MEMORANDUM

TO:	Patricia Bowie, Kathryn Glenn; Office of Coastal Zone Management
FROM:	Frank Ricciardi, Robert Almy; Weston & Sampson; Erin Healy, Mark Mahoney; Anchor QEA, LLC
DATE:	February 29, 2016
SUBJECT:	Lynn Coastal Resiliency Assessment: Task 2 Technical Memorandum
CC:	Jim Cowdell, Bill Bochnak, Mary Jane Smalley; Lynn EDIC

The City of Lynn Economic Development and Industrial Corporation (EDIC) is completing a community-based process to assess vulnerability and plan for adaptation to future climatic conditions, specifically along the Lynn shoreline and Saugus River areas. The project is funded through a grant provided by the Coastal Community Resilience Grant Program of the Massachusetts Office of Coastal Zone Management (MACZM). The overall goal of this project is to improve coastal resiliency, which refers to the capacity of shoreline areas to protect and preserve infrastructure and other socioeconomic resources in response to predicted sea level rise (SLR) and increased frequency and intensity of coastal storms.

The process to improve coastal resiliency will include identifying management measures that can be integrated into ongoing hazard mitigation efforts and waterfront development plans, as well as prioritizing new infrastructure projects and retrofits. The Lynn shoreline has a number of areas that need careful consideration and mitigation to accommodate changing climatic and sea level conditions. The Coastal Community Resilience Grant will allow the City to prioritize and focus on projects that will have the greatest benefits in terms of adaptation.

This technical memorandum summarizes progress made during Task 1 of the project, which includes the following:

- Synthesis of available relevant technical analyses and reports
- Compilation of data into a Geographic Information System (GIS)
- Development of study scenarios
- Preliminary review of relevant regulations

SYNTHESIS OF AVAILABLE RELEVANT TECHNICAL ANALYSES AND REPORTS

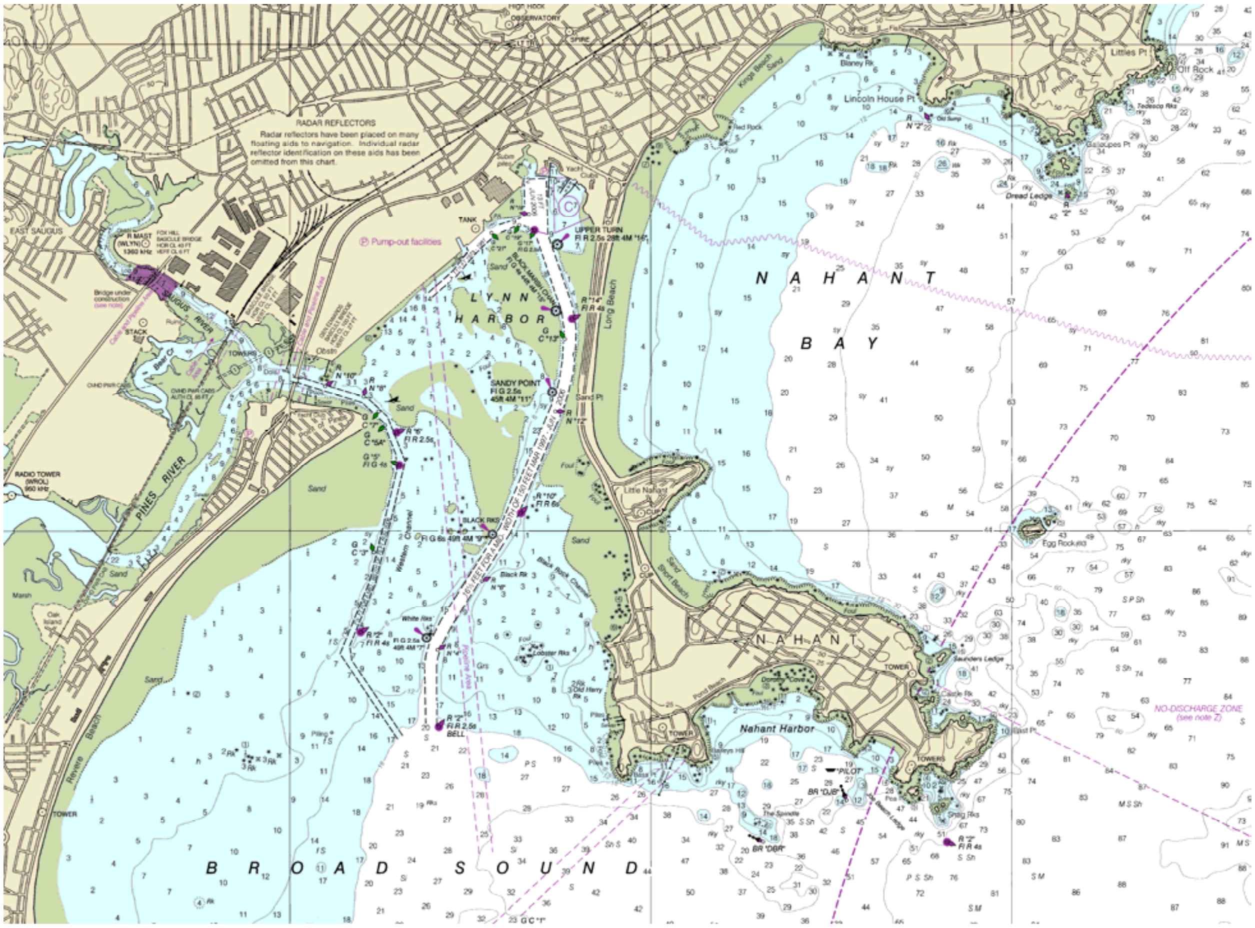
This section summarizes available technical reports relevant to the environmental setting of coastal Lynn and coastal oceanographic processes that could factor into the effects of future SLR and storm surges on the Lynn shoreline.

