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Effect of Stream Restoration on Water Quality and Quantity in the Coastal Plain of North Carolina

Cyrus N. Belenky, Dani Winter,
Chiao-Wen Lin, François Birgand, PhD.
15. March 2018

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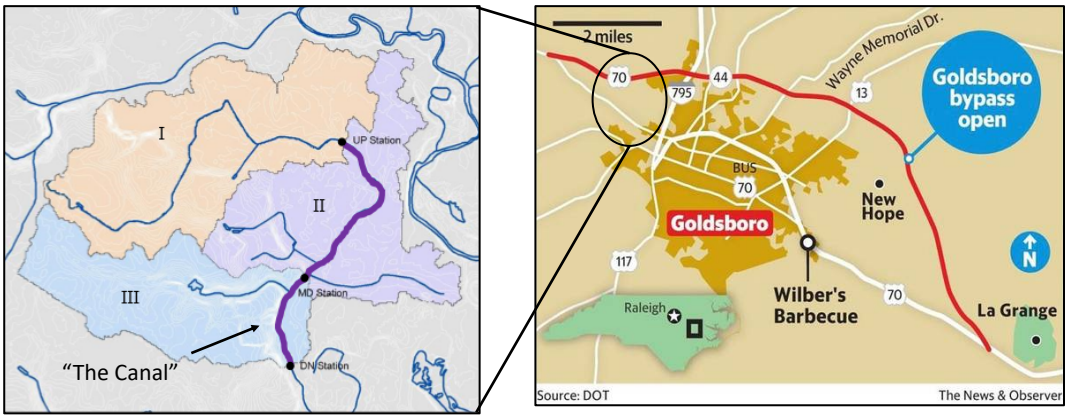
Study Site - "The Canal"

- NC Forestry Service Claridge Nursery, Goldsboro, NC



Lin et al., 2017

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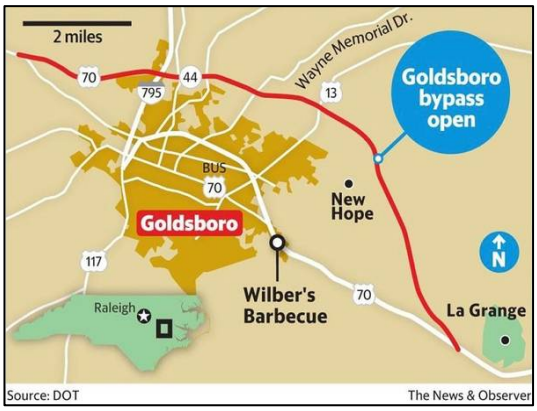
Why the Restoration?

- U.S. Highway 70 Goldsboro Bypass (R-2554)
  - 21.7 miles of new highway
- Reduce freight traffic through Goldsboro
- Improve east-west passenger transport
- Mitigation required under Section 404 of the Clean Water Act (CWA)



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Study Site - "The Canal"

Pre-Restoration:

- Agricultural Canal
- Disconnected Floodplain
- Low Sinuosity

Google Earth, 2017

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Google Earth, 2017

- Priority 2 restoration
  - Excavated a new floodplain
  - Increased sinuosity
- Length: 2.4 km

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Study Site - "The Canal"

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Google Earth, 2017

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Jack Kurki-Fox, 2016

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Restoration Breakdown

Mitigation Area	Size	Restoration Plan
"The Canal" (M1)	2456 m	• New floodplain at a lower elevation • Meandering, single-threaded channel (E stream type)
Unnamed Tributary #1 (UT1)	230 m	• Grading a floodplain for diffuse surface flow • Will form a braided channel headwater stream (DA stream type)
Unnamed Tributary #2 (UT2)	540 m	• Same as UT1
Riparian Buffer	12.9 ha	• Planting of 50 feet of buffer on both sides of streams

