Efficacy of environmental site design in protecting channel stability under changing climate

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What is Environmental Site Design (ESD) ?

ESD

- Structural BMP
- Non-Structural BMP
- Better Site Design

Image Source: Maryland Stormwater Manual

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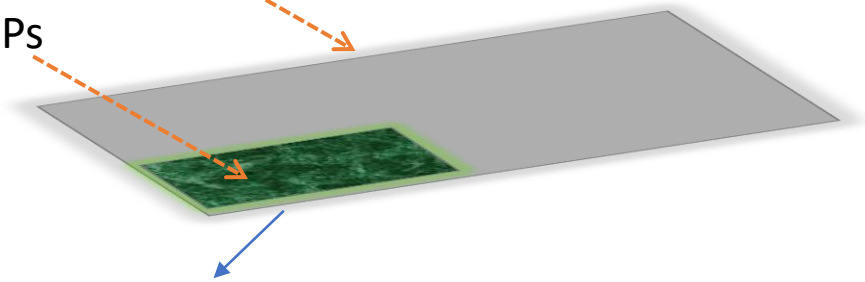
Environmental Site Design (ESD)

Postconstruction

Impervious Area

ESD BMPs



1-yr, 24hr Design Storm
Runoff Volume

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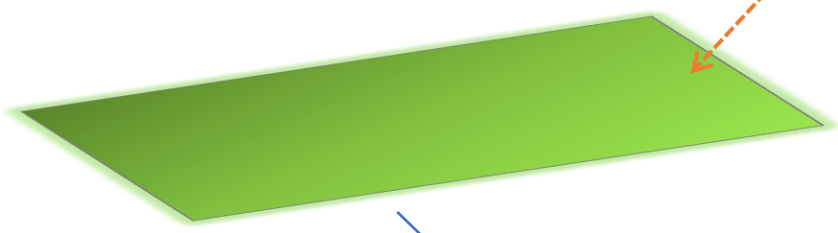
Preconstruction

Forested Condition



1-yr, 24hr Design Storm
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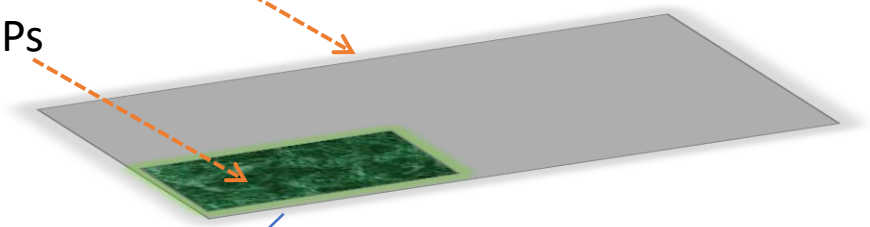
Environmental Site Design (ESD)

Postconstruction

Impervious Area

ESD BMPs



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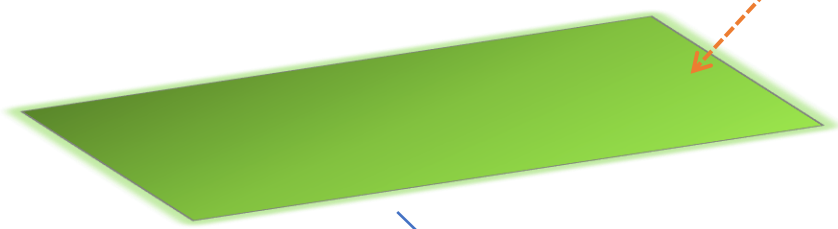

1-yr, 24hr Design Storm
Runoff Volume

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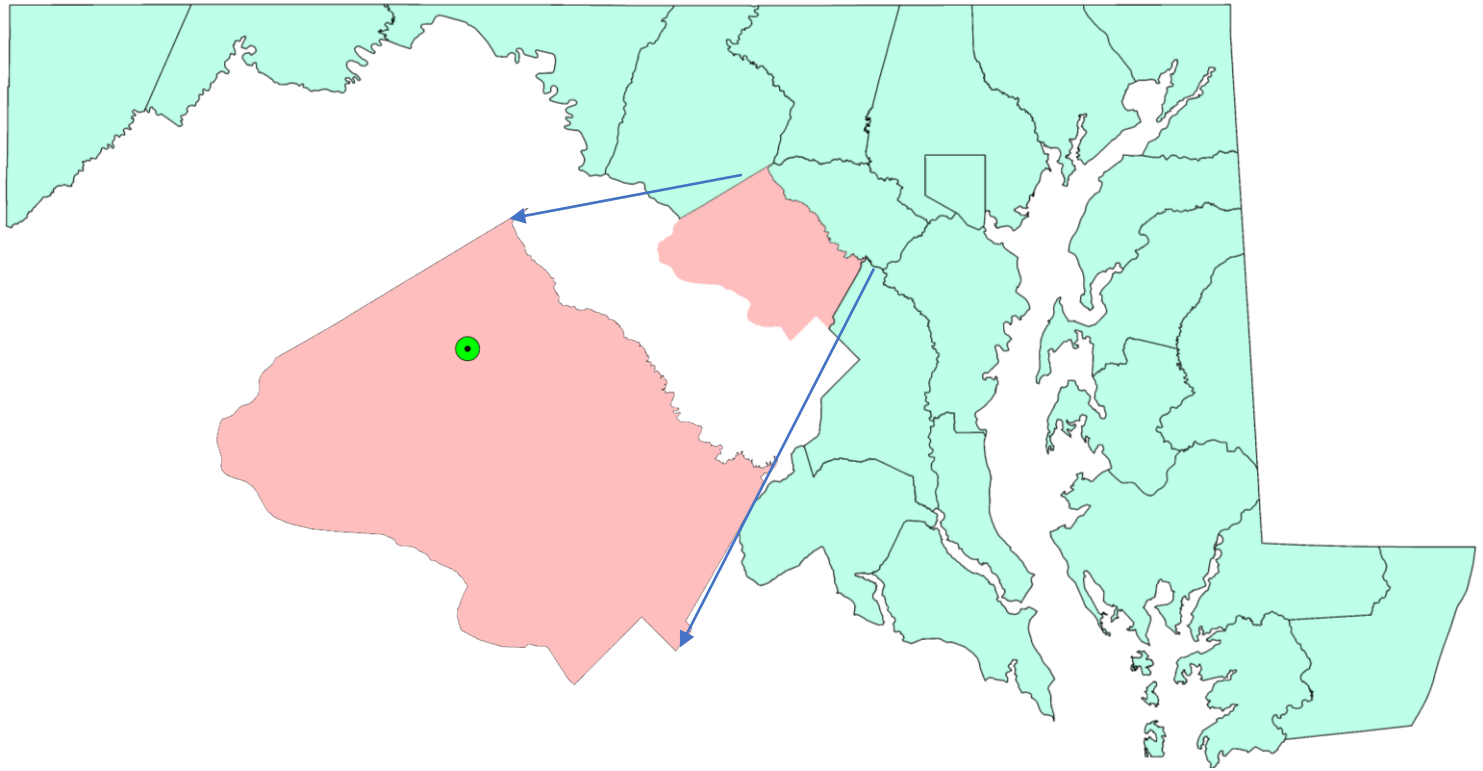
Study Site