Coastal Geomorphology

Lynn is located north of Boston, along a southeast-facing shoreline, as shown on the National Oceanic and Atmospheric Administration (NOAA) navigation chart for the Lynn coastline provided in Figure 1. The Nahant Causeway connects Nahant to the mainland at Lynn and separates the Lynn shoreline into northern and southern sections. The Nahant Causeway runs on top of a tombolo, which is a natural geologic deposit that connects an offshore deposit to the mainland. The causeway provides a natural barrier that shields Lynn Harbor from the open Atlantic Ocean.

Most of the Lynn shoreline is protected by hard infrastructure. North of the Nahant Causeway, a seawall runs along the edge of Lynn Shore Drive. Sandy beaches (Kings and Lynn beaches) and rocky intertidal areas (Red Rock Park) lie between the seawall and the ocean. Land use is primarily single- and multi-family residential, and beach areas (City of Lynn 2005). The approximately 4-mile-long shoreline is on Nahant Bay, which opens to the Atlantic Ocean.

Seawalls and bulkheads of varying types and condition run along the Lynn shoreline south of the Nahant Causeway. Soft features, such as beaches and tidal flats are also present on the water side of the seawalls (MassGIS Moris 2016). Land use is industrial intermixed with residential and commercial uses, vacant land, and Heritage State Park (City of Lynn 2005). Lynn Harbor lies between the Lynn shoreline and the Nahant Causeway and opens to Broad Sound to the south. The Saugus River discharges into the southern portion of Lynn Harbor.



Source: U.S. Department of Commerce et al. 2013

Figure 1 – Lynn Harbor and Nahant Bay Navigation Chart

Navigation

Lynn Harbor is accessed from Broad Sound via a main navigational channel (depth of -16.5 feet mean lower low water [MLLW] at mid-channel and 150 feet wide), as illustrated in Figure 1. The navigation channel leads from Broad Sound to the turning basin at the head of Lynn Harbor. The turning basin depths range from 13 to 16 feet. A privately maintained subsidiary channel leads west from the turning basin along a portion of the Lynn shoreline.

A smaller navigational channel (-7.5 feet MLLW depth at mid-channel and 75 feet wide) leads from Broad Sound to the mouth of the Saugus River. Navigational water depths decrease with distance upstream in the Saugus River.

Significant areas of tidal flats along the entrance to and within Lynn Harbor are exposed during low tide. An approximate 10-foot change in tidal elevation occurs between MLLW and mean higher high water (MHHW).

Historical Shorelines

Massachusetts shorelines from the mid-1800s to 2009 were mapped as part of the *Massachusetts Shoreline Change Mapping and Analysis Project* (USGS and MACZM 2013), a joint effort by the U.S. Geological Survey (USGS) and MACZM. The map included in Figure 2 shows the shoreline locations over time for the Lynn coastline.

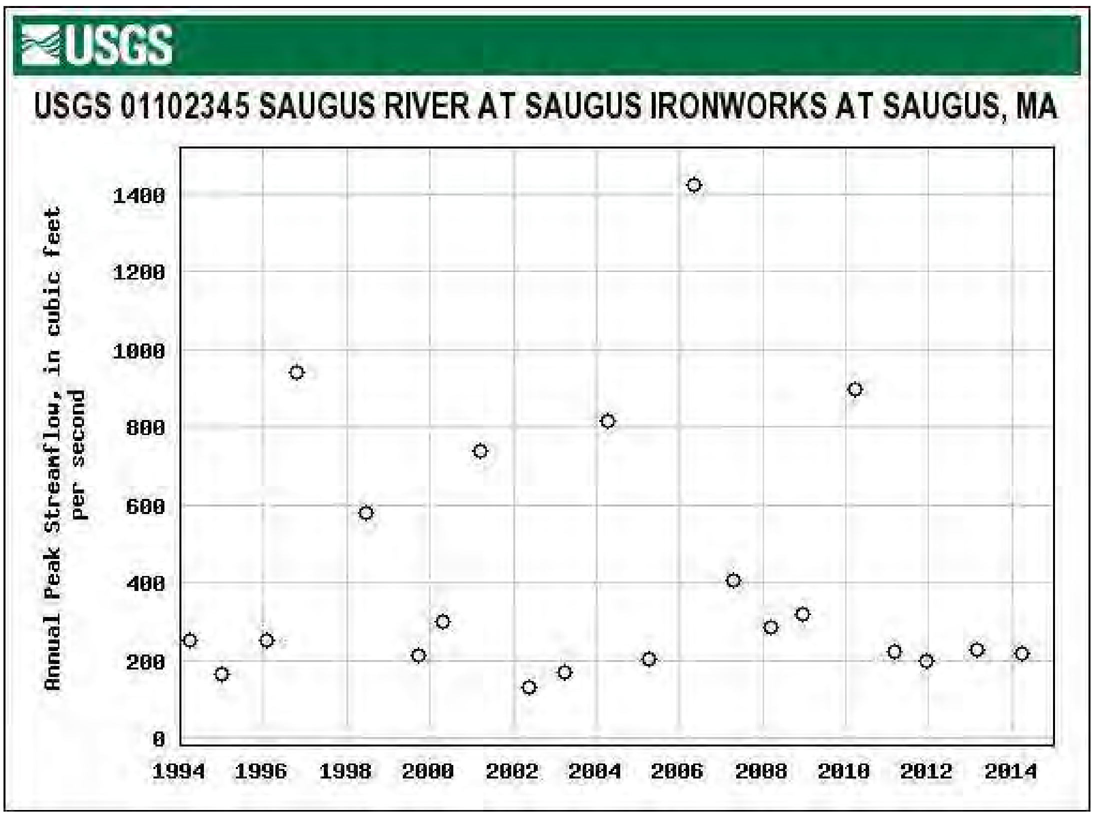
North of the Nahant Causeway, the shoreline has been relatively stable over time. South of the causeway, significant filling occurred along the Lynn shoreline down to the mouth of the Saugus River near the beginning of the 20th century. Following filling, the shoreline was hardened with protective structures, and piers and docks were constructed.

