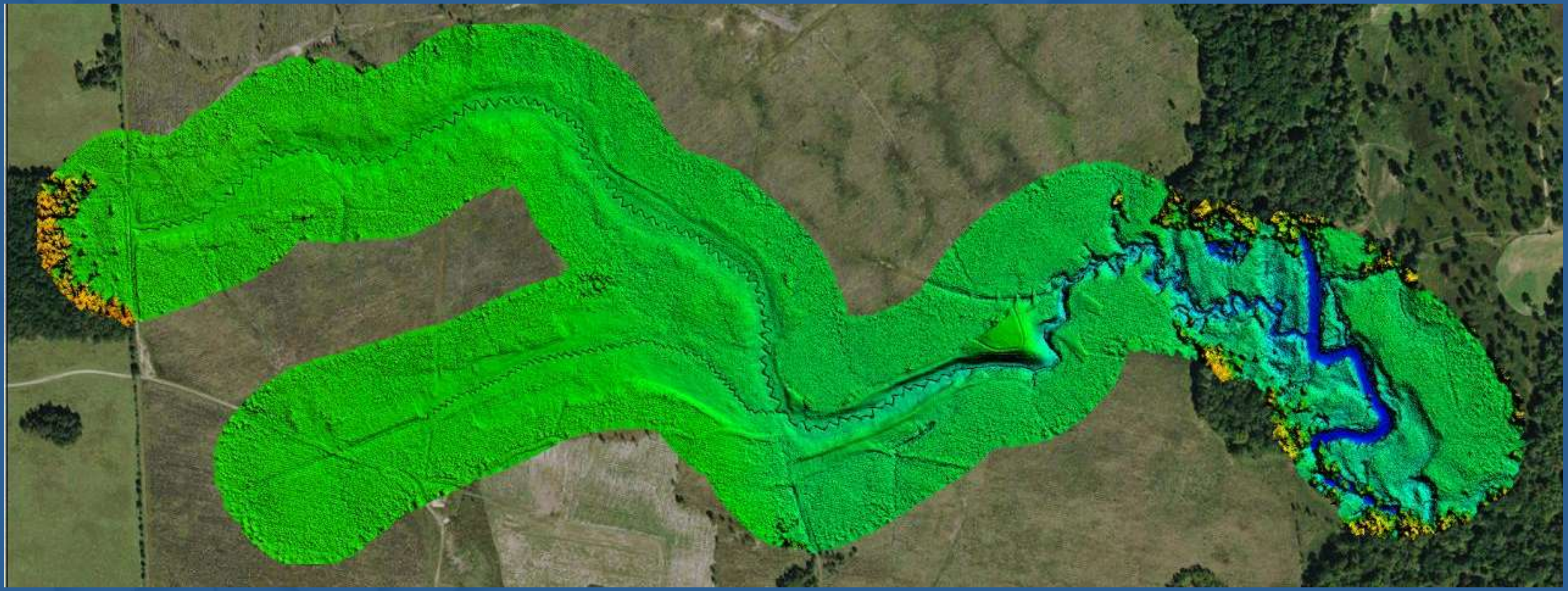

Lidar and Geomorphic Change Detection: Useful Tools for River Ecosystem Assessment and Restoration Monitoring

Geosyntec consultants

Robert M Dunn | 08.01.2022

Outline

- River survey methods
  - Traditional methods
  - “New” technologies
- LiDAR’s role
- Advantages and disadvantages
- Applications of LiDAR

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Introduction

- Traditional survey methods have long been the preferred method for assessment and monitoring
- Limited spatially to reach-scale cross-sections and longitudinal profiles
- Time consuming

The "New" Kids on the Block

- Newer methods (UAVs, ground-based Lidar, survey-grade RTK GPS, etc) are increasingly becoming more common in river ecosystem assessment and restoration monitoring.
- UAVs equipped with high-resolution Lidar scanners offer a suite of benefits for river restoration practitioners
  - Increased spatial coverage and data density
  - Collect topographic and geomorphic data beyond the traditional reach-scale, with less time

UAVs Value Proposition – Completing the Data Portfolio

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Image courtesy https://www.sensefly.com

UAV LiDAR – Advantages: Spatial Coverage

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UAV LiDAR – Advantages: Data Density

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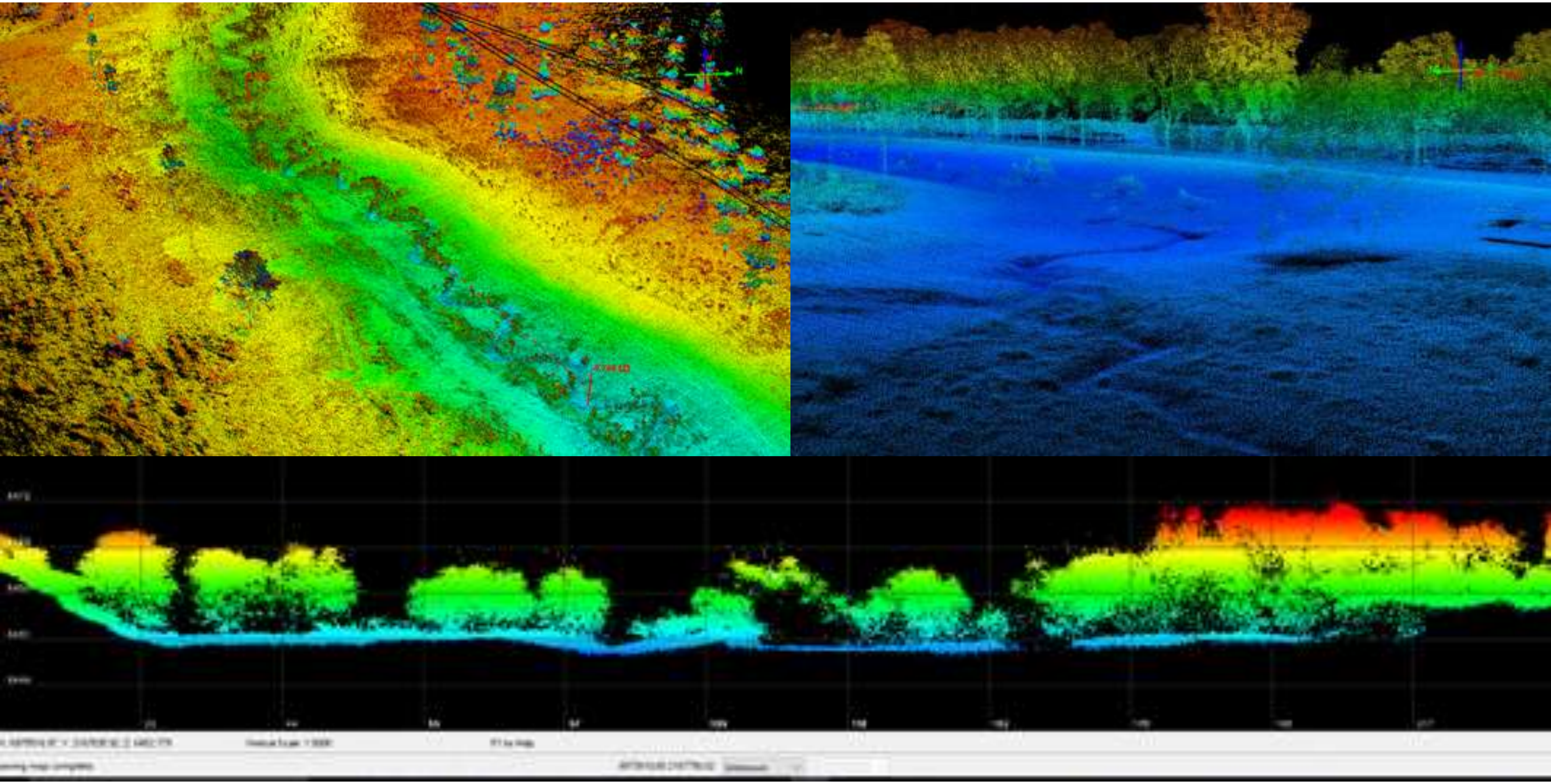

