

Municipal exposure to sea-level-rise inundation in Connecticut: a reproducible screening analysis of NOAA inundation-extent data and its sensitivity to methodological choices

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Abstract

Municipal tabulations of sea-level-rise exposure are widely used in coastal planning, but they are sensitive to processing choices that are rarely reported. We tabulated NOAA Office for Coastal Management ocean-connected inundation-extent rasters for Connecticut (0.5–10 ft above mean higher high water, MHHW; ~3 m resolution from 2023 statewide lidar) for all 169 municipalities, using 2020 Census boundaries, exact ellipsoidal cell areas and the present-day MHHW extent as a baseline mask. Newly inundated area is 34.7 km² at 1 ft, 51.3 km² at 2 ft, 68.5 km² at 3 ft and 133.3 km² at 6 ft, affecting 45 to 52 municipalities. About 70–75% of this area lies in the 24 Long Island Sound shoreline municipalities, and Old Saybrook is the most exposed in proportion to its land area (9.8% at 1 ft; 18.7% at 6 ft). Land cover shows that most newly inundated area at 1–2 ft is existing tidal marsh (developed land is 3–6%), whereas developed land reaches 27% at 6 ft. Exposure also extends up the tidal Connecticut River beyond the statutory coastal area, a signal that depends on NOAA’s inland extrapolation of the tidal surface. Municipal rankings are conditional on scenario and metric: between 1 and 6 ft, Spearman’s ρ is 0.74 for absolute area and 0.69 for share of land, and only 6 and 4 of the respective top-ten municipalities are shared. Omitting the MHHW baseline mask overstates exposure 4.6–14.7-fold, whereas generalized boundaries and aggregation to ≈ 81 m change statewide totals by less than 10% and leave rankings nearly unchanged. Low-increment estimates are sensitive to small vertical offsets (–40% to +27% at 1 ft for ± 0.5 ft). A coordinate-based heuristic in an earlier dashboard by the author correlated weakly with these estimates ($\rho = 0.45$ – 0.49) and should not be used. The results are screening-level estimates of potential permanent high-tide inundation, without independent validation, and are released with a fully reproducible workflow.

Keywords: sea-level rise; coastal inundation; land cover; bathtub model; NOAA Sea Level Rise Viewer; municipal exposure; Connecticut; Long Island Sound; reproducibility; sensitivity analysis

1 Introduction

Relative sea-level rise is expected to expand the area of coastal land reached by ordinary high tides along the Connecticut shoreline of Long Island Sound. Public Act 18-82 amended Connecticut General Statutes §25-68o(b) so that sea-level change scenarios prepared by the University of Connecticut’s Marine Sciences Division are published by the Department of Energy and Environmental Protection (DEEP) and used in municipal and state planning (State of Connecticut, 2018, 2025b). The scenario posted by DEEP, based on the assessment by the Connecticut Institute for Resilience and Climate Adaptation (CIRCA), is sea level 0.5 m (1 ft 8 in) higher than the national tidal datum in Long Island Sound by 2050 (Connecticut Department of Energy and Environmental Protection, 2026; O’Donnell, 2018). National scenarios for the end of the century span a considerably wider range (Sweet et al., 2022). Translating such water-level increments into land area requires elevation data, a representation of the present tidal surface, and rules for deciding which low ground is hydraulically reachable from the sea.

Static “bathtub” and modified-bathtub approaches have been the standard first step for this translation for more than two decades. They identify cells of a digital elevation model (DEM) lying below a specified water surface and, in the modified form, retain only cells hydrologically connected to the ocean (Titus and Richman, 2001; Poulter and Halpin, 2008; Strauss et al., 2012; Cooper et al., 2013). Their appeal is transparency and low data demand. Their known weaknesses are equally well documented. They ignore flow dynamics, drainage infrastructure and defenses, and tend to overpredict extent relative to hydrodynamic models for episodic events (Gallien et al., 2014; Seenath et al., 2016). They omit groundwater emergence and erosion (Anderson et al., 2018). Their reliability is bounded by the vertical accuracy of the DEM and of the tidal-datum transformation (Gesch, 2009, 2018; Leon et al., 2014). Results are also sensitive to horizontal resolution and to how connectivity is modelled (Poulter and Halpin, 2008). These methods are therefore appropriate for screening and prioritization, not for site-specific prediction.

The NOAA Office for Coastal Management (OCM) Sea Level Rise Viewer applies a modified bathtub method nationally. It combines lidar-derived DEMs with a VDatum-based mean higher high water (MHHW) surface, so that inundation is mapped relative to local high tide rather than to a fixed orthometric datum (NOAA Office for Coastal Management, 2017). For Connecticut, OCM distributes binary “extent” rasters of ocean-connected inundation at 0.5-ft increments from 0 to 10 ft above MHHW. The current release is derived from a ~3 m DEM built from 2023 statewide lidar (NOAA Office for Coastal Management, 2026b,a). These products are widely viewed through the online viewer. However, the viewer does not report how much land each municipality would lose to permanent high-tide inundation at a given increment. Earlier Connecticut assessments either covered a subset of municipalities at parcel scale (Andreucci and Aktaş, 2017) or reported statewide aggregates. Municipal tabulations are what local planning, hazard-mitigation and resilience programs most often require, and they invite simple rankings of “most exposed” towns.

Such tabulations are easy to produce incorrectly. This study grew out of the audit of an earlier dashboard by the author (Mestry, 2026), which displayed a town-level “flood percent” for 1-, 3- and 6-ft scenarios. On inspection, the displayed values were not derived from the inundation rasters at all. They were a function of each town’s centroid coordinates plus a manual adjustment for a hand-picked list of coastal towns. Even when the rasters are used, two further shortcuts are tempting: counting the full mapped extent (which includes water

and intertidal land already below MHHW) as “flooded,” and intersecting the 3 m rasters with generalized boundaries.

The objective of this study is therefore deliberately modest. We do not propose a new inundation method. Instead, we (i) produce a reproducible tabulation of NOAA’s ocean-connected inundation extent, net of present MHHW, for all 169 Connecticut municipalities at every 0.5-ft increment from 0.5 to 10 ft; (ii) quantify how strongly municipal rankings depend on the scenario and on the metric used (absolute area versus share of municipal land); and (iii) quantify the effect of common methodological shortcuts. These are omitting the present-day water mask, using generalized boundaries, coarsening resolution, and replacing spatial data with coordinate heuristics. All results are screening-level estimates of potential permanent high-tide inundation under NOAA’s assumptions. They are not forecasts of flood frequency, storm surge, damages or displacement.

2 Study area and data

2.1 Study area

Connecticut has 169 incorporated towns and cities (hereafter municipalities), which together cover all of the state’s territory; there is no unincorporated land. Connecticut General Statutes §22a-94(a) defines a statutory coastal area consisting of 36 named towns together with the state’s waters in Long Island Sound (State of Connecticut, 2025a; Connecticut Department of Energy and Environmental Protection, 2018). Of these, 24 front Long Island Sound (hereafter *Sound-shoreline* municipalities). We confirmed this geometrically: 21 of their Census polygons adjoin the Census water polygons for Long Island Sound, and the remaining three (Greenwich, Stamford and Stonington) extend across the water to the state boundary. The other 12 statutory coastal-area municipalities have no Sound frontage and lie mostly along the tidal Housatonic, Quinnipiac, Connecticut and Thames rivers; we label them *statutory coastal area, tidal river*. The remaining 133 municipalities are labelled *outside the statutory coastal area*. Several of these, including Haddam, East Haddam, Middletown, Cromwell and Portland, nonetheless border the tidal Connecticut River. NOAA OCM’s Connecticut DEM covers Fairfield, Hartford, Middlesex, New Haven and New London counties (NOAA Office for Coastal Management, 2026a), which contain 115 of the 169 municipalities (Figure 1). Municipalities in Litchfield, Tolland and Windham counties lie outside the mapped domain and are reported as *not mapped* rather than as unexposed.

