Incorporating Climate Change into Flood Risk Mapping in the Housatonic River Watershed

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Today’s Discussion

Future Flood Risk Project: Motivation

Current flood risk mapping practices and limitations

Future Flood Risk Project: Future Streamflows

How future streamflows are determined and results

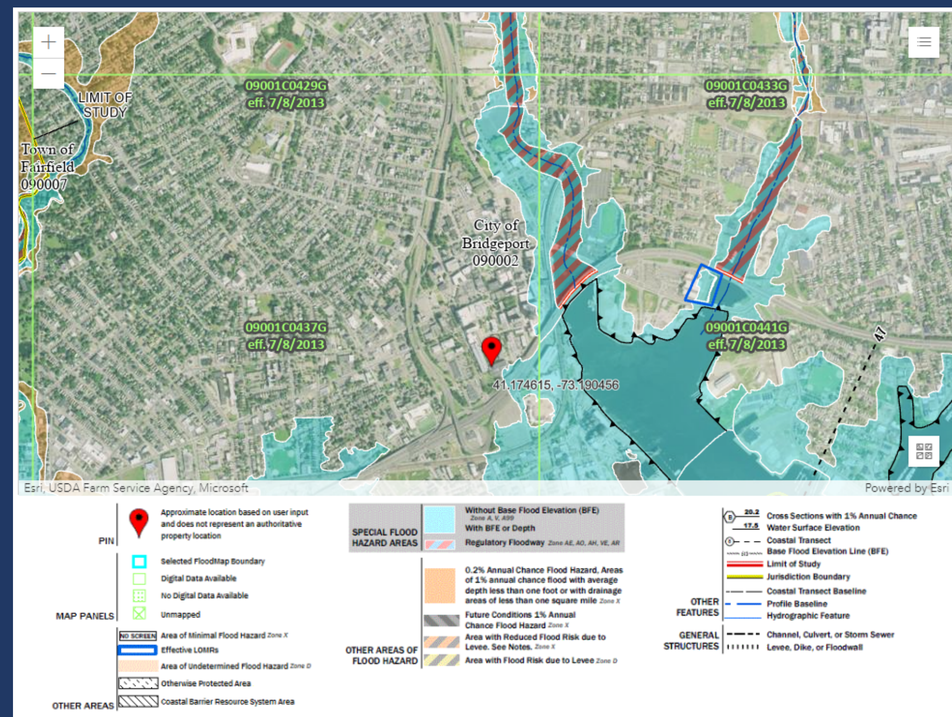
Future Flood Risk Project: Floodplain Mapping

Going from streamflows to floodplains and displaying floodplains in interactive web application (in development)

Current Flood Risk Mapping

100-year Floodplain Flood Zones:

- Zone AE (new): recently surveyed with new hydrology and hydraulics in HEC-RAS
- Zone AE (re-delineated): Base Flood Elevations derived from the effective Flood Insurance Study
- Zone A: Hydrologic modeling using USGS regression equations, weighted by streamgage statistics where applicable, with simplified (without structures or surveyed channels) one-dimensional, steady-flow, step-backwater hydraulic modeling of stream reaches using HEC-RAS
- Based on historical streamflow data
- Assumes stationarity



National Flood Hazard Layer (NFHL) displaying the effective flood hazard information in the vicinity of Housatonic Community College, Bridgeport, CT. (https://msc.fema.gov/portal/search?AddressQuery=bridgeport%2C%20ct)