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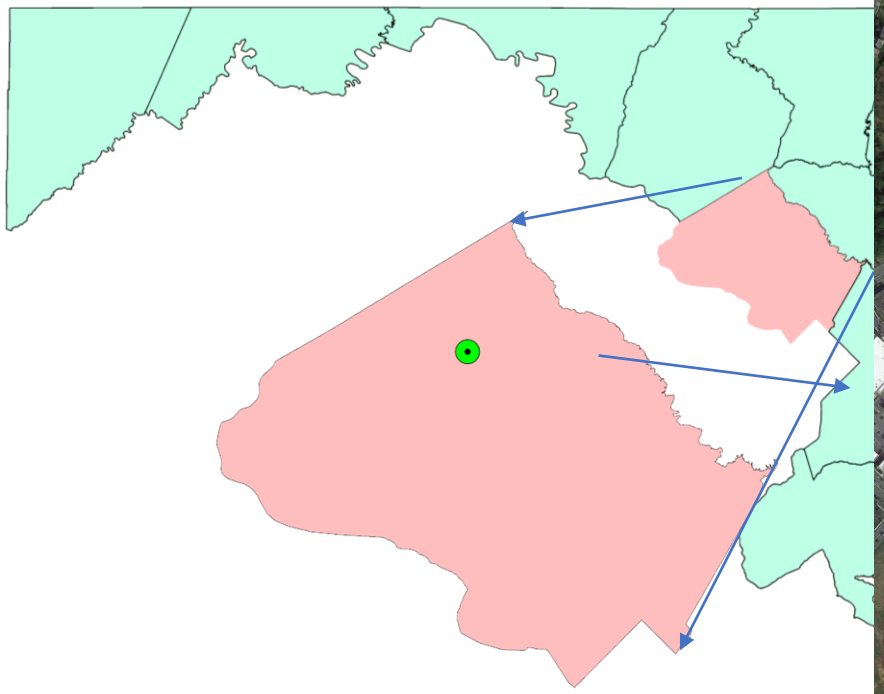

- Watershed area
  198 acres
- Total Impervious Area
  44%
- Directly Connected Impervious Area
  0%
- BMP density
  1.4 BMPs per acre

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Study Site

1993

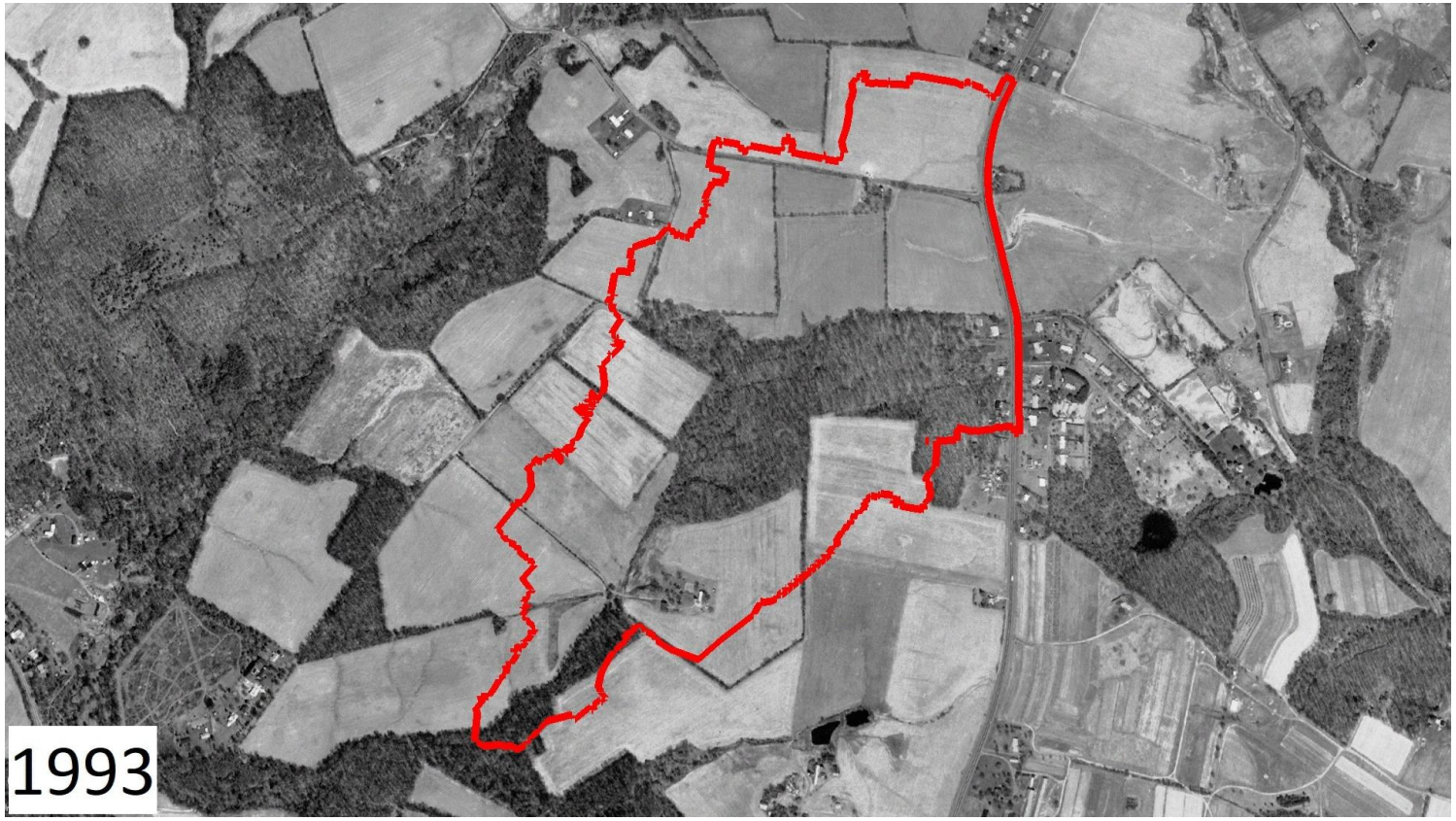
Pre-development

2005

Construction

2017

Developed



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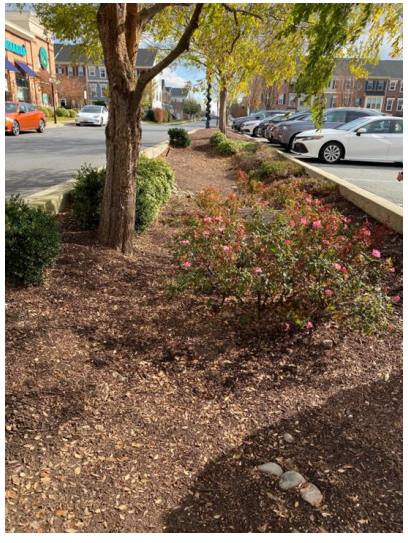
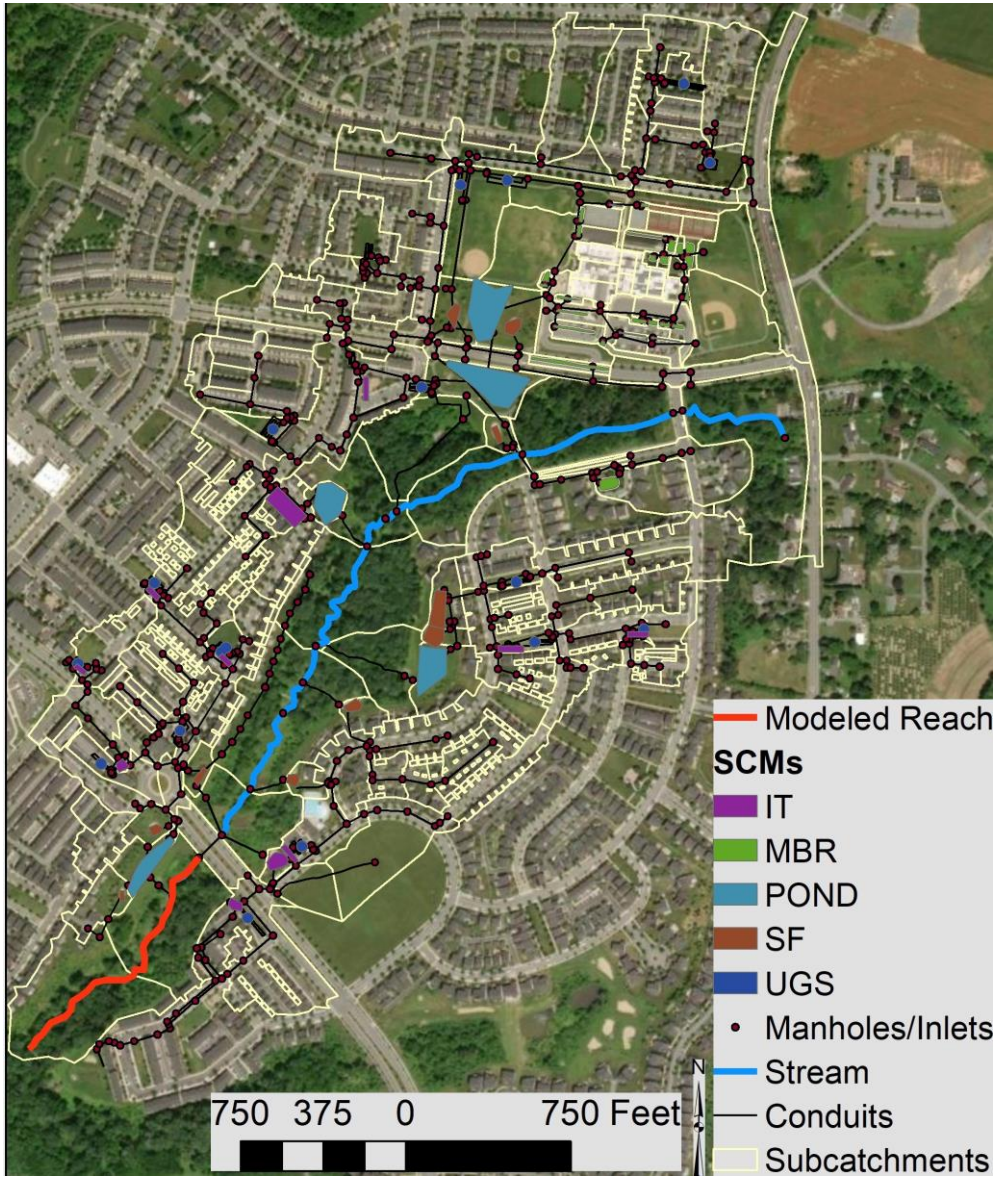
Study Site – BMPs



