Long-term erosion monitoring on Niagara Escarpment watercourses

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Long Term Erosion Monitoring

- Used to assess impacts from land development (i.e. success of SWM measures)
- Important to distinguished between natural variations and development-related impacts

- How much natural variability is expected?

Overview

1. Monitoring methodology
2. Site classification
3. Site statistics
4. Target thresholds
5. Conclusions

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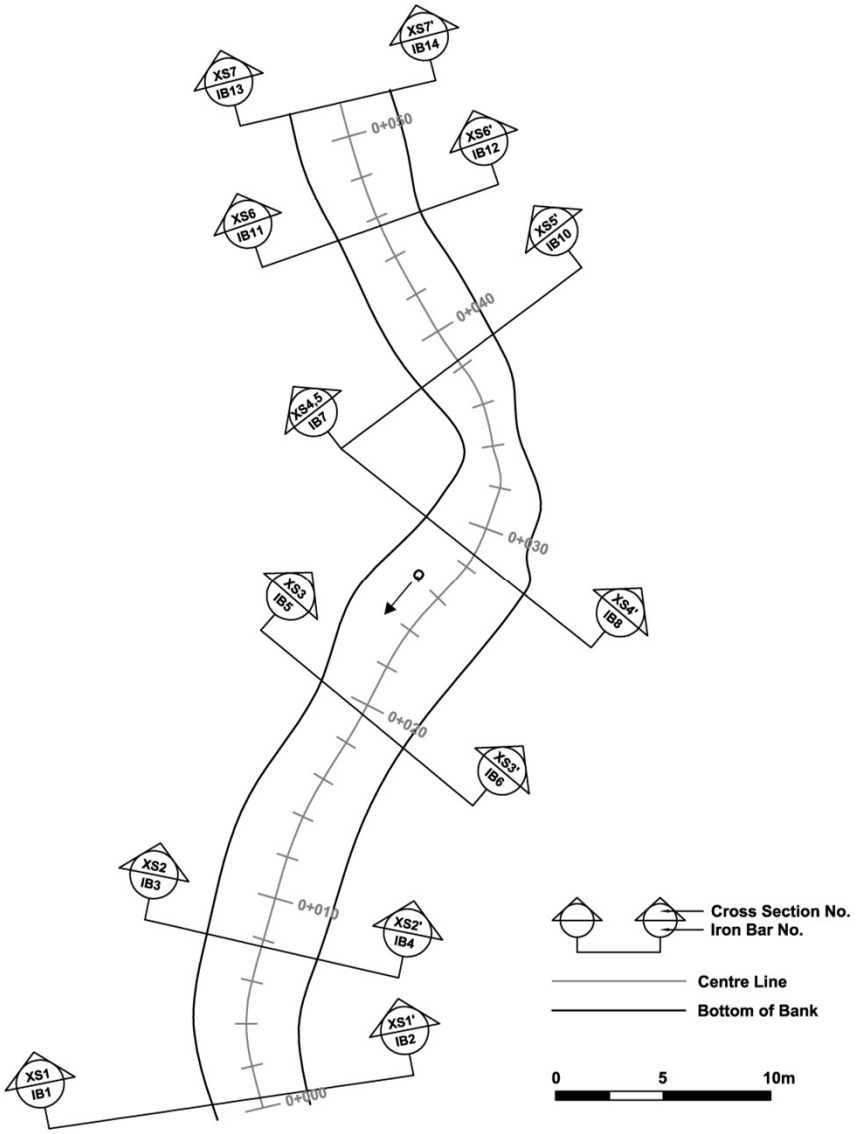
Site Information

