Quality Assurance Project Plan
For the Town of North Beach
Compound Flood Action Plan

Effective Date: May 13, 2022

Prepared By:

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Sign and Date: _____

Approval

EPA Region 3

Name:
Title: R3 Delegated Approving Official
Organization:
Sign and Date: _____

Note: This approval action represents EPA's determination that the document(s) under review comply with applicable requirements of the EPA Region 3 Quality Management Plan [https://www.epa.gov/sites/default/files/2020-06/documents/r3qmp-final-r3-signatures-2020.pdf] and other applicable requirements in the EPA quality regulations and policies [https://www.epa.gov/quality]. This approval action does **not** represent EPA's verification of the accuracy or completeness of document(s) under review, and is **not** intended to constitute EPA direction of work by contractors, grantees, or subgrantees, or other non-EPA parties.

REVISION HISTORY

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the Quality Manager.

Table 1 – Revision History

Document Control Number	History/Changes	Effective Date
#1	Creation of document	05/13/2022

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1. PROJECT MANAGEMENT

1.1. Title, Approval Page, and Revision History

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1.2. Table of Contents

See Pages 4 - 5.

1.3. Distribution List

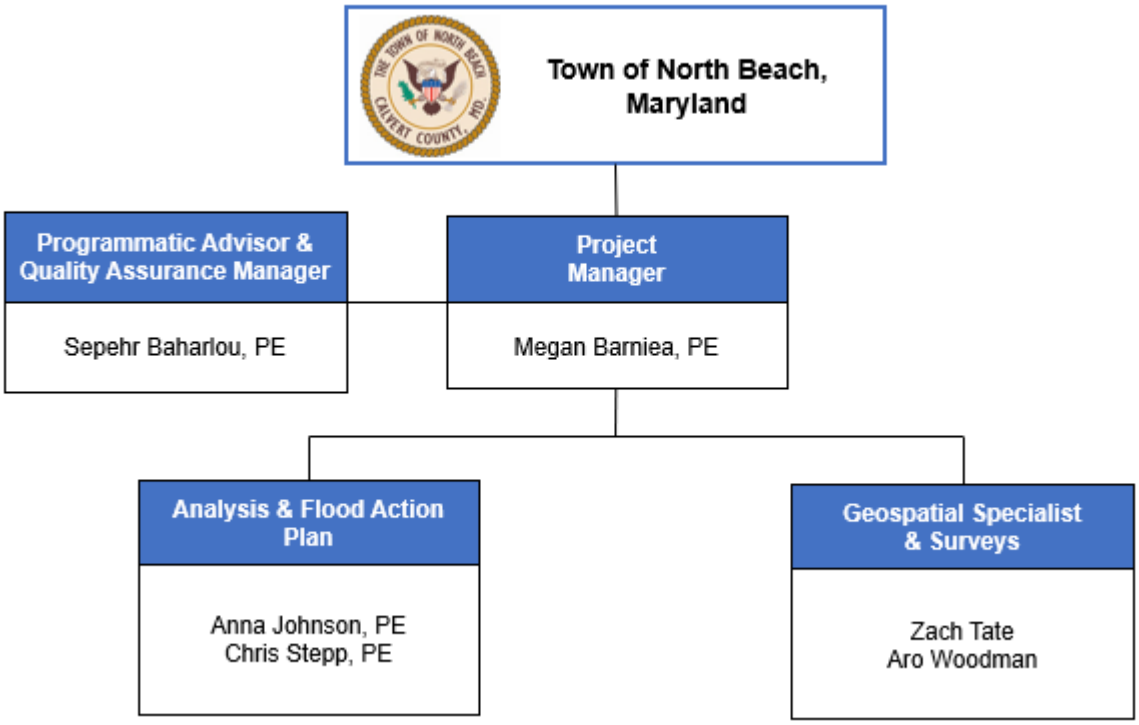
Table 2 – Distribution List

Name	Organization	Email
Stacy Milor	Town of North Beach	northbeach@northbeachmd.org
Don Bowen	Town of North Beach	dbowen@northbeachmd.org
Sasha Land	Maryland Department of Natural Resources (MD DNR)	Sasha.land@maryland.gov
Sepehr Baharlou, PE	BayLand Consultants & Designers, Inc. (BayLand)	sepehr@baylandinc.com
Megan Barniea, PE	BayLand	mbarniea@baylandinc.com
Anna Johnson, PE	BayLand	ajohnson@baylandinc.com