Micro Bio-Retention (MBR)

Pond



Infiltration Trench (IT)

Sand Filter (SF) and inlet of Underground storage (UGS)

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Modeling Framework

USGS-01644371 Stream Gage Data

SWMM
Storm Water Management Model

Climate data of 16 GCMs
- Spatio-temporal downscaled by LOCA & MACA methods
- RCP 2.5 and 4.5 emission scenario

Flow Timeseries Truncation and Compression

Bed Gradation Data

Incoming Sediment Load and Gradation

HEC-RAS 1D Quasi-Unsteady Hydraulic & Sediment Model

Channel Geometry
- LIDAR DEM
- Annual Cross-section Surveys

Sediment Output Results

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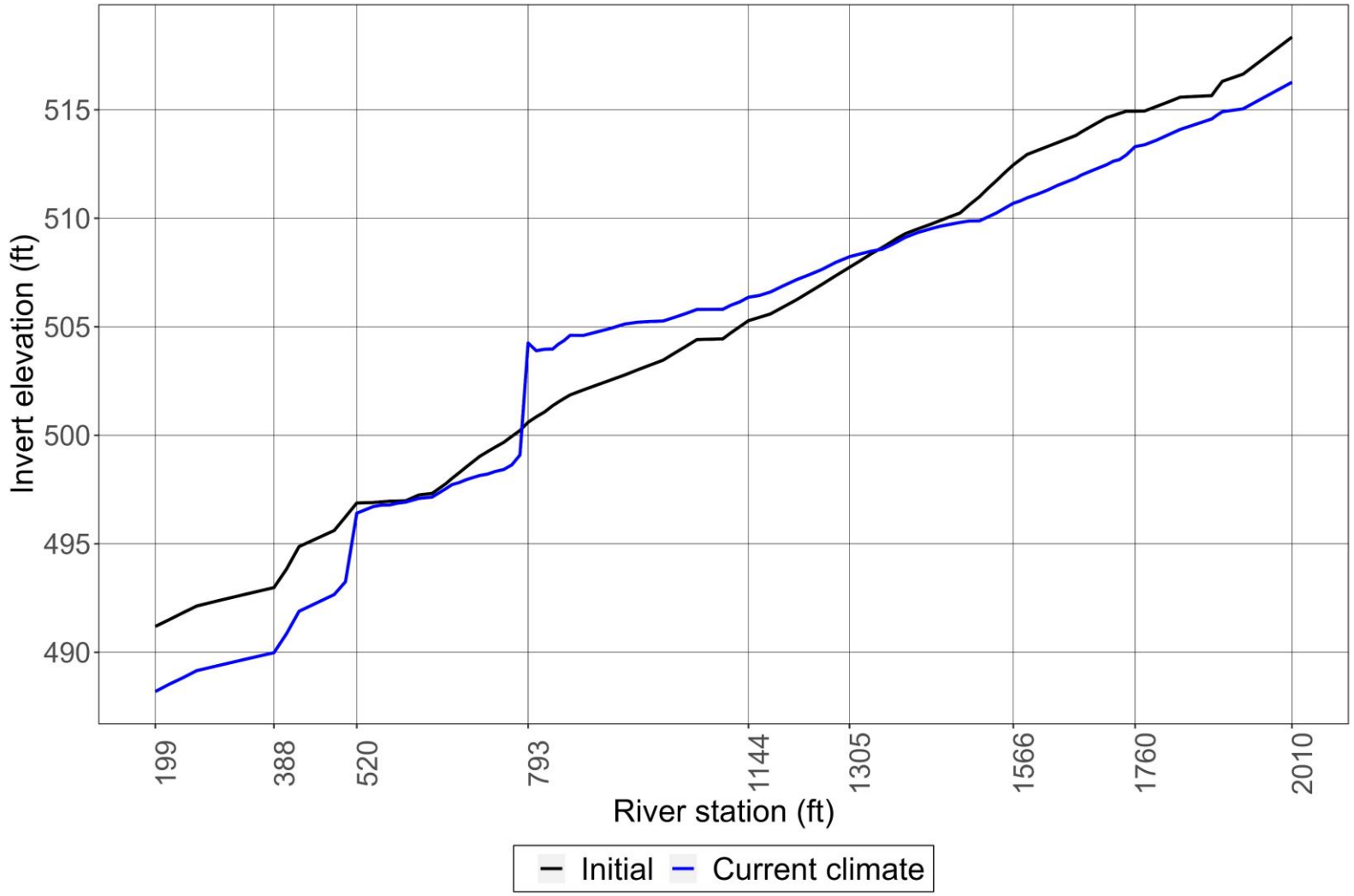
Predicted Change in Longitudinal Profile