Source: MassGIS 2016

Figure 2 – History of Lynn Shoreline Changes

Saugus River

The Saugus River discharges to the southern portion of Lynn Harbor and forms the boundary between the cities of Lynn and Revere. The Saugus River watershed, including its Pine River tributary, covers an area of approximately 47 square miles (USACE 1989a). The Saugus River originates at the outfall of Lake Quannapowitt in Wakefield and flows southeast until it discharges at Lynn. The lower approximately 4.7 miles of the river are a tidal estuary. Rumney Marsh, which was designated as an Area of Critical Environmental Concern in 1988, is located on the south shore of the river, and extends from the Boston Street Bridge to the mouth of the river (LeBlanc 2013). A USGS stream gauge (No. 01102345) is located at Saugus Ironworks and has been used to collect stage and discharge data since March 1994. Annual peak streamflows are illustrated in Figure 3. Salt water influence on the river extends upstream to this gauge.



Source: USGS 2016

Figure 3 – U.S. Geological Survey Stream Gauge at Saugus Ironworks

Coastal Oceanographic Processes

The Nahant Causeway forms a breakwater sheltering Lynn Harbor from the Atlantic Ocean. North of the causeway, the Lynn shoreline is open to the Atlantic Ocean, although Nahant provides some protection to Nahant Bay. The hardened nature of the Lynn shoreline has affected sediment transport processes. However, there is a general southwest to northeast direction of sediment transport in the vicinity of Lynn due to exposure to waves from Broad Sound on the south, and partial sheltering by Nahant Causeway to the east (USACE 1994).

History of Storms, Flooding, Erosion, and Coastal Damages

The New England coastline, including Lynn, is affected by tropical (hurricanes) and extratropical (nor'easters) storms. The main causes of wave and storm surge within Broad Sound are the nor'easters that travel northeast along the Atlantic coast and produce highest winds from the east and north (USACE 1994). Wave propagation within Broad Sound is characterized by complex refraction and diffraction processes due to Nahant Causeway, Winthrop Heights headland, and irregular bathymetry. The sheltering of Lynn by Nahant Causeway significantly decreases wave heights within Lynn Harbor. However, during the February 1978 nor'easter storm (Blizzard of 1978), the Nahant Causeway was overtopped, record high tides flooded thousands of homes and buildings, knocked out electricity, and forced the emergency evacuation of more than 4,000 people in Lynn (USACE 1989b). Record flood depths were up to 7 feet and caused damage to thousands of buildings. The storm was considered a 100-year storm event.

Tropical hurricanes also hit New England and can be stronger than nor'easters but are less common in the northeast. Hurricane Bob in 1991 was the last major hurricane to hit New England, and the Lynn area was spared the major devastation of Hurricane Sandy by a slight shift of the storm trajectory. Hurricanes typically travel from south to north, and Lynn would be susceptible to a storm surge traveling from the south into Lynn Harbor.

In addition to severe storms discussed in this memorandum, the area is impacted by smaller storm events that cause coastal flooding.

COMPILATION OF DATA INTO GIS

To support the vulnerability and risk assessment, data from several sources have been compiled into GIS. These data include infrastructure and natural resources and encompass the shoreline and Saugus River areas. The data and their sources are listed in Table 1.

Table 1 – City of Lynn GIS Data Summary

Data File Name	Data Description
Data from City of Lynn (CAI)[1]	
Building_arc.shp	Reduced set (215) of building outlines—lines
Building_poly.shp	Reduced set (215) of building outlines—polygon
Condo_points.shp	Condominium parcel information
dualzones.shp	Zoning along east Lynn coast
index_arc.shp	Map set grid—lines
index_poly.shp	Map set grid—polygon
miscline_arc.shp	Miscellaneous line, such as paths, easements, shorelines, railroad row, and parcels
parcel_arc.shp	Parcel boundaries—line
parcel_poly.shp	Parcel boundaries—polygon
QMOnline_Streets.shp	Street centerlines (with names)
RoaadNames.shp	Road name anno as line
Roads.shp	Roadway right-of-way
tanno.shp	(unclear)
townline.shp	Town boundary—line
water_arc.shp	Streams and shorelines of waterbodies ponds/rivers merged with town boundary—line
water_poly.shp	Waterbodies ponds/rivers—polygon
zoning_overlay.shp	Set of 5 zoning overlay districts along the east Lynn coast and into the Central Business District
brooks.shp	Streams—partial coincidence with water_arc.shp
coordinates.shp	Tick marks expressed in latitude/longitude whole minutes, single minute increments
dualzones-proposed.shp	Duplicate of dualzones.shp
Dualzones.shp	Duplicate of dualzones.shp
easements.shp	Easement extents and dimension annotations
ease_poly.shp	Reduced set of easement (27) as polygons
golf.shp	Gannon golf course
hilltops.shp	Named high points
linklines.shp	(unclear)
Lynn_Hydro.shp	Waterbodies ponds/lakes/swamps some named
Lynn_RR.shp	Railroad centerlines
misc.shp	Miscellaneous lines—ball fields, Lynn English High School walks
parcel_ward_info2.shp	(corrupt—cannot open)