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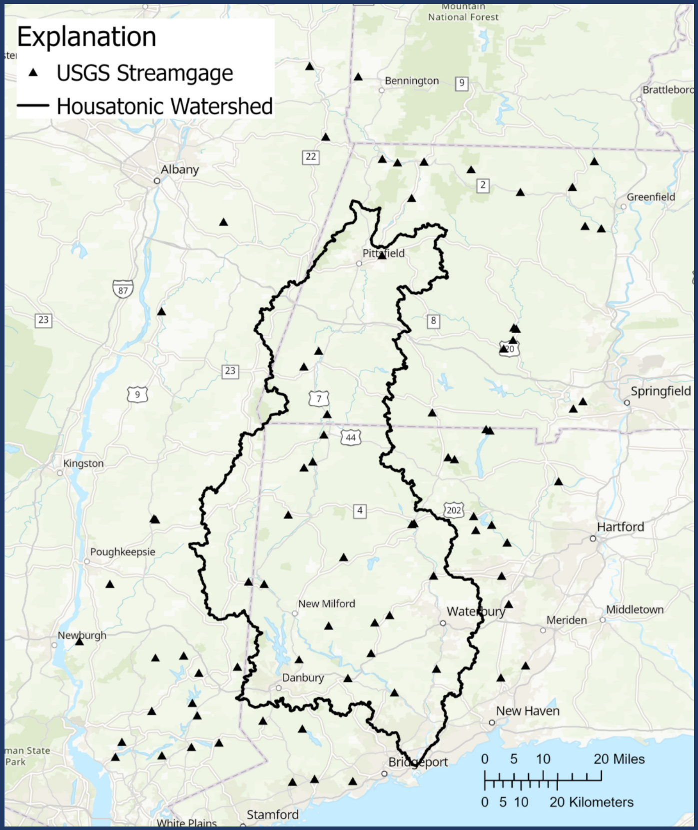
Future Flood Risk Project

Project Overview

- Pilot project in Housatonic River watershed
- Assess how streamflow might change with anticipated changes in temperature and precipitation (RCP 8.5 emissions scenario)
- Use future flood flows to predict future floodplains
- Methods:
    - Extract Precipitation-Runoff Modeling System (PRMS) from the Nation Hydrologic Model (NHM)
    - Scale precipitation and temperature inputs for 2030, 2050, and 2100
    - Use model output to characterize changes in peak flow hydrology
    - Use future flood flows to generate future floodplains
    - Compare baseline conditions to changes in streamflow and floodplain extent associated with climate change



The Housatonic River watershed and 78 streamgages used in this study span CT, MA, NY, VT.

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Future Flood Risk Project

Project Overview

https://cms.usgs.gov/centers/new-england-water-science-center/science/characterizing-future-flood-flows-flood-insurance

Characterizing Future Flood Flow ×

https://cms.usgs.gov/centers/new-england-water-science-center/science/characterizing-future-flood-flows-flood-insurance

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Characterizing Future Flood Flows for Flood Insurance Studies

ACTIVE

By New England Water Science Center September 21, 2022

Overview Science Data Publications Partners

Current methods of flood-frequency analyses for flood insurance studies assume that the statistical distribution of data from past observations will continue unchanged in the future. This is known as the assumption of stationarity. This assumption allows scientists to estimate flood magnitude and frequency based on past records and the expectation that those estimates will represent current and future conditions. However, observed trends of increases in rainfall intensity and changes in seasonal snowmelt hydrology in the northeastern United States suggest that peak-flow stationarity may no longer be an appropriate assumption. To improve the information and mapping available for decision-making throughout New England in the face of a changing climate, the U.S. Geological Survey (USGS) is developing a series of potential flood map scenarios in a pilot watershed in New England for the years 2030, 2050 and 2100.

The National Hydrologic Model (NHM) is a deterministic hydrologic model for the conterminous United States and draws on topography, land cover, soils, geology, and hydrography parameters derived from a Geographic Information System (GIS). This investigation employed a Precipitation-Runoff Modeling System (PRMS) model extracted from the

