0242	**0.0159**	0.0067	-0.0227
	RMSE (m)	0.0292	0.0126	**0.0164**	0.0244	**0.0238**	**0.0311**	0.0253	0.0308	**0.0284**	0.0203	0.0275

General Data Processing Work Flow



PROCESSING IN LSS

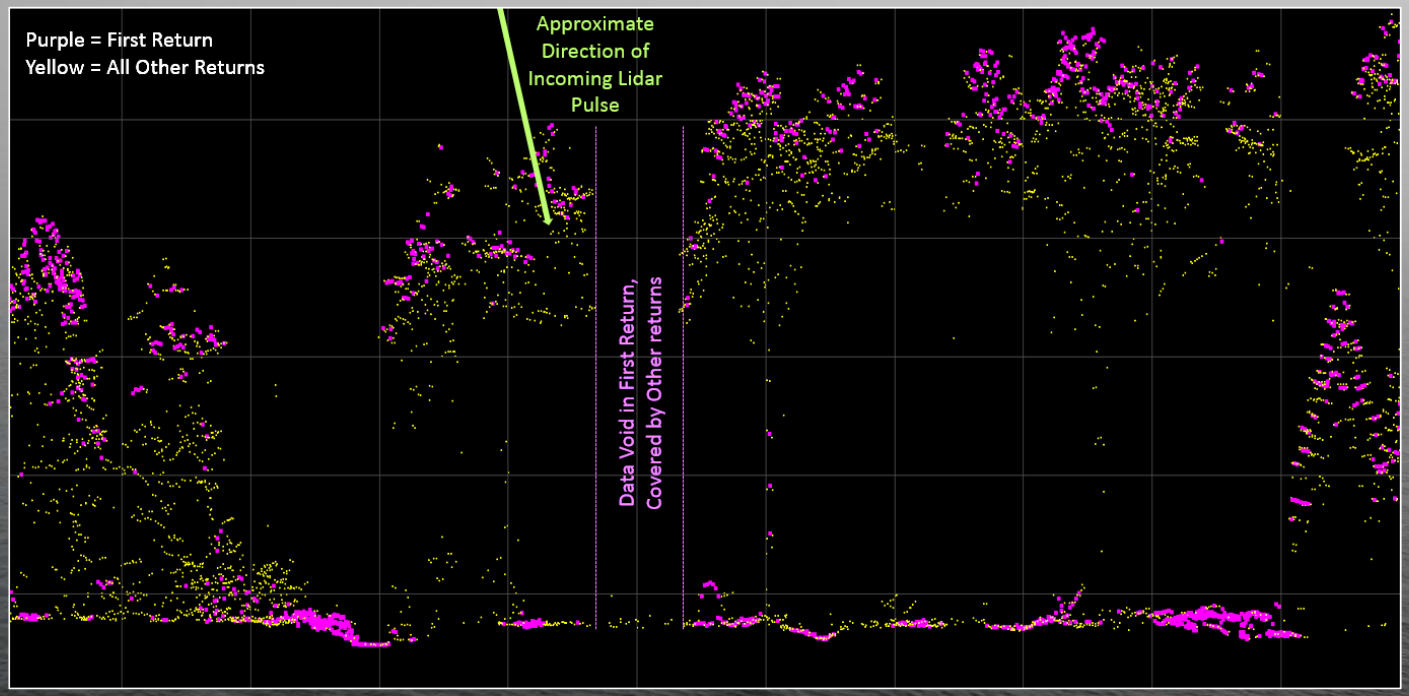


DATA QC

- USGS, National Geospatial Program (NGP) Lidar Base Specification, Version 1.2
  - Data Voids
  - Spatial Distribution
  - Relative Vertical Accuracy
    - Within Swath
    - Between Adjacent Swaths
  - Absolute Vertical Accuracy
    - Point Cloud
    - DEM

