Columbia Lake Dam Removal;
Using Drones for Quantitative Evaluation of River Restoration

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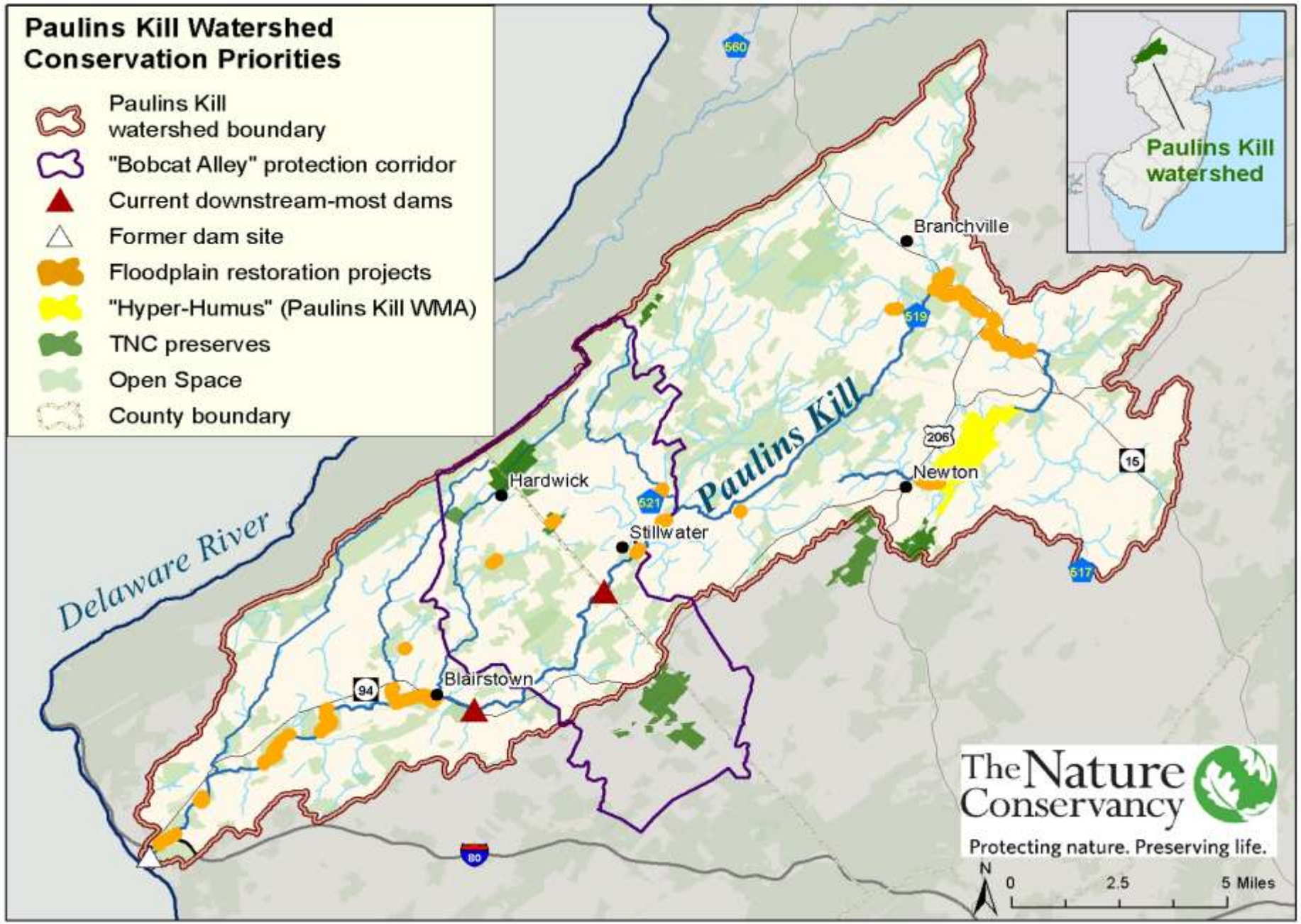

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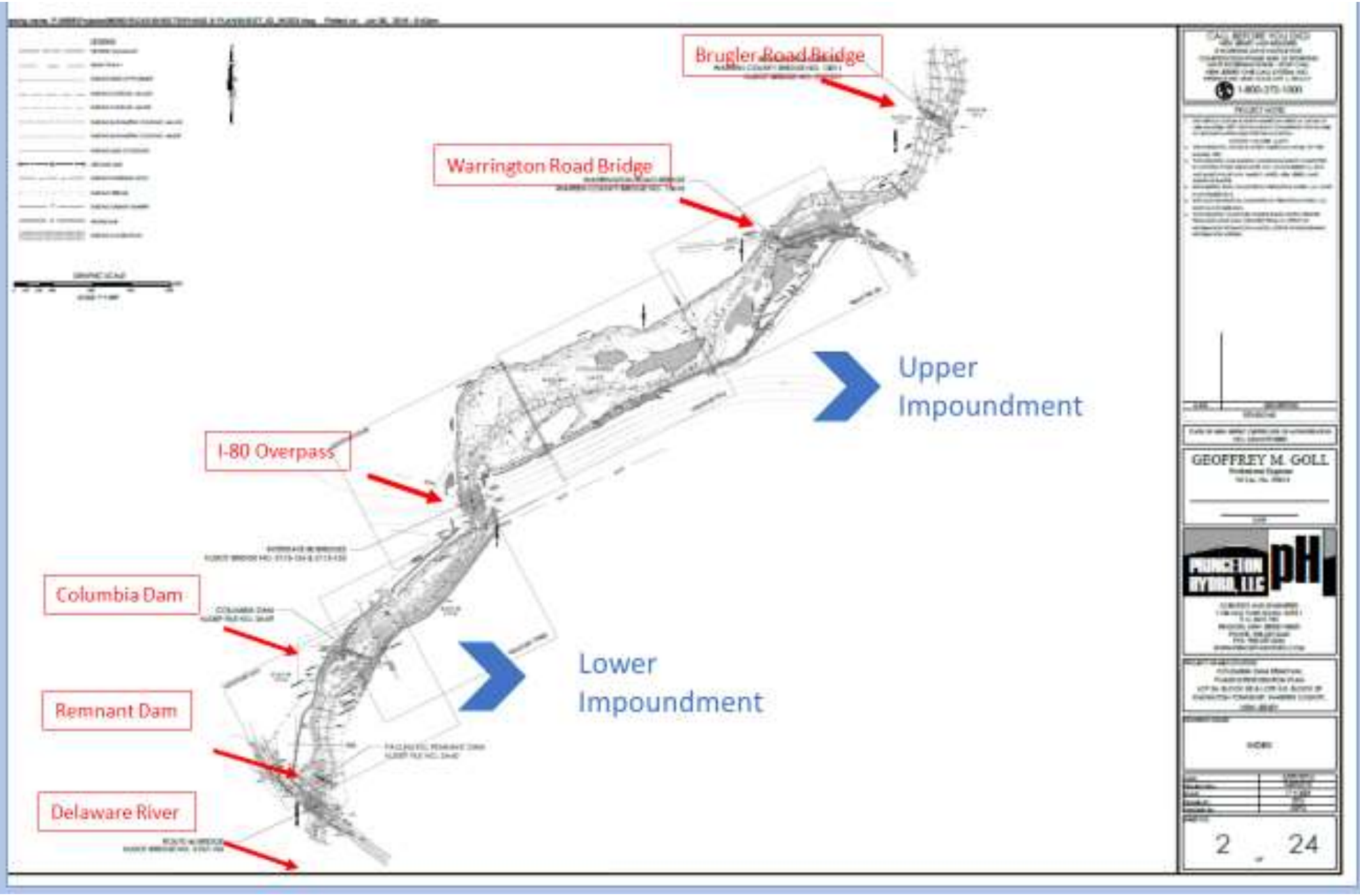
Columbia Dam Removal Project Goals

- Fish Migration
- Habitat Improvement
- Water Quality Improvement
- Natural Channel Hydraulics
- Recreational Enhancement
- Increased Public Safety
- Creating and Connecting Floodplain

A dam is gone, and the shad are back. After 100 years, the fish have returned to a Delaware River tributary.