Study Area

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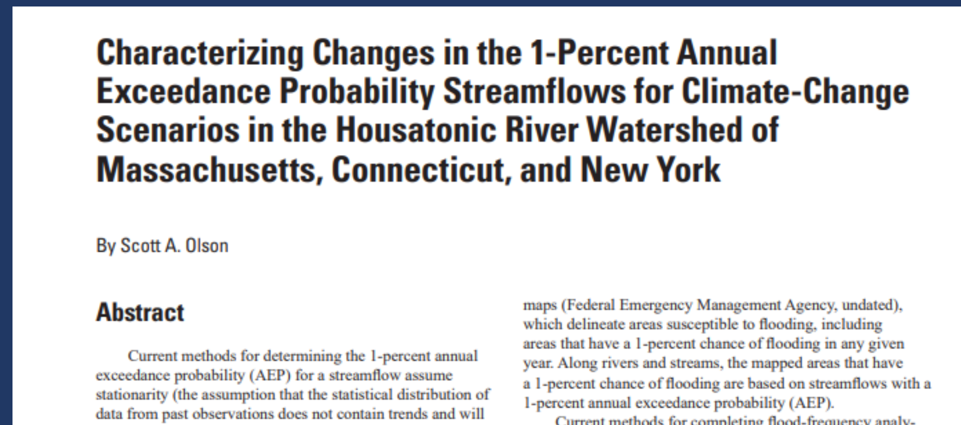
Future Flood Risk Project

Project Overview

https://cms.usgs.gov/publications/characterizing-changes-1-percent-annual-exceedance-probability-streamflows-climate



Characterizing Changes in the 1-Percent Annual Exceedance Probability Streamflows for Climate-Change Scenarios in the Housatonic River Watershed of Massachusetts, Connecticut, and New York

By Scott A. Olson

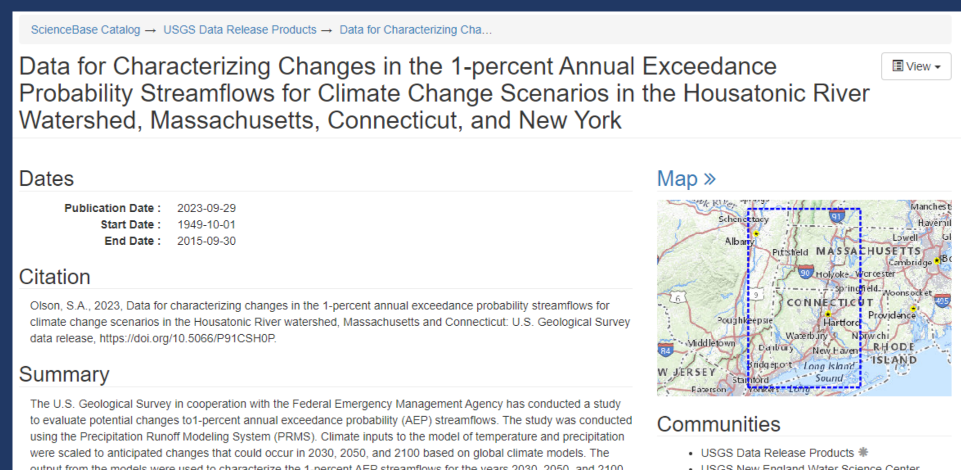
Abstract

Current methods for determining the 1-percent annual exceedance probability (AEP) for a streamflow assume stationarity (the assumption that the statistical distribution of data from past observations does not contain trends and will

maps (Federal Emergency Management Agency, undated), which delineate areas susceptible to flooding, including areas that have a 1-percent chance of flooding in any given year. Along rivers and streams, the mapped areas that have a 1-percent chance of flooding are based on streamflows with a 1-percent annual exceedance probability (AEP).

Current methods for completing flood-frequency analy-

https://www.sciencebase.gov/catalog/item/63dc12acd34e9fa19a98a183



ScienceBase Catalog → USGS Data Release Products → Data for Characterizing Cha...

Data for Characterizing Changes in the 1-percent Annual Exceedance Probability Streamflows for Climate Change Scenarios in the Housatonic River Watershed, Massachusetts, Connecticut, and New York

View

Dates

Publication Date : 2023-09-29
Start Date : 1949-10-01
End Date : 2015-09-30

Citation

Olson, S.A., 2023, Data for characterizing changes in the 1-percent annual exceedance probability streamflows for climate change scenarios in the Housatonic River watershed, Massachusetts and Connecticut: U.S. Geological Survey data release, https://doi.org/10.5066/P91CSH0P.

