

Contributions of River Bathymetry to Surface Area

Presentation to IDT-October 2015

Hypothesis

Surface area of the reach is related to topographic complexity

$$Rugosity = \lim_{N \rightarrow \infty} \frac{A_{3D}(1)}{A_{3D}(N)}$$

The more 3D surface area relative to 2D planform area the more complex the reach???

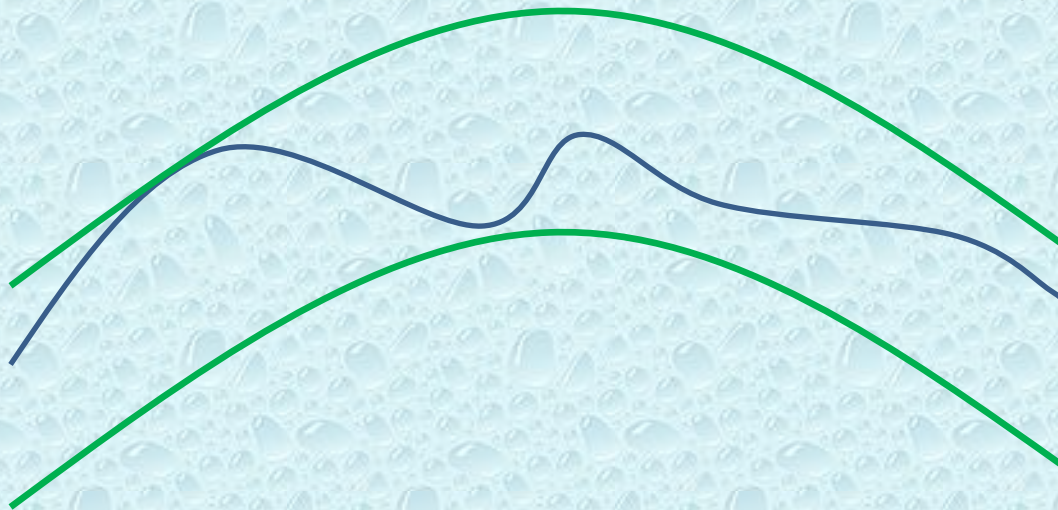
Rugosity

Rugosity is equal to

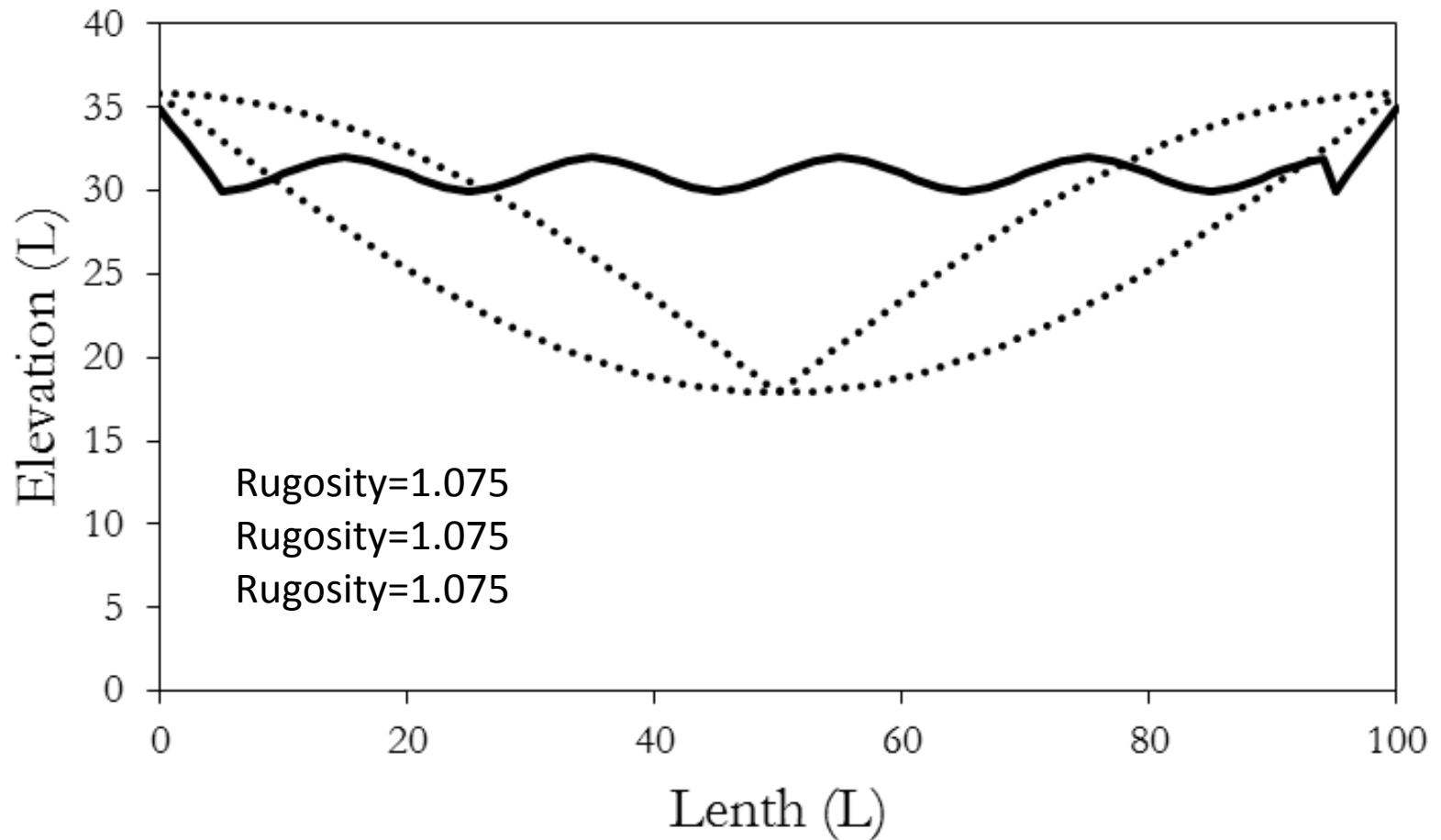
$$\lim_{N \rightarrow \infty} \frac{A_{3D}(1)}{A_{3D}(N)} = \text{Rugosity}$$

2D The analogy
Sinuosity

$$\frac{\text{Channel Length}}{\text{Valley Length}}$$



Rugosity has scale problems



Triple Decomposition Theorem

$$d(x, y) = \bar{D} + d'(x, y) + d''(x, y)$$

d= distribution of depth in the reach

\bar{D} =reach averaged depth

d'=large scale topographic variability

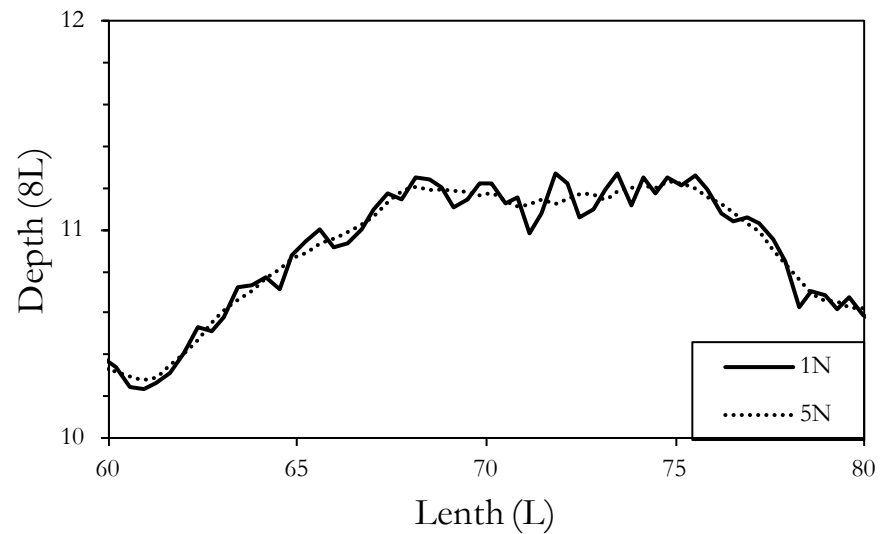
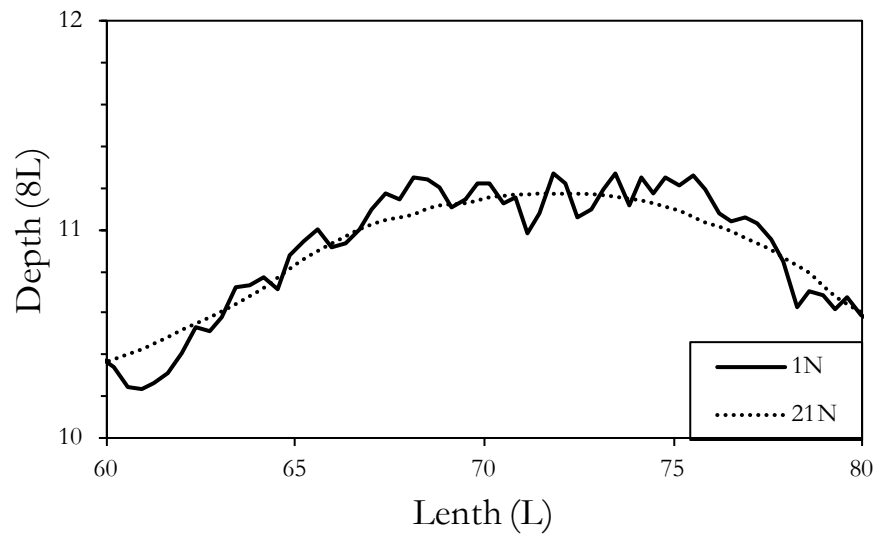
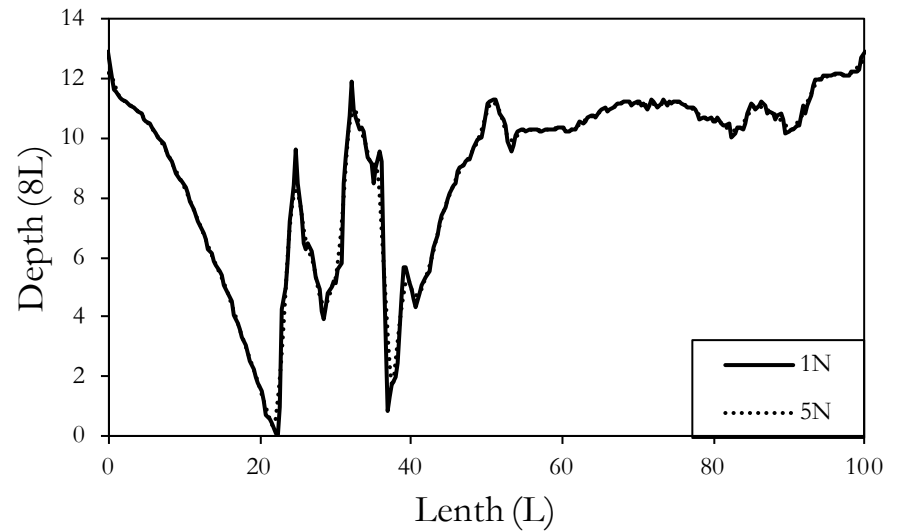
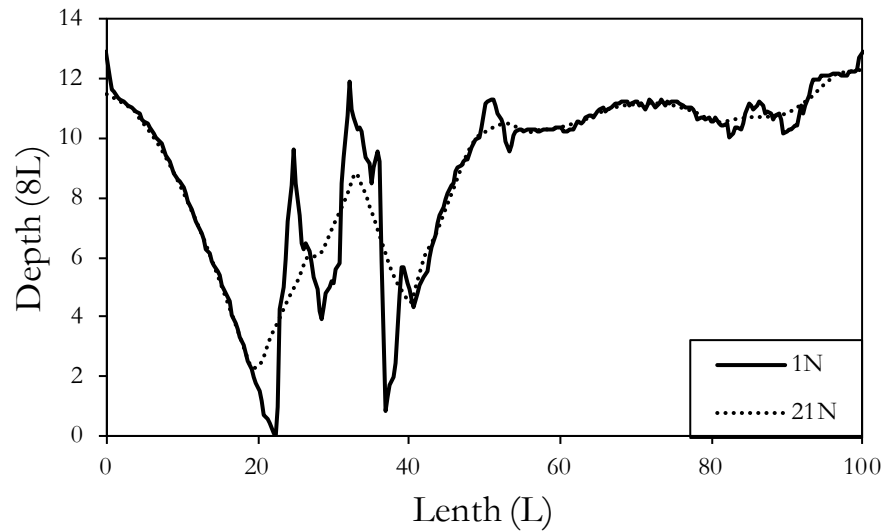
d''= small scale topographic variability

$$D + u'(x, y) = \frac{1}{N^2} \int_{x-\frac{N}{2}}^{x+\frac{N}{2}} \int_{y-\frac{N}{2}}^{y+\frac{N}{2}} u'(x', y') dy' dx'$$