Updated Apr 24, 2019;

Saed Hindash | For lehighvalleylive.com


Brugler Road Bridge
Warrington Road Bridge
Upper Impoundment
I-80 Overpass
Columbia Dam
Lower Impoundment
Remnant Dam
Delaware River
GEOFFREY M. GOLL
2 24

Drone’s eye view of project area before removal and during initial drawdown.

Typical Monitoring Measurements

- Temperature
- Dissolved Oxygen
- Turbidity
- Macroinvertebrates
- Mussels
- Eels
- Fish
- Habitat

DRONE
MONITORING
MEASUREMENT

STUDY QUESTIONS

Project outcomes the team hoped to evaluate quantitatively:

- Acres of floodplain habitat regained
- Volume of water “lost” / storage gained
- Changing channel area
- Vegetation growth over time
- Sediment/geomorphic volumetric changes either via consolidation, erosion

Will the quality of information be good enough to:

- Allow more frequent monitoring on a budget?
- Inform adaptive management decisions?
- Answer permitting questions?

Using Drones for Quantitative Evaluation

Photogrammetry raphs. The input
to photogrammet a drawing, a
measurement, or

A Digital Terrain M ion of a surface.

A Digital Surface M n of objects in an area.

The orthomosaic oves the
perspective disto er of matches (more
than 1000) is req l and therefore the
orthomosaic can

Flight Paths

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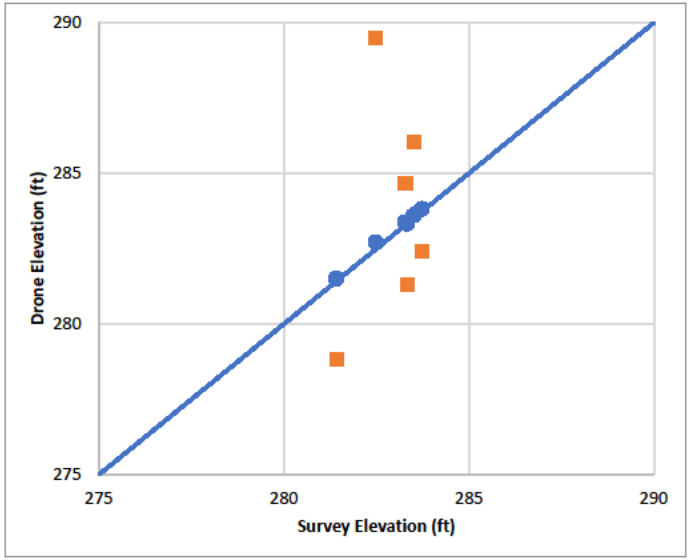
Ground Control points

Ground Control Points



Comparison between uncalibrated drone and surveyed elevations (standard error of 11.15 inches)

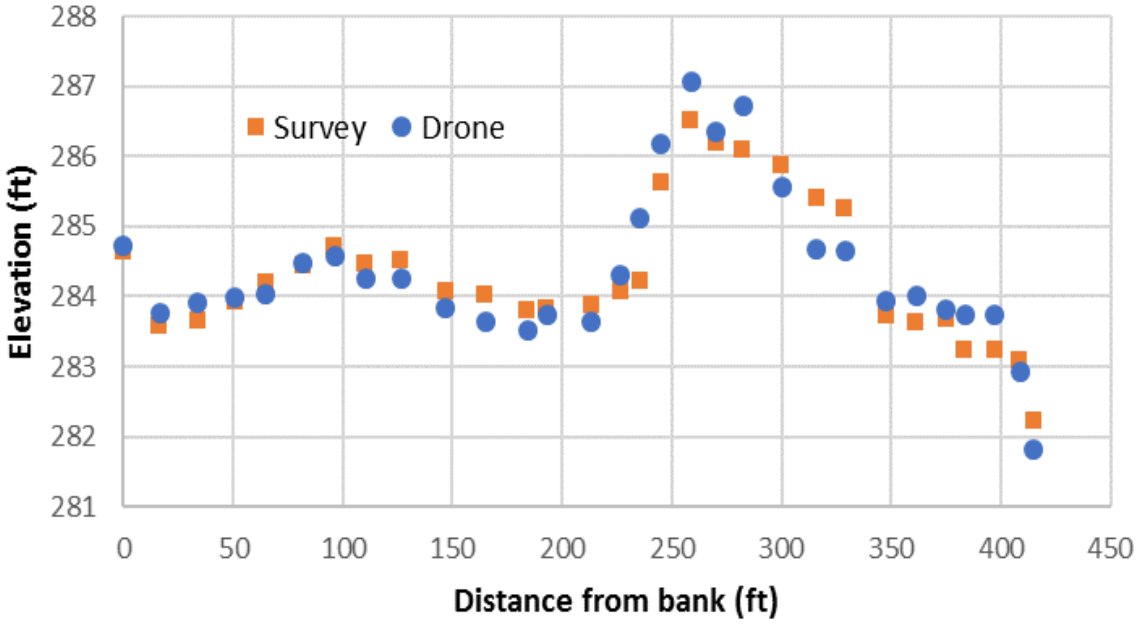
Comparison between calibrated GCP corrected drone and survey elevations (standard error of 0.90 inches).

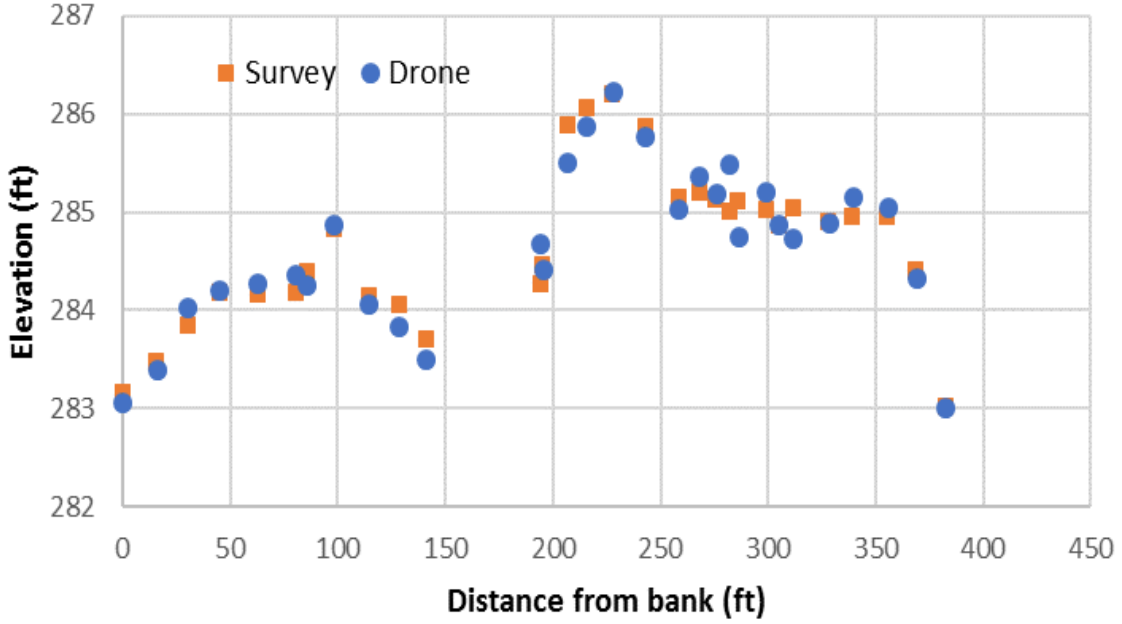
Standard error numbers relate to the validation (impact) of calibration or the measure of how close those dots are to the blue line which would be “perfect”.