Summary

The U.S. Geological Survey in cooperation with the Federal Emergency Management Agency has conducted a study to evaluate potential changes to1-percent annual exceedance probability (AEP) streamflows. The study was conducted using the Precipitation Runoff Modeling System (PRMS). Climate inputs to the model of temperature and precipitation were scaled to anticipated changes that could occur in 2030, 2050, and 2100 based on global climate models. The output from the models were used to characterize the 1-percent AEP streamflows for the years 2030, 2050, and 2100

Map »

Communities

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- USGS New England Water Science Center

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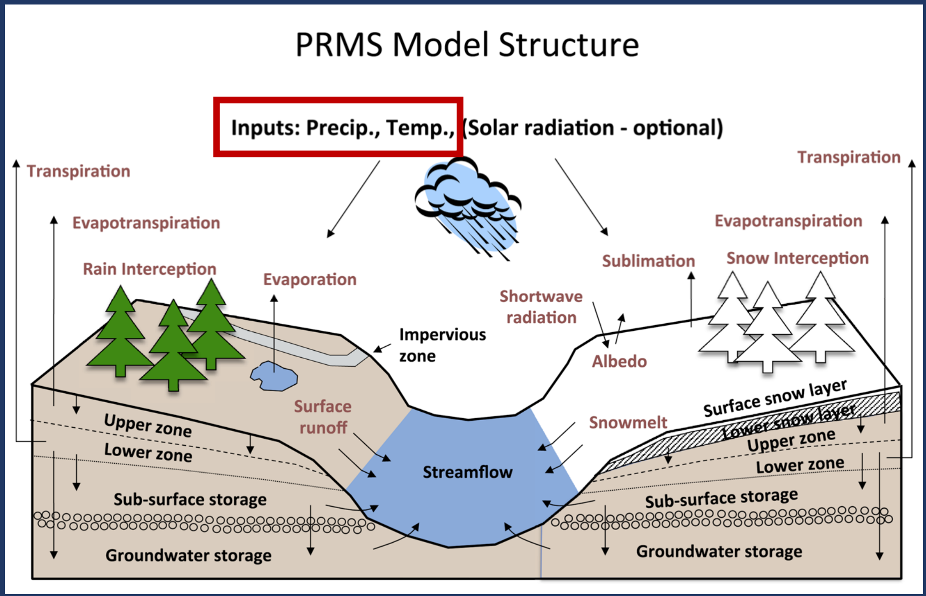
Future Flows

- Characterize 1 % annual-exceedance probability (AEP) flood flows for years 2030, 2050, and 2100
- Simulate streamflows using PRMS
- Inputs of temperature and precipitation are scaled using estimates from General Circulation Models
- Baseline conditions compared to changes associated with climate change to develop scalar for years 2030, 2050, and 2100

Olson, S.A., 2023, Characterizing changes in the 1-percent annual exceedance probability streamflows for climate-change scenarios in the Housatonic River watershed of Massachusetts, Connecticut, and New York: U.S. Geological Survey Scientific Investigations Report 2023–5090, 16 p., https://doi.org/10.3133/sir20235090



Visual representation of the process used in PRMS (https://pubs.usgs.gov/of/2012/1274/methods.html).

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Future Flows

Table 3. Temperature and precipitation adjustments applied to the climate datasets input to the Precipitation Runoff Modeling System models for the Housatonic River and surrounding watersheds in Massachusetts, Connecticut, and New York.

[Data are from Olson (2023). The Precipitation Runoff Modeling System is from Leavesley and others (1983)]

Adjusted parameter	Adjustment applied to climate dataset		
	2030	2050	2100
Temperature increase, in degrees Fahrenheit	2.8	4.9	10.2
Precipitation increase, in percent	5.04	7.74	12.05

Table 4. Percentage change in the 1-percent annual exceedance probability computed using the annual instantaneous peak streamflows based on changes in precipitation and temperature at streamgages with unregulated and regulated streamflows in Massachusetts, Connecticut, and New York.