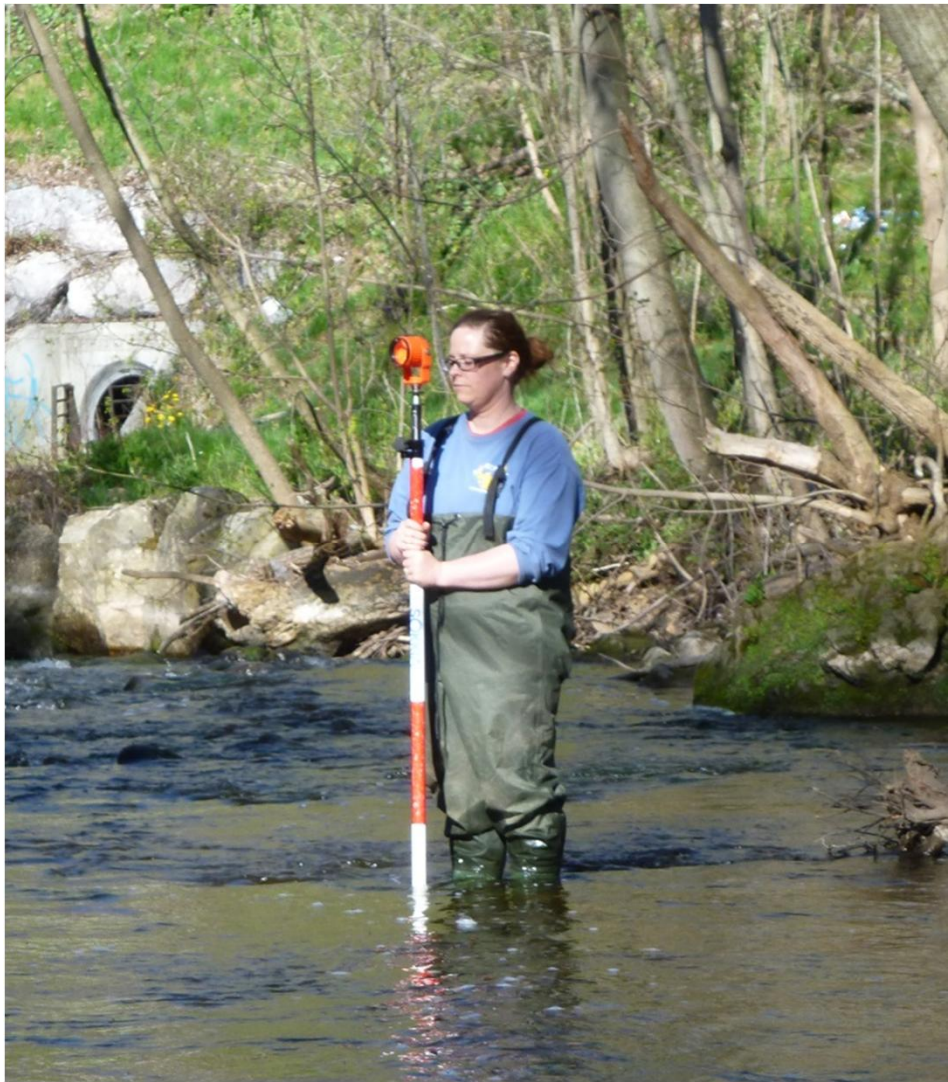
- 20 sites
- 4 to 10 cross-sections per site
- 135 cross-sections total
- 3 surveys per year (spring, summer, fall)
- 6 years of data