Point density averages between 250 and 500 pts/m^2

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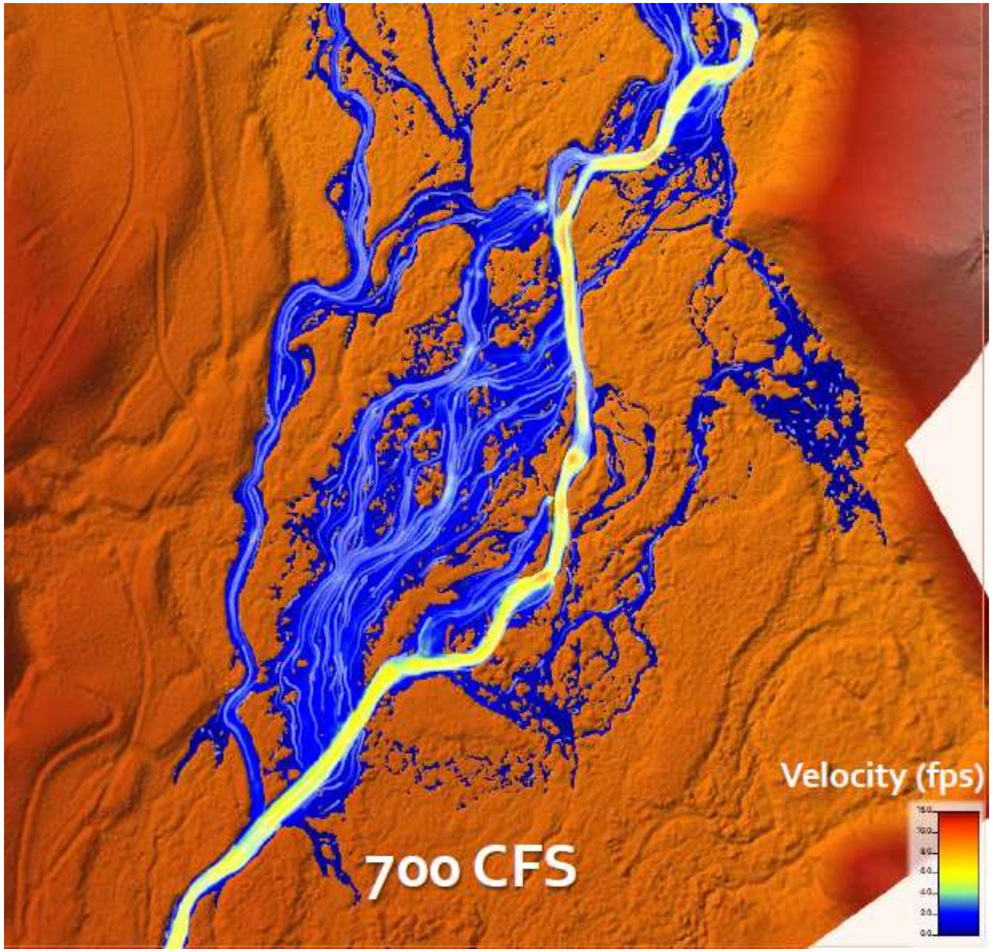
LiDAR Uses in River Ecosystems

- Hydrology Modeling
- Floodplain Mapping
- Riparian Vegetation Mapping
- Watershed delineations
- As-built surveys
- Restoration Monitoring
- Channel Morphology
  - **Geomorphic Change Detection**
  - Lateral Migration Analysis
  - Channel Evolution
  - Impacts of prescribed flows to channel morphology