[Data are from Olson (2023). %, percent; °F, degree Fahrenheit]

Temperature change	Precipitation change			
	0%	5.04%	7.74%	12.05%
Streamgages with unregulated streamflow				
0 °F	0.0	8.8	13.3	20.7
2.8 °F	−1.5	7.4	11.9	19.5
4.9 °F	−1.6	7.0	11.7	19.2
10.2 °F	−3.1	5.3	9.9	17.3
Streamgages with regulated streamflow				
0 °F	0.0	9.1	13.7	21.3
2.8 °F	−1.7	7.0	11.5	18.8
4.9 °F	−2.0	7.0	11.7	18.9
10.2 °F	−3.1	5.5	10.3	17.8

Table 5. Percentage changes in the 1-percent annual exceedance probability streamflows for 2030, 2050, and 2100 computed using the annual instantaneous peak streamflows in Massachusetts, Connecticut, and New York.

Parameter	Scenario		
	2030	2050	2100
Unregulated streamflow	7.4	11.7	17.3
Regulated streamflow	7.0	11.7	17.8

Olson, S.A., 2023, Characterizing changes in the 1-percent annual exceedance probability streamflows for climate-change scenarios in the Housatonic River watershed of Massachusetts, Connecticut, and New York: U.S. Geological Survey Scientific Investigations Report 2023–5090, 16 p., https://doi.org/10.3133/sir20235090

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Future Flows to Generate Future Floodplains

Table 5. Percentage changes in the 1-percent annual exceedance probability streamflows for 2030, 2050, and 2100 computed using the annual instantaneous peak streamflows in Massachusetts, Connecticut, and New York.

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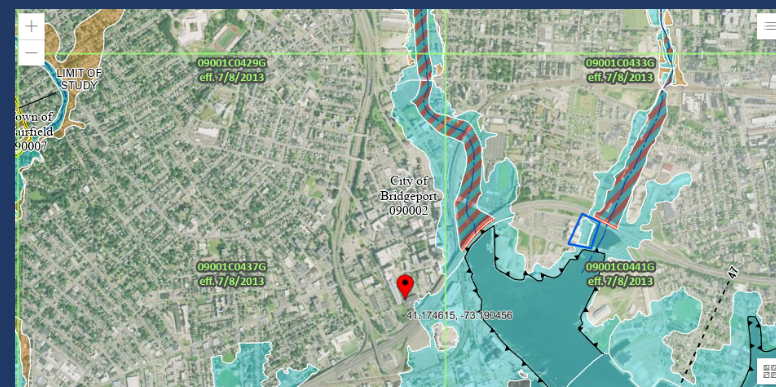
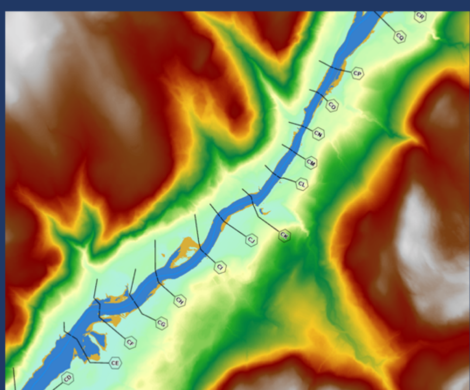


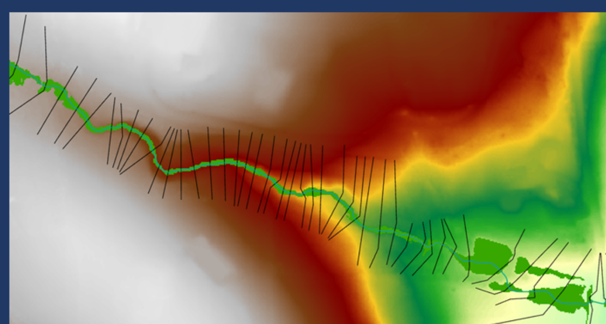
Non-regulatory product similar to NFHL map above

