Demystifying Hydrologic and Hydraulic Models: Flooding Studies 101

MVP Winter Webinar Series 2025

MA Executive Office of Energy and Environmental Affairs

Agenda

- MVP Program Updates
- Flood Studies, Model Types, Vocabulary and Data Needs
- Community Spotlight: Worcester
- Q&A

Other notes:

- Recording
- Please use the Q&A box for questions

Municipal Vulnerability Preparedness (MVP) Program

A state and local partnership to build resilience to climate change by building capacity to respond to climate effects at the local level and pilot innovative adaptation practice.

MVP Planning 1.0
99% participation
349 communities

MVP Planning 2.0

FY24 Pilot: **32** municipalities & **1** Tribe

Action Grant Projects
FY 18: **37**
FY 19: **36**
FY 20: **53**
FY 21: **41**
FY 22: **66**
FY 23: **73**
FY 24: **79**
FY 25: 71 ($52.4M)

Total Awards Planning & Action $180M to date

Berkshires & Hilltowns Regional Coordinator:
Emma Sass

Northeast Regional Coordinator:
Michelle Rowden

Greater Boston Regional Coordinator:
Carolyn Norkiewicz

MVP Director: Kara Runsten

MVP Deputy Director: Marissa Robertson

MVP Program Coordinator: Elder González Trejo

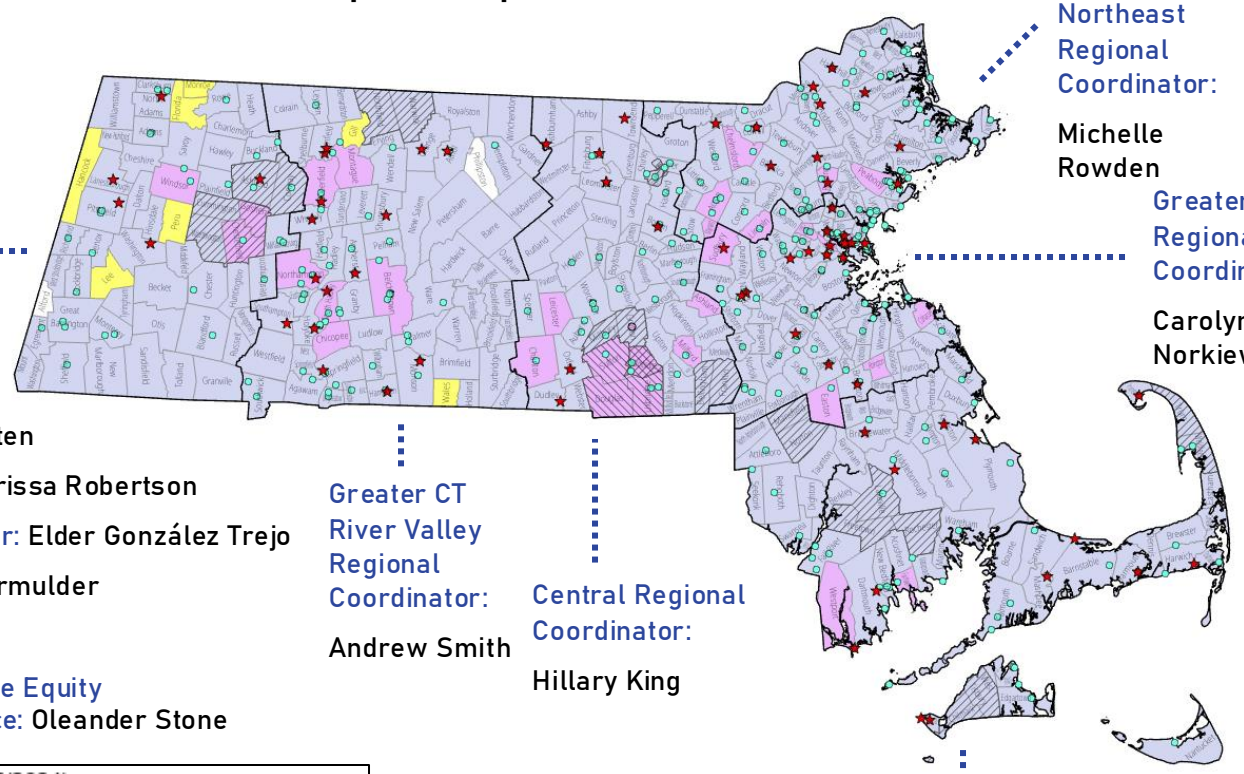
GIS Specialist: Sula Watermulder

MVP Fellow: Emily Murad

Deputy Director of Climate Equity and Environmental Justice: Oleander Stone

Greater CT River Valley Regional Coordinator:
Andrew Smith

Central Regional Coordinator:
Hillary King



Southeast Regional Coordinator:
Courtney Rocha

[Contact MVP Regional Coordinator | Mass.gov]

Program Updates

- **Apply for an MVP Action Grant**

- **EEA Climate Newsletter**
  - Stay up to date!