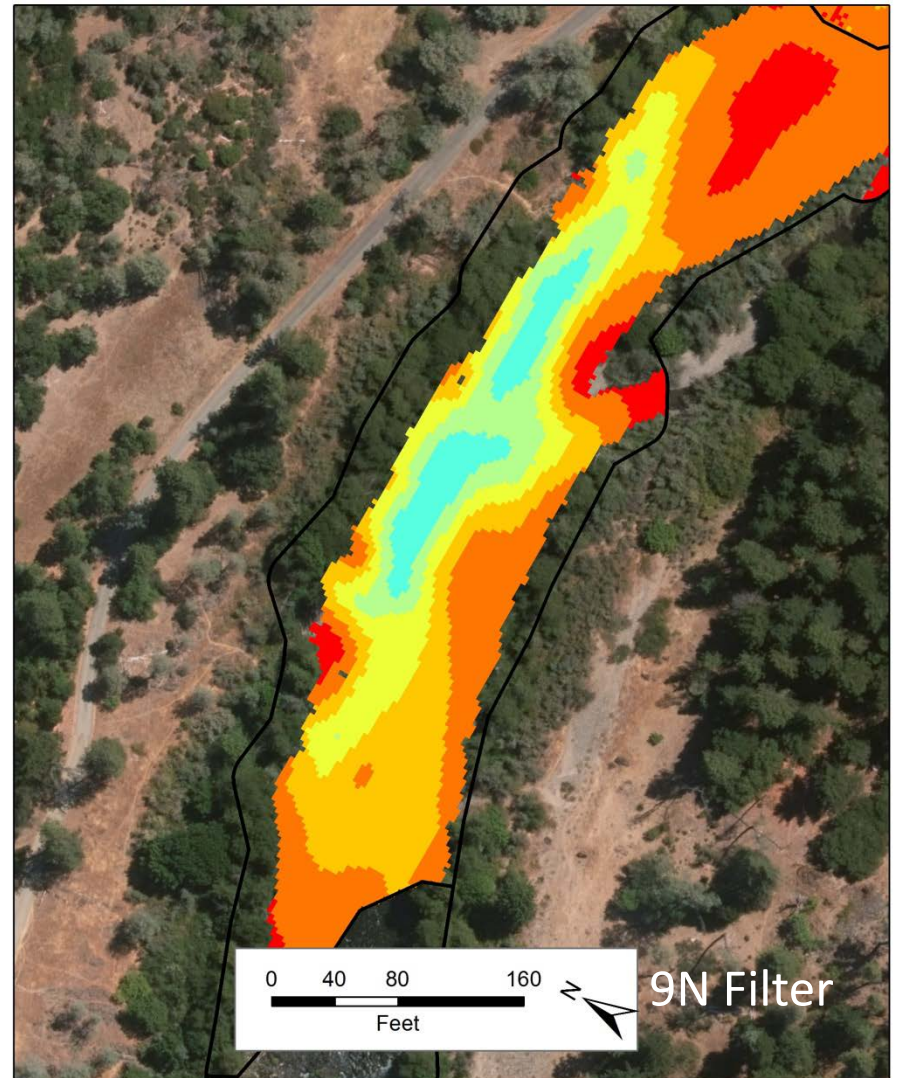
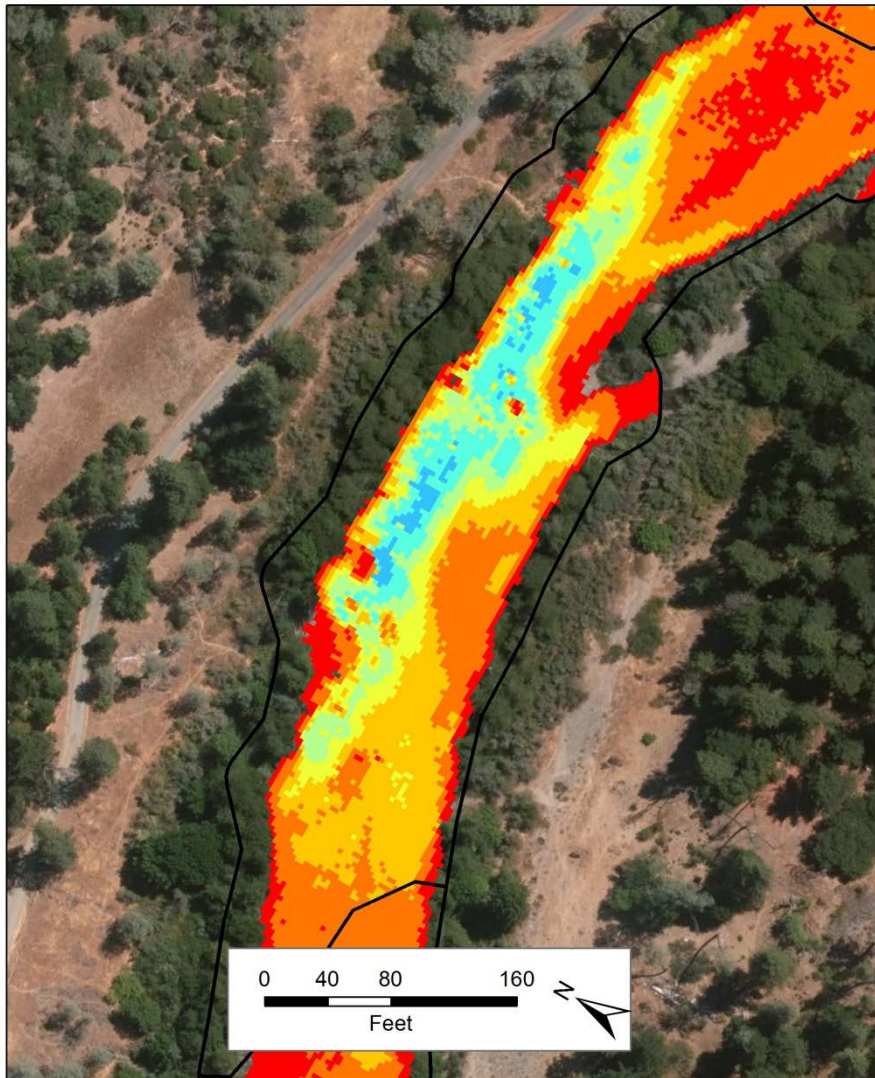
N=spatial-step used to isolate u' and u''

Remember This We Will Use It Shortly !!!

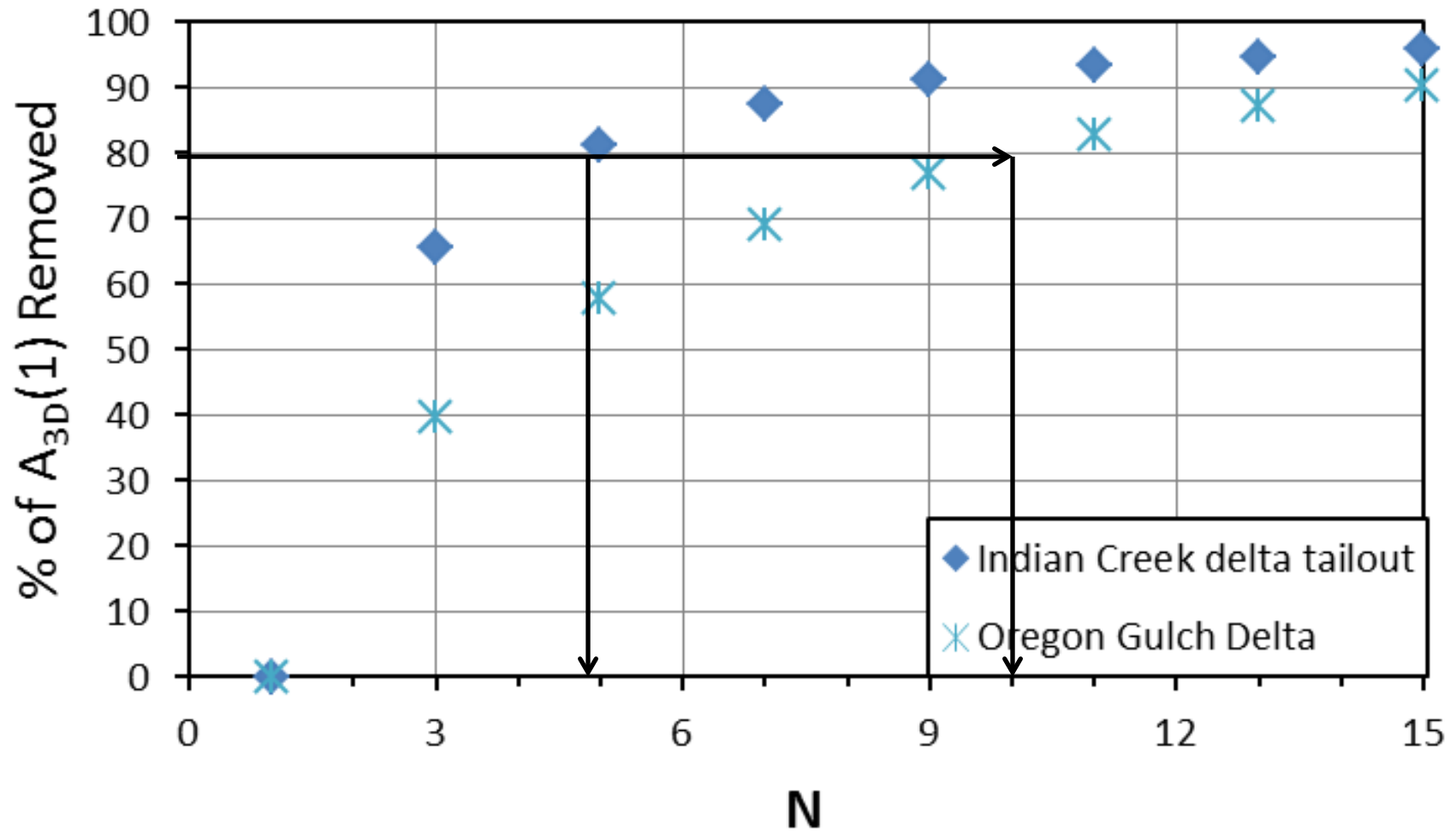
Filtering (2D)