Data QC - Interesting Data Points

- Issues with Data Voids and Spatial Clustering Checks using First Return Only

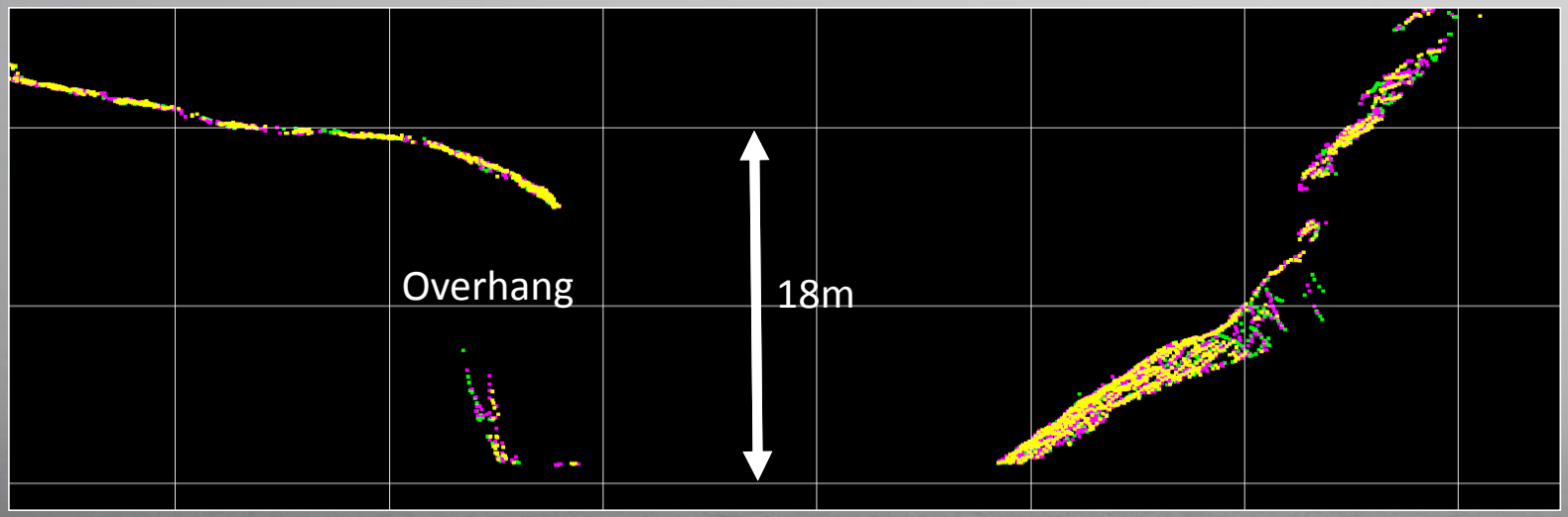


Data QC – Interesting Data Points

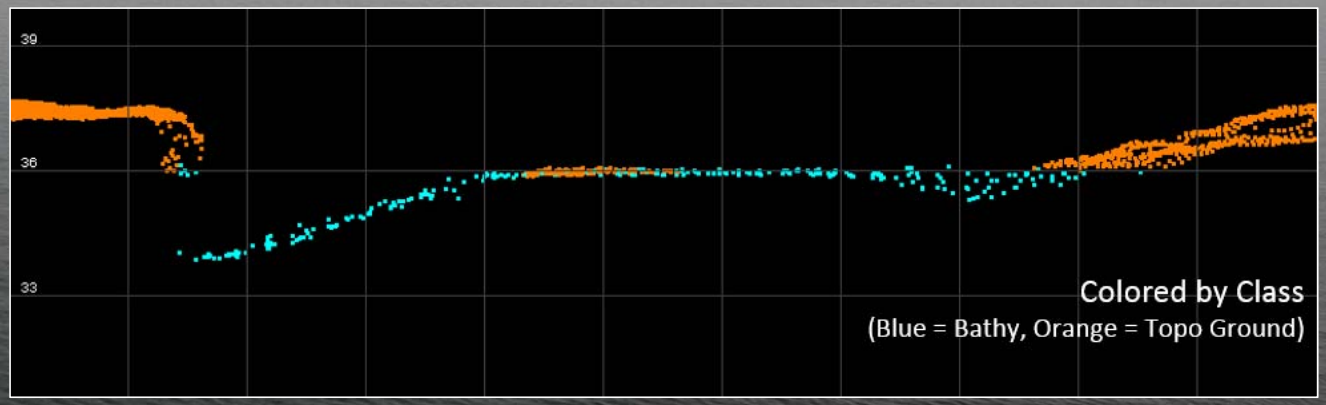
- Overlap consistency checks in steep overhanging areas

	Topo	Topo Required	Bathy	Bathy Required
RMSDz (cm)	4.3	< 8	6.8	<14.8
Maximum Difference (cm)	186.1	+/- 16	91.5	+/- 29.6
Mean Delta Z (cm)	2.9		5.0	
St Dev. Of Delta Z (cm)	3.2		4.5	
No. of Comparison Cells	1,753,381		296,370	
% of cells above required Maximum	0.86		0.30	