1.4. Project Organization

Table 3 – Project Organization			
Title & Responsibility	**Name**	**Agency Affiliation**	**Number & Email**
MD DNR Grant Manager – oversees grant award	Sasha Land Coastal Planner	MD DNR	410.260.8718 Sasha.land@maryland.gov
Town Clerk – oversees direction of project/Town grant management	Stacy Milor	Town of North Beach	443.646.2415 northbeach@northbeachmd.org
Director of Public Works – provides input on Town priorities related to flooding and mitigation strategies	Don Bowen Public Works Director	Town of North Beach	44.624.2161 dbowen@northbeachmd.org
Project Manager – directs day-to-day work of the project	Megan Barniea, PE Senior Project Manager	BayLand	410.694.9401 mbarniea@baylandinc.com
Programmatic Advisor and Quality Assurance Manager – oversees data quality assurance and maintains QAPP	Sepehr Baharlou, PE Principal	BayLand	410.694.9401 sepehr@baylandinc.com

Figure 1 – Project Organization Chart



1.5. Problem Definition and Project Background

Over the past several years, North Beach has experienced heavier and more frequent flooding from compound flooding events (i.e., coastal, and rainfall-induced). This repeated flooding from different sources has posed a significant nuisance to residents and businesses and caused considerable damage to homes, vehicles, businesses, and infrastructure. The flooding also diminishes quality of life for residents, tourists, and businesses and increases the amount of polluted runoff to the Chesapeake Bay and adjacent wetlands.

Sea level rise and increasing precipitation associated with climate change will only exacerbate current flooding problems in the Town and may necessitate more drastic flood mitigation measures over the long term.

This project seeks to address both coastal and rainfall-induced flooding issues with a comprehensive and compound flood action plan for the Project Area (Figure 2). The plan will incorporate current data where possible, including the 2018 Maryland Climate Change Commission Sea Level Rise Projections and the 2021 Draft Guidance for Using the 2018 SLR Projections. The plan will identify and characterize both coastal and stormwater flooding problems, assess the vulnerability of important assets to these hazards, identify solutions to mitigate the problems along with an implementation roadmap, outline ways to pay for these solutions, and include conceptual designs for mitigation in priority areas.

This compound flood action plan is a priority for the Town. Current mitigation measures include additional and/or mobile stormwater pumps, pump station upgrades, numerous outfall clean-up activities, citizen projects to eliminate debris and reduce runoff, a berm, and a road elevation project completed by the Maryland State Highway Administration. The Town also has an aggressive and active flood advisory committee, comprised of Town staff and residents, who have been working together to address flooding and to help sustain mitigation efforts over time.

Figure 2 – Town of North Beach Study Area

1.6. Project / Task Description and Schedule

The project team has developed a detailed program of work necessary to successfully complete the project design goals. This approach satisfies the scope of work and is consistent with the grant funding requirements. The work plan intends to focus most of our effort in developing solutions to alleviate flooding. Additionally, our scope of work closely follows the Flood and Sea Level Rise Action Plan Framework located in Appendix A.

Specific activities proposed include:

Task 1 - Project Initiation

- Review grant funding agencies' requirements.
- Attend virtual kickoff meeting with the Town representatives and other stakeholders to review scope of work, project timeframe and Plan's purpose and objectives
- Prepare and submit Quality Assurance Project Plan (QAPP) in accordance with the Environmental Protection Agency (EPA) requirements.
- Address EPA comments as necessary and obtain approval of QAPP from EPA Project Officer.