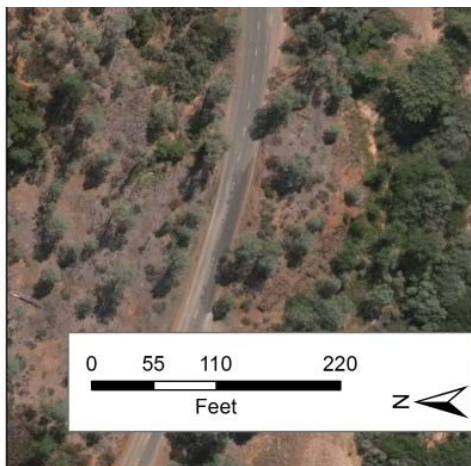
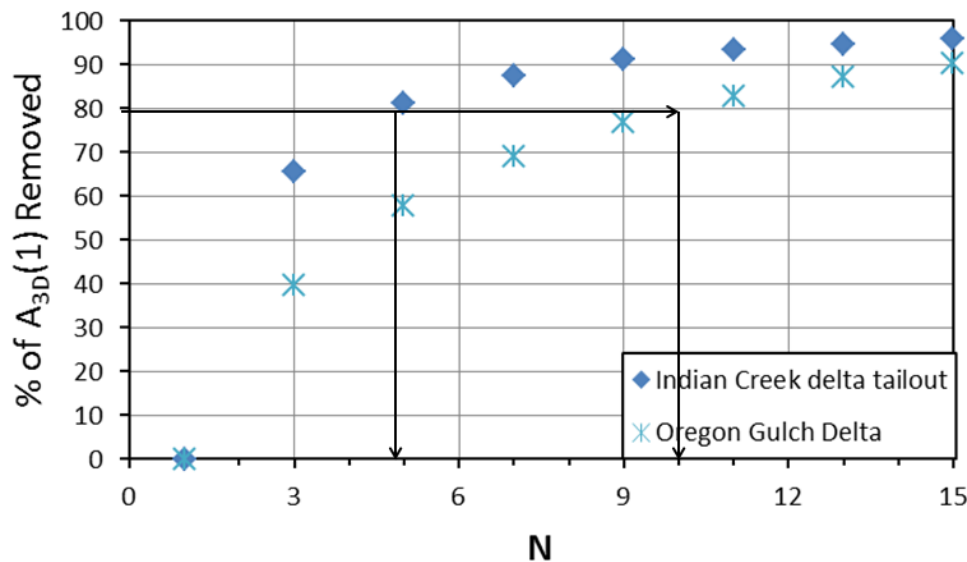
Filtering (3D)



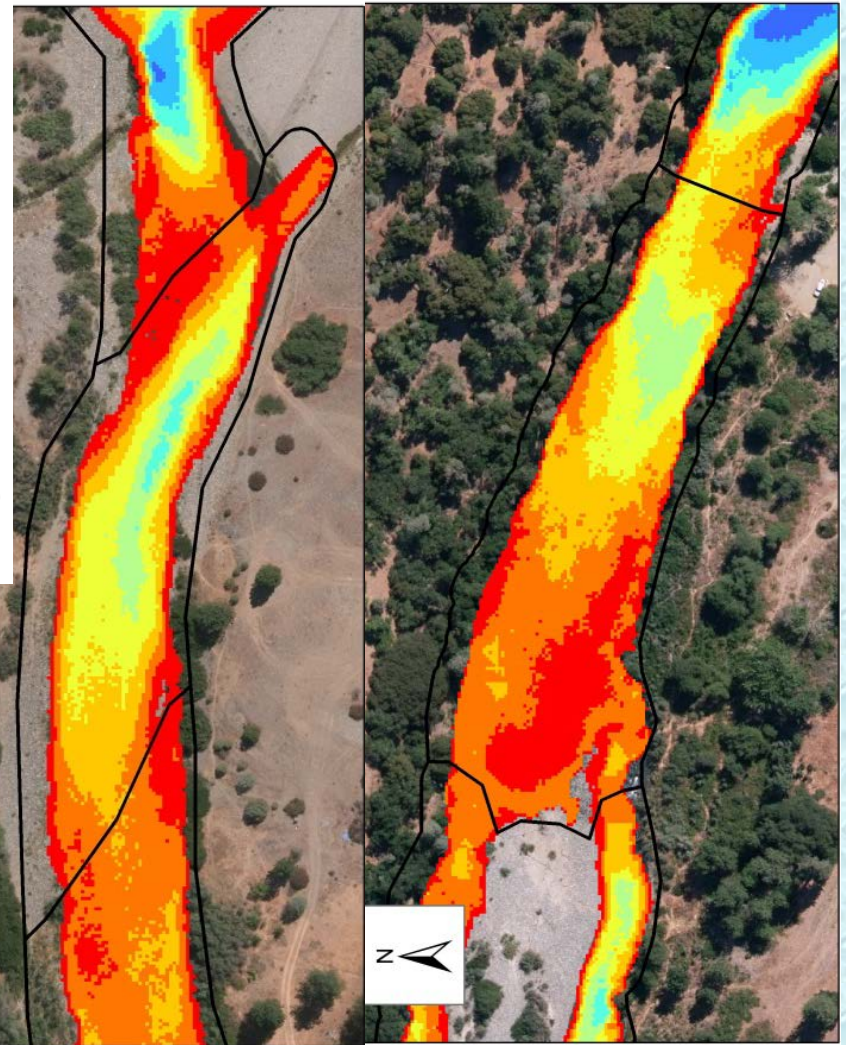
What Is the Effect of Filtering?



What Is the Effect of Filtering?

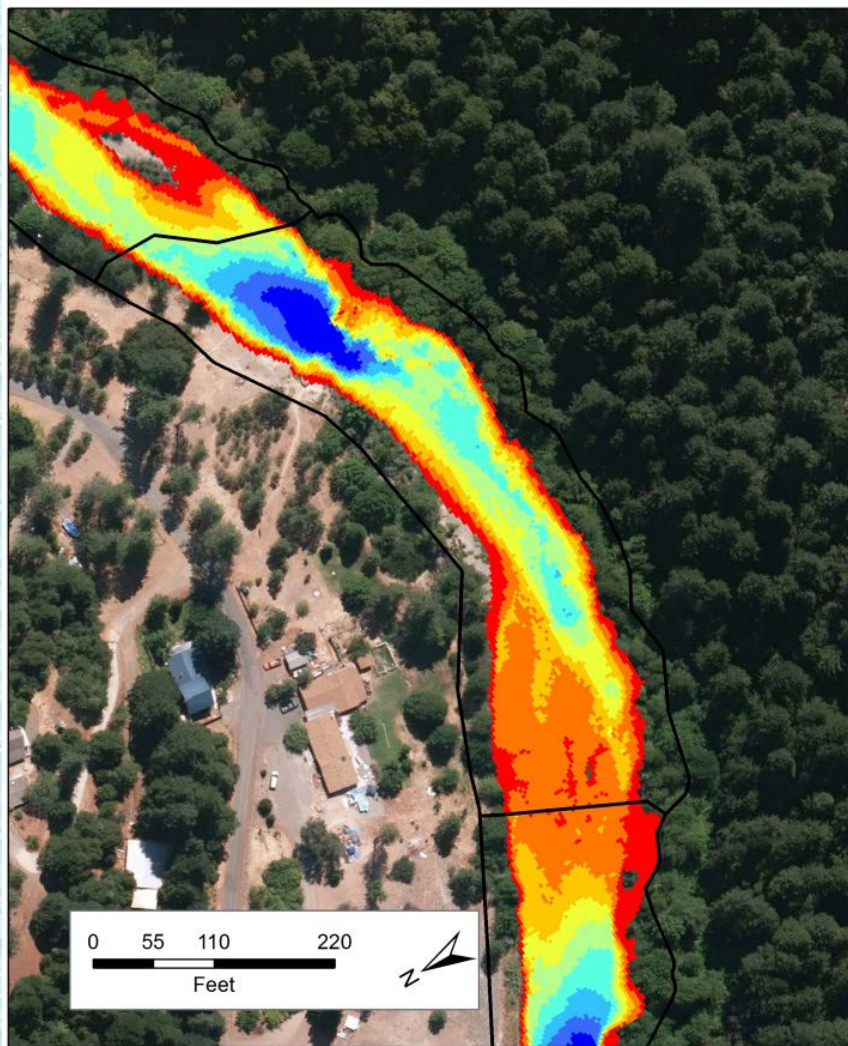


(1.014, 10.0)

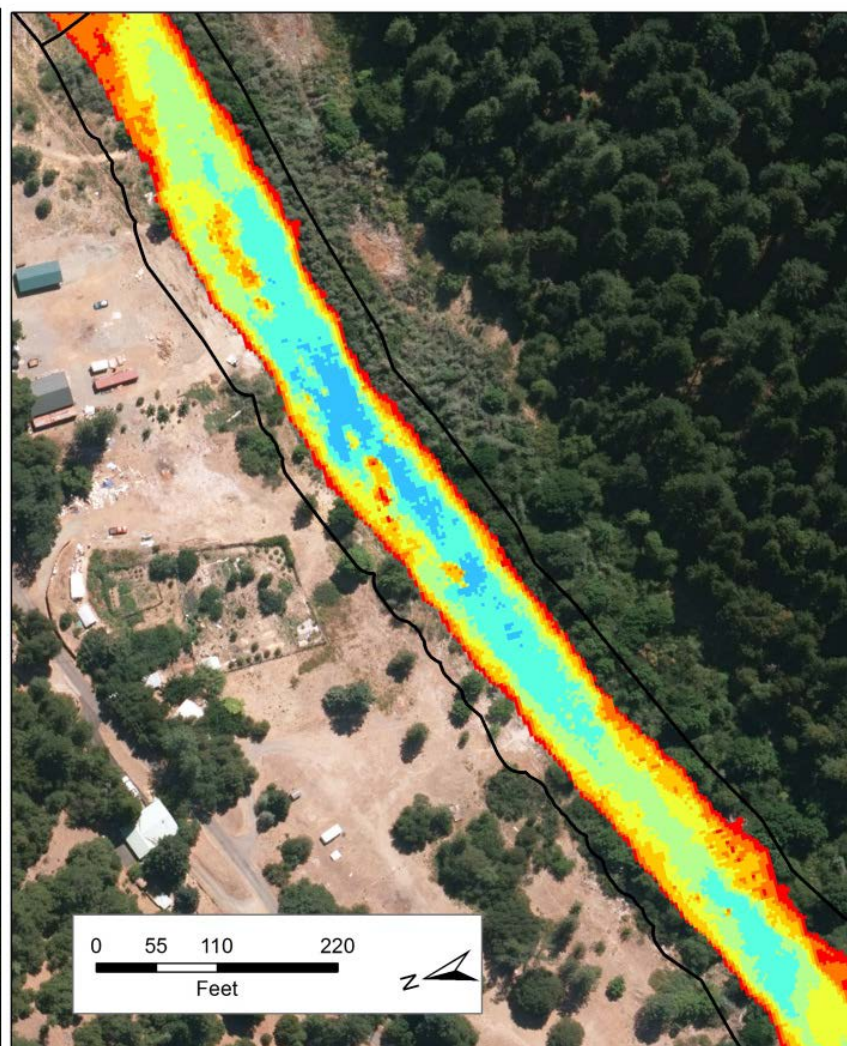


(1.010, 4.8)

What Does it Mean?