- **The Climate Resilience Playbook**
  - Developed in partnership with MAPC and PVPC
  - An online, interactive tool that local planners can use to identify and scope out resilience actions for their communities
  - Expected release this spring
- **MVP 2.0**
  - New awards were announced last week!
  - Significant updates to the process based on pilot round feedback including:
    - Equity Partners to assist with items like Community Liaison recruitment and inclusive engagement.
    - Updates to the Guides for Equitable and Actionable Resilience (GEAR tool)
    - And more!

Flood Studies: What is the Goal?

- **Mapping:** Where could flooding happen under different storm scenarios?
- **Plan:** How can flooding shape river or stream channels, cause erosion, etc. over time?
- **Manage:** How may different interventions reduce flooding?

What else?

Vocabulary: Physical Terms

- **Stage**: Used to describe the elevation of water in a river or stream. Can also be used categorically to describe the elevation in terms of locally significant thresholds ("flood stage", "bank full stage")
- **Velocity:** Velocity of moving water (distance traveled per time)
- **Discharge:** The volume of water passing through a flow cross-section (e.g. river, stream, pipe) per unit of time. Can also be described as "flow rate“ or “stream flow”
- **Depth:** Distance between water surface and the ground or river/stream bed below it.
- **Extent:** Area covered by flood waters.
- **Water Quality:** Describes dissolved and suspended items and substances in water; for example pathogens, sediment, and chemicals other than water.

Vocabulary: Flood Magnitude & Rarity

- **Return Period:** Quantitatively describes the rarity and severity of a flood or precipitation event by the number of years, on average, in which one storm is likely to occur. For example, a "hundred-year flood" has a one in one hundred chance of occurring (or being exceeded) in any given year.
- **Annual exceedance probability:** The chance that any given flood or storm will be equaled or exceeded in any given year. For example, a hundred-year storm has a 1% annual exceedance probability.
- **Cumulative exceedance probability:** The chance that any given flood or storm will be equaled or exceeded over a specified period of time. For example, a hundred-year storm has a 26% chance of being equaled or exceeded within 30 years.
- **Design Storm**: A storm (amount of precipitation occurring over a specific duration) with a specified return period used in a specific design context as a required or recommended performance standard. For example, stormwater drainage systems may be designed to accommodate the 10-year, 24-hour storm.
- **Design Flood:** Flood conditions with a specific return period used in a specific design context as a required or recommended performance standard. For example, hospitals may be designed so that critical equipment is located above the estimated elevation of the 500-year flood.

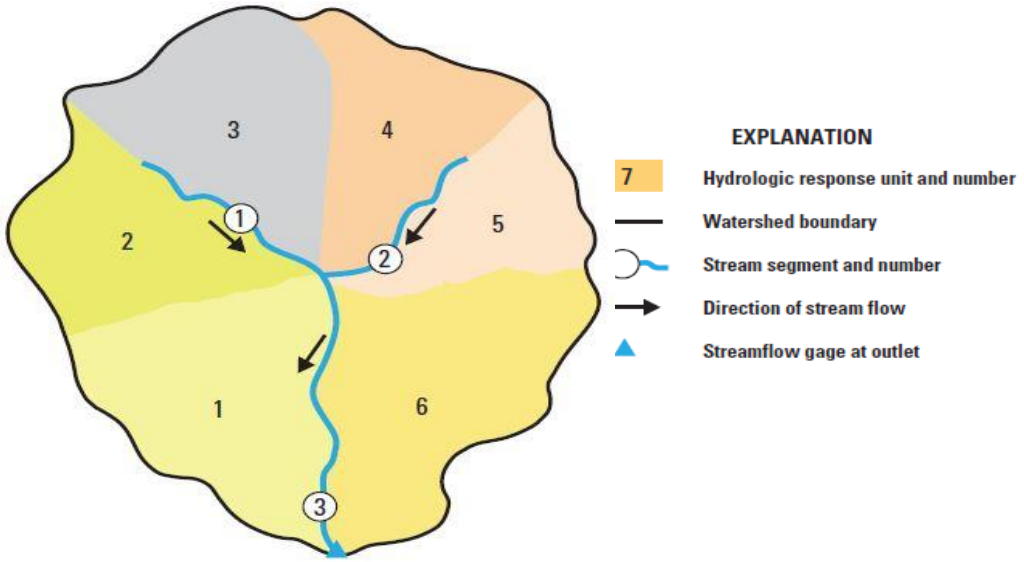
Vocabulary

Other vocabulary?

Model Types: Hydrologic Model

Understand how water moves between different parts of the hydrologic system: Precipitation, infiltration into the soil, runoff (streamflow), and evaporation and transpiration.

- Input: Precipitation, temperature, solar radiation
- Output: Stream or river discharge



How much water?
Where is it in the "buckets" of the water cycle?
How fast is it moving between "buckets"?

