Estimating water flux over a tidal cycle in tidal marsh networks based on tidal prism and gauge height

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I. Abstract

The measurement of discharge in tidal channels is difficult to do due to rapid variations in gauge height and velocities. One way this could be done is through the evaluation of changes in tidal prism over time, which requires extensive morphological data. The purpose of this project is to identify conditions under which the tidal prism method is likely to be accurate compared with velocity measurement methods. It is possible to accurately measure channel widths and channel surface areas from aerial data. Combined with field measurements of channels, tidal prisms can be estimated. This method, however, is not appropriate for small (low order tidal networks).

II. Hypotheses

1. The velocity-area method is most appropriate for channels that do not change their shape over the tidal cycle. Simple, low order channels are likely to meet this criterion.
2. The tidal prism method for obtaining discharge is most suitable for larger stream orders where channel width can be obtained accurately from aerial photographic data.

III. Field Site and Methods

Located on Patuxent River, it is a freshwater tidal marsh.

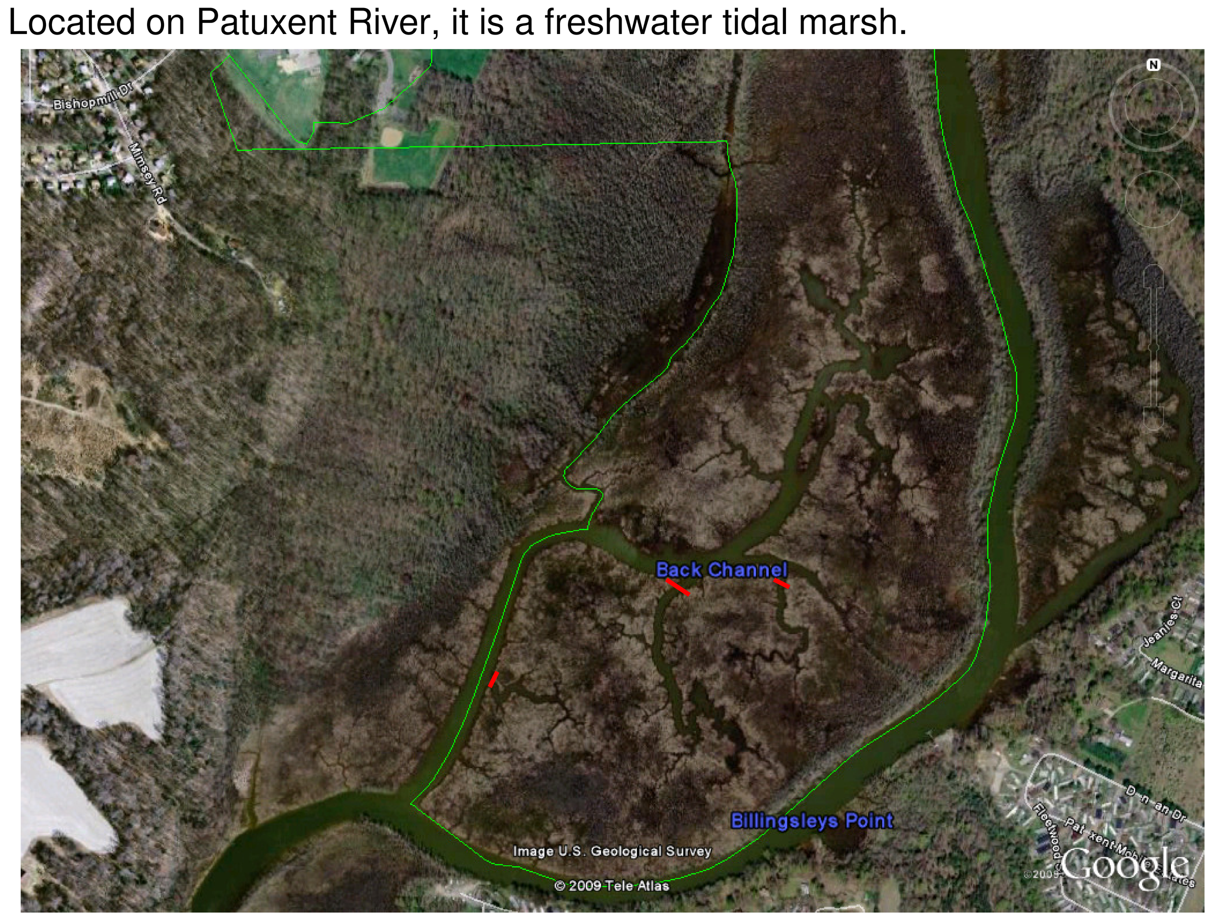


Image showing entire field site.