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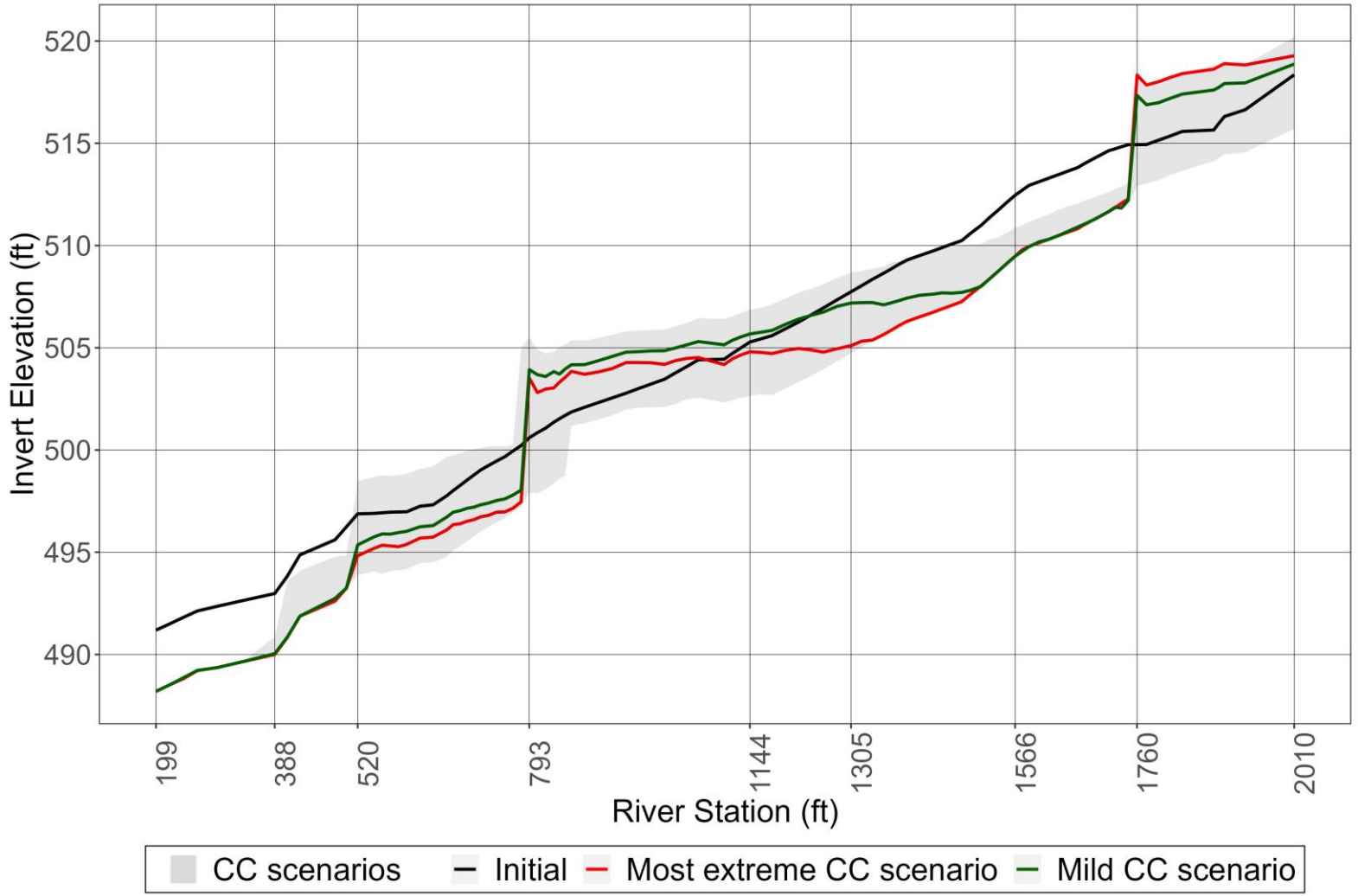

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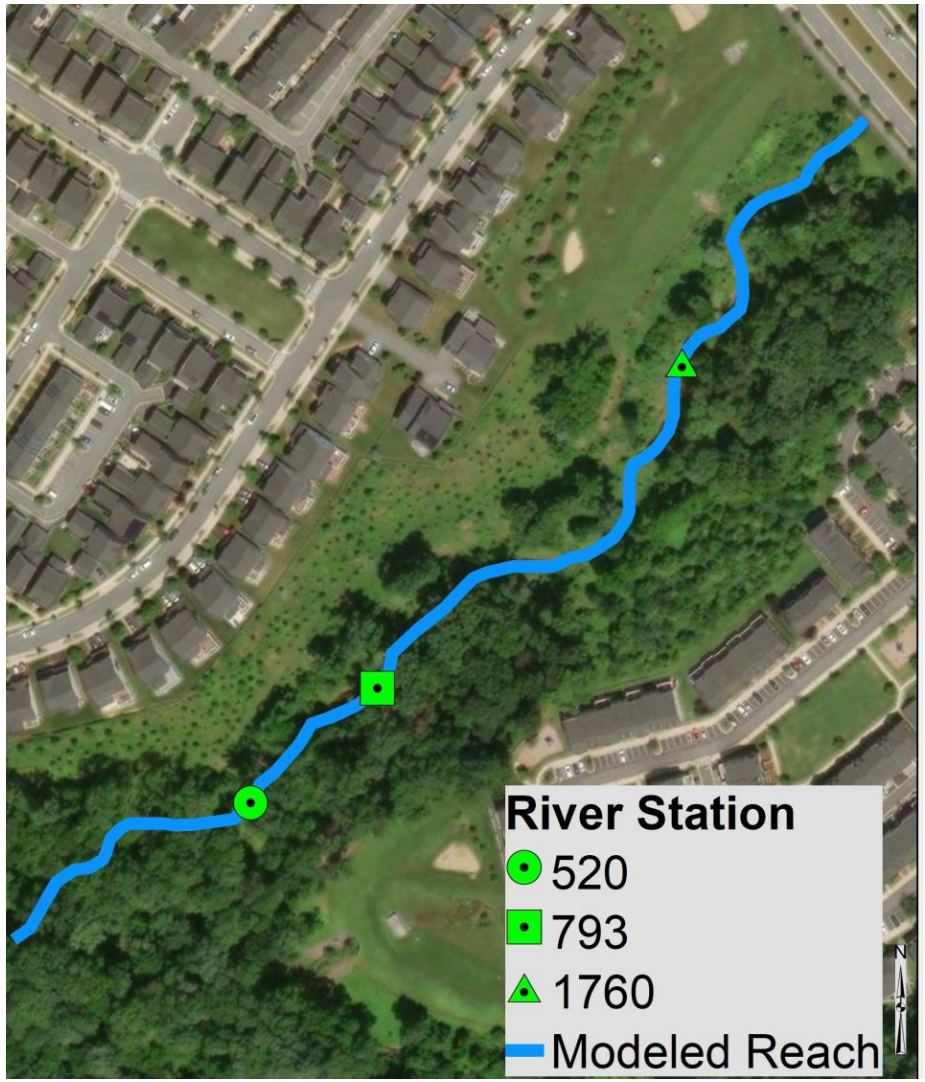
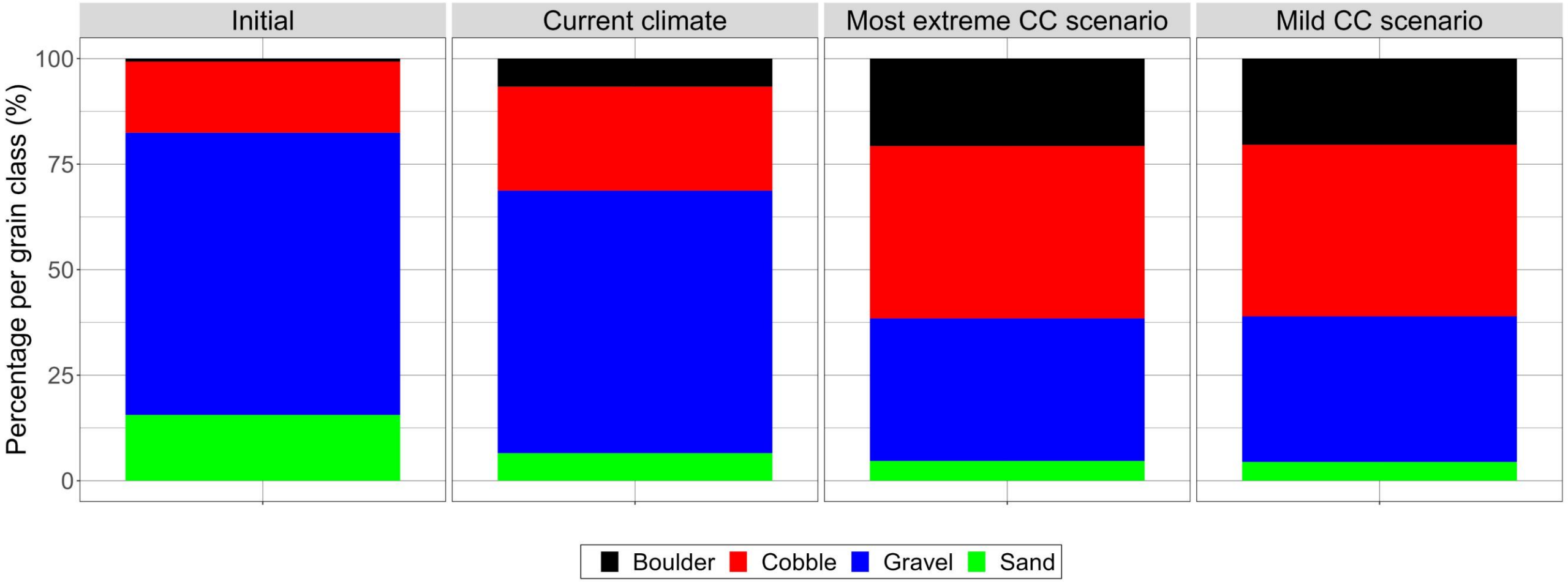
Change in Bed Gradation