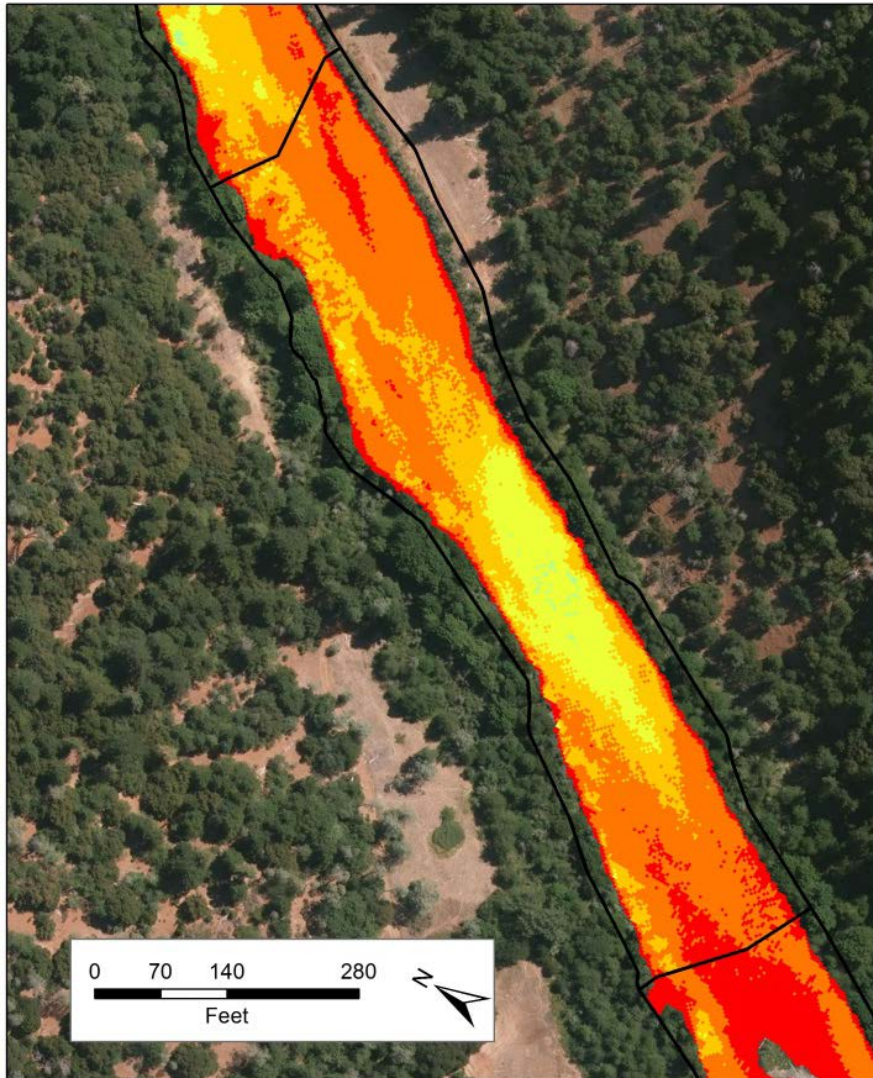


(1.042, 12.4)

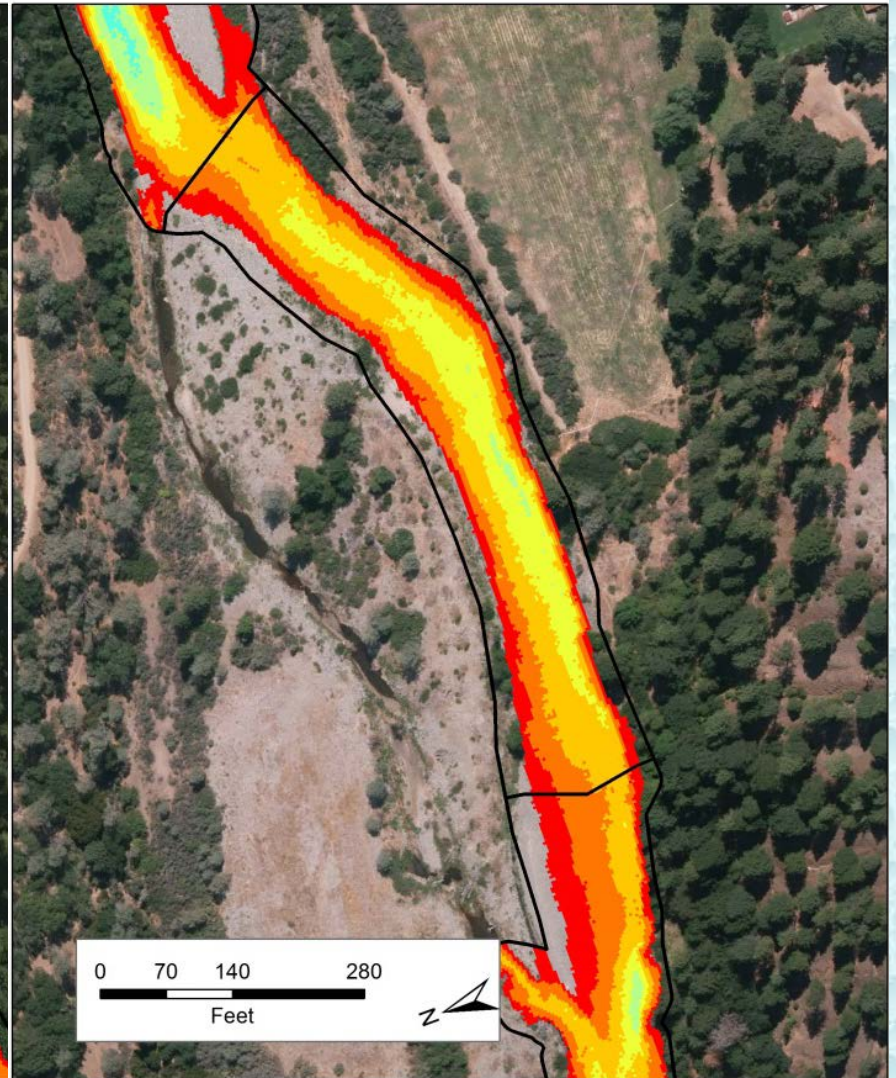


(1.038, 7.6)

What Does it Mean?

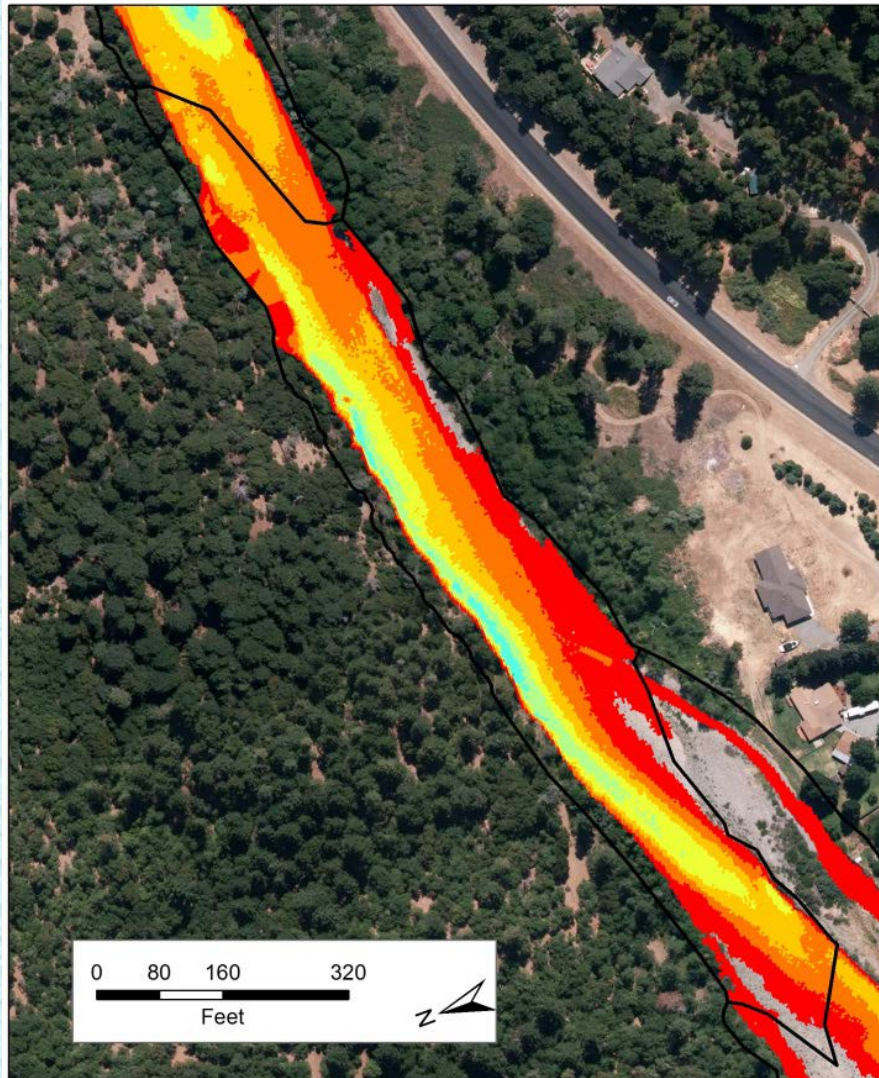


(1.010, 5.9)

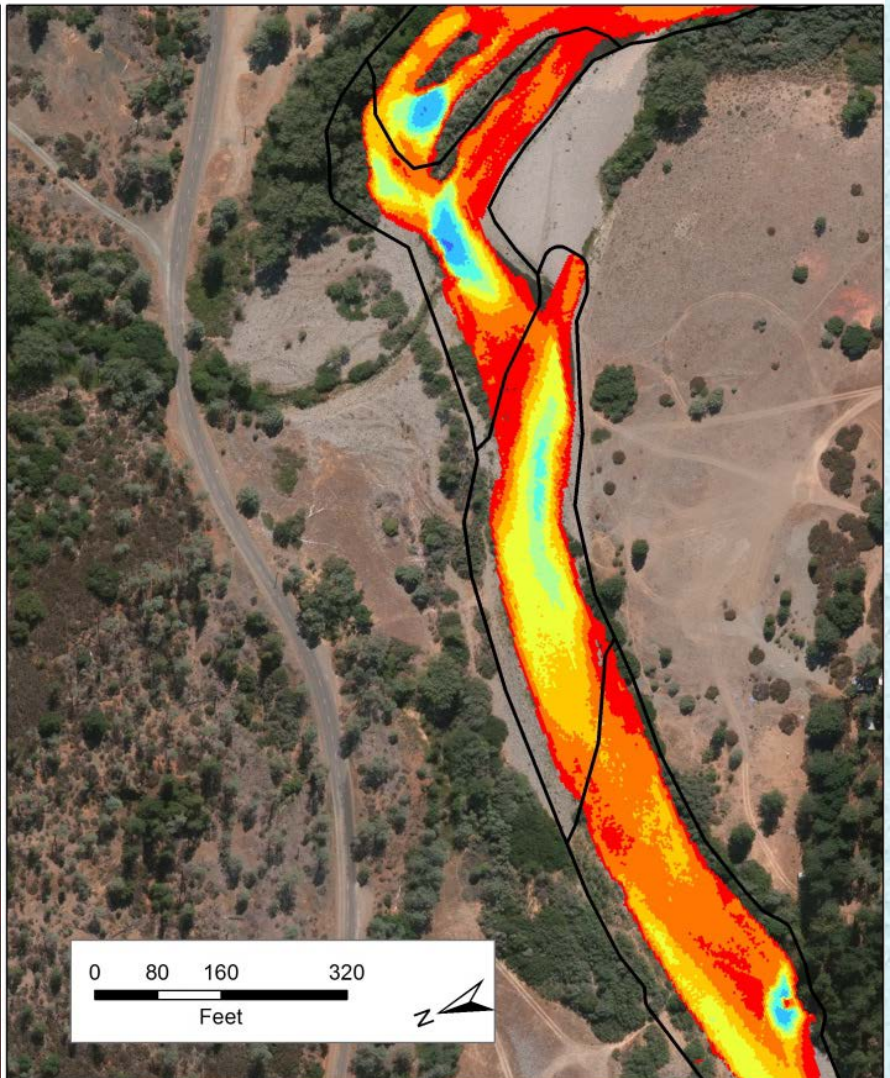


(1.010, 10.7)

What Does it Mean?