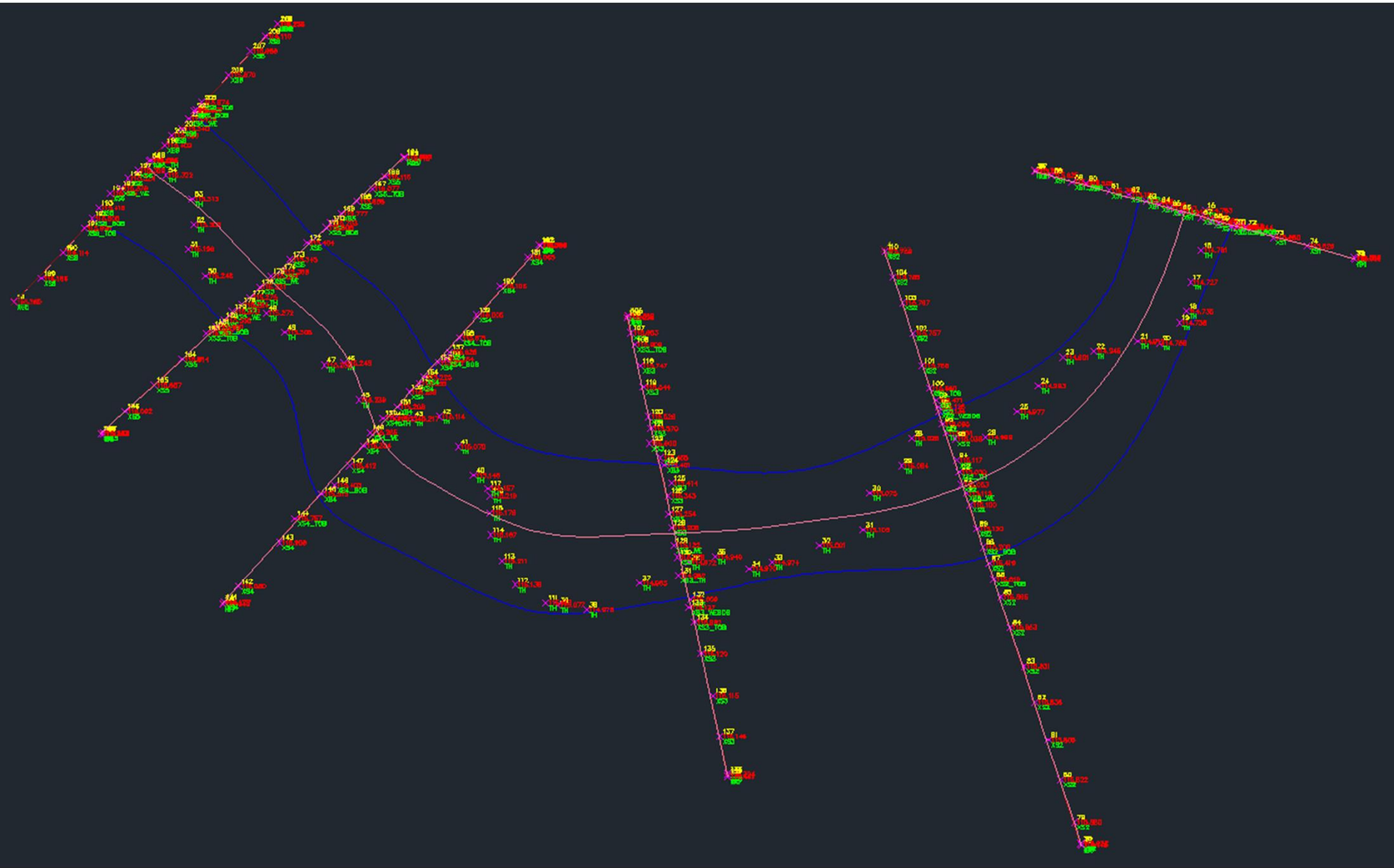
Survey Control

Survey Control

Data Collection

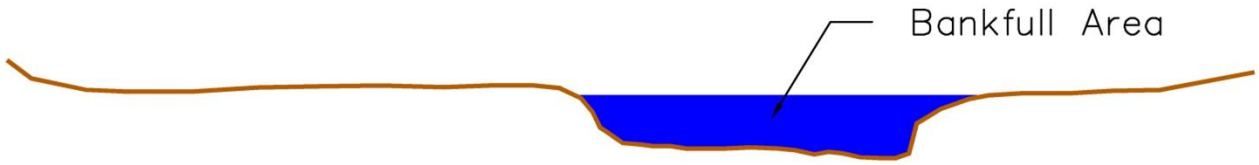


Data Processing

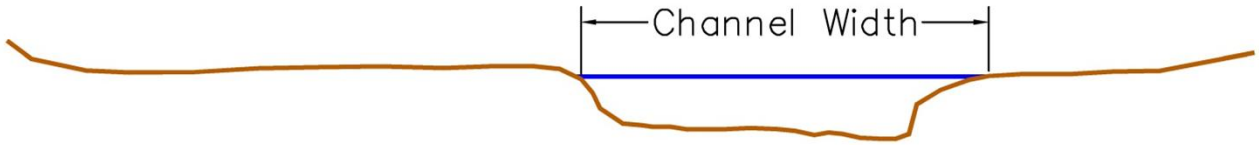


Cross-Section Analysis

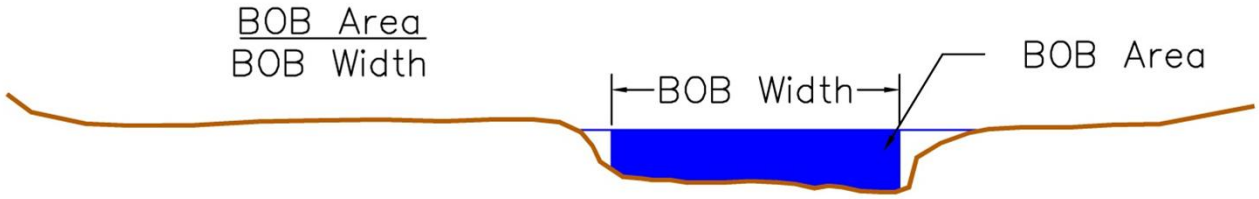
- Area



- Width



- Depth