Task 2 - Information Gathering

- Collect data on historic flooding in North Beach.
- Review Town-provided as-built drawings, mitigation measures implemented, community input, and other relevant data.
- Utilize online resources, including but not limited to, State LiDAR, County GIS data, Maryland Environmental Resources and Land Information Network (MERLIN), Maryland DNR Coastal Atlas to create base map of existing conditions.
- Perform a field drainage assessment to photo document drainage characteristics, including but not limited to flow patterns, flooding, and erosion.
- Identify flooding extents and signs of infrastructure deterioration and failure.
- Document any locations suitable for new and/or retrofit SWM, green infrastructure BMPs, and other nature-based solutions to provide flood relief.
- Identify roadway, stormwater, and coastal locations and structures requiring a topographic survey.
- Perform a site investigation to field-verify this existing data provided by the Town using Real-Time Kinematic (RTK) Global Positioning System (GPS) data. Critical elevations of roadway and drainage infrastructure including but not limited to SWM BMPs; drainage infrastructure including culverts, storm drain inlets, manholes, and outfalls, and drainage swales as well as coastal infrastructure such as piers and bulkheads will be obtained and documented. Up to two days of a 2-man survey crew is budgeted for this task.
- Update base map to include surveyed data and other items noted form field investigations.

Task 3 - Identifying Challenges

- Develop current conditions hydrologic models with National Resources Conservation
- Service (NRCS) Technical Release-55 (TR-55) methodology and perform hydraulic
- analysis of existing stormwater infrastructure utilizing EPA-SWMM as necessary to
- identify and categorize any deficiencies.
- Identify flooding stressors from rainfall, tidal (nuisance) and storm surge flooding.
- Stressors include, but are not limited to:
  - Deficiencies in the stormwater infrastructure and/or coastal flood protection system;
  - Low-lying elevation;
  - Erosion;
  - Soil conditions and/or high water tables;
  - Land subsidence; and
  - Areas of significant impervious coverage.
- Participate in public meeting to solicit input on vulnerable areas to aid in the
- development of the prioritization table.
- Assess Flood Risk and Impacts on the Town of North Beach by:
  - Identifying the assets located within the study limits. This scope of work includes the assets seaward of Greenwood Avenue and between 1st and 11th Street.
  - Determine vulnerability based on exposure, sensitivity, and adaptive capacity of the assets to specific flooding scenarios. The flooding scenarios will be determined and discussed with the Project Team during this phase.
  - Determine the consequences of flooding by assessing the physical, social and economic impacts resulting from the specific flooding scenarios.
  - Determine the probability of each flooding scenario occurring. The probability will be assessed for current conditions and with future Sea Level Rise (2030, 2050, 2100).
  - Once defined, the vulnerability and consequences of flooding of each asset and the probability of that flooding scenario occurring will be combined to assign a risk level for each asset. Based on this risk level, the assets will be ranked in a prioritization table for project implementation.

It is understood that mapping of flooding scenarios has been conducted separately and will be provided by the Town for use in this study.

Task 4 - Develop Flooding Mitigation Strategies

- For each asset identified in the previous section, multiple nature-based and structural mitigation strategies will be developed that address the 4 Ts of Risk Management – Tolerate risk, Terminate risk, Transfer risk, or Treat risk.
- Utilize MARISA to determine the NOAA Atlas 14 precipitation data and RAND Corporation climate projections for the study area to determine the projected rainfall estimates due to climate change. The climate change projection will consider the planning horizon(s) applicable for the useful service life of the developed mitigation strategies.
- Develop hydraulic analysis for proposed mitigation strategies utilizing climate change projections and EPA-SWMM to determine anticipated system performance.
- Perform an Alternatives Analysis comparing the mitigation strategies based on expected

life spans, performance, adaptive capacity, environmental impacts, socio-economical benefits and impacts, construction consideration, maintenance requirements, and implementation costs.

- Identify the preferred alternative through development of a decision matrix by assigning a value to each alternative on how it addresses the ranking criterion.
- Develop concept level designs (10% schematic and costs) for the preferred alternatives.
- Identify any necessary easements and/or permitting requirements for each concept design.
- In coordination with the Project Team, an Implementation Plan will be developed with the following components:
  - Preferred alternatives listed per the prioritization table developed in Task 3.
  - Time frames for Implementation ranked as Immediate Action Required, Short Term, Long Term, and Monitor for areas or assets that may require action to mitigate flooding in the future.
  - Estimated total implementation costs for each time frame.