NC DOT, 2011

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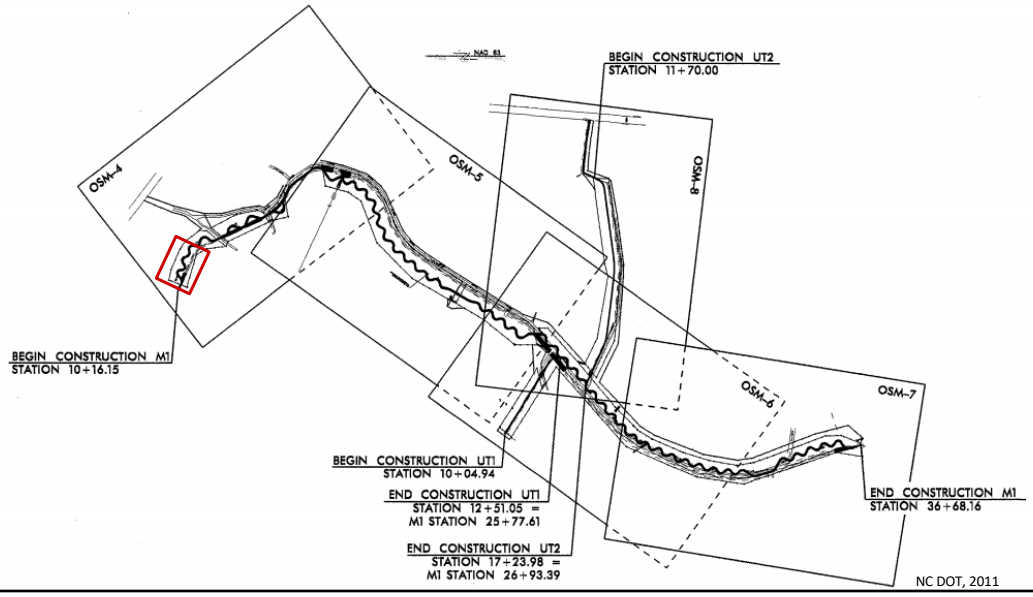
Restoration Plan View



NC DOT, 2011

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Stream Restoration to Date

- 1990-2005 ~ $1 billion/year in North America
  - Only 10% are monitored (Bernhardt et al., 2005)
- Poor monitoring methods (Morandi et al., 2014)
  - Weak link between restoration and measured effect
  - Conclusions w/ the most positive results used the poorest methods
    - Insufficient pre- and post-restoration monitoring (Downs et al., 2002)
- Load error of ±20-30% w/ infrequent sampling (Lin et al., 2017)
- 1 km canal => 5% reduction nitrate & 3% total N
  (Birgand et al., 2000)

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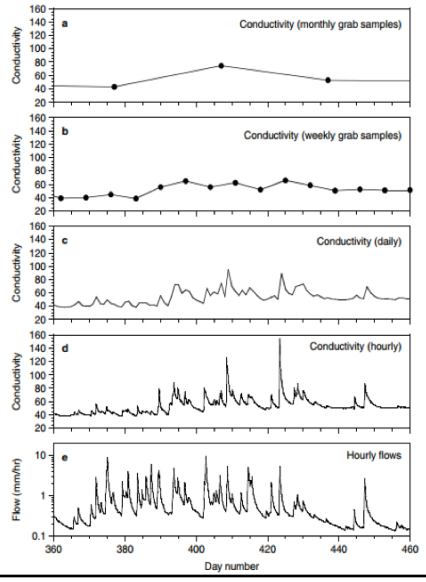
Sampling Frequency Matters



Kirchner et al., 2004

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Research Questions

1. What is the restoration effect on water quality and quantity?

2. Will results be congruent with Birgand et al., (2000)?
   (1 km canal => 5% reduction nitrate & 3% total N)

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Goals & Objectives

1. Continue water quality monitoring post restoration
   – 3 years pre-restoration by Chiao-Wen Lin (Lin et al., 2017)
2. Conduct high frequency sampling (every 15 minutes) with submersible UV-Vis spectrophotometers
   – Load error of ±2% (Lin et al., 2017)
3. Quantify restoration effect
   – Water Quality
   – Hydrology
   – Temporal changes of water quality & hydrology

Birgand, Francois; RNS 7101: Continuing Intensive Monitoring of Nutrient and Material Load in Claridge Nursery Stream "The Canal": assessing the water quality impacts & benefits of a stream restoration in the coastal plain

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Monitoring Timeline

Chiao-Wen Lin	Dani Winter	Cyrus Belenky	Qianyu Hang
2014-2016	2016	2016-2018	2018-
Pre-Restoration	During Restoration	Post-Restoration	Post-Restoration