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Site Classification

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Site Statistics

Mean

$$\mu = \frac{\sum_{i=1}^{N} X_i}{N}$$

Standard Deviation

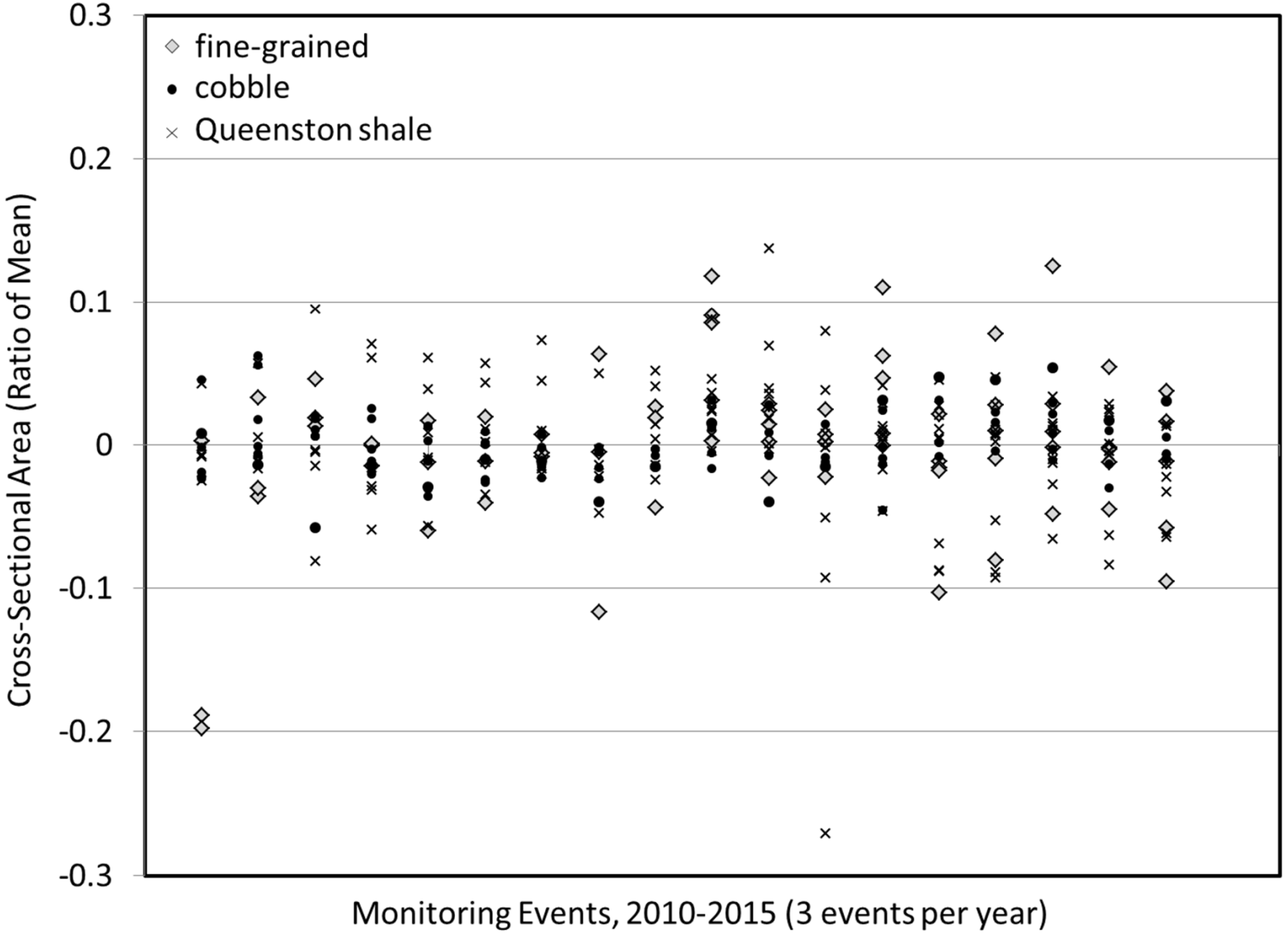
$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \mu)^2}{N}}$$