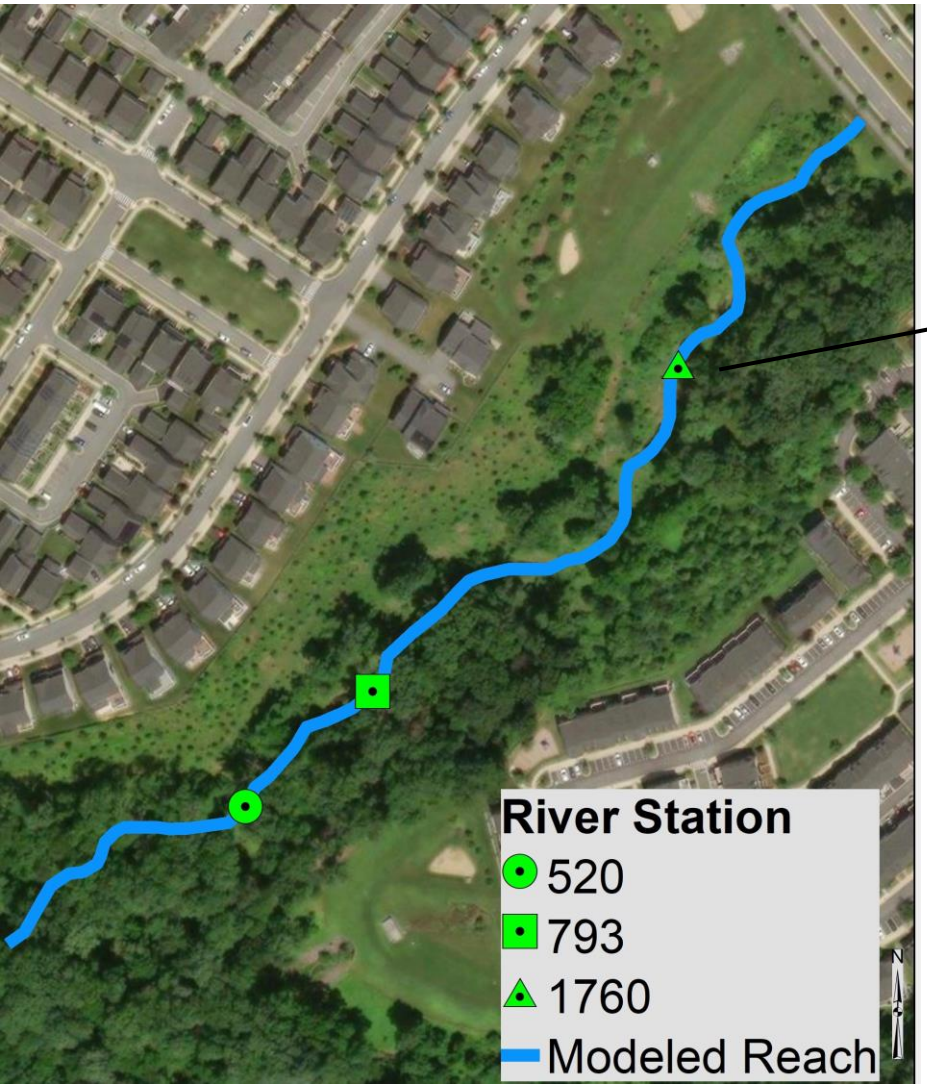


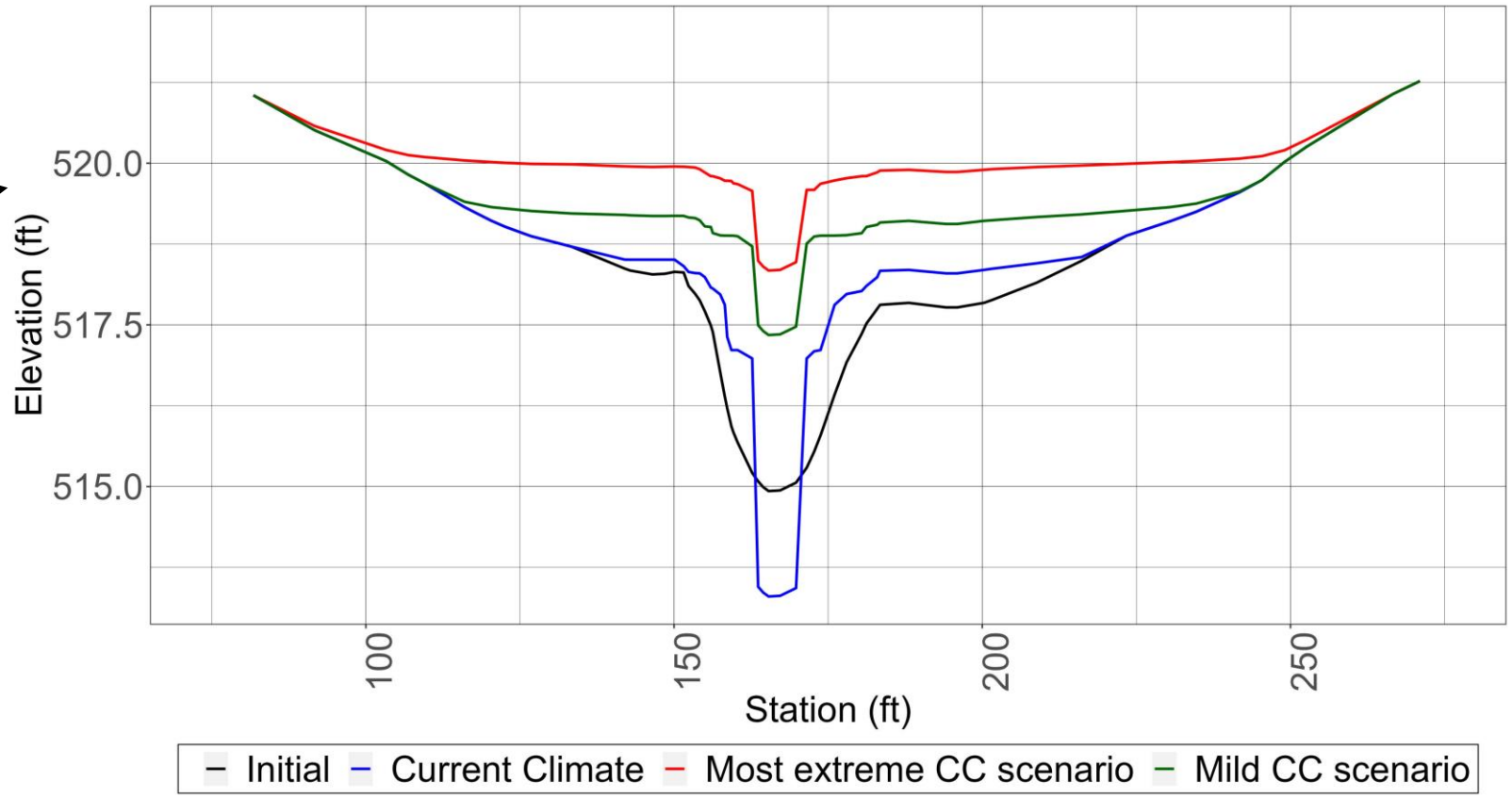
Change in Bed Gradation

River Station- 1760



Change in Cross-Section





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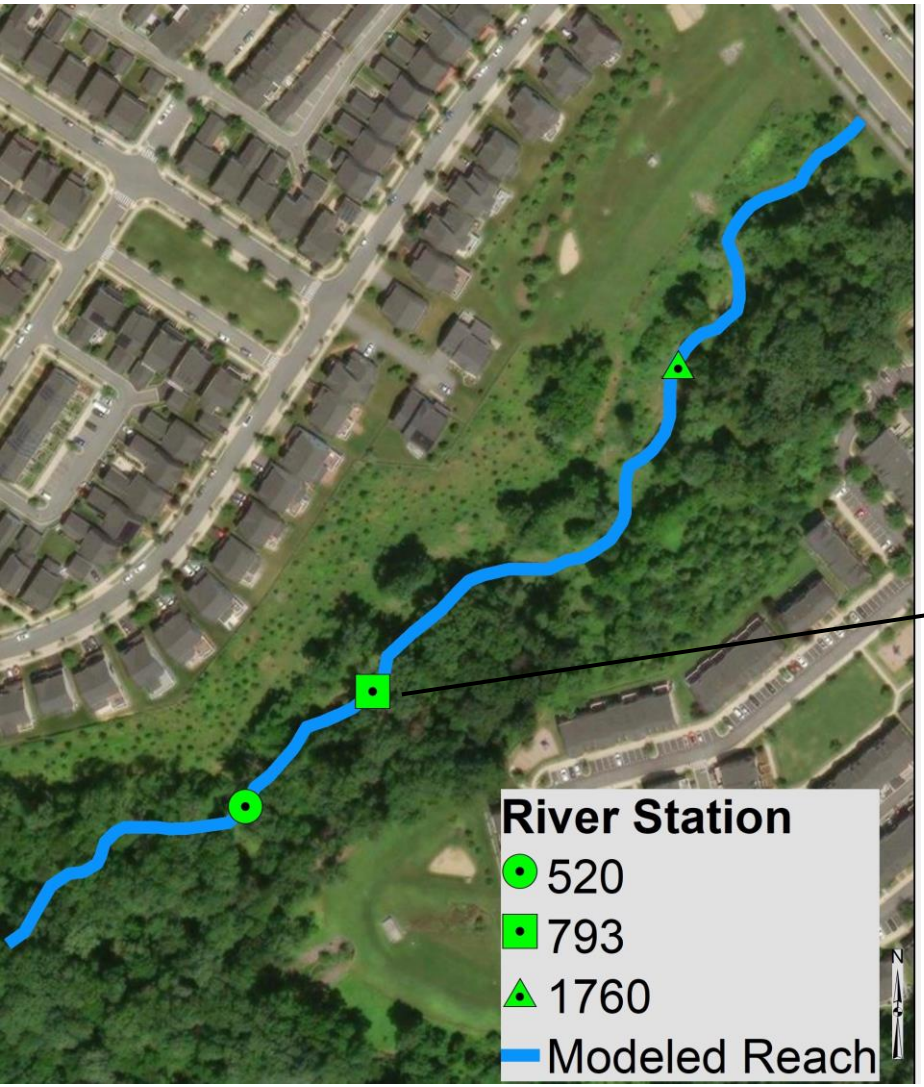