Task 5 - Identify Funding Sources

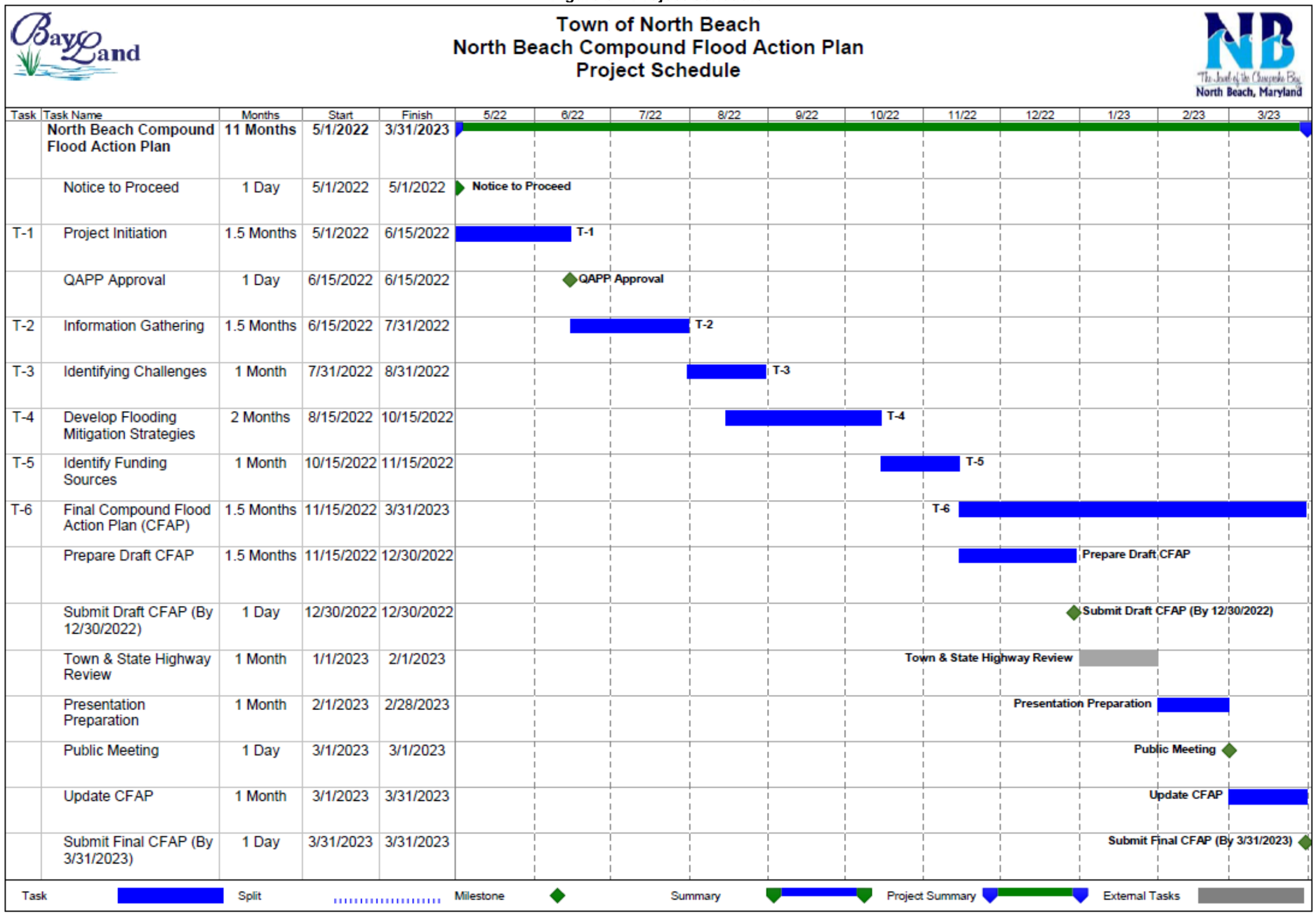
- Identify funding sources
  - Assess how construction and maintenance funds can be obtained through grant programs, loans, bonds, or other revenue streams.
  - Evaluate options for shared construction and maintenance costs by multiple entities.
- Attend virtual meetings with Town to discuss funding sources and solicit feedback.