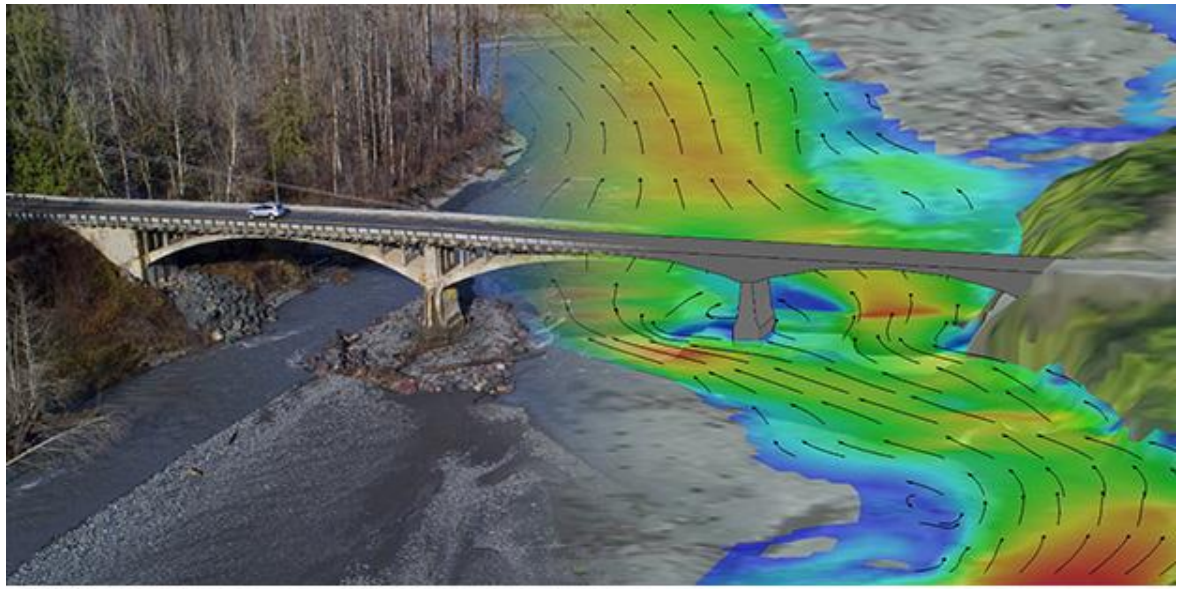
Use hydrologic model to...

- Understand river flow regime (how flow rate changes over days, months, seasons, or years...)
- Investigate influence of climate on river flows
- Quantify flood design flows
- Develop reservoir operating policies

Model Types: Hydraulic Model

Understand how water moves in space, over land, in rivers and streams, or in pipes based on physics.

- Input: Water volume, water discharge
- Output: Water location, depth, velocity, direction, elevation



Source: FHWA.

Where and how is the water moving? How does it interact with the shape of the landscape, infrastructure, etc.?