The tidal prism was calculated for the tidal network.

Air photo measurements were made using the "Ruler" tool provided by Google Earth.

Data for air photos were provided by the U.S. Geological Survey for the region containing this field site.

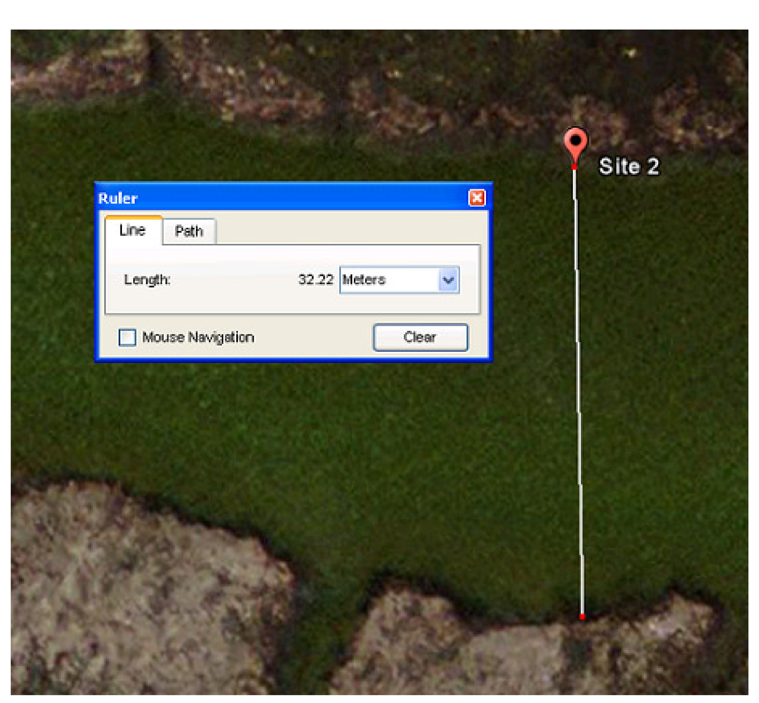


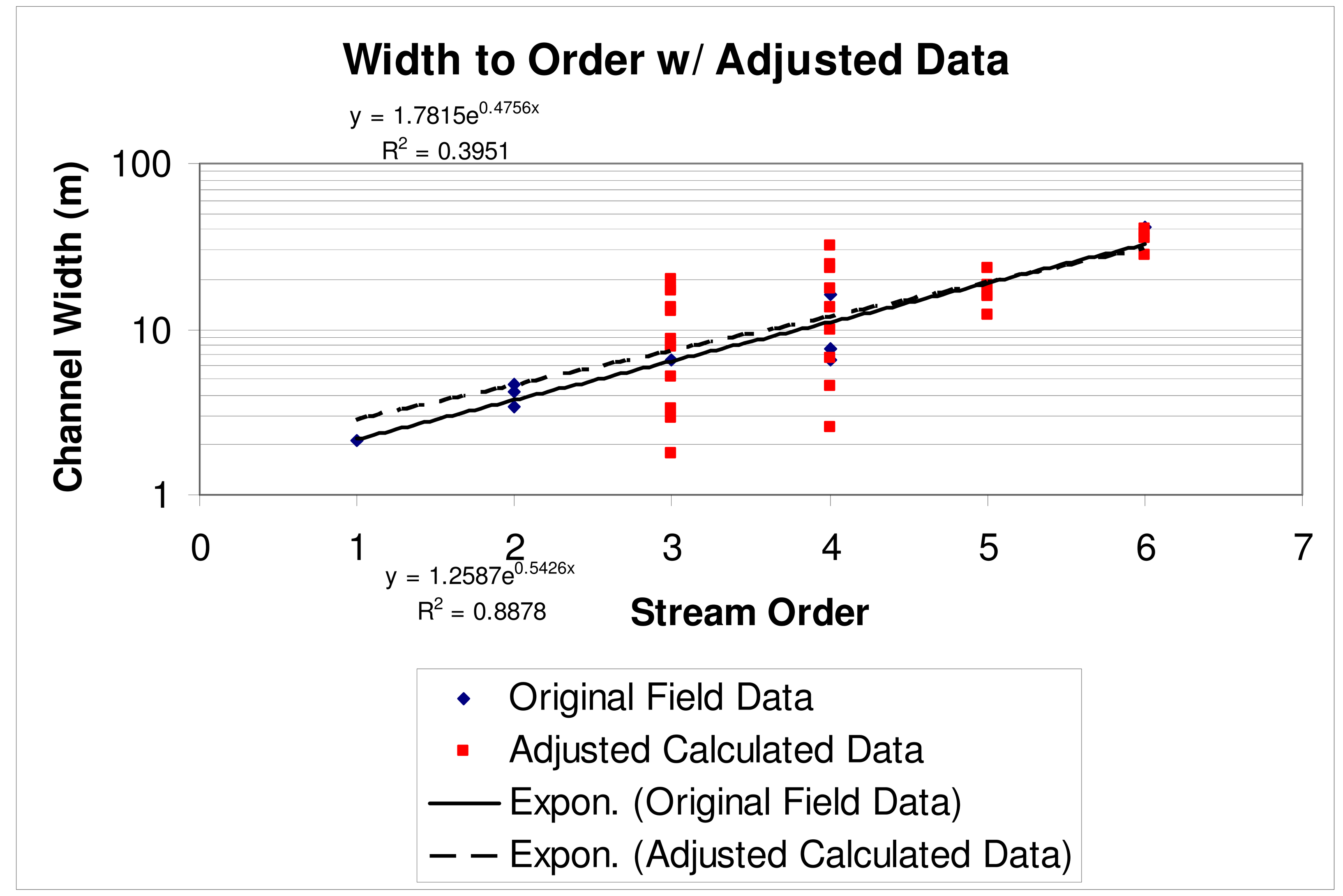
Image of width measurements being made using Google Earth's "Ruler" tool.

Measurements

1. Channel widths and stream orders were measured from air photos.
2. Channel surface areas were determined. Measured out 5, 10, or 20 m intervals along channels banks for large channels. Width measurements were taken at end of each interval.