Task 6 - Final Compound Flood Action Plan

- Prepare comprehensive Compound Action Plan report documenting the work completed under Tasks 1 through 6.
- Submit the draft report to the Town and stakeholders for review. Revise draft report and concept exhibits per Town comments.
- Prepare PowerPoint presentation of the Compound Flood Action Plan.
- Submit the presentation to the Town for review and comment. Address comments and finalize presentation.
- Attend one (1) public meeting to present the findings to the Town and stakeholders. Lead the meeting, present the project, and answer questions.
- Address responses to comments as necessary and revise Compound Flood Action Plan report with Town concurrence.
- Submit final Compound Flood Action Plan report.

BayLand has prepared a project schedule beginning on the Notice to Proceed (NTP) date, which incorporates key milestone dates, phase tasks, review times, and public meetings. We recognize that both internal and external delays can occur, and we will work to make up any lost time or unforeseen circumstances and communicate such occurrences to project participants. BayLand will make every attempt to recover the schedule from such delays and maintain the overall project schedule. We are highly confident that we can achieve the timeline shown on the schedule and will make every effort to expedite the schedule whenever possible.

Figure 3 – Project Schedule



1.7. Quality Objectives and Criteria for Measurement Data

1.7.1. Objectives and Project Decisions

The objective of the project is to perform hydrologic, hydraulic, and hydrodynamic analyses of the project area to formulate mitigation strategies that address inundation. Information collected from the field and desktop analyses will be measured and maintained at the maximum precision of the instruments and programs.

1.7.2. Action Limits / Levels

Not Applicable (N/A).

1.7.3. Measurement Performance Criteria / Acceptance Criteria

Field data will be collected using real time kinematic positioning (RTK) to identify areas of interest, determine structure elevations, establish drainage patterns and truth-check available Light Detection and Ranging (LiDAR) data. With sound satellite connection, the RTK reports coordinates and elevations to the thousandth of a foot. If it is determined that conditions would result in precision less than one tenth of a foot, then measurements will have to be postponed until the precision can be met.

Hydrologic and hydraulic analyses will be performed using accepted government modeling programs such as TR-55, TR-20, Hydraulic Toolbox, and/or EPA-SWMM. The precision of field collected data will be maintained to the maximum extents practicable. Field data collected to 0.001 precision will be recorded to the nearest 0.01 as necessary to develop the hydraulic analyses using the above programs. TR-55 and EPA-SWMM are limited to a precision of 0.01 for all output values and most of the required input values. While TR-20 and Hydraulic Toolbox are capable of displaying an output precision of 0.001, it is common practice to evaluate at 0.01 for consistency and because results of TR-55 are incorporated into the inputs. Arithmetical calculations the utilize collected data (such as swale depth or slope) will be reported to the nearest 0.1 to account for inherent field variability and overall reduction in degrees of freedom. Results of the analyses will be presented to a reasonable precision that facilitates planning-level prioritization of alternatives.

The hydrodynamic analysis will be conducted using water level measurements taken at the National Oceanic and Atmospheric Administration (NOAA) Tide Stations 8575512 Annapolis, MD and 8577330 Solomons Island, MD. Measurement are reported to the 0.01 precision, which will be applied to all hindcast data. All future projections and flooding depths will be reported to the 0.1 precision to account for the greater level of uncertainty of water level elevations.

1.8. Special Training and Certification Requirements

The staff committed to this project include Professional Engineers, Project Management Professionals, and Certified Floodplain Managers. Staff have extensive experience and training in hydrology and hydraulic (H&H) modeling, coastal analysis, water quality modeling, geospatial analysis, stormwater best management practice (BMP) planning and design, and other specialties related to Water Resource and Coastal assessments.