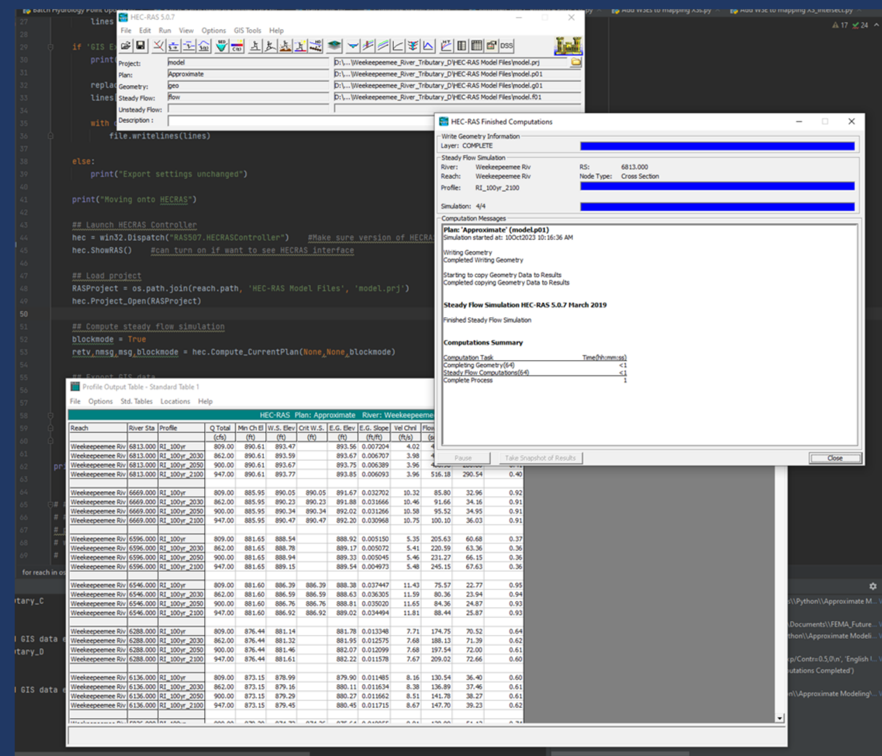
Future Flood Risk Project

Generate Future Floodplains

- Generate future 100-year floodplains using anticipated future streamflows
- Method varies by model
  - New Zone AE and Zone A models:
    - Take advantage of existing HEC-RAS models
    - Use percent change scalar to determine future streamflows and run in HEC-RAS to produce future water-surface elevations







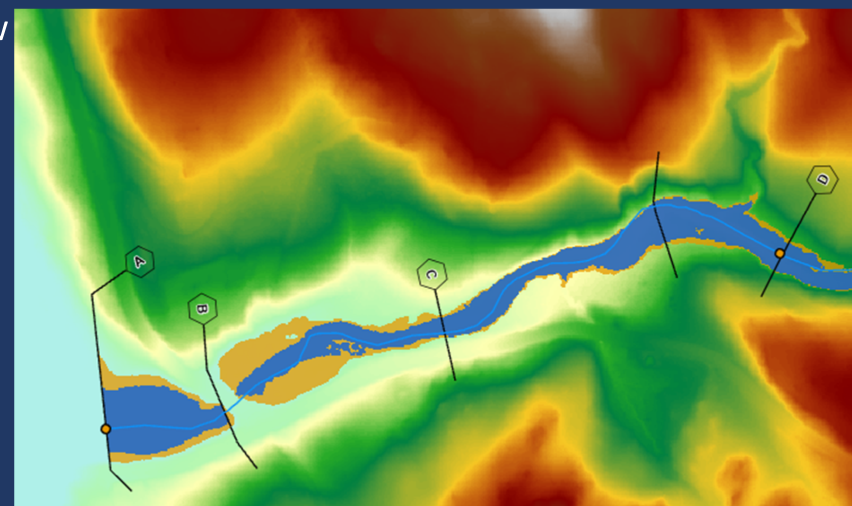
Future Flood Risk Project

Generate Future Floodplains

- Generate future 100-year floodplains using anticipated future streamflows
- Method varies by model
  - Redelineated Zone AE:
    - HEC-RAS model not available
    - Knowns: present water-surface elevations and flow values from Flood Insurance Study report
    - Utilize relationship between present streamflow and water-surface elevation, and future streamflow determined from scalar