1 Cartographic Associates, Inc. (CAI), is the GIS service provider for the City of Lynn.

Data File Name	Data Description
paths.shp	Trails in Lynn Woods, cemeteries, and walkways of Lynn English High School
playground-pt.shp	Playground locations with names—point
precinct-line.shp	Ward/precinct boundary—lines
precinct.shp	Ward/precinct boundary—polygon
riveredge.shp	Waterbodies ponds/lakes as diminishing non-concentric shapes—line
road-line-lynn_only.shp	Roadway right-of-way—mostly identical to Road.shp but some differences exist
row.shp	Paper street rights-of-way with annotation—line
RRD.shp	Residential reuse district and Central Business District intersection
schools.shp	School locations, named and type—point
SOBuffer.shp	Buffer from parcels with sex offender restrictions (does not include Lynn Woods)—polygon
sobuffer1000.shp	1,000-foot buffer from parcels with sex offender restrictions (includes Lynn Woods)—polygon
sobuffer500.shp	500-foot buffer from parcels with sex offender restrictions (includes Lynn Woods)—polygon
SORestrictions.shp	Parcels with sex offender restrictions
squares2.shp	Named major road intersections (56)—point
street-names.shp	Road annotation—line
towns.shp	All towns in Massachusetts—polygon
towns_local.shp	Lynn and surrounding communities boundaries south to Chelsea, North to Beverly, west to Reading—polygon
towns_local_lines.shp	Lynn and surrounding communities boundaries south to Chelsea, North to Beverly, west to Reading—line
town_bound_par.shp	City boundary—polygon
ward-labels.shp	28 ward and precinct labels—point
ward-line.shp	Ward boundary—line
ward.shp	Seven ward boundaries—polygon
wsco2.shp	Washington Street and Sagamore Hill district bounds—polygon
zoning_overlays_proposed.shp	Set of four zoning overlay districts along the east Lynn coast into the Central Business District
hp163.shp	3-meter contours
eotroads_163.shp	Street centerlines
*.tif files	Light Detection and Ranging (LiDAR) data

Data File Name	Data Description
Data from City of Lynn (Utility data is East Lynn only unless noted) [2]	
Sewer_Utility_Lines.shp	Sewer mains, combined and separated—lines
buildings.shp	Building—polygon
contours.shp	1-foot contours (full city)—line
Curbs.shp	Curb or edge of pavement (full city)—line
dtm.shp	Digital terrain model spot elevations (full city)—point
Paved_Driveway.shp	Paved driveway bounds (full city)—line
Paved_Parking.shp	Paved parking areas/lots (full city)—line
rr.shp	Railroad tracks (full city)—line
Unpaved_Driveway.shp	Unpaved driveway bounds (full city)—line
Unpaved_Parking.shp	Unpaved parking areas/lots (full city)—line
veg.shp	Tree/shrub lines (full city)—line
vegpts.shp	Tree points (full city)—point
CSO_Outfall.shp	Combined sewer overflow outfalls (7)—point
Stormwat.shp	Stormwater outfalls (17)—point
Zoning_Cama_Parcel_2_7_2006.shp	Cama parcels (full city)—polygon
Catch_Basins.shp	Drainage catch basins—point
Lynn_Boundary.shp	City boundary (full city)—polygon
HydrantPartialJan28_2013_2.shp	Hydrant locations—point
EOTROADS_ARC_163.shp	Road centerlines (full city)—line (coordinate system needs correcting)
Lynn_Roads.shp	Road centerlines (full city)—line
SewerLines.shp	Sewer mains, combined and separated, includes portions along commercial, cottage, bennet, and others—lines
SewerPoints.shp	Sewer manholes, drain catchment basins and other points corresponding to SewerLines.shp—point
Lynn_Sewer_Drain_Overview_dwg_Polyline.shp	CADD file export of all lines; Neds projection definition—line
WaterLines.shp	Water mains w/ diameter (mostly known) and material (mostly unknown)—line
WaterPoints.shp	Hydrants, gate valves, manhole locations—point
WaterPoints.shp	Duplicate of WaterPoints.shp
*.sid files	Raster data—ortho photographs of various quality and age
MWRAWaterFittings	MWRA[3] water fittings—point

2 City of Lynn is in the process of completing entry of utility data in its GIS for all City areas.
3 Massachusetts Water Resources Authority

Data File Name	Data Description
MWRAWaterMeters	MWRA water meters—point
MWRAWaterPipes	MWRA water pipes—line
Reported_Backup	Reported sewer backups with address and resolution, 2013 and some 2014 (27)—point
SSO_ReportedBackups2014	Reported sewer backups with address and resolution, 2014 (179)—point
Data from MORIS (Massachusetts Ocean Resource Information System)	
MORIS_BATHY_FATHOMS_POLY.shp	Bathymetry in number of fathoms—polygon
FEMA NHFL	Federal Emergency Management Agency National Flood Hazard Layer—polygon
MORIS_SHORELINES_ARC.shp	Highwater shorelines—line
MORIS_TRANSECTS_ARC.shp	Shoreline change transcects—line
MORIS_CSI_PRIVATE_ARC.shp	Private shoreline stabilization structures—line
MORIS_CSI_PUBLIC_ARC.shp	Public shoreline stabilization structures—line

STUDY SCENARIOS

This section presents the proposed scenarios to evaluate future effects of changing climate and predicted SLR on the Lynn shoreline, with the objective of providing information to support planning to improve coastal resiliency. Based on these scenarios, inundation maps will be developed depicting the depth and extent of inundation under the identified scenarios.