Coefficient of Variance

$$C_v = \frac{\sigma}{\mu}$$

Cross-Sectional Area Standardized Data

Field Site Average Standardized by Monitoring Period Average



Spatial versus Temporal Variability

Coefficient of Variation (CoV)

Average Spatial Variability (between cross-sections)

CoV Data	Average	Standard Deviation	Max / Min
Cross-Sectional Area	31%	15%	89% / 5%
Bankfull Width	21%	10%	54% / 6%
Bankfull Depth	24%	10%	73% / 9%

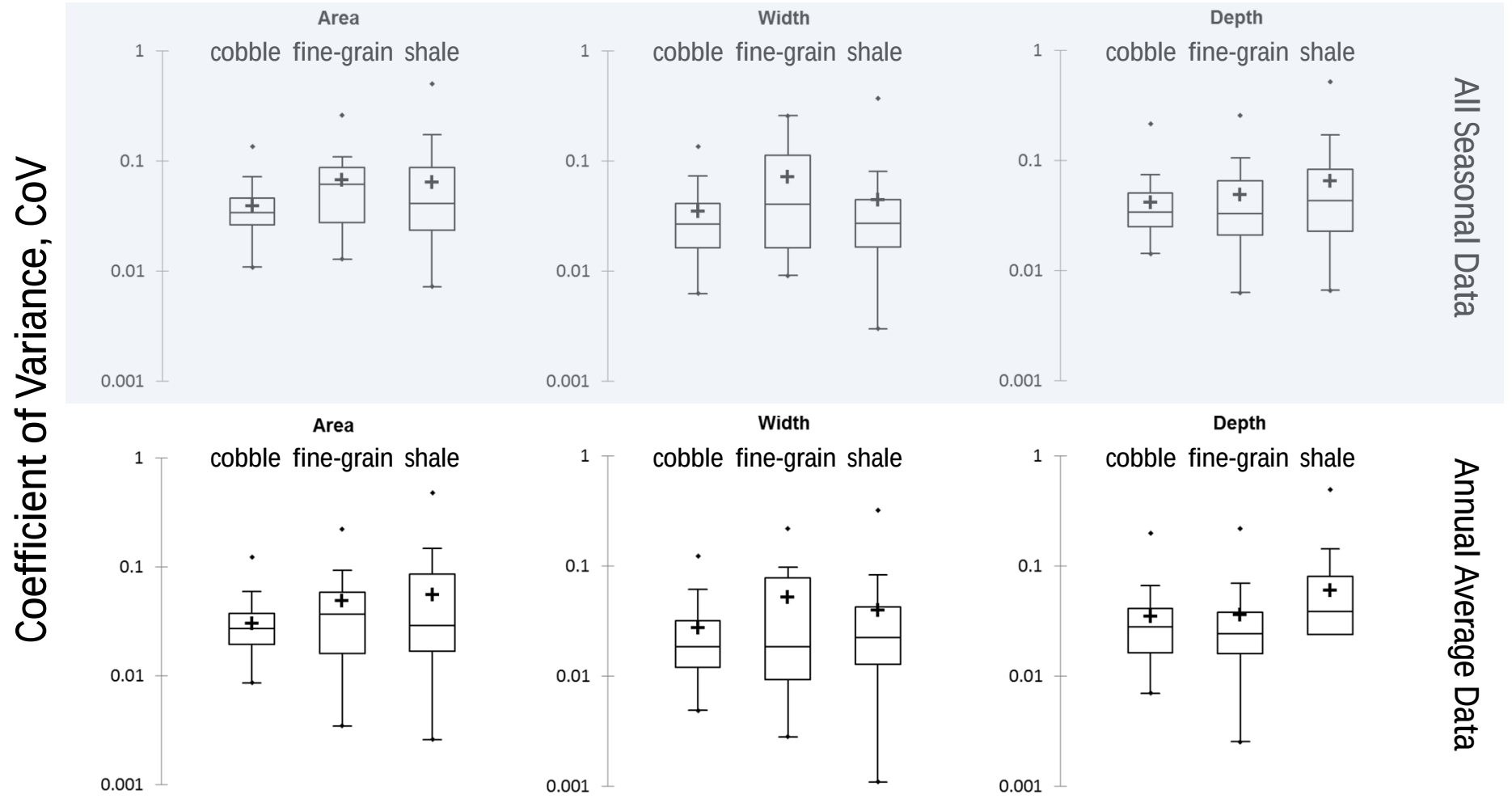
Average Temporal Variability (between seasonal monitoring events)