Applications in River Assessment

- Geomorphic Change Detection

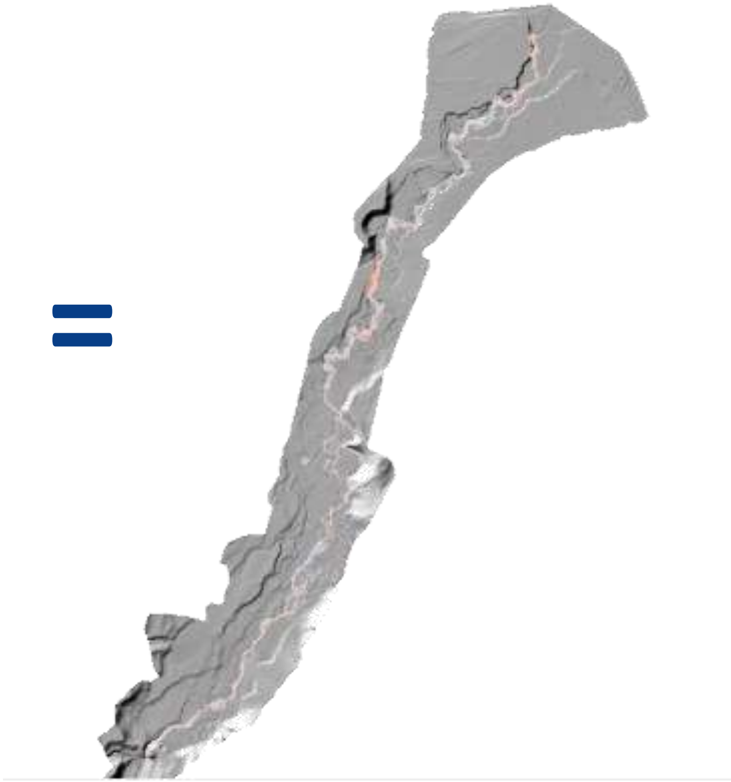
Original Topographic Surface

-

New Surface

=

DoD



Geomorphic Change Detection

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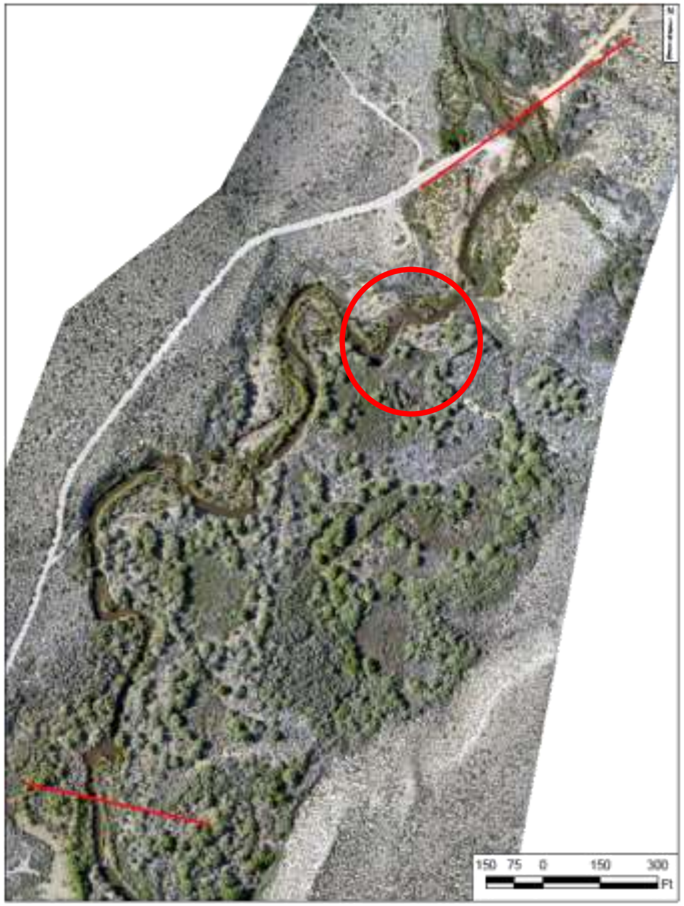
Geomorphic Work Observed from LiDAR Surveys:

- Major meander bend formation, point bar extension, and terrace erosion
- Increased channel length and creation of new floodplain