Data QC – Interesting Data Points



Topo Example

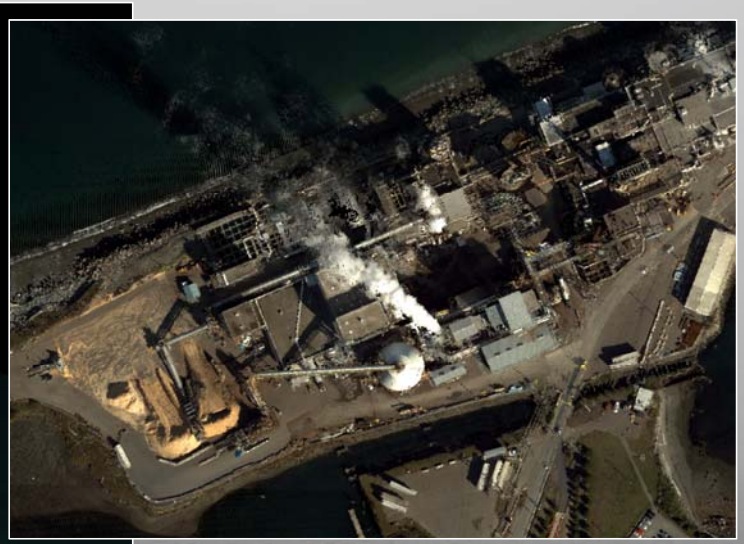


Bathy Example

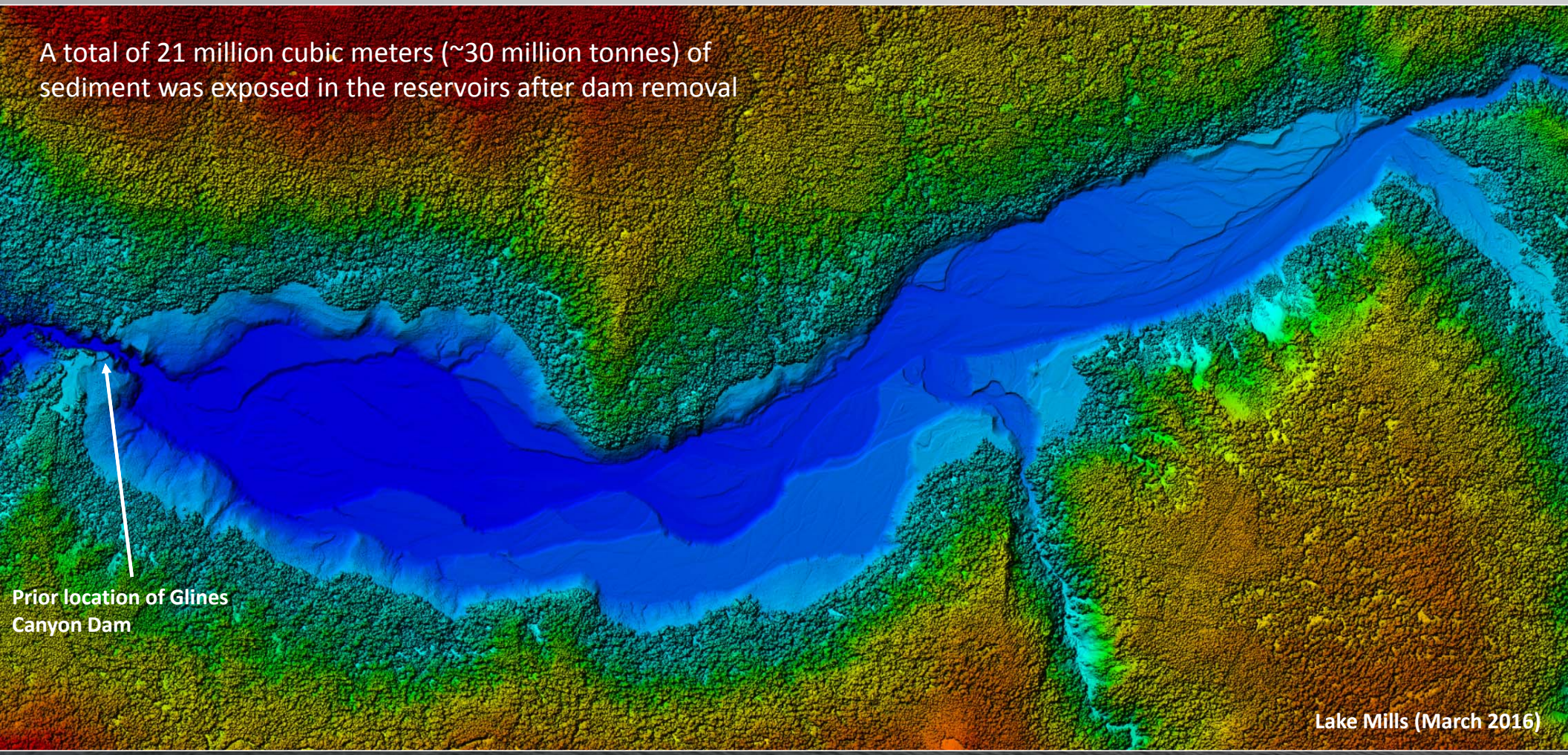
Products Created

- LAS 1.4, point record 7 format (by Tile and by Flight Line)
- RCD30 4 Band Imagery Mosaics (by Tile)
- Bare Earth DEM (by Tile)
- Intensity Images (by Tile)
- FGDC metadata files by Product Type