Technical Approach

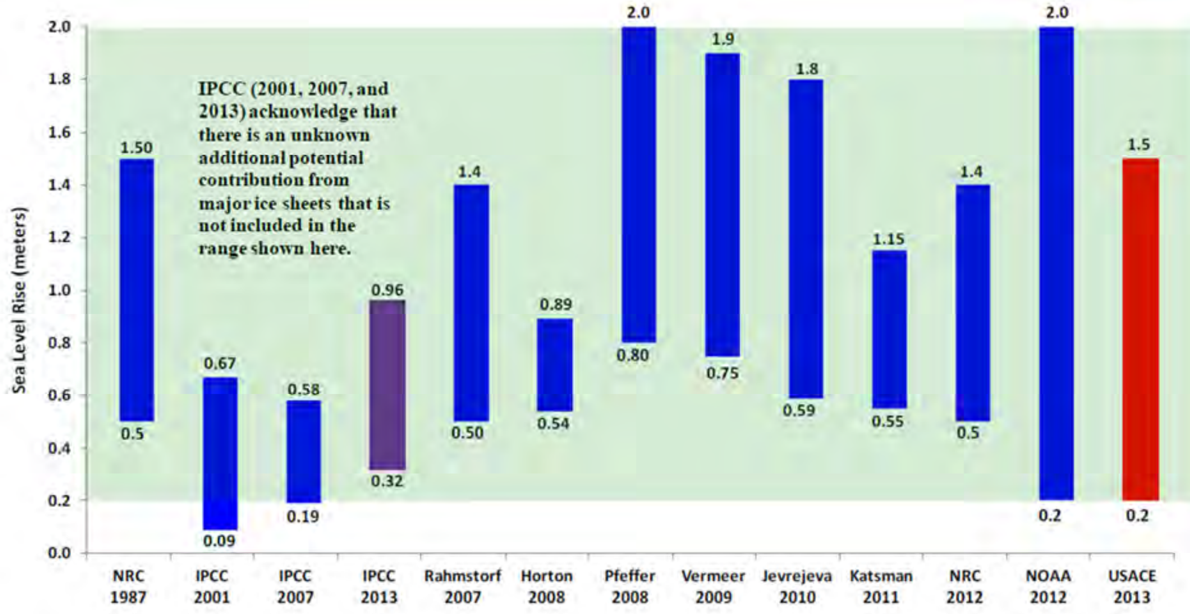
Our approach is based on *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning* (MACZM 2013) and *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris et al. 2012), the latter being the guidance developed by NOAA and other federal agencies. We also reviewed the U.S. Army Corps of Engineers' (USACE's) engineering technical guidance on evaluating SLR (USACE 2014). The elements of the scenarios are described below.

Sea Level Rise Scenarios

Future SLR is a combination of local/regional SLR due to land subsidence/uplift or regional oceanographic changes, plus global SLR, which is due to climate change effects. These two elements are discussed in the following sections.

Global Sea Level Rise

Global SLR is the projection of estimated future SLR due to the effects of climate change, including increased sea water temperature and ice sheet melt. A wide range of estimates have been developed by scientists throughout the world, as depicted in Figure 4.

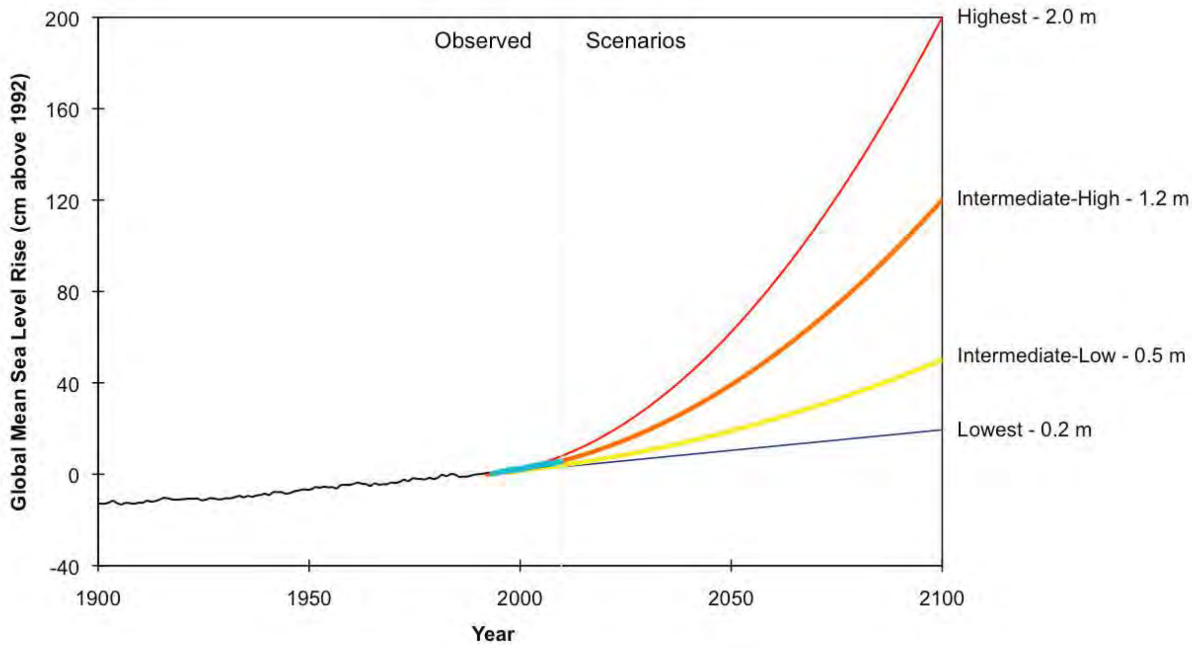


Source: USACE 2014

Figure 4 – Comparison of Maximum and Minimum Estimates of Global SLR by the Year 2100