TABLE 1: SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA SQ MILES	PEAK DISCHARGES (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
CLAPBOARD OAK BROOK					
Mouth at Lake Lillinonah	2.4	330	690	920	1,725
1,900 Feet Upstream of Mouth	2.0	320	670	895	1,675
8,340 Feet Upstream of Mouth	0.8	275	355	395	505
Upstream Study Limit	0.4	160	210	235	295



$$future\ WSE = \left(\frac{\left(\frac{\log(500yr\ Q)}{\log(future\ Q)} \right)}{\log(500yr\ Q) - \log(100yr\ Q)} \right) * (500yr\ WSE - 100yr\ WSE) + 500yr\ WSE$$

where, $future\ Q = 100yr\ Q * scalar + 100yr\ Q$

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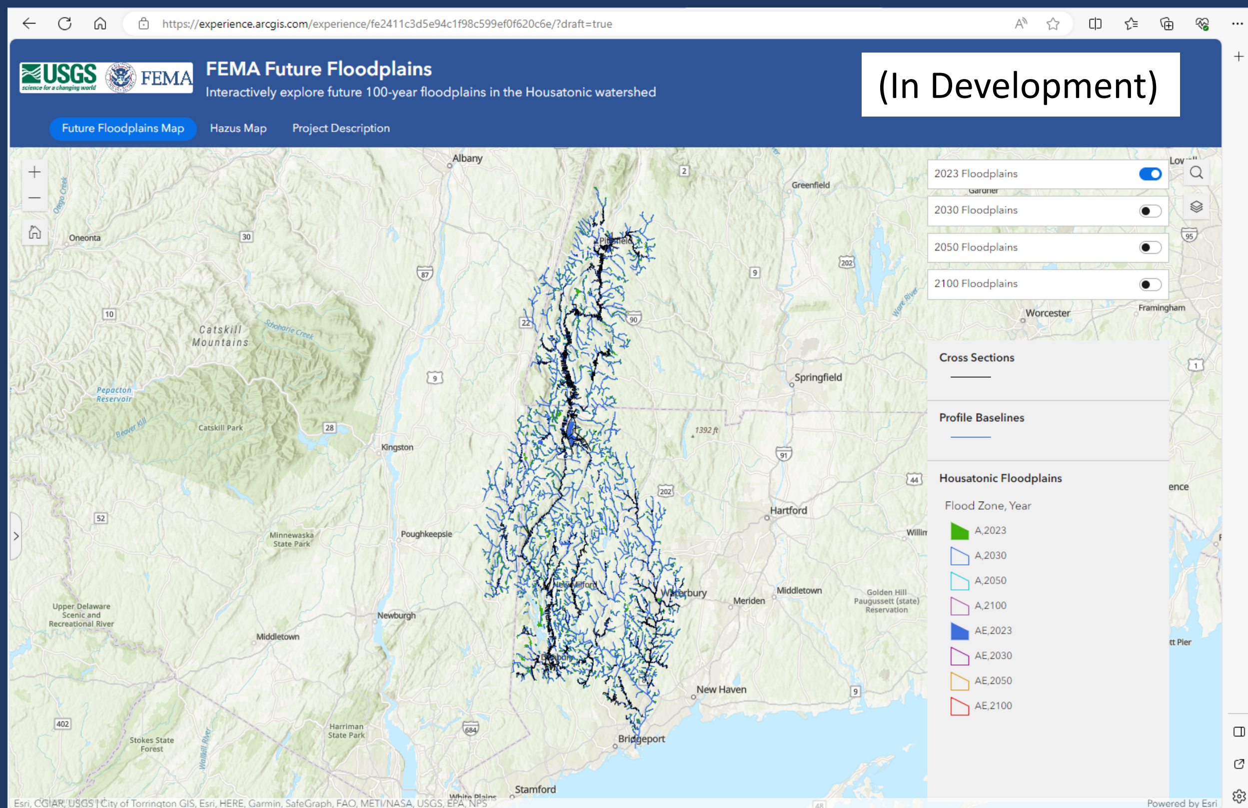
Future Floodplains Data Viewer