(1.014,6.5)



(1.014,10.0)

Isolating small/large scale topographic variability

The Hussain & Reynolds Triple Decomposition Theorem is used to decompose the mean depth into small and large scale topographic variability.

Essentially filtering removes small scale fluctuations from the depth field and 3D area is calculated.

Triple Decomposition Theorem

$$d(x, y) = \bar{D} + d'(x, y) + d''(x, y)$$

d = distribution of depth in the reach

\bar{D} =reach averaged depth

d' =large scale topographic variability

d'' = small scale topographic variability

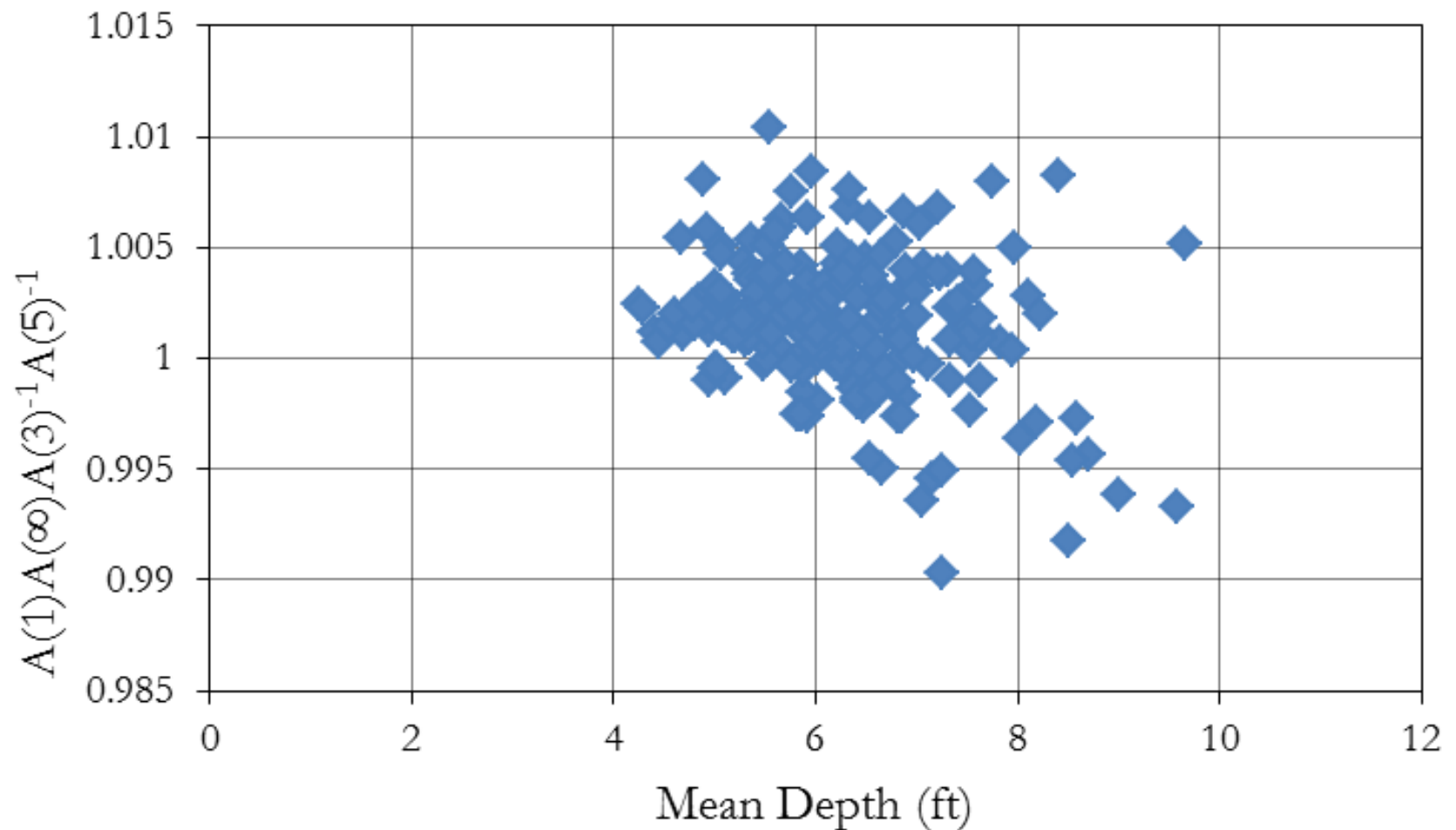
$$D + u'(x, y) = \frac{1}{N^2} \int_{x-\frac{N}{2}}^{x+\frac{N}{2}} \int_{y-\frac{N}{2}}^{y+\frac{N}{2}} u'(x', y') dy' dx'$$

N =spatial-step used to isolate u' and u''

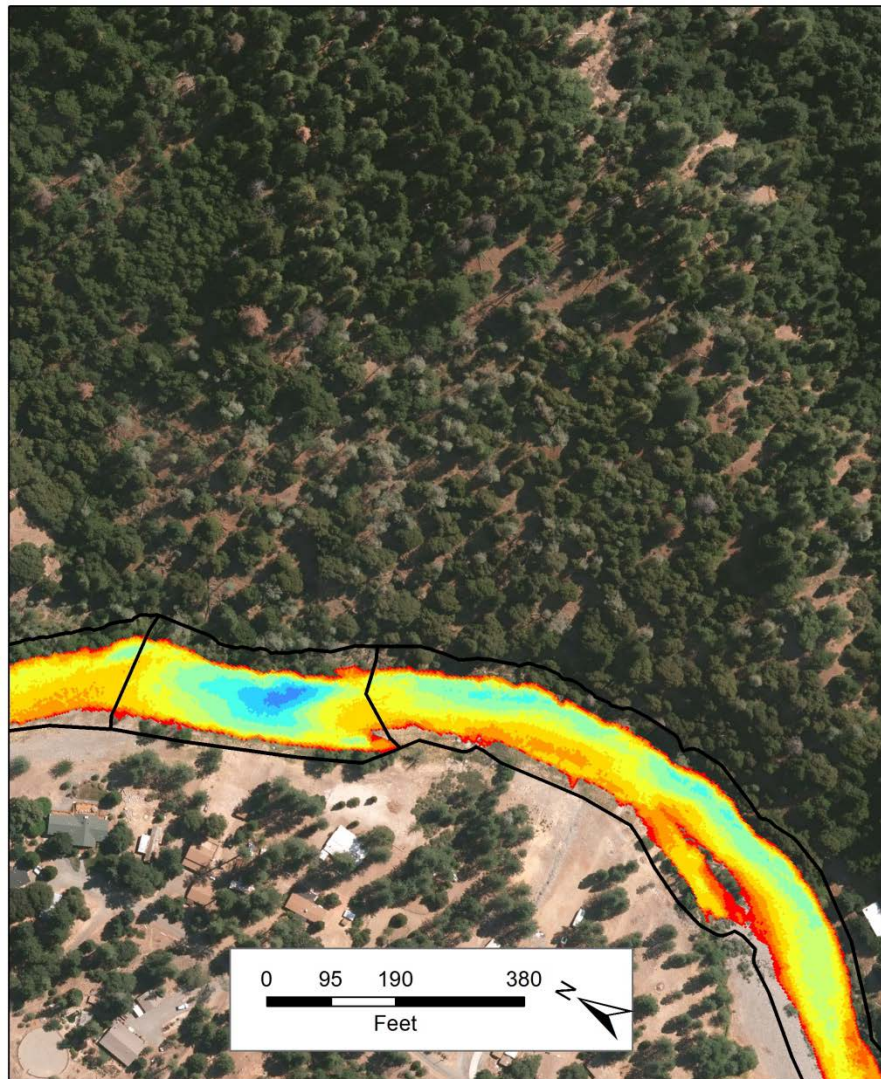
Contributions to Area

- Small Scale = $\frac{A(1)}{A(3)}$
- Large Scale = $\frac{A(5)}{A(\infty)}$
- Disparity of Scale = $\frac{A(1)}{A(3)} \frac{A(\infty)}{A(5)}$

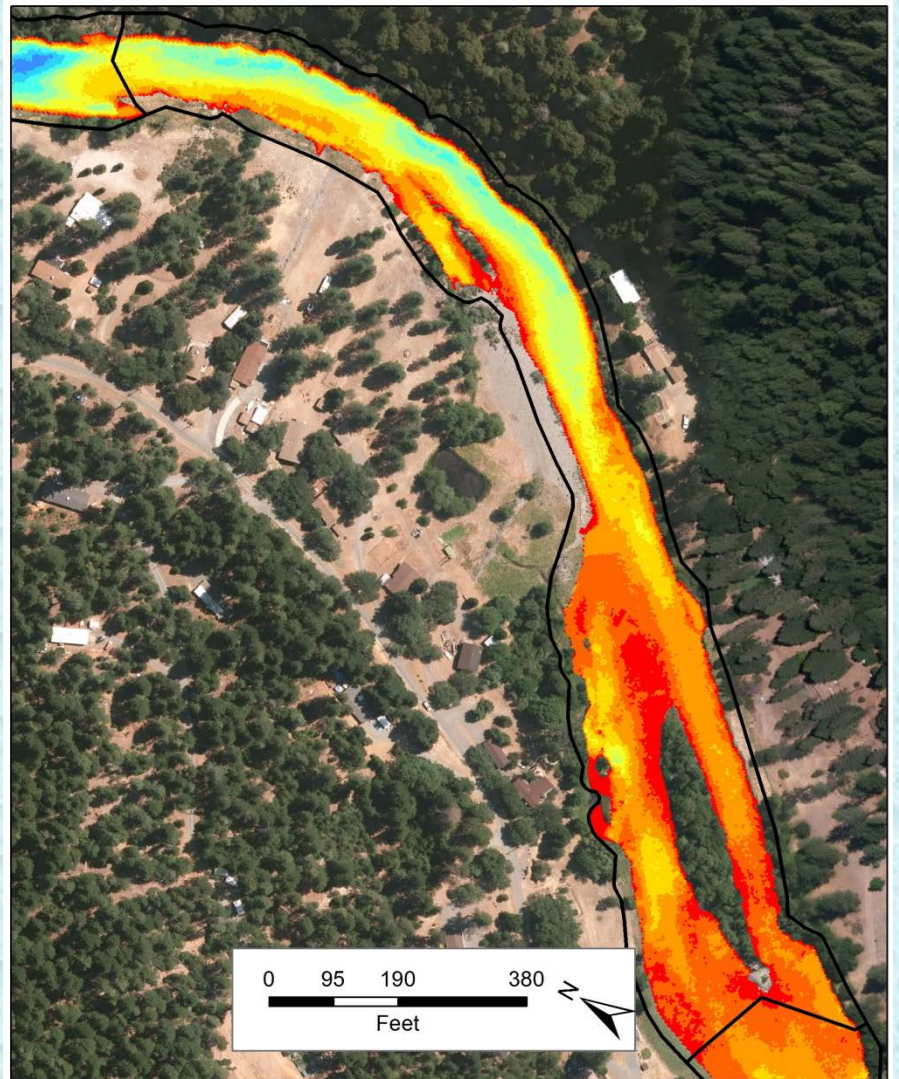
Scale Separation Related to Depth?



