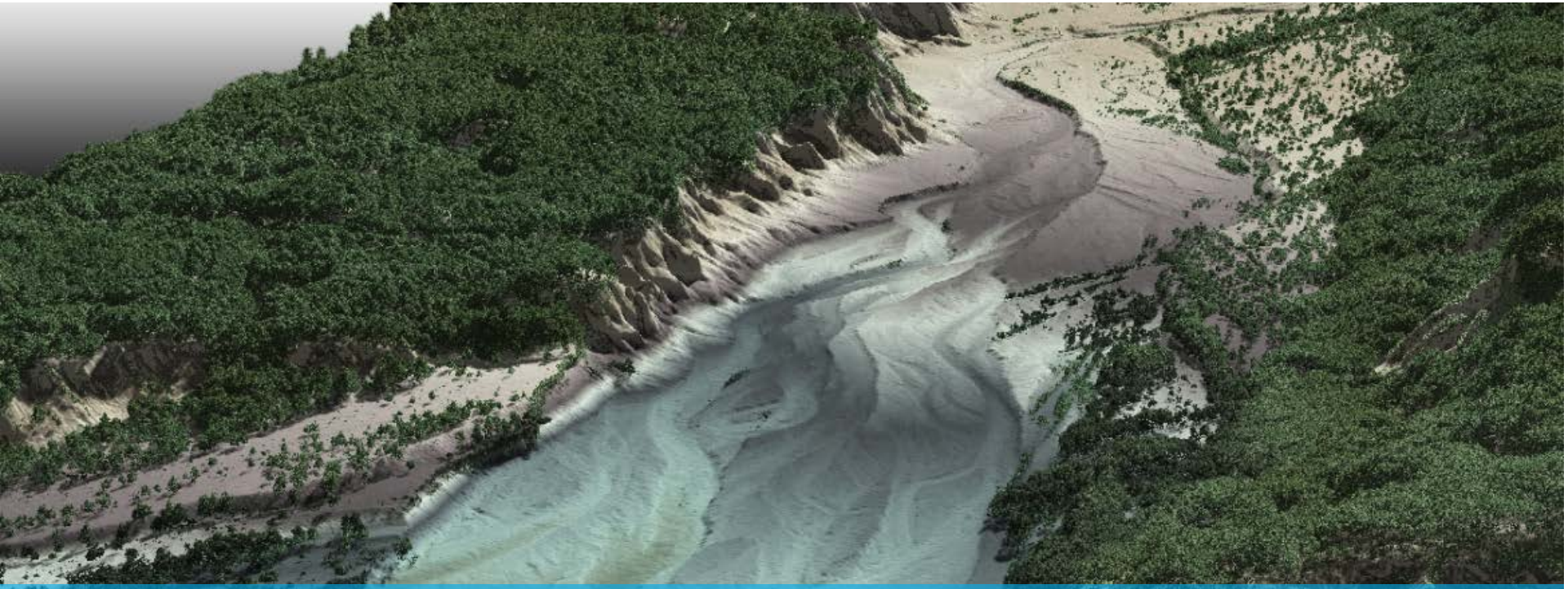
quantum SPATIAL

Application of Topobathymetric Laser Scanning for Mapping Shallow Riverine Environments



Joint Airborne LiDAR Bathymetric Technical Center of Expertise (JALBTCX) Annual Conference, Corvallis, OR 6/18/2015

Russ Faux, Colin Cooper, Nick Kules

- Full-Service Surveying, Mapping, Remote Sensing, and GIS Capabilities.
- 14 Offices in North America with 400+ geospatial professionals.

Acquire

Airborne LiDAR
Topo-Bathy LiDAR
Ground Mobile LiDAR
Large Format Cameras
Oblique Cameras
Thermal Infrared Imaging
Hyperspectral Imaging

Analyze

Topographic Maps
Planimetric Maps
Orthophotos
Full Feature Classification
3D and 4D Models
Enterprise GIS
Geospatial Cloud Solutions

Answer

Regulatory Compliance
Vegetation Analysis
Environmental Monitoring
Land Use and Permitting
Infrastructure Management
Hazard Detection
Disaster Preparedness

Presentation Overview

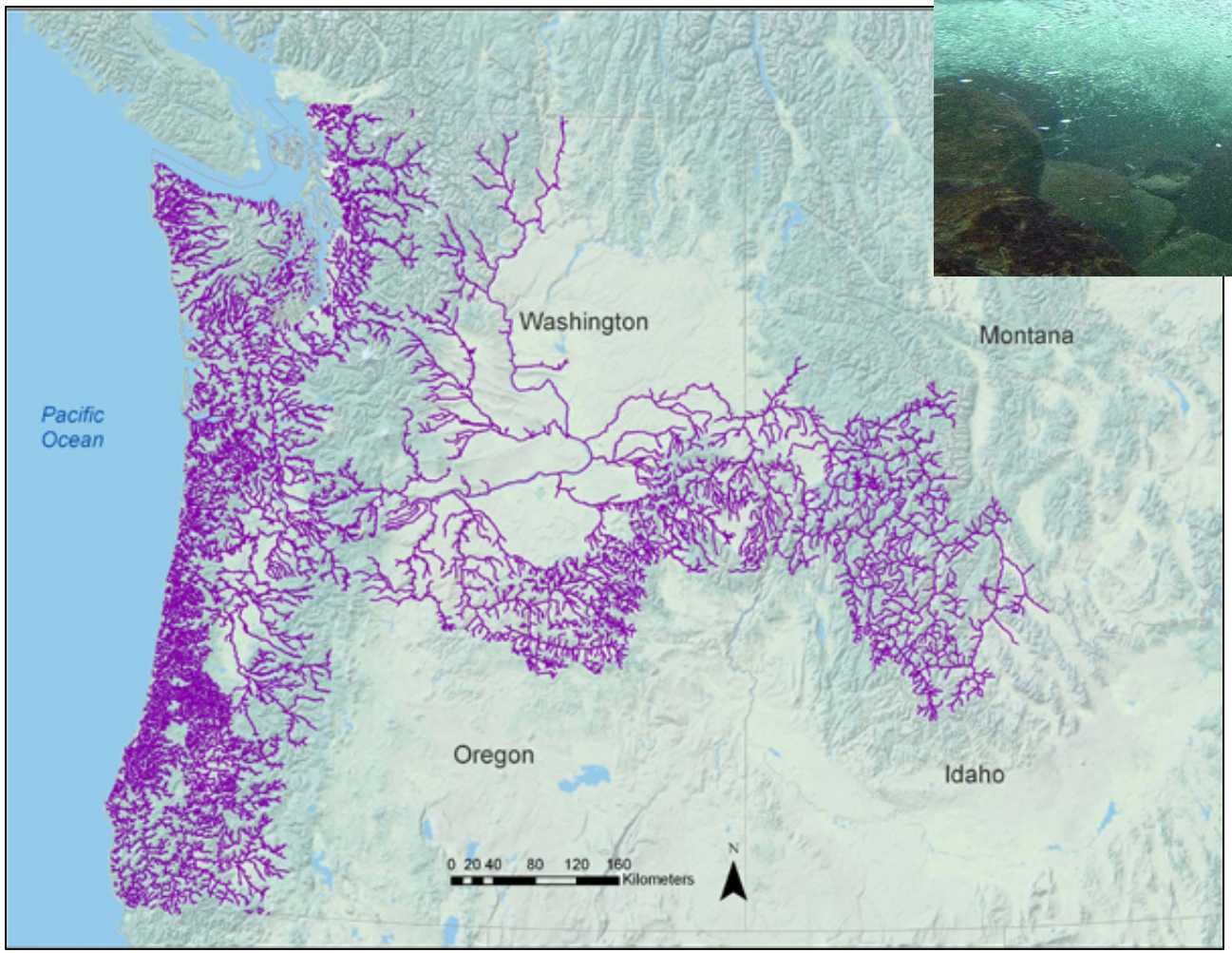
- Background
- Results
  - Accuracy
  - Applications
  - Challenges
- Future Plans

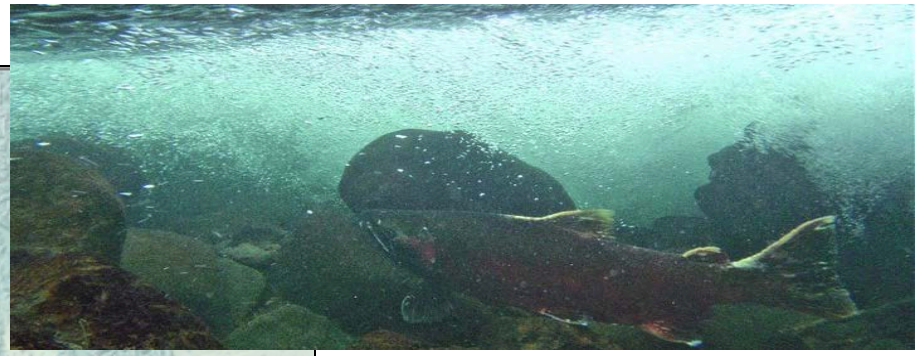
Riverine Applications

Northwestern Division, as all other Corps divisions, is organized to manage its districts' civil works activities based on river basins rather than state boundaries. Its primary civil works missions encompass flood damage reduction, navigation, hydropower, fish and wildlife, water quality, irrigation, recreation, and disaster response. Within its jurisdiction are **77 dams and reservoirs, 29 hydropower plants, and 1,600 miles of navigable channels**."
(http://www.nwd.usace.army.mil/About/History.aspx)

Interagency Regional Monitoring Program - The Aquatic and Riparian Effectiveness Monitoring Plan (AREMP) characterizes the ecological condition of watersheds and aquatic ecosystems in the entire area covered by the Northwest Forest Plan (57 million acres).