3. For small channels, channel length was measured and channel width was predicted based on stream order.
4. Air photo measurement error was determined by measuring five objects of known lengths using air photos. Measurements of each object were made five times.

IV. Results

Channel Width vs. Stream Order



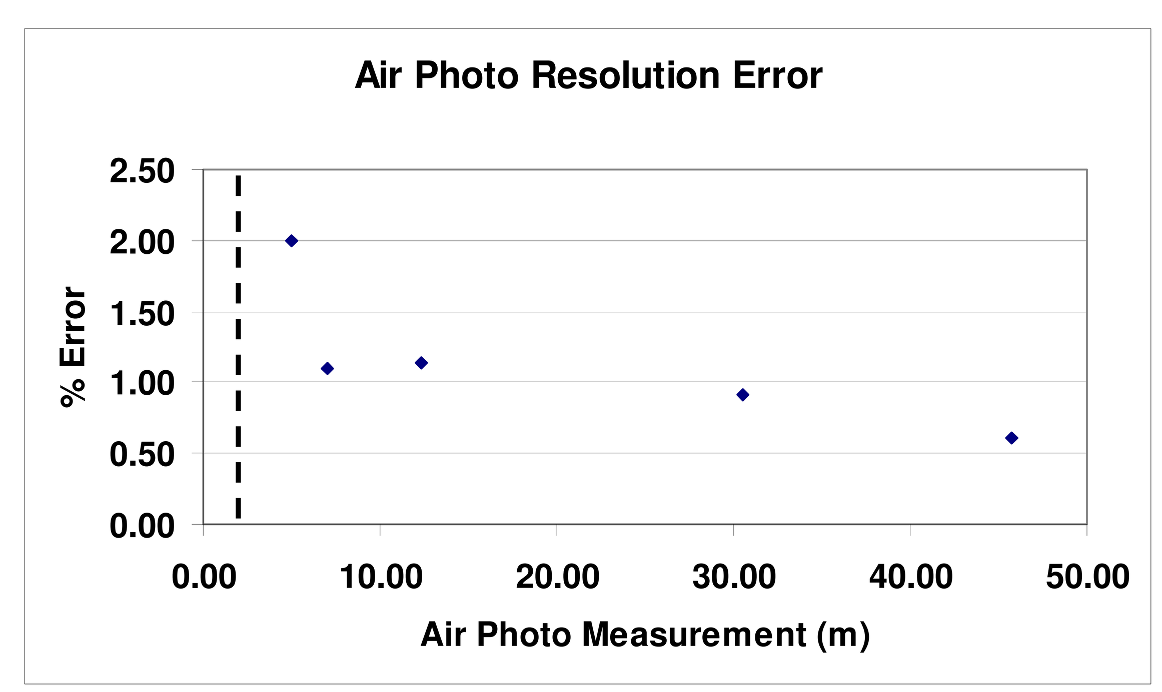
- Wide variability in channel width data. Width should be measured in the field rather than estimated from stream order.
- Data indicate that 1st order channels are not easily observed on air photos.
- Field measurements are needed to accurately depict low order stream channels.