May 2017 Imagery

Oct 2017 Imagery

Geomorphic Change Detection: Results

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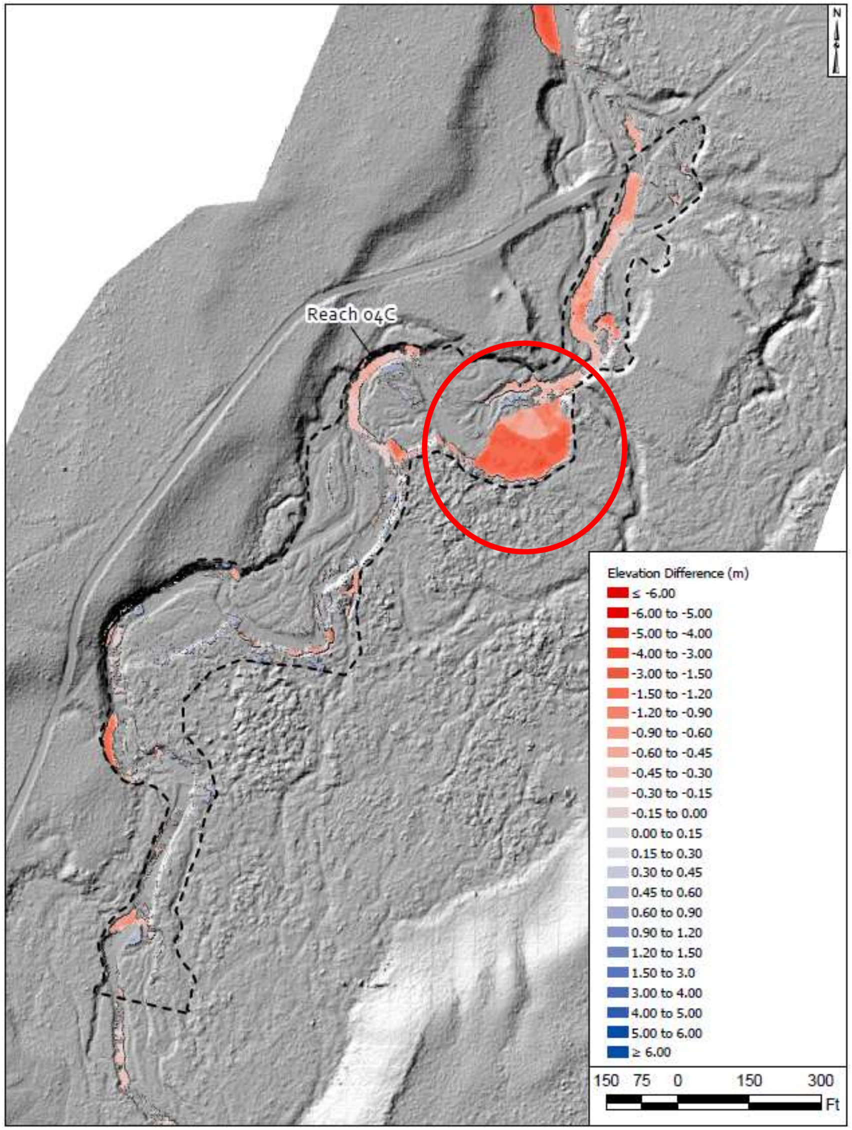
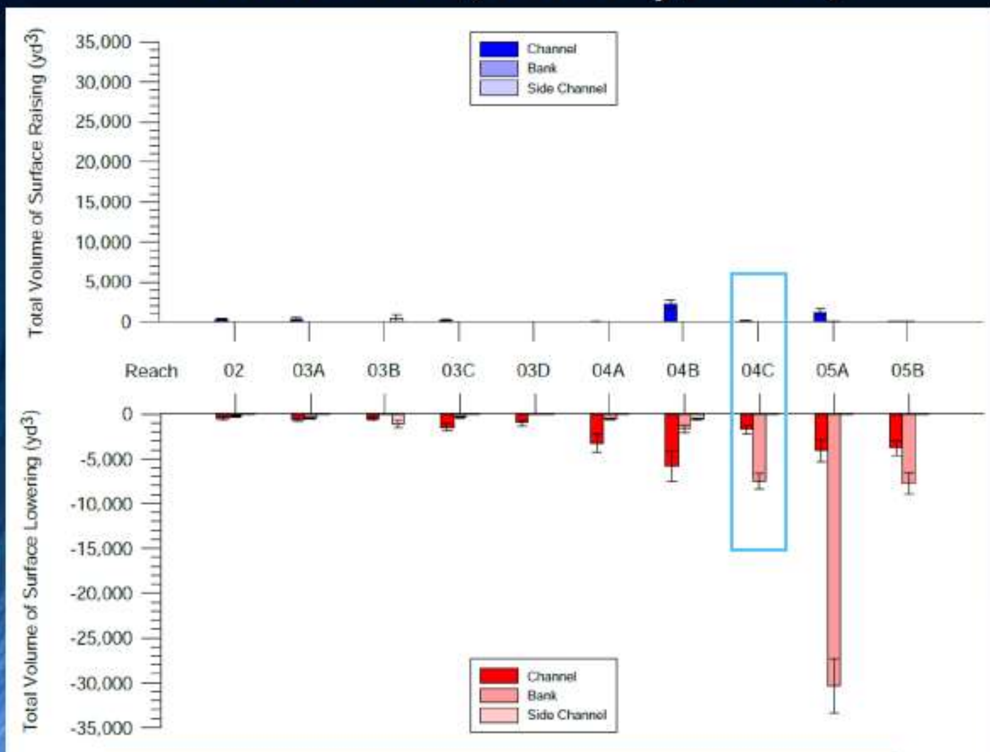
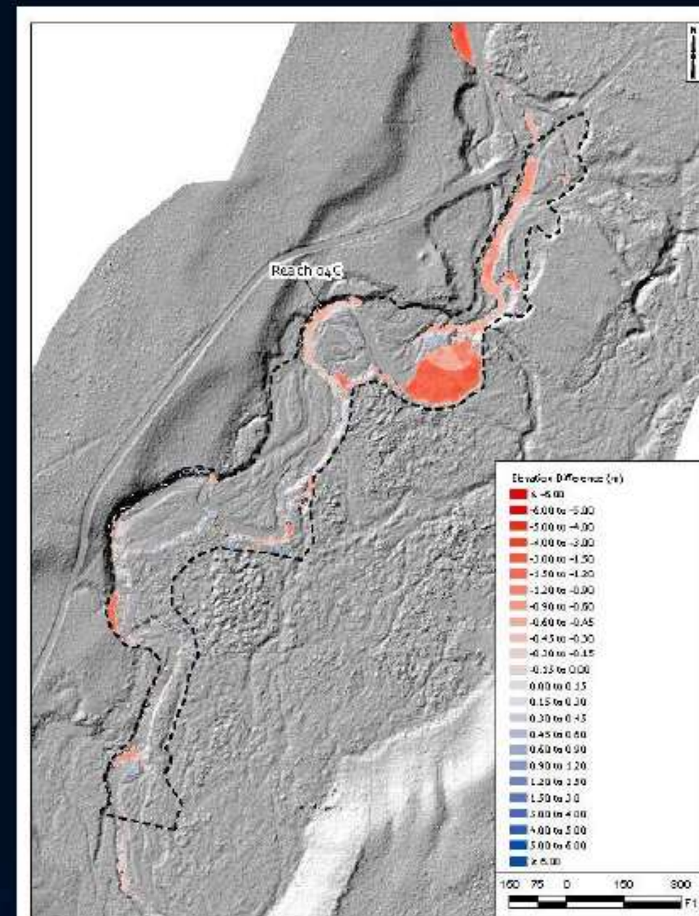


Attribute	Thresholded DoD Estimate:			
AREAL:				
Total Area of Surface Lowering (m²)	6,701			
Total Area of Surface Raising (m²)	1,354			
Total Area of Detectable Change (m²)	8,055			
Total Area of Interest (m²)	NA			
Percent of Area of Interest with Detectable Change	20%			
VOLUMETRIC:			± Error Volume	% Error
Total Volume of Surface Lowering (m³)	7,489	±	1,186	16%
Total Volume of Surface Raising (m³)	682	±	253	37%
Total Volume of Difference (m³)	8,171	±	1,438	18%
Total **Net** Volume Difference (m³)	**-6,807**	**±**	**1,212**	-18%
VERTICAL AVERAGES:			± Error Thickness	% Error
Average Depth of Surface Lowering (m)	1.12	±	0.18	16%
Average Depth of Surface Raising (m)	0.50	±	0.19	37%
Average Total Thickness of Difference (m) for Area of Interest	0.20	±	0.04	18%
Average **Net** Thickness Difference (m) for Area of Interest	**-0.17**	**±**	**0.03**	-18%
Average Total Thickness of Difference (m) for Area With Detectable Change	1.01	±	0.18	18%
Average **Net** Thickness Difference (m) for Area with Detectable Change	**-0.85**	**±**	**0.15**	-18%
PERCENTAGES (BY VOLUME)				
Percent Elevation Lowering	92%			
Percent Surface Raising	8%			
Percent Imbalance (departure from equilibrium)	-42%			
Net to Total Volume Ratio	-83%			