Salmon Habitat – Pacific Northwest

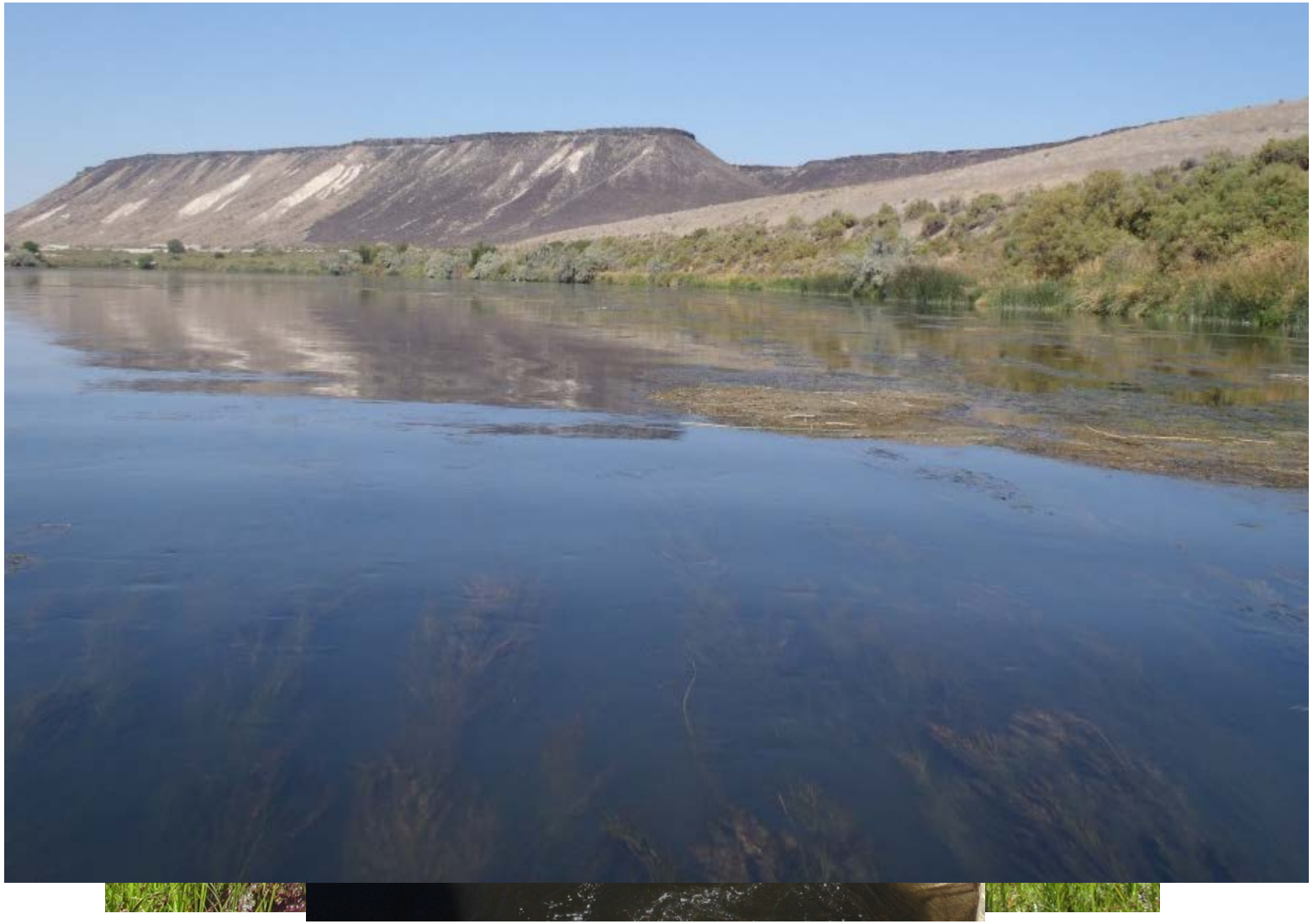




Pacific Salmon migrate 900 miles inland!

http://stateofthecoast.noaa.gov/com_fishing/pacific_salmon.html

Pacific Northwest Rivers



Topo-Bathy Sensor

- QSI deployed the Riegl VQ-820-G sensor with co-acquired NIR LiDAR and 3-band digital imagery.
  - High Pulse Rate, Short Pulse Width
  - Online waveform digitizing
  - Full Wave Form

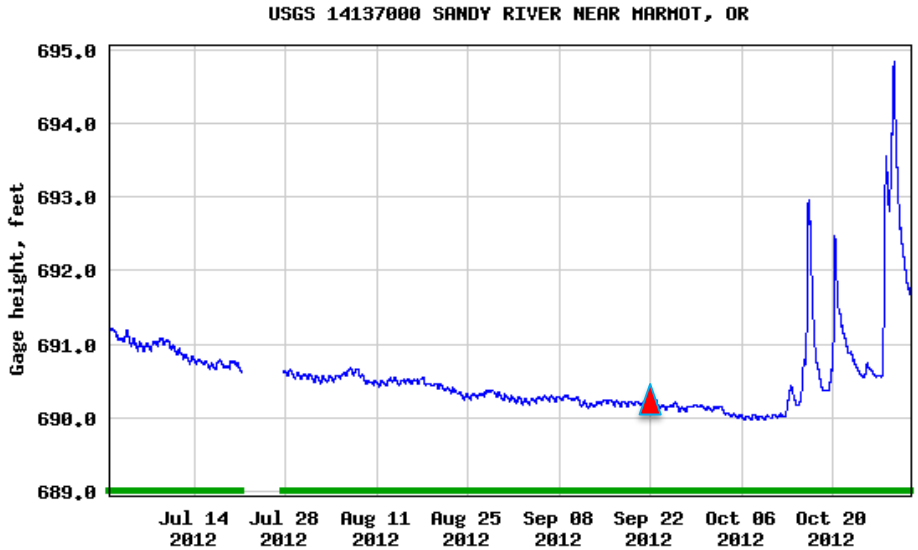
Riegl VQ-820G Bathymetric Sensor

LiDAR Survey Settings & Specifications	
Aircraft Used	Cessna Caravan
Sensor	**Riegl VQ-820G**
Survey Altitude (AGL)	600 m
Target Pulse Rate	284 kHz
Laser Spot Diameter	60 cm
Field of View	40^0
GPS Baselines	≤13 nm
Maximum Returns	unlimited
Intensity	16-bit
Resolution/Density	≥ 4 pulses/m^2

Project: Sandy River, OR

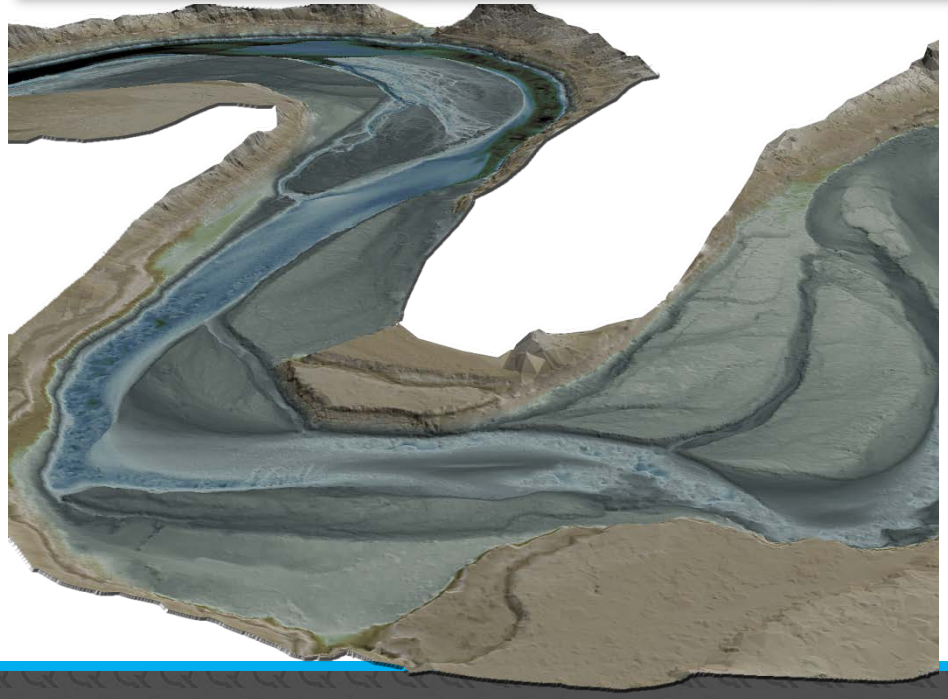
Survey Conditions:

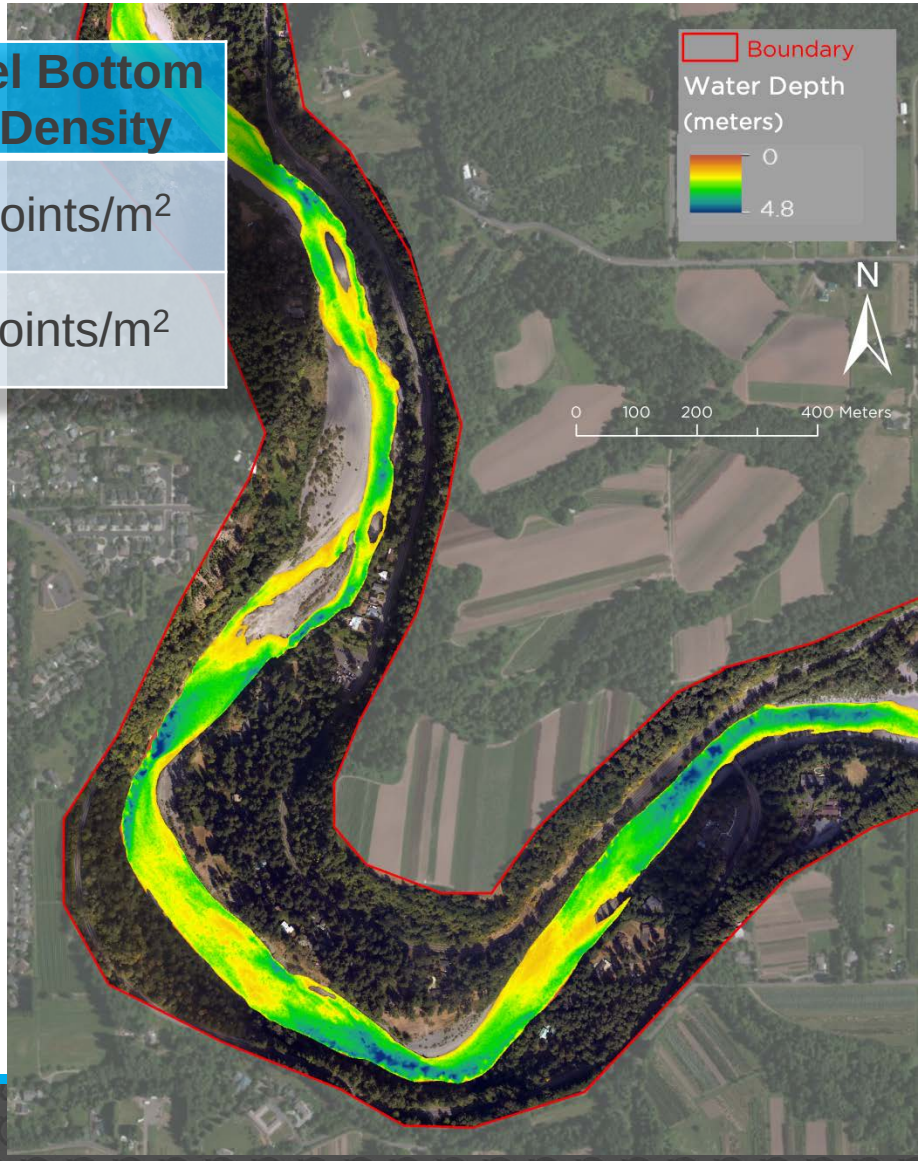
- 42 miles of river
- Low flow, maximum water clarity
- Secchi depth = 2.1 meters measured at Oxbow Park