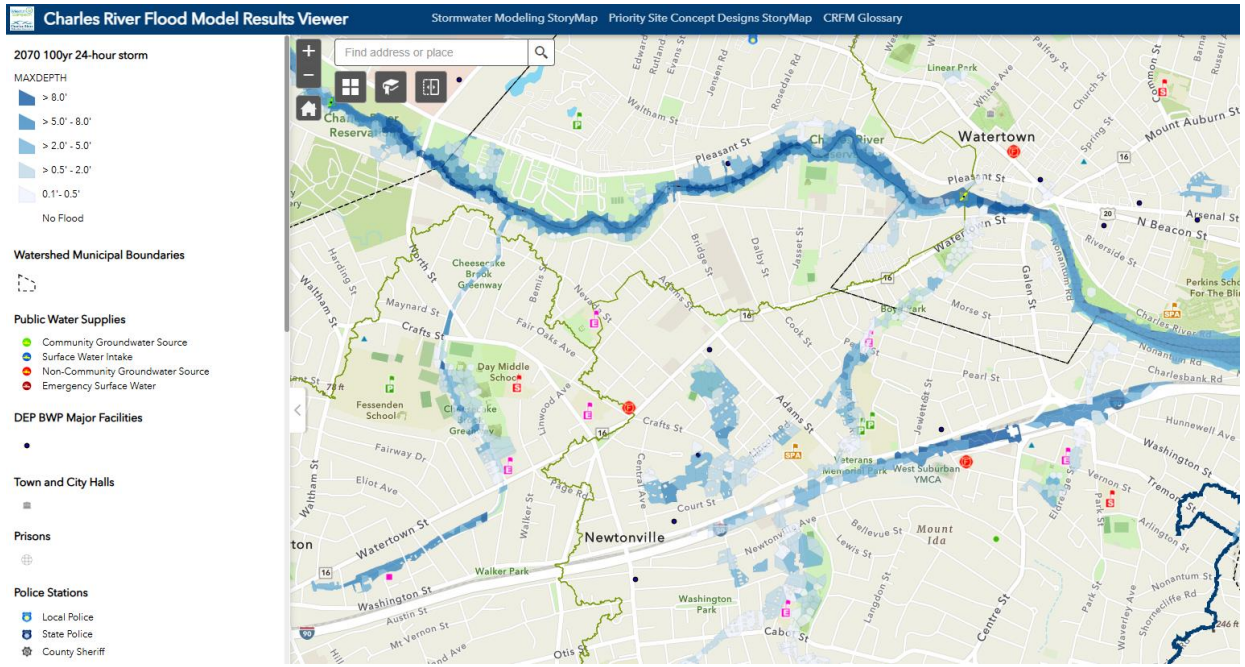
Use hydraulic model to…

- Understand relationship between river discharge and river elevation
- Map flooding
- Assess and diagnose issues with stormwater infrastructure
- Compare infrastructure alternatives
- Understand erosion and sedimentation rates
- Understand water quality issues

Model Types: H&H Model

Understand how water inputs (precipitation, incoming flow) translate to hydraulics.

- Input: Precipitation, streamflow inputs
- Output: Water location, depth, velocity, direction, elevation



Credit: Charles River Watershed Association

Where and how is the water moving? How does it interact with the shape of the landscape, infrastructure, etc.?

Use H&H model to…

- Map river flooding and/or stormwater flooding
- Assess and diagnose issues with stormwater infrastructure
- Compare infrastructure alternatives
- Understand erosion and sedimentation rates
- Understand water quality issues

Water Model Purpose

- **Hydrologic and/or Hydraulic models are used for more than just flood studies. Some examples:**
  - Study **flow regime**: How much time does a river spend at different flow rates? At what times of year? How does this affect aquatic ecosystems?
  - Study **drought**: What weather patterns could cause drought? How to manage water resources systems to ensure water supply reliability?
  - **Infrastructure design**: How to design bridge supports, etc. to minimize harmful hydraulic & erosive impacts?
  - **Water quality**: Where are contaminants coming from in the watershed? Where are they going? How to reduce contaminant load/improve water quality?

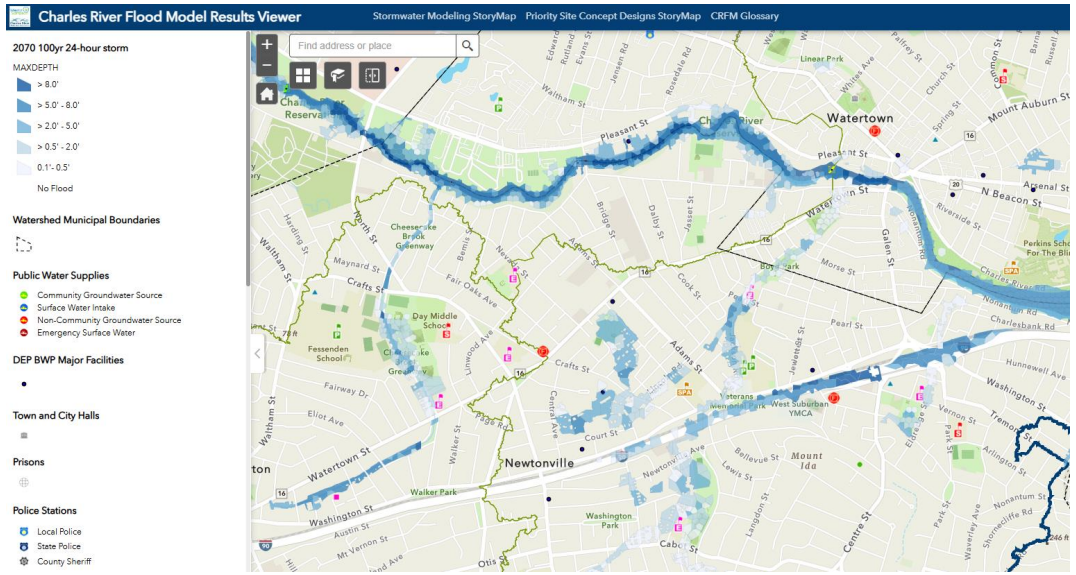
What else?

Takeaway: Not all water models are designed for flooding. Use a model designed for the purpose you have in mind.

Water Model Setup

Both images below are from hydraulic models!