Analyses

Geomorphic Change Detection (RY2017/2018)





RY 2017/2018 → significant changes in bed and banks

Geomorphic Change Detection

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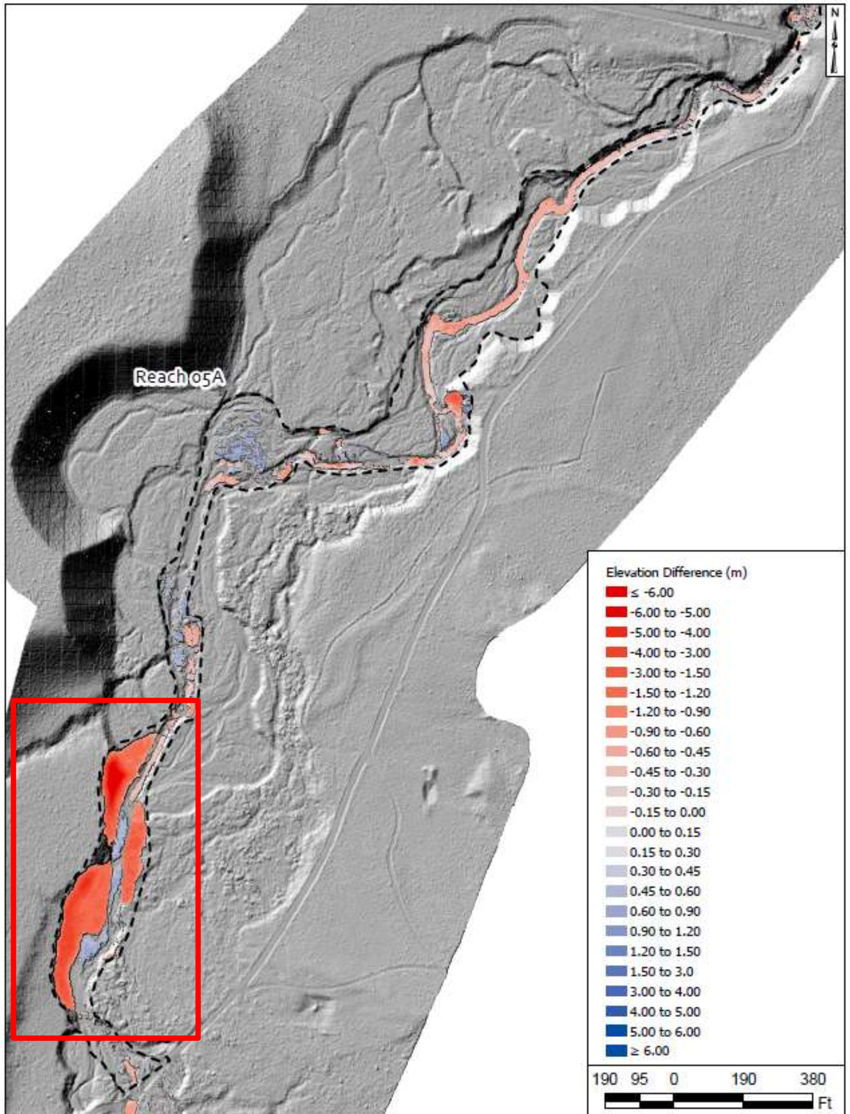
Geomorphic Work Observed from LiDAR Surveys:

- Major terrace erosion from meander and point bar extension
- Increased channel length and creation of new floodplain

May 2017 Imagery

Oct 2017 Imagery

Geomorphic Change Detection: Results



Attribute	Thresholded DoD Estimate:			
AREAL:				
Total Area of Surface Lowering (m²)	16,671			
Total Area of Surface Raising (m²)	5,386			
Total Area of Detectable Change (m²)	22,056			
Total Area of Interest (m²)	NA			
Percent of Area of Interest with Detectable Change	35%			
VOLUMETRIC:			± Error Volume	% Error
Total Volume of Surface Lowering (m³)	26,594	±	3,362	13%
Total Volume of Surface Raising (m³)	3,136	±	1,138	36%
Total Volume of Difference (m³)	29,730	±	4,500	15%
Total **Net** Volume Difference (m³)	**-23,459**	**±**	**3,550**	-15%
VERTICAL AVERAGES:			± Error Thickness	% Error
Average Depth of Surface Lowering (m)	1.60	±	0.20	13%
Average Depth of Surface Raising (m)	0.58	±	0.21	36%
Average Total Thickness of Difference (m) for Area of Interest	0.47	±	0.07	15%
Average **Net** Thickness Difference (m) for Area of Interest	**-0.37**	**±**	**0.06**	-15%
Average Total Thickness of Difference (m) for Area With Detectable Change	1.35	±	0.20	15%
Average **Net** Thickness Difference (m) for Area with Detectable Change	**-1.06**	**±**	**0.16**	-15%
PERCENTAGES (BY VOLUME)				
Percent Elevation Lowering	89%			
Percent Surface Raising	11%			
Percent Imbalance (departure from equilibrium)	-39%			
Net to Total Volume Ratio	-79%			

Geomorphic Change Detection

Geomorphic Work Observed from LiDAR Surveys:

- Major channel migration, point bar extension, and terrace erosion
- Increased channel length and creation of new floodplain