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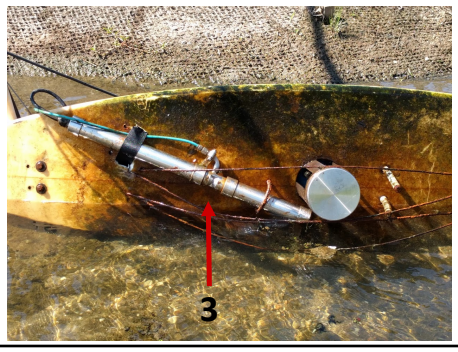
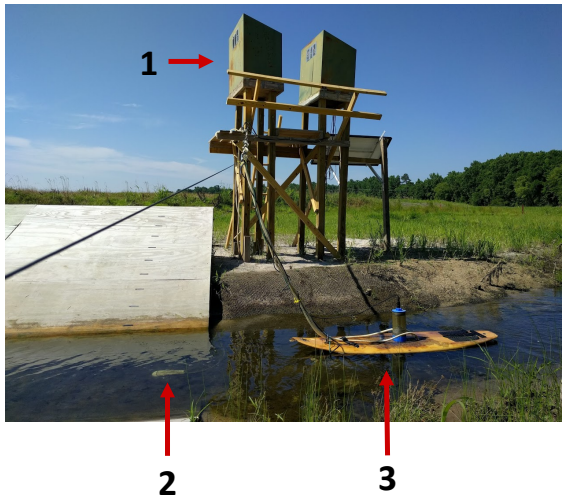
Data Collection: Site Setup

1. Time Paced Discrete Samplers
2. Doppler Velocity Meters
3. UV-Vis Spectrophotometers





Cyrus Belenky, 14. June. 2017

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Data Collection: Sampling Methods

Equipment	Parameter	Purpose	Sampling Interval
Manual Velocity Meter	Velocity, Stage	Flow rate calibration	2 weeks
Discrete Sampler	NH_3, NO_x, TKN, TDN, TSS, DOC, TP, $PO_{4,}$	Local calibration	14 hours
Doppler Velocity Meter	Velocity, Stage	Flow rate calculations	15 minutes
UV-Vis Spectrophotometer	NO_3, Turbidity, DOC, TOC	Cumulative load calculations	15 minutes

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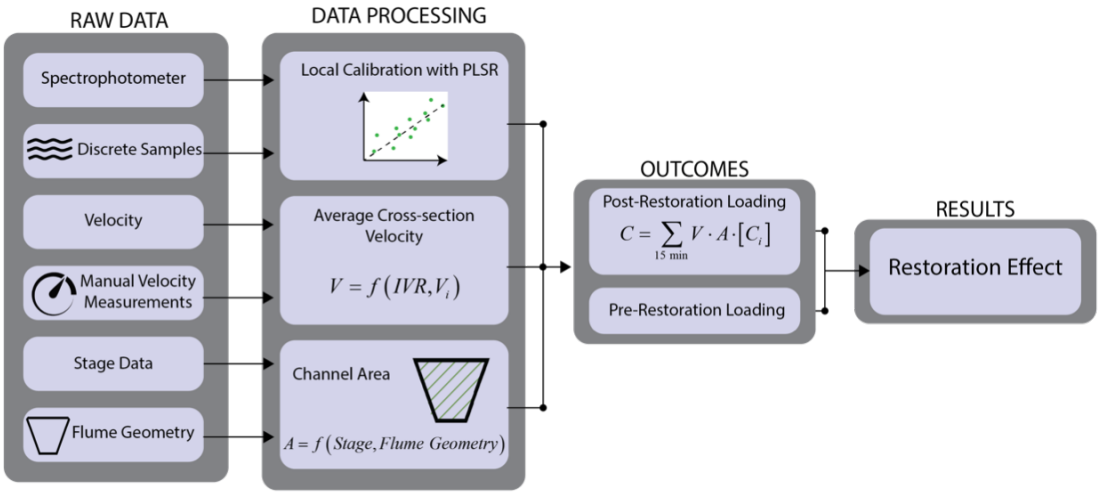
Analyzing the Data