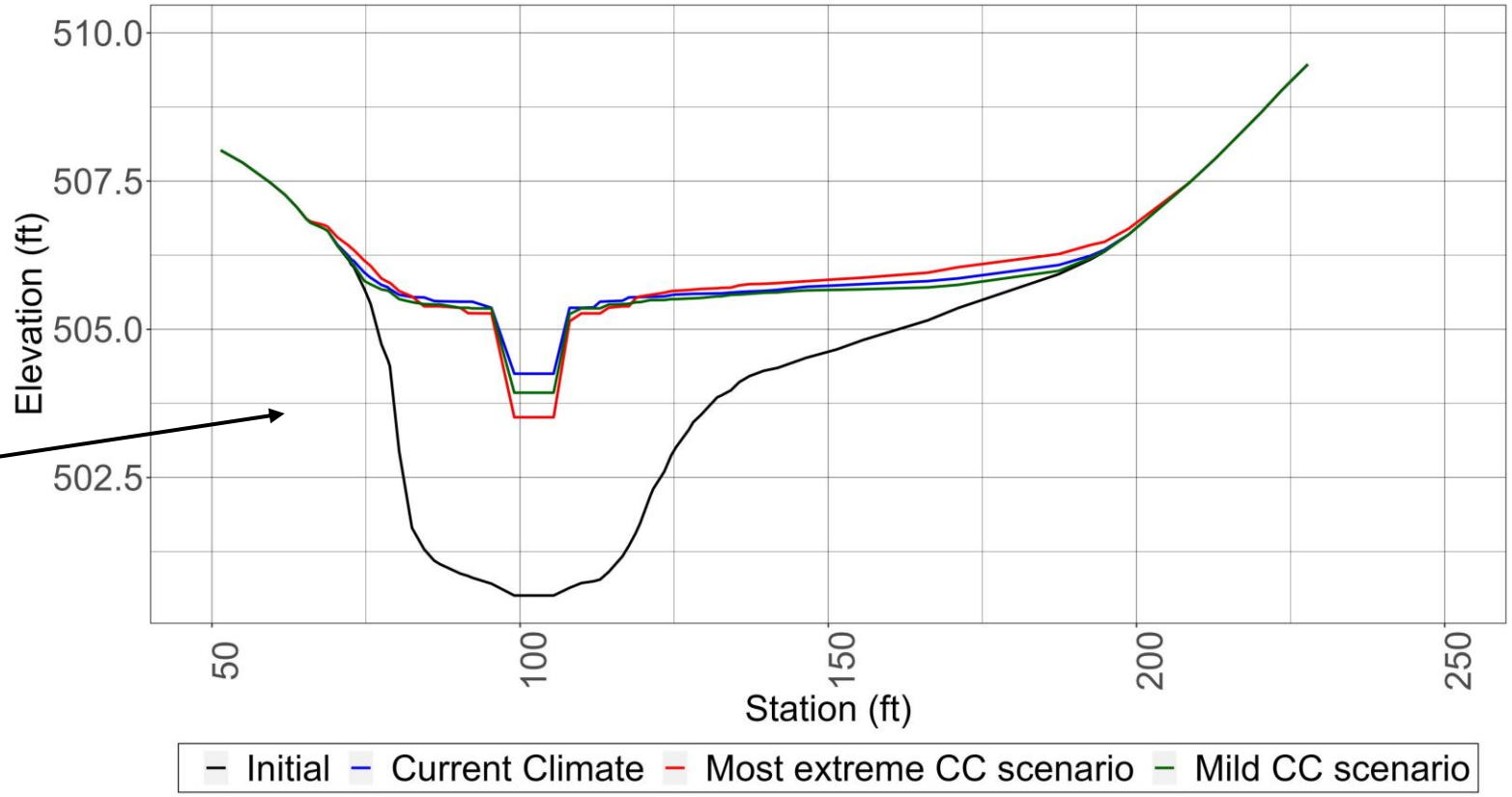

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