Error for Channel Width Measurements

Width of Home Driveway				
Aerial Photo		Actual		% Error
ft	m	ft	m	
23.29	7.10	23.00	7.01	1.26
23.33	7.11	23.00	7.01	1.43
22.96	7.00	23.00	7.01	0.17
23.50	7.16	23.00	7.01	2.17
23.11	7.04	23.00	7.01	0.48
			% Error	1.10

Width of BWI Runway 4/22				
Aerial Photo		Actual		% Error
ft	m	ft	m	
150.63	45.91	150.00	45.72	0.42
151.78	46.26	150.00	45.72	1.19
149.44	45.55	150.00	45.72	0.37
150.63	45.91	150.00	45.72	0.42
150.97	46.02	150.00	45.72	0.65
			% Error	0.61

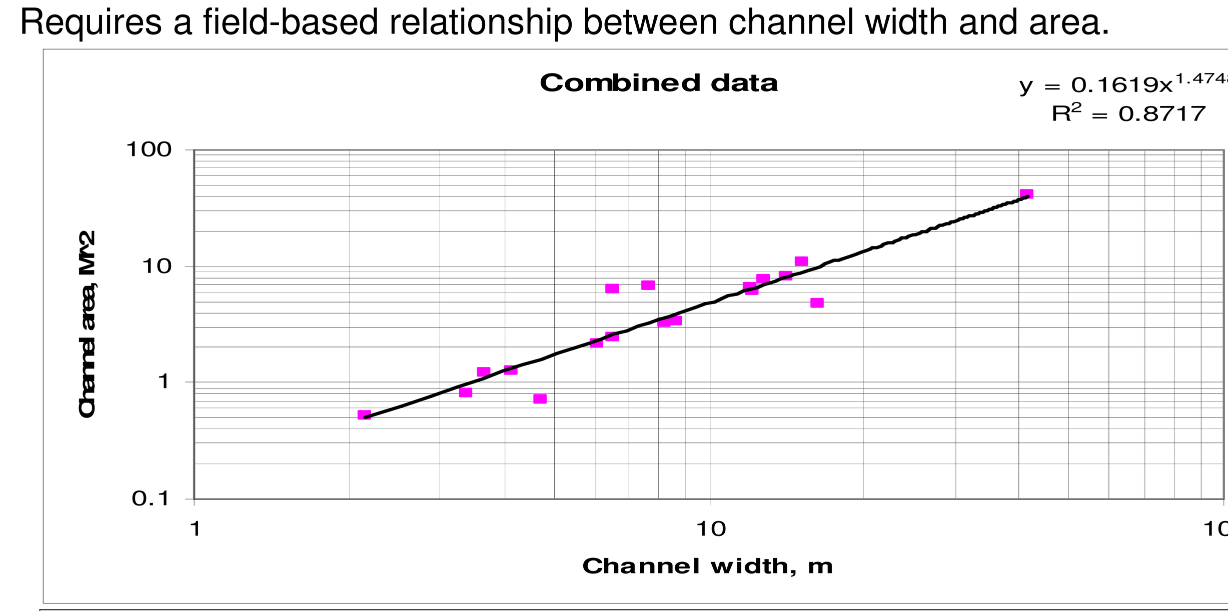
- Percent error of air photo measurements decreases for wider channels.
- Low order channels are hidden by vegetation – about a 2 m detection limit (dashed line on graph) for vegetated channels.