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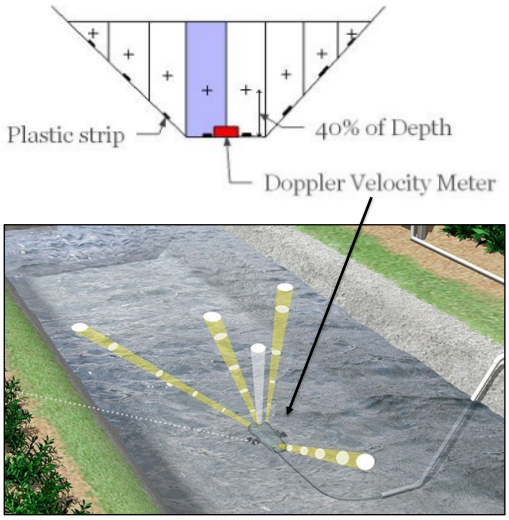
Determining Flowrate

- $A = f(Stage, Channel\ Shape)$
  - Stage from velocity meter
  - Geometry from survey
- $V_c = f(IVR, V_i)$
  - Index Velocity Rating (IVR)
    - Correlation between biweekly manual velocity measurements velocity meter data
- $Q = V_c * A$



Top: Lin et al., (2017), Bottom: sontek.com

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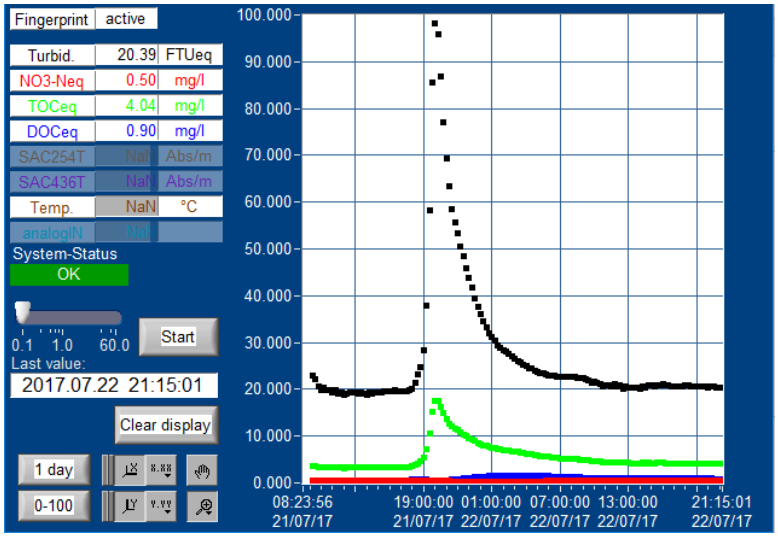
Calculating Concentration

- Global Calibration
  - Turbidity
  - NO_3-N
  - TOC
  - DOC
- Local Calibration
  - NO_3-N
  - NH_4-N
  - TDN
  - TKN
  - DOC
  - TP
  - PO_4-P



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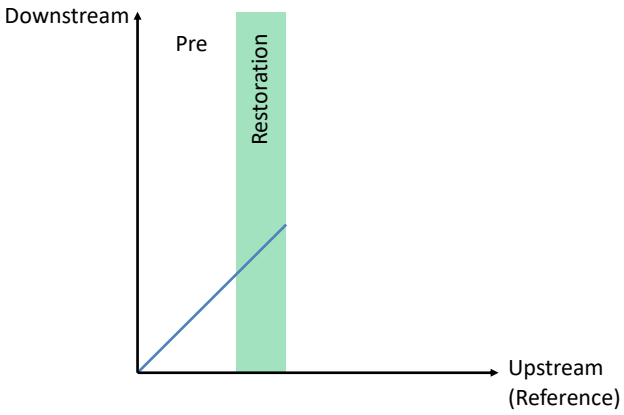
Influence of Sampling Error on Restoration Effect



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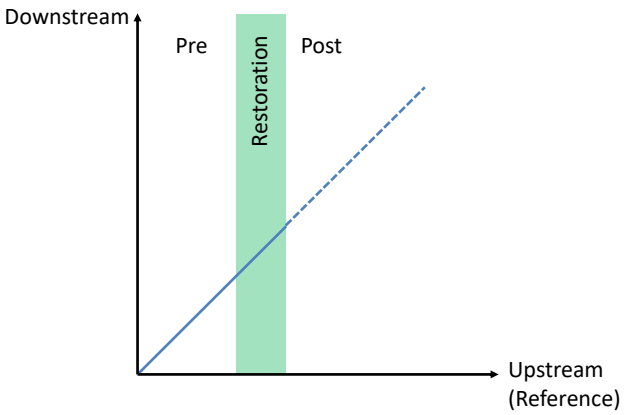