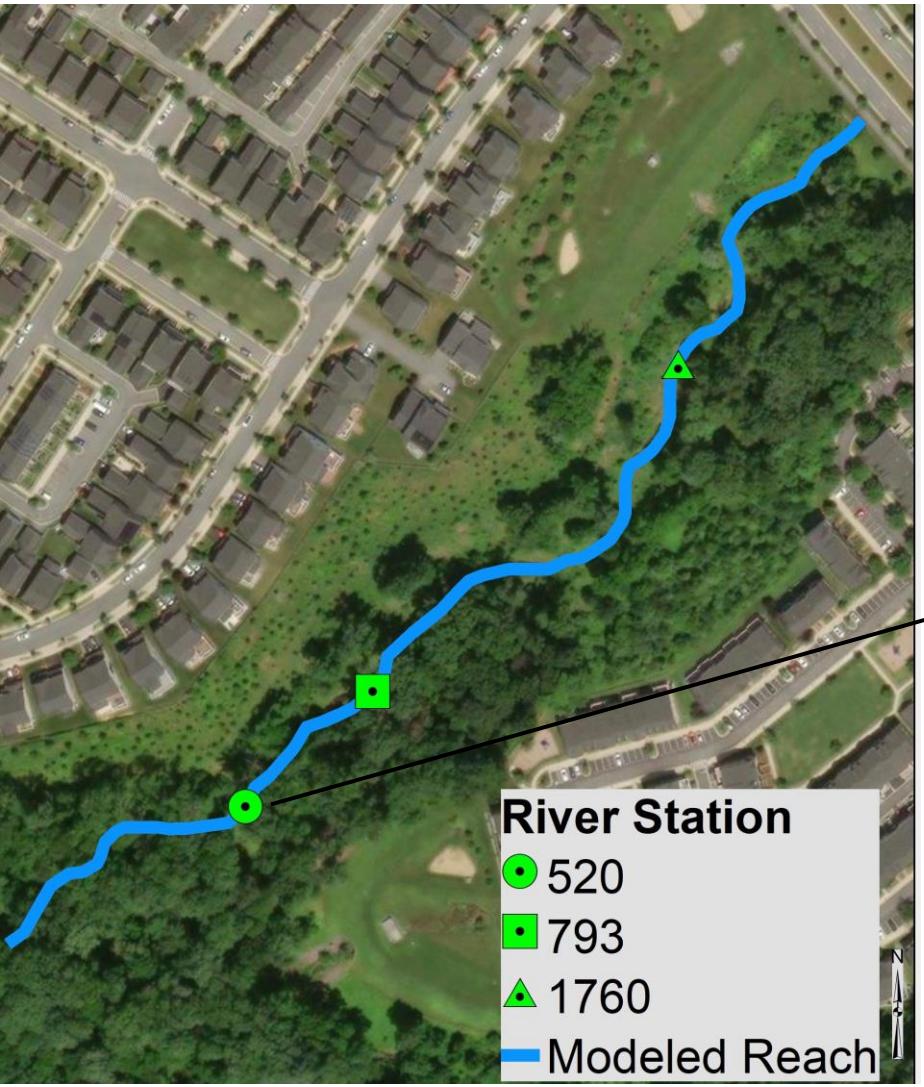
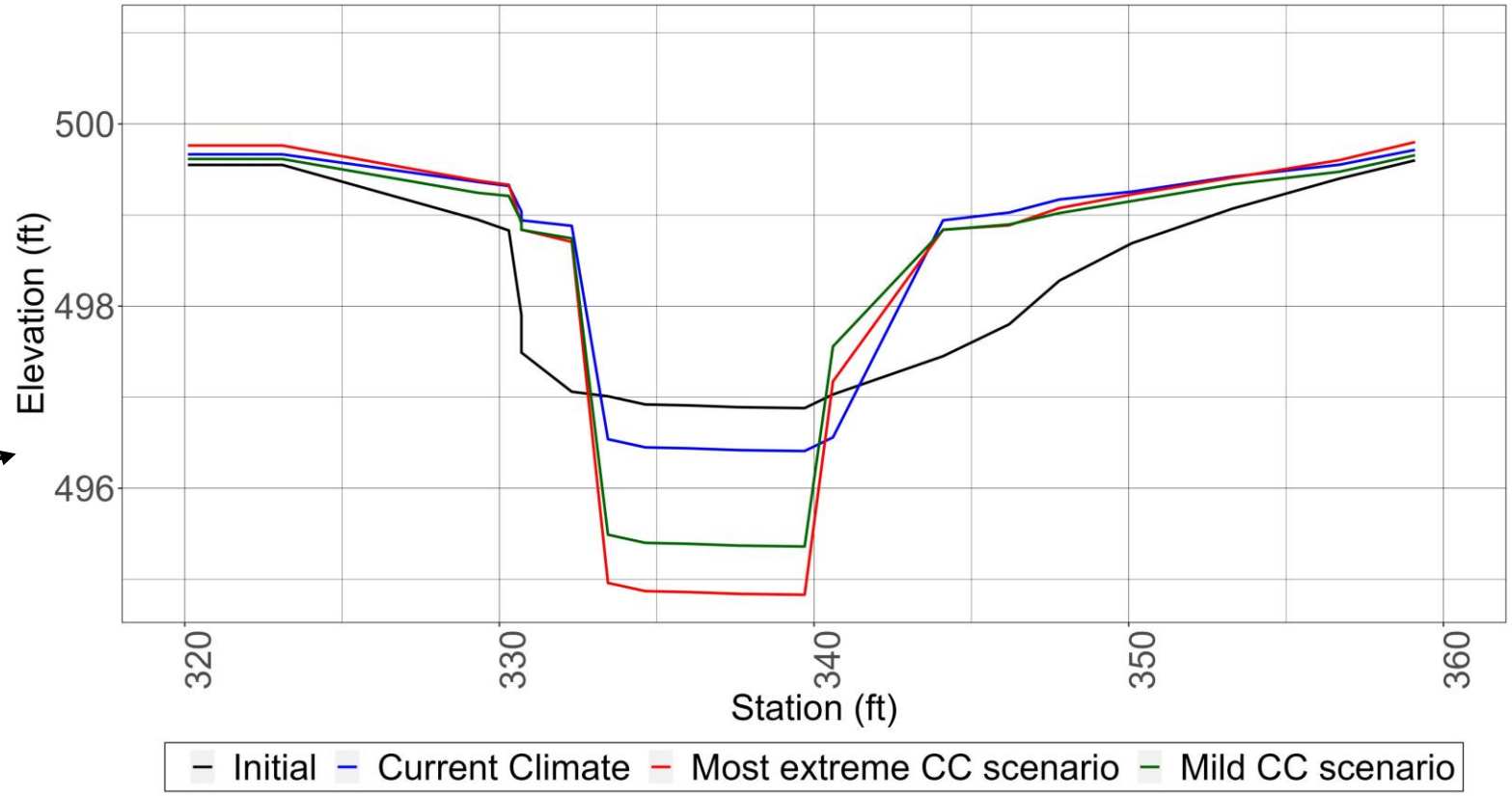