2.2 Inundation extent rasters

We used all 21 Connecticut extent rasters (CT_connectRaster_0_0 to CT_connectRaster_10_0) downloaded from NOAA OCM on 20 October 2026 (NOAA Office for Coastal Management, 2026b). Each is an unsigned 8-bit cloud-optimized GeoTIFF on a common NAD83 geographic grid (EPSG:4269) with a cell size of 2.69×10^{-5} degrees (≈ 3.0 m north–south by ≈ 2.25 m east–west at 41.3°N) and 40,510 rows by 72,204 columns. A value of 1 denotes a cell inundated and hydrologically connected to the open ocean when water stands the stated number of feet above MHHW; 255 denotes all other cells. NOAA’s method adds each increment to an interpolated VDatum MHHW surface expressed in NAVD88, compares the result with the

DEM, and retains the 8-connected region linked to open water (NOAA Office for Coastal Management, 2017). Unconnected low-lying areas are distributed separately and are *not* included in the extent rasters. The 0.0-ft raster represents present-day MHHW. It covers open water, tidal channels and intertidal land already flooded at high tide, and we use it as the baseline mask. NOAA characterizes these data as a screening-level tool (NOAA Office for Coastal Management, 2026b). The source DEM’s vertical accuracy is not independently tested by NOAA; the source lidar was specified to meet FEMA flood-mapping requirements (NOAA Office for Coastal Management, 2026a).

2.3 Municipal boundaries

Municipal boundaries and official land areas were taken from the U.S. Census Bureau 2020 TIGER/Line county-subdivision file for Connecticut (U.S. Census Bureau, 2020). The 2020 vintage retains the historical county codes required to identify NOAA’s mapping domain; later vintages use planning regions. Four placeholder polygons representing undesignated water in Long Island Sound (“county subdivisions not defined”) were removed, leaving 169 municipalities. Both the rasters and TIGER/Line are referenced to NAD83 geographic coordinates, so no datum transformation was applied. The Census land area (ALAND) was used as the denominator for proportional exposure. For comparison only, we also used the unattributed town polygons distributed with the original dashboard, which average 13.5 vertices per municipality versus 479 in TIGER/Line.

3 Methods

3.1 Input verification

All raw inputs were checksummed (SHA-256). Every raster was checked for identical grid geometry and coordinate reference system. Values were inventoried over all 2.9×10^9 cells per raster, and the expected nesting of the scenarios was verified cell by cell: any cell wet at level s must be wet at every level above s . Wet-cell counts were compared with the summary statistics embedded by NOAA in each file.

During verification we found that the three rasters bundled with the original dashboard were not the distributed NOAA files. They used a different cell size (2.701×10^{-5} degrees) and a different no-data convention, and their provenance could not be established. They were therefore excluded.

3.2 Exposure metric

For each municipality m and increment s we computed newly inundated land

$$A_{m,s} = \sum_{i \in m} a_i \mathbf{1}[w_{i,s} = 1 \wedge w_{i,0} \neq 1], \quad (1)$$

where $w_{i,s}$ is the value of cell i in the raster for increment s , $w_{i,0}$ is the baseline (0.0 ft) value, and a_i is the ellipsoidal area of cell i . A cell was assigned to the municipality containing its centre. Because cell area on a latitude–longitude grid varies only with latitude, a_i was computed analytically for each row on

the GRS80 ellipsoid from the authalic-latitude expression (Snyder, 1987). It was cross-checked against geodesic polygon areas from PROJ’s implementation of Karney (2013), which agreed to better than one part in 10^8 . Proportional exposure was $P_{m,s} = 100A_{m,s}/\text{ALAND}_m$. $A_{m,s}$ therefore measures area lying above present MHHW but within NOAA’s ocean-connected extent at s ft. This includes presently dry land, existing wetlands (notably high tidal marsh) and inland water bodies above MHHW, so it is not a measure of developed land at risk; the land-cover overlay (Section 3.5) quantifies these components. We interpret $A_{m,s}$ as potential permanent high-tide inundation under a static, present-day landscape.

The computation streamed through the grid in horizontal strips of 510 rows, rasterizing the municipal polygons onto each strip and accumulating areas with weighted histogramming. One pass over all 21 rasters produced every primary and sensitivity metric.

3.3 Ranking analysis

Municipalities were ranked by $A_{m,s}$ and by $P_{m,s}$ at four primary increments: 1, 2, 3 and 6 ft. The 1-, 3- and 6-ft levels match the original dashboard; 2 ft is the 0.5-ft step closest to Connecticut’s 20-inch planning value. Rank agreement between pairs of increments, and between the two metrics, was summarized with Spearman’s ρ and Kendall’s τ computed in SciPy (Virtanen et al., 2020). It was also summarized by the overlap of the ten highest-ranked municipalities and by the number of municipalities whose rank changed by five or more places. Rank statistics were restricted to mapped municipalities with non-zero exposure in at least one of the compared increments. These statistics describe agreement among deterministic tabulations; no sampling inference is implied, so no p -values are reported.

3.4 Sensitivity analyses

We evaluated five methodological choices. (1) *Baseline masking*: exposure computed from the full extent at s ft without removing the 0.0-ft extent. (2) *Boundary source*: newly inundated area assigned using the generalized dashboard polygons instead of TIGER/Line. (3) *Resolution*: the baseline and scenario rasters were each aggregated to 10×10 (≈ 27 m) and 30×30 (≈ 81 m) blocks by majority rule, a block being wet if at least half its cells were wet; newly inundated area was then recomputed with block-centre assignment to municipalities. This mimics an analyst working from coarser derived products. It is not equivalent to rerunning the bathtub model on a coarser DEM, which would also alter connectivity. (4) *Boundary allocation*: the share of newly inundated area lying in cells adjacent to an internal municipal boundary, an upper bound on area that centre-based assignment could place in the wrong municipality. (5) *Cell area*: areas recomputed with a single nominal cell area instead of row-specific ellipsoidal areas. In addition, exposure at $s \pm 0.5$ ft was compared with exposure at s as a simple indication of how results respond to a vertical offset of about 15 cm in the combined DEM and tidal surface. This is comparable in magnitude to plausible lidar and datum-transformation errors (Gesch, 2018). It is a sensitivity bracket, not a probabilistic uncertainty interval.

3.5 Land-cover composition of exposed area

To interpret what newly inundated area currently consists of, we overlaid NOAA’s Coastal Change Analysis Program (C-CAP) 2016 high-resolution land cover for Connecticut (NOAA Office for Coastal Management, 2024). The product classifies summer 2016 imagery into standard C-CAP classes and has a reported overall accuracy of 85.3%; class-level accuracy ranges from 33% (user’s accuracy, estuarine scrub/shrub wetland) to over 95% (impervious surfaces, open water). The land-cover raster was resampled to the NOAA grid by nearest neighbour, which assigns each ~ 3 m cell the class at its centre, and newly inundated area was summed by class using the same ellipsoidal cell areas. Classes were grouped as developed (impervious), developed open space, agriculture and upland vegetation, estuarine (tidal) wetland, palustrine (freshwater) wetland, unconsolidated shore and bare land, and open water. The analysis describes what occupies the exposed footprint; it does not estimate damage, and the 2016 imagery predates the 2023 lidar used for the inundation surfaces.

3.6 Assessment of validation options

We looked for publicly available observations that could test the inundation extents independently. None was suitable. NOAA’s high-tide flooding products for Connecticut tide gauges are station records and projections of the number of days on which water levels exceed minor coastal-flood thresholds (NOAA Center for Operational Oceanographic Products and Services, 2023). They describe how often episodic flooding occurs at a gauge, not which land is permanently below a raised high tide, and they contain no mapped extents. Mapped flood-hazard zones and post-storm inundation records describe storm surge and wave-driven events, which a static high-tide analysis is not designed to reproduce. NOAA’s Mapping Confidence layers propagate elevation and tidal-surface error to classify cells as wet or dry with high or low confidence at each level (NOAA Office for Coastal Management, 2023). They characterize uncertainty within the same model rather than testing it against observations. Comparing the extents with any of these sources would have produced a misleading appearance of validation, so we report the verification of our processing (Section 3.1 and the reproducibility package) separately from physical validation, which remains outside the scope of this study.

3.7 Comparison with the coordinate heuristic

The original dashboard’s scores were reproduced exactly from its source code (Mestry, 2026). Each town’s centroid was computed from the dashboard polygons. A latitude- and longitude-based score was scaled by scenario (factors 18, 34 and 56 for 1, 3 and 6 ft), 1.5 times the scenario was added for 20 hard-coded municipalities, and the displayed “flood percent” was 1.15 times the score. We compared these values with $P_{m,s}$ for mapped municipalities at 1, 3 and 6 ft.