Casey versus The Drone

comparing elevational data

drone flights vs. land survey
selected cross sections (upper impoundment)

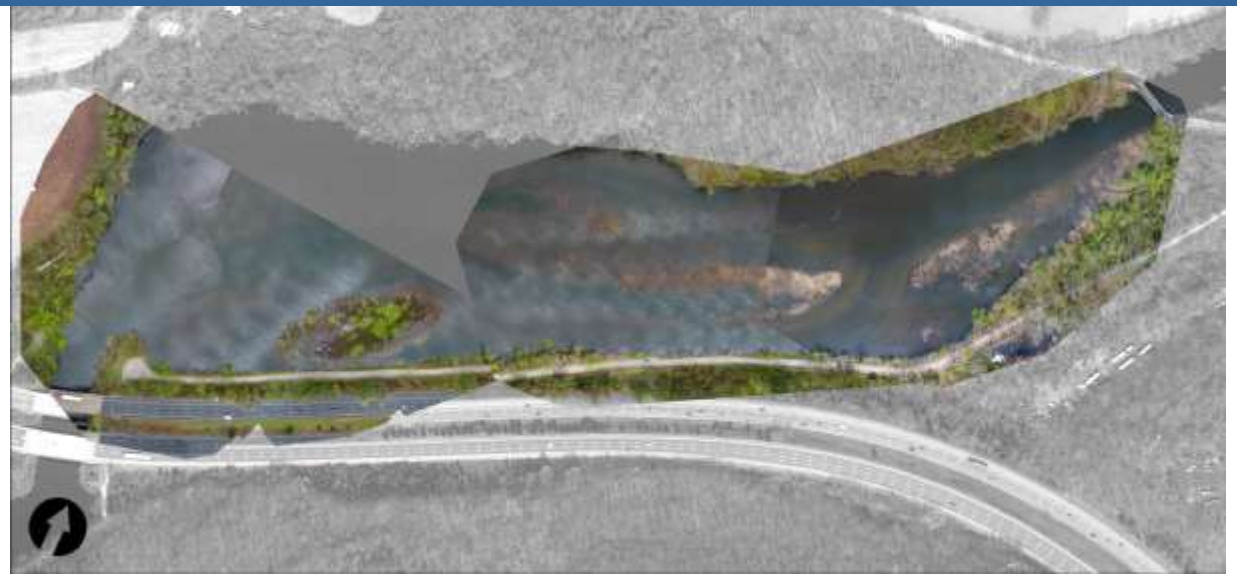


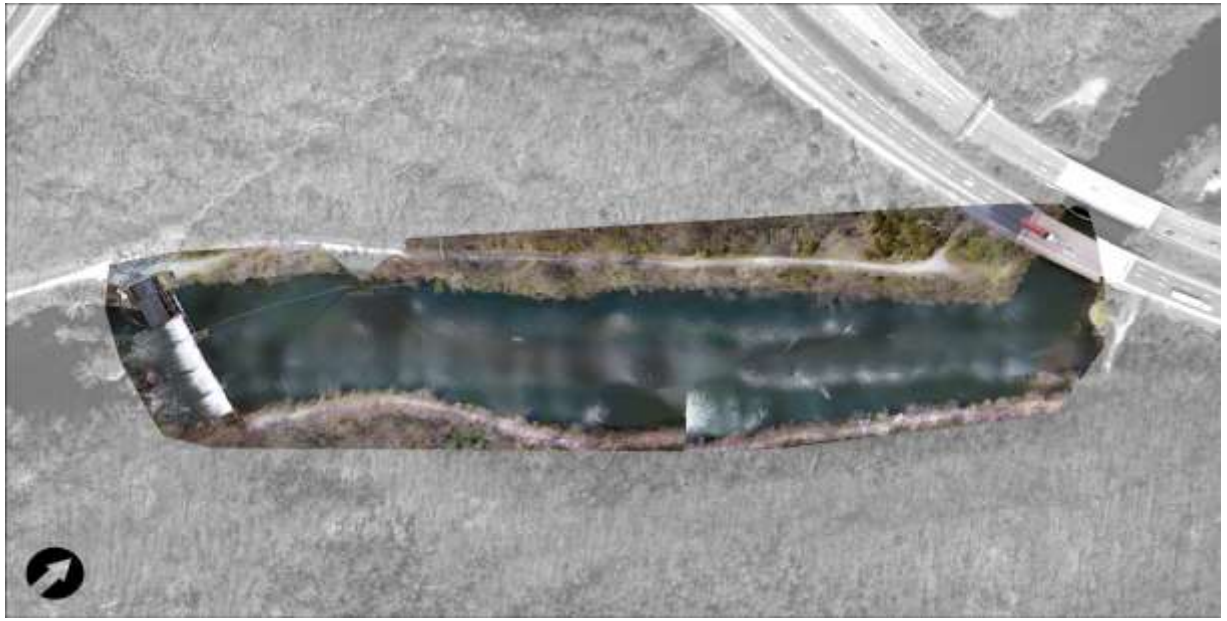


Cross Section #1
Average Error = -0.040 ft
Root Mean Square Error = 0.381 ft

Cross Section #2
Average Error = 0.006 ft