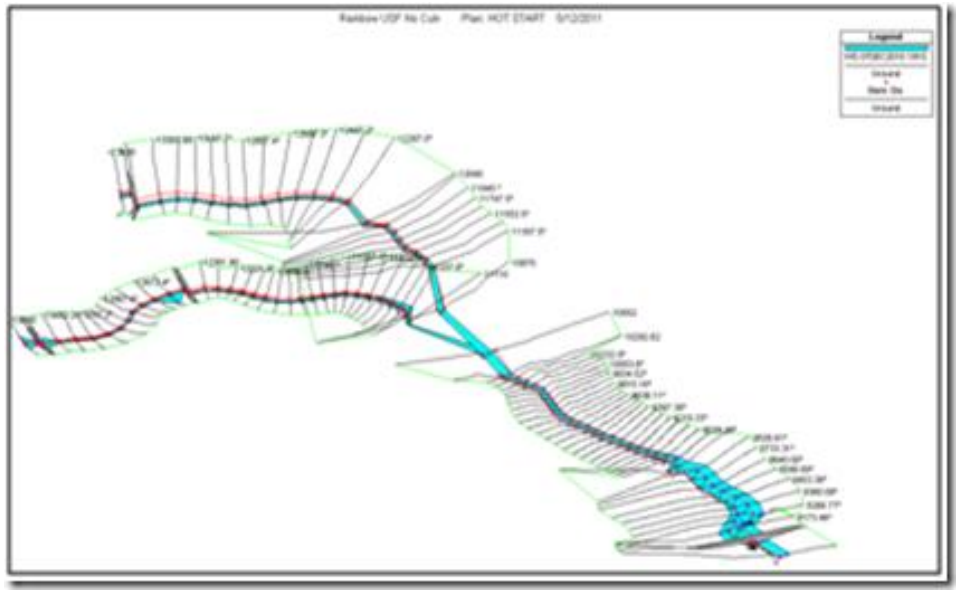
This map shows output from a hydrologic & hydraulic model covering the Charles River watershed. The model simulates the interaction between precipitation and the landscape, including stormwater infrastructure. The resulting mapped flooding includes both river flooding and stormwater flooding.



Credit: Charles River Watershed Association

The diagram below shows the cross-section setup of a hydraulic model of part of a stream network. This hydraulic model does not simulate how precipitation translates to streamflow; streamflow is an external input.

The model is focused on the hydraulics of river flooding. It cannot map stormwater flooding.



Credit: USACE

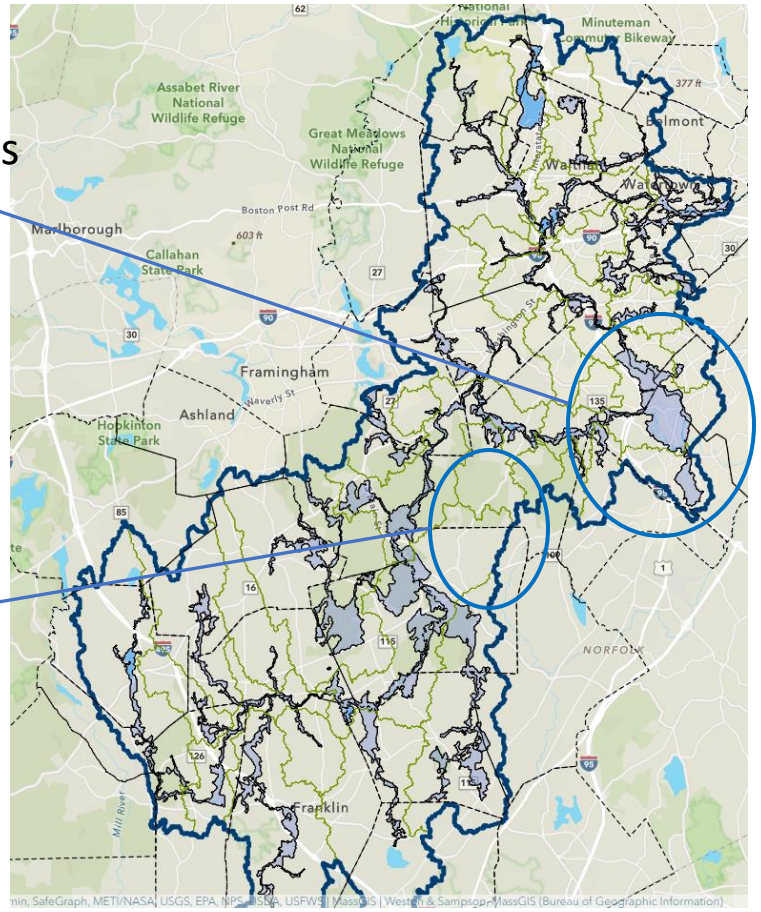
Takeaway: Not all "hydraulic models" do the same thing.
Ask what types of water movement the model includes. Does it model all the types of flooding that are important to the project?