V. Results

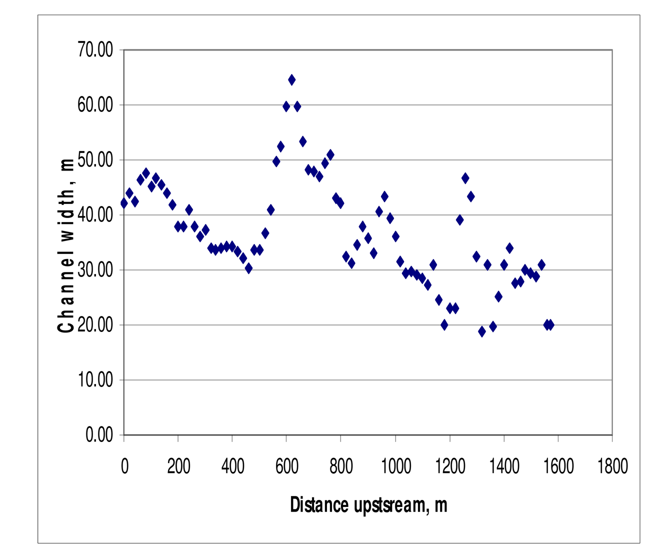
Channel Area and Tidal Prism

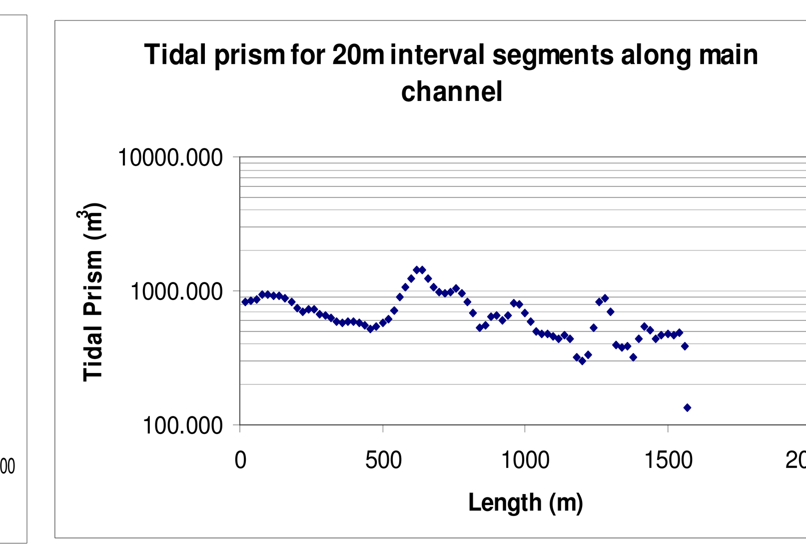
- Tidal prism measurements can be made for 2nd order and higher channels.
- Requires a field-based relationship between channel width and area.



Relationship between channel width and channel area based on field measurements.
Data from Karen Phemister and Emily Seldomridge.