Root Mean Square Error = 0.194 ft

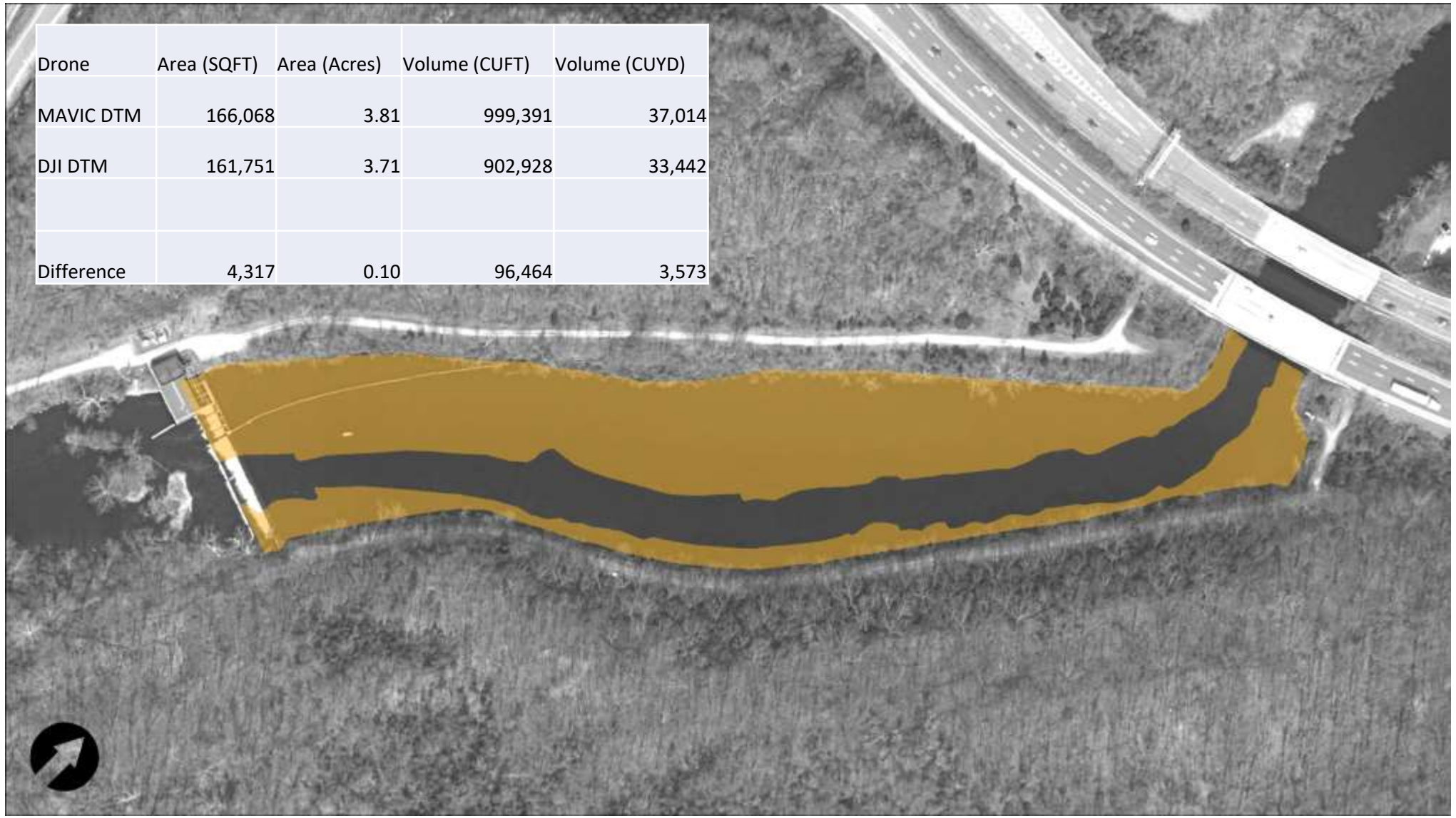
Data Collection Over Water



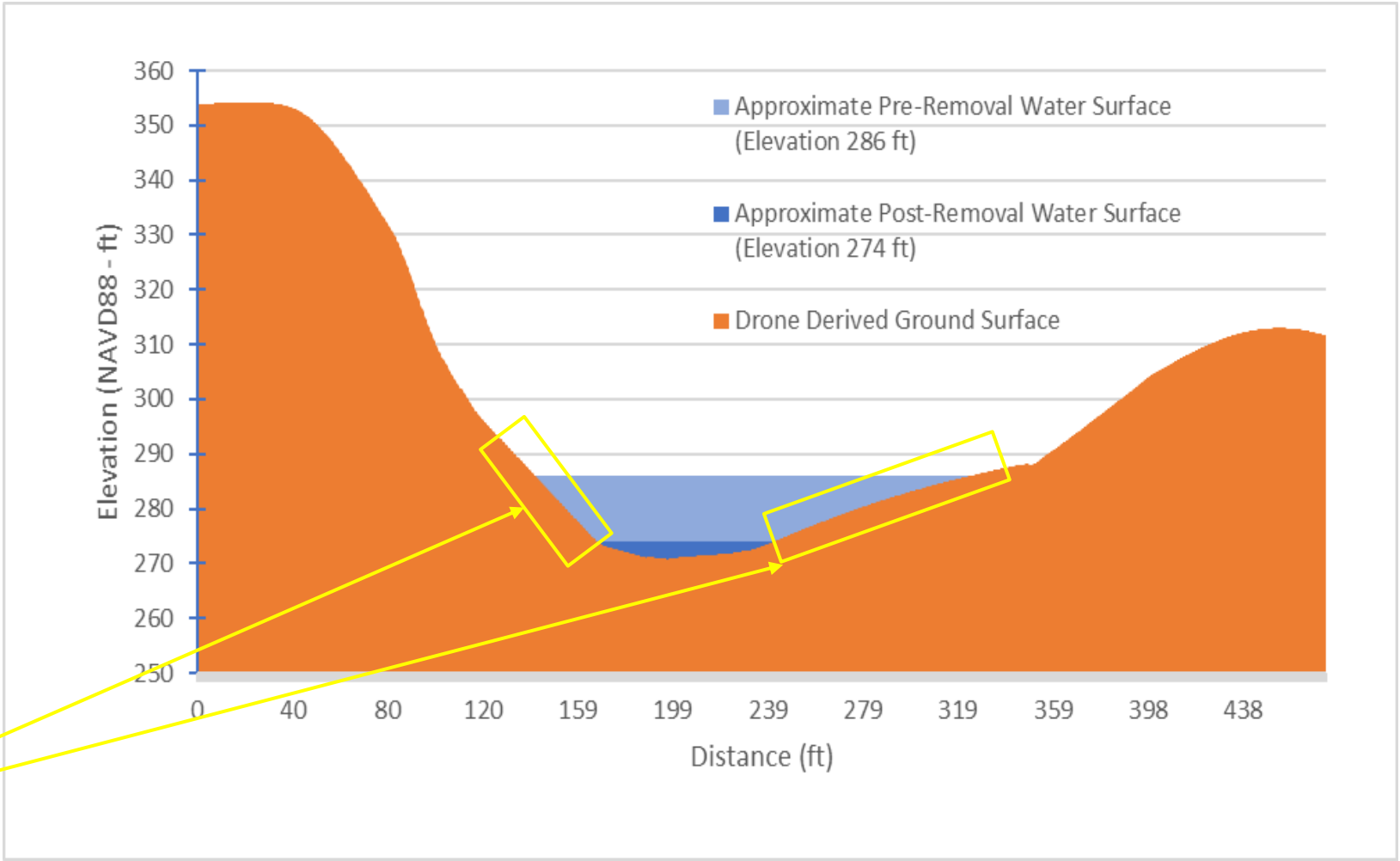


Calculations

Drone	Area (SQFT)	Area (Acres)	Volume (CUFT)	Volume (CUYD)
MAVIC DTM	166,068	3.81	999,391	37,014
DJI DTM	161,751	3.71	902,928	33,442
Difference	4,317	0.10	96,464	3,573