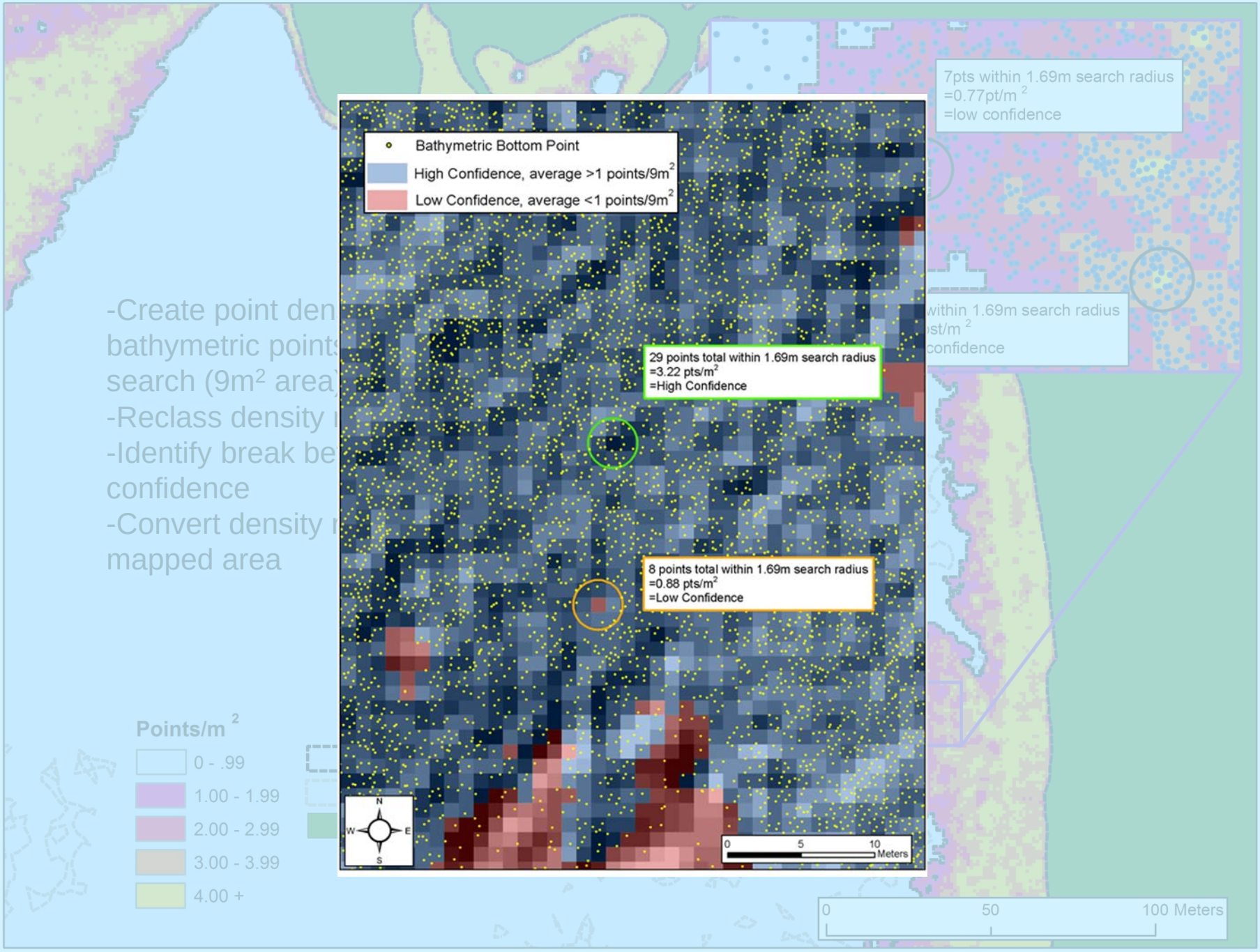


Sandy River, Oregon

Cover Classification	% of total area	Channel Bottom Point Density
High Confidence	83%	1.96 points/m^2
Low Confidence	17%	0.11 points/m^2

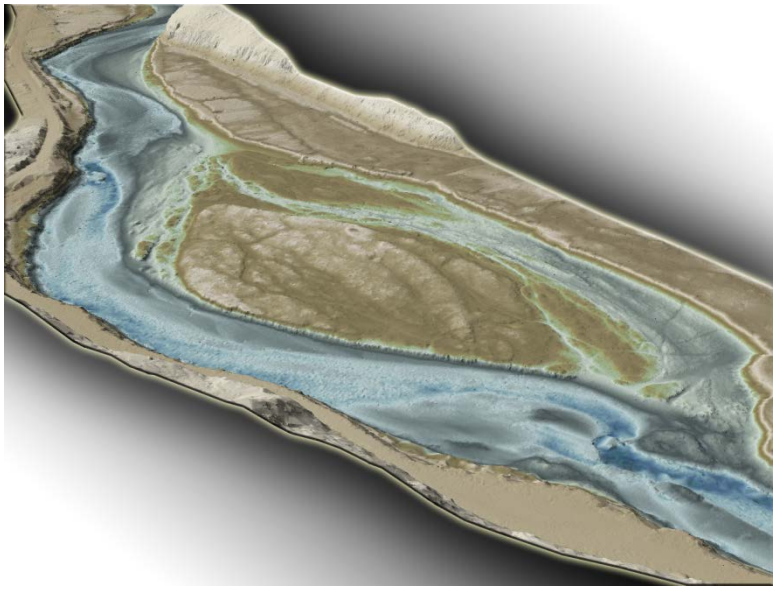





7pts within 1.69m search radius
=0.77pt/m 2
=low confidence
-Create point den
bathymetric point
search (9m2 area
-Reclass density
-Identify break be
confidence
-Convert density
mapped area
Points/m 2
0 - .99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 +
0
50
100 Meters
Bathymetric Bottom Point
High Confidence, average >1 points/9m2
Low Confidence, average <1 points/9m2
29 points total within 1.69m search radius
=3.22 pts/m2
=High Confidence
8 points total within 1.69m search radius
=0.88 pts/m2
=Low Confidence
N
W
E
S
0
5
10
Meters

Accuracy – Sandy River

	Bare Earth (Topo) Absolute Accuracy (Hard Surface RTK points)	High Confidence Bathymetric Accuracy (In Channel Points)	Low Confidence Bathymetric Accuracy (In Channel Points)
Sample	164	303	28
Median (m)	0.004	-0.058	-0.248
RMSE (m)	0.030	0.184	0.418
1σ (m)	0.030	0.177	0.397
1.96σ (m)	0.060	0.347	0.779

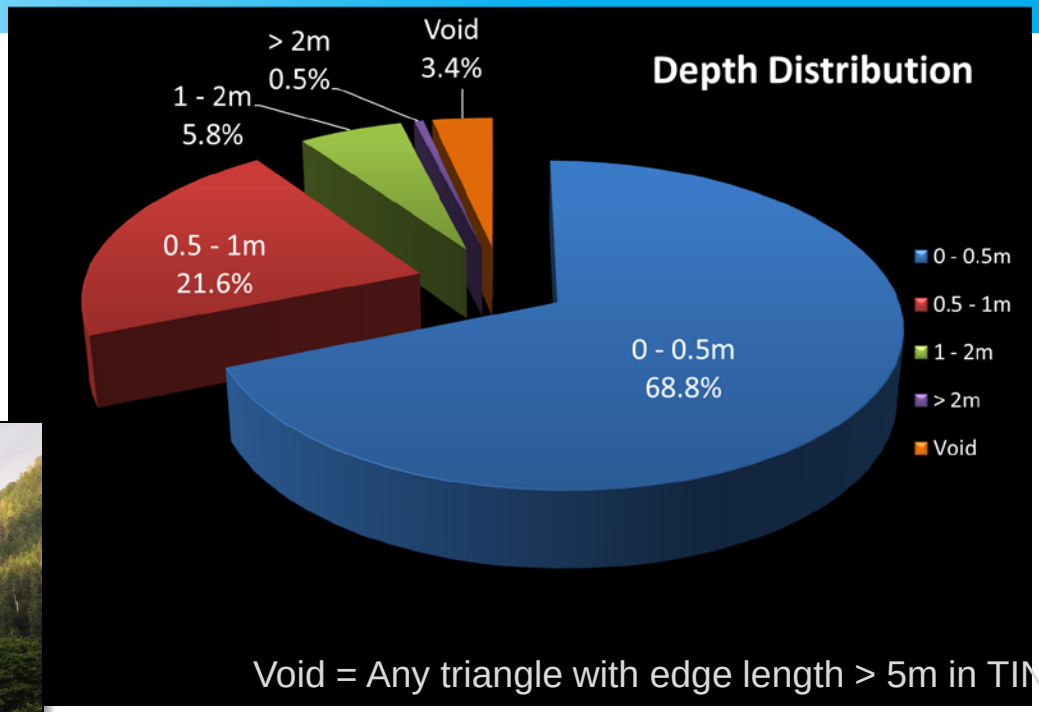


Comparison Factors

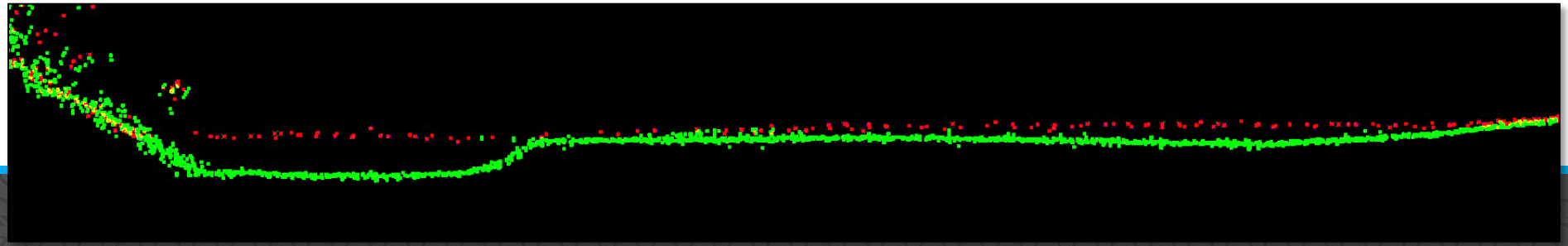
- Surface Properties (flat vs rocky or slanted)
- Wading conditions
- GPS quality
- Resolution