Water Model Setup

More detailed hydraulics calculations

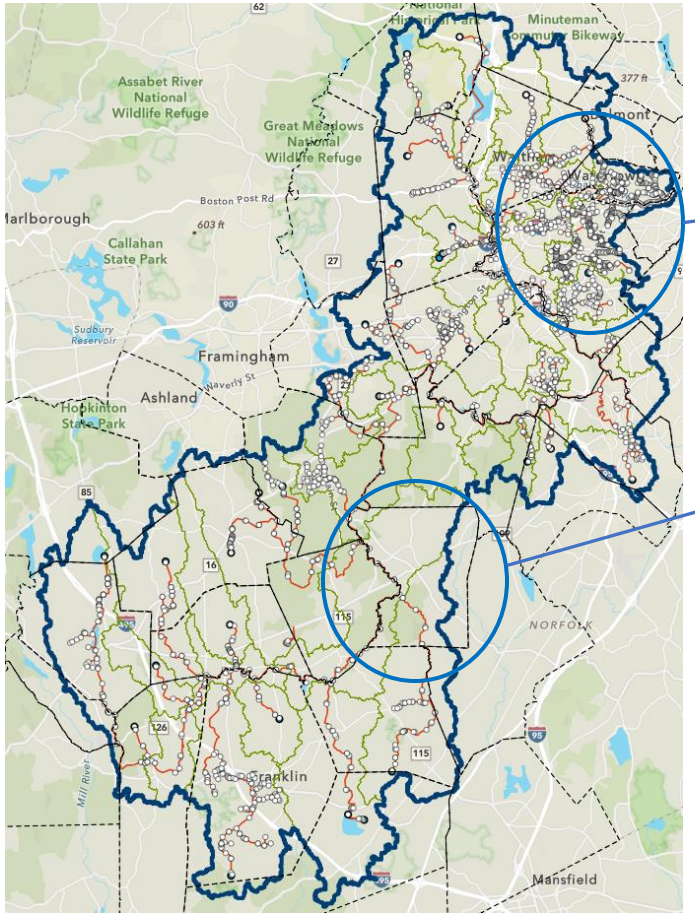
Less detailed hydraulics calculations

Charles River Flood Model:
2D Hydraulics Simulation Areas (Blue)



Credit: Charles River Watershed Association

Charles River Flood Model:
Modeled stormwater pipes (red)



More stormwater infrastructure detail

Less stormwater infrastructure detail

Takeaway: Models may represent different parts of the modeled area at different levels of detail.

Water Model Descriptors

- **Stormwater Model**
  - May refer to a hydraulic model or H&H model. Model which simulates hydraulics of water on the land surface and typically in and through stormwater infrastructure. The emphasis is typically on the land surface and stormwater infrastructure, though the hydraulics of water in stream and river channels may also be modeled. "Stormwater models" may be used with a focus on mapping flooding, identifying or comparing potential stormwater infrastructure improvements, or with diagnosing and addressing water quality issues.
- **Drainage Model:**
  - Stormwater model with explicit focus on stormwater and/or drainage infrastructure. The goal of studies conducted with "drainage models" is likely related to identifying areas for improvement in the network of stormwater infrastructure, and/or comparing alternative stormwater infrastructure designs. "Drainage models" may or may not be well set up to map flooding on the land surface.
- **Watershed Model:**
  - May be used to describe models with various forms and purposes. Sometimes used to describe hydrologic models with a water quality focus, flood focus, flow regime focus, or other water resources purpose. May also describe an integrated hydrologic/hydraulic model with a flood focus which covers an entire watershed.
- **Rainfall/Runoff Model:**
  - May refer to either a hydrologic model or a hydrologic & hydraulic model.

Takeaway: Make sure you are on the same page as a potential vendor on how the model works and what you need it for.