3.8 Reproducibility

The workflow consists of seven Python scripts run in sequence (Python 3.13; rasterio 1.5.2 with GDAL 3.12.2, GeoPandas 1.2.0, pyproj 3.8.0 with PROJ 9.8.1, NumPy 2.5.3, pandas 3.0.5, SciPy 1.18.1, Matplotlib

3.11.2). Every number in the Results, every table and every figure is generated by the scripts; manuscript values are inserted from an automatically written macro file rather than transcribed by hand.

4 Results

4.1 Input verification

All 21 NOAA rasters shared an identical grid and contained only the values 1 and 255. The scenarios were strictly nested, with no cell wet at one increment and dry at any higher increment (zero violations across the 20 successive pairs). Wet-cell counts computed over the full grids matched the counts embedded by NOAA in every file exactly. The 169 TIGER/Line polygons were valid and non-overlapping, and their land areas summed to 12,541.7 km². Newly inundated cells falling outside every Connecticut municipal polygon amounted to 0.43 km² at 6 ft and 0.61 km² at 10 ft; these lie mainly within the undesignated Long Island Sound water polygons and along state lines. No inundation, present-day or projected, occurred in any municipality outside NOAA's five-county domain.

4.2 Statewide exposure

Within Connecticut's municipalities, the present-day MHHW extent (the 0.0-ft raster) covers 475.1 km², mostly harbors, tidal rivers and intertidal flats inside municipal boundaries. Net of this baseline, newly inundated area rose from 20.7 km² at 0.5 ft to 34.7 km² at 1 ft, 51.3 km² at 2 ft, 68.5 km² at 3 ft, 133.3 km² at 6 ft and 207.1 km² at 10 ft (Figure 2a). Connecticut's 0.5 m planning value falls between the 1.5-ft (0.46 m) and 2.0-ft (0.61 m) rasters, which correspond to 44.0 and 51.3 km², respectively. The curve is steepest over the first foot. The first 0.5 ft alone accounts for 20.7 km², consistent with extensive low-lying land, much of it presumably vegetated tidal marsh, lying within a few tenths of a metre of present MHHW. Above 2 ft, exposure grows roughly linearly, adding 17–25 km² per foot.

The 24 Sound-shoreline municipalities account for 74% of newly inundated area at 1 ft and 71% at 6 ft. The 12 tidal-river municipalities of the statutory coastal area account for 14% at 1 ft and 8% at 6 ft. Exposure is not confined to the statutory coastal area. Municipalities outside it, almost all along the tidal Connecticut River, contribute 12% of the total at 1 ft (9 municipalities) and 20% at 6 ft (16 municipalities). The largest contributions come from Portland (1.73 km² at 1 ft) and Cromwell (1.20 km² at 1 ft; 11.6% of its land at 6 ft). Exposure in Hartford County municipalities is nearly absent at 1 ft (0.1 km²) but reaches 14.1 km² across 8 municipalities at 6 ft. This upriver signal depends on NOAA's extrapolation of the tidal surface along the river and is discussed in Section 5.4.

4.3 Municipal distribution

The number of municipalities with any newly inundated land increased only modestly with water level, from 45 at 1 ft to 52 at 6 ft and 56 at 10 ft. Proportional exposure, however, deepened substantially. The number of municipalities with at least 1% of their land newly inundated rose from 19 at 1 ft to 27 at 2 ft, 30 at 3 ft and 41 at 6 ft. The corresponding counts at $\geq 5\%$ were 2, 3, 7 and 21 (Figure 3). Exposure was concentrated. The

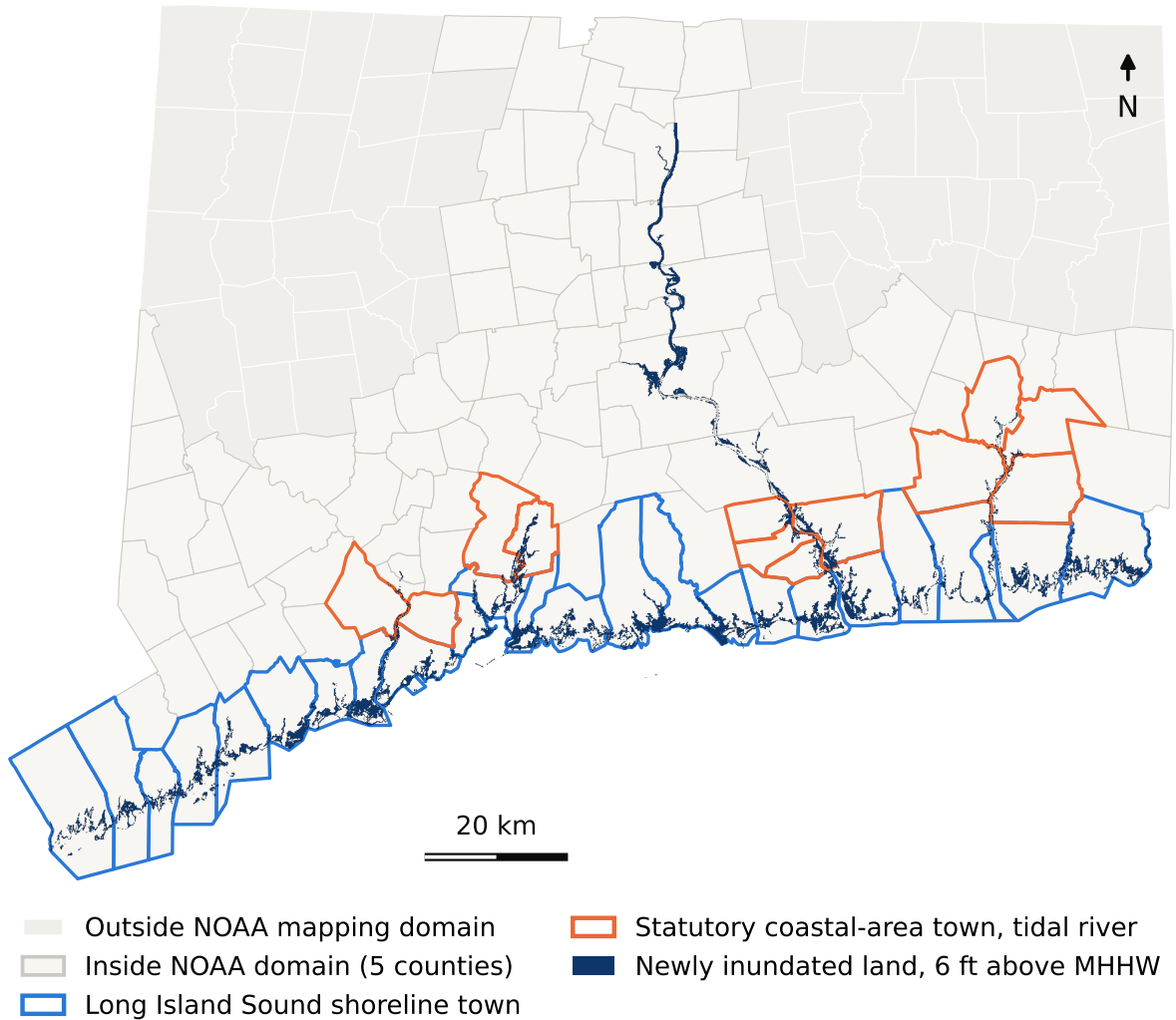


Figure 1: Study area. Connecticut’s 169 municipalities, showing NOAA’s five-county mapping domain, the 24 Long Island Sound shoreline municipalities and the 12 tidal-river municipalities of the statutory coastal area (CGS §22a-94(a)), and newly inundated land at 6 ft above MHHW. The inundation overlay is resampled for display (maximum of ≈ 24 m blocks drawn at 60 m); all calculations use the native ~ 3 m grid. Projection: NAD83 / Connecticut (EPSG:6433). Data: NOAA OCM; U.S. Census Bureau TIGER/Line 2020.