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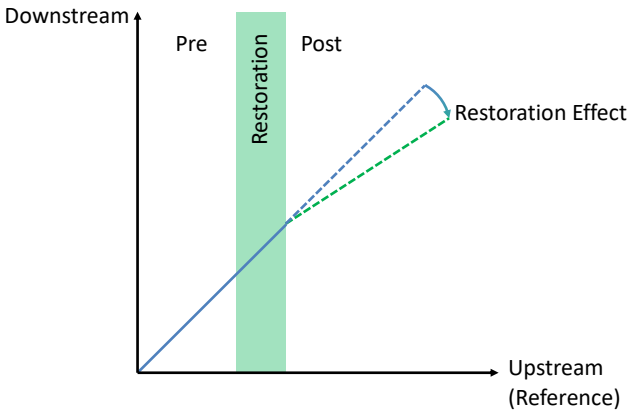

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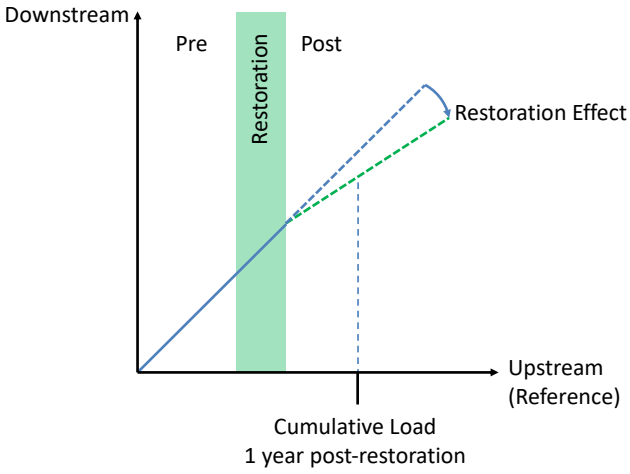

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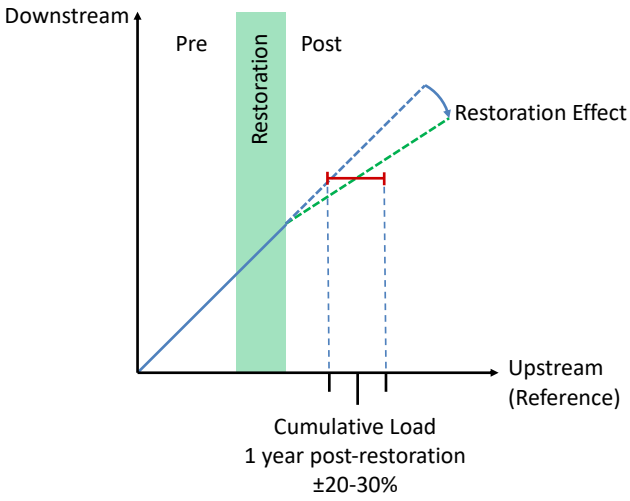

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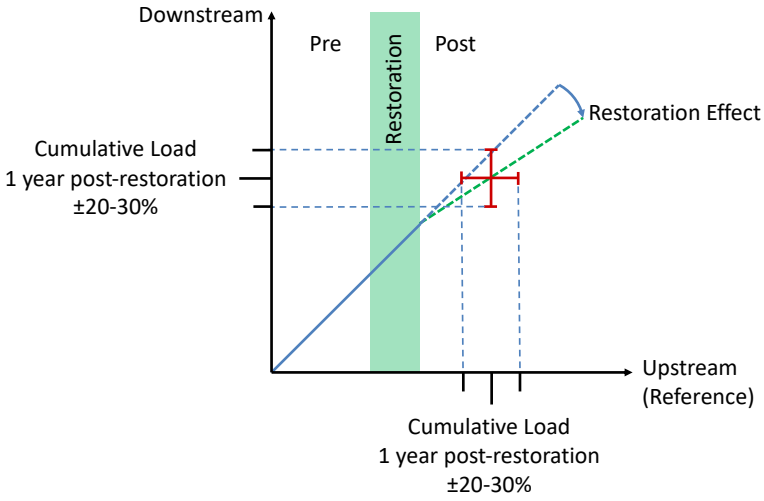