May 2017 Imagery

Oct 2017 Imagery

Geomorphic Change Detection: Results

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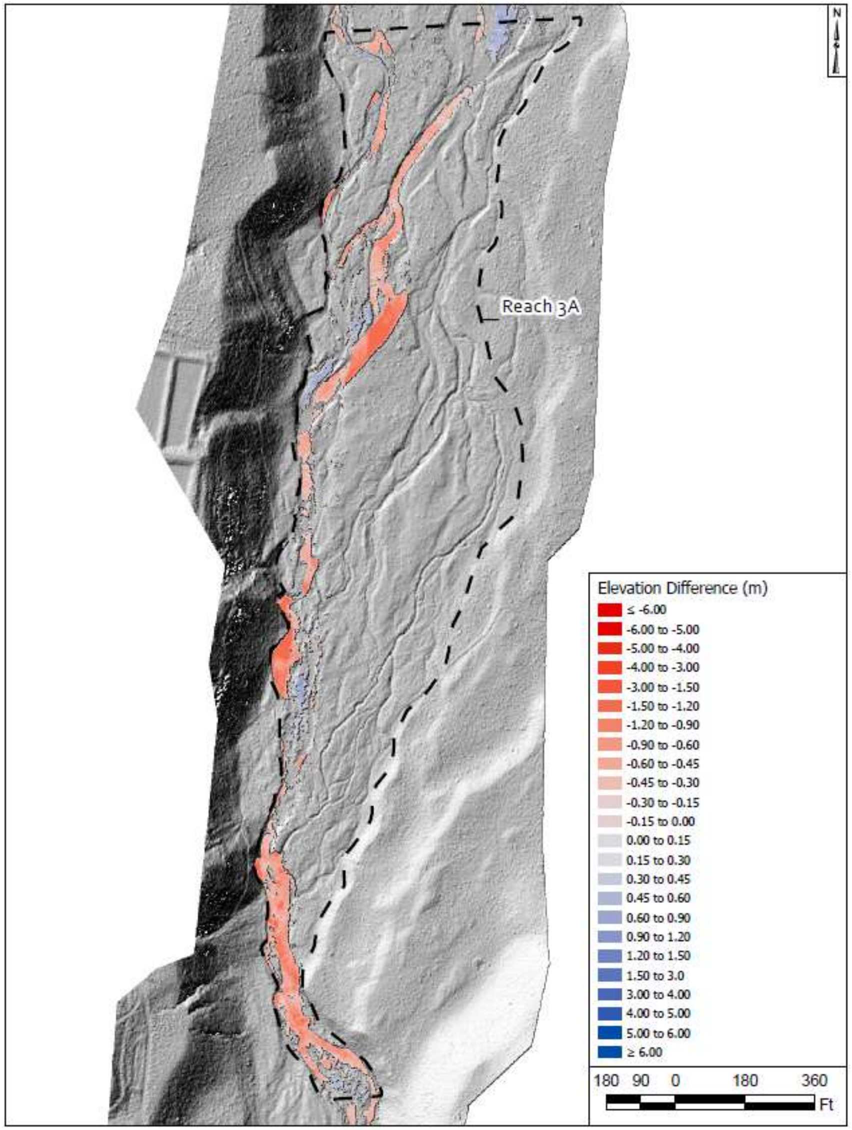
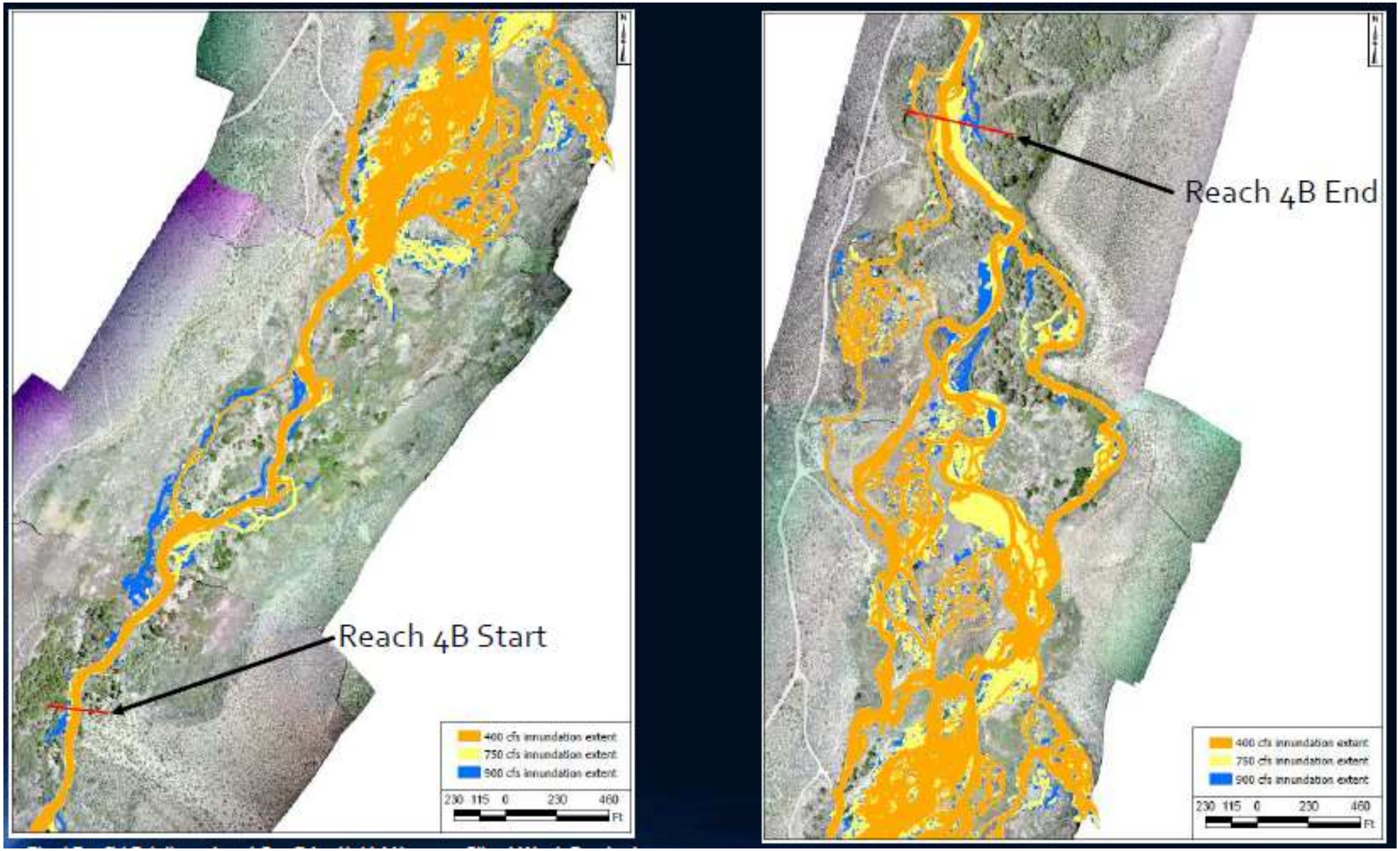