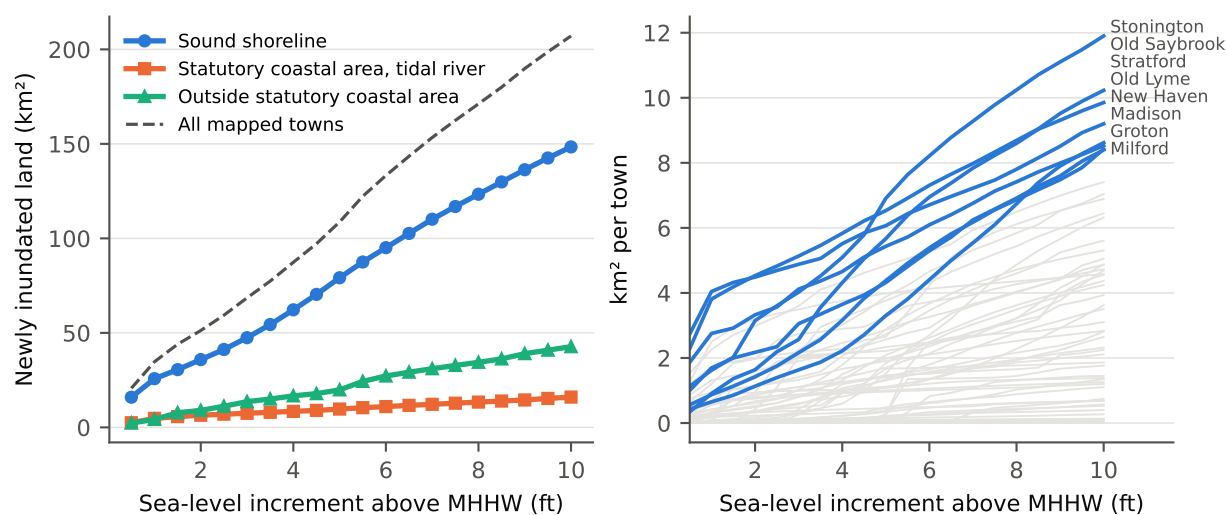
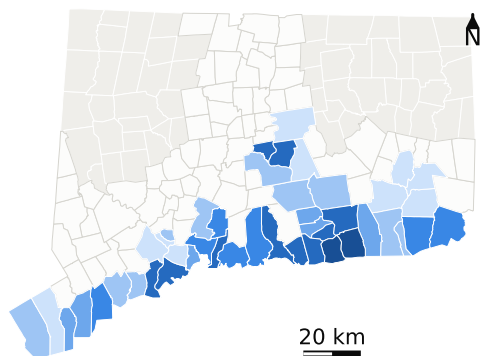


Figure 2: Exposure curves across all 20 increments. (a) Statewide newly inundated land by municipality class. (b) Individual municipalities; the eight with the largest exposure at 10 ft are highlighted.

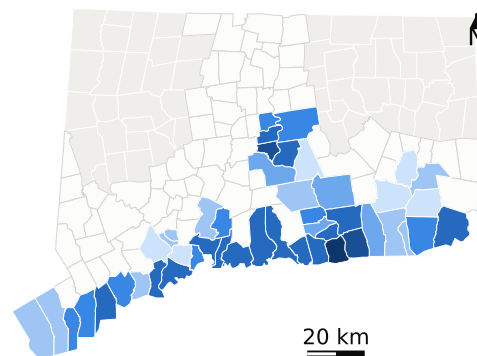
Table 1: Newly inundated land (km²) and share of municipal land (%) for the 20 municipalities with the largest area at 6 ft. Land area is Census 2020 ALAND. The complete table for all municipalities and all 20 increments is provided in the reproducibility package.

Municipality	Land (km²)	1 ft		2 ft		3 ft		6 ft	
		km²	%	km²	%	km²	%	km²	%
Stonington	100.1	1.62	1.62	3.15	3.15	4.03	4.02	8.21	8.21
Old Saybrook	39.0	3.81	9.77	4.53	11.62	5.14	13.17	7.31	18.74
Stratford	45.3	0.91	2.01	1.64	3.62	2.57	5.68	6.95	15.35
Old Lyme	59.6	4.04	6.78	4.49	7.53	4.88	8.19	6.71	11.25
Madison	93.6	2.75	2.94	3.33	3.55	4.12	4.40	6.09	6.51
Groton	80.6	0.87	1.08	1.42	1.77	2.16	2.69	5.38	6.68
Milford	57.4	1.69	2.95	2.17	3.78	3.05	5.32	5.30	9.22
Guilford	121.9	2.26	1.86	2.98	2.45	3.60	2.95	5.28	4.33
Fairfield	77.4	0.34	0.44	0.94	1.22	2.25	2.91	4.66	6.02
New Haven	48.4	0.65	1.35	1.13	2.34	1.64	3.38	4.41	9.10
Branford	56.6	0.85	1.50	1.47	2.60	2.10	3.71	4.31	7.61
Portland	60.5	1.73	2.85	1.98	3.27	2.17	3.59	4.22	6.98
Lyme	82.4	2.50	3.04	3.20	3.89	3.49	4.24	4.13	5.01
Cromwell	32.3	1.20	3.73	1.97	6.11	2.74	8.49	3.73	11.56
Norwalk	59.3	0.43	0.72	0.61	1.03	1.03	1.73	3.68	6.20
Westport	51.7	0.87	1.69	1.12	2.17	1.41	2.74	3.46	6.69
East Haven	31.8	0.69	2.18	1.45	4.56	2.02	6.35	3.26	10.25
Clinton	42.0	1.32	3.14	1.59	3.79	1.90	4.53	2.93	6.97
Bridgeport	41.6	0.08	0.20	0.17	0.42	0.34	0.82	2.70	6.49
Greenwich	123.6	0.32	0.26	0.49	0.39	0.80	0.65	2.62	2.12

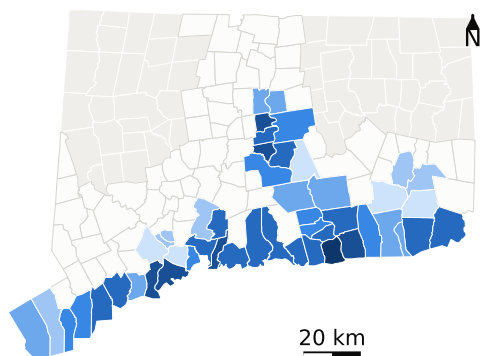
1 ft above MHHW



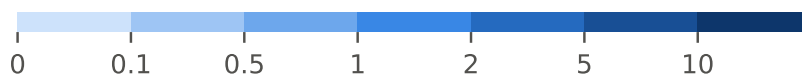
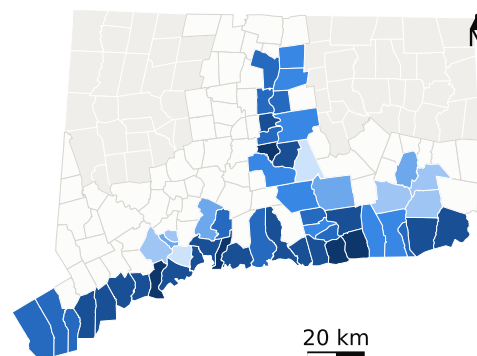
2 ft above MHHW



3 ft above MHHW



6 ft above MHHW



Newly inundated share of municipal land area (%) · light grey: not mapped · white: none

Figure 3: Newly inundated share of municipal land area (Census ALAND) at 1, 2, 3 and 6 ft above MHHW. White: mapped, no newly inundated land; grey: outside NOAA's mapping domain. Projection: EPSG:6433.