Quinault River, WA

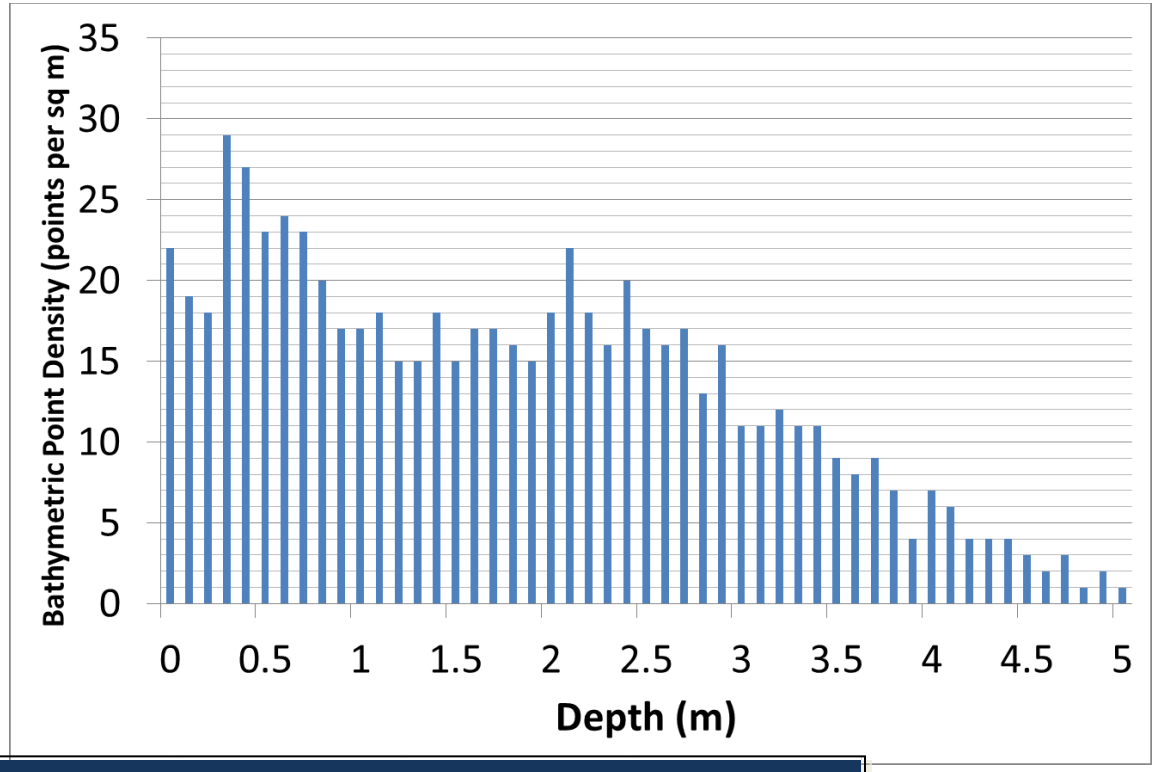
20.2 river miles



Void = Any triangle with edge length > 5m in TIN



Quinault River, WA Accuracy



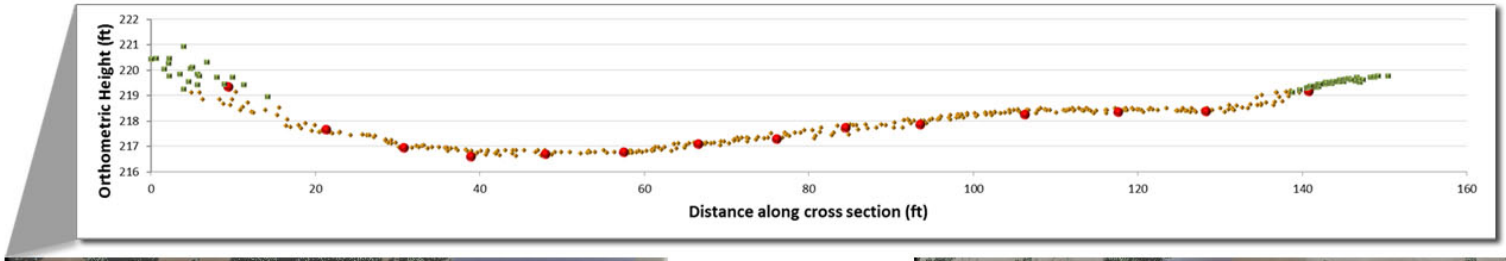
Supplemental and Consolidated Vertical Accuracies						
	SVA					CVA
Land Cover Class	Cobbled Bathymetric Surface	Large Gravel Bathymetric Surface	Gravel Bathymetric Surface	Sandy Bathymetric Surface	Edge of Water	All Land Cover Classes
Sample	63 points	157 points	21 points	42 points	53 points	336 points
Median	0.048 m	0.026 m	-0.047 m	-0.024 m	0.014 m	0.018 m
RMSE	0.072 m	0.047 m	0.067 m	0.057 m	0.041 m	0.056 m
Standard Deviation (1σ)	0.064 m	0.038 m	0.047 m	0.051 m	0.039 m	0.054 m
95th Percentile	0.129 m	0.093 m	0.110 m	0.094 m	0.075 m	0.093 m

Combined Accuracy Statistics

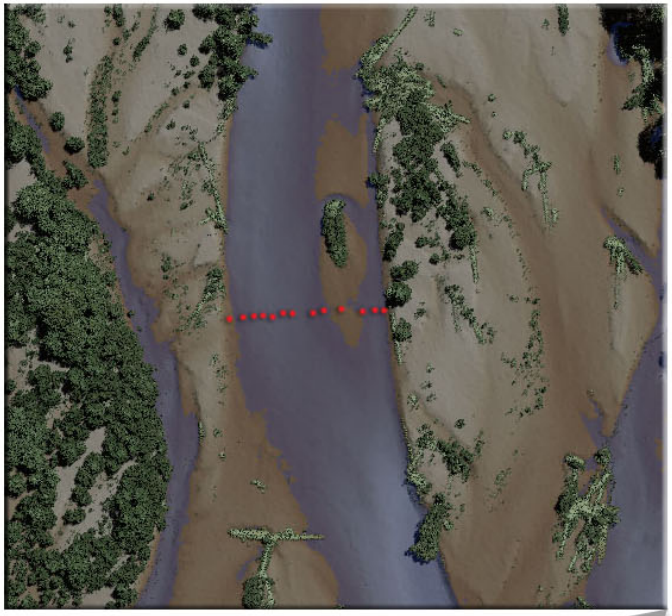
Overall Bathymetric Accuracies (2012 - 2015)	Type							
	Absolute (m)	Range (m)			Relative (m)	Range (m)		
RMSE	0.06	0.03	-	0.18	0.05	0.01	-	0.07
Standard Deviation (1σ)	0.06	0.03	-	0.18	0.01	0.00	-	0.03
1.96σ	0.11	0.06	-	0.35	0.02	0.00	-	0.05
	Average	Range (of project averages)						
Pulse Density (first return ppsm)	13.3	4.0	-	26.8				

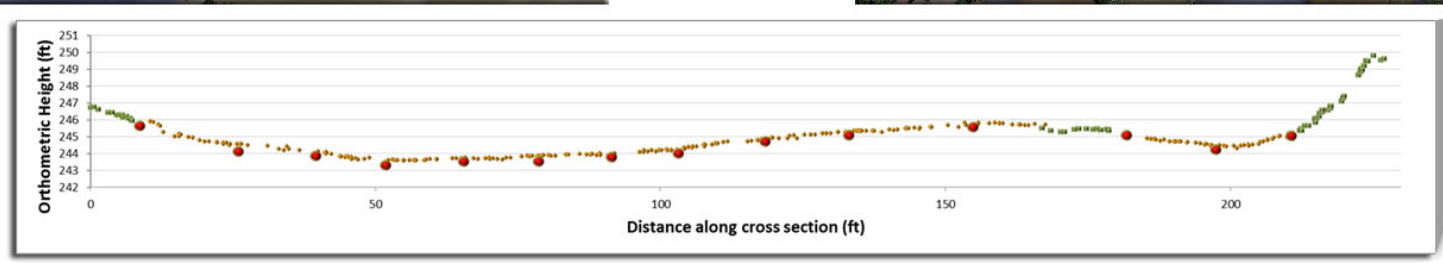
- Absolute accuracy calculated as Z difference from RTK points taken within channel
- Relative accuracy calculated as Z difference between flight-line surfaces
- Pulse density is aggregate (includes overlap)