Colorized Point Cloud

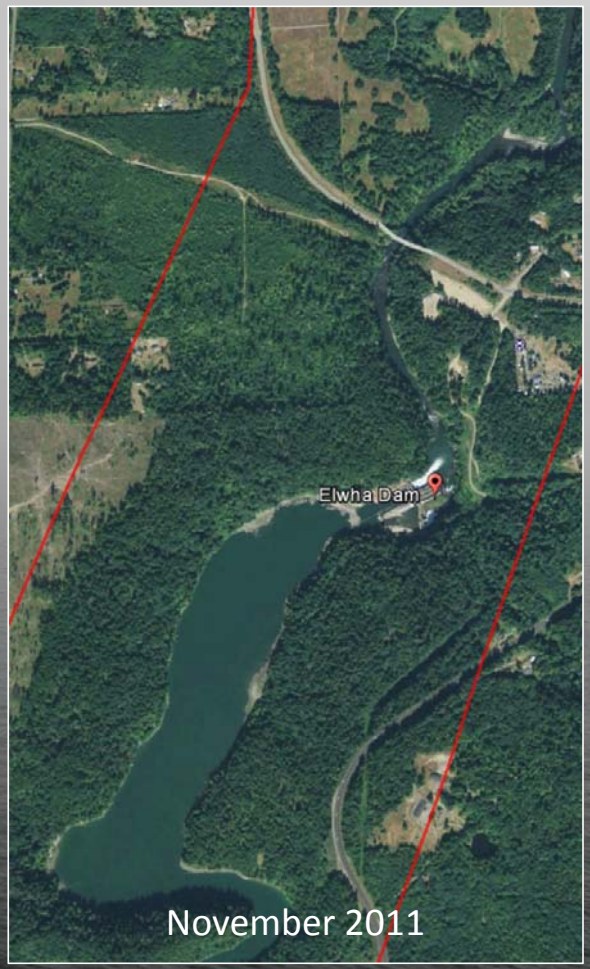


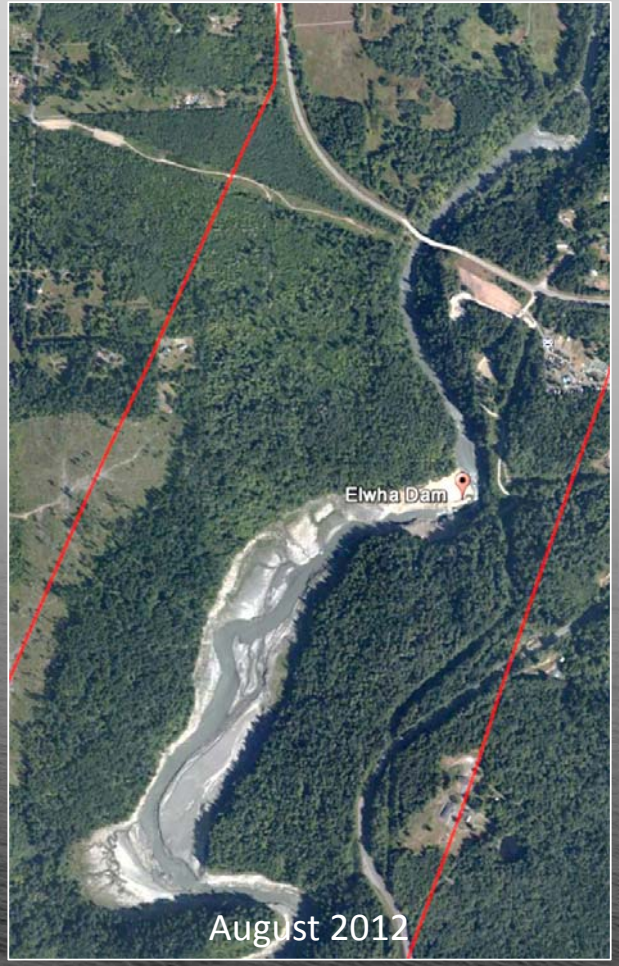
Steep Slopes Represented


A total of 21 million cubic meters (~30 million tonnes) of sediment was exposed in the reservoirs after dam removal
Prior location of Glines Canyon Dam
Lake Mills (March 2016)