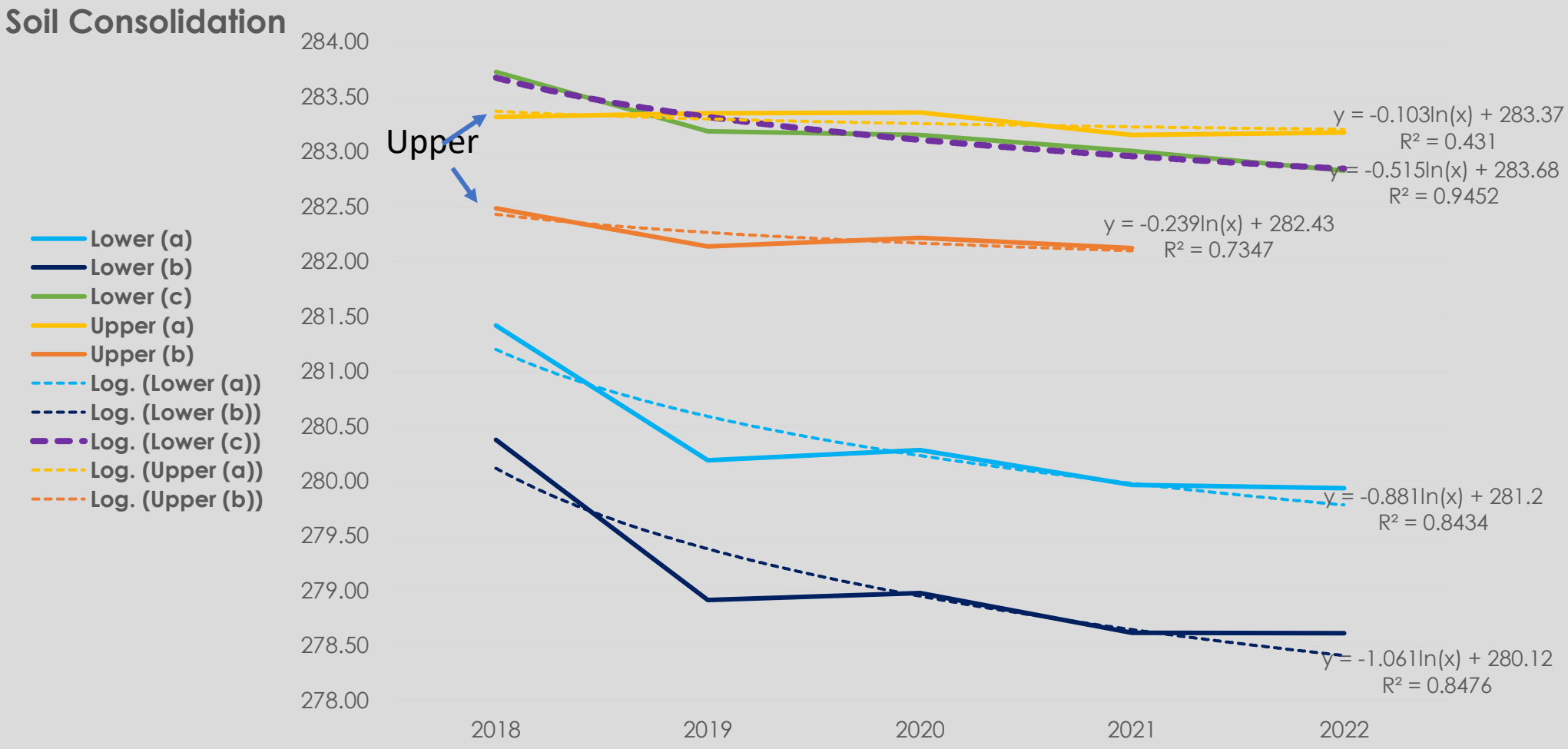


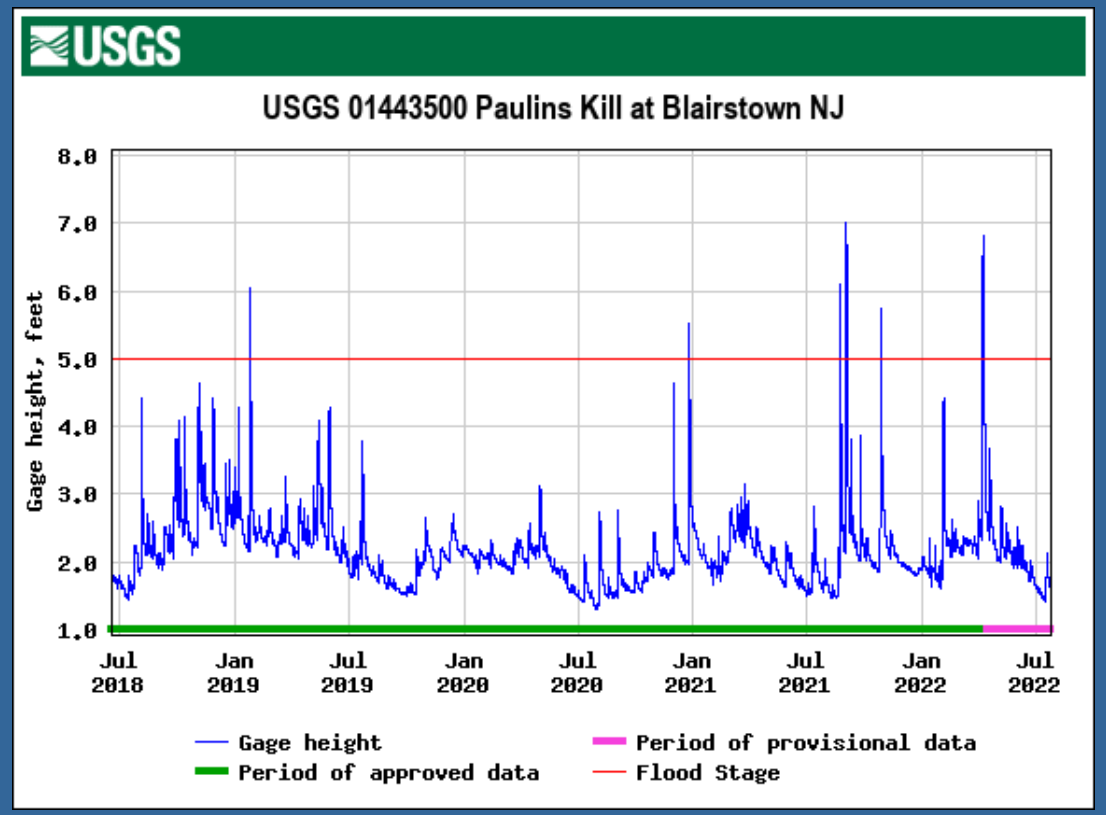
Calculations

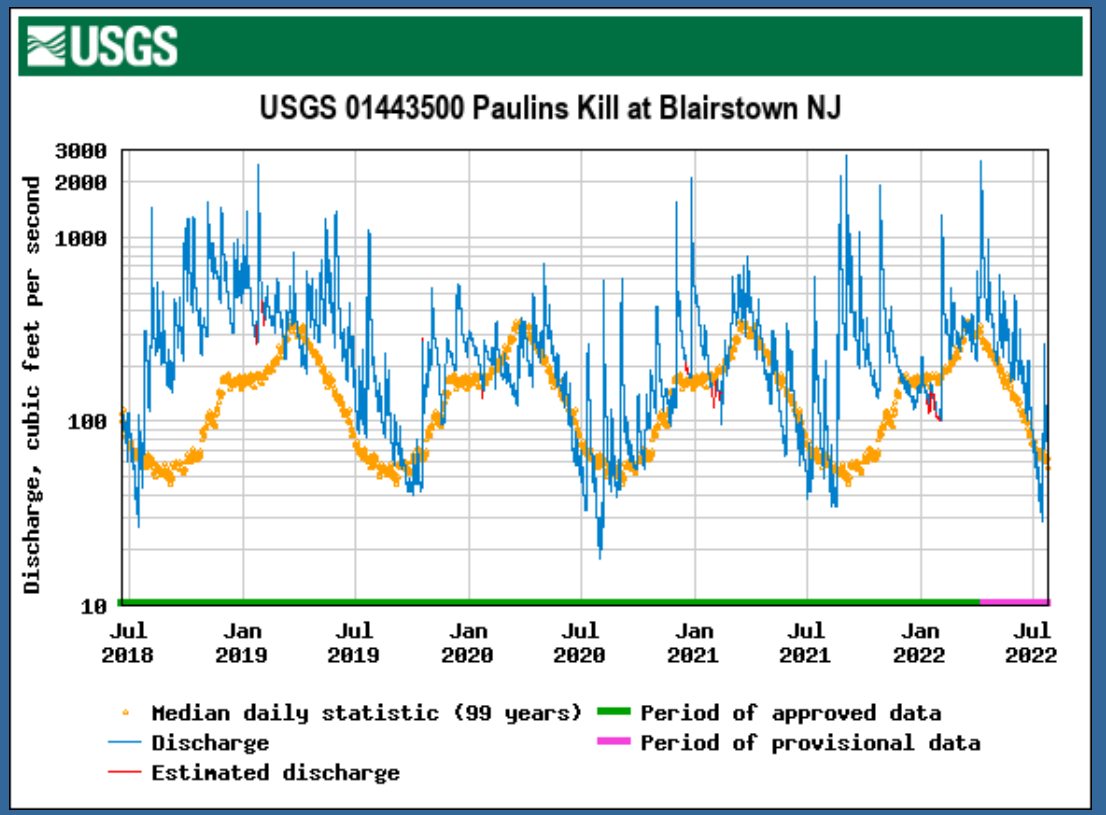


Increased riparian habitat

Soil Consolidation





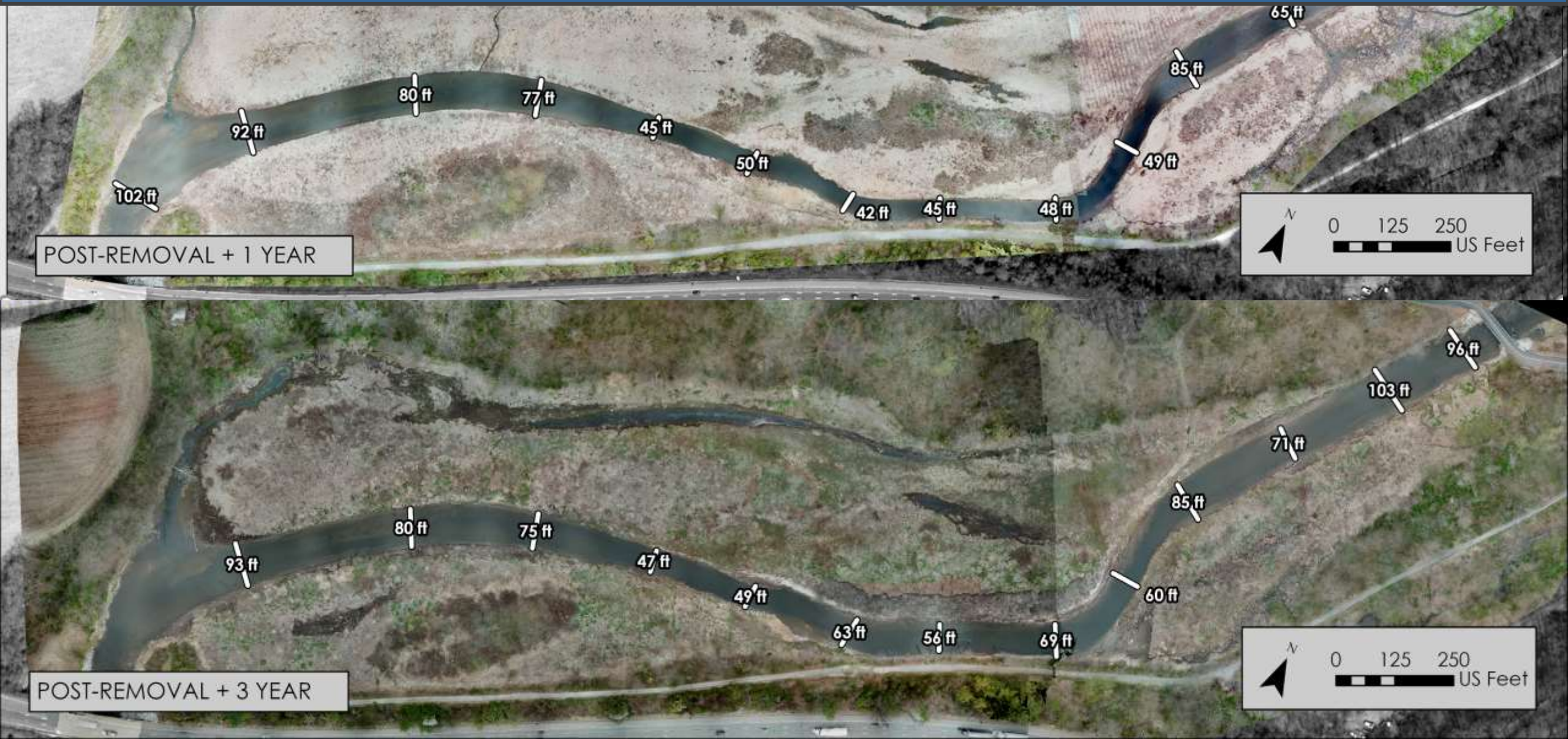


Flows During First Four Years of the Project