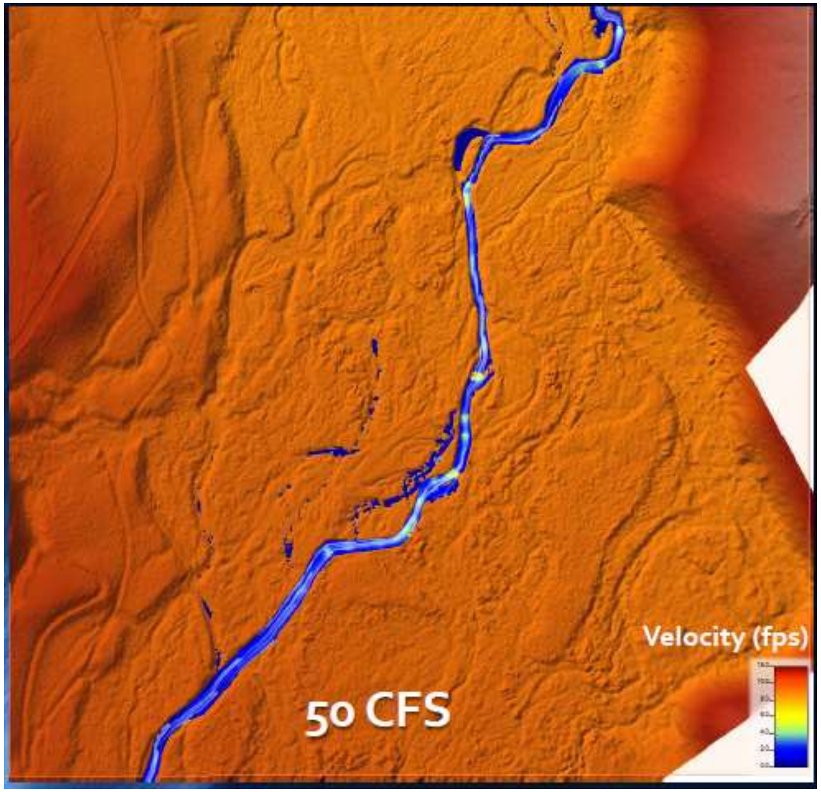
Attribute	Thresholded DoD Estimate:			
AREAL:				
Total Area of Surface Lowering (m^2)	11,111			
Total Area of Surface Raising (m^2)	1,852			
Total Area of Detectable Change (m^2)	12,963			
Total Area of Interest (m^2)	NA			
Percent of Area of Interest with Detectable Change	28%			
VOLUMETRIC:			± Error Volume	% Error
Total Volume of Surface Lowering (m^3)	9,047	±	1,881	21%
Total Volume of Surface Raising (m^3)	891	±	315	35%
Total Volume of Difference (m^3)	9,938	±	2,197	22%
Total **Net** Volume Difference (m^3)	**-8,156**	±	**1,908**	-23%
VERTICAL AVERAGES:			± Error Thickness	% Error
Average Depth of Surface Lowering (m)	0.81	±	0.17	21%
Average Depth of Surface Raising (m)	0.48	±	0.17	35%
Average Total Thickness of Difference (m) for Area of Interest	0.22	±	0.05	22%
Average **Net** Thickness Difference (m) for Area of Interest	**-0.18**	±	**0.04**	-23%
Average Total Thickness of Difference (m) for Area With Detectable Change	0.77	±	0.17	22%
Average **Net** Thickness Difference (m) for Area with Detectable Change	**-0.63**	±	**0.15**	-23%
PERCENTAGES (BY VOLUME)				
Percent Elevation Lowering	91%			
Percent Surface Raising	9%			
Percent Imbalance (departure from equilibrium)	-41%			
Net to Total Volume Ratio	-82%			