1.9. Documents and Records

The use of accurate, pertinent, and latest input datasets is key to the development of H&H models that can simulate conditions. Similarly, metadata associated with field measurements will be documented and retained as per Federal Geographic Data Committee requirements. All datasets used for the study are assumed quality-reviewed and suitable for use in the analysis. Impervious surfaces, buildings, infrastructure, and topographic information will be extracted from the GIS data to establish a basemap. Stormwater infrastructure, pertinent topographic information, and features of interest will be collected during the field survey and added to the basemap. Surveyed data will supersede GIS data due to its higher precision and more accurate reflection of current field conditions. Aerial imagery, historical photographs, and property information will be cross-referenced with GIS and surveyed data to ensure accurate reporting and serve as an additional quality control measure.

The hydrodynamic and coastal analyzes will utilize publicly available data from NOAA Tides and Currents. Because the Town of North Beach is located between two tide stations, measurements will be spatially interpolated between the two sites to determine conditions along the Town of North Beach shoreline. Current and future water levels will be compared with LiDAR elevations obtained from MD iMap to determine flood depths resulting from coastal flooding.

Metadata documentation of public datasets can be referenced for additional details on precision and tier level. For County provided data, data holdings quality and precision are the responsibility of the Calvert County GIS Program overseen by the County's GIS Coordinator. A complete list of data and sources to be utilized as part of this study is provided in Table 4.

Table 4 – Data Source List

Data	Source
Aerial Imagery/ LiDAR	MD iMap
GIS Data	Calvert County
Survey Data	BayLand / RTK
Past and Current Water Level Measurements	NOAA Tides and Currents
As-built Documents	Town of North Beach
Historical Photographs	Town of North Beach
Town of North Beach Plats	Maryland State Archives

Datasets, records, and documents anticipated to be produced during this study include the following:

1.9.1. QAPP Distribution

The current approved QAPP will be distributed to the project staff (as listed on the Distribution List) in either hard copy of electronic format. Changes to the QAPP will be discussed with the project management team and then issued as an advisory email when a revision to the QAPP is warranted. Revisions of specific items in the QAPP usually will not warrant republication of the

entire QAPP; the QAPP will be revised, as necessary. If the QAPP is revised in its entirety, then copies of the new QAPP will be distributed to those on the Distribution List. Electronic and/or hard copies will be maintained in the Project Manager's office.

1.9.2. Field Documentation and Records

Field documentation and records will be immediately scanned upon returning to the office. Scans will be saved locally and hard copies maintained. Field data will be digitized and incorporated into the survey data by manually transposing information from field sheets into the appropriate dataset. Accuracy and completeness of the data transfer will be initially reviewed by the Drainage Assessment leader before being submitted to the Quality Assurance Officer for official review.

Field data will be used to establish hydrologic and hydraulic analysis parameters and visually shown on the drainage plans. Copies of the raw field data will not be directly included in the final report but will be available upon request.

1.9.3. Laboratory Documentation and Records

N/A.

1.9.4. Quarterly and/or Final Reports

The final report will be distributed electronically or as hard copies. The final report will include results of the drainage assessment, results of the hydrologic and hydraulic analyses, results of hydrodynamic and coastal analysis, maintenance and/or improvement recommendations, and an implementation plan for potential improvements with associated costs.

2. DATA GENERATION AND ACQUISITION

2.1. Experimental Design / Methodology

Field data relevant for the drainage assessment, H&H and coastal analysis will be collected. This includes any pipe inverts, distinguishable high and low points, drainage structure, outfalls, seawalls, revetment, piers, and other notable infrastructure. Data that could be useful for placement or design of mitigation alternatives will also be collected, including low-lying areas, beach and marsh areas, and conveniently located open areas. Field data will be surveyed to the maximum extent possible. Field data that is not directly surveyed will be hand-documented and managed per Section 1.9.2. Hand-documented field data will be recorded on full size maps that contain GIS and property information. One set of maps will be blank and contain buildings, impervious surfaces, and topography. Another set of maps will have the same data as above overlaid on aerial imagery to assist in field-locating features. Samples of the maps are included in Appendix B.

2.2. Sampling Methods

There will be no samples collected during this study; therefore, this section is not applicable.

2.3. Sample Handling and Custody

There will be no samples collected during this study; therefore, this section is not applicable.