Quinault River, WA - Absolute Accuracy



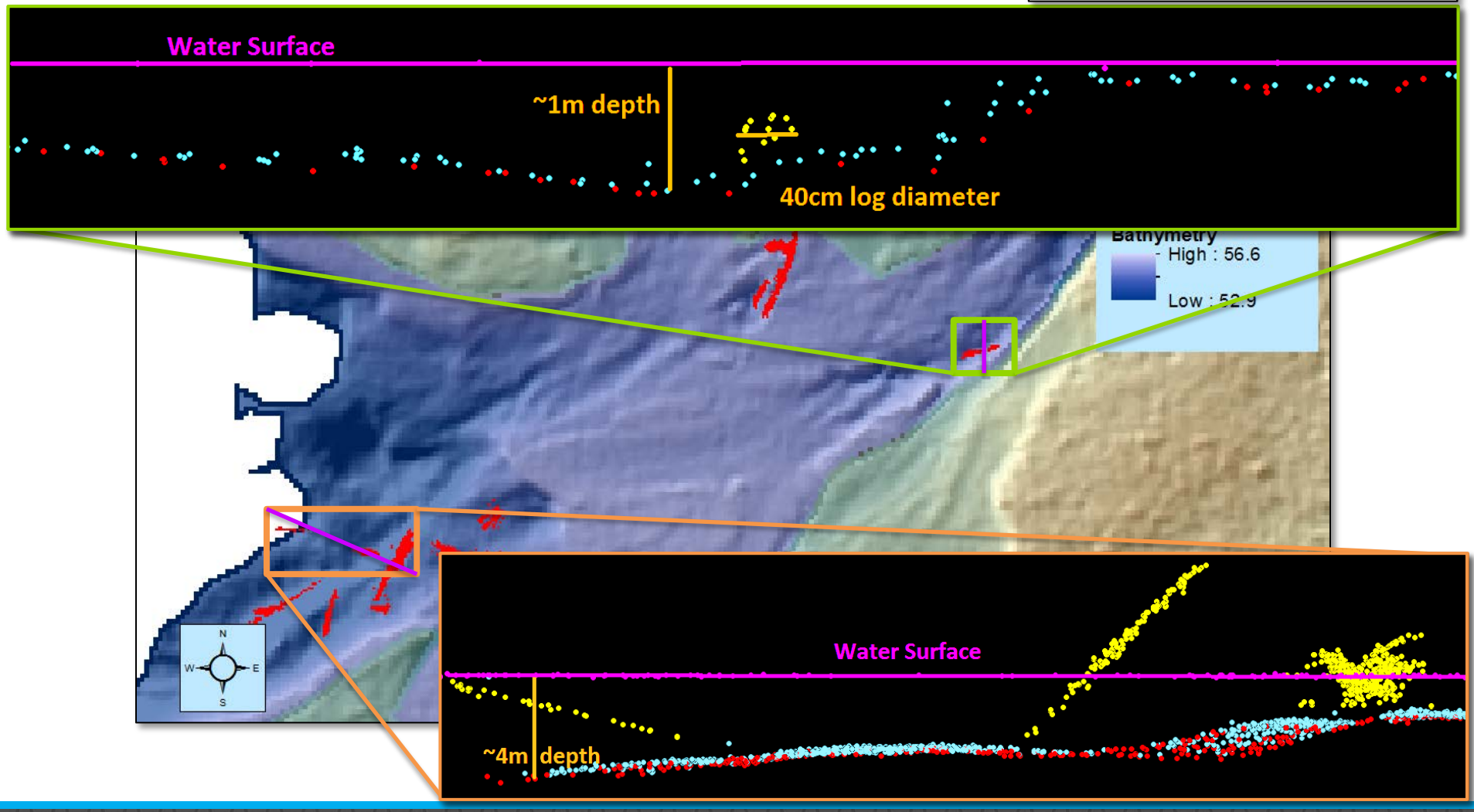
Bathymetry
Ground
RTK



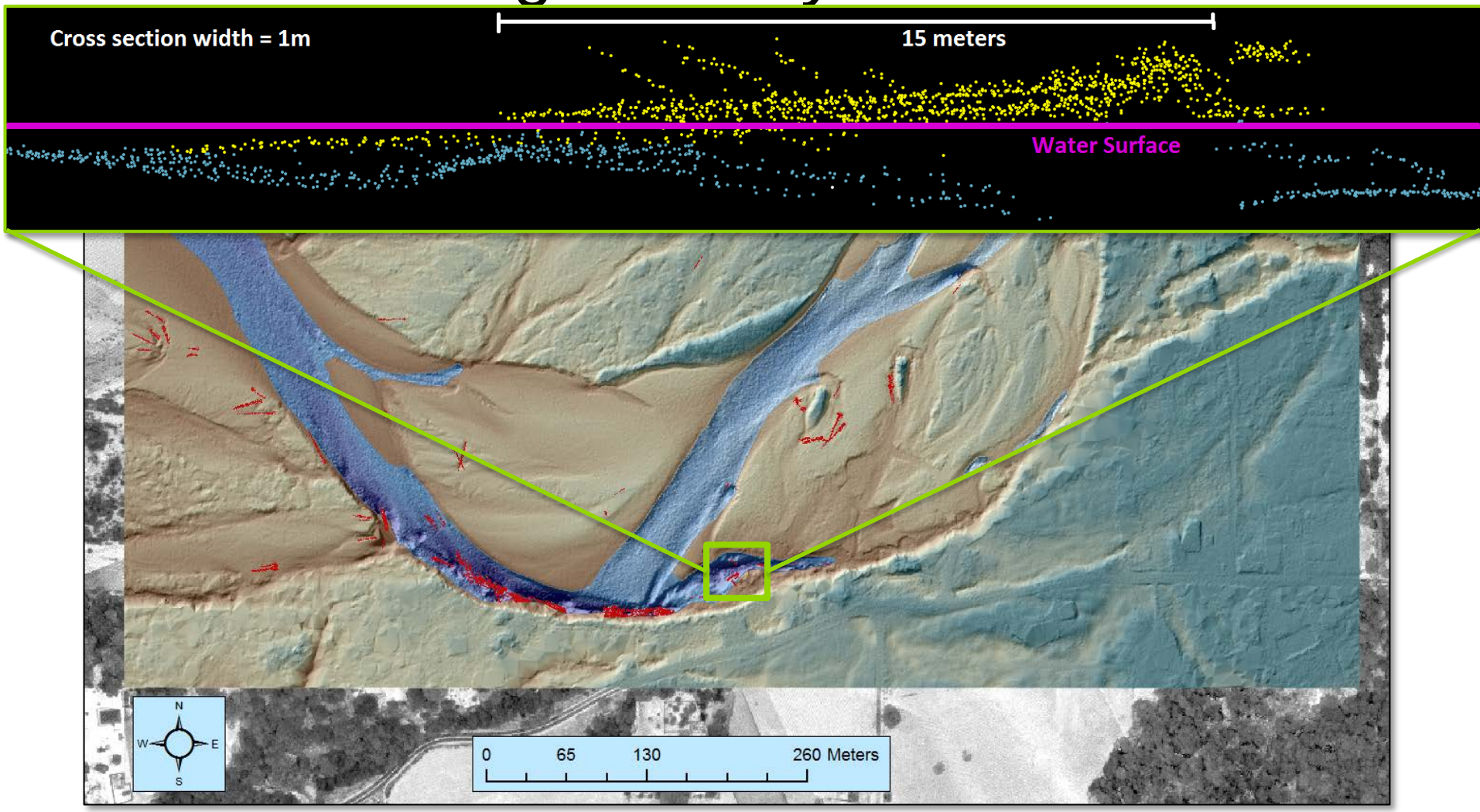


Quinault River – Habitat Metrics

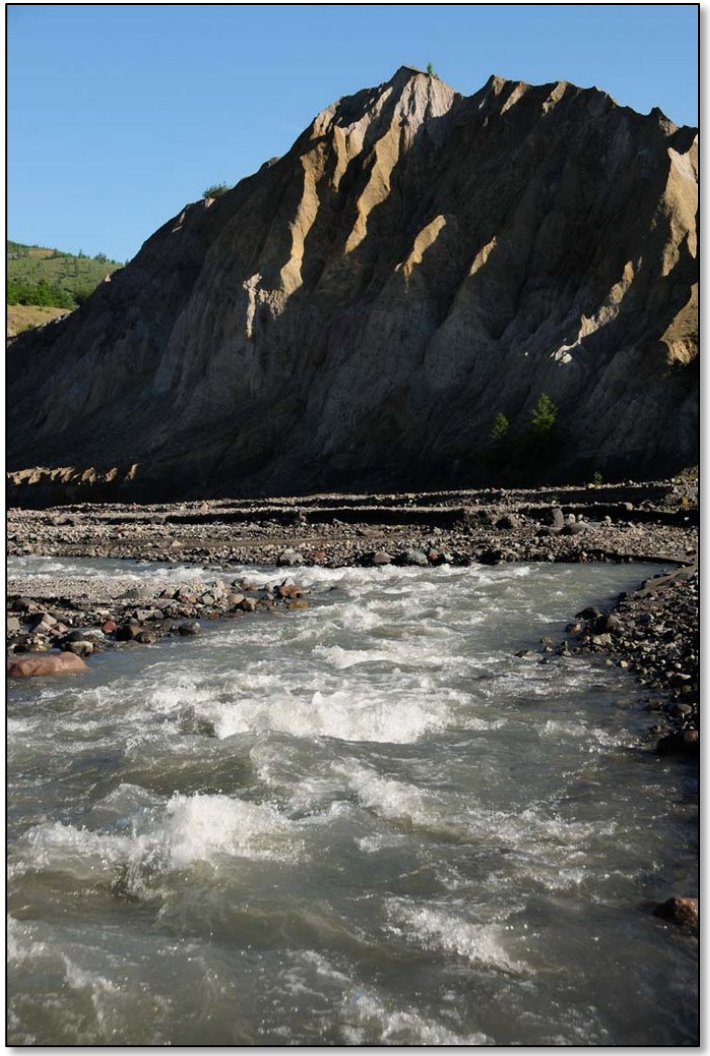
Large Woody Debris



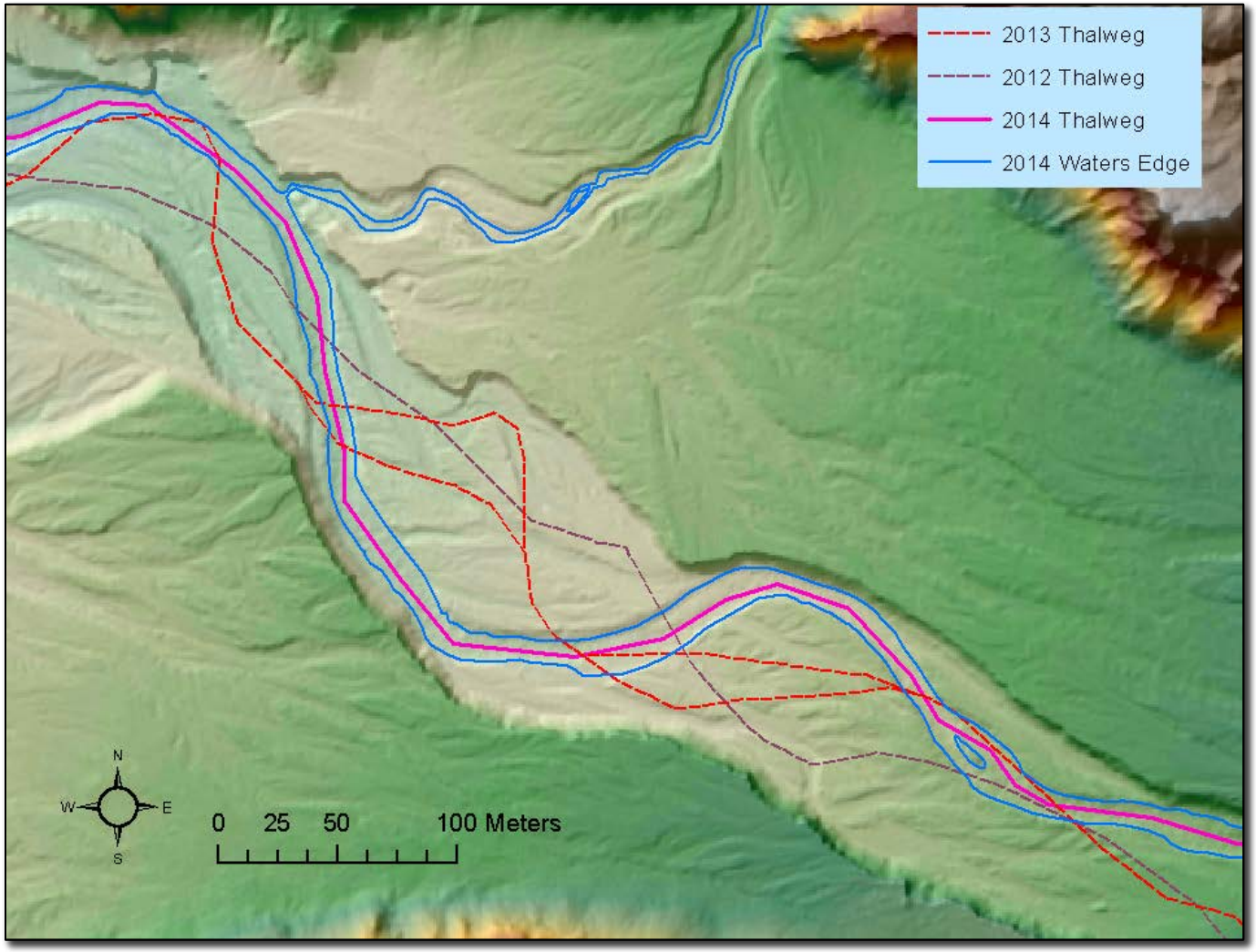
Large Woody Debris



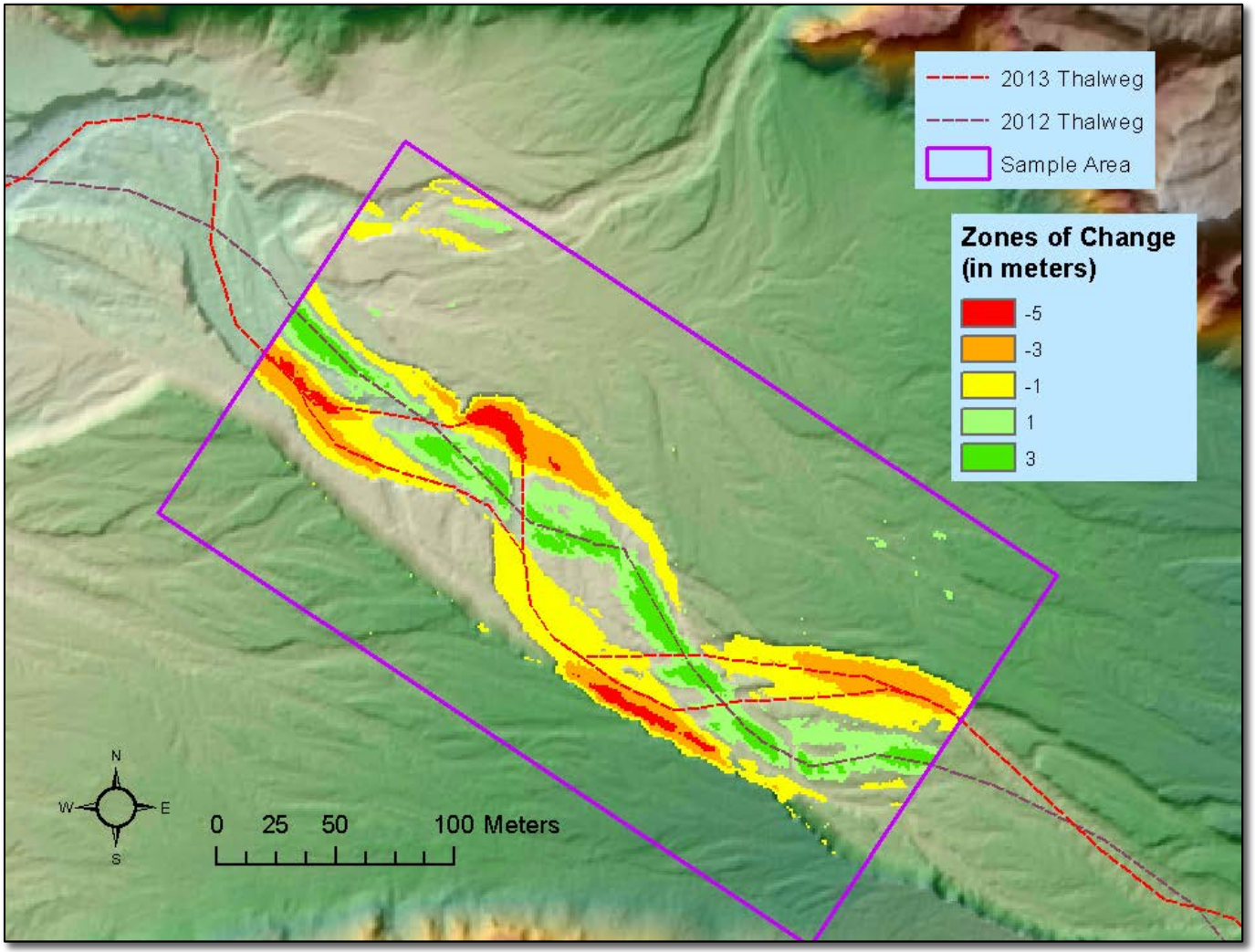
Toutle River, WA