Changes in Sediment Yield

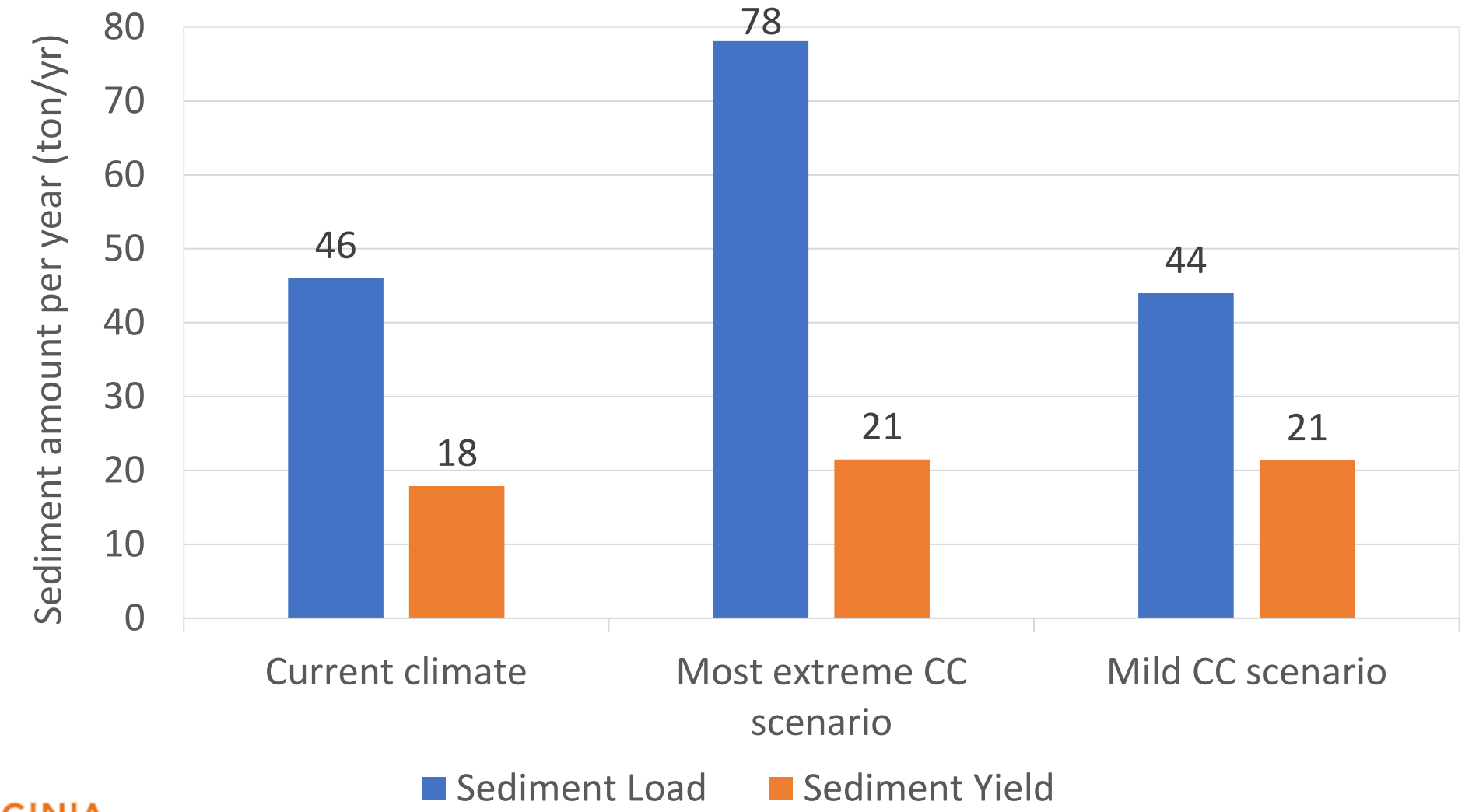
Sediment Load

- Incoming Flow Distribution
- Upstream LULC
- Incoming Sediment Load
- Incoming Load Gradation

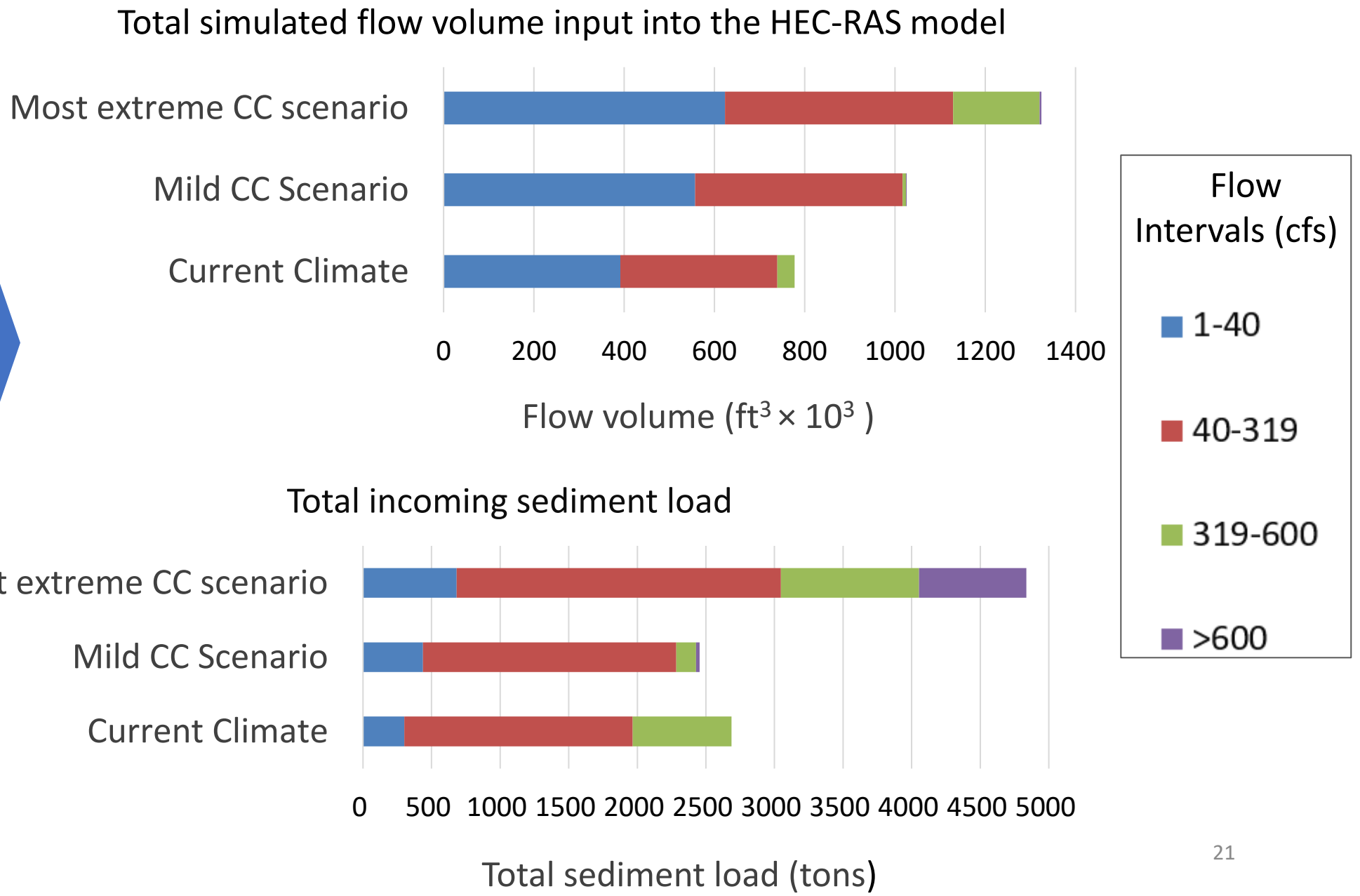
Sediment Yield

- Bed Gradation
- Channel Geometry
- Sediment Availability at Bed
- Stress History

Changes in Sediment Yield



Effect of Flow Distribution on Sediment Load



Key Findings

Channel expected to degrade even more than current condition in all CC scenarios even with the widespread application of ESD

Projected increase in low frequency, high magnitude storm events will increase the mobilization of existing cobbles and small boulders

Current stormwater regulations for the State of Maryland employing ESD are not protective of stream stability under current and future climate

Recommendations

- Use continuous, catchment-scale modeling to design stormwater management systems.
- To ensure channel stability, base stormwater management design on matching pre- and post-development total sediment transport over 10+ years.
- Explore use of SCM real time control to reduce overflow of large scale SCMs during closely occurring storm events.

Acknowledgment

Questions