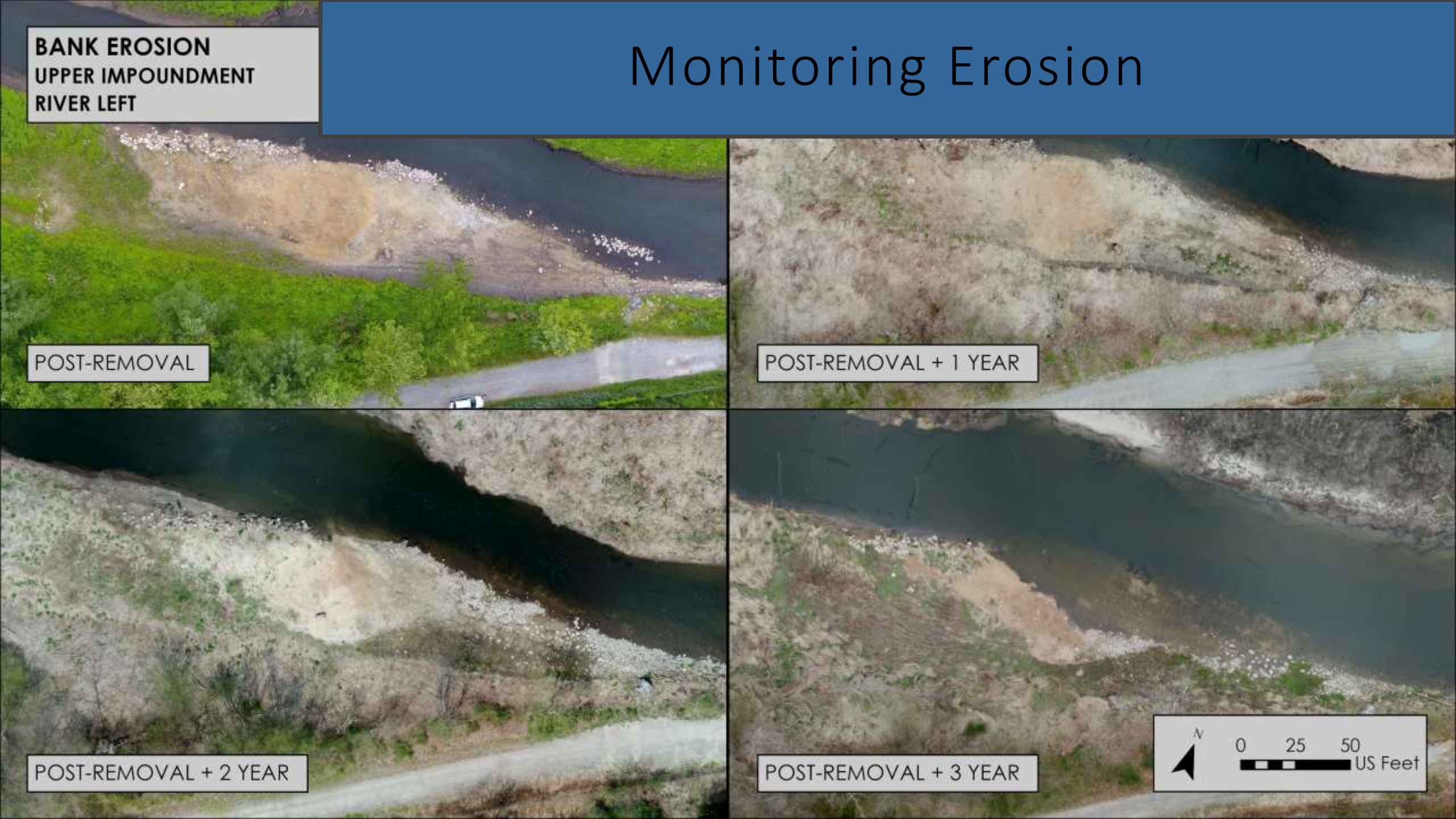
Practical “everyday” uses

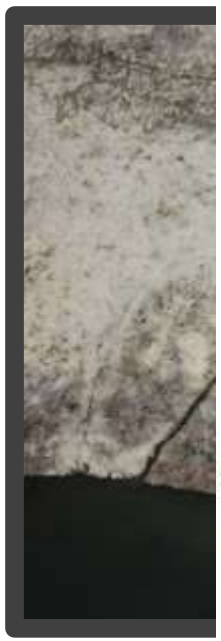
Figure 1 Upper impoundment showing conditions in June 2019 (top) and April 2020 (bottom). The widths of the river channel in each photograph align with the other.