What Does it Mean?

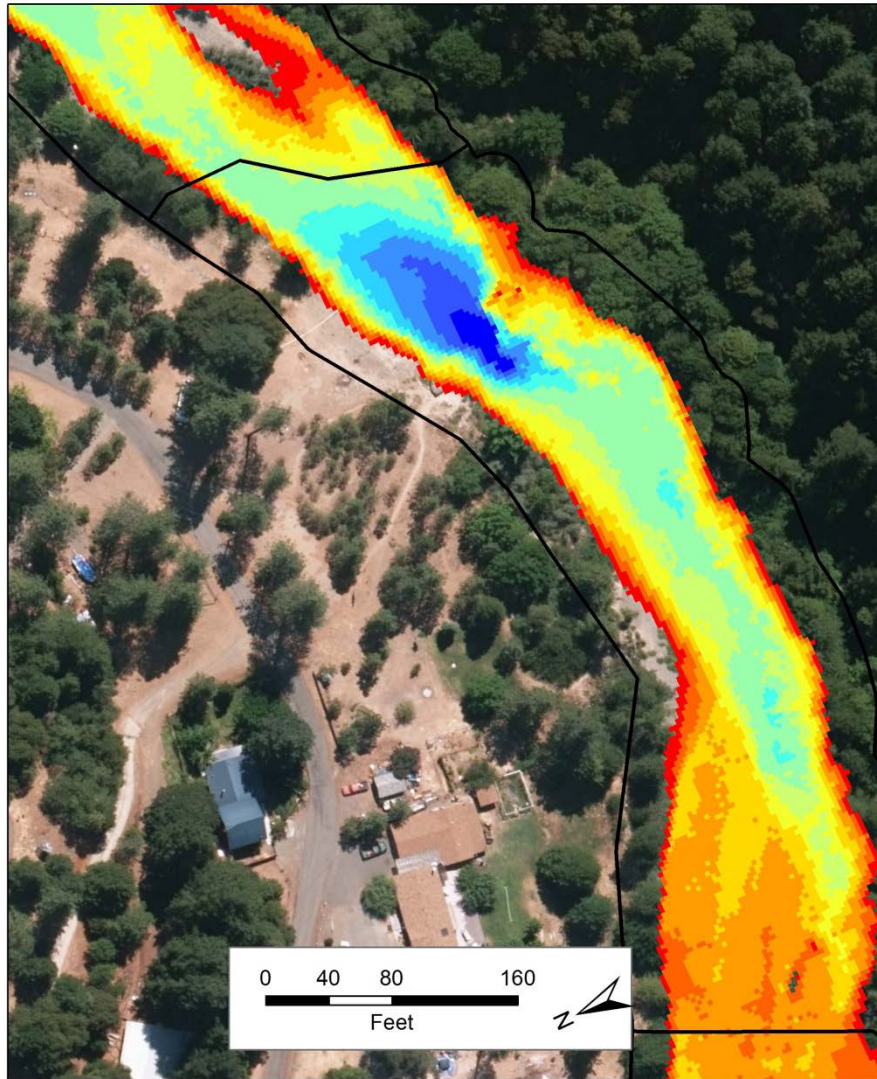


(0.999)

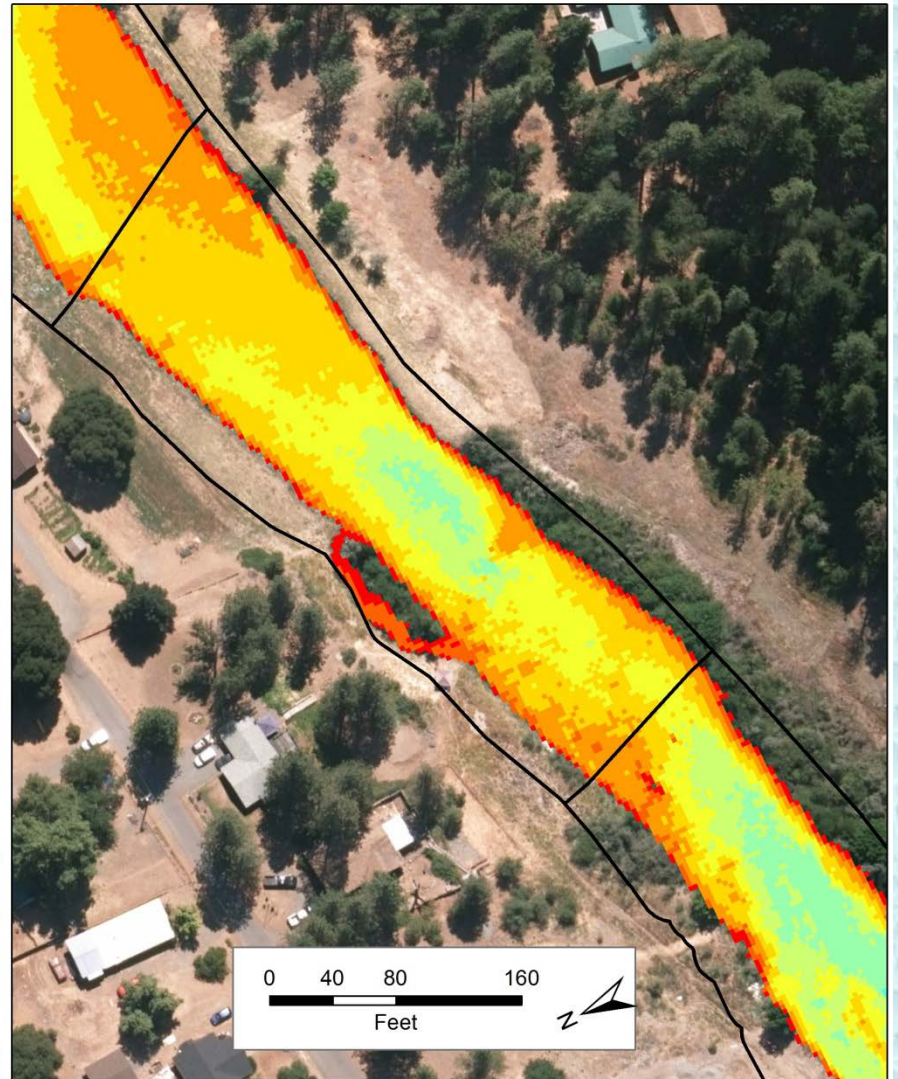


(1.0067)

What Does it Mean?



(0.995)



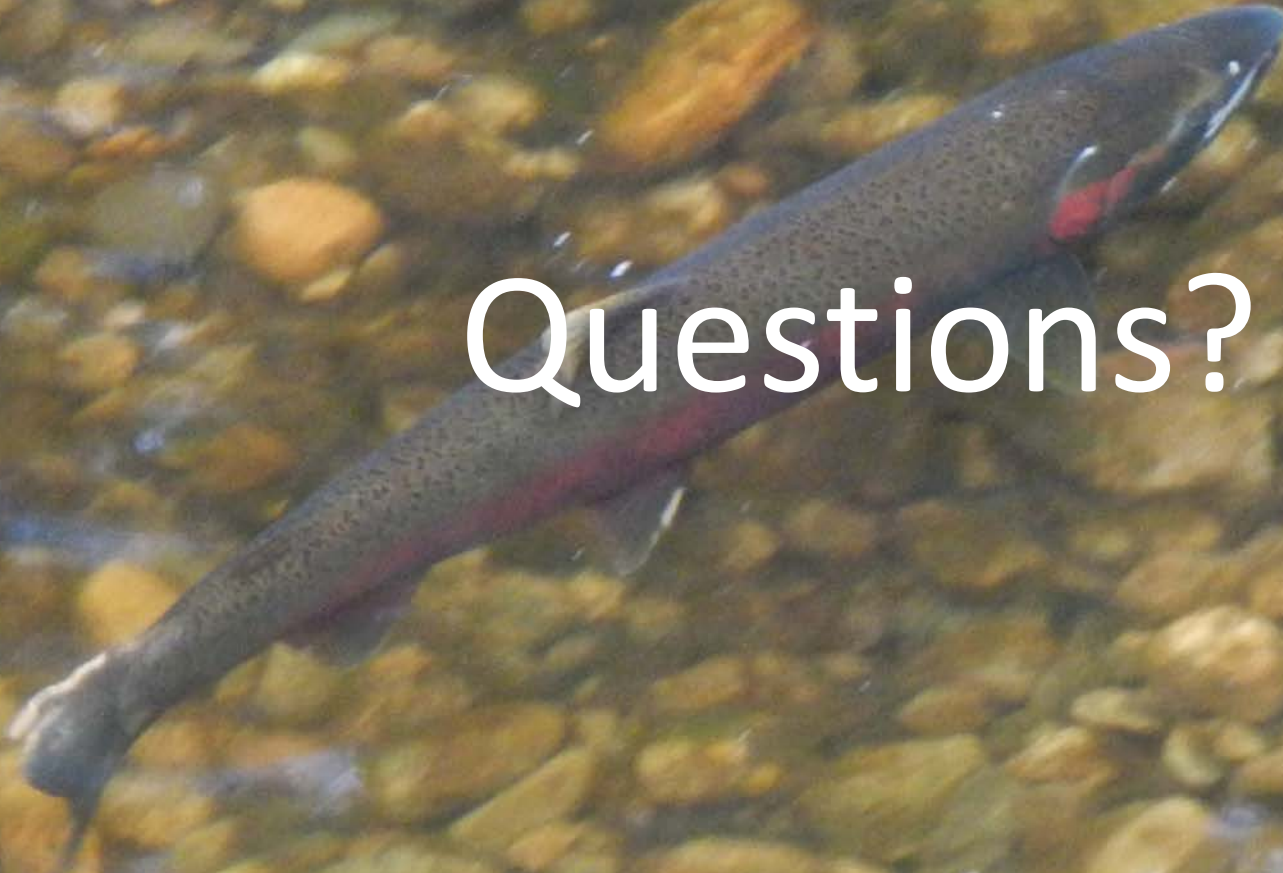
(1.0058)

What Does it Mean?