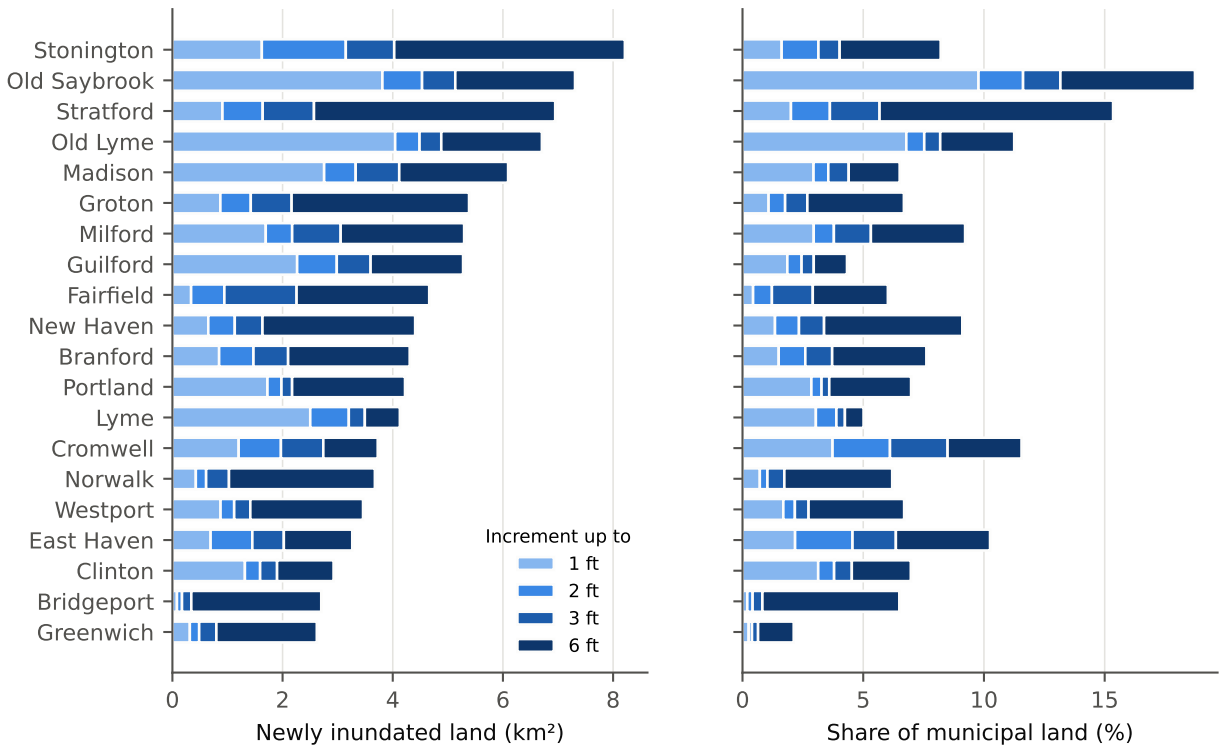
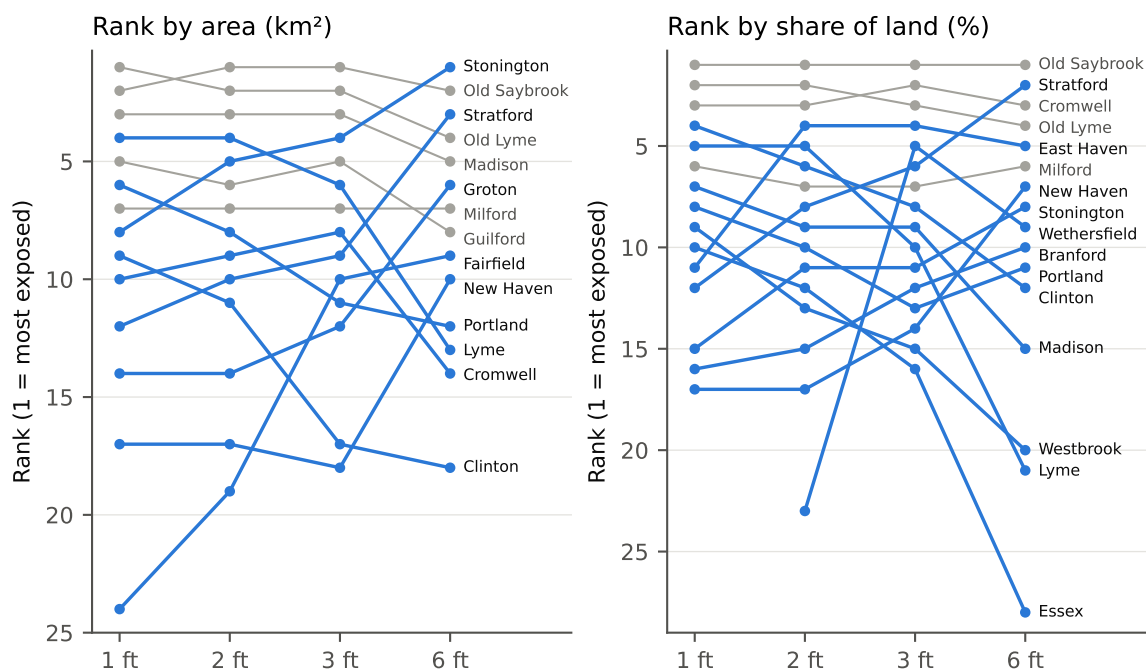


Figure 4: Newly inundated land for the 20 municipalities with the largest area at 6 ft: absolute area (left) and share of municipal land (right). Segments show the increment added at each successive primary level.

Table 2: Agreement of municipal rankings between primary increments. Computed for mapped municipalities with non-zero exposure in at least one of the two increments compared. “Shifts ≥ 5 ” is the number of municipalities whose rank changed by five or more places.

Metric	Scenarios	n	Spearman ρ	Kendall τ	Top-10 overlap	Shifts ≥ 5
Area (km ²)	1 vs 2 ft	47	0.900	0.796	9	12
Share of land (%)	1 vs 2 ft	47	0.873	0.787	8	8
Area (km ²)	1 vs 3 ft	49	0.841	0.714	8	21
Share of land (%)	1 vs 3 ft	49	0.792	0.689	7	24
Area (km ²)	1 vs 6 ft	52	0.741	0.554	6	37
Share of land (%)	1 vs 6 ft	52	0.695	0.525	4	40
Area (km ²)	2 vs 3 ft	49	0.959	0.865	9	6
Share of land (%)	2 vs 3 ft	49	0.947	0.848	9	7
Area (km ²)	2 vs 6 ft	52	0.799	0.627	7	35
Share of land (%)	2 vs 6 ft	52	0.805	0.619	6	39
Area (km ²)	3 vs 6 ft	52	0.857	0.706	8	25
Share of land (%)	3 vs 6 ft	52	0.883	0.715	7	26



Municipalities ranked in the top 10 at any primary scenario. Blue: rank changes by ≥ 5 places; line gaps: no exposure at that level.

Figure 5: Rank of municipalities by absolute newly inundated area (left) and by share of land (right) at the four primary increments, for municipalities ranked in the top ten at any increment.

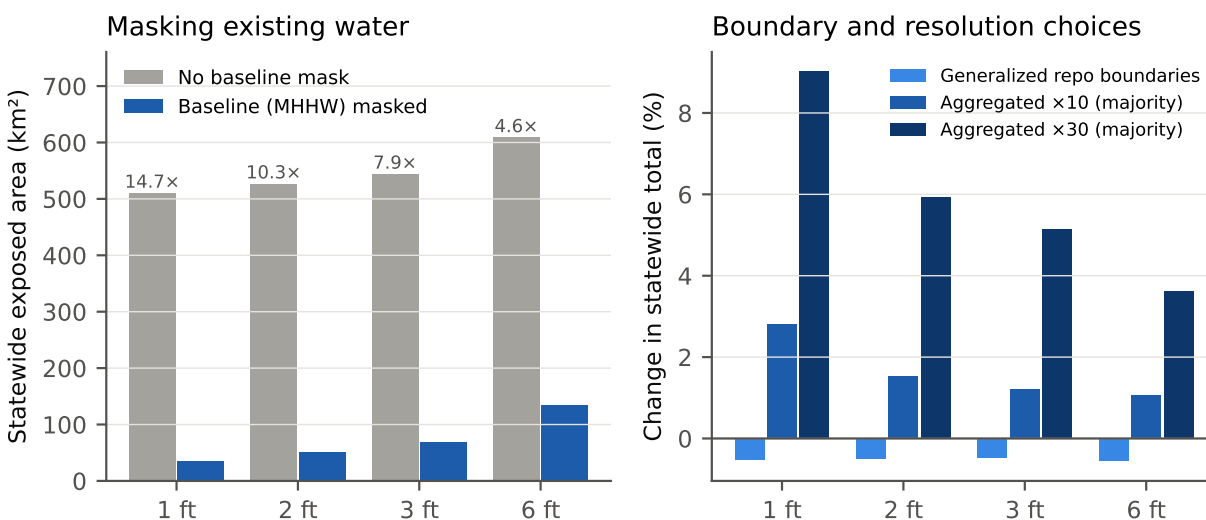


Figure 6: Effect of methodological choices on statewide totals. Left: exposure with and without removal of the present-day MHHW extent (labels give the ratio). Right: change relative to the reference from using the generalized dashboard boundaries and from majority-rule aggregation of the rasters by factors of 10 (≈ 27 m) and 30 (≈ 81 m).