MONITORING ADAPTIVE MANAGEMENT



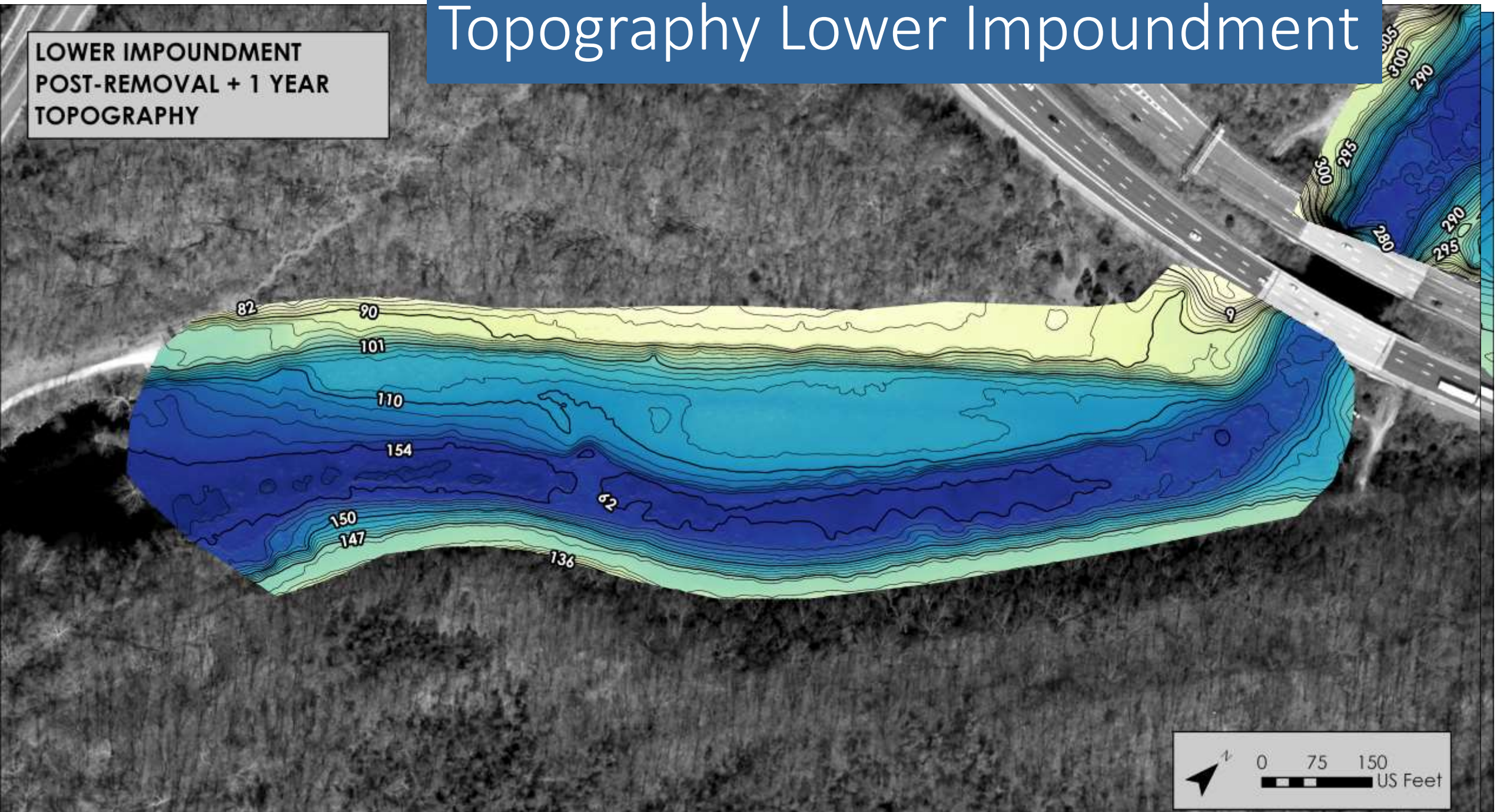
Monitoring Erosion

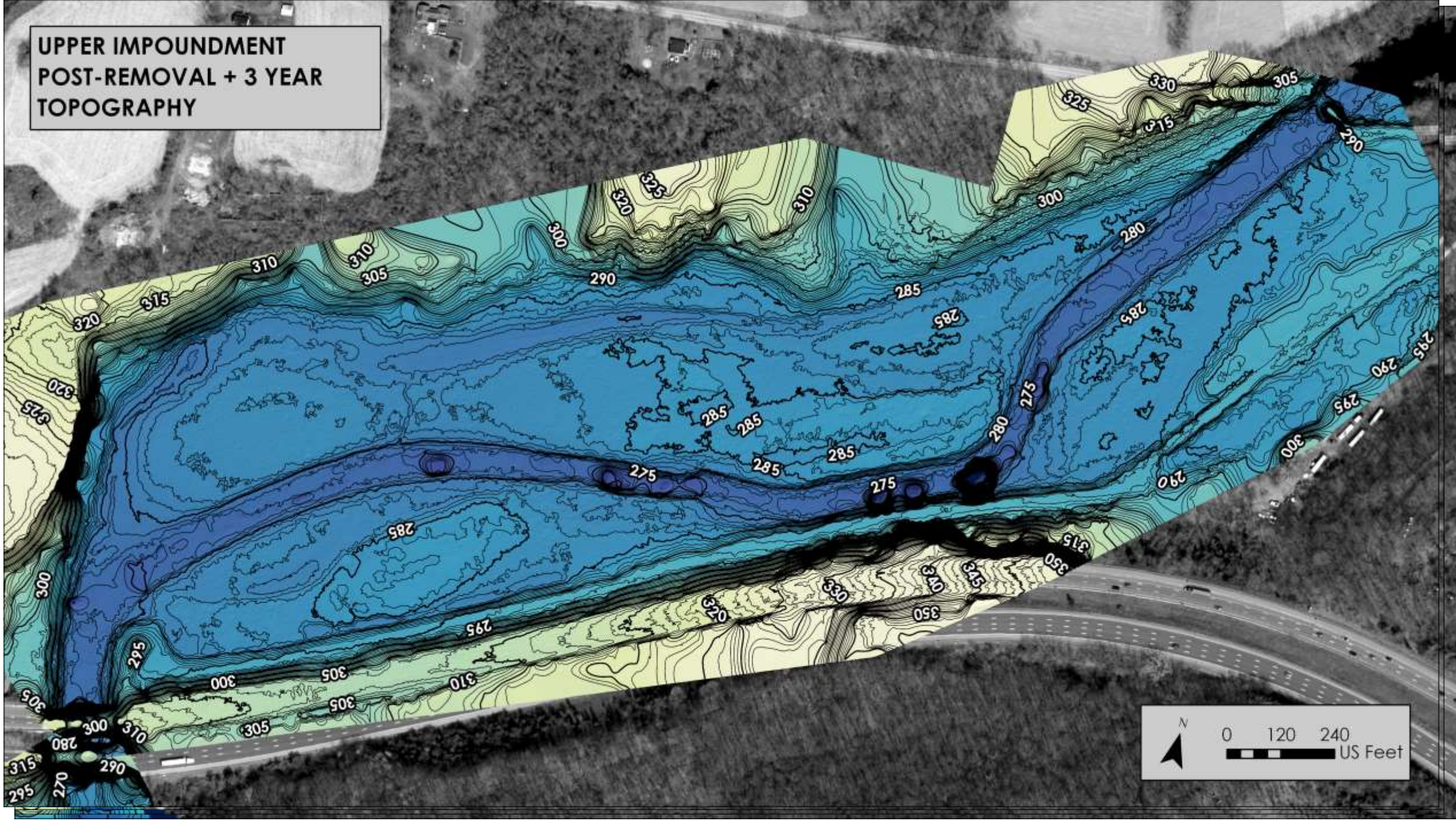


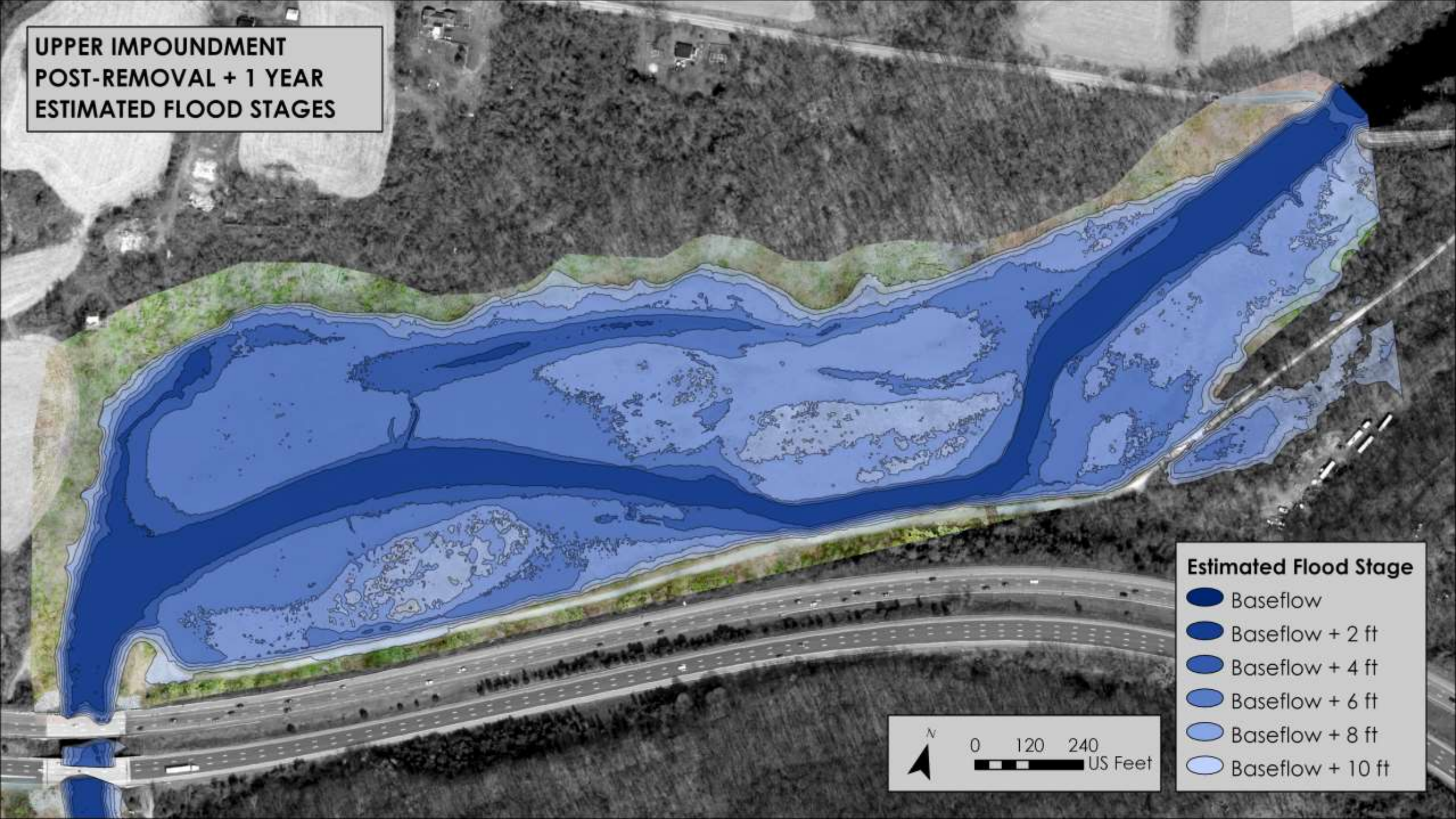


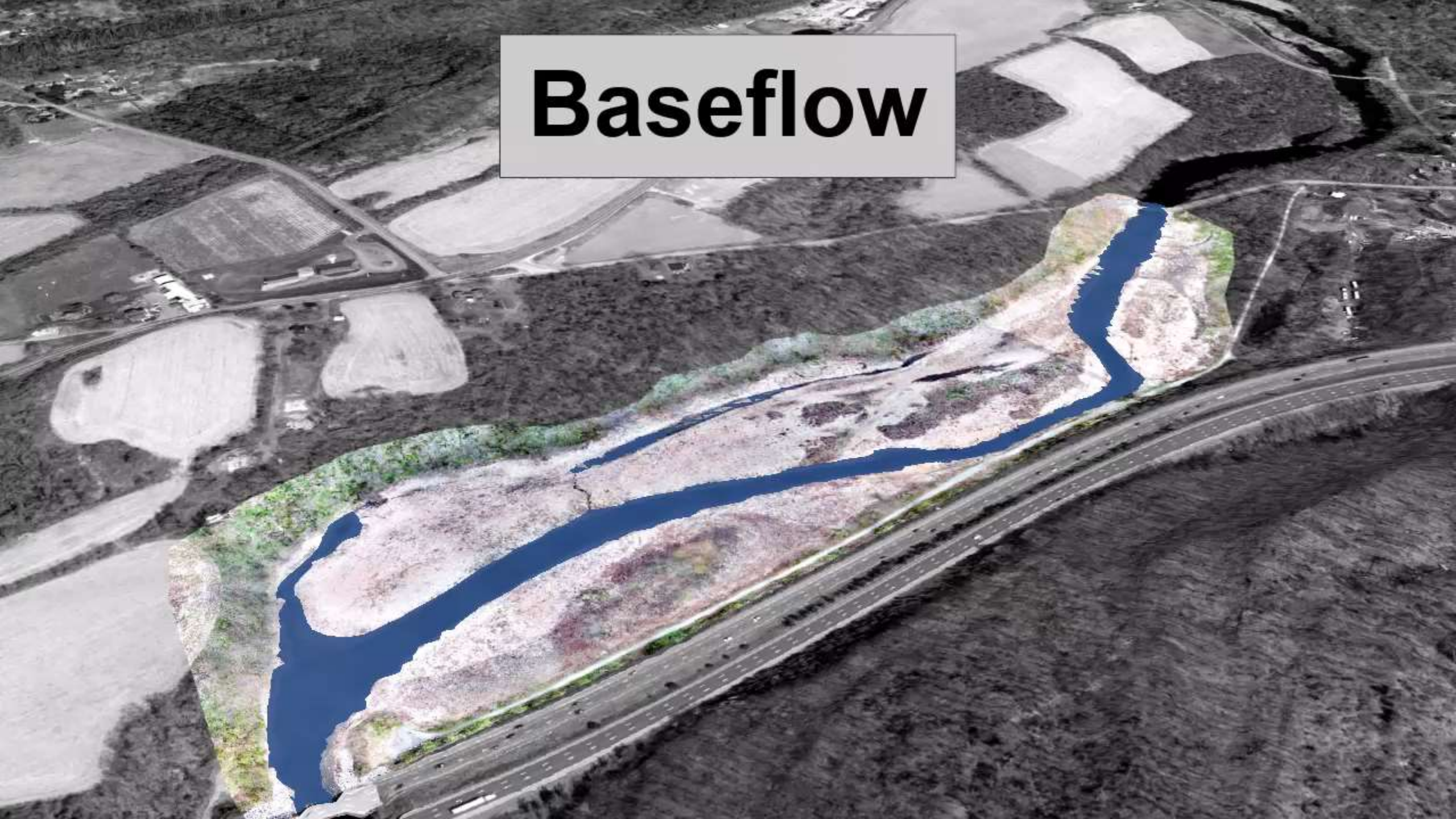

POTENTIAL REMNANT
LOWER IMPOUNDMENT
RIVER RIGHT
POST-REMOVAL
POST-REMOVAL + 1 YEAR
POST-REMOVAL + 2 YEAR
POST-REMOVAL + 3 YEAR
N
0
25
50
US Feet

Topography Lower Impoundment




UPPER IMPOUNDMENT
POST-REMOVAL + 3 YEAR
TOPOGRAPHY
N
0
120
240
US Feet


UPPER IMPOUNDMENT
POST-REMOVAL + 1 YEAR
ESTIMATED FLOOD STAGES
Estimated Flood Stage
Baseflow
Baseflow + 2 ft
Baseflow + 4 ft
Baseflow + 6 ft
Baseflow + 8 ft
Baseflow + 10 ft
N
0
120
240
US Feet


Baseflow

Lessons Learned in the Field

- Water or dense vegetation can make elevation data unusable.
- Use the maximum amount of GCPs possible. Choose existing infrastructure not expected to change such as bridges, roads or rooftops.
- A double grid flight path is necessary for good 3-D mapping and data accuracy.
- The elevation of the launch area should be surveyed for each flight.
- Battery requirements and year-round vegetation is important for flight planning.
- Avoid times when sun glare and shadow will be problematic.

Lessons Learned Processing Data

- GCPs should be consistent between flights and resurveyed before each flight.
- Seasonality is important. Unlike LiDAR, photogrammetric methods can't penetrate vegetation.
- Path layout is important, the upper impoundment post conditions used a single rather than double grid. Double grids are recommended for 3D models.
- WSEL data is important since surfaces can't be properly modeled over open water.

Note: For the most part, addressing our "Lessons Learned" in the field will fix the processing problems that we saw.

Conclusions

- Yes, quantitative monitoring of restoration work is possible.
- Waterbodies present special challenges to data collection.
- Practice runs are necessary to determine if error is acceptable for your purposes.
- Different drones/cameras did not create significant calculation differences – in *our* acceptable error range.
- The information has been useful in discussions with and reporting to regulators.

Thank you.
Questions?

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Check out njdams.org