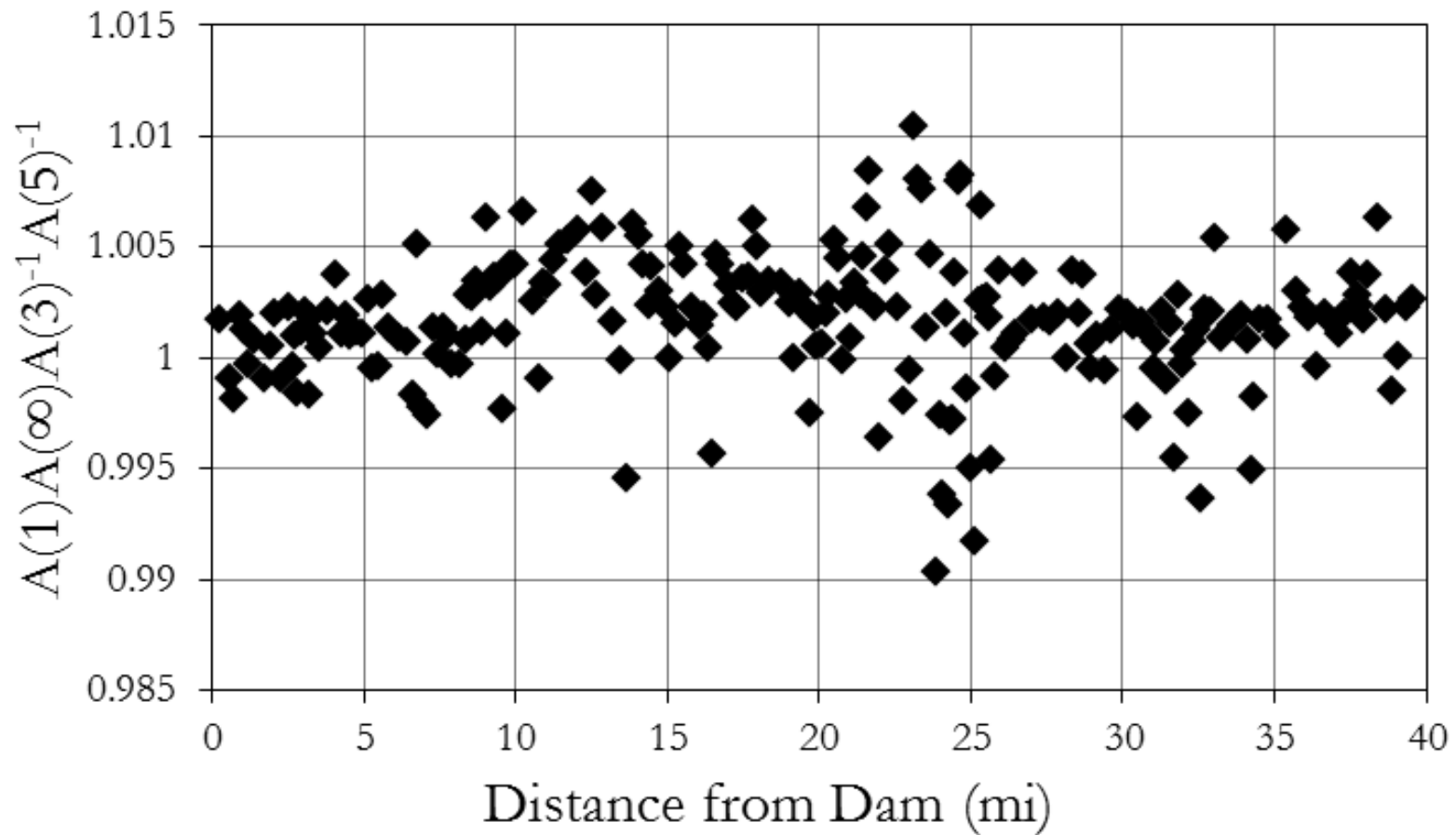
- We relate topographic complexity with 3D area
- Triple Decomposition Theorem is used to isolate small and large scale contributions to area
- Specific scales are used to characterize reach morphology

The End

Questions?

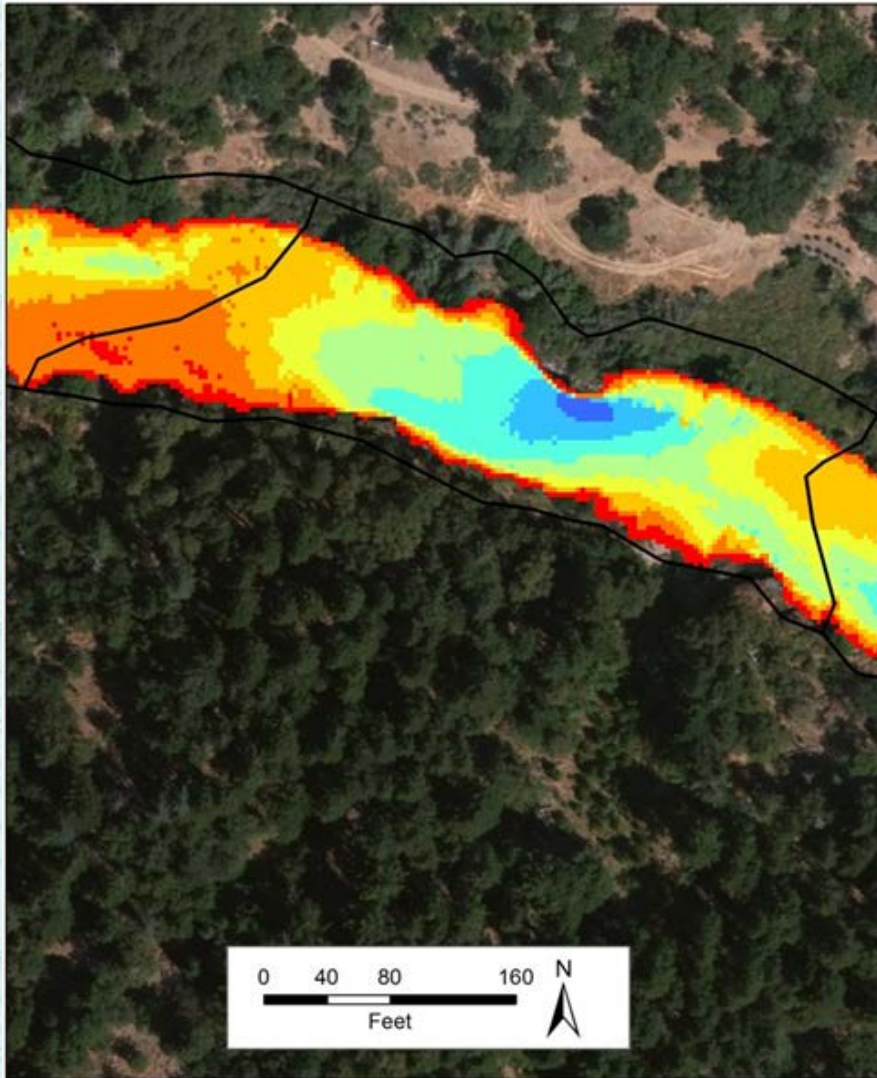


What Does it Mean?

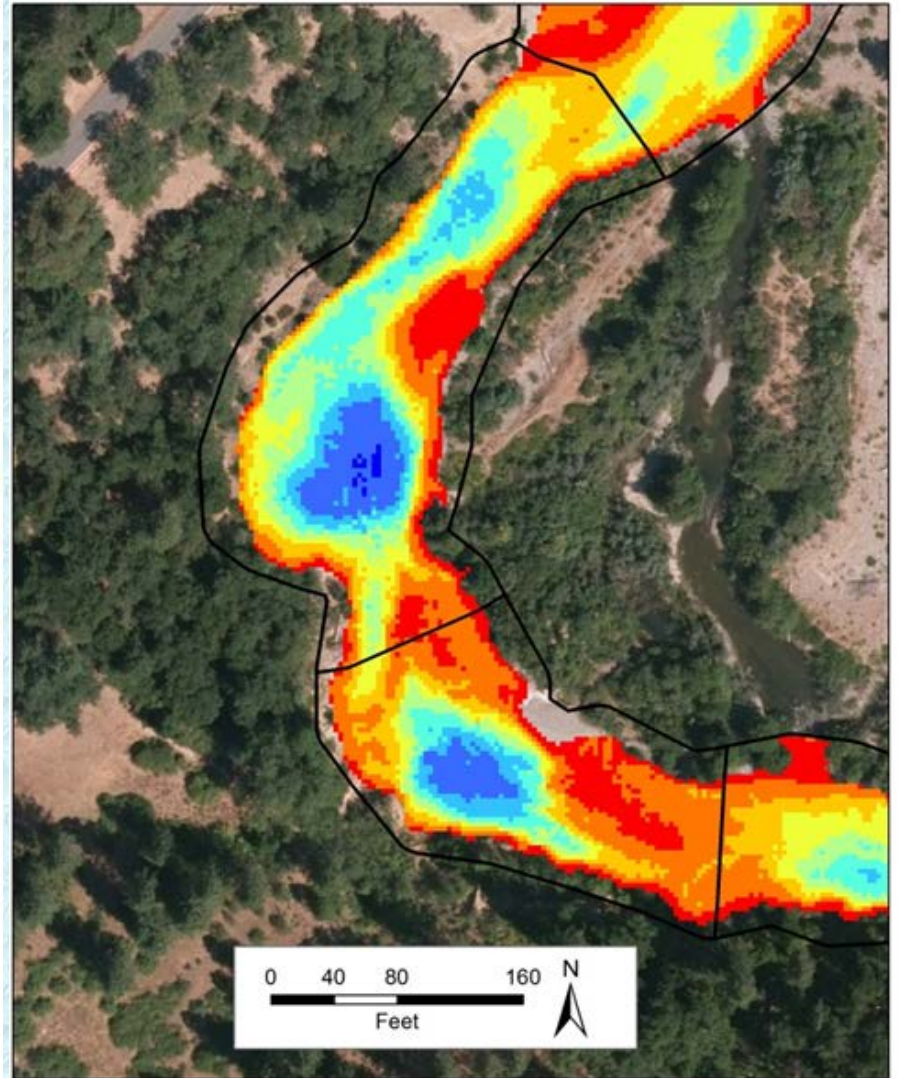


This provides a relative measure of the contributions to complexity by large and small scale features but lacks the ability to define complexity

What Does it Mean?