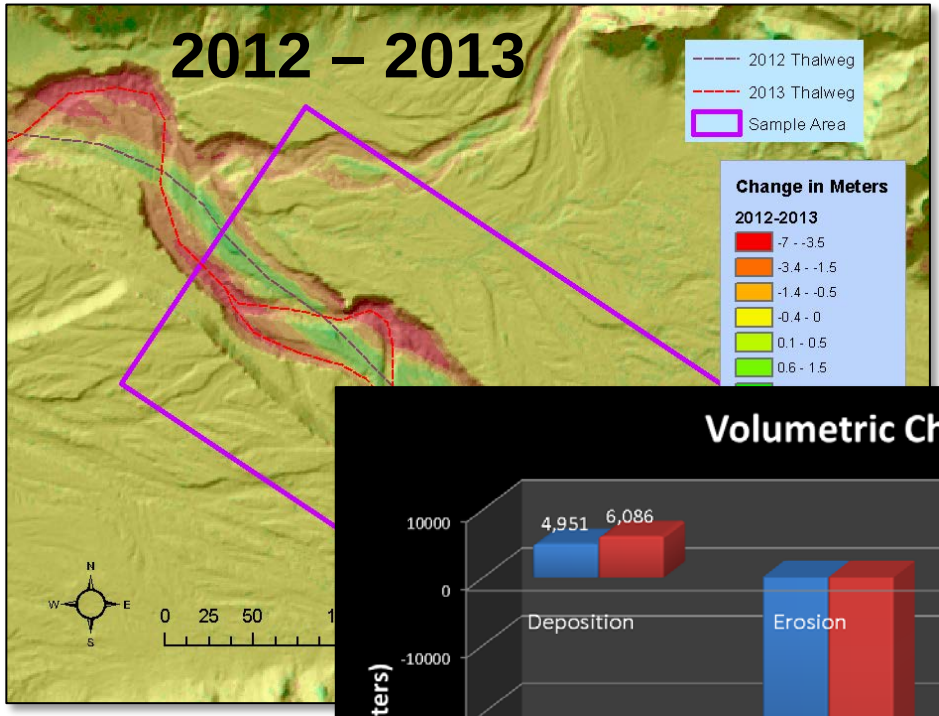
Toutle River, WA - Topobathymetric LiDAR

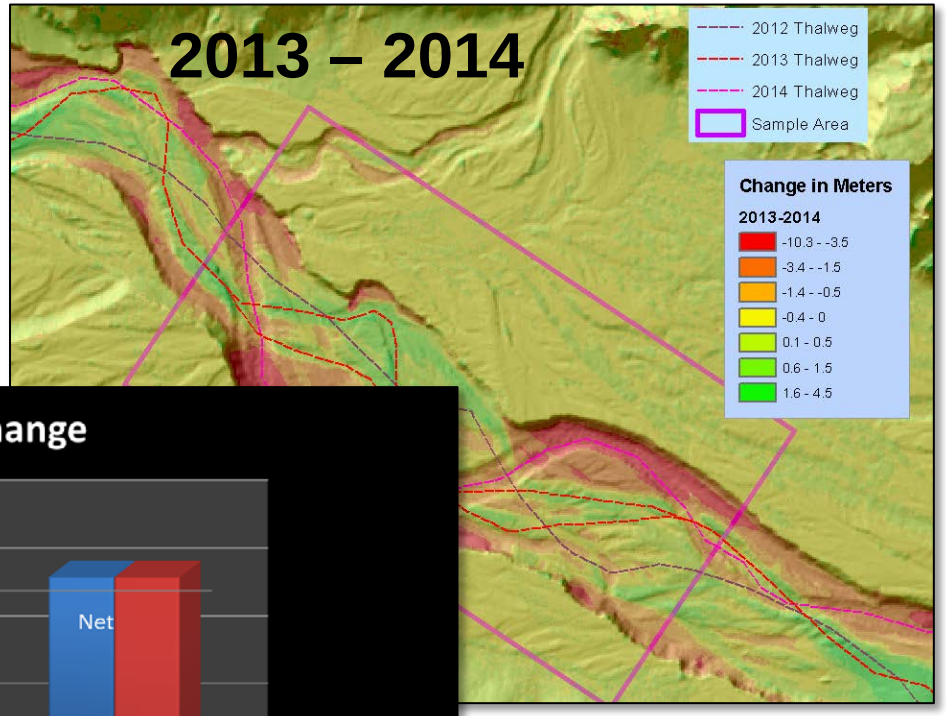


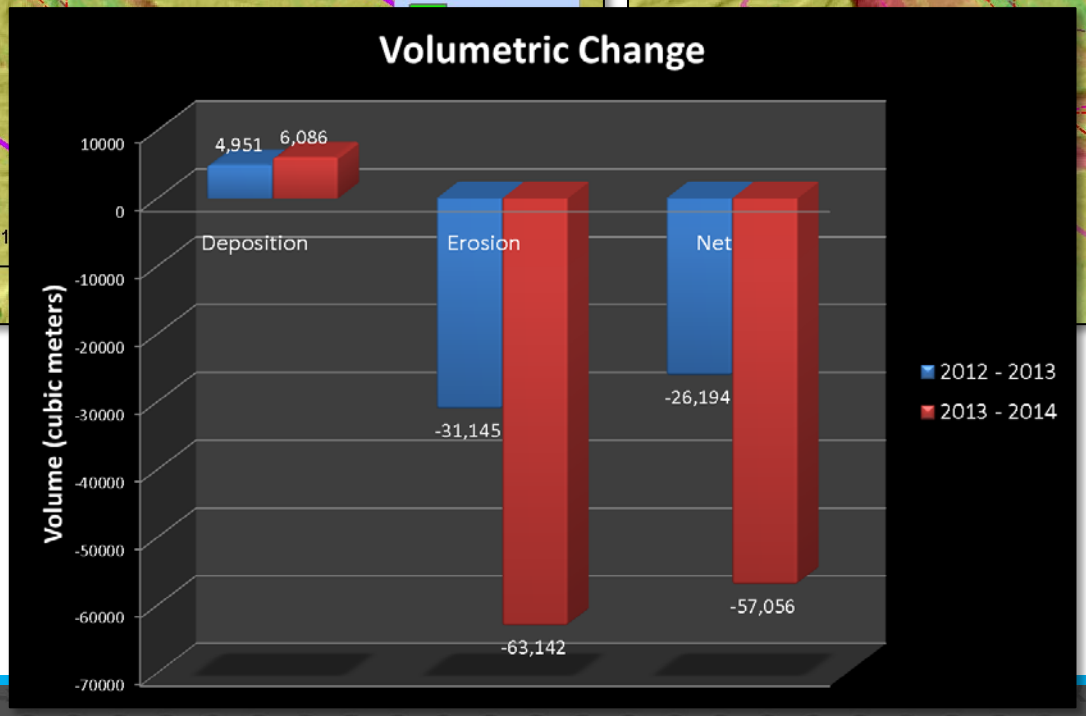
Quantifying Multiyear Change



Toutle River - Volumetric Changes







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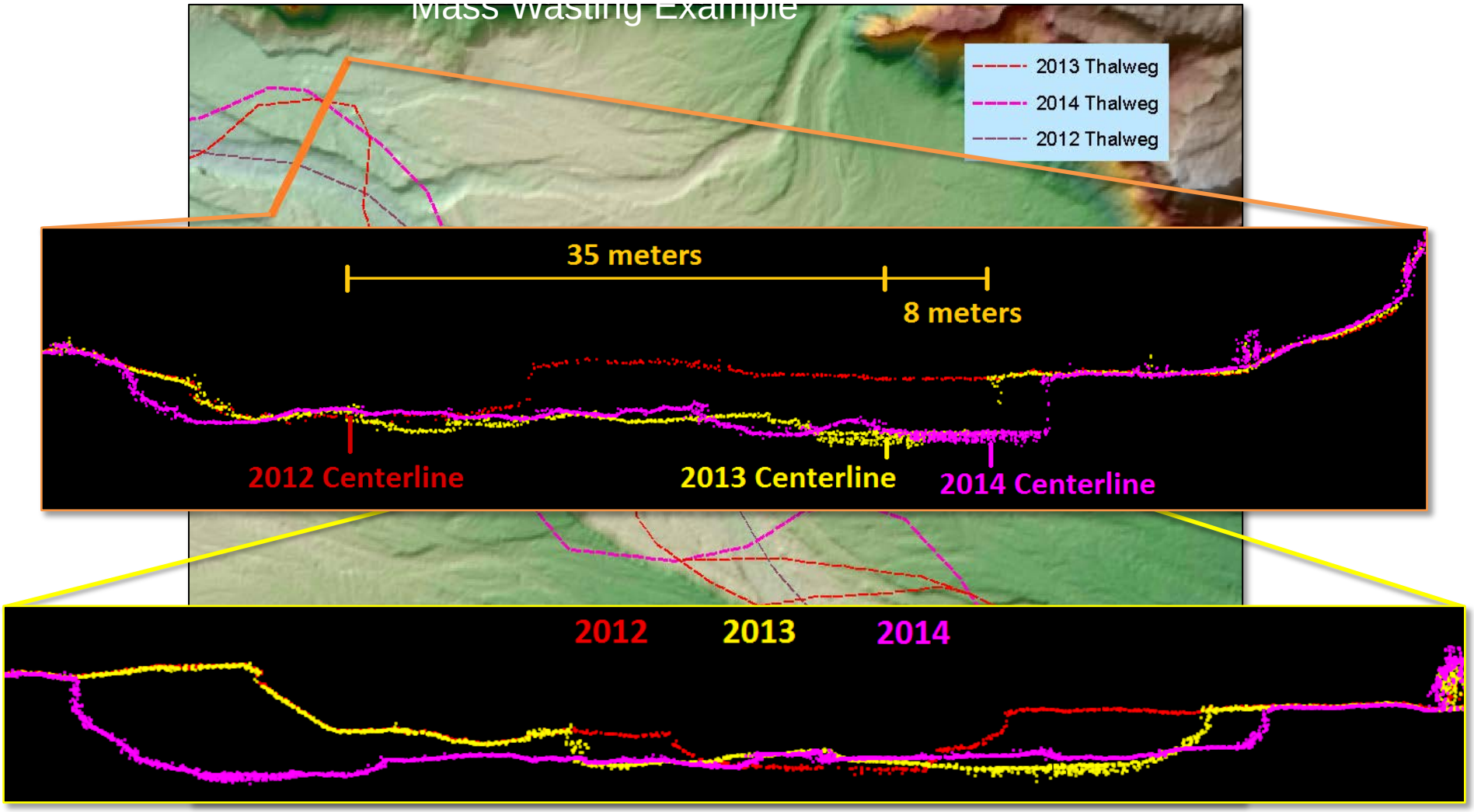
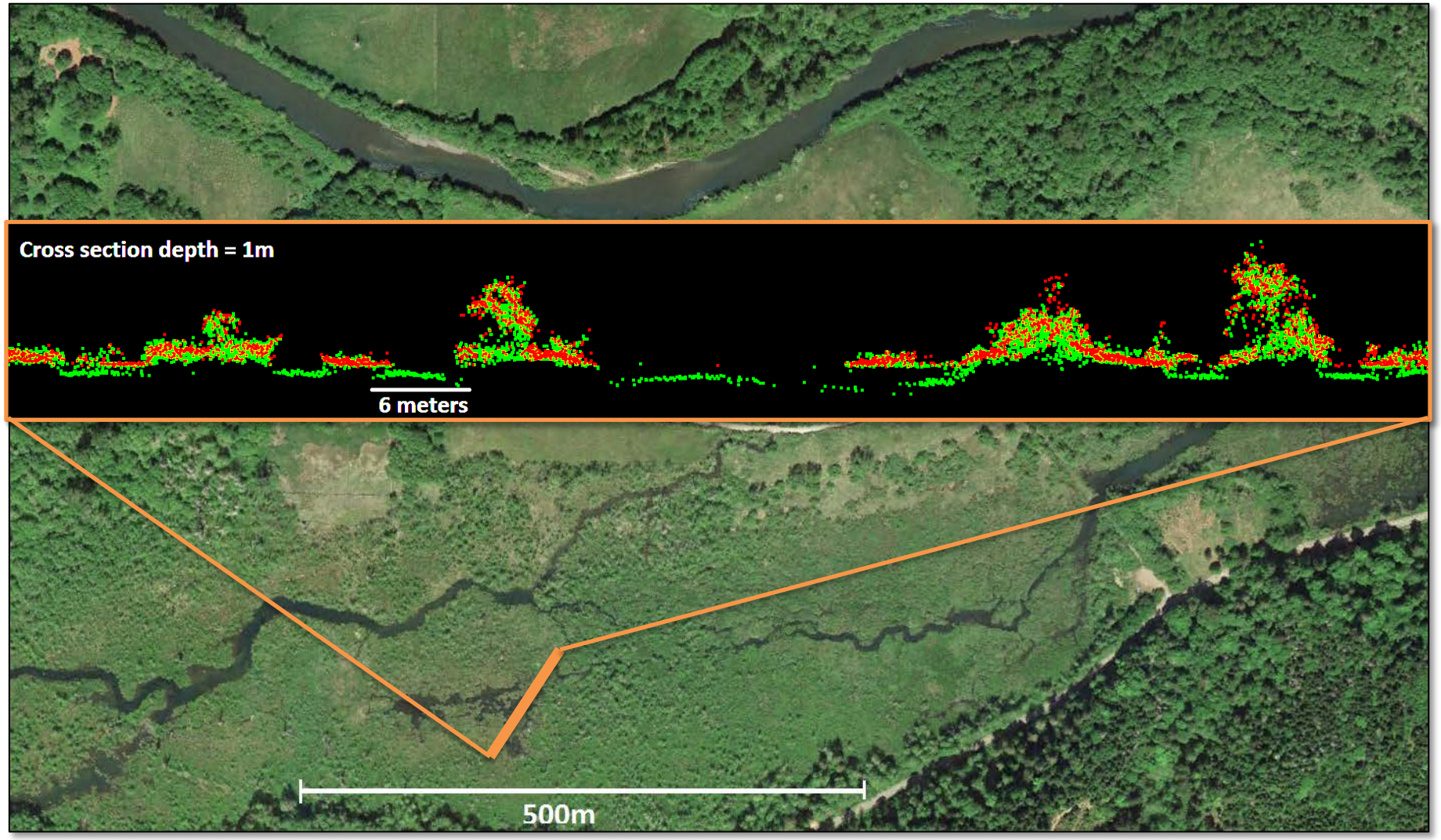