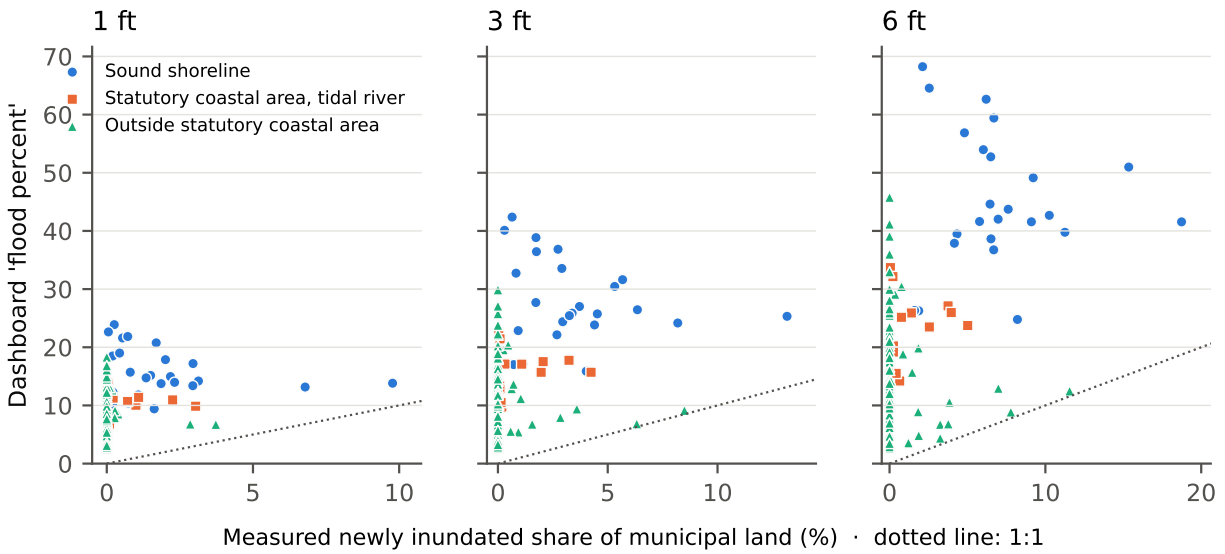


Figure 7: Original dashboard “flood percent” (a coordinate-based heuristic) versus measured newly inundated share of land for the 115 mapped municipalities at 1, 3 and 6 ft. The dotted line is the 1:1 line.

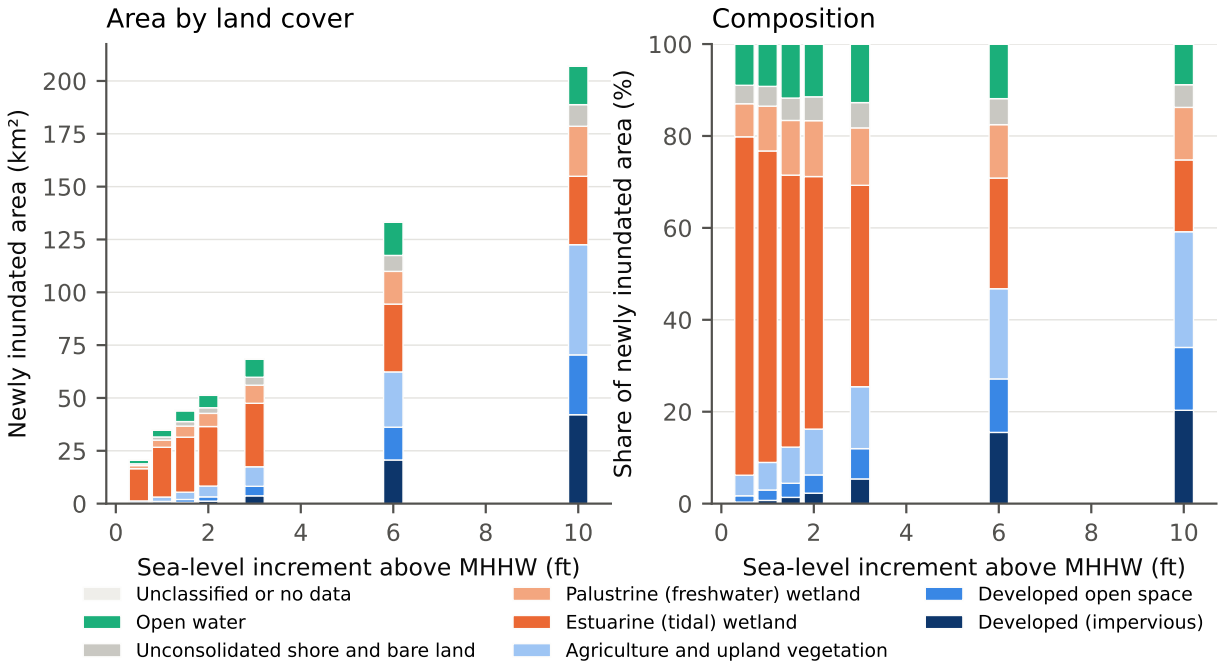


Figure 8: Land cover (NOAA C-CAP 2016, 1 m) within newly inundated area at selected increments: absolute area (left) and composition (right). Developed comprises impervious surface and developed open space. Bars are placed at their increment on a numeric axis.

Table 3: Sensitivity of exposure to methodological choices. ^aMunicipalities with ≥ 0.1 km² of newly inundated land in the reference analysis.

Variant	1 ft	2 ft	3 ft	6 ft
Reference (TIGER/Line, 3 m, MHHW masked), km ²	34.7	51.3	68.5	133.3
No baseline mask, km ²	509.8	526.4	543.6	608.4
ratio to reference	14.7×	10.3×	7.9×	4.6×
Generalized dashboard boundaries, statewide change (%)	−0.5	−0.5	−0.5	−0.6
median change per municipality (%) ^a	2.6	2.6	2.5	2.0
maximum change per municipality (%) ^a	59	48	74	21
Aggregated to ≈ 27 m, statewide change (%)	2.8	1.5	1.2	1.1
median change per municipality (%) ^a	3.5	2.0	1.7	1.0
Spearman ρ with reference	0.996	0.999	0.999	0.999
Aggregated to ≈ 81 m, statewide change (%)	9.0	5.9	5.1	3.6
median change per municipality (%) ^a	8.9	7.1	4.8	4.0
Spearman ρ with reference	0.989	0.995	0.997	0.998
Area in cells adjacent to internal boundaries (%)	0.17	0.24	0.25	0.23
Constant cell area, max error per municipality (%)	0.48	0.55	0.62	0.84
Level −0.5 ft, statewide change (%)	−40	−14	−13	−8
Level +0.5 ft, statewide change (%)	27	16	13	8

Table 4: Land cover of newly inundated area by C-CAP 2016 class group at the four primary increments (mapped municipalities only).

C-CAP 2016 class group	1 ft		2 ft		3 ft		6 ft	
	km ²	%	km ²	%	km ²	%	km ²	%
Developed (impervious)	0.2	0.7	1.2	2.3	3.7	5.4	20.7	15.5
Developed open space	0.8	2.3	2.0	4.0	4.5	6.6	15.5	11.6
Agriculture and upland vegetation	2.1	6.0	5.1	10.0	9.2	13.5	26.2	19.6
Palustrine (freshwater) wetland	3.4	9.8	6.2	12.2	8.6	12.5	15.5	11.6
Estuarine (tidal) wetland	23.5	67.8	28.2	55.0	30.0	43.8	32.1	24.1
Unconsolidated shore and bare land	1.5	4.3	2.7	5.2	3.8	5.5	7.5	5.7
Open water	3.2	9.2	5.9	11.5	8.7	12.7	15.8	11.8
Unclassified or no data	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Total	34.7	100	51.3	100	68.5	100	133.3	100

ten most exposed municipalities held 66% of statewide newly inundated area at 1 ft, falling to 45% at 6 ft as exposure spread to more municipalities.