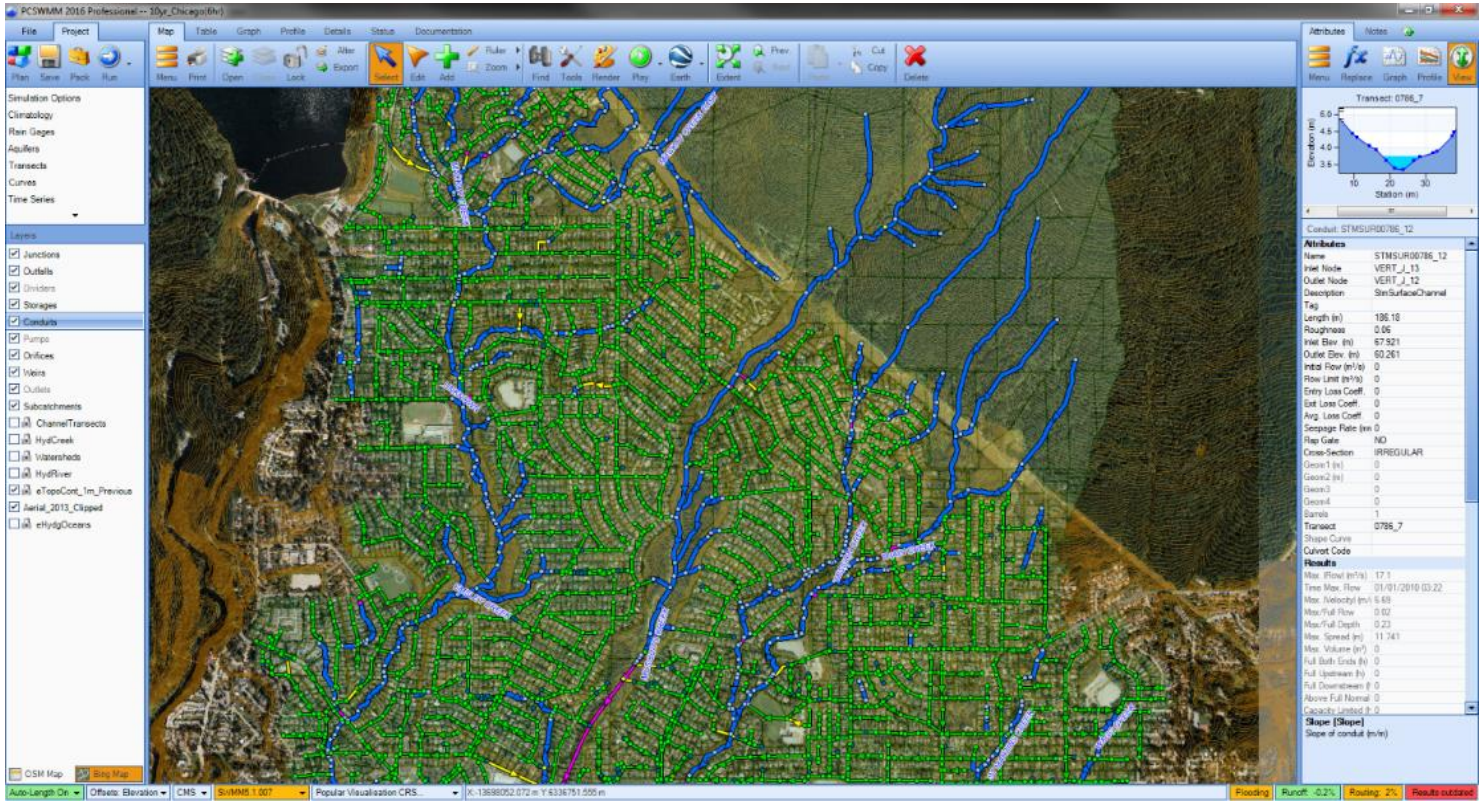
Data Needs

Typically publicly available:

- Elevation data
- Soil properties data
- Hydrography data
- Land cover data
- Streamflow data at gages

May require work to develop:

- Detailed elevation data
- Detailed soils data
- Bathymetry data (shape of river/stream channel)
- Past flood locations
- Stormwater infrastructure data



Credit: Computational Hydraulics, Inc. (CHI); City of Vancouver

Takeaway: Depending on the purpose, some flood models may require a high level of data development to properly configure. This may entail field work, record drawings review, and/or other methods.

Takeaways

- Not all water models are designed for flooding.
- Not all flood studies have the same goals.
- Flood models can incorporate different processes. For example, some may model stormwater and riverine flooding, while others may model only riverine flooding.
- Flood models may represent some parts of the modeled area in more detail than others
- Some level of field data collection or background research may be necessary to develop the data needed for a flood model
- Some terms related to flood modelling don't have a precise definition and may be used to mean different things by different people.

What you can do:

- Ask what the model is designed for. Is it designed with a focus on flooding?
- Be clear about what you want to learn from the flood study and what products you need
- Identify the type(s) of flooding that are important to model. Ask how the model will simulate those types of flooding.
- Identify which areas are of most interest
- Ask what data is needed to set up a model that meets project needs

Office of Climate Science Updates

Climate Resilience Design Standards & Guidance

RMAT's Climate Resilience Design Standards (CRDS) Tool **HAS BEEN UPDATED**!

- ***NEW*** Heat metrics now provided
- ***NEW*** Coastal flood maps--wave action water elevation

Technical Assistance **Office Hour Sessions** are available!

3rd Tuesday of the month @ **10-10:30 am** and **10:30-11 am**
ALSO **2nd and 4th Wednesdays** of March @ **10-10:30 am** and **10:30-11 am**

Sign up on:
https://outlook.office365.com/book/MAOfficeofClimateSciencesOfficeHour@massgov.onmicrosoft.com/