In Parris et al. (2012), United States agencies, led by NOAA (and including USGS, Department of Defense, and USACE), considered available climate assessment data, including the Intergovernmental Panel on Climate Change (IPCC) *Fourth Assessment Report* (IPCC 2007), and identified four global SLR scenarios, which are described below and depicted in Figure 5:

- **Highest Global SLR.** Calculated based on estimated ocean warming (IPCC 2007) and maximum possible glacier and ice sheet loss by the end of the century. This is the most extreme scenario and is only appropriate for situations with little tolerance for risk (e.g., new critical infrastructure with a long anticipated life cycle, such as a power plant).
- **Intermediate-High Global SLR.** Average of high end of semi-empirical, global SLR projections based on statistical relationship between ice sheet loss and air temperature.
- **Intermediate-Low Global SLR.** Based on upper end of IPCC (2007) global SLR projections. This scenario is based primarily on ocean warming with little ice sheet melt.
- **Lowest Global SLR.** Based on historical (1900 to 2009) global SLR rate (1.7± 0.2 millimeters per year [mm/yr]) and assumes rates of ocean warming similar to recent trends.



Source: Parris et al. 2012

Figure 5 – National Climate Assessment Global Sea Level Rise Scenario Projections

Local/Regional SLR

Local/regional SLR can be determined based on local historical tide gage data. This SLR rate is estimated as a linear trend based on historical water level data and includes local/regional land subsidence or uplift, and regional oceanographic changes such as changes in circulation patterns. We propose to use the Boston, Massachusetts, tide gage station data from 1921 to 2014, which provides both a location close to Lynn (9 miles distance) and long-term data required to identify trends (Table 2).

Table 2 – Local/Regional Sea Level Rise—Boston, Massachusetts

Station	Mean Sea Level Trend and 95% Confidence Interval		Period	Century Rate (feet/100 years)
	Millimeter/Year	Inch/Year		
Boston, Massachusetts	2.81 ± 0.17	0.11 ± 0.007	1921 to 2014	0.92

Source: NOAA 2016

For the Lynn assessment, we recommend using the NOAA Intermediate-High Global SLR and the Lowest Global SLR projections to estimate future SLR conditions. The NOAA Intermediate-

High Global SLR projection accounts for both ice sheet loss and increased air temperature effects and provides a reasonably conservative upper bound SLR scenario for planning purposes. Note that although this is a high-end scenario, it is not the worst-case NOAA Highest Global SLR, which is a lower probablity projection, and is intended to assess critical infrastructure and resources with very small tolerance for risk and long operational life cycles. The Lowest Global SLR projection is useful as a baseline evaluation for near-term vulnerability analysis. We recommend the above range partially due to the uncertainties surrounding SLR data and interpretions in scientific circles.

By comparing the global SLR historical rate of 1.7 mm/yr and the local/regional SLR historical rate of 2.81 mm/yr, local/regional effects (such as land subsidence) can be estimated to be approximately 1.1 mm/yr (2.8 mm/yr to 1.7 mm/yr). This rate will be added to the scenarios outlined above in order to account local/regional effects.

To calculate SLR, we will follow methods outlined in Parris et al. (2012) and MACZM (2013). In addition, we may use the USACE Sea Level Change Curve Calculator (http://corpsclimate.us/ccaceslcurves.cfm) to generate SLR projections and perform additional calculations as needed.

Sea Level Rise Time Horizons

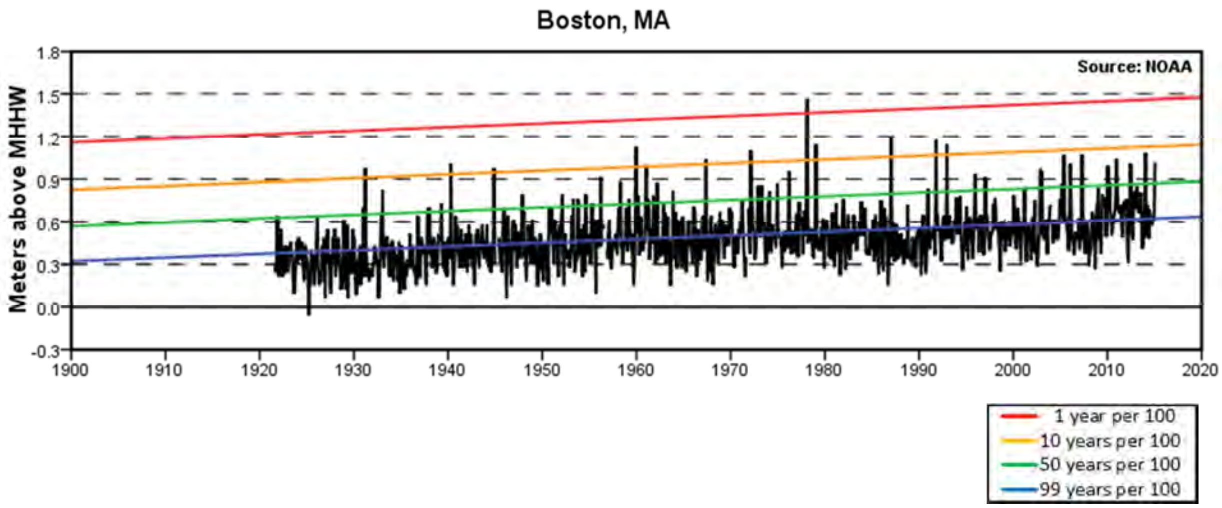
We propose mapping inundation for the following time periods:

- **2041 (25 years from 2016).** Twenty-five years is useful to evaluate future impacts on existing infrastructure and will be used to support shorter term adaptation planning. This also provides a timeframe for tracking future SLR trends and making any refinements to adaptation planning that may be needed if SLR trends differ from the current understanding.
- **2066 (50 years from 2016).** Fifty years is the approximate average service life for municipal infrastructure and is useful for longer term adaptation planning

Therefore, as previously discussed, due to the level of uncertainty, we are not currently preparing inundation maps for the 100-year time horizon (2116). As shown in Figure 5, the estimated projections vary widely at this time horizon, reflecting the very high level of uncertainty associated with forecasting 100 years out. Further, 100 years is beyond the anticipated life cycle of most municipal infrastructure.

