Predicting freshwater inflows to Frenchman Bay, Maine

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Introduction

- Frenchman Bay in central Maine supports an economically important shellfishing industry
- Land-sea connections pose threats to water quality conditions with implications to shellfish harvesting activities and public health
- Bacteria pollution derived from precipitation runoff generation in watersheds surrounding Frenchman Bay can lead to temporary closures to shellfish harvesting
- Sustainability solutions for the shellfishing industry in the estuary require knowledge of rainfall and runoff relations in contributing watersheds
- We predict freshwater inflows into Frenchman Bay related to 24-hour precipitation event scenarios of varying precipitation depths with the aim of informing shellfishery management

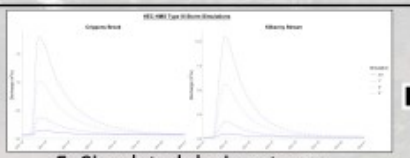
Study Area

1. Delineated Frenchman Bay watersheds

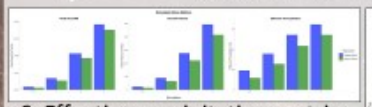
Methods

- Delineate watersheds and subbasins using an estuary delineation tool (Fig. 1; see Bea Van Dam's poster presentation)
- Use the HEC-HMS watershed hydrology simulation platform (U.S. Army Corps of Engineers 2020) to fit models relating rainfall to runoff for nine storm events in two estuary watersheds with discharge gages: Crippens Brook and Kilkenny Stream (Figs. 2 to 4)
- Derive precipitation data using daily 4-km PRISM precipitation estimates (PRISM Climate Group 2020) decomposed into hourly rates of input using local weather station rainfall data
- Estimate baseflow using observed discharge data, use the watershed's average recession coefficient for the last four storms when a storm occurs on the recession limb of a proceeding storm
- Estimate reach lag times using Manning's equation and reach geometries from StreamStats (USGS 2020)
- Estimate parameters for the SCS curve number runoff generation method:
  - Subbasin curve number: Derive from SSURGO soil hydrologic group (NRCS 2020) and 2015 North American Land Cover 30-m data (NALCMS 2020), adjust based on possible storm antecedent moisture conditions (AMCs)
  - Initial abstraction: Derive from curve number and initial abstraction ratio
  - Calibrate storm AMC, initial abstraction ratio, and translation of GIS data to curve numbers using observed storm runoff volumes
- Estimate parameters for the Clark unit hydrograph runoff routing method:
  - Subbasin time of concentration: 95th percentile of the time taken for simulated raindrops to reach the subbasin outlet
  - Subbasin storage coefficient: Median storage coefficient from model optimization on the last four storms
- Use fitted HEC-HMS models to simulate 0.5", 1", 2", and 3" NRCS Type III storm events with normal AMC (Fig. 5)
- Scale storm simulations to 14 ungaged Frenchman Bay watersheds by drainage area (Fig. 7)
  - Scale Crippens Brook simulations to Jordan River and Fosters Brook watersheds
  - Scale Kilkenny Stream simulations to all other watersheds

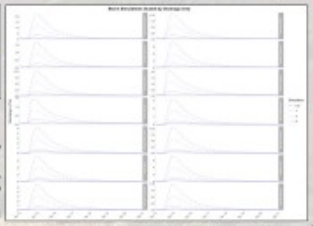
Results



5. Simulated design storms



6. Effective precipitation metrics



7. Predictions for other watersheds through scaling by drainage area

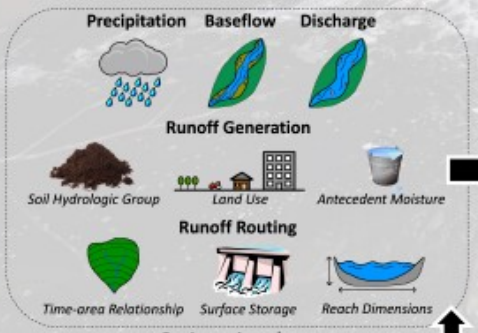
Discussion

- We produced initial predictions of freshwater inflow into Frenchman Bay from estuary watersheds in response to design storm events
- Our models predicted hydrographs for Crippens Brook and Kilkenny Stream which are reasonably close to observed discharge (Fig. 4)
- We found it necessary to adjust curve numbers based on possible AMCs, suggesting wetter initial soil conditions later in the year
- We predict variation in the percentage of rainfall which becomes runoff as a function of storm precipitation depth (Fig. 6)

Future Work

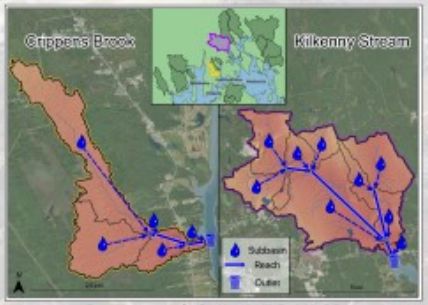
- Produce more realistic storm simulations for ungaged Frenchman Bay watersheds by creating HEC-HMS models for each
  - Use the tuned methods for estimating SCS curve number method parameters
  - Regress subbasin storage coefficient on subbasin slope and area
- Explore variability in precipitation across Frenchman Bay using PRISM data and deploying additional precipitation gages
- Assess accuracy of the National Water Model (NOAA 2016) in Frenchman Bay watersheds using observed and predicted storm discharge (see Jeremy Braun's poster presentation)
- Attach pollution concentrations to simulated hydrographs to explore pollution inflow and residence time in Frenchman Bay

Hydrologic Modeling



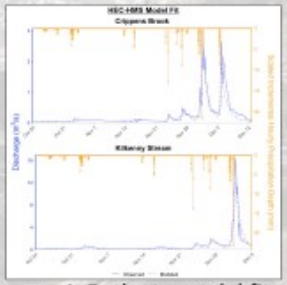
2. Acquire data

Inputs



3. Fit models in HEC-HMS

Predict



4. Evaluate model fit

Calibrate

Acknowledgements

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References available upon request from *kenen.goodwin@maine.edu*