Need a different date/time? Email us at climatescience@mass.gov

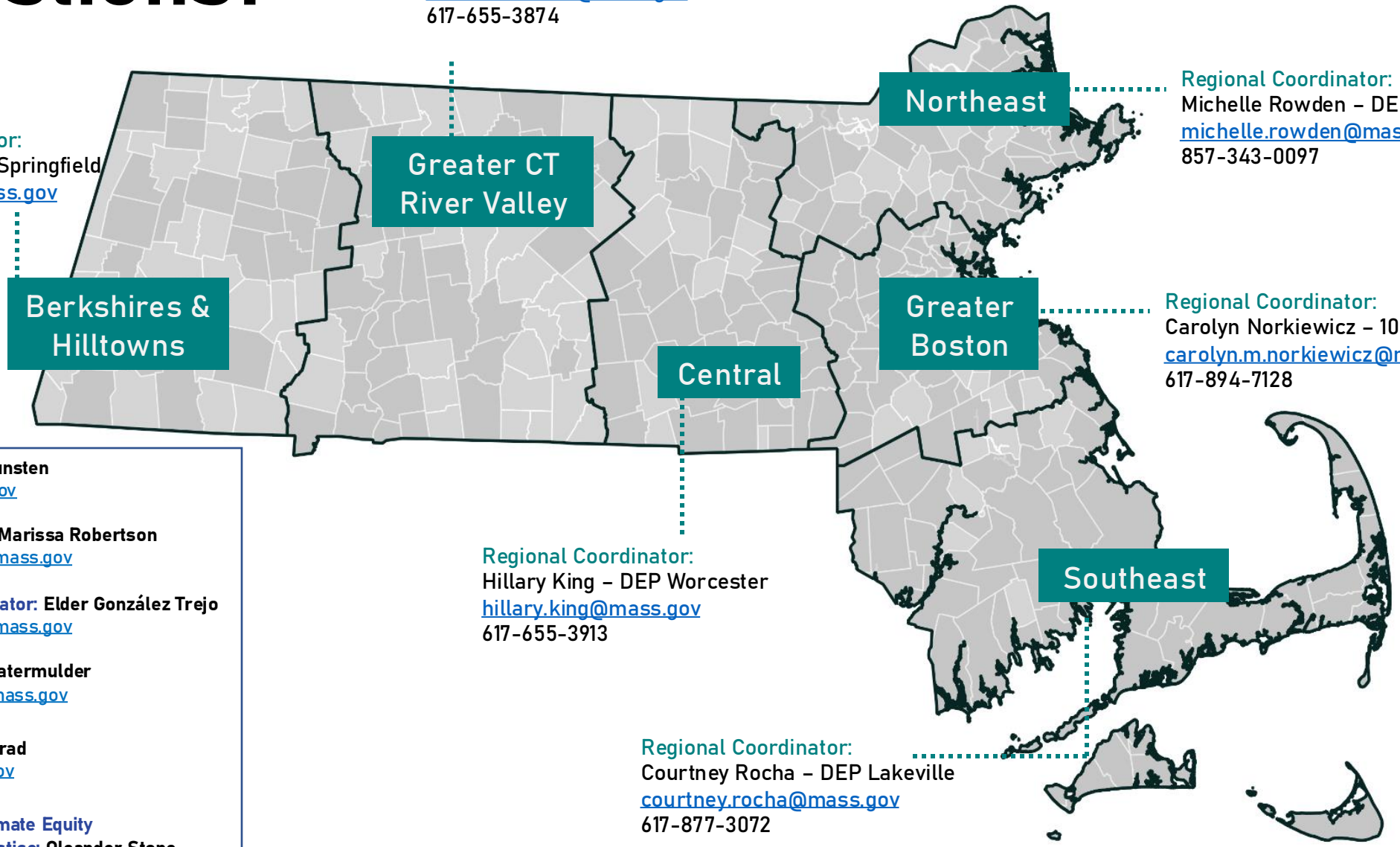
More Resources: Guide & Tips on How to Effectively Use ResilientMass Climate Data/Tools

Check out: https://www.youtube.com/watch?v=EnSRGhVpQ3E

Questions?

Regional Coordinator:
Andrew Smith – DEP Springfield
andrew.b.smith@mass.gov
617-655-3874

Regional Coordinator:
Emma Sass - DEP Springfield
emma.m.sass@mass.gov



Regional Coordinator:
Michelle Rowden – DEP Lawrence
michelle.rowden@mass.gov
857-343-0097

Regional Coordinator:
Carolyn Norkiewicz – 100 Cambridge St.
carolyn.m.norkiewicz@mass.gov
617-894-7128

Regional Coordinator:
Hillary King – DEP Worcester
hillary.king@mass.gov
617-655-3913

Regional Coordinator:
Courtney Rocha – DEP Lakeville
courtney.rocha@mass.gov
617-877-3072

MVP Director: Kara Runsten
kara.runsten@mass.gov

MVP Deputy Director: Marissa Robertson
Marissa.robertson2@mass.gov

MVP Program Coordinator: Elder González Trejo
elder.gonzaleztrejo@mass.gov

GIS Specialist: Sula Watermulder
sula.watermulder2@mass.gov

MVP Fellow: Emily Murad
emily.murad@mass.gov

Deputy Director of Climate Equity and Environmental Justice: Oleander Stone
oleander.stone@mass.gov

Find your region by municipality: https://www.mass.gov/service-details/contact-mvp-regional-coordinator