ELWHA DAM

Elwha Dam
September 2009

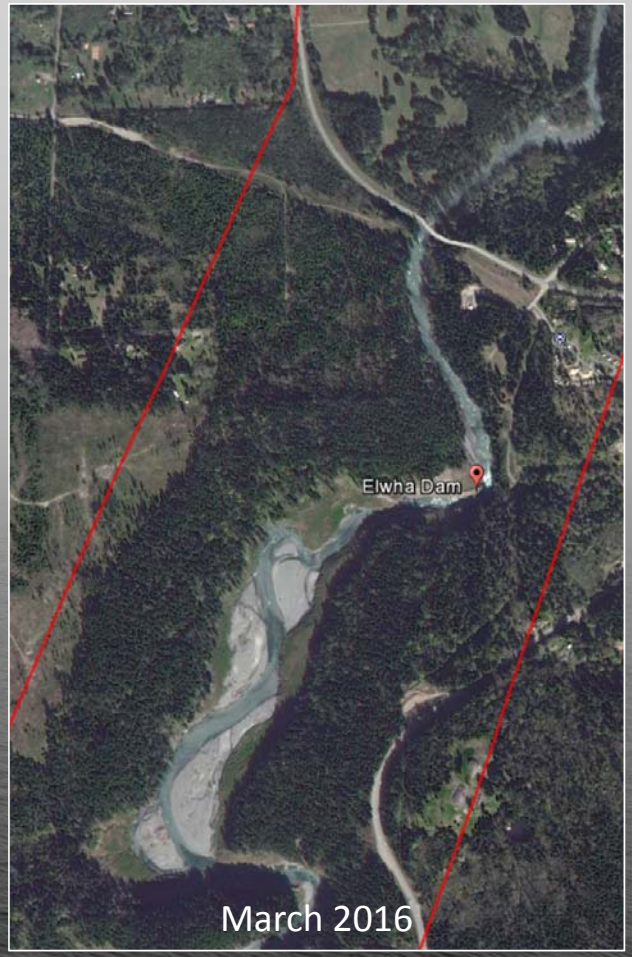

Elwha Dam
November 2011


Elwha Dam
August 2012

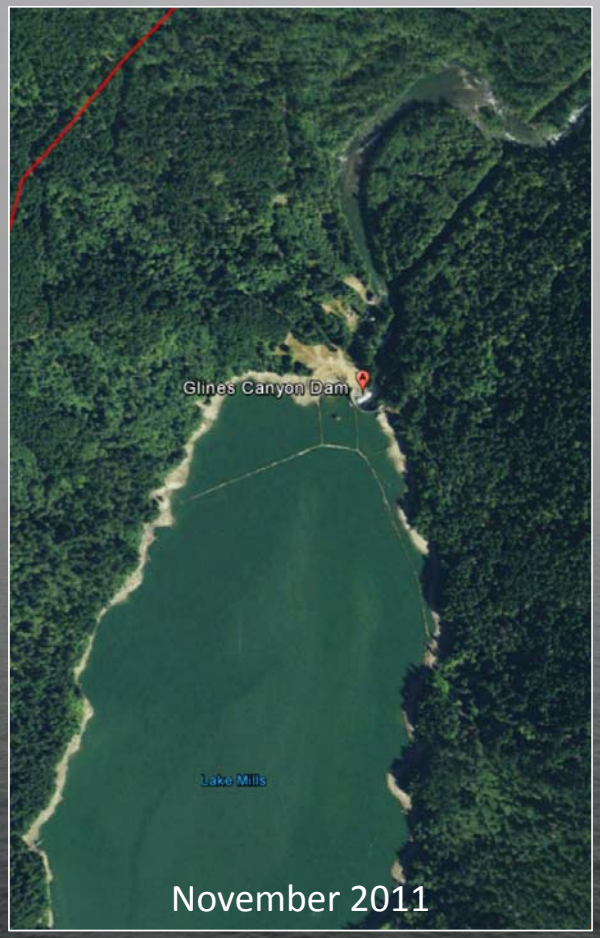
Elwha Dam