Old Saybrook had the largest proportional exposure at every one of the 20 increments, from 9.8% of its land at 1 ft to 18.7% at 6 ft. By absolute area, Old Lyme ranked first at 1 ft (4.04 km²), Old Saybrook at 2 and 3 ft, and Stonington at 6 ft (8.21 km²; Table 1, Figure 4). Several of the state’s largest cities show the opposite pattern: little exposure at low increments and a sharp increase between 3 and 6 ft. Bridgeport’s newly inundated area grew from 0.34 km² at 3 ft to 2.70 km² at 6 ft (rank 36 to 19). Stamford’s grew from 0.29 to 2.48 km² (rank 37 to 22).

4.4 Sensitivity of municipal rankings to scenario and metric

Rankings were broadly similar between adjacent increments but diverged as the gap between increments widened (Table 2, Figure 5). Between 2 and 3 ft, Spearman’s ρ for absolute area was 0.96 and nine of the ten most exposed municipalities were shared. Between 1 and 6 ft, ρ fell to 0.74 for area (Kendall’s $\tau = 0.55$) and 0.69 for share of land. Only 6 (area) and 4 (share) of the ten most exposed municipalities were common to both increments. Of the 52 municipalities compared, 37 changed rank by five or more places by area, and 40 by share of land. The choice of metric mattered as well. Within a single increment, rankings by area and by share agreed with ρ between 0.88 and 0.95, but the top-ten lists shared only 6 municipalities at 6 ft (8 at 1 ft). Large municipalities with long shorelines, such as Guilford and Madison, rank higher by area. Small municipalities with extensive marsh, such as Cromwell and East Haven, rank higher by share.

4.5 Sensitivity to methodological choices

Omitting the baseline mask was by far the most consequential error (Table 3, Figure 6). Counting the full NOAA extent within municipal boundaries as “flooded” gave 509.8 km² at 1 ft, 14.7 times the newly inundated area. The overstatement declined to 4.6 times at 6 ft because the fixed baseline becomes a smaller fraction of the total.

Boundary generalization had little effect on the statewide total (−0.5% at 1 ft) because most misallocated area simply moves between neighbouring municipalities. Per municipality, however, using the generalized dashboard polygons changed newly inundated area by a median of 2.6% and by up to 74% among municipalities with at least 0.1 km² of exposure. Proportional metrics are additionally affected through the denominator, because the generalized polygon areas differ from official land areas by up to 88% (Section 2.3).

Aggregating to ≈ 27 m cells changed statewide totals by 1–3%. Aggregating to ≈ 81 m increased them by 3.6–9.0%, with larger relative inflation at low increments where inundated patches are narrow and fragmented. Municipal rankings were nonetheless insensitive to aggregation ($\rho \geq 0.989$ at ≈ 81 m). Centre-of-cell assignment placed at most 0.25% of newly inundated area in cells adjacent to an internal municipal boundary, bounding the possible allocation error. Using a single nominal cell area (6.73 m²) instead of row-specific ellipsoidal areas changed municipal totals by at most 0.8%.

Exposure was most sensitive to small vertical offsets at the lowest increments. Shifting the water level by −0.5 or +0.5 ft changed statewide exposure at 1 ft by −40% and +27%. At 6 ft the change was only $\pm 8\%$

(−8% and +8%). Rank orders were robust to these offsets ($\rho \geq 0.970$).

4.6 Comparison with the coordinate heuristic

The dashboard’s “flood percent” bore little relation to the spatially explicit estimates (Figure 7). Across the 115 mapped municipalities, rank correlation with measured proportional exposure was $\rho = 0.45$ – 0.49 , and the two top-ten lists shared only 1–2 municipalities. The heuristic exceeded measured exposure in absolute terms by a mean of 9.4 percentage points at 1 ft and 21.2 points at 6 ft. At 6 ft it assigned $\geq 10\%$ to 59 mapped municipalities whose measured exposure was below 1%. Statewide it assigned $\geq 10\%$ to 67 municipalities outside the statutory coastal area. For example, Greenwich was shown as 68% flooded at 6 ft against a measured 2.1%. New Canaan, which has no tidal shoreline, was shown as 46% flooded against a measured 0.0%. Conversely, 21 municipalities with more than 1% measured exposure at 6 ft were not among the 20 hand-listed coastal towns. These include the Sound-shoreline municipalities of Darien, East Lyme, Waterford and Stonington and a series of Connecticut River municipalities, none of which received the heuristic’s coastal adjustment.

4.7 Land cover within the newly inundated area

Land-cover totals reproduced the main pipeline’s statewide exposure exactly (relative difference below $10^{-10}\%$), so every newly inundated cell was assigned a C-CAP class; less than 0.1% fell in unclassified or no-data cells. At low increments, newly inundated area is dominated by existing tidal marsh (Figure 8, Table 4). Estuarine wetland accounts for 74% of the area at 0.5 ft, 68% at 1 ft and 55% at 2 ft. Developed land (impervious surface plus developed open space) accounts for 3% at 1 ft (1.0 km²) and 6% at 2 ft (3.2 km²). The composition shifts at higher increments. At 6 ft developed land makes up 27% (36.2 km²) and estuarine wetland 24%; at 10 ft the corresponding shares are 34% and 16%. The estuarine-wetland area itself nearly saturates above about 3 ft (30.0 km² at 3 ft and 32.1 km² at 6 ft), so additional exposure increasingly falls on developed and upland land. Open water lying above present MHHW (for example ponds, impoundments and river reaches) makes up 9% at 1 ft and 12% at 6 ft, confirming that the exposure metric includes some inland water. For comparison, the present-day MHHW extent within municipalities (475 km²) is mostly open water (421 km²).

The municipalities with the most developed land in the newly inundated area differ from those leading the total-area rankings. At 2 ft, the largest developed areas are in New Haven (0.44 km²), Fairfield (0.44 km²) and Stratford (0.43 km²). At 6 ft they are in Stratford (4.31 km²), Fairfield (2.95 km²) and New Haven (2.86 km²). By contrast, in Old Saybrook, Old Lyme and Stonington, which lead by total or proportional area, 71–89% of the newly inundated area at 2 ft is estuarine wetland.

5 Discussion

5.1 What the tabulation adds

The methods used here are not new. They follow the modified-bathtub approach that NOAA, Climate Central and many regional studies have applied for two decades (Titus and Richman, 2001; Poulter and Halpin, 2008; Strauss et al., 2012; NOAA Office for Coastal Management, 2017), and the inundation surfaces themselves are NOAA's. The contribution is narrower and practical. It provides a complete, reproducible, municipality-by-municipality accounting of NOAA's current Connecticut product, net of present MHHW, at every published increment. It also documents several features of that accounting that matter for planning use but are not apparent from the online viewer.

First, the two rasters that bracket Connecticut's 0.5 m planning value (1.5 and 2.0 ft) differ by about one-sixth in statewide exposure. Because the curve is steep at low increments, the choice of nearest raster is not trivial. Users targeting 0.5 m should report both bracketing levels rather than rounding. Second, a non-trivial share of exposure lies outside the statutory coastal area, almost entirely along the Connecticut River. Third, municipal rankings are conditional on both the scenario and the metric. A "most exposed" list prepared for a 1-ft scenario retains fewer than two-thirds of its members at 6 ft, and lists by area and by share differ substantially even within one scenario. Rankings should therefore be reported with the scenario and metric stated, and preferably across several of each, rather than as a single league table. Fourth, the land-cover overlay shows that at the increments most relevant to mid-century planning, most newly inundated area is existing tidal marsh rather than developed land. Exposure totals at those levels therefore describe potential marsh submergence and habitat change at least as much as risk to buildings and infrastructure. Developed-land exposure becomes a substantial share only at higher increments, and it is concentrated in a different set of municipalities.