Storm Surge Consideration

Storm surges pose a significant threat to coastal resources, particularly when combined with rising sea levels. Water levels in Boston Harbor since 1920 and return rate of those storms are illustrated in Figure 6. The Blizzard of 1978, which was a 100-year storm with a 1% probability of occurrence, is the highest water level on the graph.



MHHW = Mean Higher High Water, average height of the higher high waters over a 19-year period
1 year per 100 is equivalent to a 1% probability of a storm occurring in any 1 year; 10 years per 100 is 10%.
Source: USACE 2014

Figure 6 – Monthly Mean Sea Level Time Series (Boston Tide Gage)

We propose to consider storm surges with 1% probability (100-year return) and the 10% probability (10-year return) in inundation analyses. The effects of storm surge and the resultant water level elevations and inundation will be evaluated based on several lines of evidence. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, which estimates storm surge based on several thousand hypothetical hurricanes, will be the basis of the evaluation. The results of the analysis will be compared with known flooding events associated with nor'easters that have occurred in the area, such as the Blizzard of 1978 or the 1991 "No Name" storm. The sensitivity of the shoreline to erosional effects will be evaluated, and the effects of wave run up associated with storms will be calculated where relevant. The possible effects of Saugus River flows will be considered in a more qualitative manner. The evaluation will also include a full discussion of uncertainties associated with each line of evidence and the overall estimate of inundation.

SUMMARY OF RELEVANT CITY OF LYNN REGULATIONS

Planning and regulatory documents are some of the tools the City has to address risk due to predicted SLR. As part of this coastal resiliency assessment, local regulations and plans will be reviewed, and opportunities will be identified to revise existing plans and make regulatory modifications that could increase coastal resiliency. In general, the types of regulatory changes would pertain to land use, zoning, and building codes.

In Task 1, the regulations and plans were identified. These will be further reviewed, and recommendations for modifications will be developed in Tasks 2 and 3.

The following is a list of local regulations and plans that are identified for review, and additional details on each are provided in Table 3:

- City of Lynn General Wetlands Protection By-Laws (Lynn Conservation Commission Regulations)
- City of Lynn Zoning Ordinance (2009)
- Site Plan Review (Section 16B) Waterfront Zone Site Plan Review Committee
- City of Lynn Open Space and Recreation Plan
- City of Lynn Hazard Mitigation Plan, 2013 Plan Update
- City of Lynn Waterfront Master Plan

In addition, other local regulations and plans that will be reviewed include the following:

- Massachusetts Building Codes (adopted by the City of Lynn)
- City of Lynn EDIC Economic Development Plan (2005)
- Lynn Harbor Coastal Survey (map)
- Lynn Habitats (map)
- Lynn Protected Open Space (map)
- Lynn Waterfront Growth District (map)
- Lynn Zoning (map)
- Lynn Shore Map (Massachusetts Department of Conservation and Recreation)

Table 4 – Local Regulations and Planning Document Summary

Planning Document	Section	Title	Scope of Section
General Wetlands Protection By-Law (2001)	I.	Purpose	Protect wetlands consistent with State Law
	II.	Areas Subject to Jurisdiction	General description
	III.	Notice of Intent	Defines basis of analysis
	VII.	NOI and Conditions	Basis for requiring mitigation and Order of Conditions
	XX.	Design Criteria	Calculation of impacts, detention/retention basin design, riprap
	XXI.	Performance Standards	Areas protected, replication of damaged areas, calculation of flooded areas, vernal pools, lands within 100 feet, drainage restrictions
	Appendix A	Definitions	
Priority Habitats Map (2008)		City of Lynn, Priority Habitats and Estimated Habitats	Delineates habitats for rare species
Zone Ordinance (2009)	1	Purpose	Regulates use, construction, and repair of buildings
	2	Definitions	
	3	Establishment of Districts	Establishes and delineates districts shown on the City Zoning Map
	4	Use Regulations	Defines permitted uses for each district
	7	Non-Conforming Uses	Provides for rebuilding non-conforming structures if damaged under certain conditions
	12	Special Permits	Establishes process for City Council to permit certain uses not provided in zoning
	16	Site Plan Review	Defines process and submittal requirements for site plans, review criteria Establishes Waterfront Zone Site Plan Review Committee and process
Lynn Zoning Map (2011)		Zoning Map, City of Lynn	Delineates zoning districts at the individual parcel level