Skokomish Estuary, WA - Wetland Complexity



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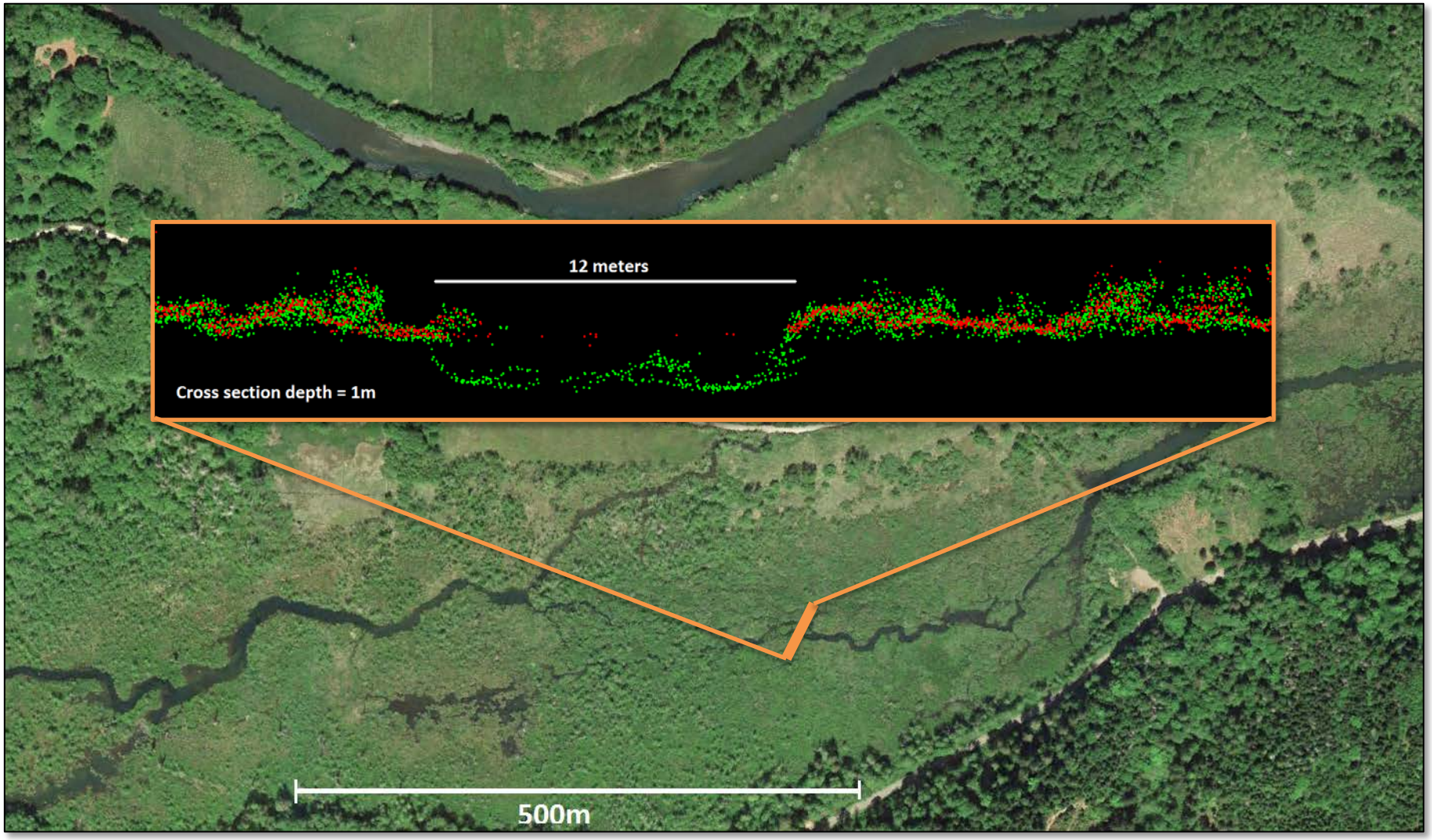
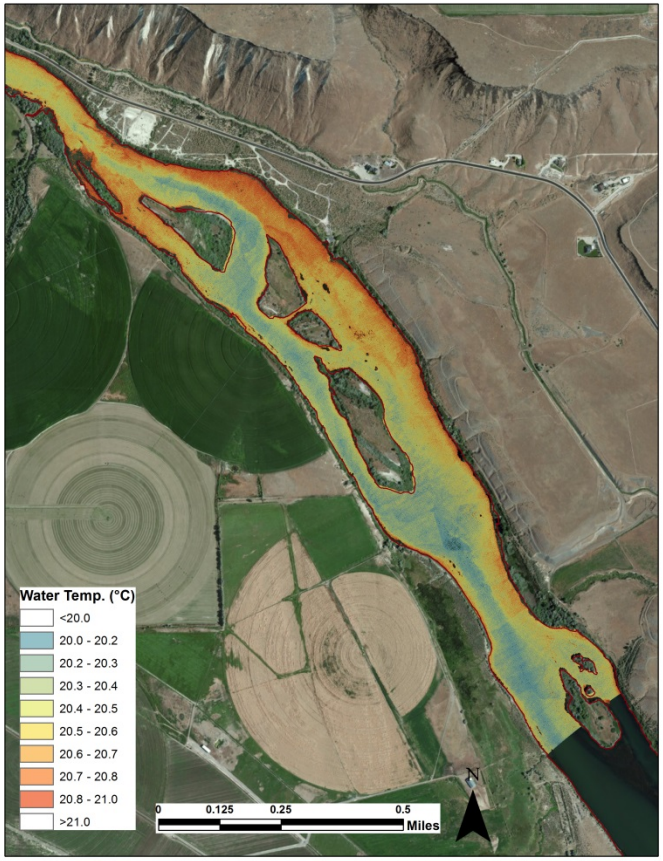
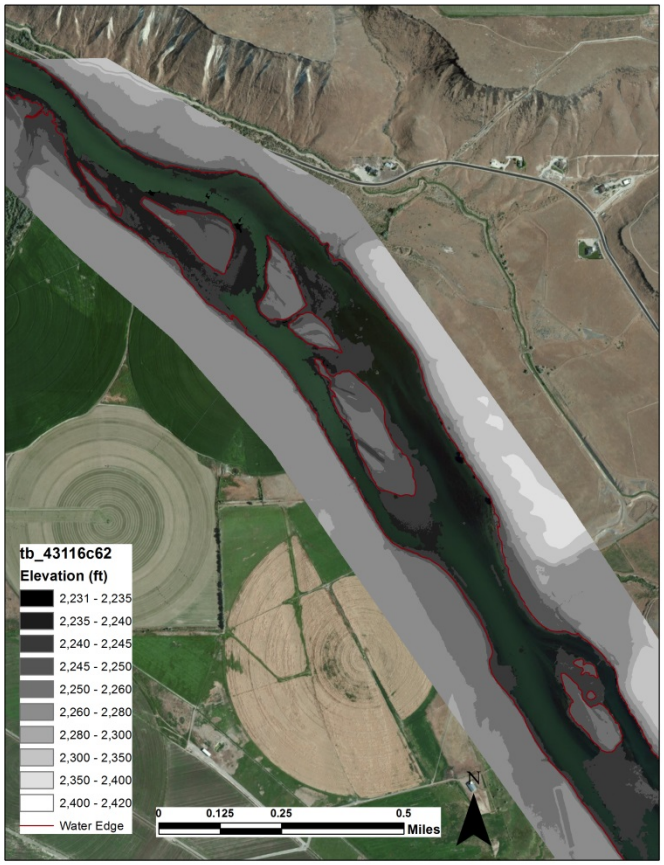
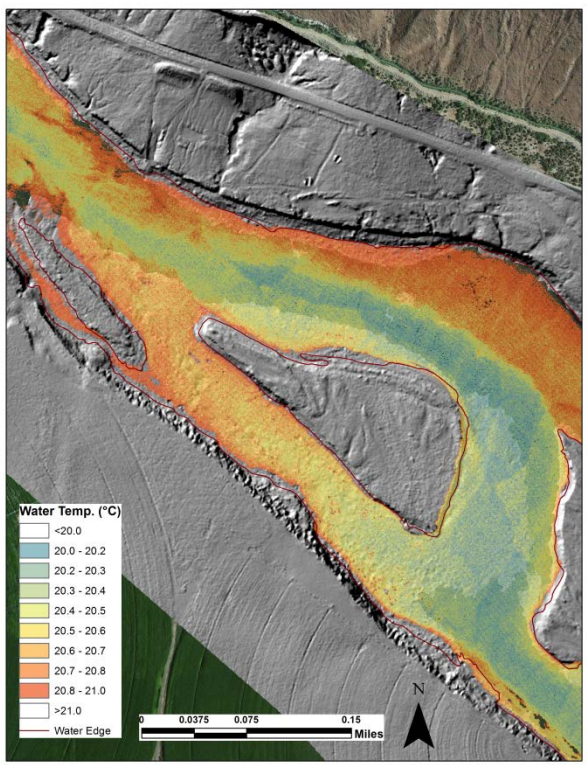