Elwha Dam
July 2013

Elwha Dam
September 2015


Elwha Dam
March 2016

GLINES CANYON DAM



November 2011

August 2012

July 2013

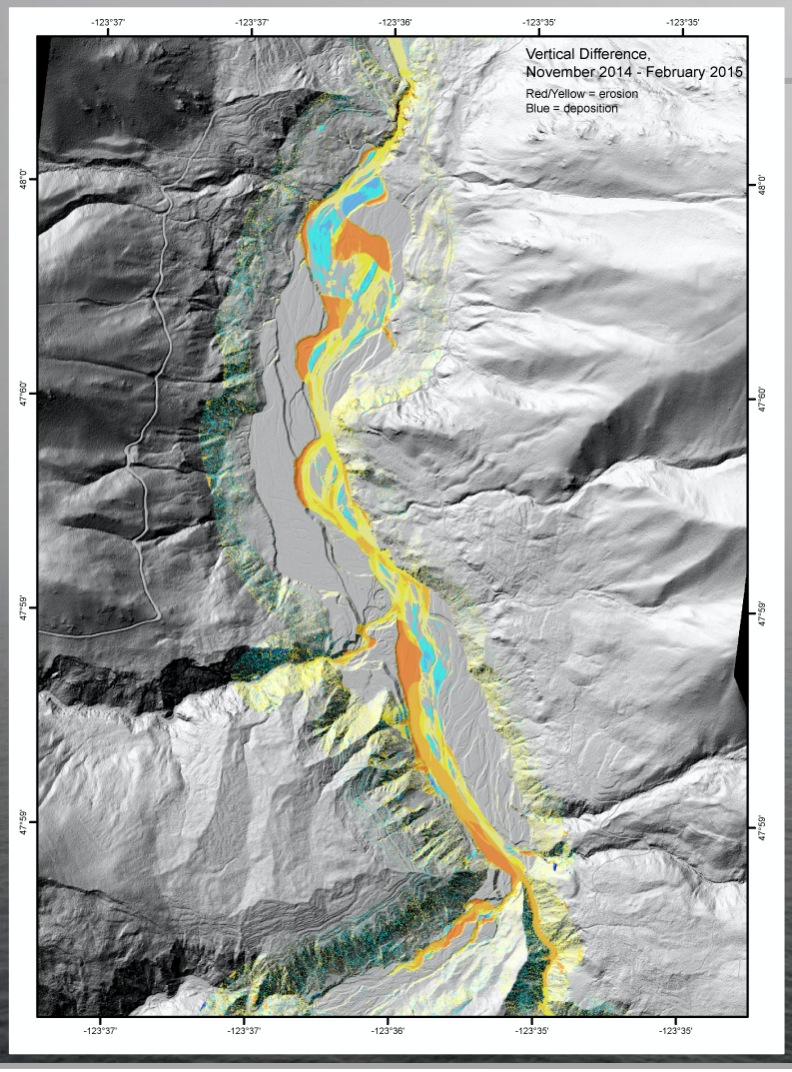