Table 4 Continued

Open Space and Recreation Plan (2005)	II.A	Statement of Purpose	Identifies open space and recreational needs of City residents, identifies methods to protect natural resources
	IV.	Environmental Inventory and Analysis	Describes topographic, geologic characteristics of the City with a summary of hydrologic and biologic resources
	IV.C	Water Resources	Briefly discusses flood zones and waterfront from a recreation perspective
	IV.G	Environmental Challenges (vision)	Identifies steep slopes along the Saugus River subject to erosion and sites that have subsurface contamination
	VII.C	Management Needs, Potential Change in Use	Summarizes challenges due to staffing restrictions and constraints to change in use at existing sites
	VIII	Goals and Objectives	Improve access to water front areas Provide incentives to private waterfront recreation
	IX	Five-Year Action Plan	Includes "Waterfront Improvements" as a 6.5-acre public park and "Saugus River" as "conserve and utilize open spaces"
Protected Open Space Map (2008)		Protected Open Space, City of Lynn	Delineates open space, public ownership (municipal/state) and wetlands/ponds
Hazard Mitigation Plan (2012)	IV	Risk Assessment	Based on available (2012) hazard and land use data, identified critical infrastructure, assessed the potential areas of flooding per FEMA flood zones
	VIII	Hazard Mitigation Strategy	Contains new measures and measures carried forward from the 2005 plan; all measures prioritized based on current conditions
	Appendix B	Hazard Mapping	Shows flood zones and critical infrastructure, as well as composite hazard delineation
Waterfront Master Plan Report (2007)	2	Existing Conditions	Describes built environment along ocean front
	2	Environmental Issues	Provides a general discussion of site contamination issues in waterfront parcels
	3	Design Guidelines	Provide general guidance for buildings and roadways focusing of aesthetics
Waterfront Growth District (2011)		Waterfront Growth District in Lynn	Formerly delineates the area addressed in the Waterfront Mater Plan Report

Although recommendations will not be developed to modify federal and state regulations, it will be important to understand these regulatory frameworks that are relevant to coastal areas. These regulations are listed below.

Federal Regulations and Orders

- Coastal Zone Management Act
- NOAA Federal Consistency Rules
- Federal Emergency Management Agency, National Flood Insurance Program
- USACE, Regulation ER 1100-2-8162
- Floodplain Management, Executive Order, May 24, 1977
- Preparing the United States for the Impacts of Climate Change, Executive Order, (November 1, 2013)

Massachusetts State Regulations

- Oceans Act of 2008
- 301 Code of Massachusetts Regulations (CMR) 28.00 Implementing Regulations for the Ocean Management Plan
- 301 CMR 20.00: Coastal Zone Management Program
- Massachusetts Wetlands Protection Act (M.G.L. Chapter 131, Section 40)
- 310 CMR 10.00 Implementing Regulations for the Wetlands Protection Act
- Massachusetts Office of Coastal Zone Management Policy Guide – October 2011
- Massachusetts Environmental Policy Act (MEPA) 301 CMR 11.00
- 301 CMR 22.00: Coastal Facilities Improvement Program and Harbor Planning Program
- 301 CMR 23.00: Review and Approval of Municipal Harbor Plans
- Chapter 91 Public Use of Tidelands and other Public Waterways
- Massachusetts Contingency Plan (MCP) 310 CMR 40.00
- Ocean Development Mitigation Fee
- Ocean Resources and Waterways Trust Implementation Guidelines
- Global Warming Solutions Act of 2008
- Water Quality certification (Section 404 CWA)

REFERENCES

City of Lynn, 2005. *City of Lynn Open Space & Recreation Plan Update IV*. Prepared by the City of Lynn Office of Economic and Community Development, Park Department, and Inspectional Services – Planning Division. July 2005.

IPCC (Intergovernmental Panel on Climate Change), 2007. *Fourth Assessment Report*.

LeBlanc, Joan, 2013. *Saugus River Watershed Water Quality Monitoring Program, 2013-2016 Quality Assurance Project Plan*. May 9, 2013.

MACZM (Massachusetts Office of Coastal Zone Management), 2013. *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning*. December 2013.

MassGIS (Massachusetts Department of Energy and Environmental Affairs), 2016. Massachusetts Shoreline Change Browser. Accessed: January 2016. Available from: http://maps.massgis.state.ma.us/map_ol/czm_shorelines.php.

MassGIS Moris (Massachusetts Department of Energy and Environmental Affairs), 2016. Moris: CZM's Online Mapping Tool. Accessed: January 2016. Available from: http://maps.massgis.state.ma.us/map_ol/moris.php.

NOAA (National Oceanic and Atmospheric Administration), 2016. Tides and Current. Accessed: January 2016. Available from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8443970.

Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss, 2012. *Global Sea Level Rise Scenarios for the United States National Climate Assessment*. NOAA Tech Memorandum OAR CPO-1. December 6, 2012.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, and Coast Survey, 2013. Salem and Lynn Harbors. Chart 13275. Scale 1:25,000. November 2013. Updated October 28, 2015.

USACE (U.S. Army Corps of Engineers), 1989a. *Saugus River and Tributaries Flood Reduction Study – Appendix B: Hydrology and Hydraulics*. June 1989.

USACE, 1989b. *Flood Damage Reduction – Feasibility Report and Final Environmental Impact Statement/Report*. December 1989.

USACE, 1994. *Revere Beach and Point of Pines, Massachusetts, Shore Font Study*. Miscellaneous Paper CERC-94-1. USACE, Waterways Experiment Station. January 1994.

USACE, 2014. Engineer Technical Letter (ETL) 1100-2-1, Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation. June 30, 2014.

USGS and MACZM (U.S. Geological Survey and Massachusetts Office of Coastal Zone Management), 2013. *Massachusetts Shoreline Change Mapping and Analysis Project, 2013 Updat*e. Open File Report 2012-1189.

USGS (U.S. Geological Survey), 2016. Saugus River Streamflow Gauge at Saugus Ironworks. Accessed: January 2016. Available from: http://waterdata.usgs.gov/usa/nwis/uv?01102345.