5.2 Which methodological choices matter

The sensitivity analyses separate choices that change conclusions from those that do not. Failing to remove present-day water is not a minor bias: it inflates exposure by an order of magnitude at the increments most relevant to mid-century planning. It also inverts the meaning of the metric, because municipalities with large harbors appear most "flooded" at any increment. It is easy to make, because NOAA's extent rasters include the 0.0-ft area by design. NOAA's own method describes masking with the zero-rise extent for land-only display (NOAA Office for Coastal Management, 2017), and any municipal tabulation should do the same.

Boundary generalization and moderate coarsening matter much less for statewide totals but can matter for individual municipalities. The tens-of-percent errors produced by the generalized dashboard polygons in some towns are large enough to change local conclusions. Aggregation to ≈ 81 m inflated totals by a few percent and up to about 9% at 1 ft while preserving ranks. This is consistent with earlier findings that horizontal resolution affects modelled extent (Poulter and Halpin, 2008), although our aggregation experiment does not reproduce the additional connectivity changes a coarser DEM would introduce. By contrast, the vertical sensitivity at 1 ft (-40% to $+27\%$ for ± 0.5 ft) indicates that low-increment results are only as reliable as the DEM and the MHHW surface. This echoes the conclusion of Gesch (2018) that vertical uncertainty

limits the smallest increment that can be mapped with confidence. Results at 0.5 and 1 ft should be read as indicative orders of magnitude for each municipality.

5.3 The heuristic as a cautionary case

The original dashboard illustrates a broader risk in quickly built decision tools: a quantity labelled as a physical measurement (“flood percent”) can be entirely synthetic. Its scores encoded the reasonable intuition that southern, western and shoreline towns are more exposed. However, its magnitudes were arbitrary, it assigned substantial flooding to municipalities with no tidal shoreline, and it omitted coastal municipalities absent from a hand-made list. Its rank correlation with measured exposure ($\rho \approx 0.45\text{--}0.49$) partly reflects the coarse coastal/inland gradient, which any location-based score captures. Its near-zero agreement on which municipalities are most exposed shows that it cannot support local conclusions. We report this comparison so that the dashboard’s numbers are not cited and to illustrate why derived quantities should be traceable to source data.

5.4 Upriver exposure along the Connecticut River

Exposure in Portland, Cromwell, Wethersfield, Glastonbury, Hartford, Windsor and neighbouring municipalities follows from NOAA’s representation of MHHW along the tidal Connecticut River. Where VDatum provides no tidal datum, the method extends tidal trends inland by interpolation along the river (NOAA Office for Coastal Management, 2017). These results should be treated with particular caution for three reasons. The extrapolated tidal surface is less constrained than along the open coast. River discharge, rather than tide, dominates water levels for much of the year in the upper tidal river. And riverine flood-control structures and drainage infrastructure are not represented as active systems in a static analysis (Gallien et al., 2014). Unconnected low-lying areas behind such features are also excluded from the extent rasters. Upriver exposure is better interpreted as land lying low relative to the extrapolated high-tide surface than as a confident projection of permanent tidal inundation. That said, the signal is coherent across increments and municipalities, and it identifies places that municipal sea-level planning focused on the statutory coastal area could overlook.

5.5 Implications for coastal planning in Connecticut

The tabulation is most useful as a screening and prioritization aid, and less useful as an estimate of what any one municipality will lose. Five practical points follow. First, analyses tied to the state’s 0.5 m planning scenario should report both bracketing NOAA levels (1.5 and 2.0 ft) rather than a single rounded value. Second, comparisons among municipalities should state which metric is used. Absolute area identifies where the most land is affected, while share of land identifies where exposure is largest relative to the size of the community, and the two lead to different priorities. Third, where the planning concern is developed land rather than total area, the land-cover results identify a different set of priority municipalities from the area-based rankings. Fourth, municipalities along the tidal Connecticut River that lie outside the statutory coastal area appear in the results. They merit attention in regional planning, with the caveats discussed above.

Fifth, the municipal values are a starting point for site-specific work. That work should use local elevation surveys, drainage and infrastructure information, and hydrodynamic modelling where decisions depend on the result. The estimates are not suitable for parcel-level decisions, permitting or engineering design, which NOAA also advises against (NOAA Office for Coastal Management, 2026b).

6 Limitations

The analysis inherits all limitations of static inundation mapping and of NOAA’s product, and it adds no independent validation. In particular:

1. *No validation against observed inundation.* No publicly available dataset maps observed permanent high-tide inundation in Connecticut; gauge-based high-tide-flooding records and storm-flood maps measure different phenomena (Section 3.6). No accuracy metrics are therefore reported. Agreement with NOAA’s embedded statistics and the independent recomputation verify our processing, not the physical correctness of the inundation surfaces.
2. *Static, present-day landscape.* The rasters assume present topography and present tidal range. They omit erosion, accretion, marsh migration, subsidence, tidal-range change, groundwater emergence (Anderson et al., 2018), storm surge and waves. Flood defenses and drainage are represented only insofar as they are captured in the DEM, and engineered flow paths (culverts, tide gates) are not represented (NOAA Office for Coastal Management, 2017; Seenath et al., 2016).
3. *Connectivity rule.* Only ocean-connected inundation is counted; unconnected low-lying areas below the water surface, which NOAA distributes separately, are excluded. Exposure may therefore be underestimated where water can reach such areas through unmapped culverts, and overestimated where connectivity runs through features that would in practice block flow (Poulter and Halpin, 2008).
4. *Vertical uncertainty.* NOAA does not report a tested vertical accuracy for the Connecticut DEM. Our ± 0.5 -ft bracket is a sensitivity test, not a probabilistic interval. A formal treatment would propagate DEM and VDatum errors (Leon et al., 2014; Gesch, 2018).
5. *Land-cover interpretation.* The C-CAP land cover represents summer 2016, while the inundation surfaces use 2023 lidar. Class accuracy varies (85.3% overall, with lower accuracy for some wetland classes), and nearest-neighbour sampling assigns each ~ 3 m cell a single class. “Developed” denotes impervious surface or managed open space, not buildings, parcels or assets, and no damage, population or property estimates are made.
6. *Mapping domain.* Municipalities outside NOAA’s five-county DEM are not mapped. On physical grounds their exposure to tidal inundation within 10 ft of MHHW is expected to be negligible, but this was not tested here.
7. *Scenario interpretation.* Increments are expressed above present MHHW and are not tied to particular years. Mapping them to time requires a specific projection and emissions or likelihood assumption (Sweet et al., 2022; O’Donnell, 2018).

8. *Resolution experiment.* Aggregating NOAA’s outputs does not reproduce the full effect of mapping from a coarser DEM, which would also change connectivity.

7 Conclusion

Using NOAA’s current Connecticut inundation-extent rasters and official municipal boundaries, we estimate that 34.7 km² of land across 45 municipalities would lie below MHHW plus 1 ft. The figure rises to 51.3 km² at 2 ft and 133.3 km² across 52 municipalities at 6 ft. About seven-tenths of this area is in the 24 Long Island Sound shoreline municipalities, with Old Saybrook the most exposed in proportion to its land area at every increment. At 1 and 2 ft, most of the newly inundated area is existing tidal marsh and developed land makes up 3% and 6% of the total; at 6 ft developed land rises to 27%. These are screening-level estimates of potential permanent high-tide inundation, not forecasts. Three practical lessons follow for anyone producing municipal tabulations from such products. Present-day water must be masked, or exposure is overstated roughly five- to fifteen-fold. Rankings must be reported with the scenario and metric stated, because they change materially across both. And low-increment results are sensitive to small vertical errors. The coordinate-based scores of the original dashboard should not be used as estimates of flooding. The reproducible tabulation provided here can serve instead as a transparent starting point for more detailed, locally validated assessments.

Data and code availability

All source data are publicly available from their providers and are not redistributed. The NOAA OCM Connecticut extent rasters are available at https://coast.noaa.gov/slrdata/Extent_Rasters/CT/index.html (downloaded 20 October 2026). The U.S. Census Bureau 2020 TIGER/Line county subdivisions are available at https://www2.census.gov/geo/tiger/TIGER2020/COUSUB/tl_2020_09_cousub.zip. SHA-256 checksums of every input file are recorded in the reproducibility package. The analysis code, environment specification, complete output tables for all municipalities and increments, figures, and data documentation are archived on Zenodo at 10.5281/zenodo.23522958. The original dashboard is available at https://github.com/aravmestry/ct_coastal_model (commit d274545).

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