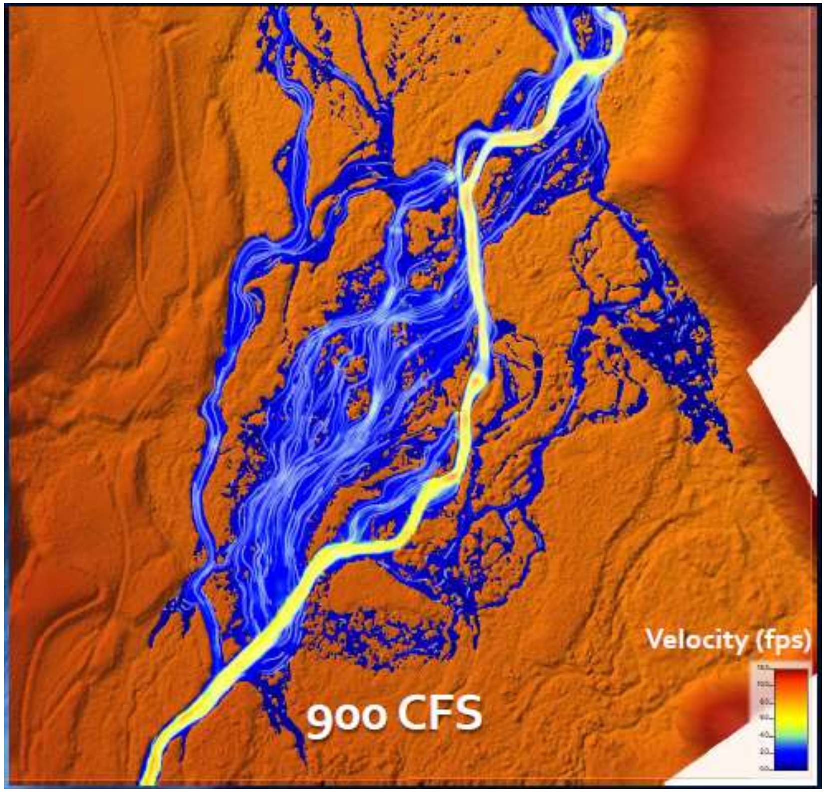

May 2017
Oct 2017

Floodplain Inundation Mapping



H&H Modeling





High-Res Aerial Imagery

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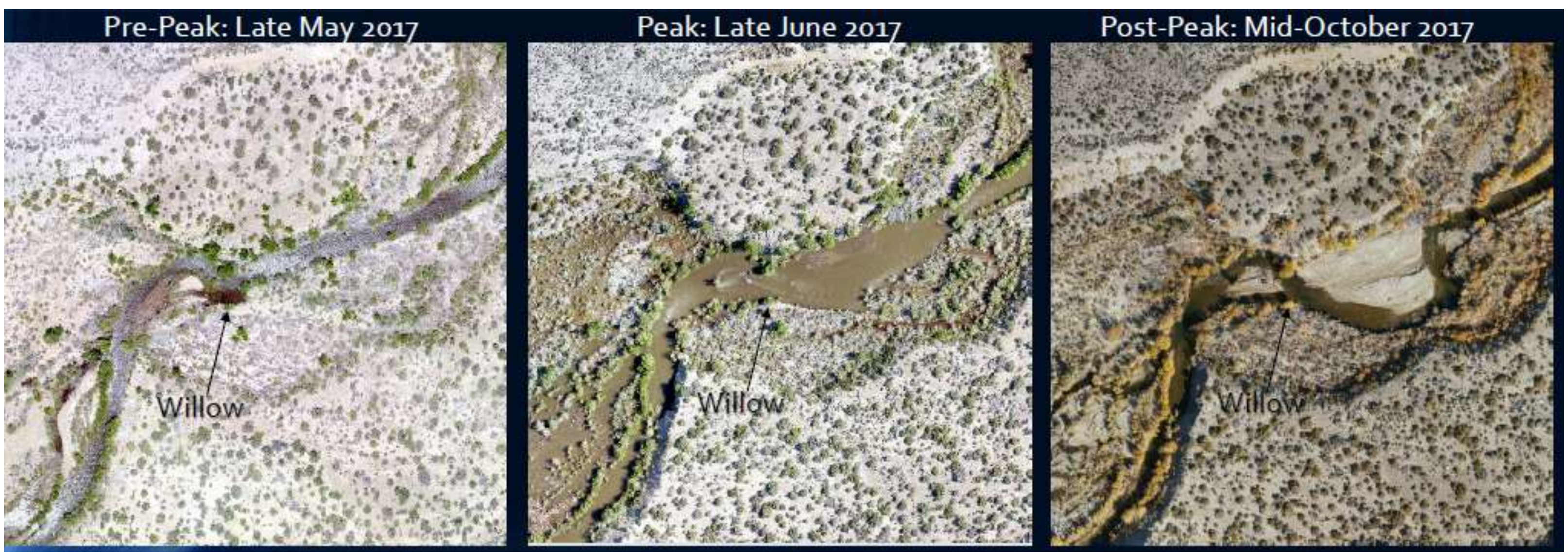

High-Res Aerial Imagery

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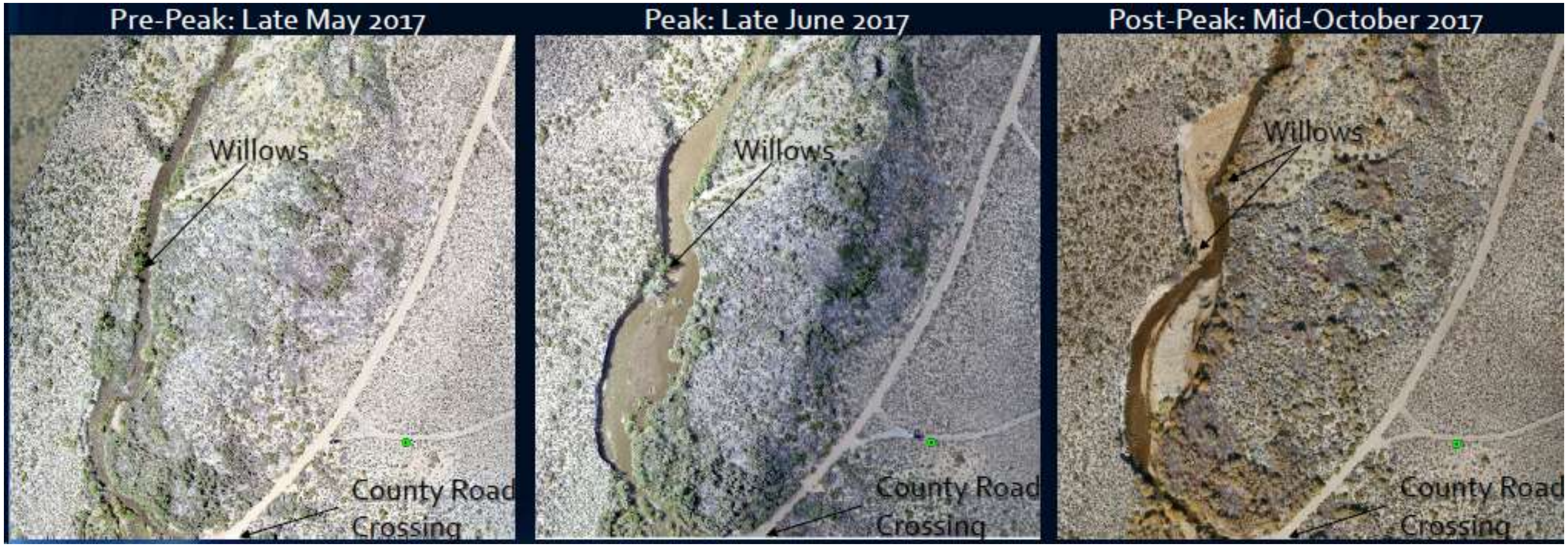

Considerations

- Increased spatial coverage and data density
  - Allow practitioners to better understand the geomorphic rate and magnitude of change and how this relates to stream-system processes influencing form and function of a river system, especially in post-restoration scenarios.
- Increased spatial coverage allows practitioners to evaluate system wide process over time
- Practitioners can focus monitoring and assessment efforts in the future on reaches that have displayed significant geomorphic change
- Particularly useful in restoration monitoring for targeting reaches not meeting restoration criteria
  - Focused mitigation and rehabilitation

Questions