2.4. Analytical Methods

There will be no environmental samples collected during this study; therefore, the only analytical methods applicable to the project are the methods discussed in Section 2.1.

2.5. Quality Control Requirements

The locations and elevations of field data will be verified against the most recent GIS, LiDAR and aerial data available.

2.6. Instrument / Equipment Testing, Inspection, and Maintenance

There will be no samples collected during this study; therefore, this section is not applicable.

2.7. Instrument / Equipment Calibration and Frequency

There will be no samples collected during this study; therefore, this section is not applicable.

2.8. Inspection / Acceptance Requirements for Supplies and Consumables

There will be no samples collected during this study; therefore, this section is not applicable.

2.9. Data Acquisition Requirements (Non-Direct Measurements)

Existing data will be utilized to supplement field collected data, as necessary. GIS data will be compiled from County resources and used to establish the basemap for the area. As-built and property documents will be researched and referenced for the field survey verification.

2.10. Data Management

All data will be saved locally by the Engineer to hard drives with backup redundancy. Hard copies of documents such as field maps will be scanned and retained. Raw data, models, and information not directly included in the final report will be saved locally and will be available upon request. Documents included in each submittal and documents with significant revisions will be archived in separate folders for future reference.

It is anticipated that all data analysis will be conducted using the latest version of publicly available EPA-SWMM (Version 5.1), ArcGIS (Version 10.8), Hydraulic Toolbox, (Version 5.1), AutoCAD Civil 3D (2019), TR-55, and TR-20. Data validation and transformation information can be found in Section 1.7 and Section 4.

3. ASSESSMENT AND OVERSIGHT

3.1. Assessments and Response Actions

All deliverables to be submitted will be produced and reviewed against the project scope and applicable design/submittal standards. Producers of the work will self-certify the adherence and quality of the product before submitting for QC review. Megan Barniea or her designee will be responsible for QA/QC review and will coordinate the review with the Programmatic Advisor and Quality Assurance Manager, Sepehr Baharlou. Comments will be compiled and summarized in digital format and saved locally. Questions and comments will be discussed and reviewed between QA/QC reviewers and those performing the work before updates are made. The comments will be addressed accordingly and resubmitted to Megan Barniea for final review and approval. Disputed comments will be elevated to the proper authority level, as applicable. All comments will be resolved before finalization and submittal of deliverables. A source analysis will be performed for any significant issues discovered during the review. BayLand will maintain regular correspondence with the Town Project Manager throughout the project to discuss the status of deliverables and schedule.

3.2. Reports to Management

BayLand will submit monthly invoices to the Town with itemized work performed during the billing cycle. The Town will use the monthly invoice justifications to submit progress reports to the DNR Grant Manager. Each report will document the progress toward the project goals, objectives, and final deliverables. The report will briefly summarize the activities, difficulties encountered, and any changes in staffing, budget, or deliverable date.

4. DATA REVIEW AND USABILITY

4.1. Data Review, Verification, and Validation Requirements

Section 2.5 describes the methods BayLand will use to collect and verify data. Sections 2.10 and 3.1 discuss the methods BayLand will use to accept, reject, and qualify data for the project.

4.2. Verification and Validation Methods

BayLand will use field-collected data, State LiDAR and County GIS datasets, photos of past flooding, and other data sources to effectively calibrate and/or validate the hydrologic, hydraulic, and coastal analyses. Results will be compared to historical events and reasonably anticipated outcomes based on site characteristics and inputs.

4.3. Reconciliation with User Requirements

Results of the drainage assessment, hydrologic & hydraulic analyses and coastal analysis will be used to compile a list of prioritized alternatives to address the inundation concerns. Results of the hydrologic, hydraulic, and coastal analyses will be used to determine the most vulnerable areas and impacts of improvement strategies. Strategies will be prioritized based on the analysis and vulnerability assessment. Anomalous survey points and/or results of the analyses will be investigated and remedied as applicable. Any significant QC issues, including but not limited to anomalous survey points, encountered during the project will be detailed in the final deliverable, including comments on how they were resolved.