GLINES CANYON DAM

July 2013

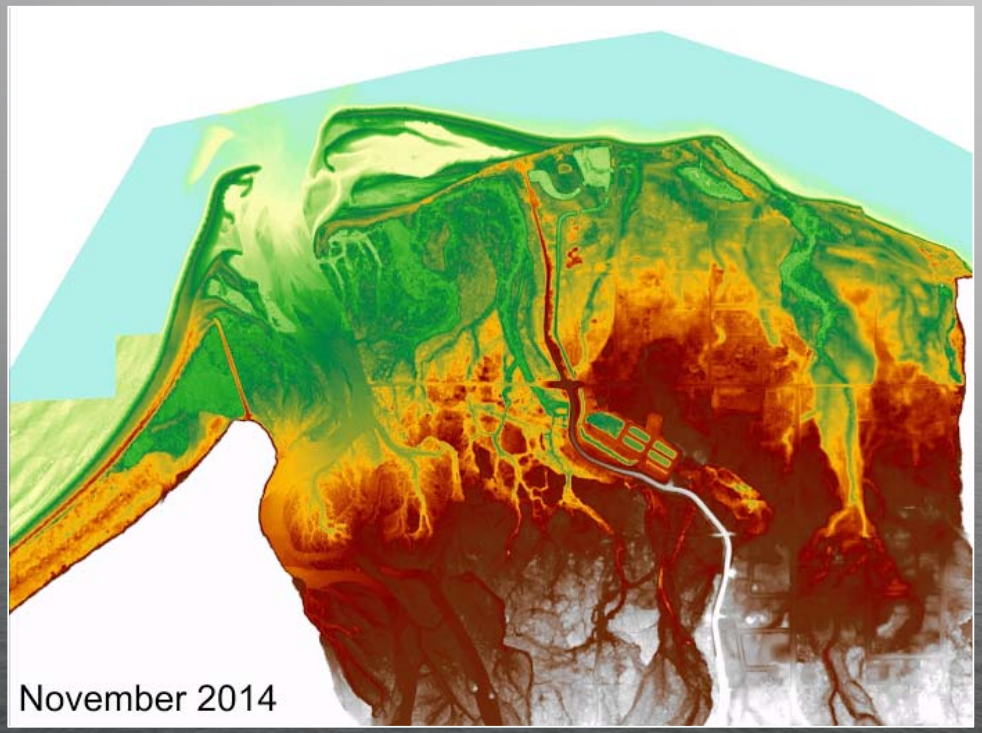
September 2015

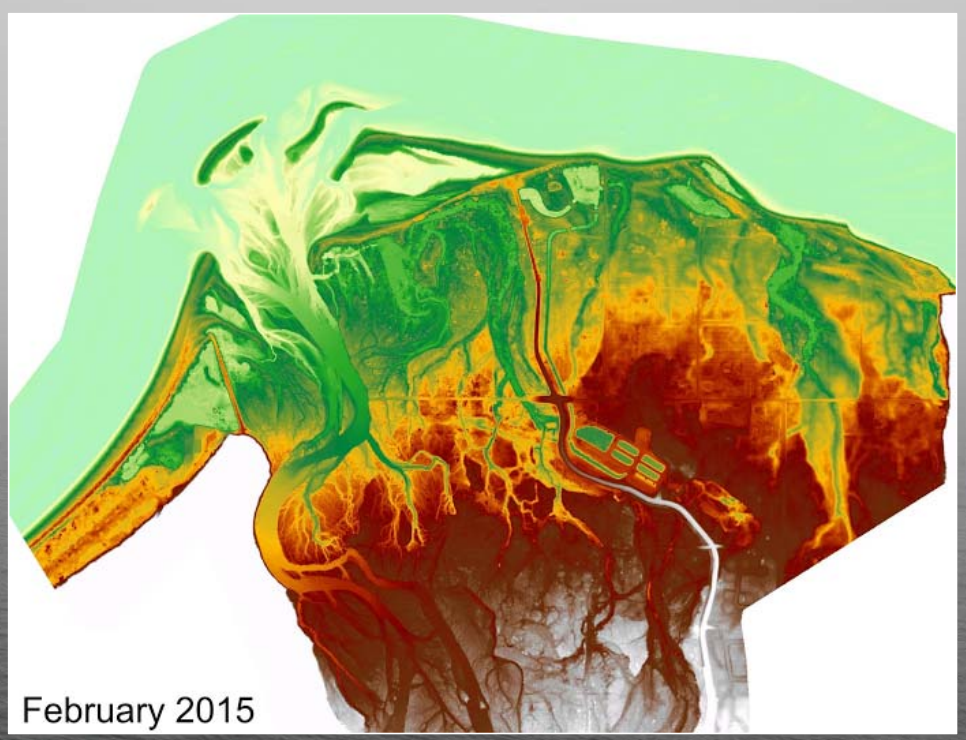
March 2016

Changes in Sediment