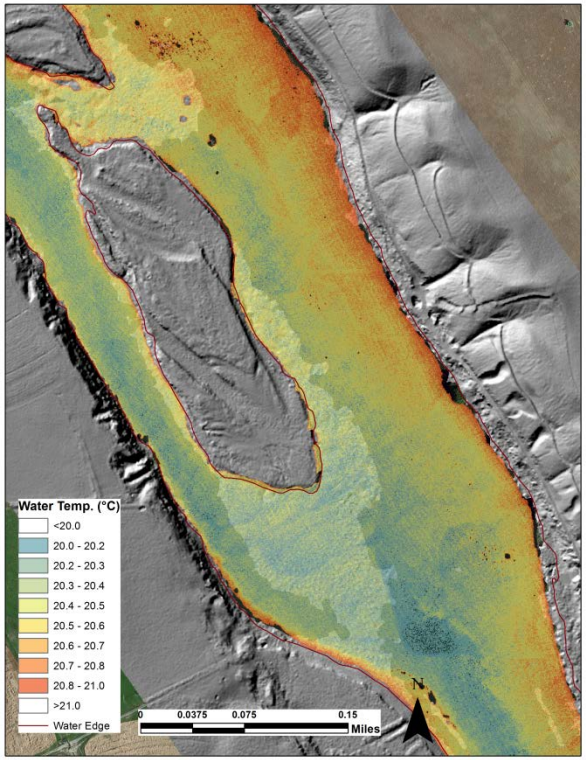
Multi-sensor integration

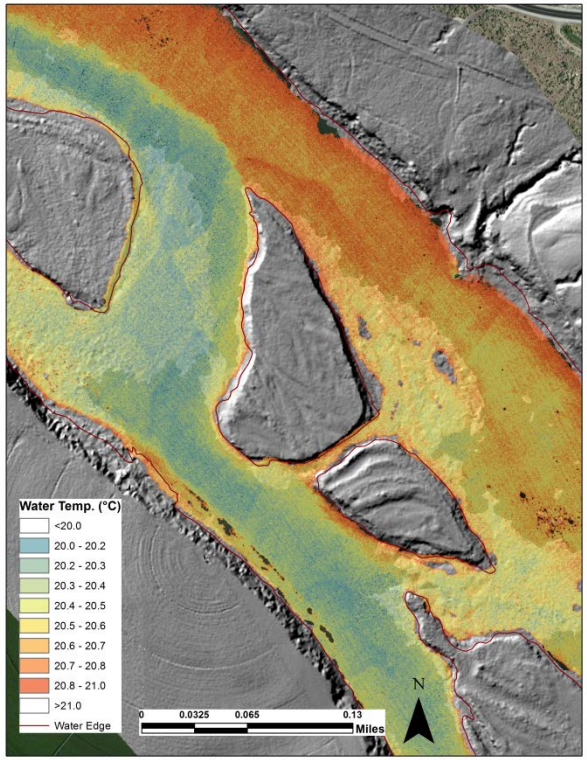




Topobathymetric LiDAR and Thermal IR

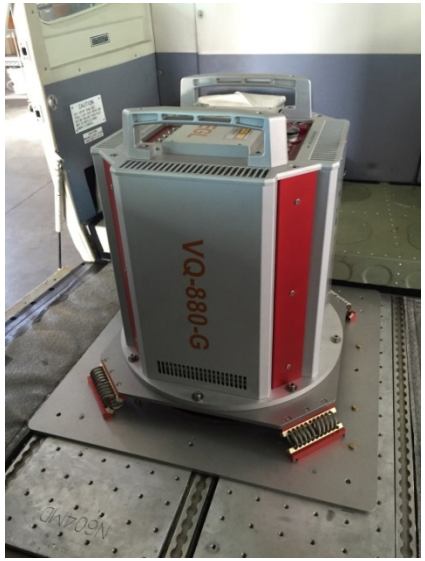




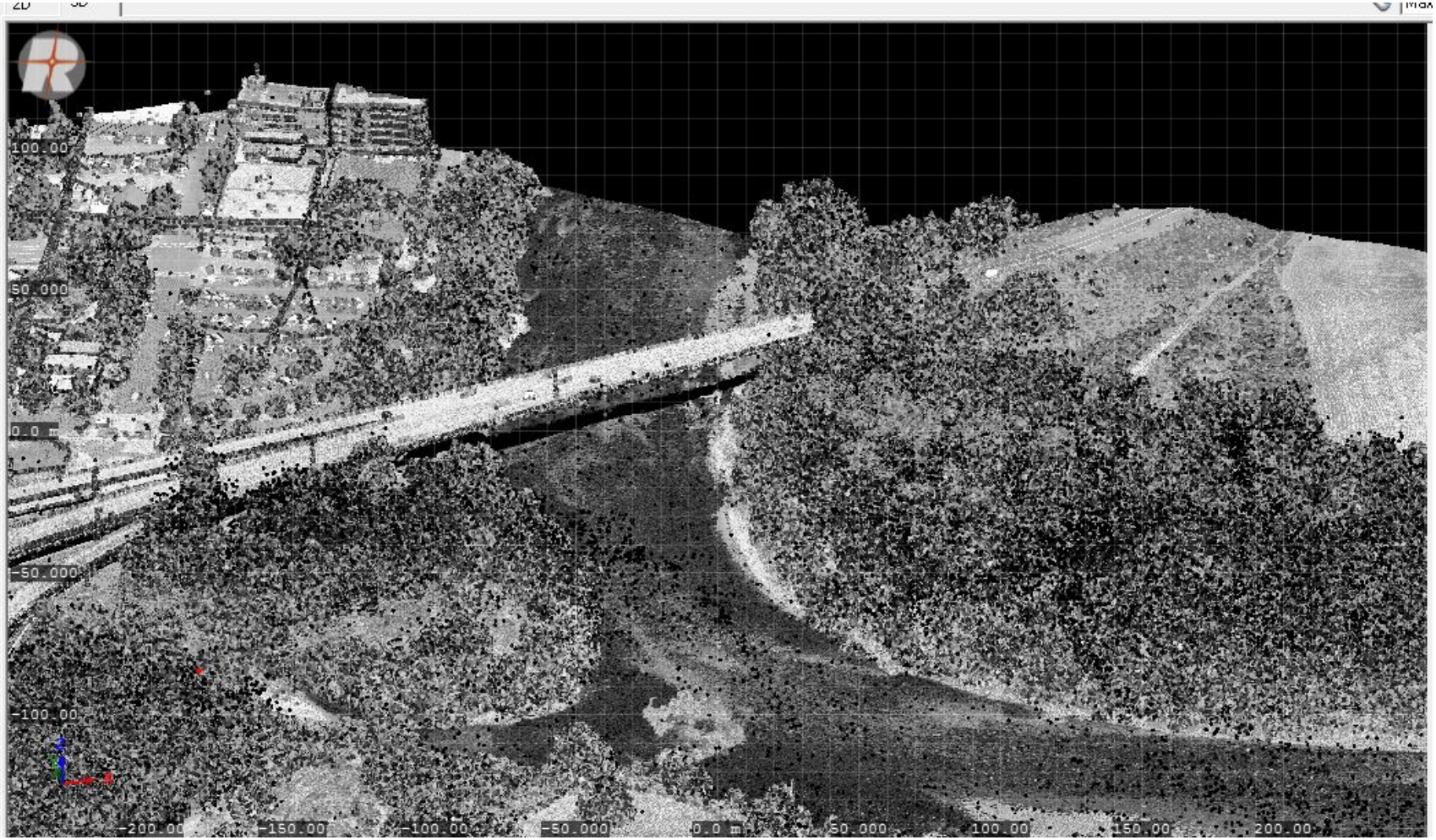


Ongoing Efforts

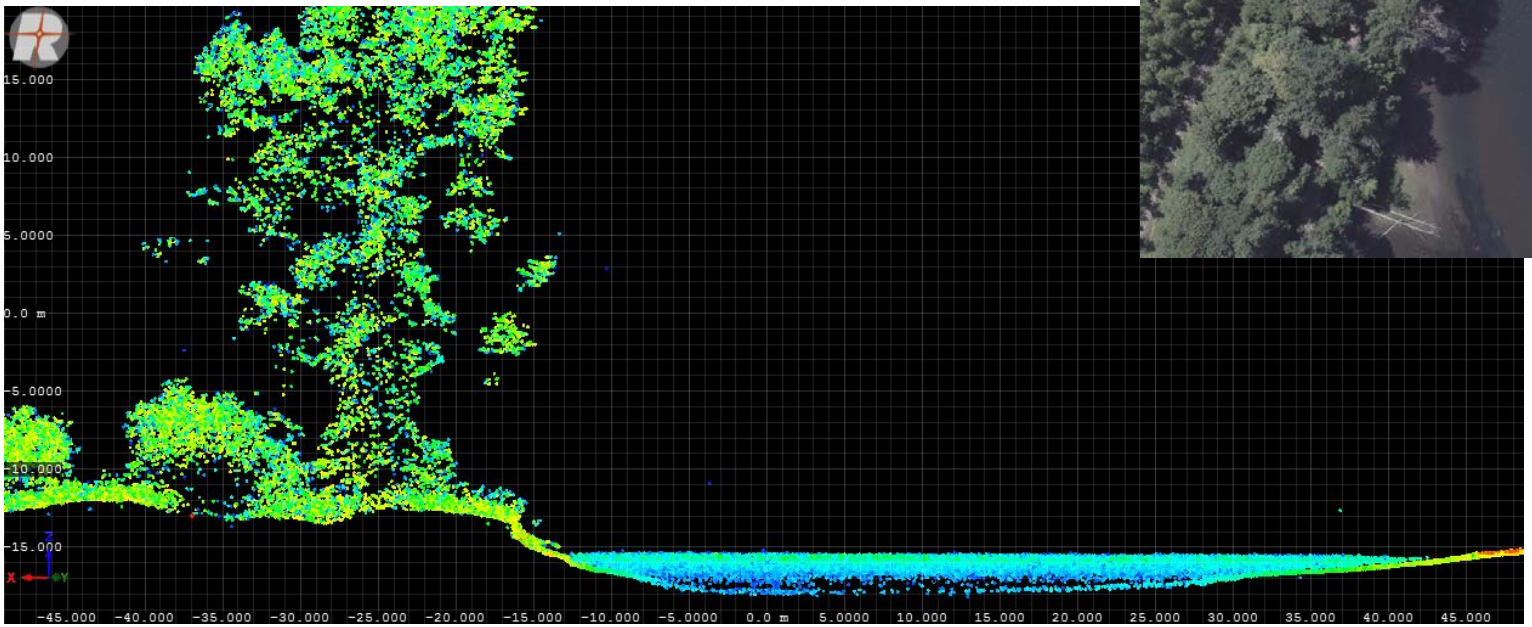
- Operational tests of Riegl VQ-880-G (June 2015)
- LAS1.4 Support Tools – FWF and ExtraByte Storage
- Additional riverine projects with Riegl VQ-820-G and thermal IR
- Develop methods to further quantify uncertainty and accuracy standards
- Automated feature extraction methods for in-channel metrics



Riegl VQ-880-G (6/16/15)



Riegl VQ-880-G (6/16/15)



Summary

Considerations

How Deep? Depends on turbidity and bottom reflectivity

Sensor Selection
- Know your area
- Know your intent

Ground Truth important

Client expectations

Challenges

Processing Techniques
- Point Classifying
- FWF utilization

Refraction – getting the most accurate correction

Connecting user groups and Developing standards

Mountainous Terrain

Advantages

Mapping of shallow areas across a large scale

Accessibility
- Safety
- Difficult Areas

Fully integrated land water model at **high resolution**

Sensor add-ons
- Multi-λ LiDAR
- Imagery

Thank you!
Questions?

Russ Faux
faux@quantumspatial.com