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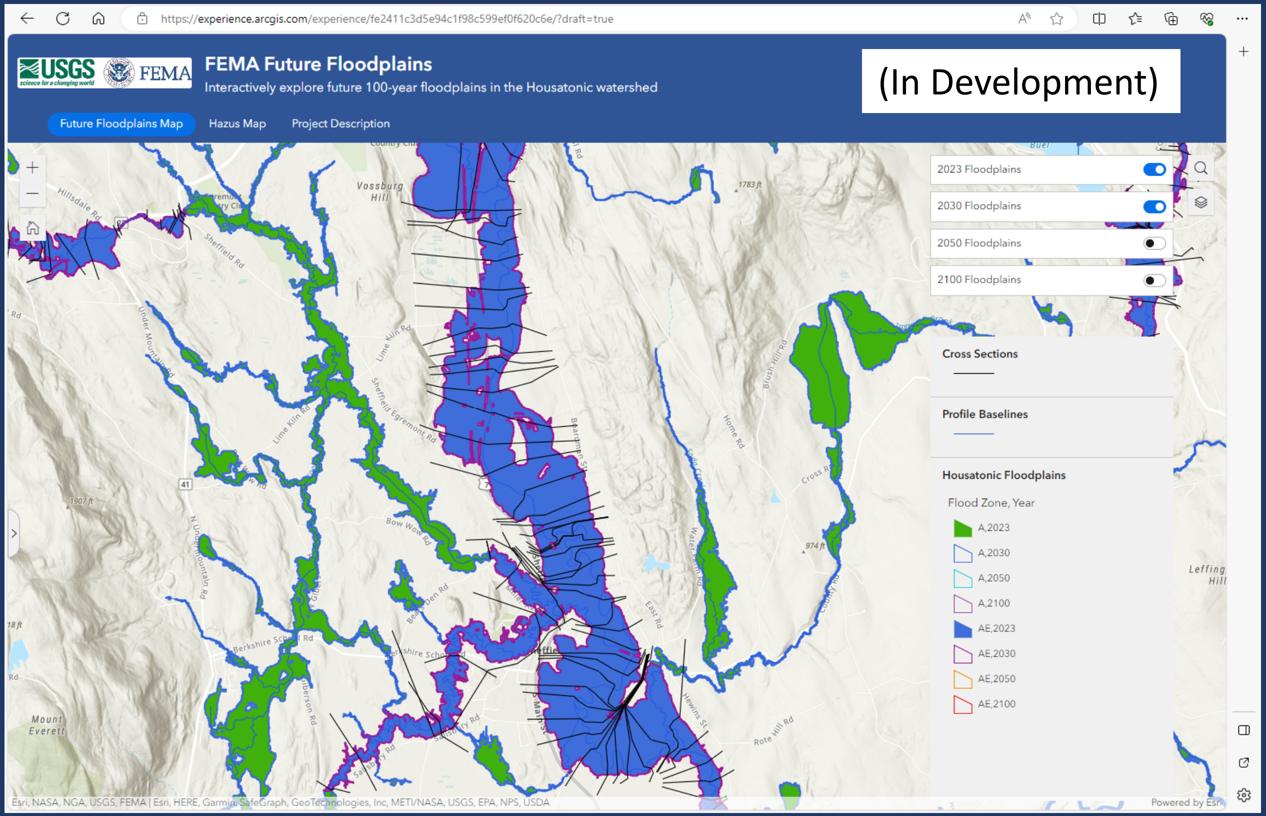
Future Floodplains Data Viewer



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Future Products

Anticipated Fall/Winter 2024 (with preliminary flood risk mapping products)

- Online web application to communicate expected difference in floodplain extent
- Scientific Investigations Report discussing how the future floodplains were generated
- Data Release to support Scientific Investigations Report and web application

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Acknowledgements

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Contact Information

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Housatonic River at Falls Village, CT USGS gage during normal flows on March 30, 2017 (top image) and high flows following Hurricane Irene on August 29, 2011 (bottom image).