CoV Data	All Events	Annual Averages	Seasonal Only
Cross-Sectional Area	5.7%	4.5%	1.2%
Bankfull Width	5.0%	3.7%	1.2%
Bankfull Depth	5.2%	4.3%	0.9%
Expected Range: All Stream Classes All Parameters	5 – 6%	4 – 5%	1 – 2%

Note: Spatial variability is an order of magnitude larger then the seasonal variability!

Variance by Stream Class

CoV for Each Cross-Section through Time



t-tests: Is the mean CoV statistically different between the stream classes?

Differences in Variance between Stream Classes

p-values (two-tail) for t-tests assuming unequal variances (log-transformed data)
95% Confidence for Significance (p-value < 0.05)

All Seasonal Data	Cross-Sectional Area	Bankfull Width	Bankfull Depth
Cobble ≠ Queenston	0.022 **ü**	0.984 **û**	0.067 ~
Cobble ≠ Fine-grained	0.019 **ü**	0.040 **ü**	0.897 **û**
Fine-grained ≠ Queenston	0.567 **û**	0.045 **ü**	0.156 **û**

Annual Data	Cross-Sectional Area	Bankfull Width	Bankfull Depth
Cobble ≠ Queenston	0.043 **ü**	0.408 **û**	0.044 **ü**
Cobble ≠ Fine-grained	0.374 **û**	0.349 **û**	0.477 **û**
Fine-grained ≠ Queenston	0.611 **û**	0.156 **û**	0.031 **ü**

Observations

Queenston and fine-grained variances are statistically different from cobble for cross-sectional area

Differences in variance of fine-grained are explained by *seasonal variability* in bankfull width

Differences in variance of Queenston are largely explained by variance in bankfull depth (bed dynamics), which is NOT as sensitive to seasonal variability

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Erosion Target Thresholds

to detect signals of development impacts

Cross-sectional area (typically ± 20% threshold)

Cross-Sectional Area	Avg. CoV	95th Percentile	99th Percentile
Cobble	4%	7%	11%
Fine-grained	7%	15%	24%
Queenston	7%	15%	32%

Bankfull depth (typically ± 20% threshold), substrate aggradation/degradation

Bankfull Depth	Avg. CoV	95th Percentile	99th Percentile
Cobble	4%	7%	11%
Fine-grained	5%	15%	17%
Queenston	7%	21%	33%

Typical 20% thresholds, may overestimate cobble, but OK for fine-grained and Queenston.

Local cross-section exceedances are common in the Queenston sites, but site averages typically remain below the erosion target threshold.

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Stream Morphology Monitoring Recommendations

to detect signals of development impacts

- Spatial variability is greater than temporal variability
  - Monitor more cross-sections rather than more often
- Fine-grained head water channels see higher seasonal variation
  - Multiple measurements annually are useful for these sites
  - Annual monitoring (once per year) may be sufficient for cobble and Queenston shale sites
- Variability differs by channel type
  - A “one-size-fits-all” approach to target thresholds may under-estimate or over-estimate natural variability
  - Classification by alluvial bed material type is useful
  - Monitoring schemes and target thresholds should reflect the expected natural variation of different stream types