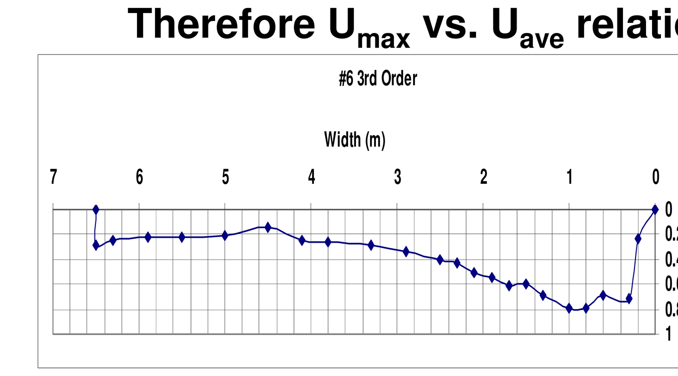
Tidal Prism for 5th Order Stream

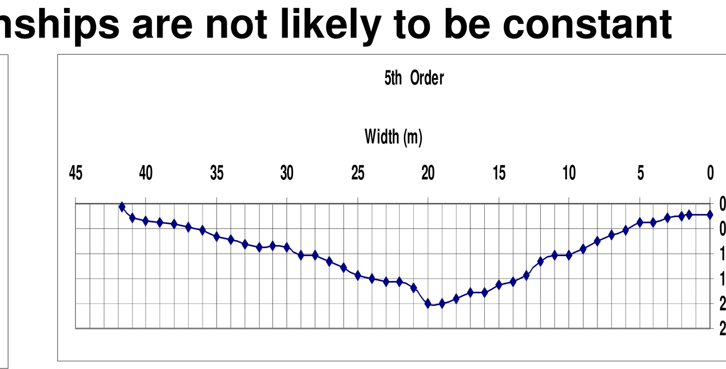


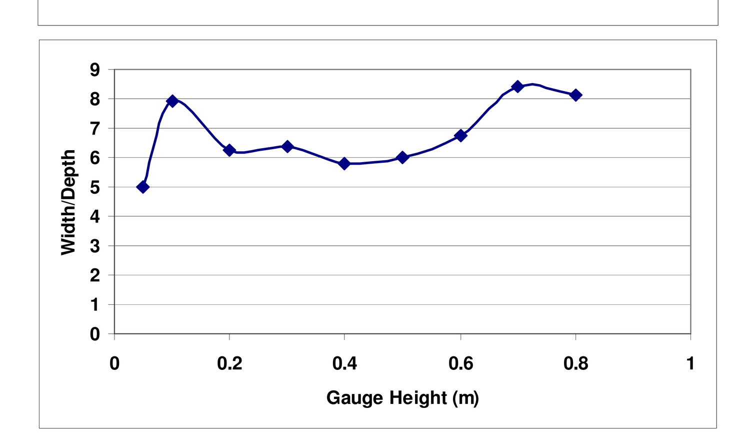


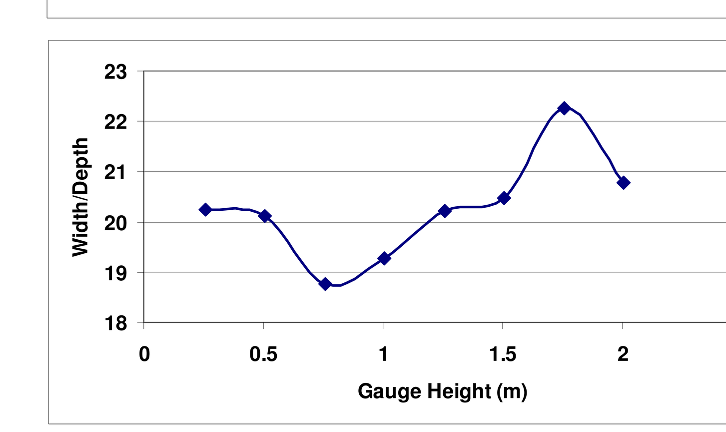
- Diagrams above show the variations with width and tidal prism in the 5th order tidal network. Tidal prism data and gauge height data can be used to determine discharge over a tidal cycle.
- Total tidal prism volume for 5th order channel is 53495.785 m³. This is 99.992% of total tidal prism volume for entire watershed.

Channel Shape: The low order channels changed shape with discharge. Therefore U_{max} vs. U_{ave} relationships are not likely to be constant









VI. Conclusions

Two components of tidal prism, channel width and length, can be accurately measured from air photos for 2nd order channels and higher.

Field measurements are required to determine channel area.

1st order channels cannot be seen or accurately measured using air photos due to vegetation and photo resolution, field measurements must be made.

Channel morphology of low order streams is not simple, therefore traditional field methods for measurement of discharge must be made for 1st and 2nd order channels.

References, Data Sources, and Acknowledgements

Chen, Yen-Chang, Chiu, Chao-Lin, 2002, An efficient method of discharge measurement in tidal streams, Journal of Hydrology, v. 265, p. 212-224.

Google Earth

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