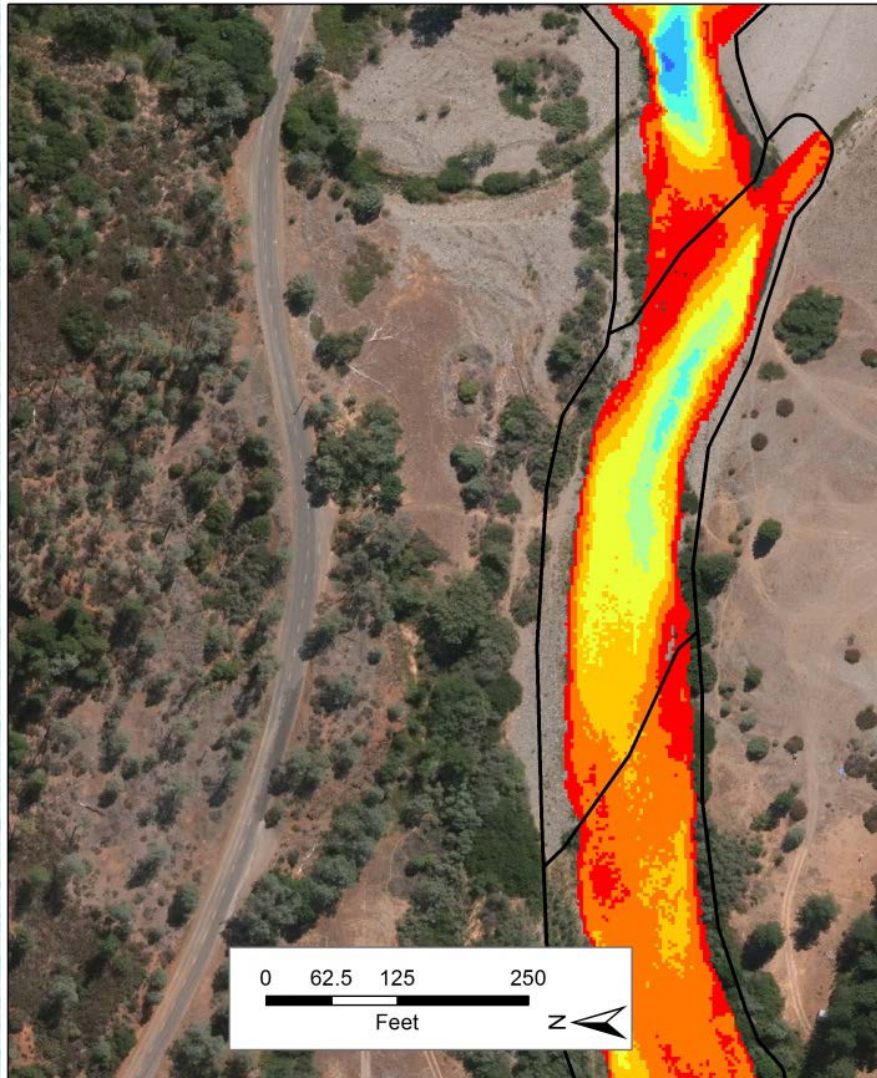


(1.045,6.8)

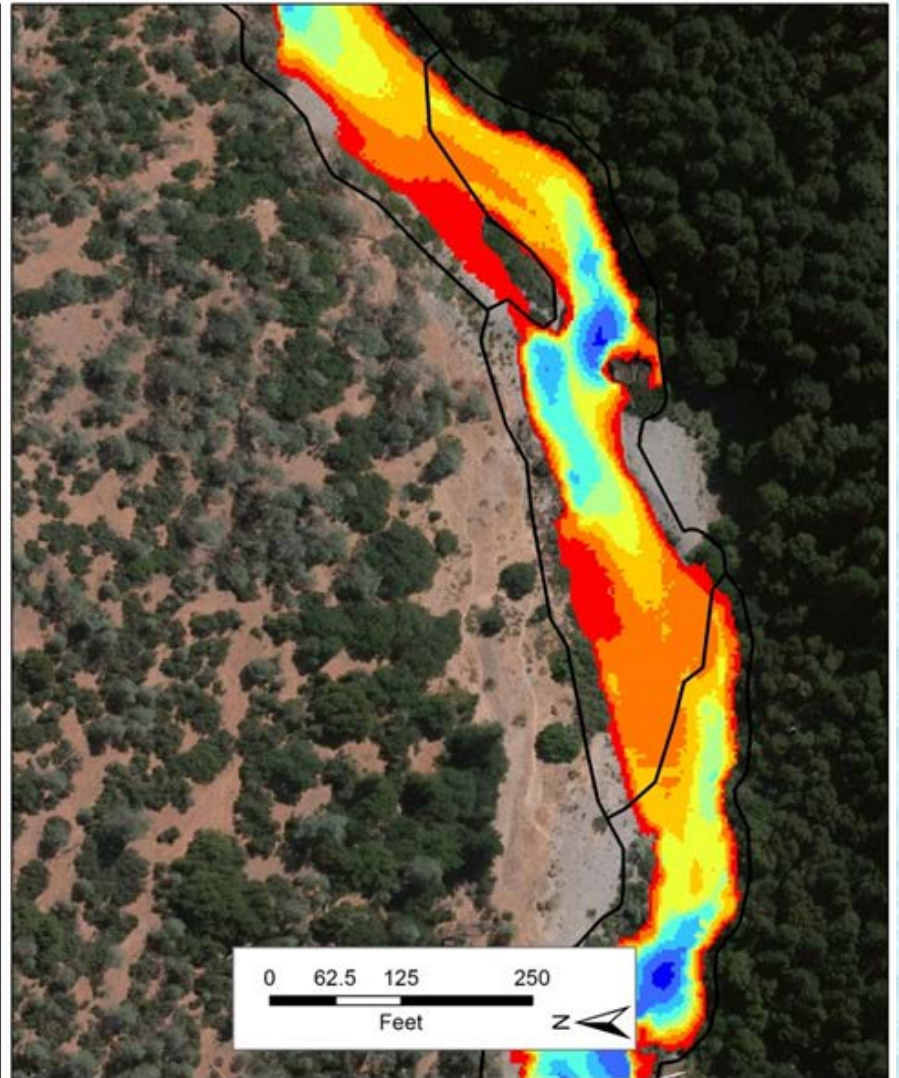


(1.044,11.5)

What Does it Mean?

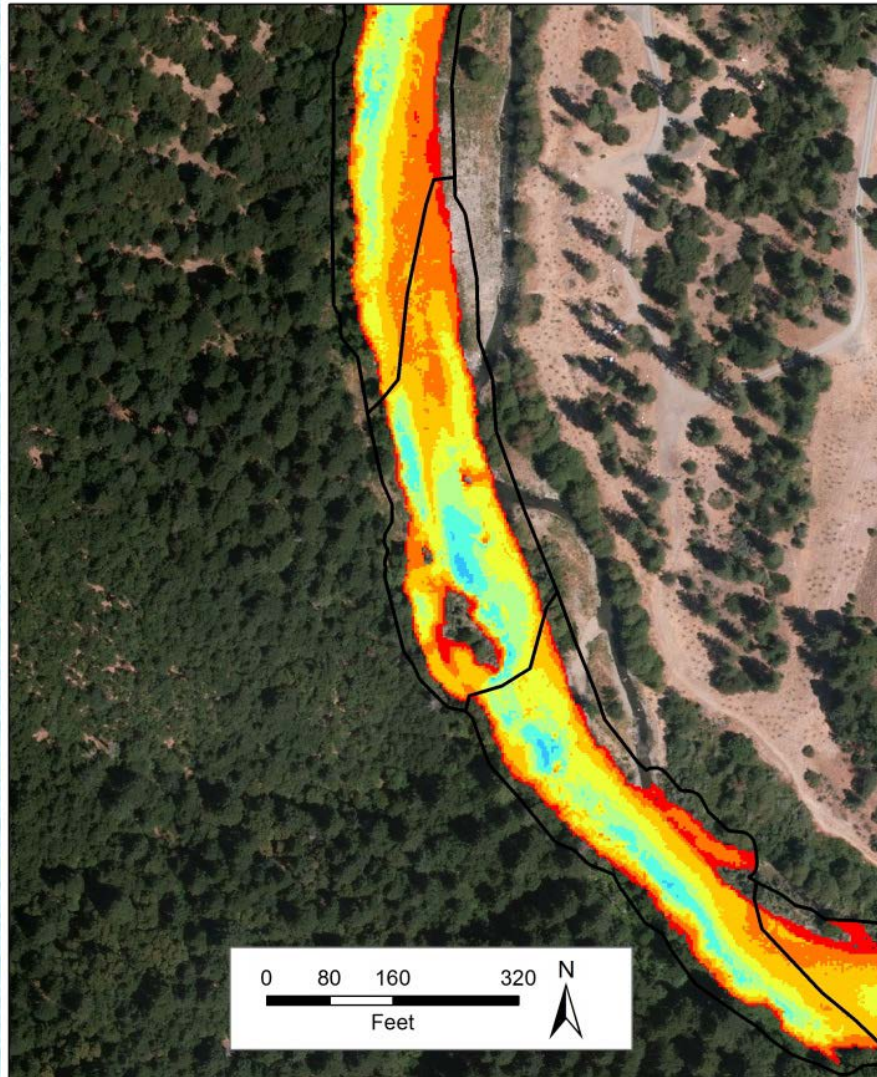


(1.014, 10.0)

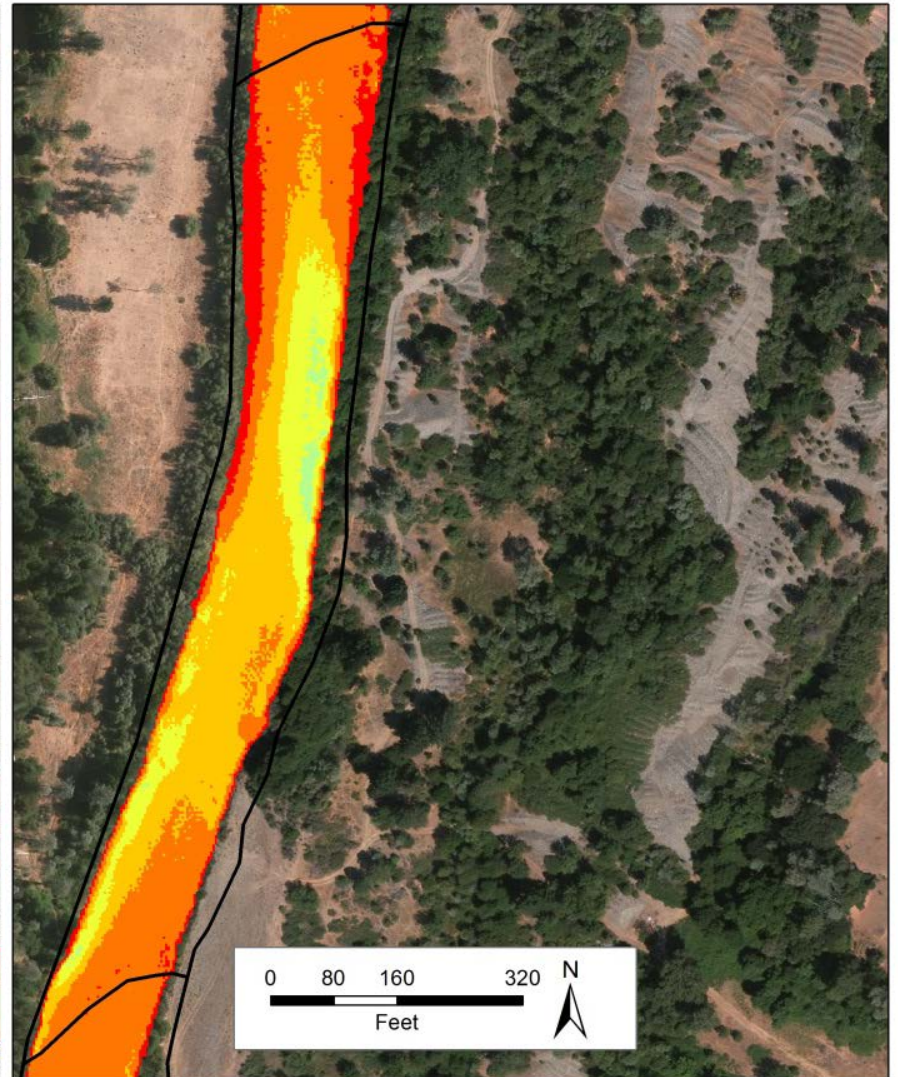


(1.039, 10.1)

What Does it Mean?



(1.027, 6.3)



(1.007, 6.2)