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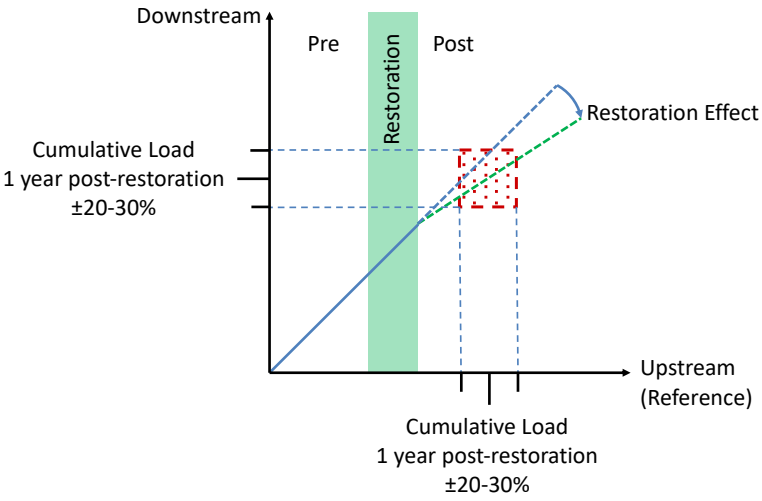

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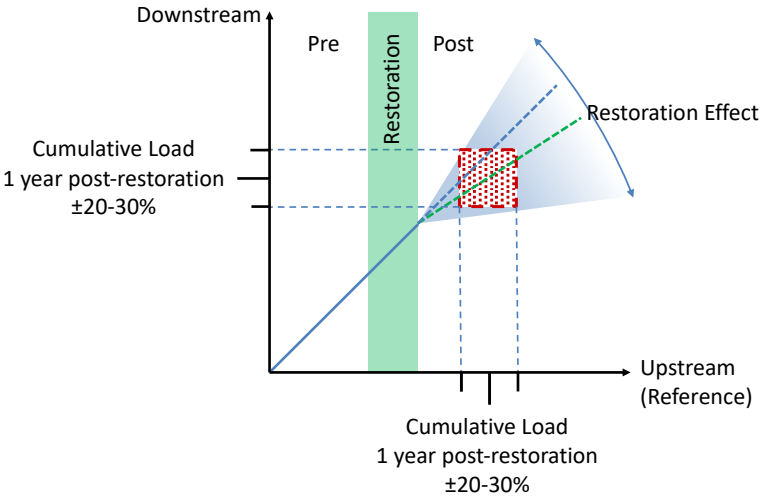

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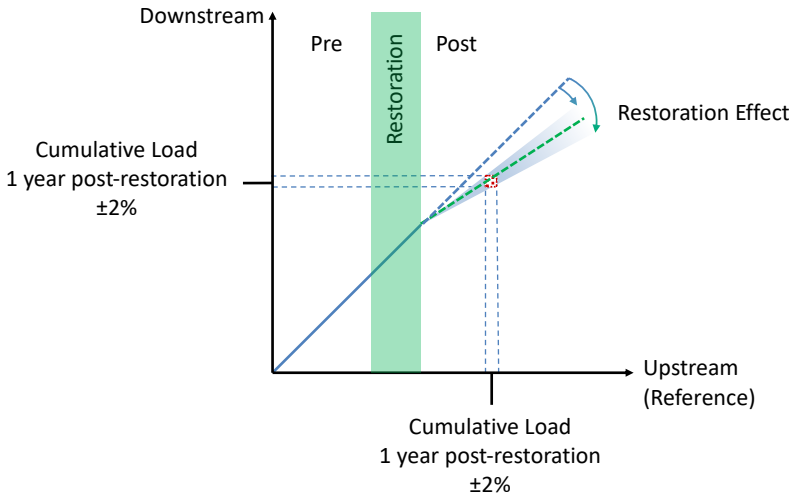

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Next Steps

1. Conduct PLSR with spectral data

2. Compare cumulative loads
   - Upstream vs. Midstream vs. Downstream
   - Pre- vs. Post-Restoration

3. What was the restoration effect within the first year?

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