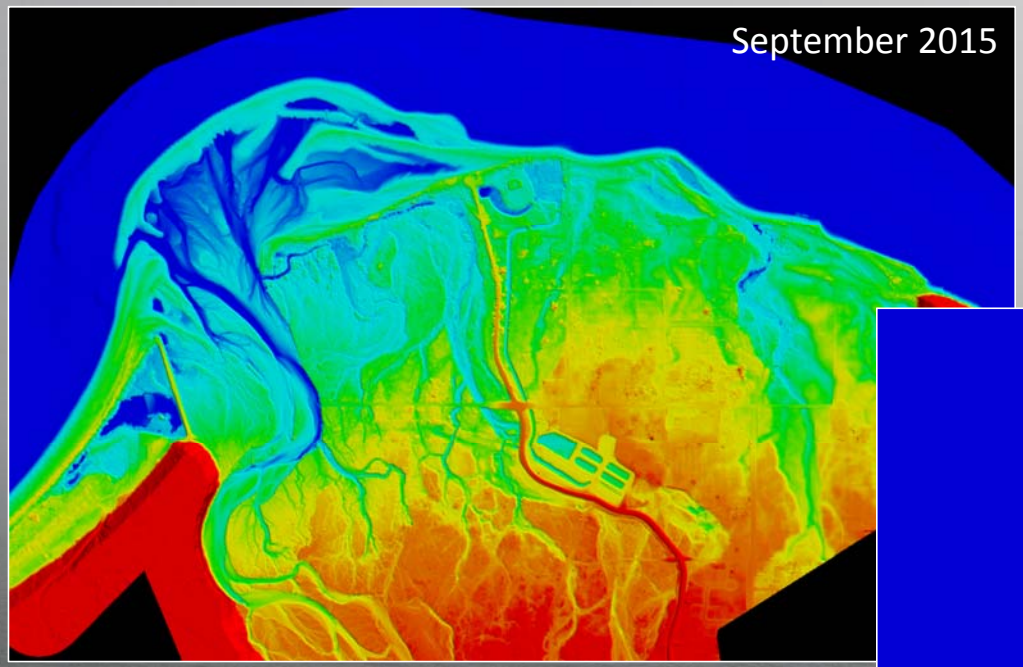


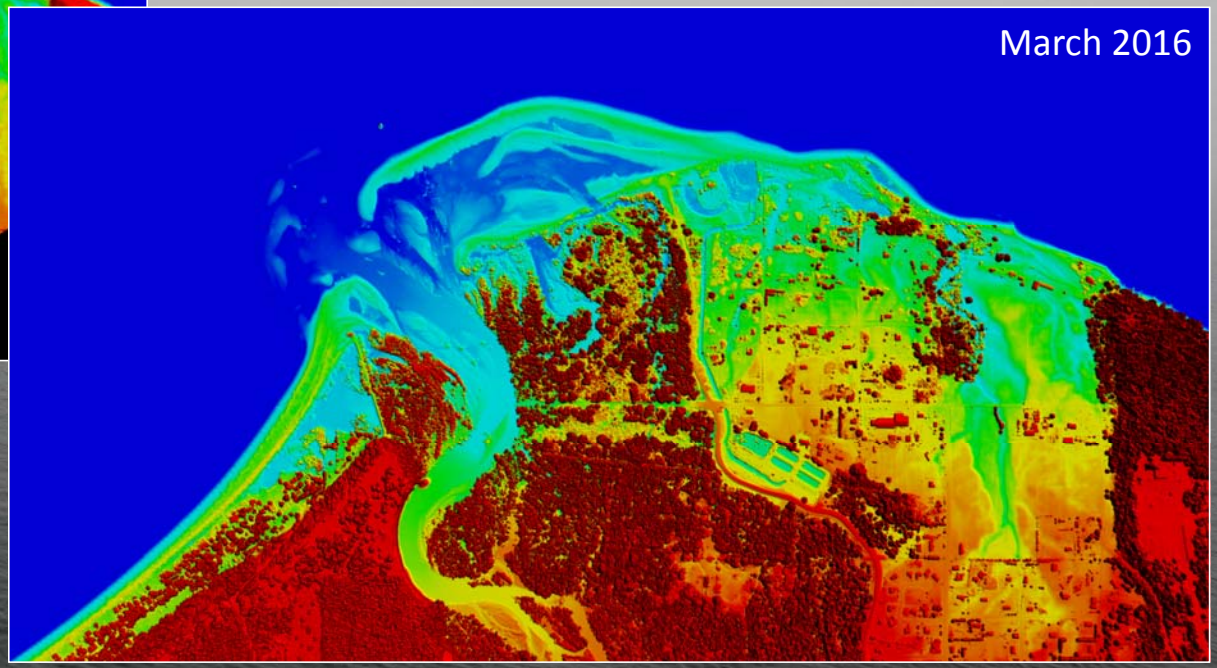
Coastal Changes in Sediment





Coastal Changes in Sediment





THANK YOU

Carol Lockhart

Carol@GeomaticsDS.com