5. REFERENCES

- *Quality Assurance Project Plan for the Lower North East Creek Watershed Management Plan, February 2021.* Dewberry.

- *Region 3 Quality Assurance Project Plan Review Checklist*, US EPA. www.epa.gov/sites/default/files/2015-06/documents/QAPP_review_checklist.pdf.

APPENDIX A – Flood and Sea Level Rise Action Plan Framework

Flood and Sea Level Rise Action Plan Framework

Outline

1. **Executive Summary**

2. **Introduction**
   a. Background and context, highlighting the power of a coordinated approach on issues shared by any neighboring towns, the county, or other entities, as appropriate.
   b. Town's vision and goals for its future regarding the impacts of flooding and sea level rise (SLR). Include a brief description of the town's planning horizons (*e.g.*, 2030, 2050, and 2100).
      [Community input opportunity - preferably after previous education and outreach to inform them of the process]
   c. Purpose and objectives of the plan
      i. Statement of purpose: The plan will identify and characterize nuisance flooding and flooding from larger storm events using the best available science; assess the vulnerability of specific geographic areas in the community; recommend mitigation and adaptation options tailored to each area to address sea level rise impacts including flooding; and prepare implementation strategies.
      ii. Plan objectives and outputs
   d. Plan development process
      i. Project approach
      ii. Project timeline
      iii. Project roles (include town and technical assistance provider roles)
      i. Community outreach and engagement process. Include points throughout the plan development process where community input should be obtained (*e.g.*, identifying flood impacts, ranking assets impacted by flooding, prioritizing projects, programs, and strategies to reduce flood risks, and prioritizing budget and financing scenarios). These suggested points are noted throughout this framework in bold italics with square brackets, e.g. ***[Community input]***, and the accompanying Community Engagement Process diagram shows how the different sections of this framework align with different points and types of community engagement.

         See the companion **Outreach and Engagement Recommendations** document and the **Community Engagement Process** diagram (attached).

e. Linkages between this plan and other plans, goals, and initiatives
    i. Town, county, state, federal, and other entities
        1. Outline the process for coordination across these entities regarding shared challenges, solutions, and strategies, to include how the town's plan will link with other jurisdictions' plans, where appropriate.

3. Challenges

a. Current nuisance flooding (pluvial, fluvial, and coastal) and flooding from larger storm events (*e.g.*, storms like hurricanes, nor'easters, and thunderstorms). Identify contributing factors shared with other jurisdictions. Include maps and hydrological, meteorological, and any other available data. ***[Community input]***
    i. Contributing factors to be investigated may include, for example:
        1. Existing stormwater and flood systems (i.e., drains, pumps, grading, bulkheads, jetties, berms, living shoreline, roads, bridges, water storage and absorption capacity)
        2. Low land elevation and land subsidence
        3. High water table
        4. Littoral drift and shoreline erosion
        5. Development prior to current floodplain regulations
        6. Runoff from outside town's boundaries
b. Current flood impacts on town, including the physical, social, and economic consequences of flooding. Identify current flood impacts shared with other jurisdictions. Include maps, photos, and quantitative and qualitative data, as available. Also, consider including criticality assessments[1] for infrastructure and services. ***[Community input on how flooding impacts them; may also use community input and engagement to narrow down which physical, social, and economic impacts to investigate in more detail.]***
    i. Physical consequences of flooding to assess may include impacts to the natural and built environment, like: residential, commercial, cultural, historical, maritime, parks and recreational facilities; natural features that mitigate flooding, like tidal marshes and tree canopy; infrastructure like public or municipal buildings, roads, bridges, stormwater system, wastewater treatment plan and other utilities; and, emergency service facilities, like police and fire.
    ii. Social consequences of flooding to assess may include effects on certain populations or the community as a whole, like: impacts on the quality of life for residents and visitors; displacements or elimination of recreational amenities and/or access to them; disruption to community wide gatherings,

[1] Criticality assessment, or analysis, is a common practice in infrastructure asset management programs and can also be applied to flood risk assessments. The process involves identifying important assets and ranking them based on the consequences of their failure (their "consequence of failure" or "criticality"). The results of such an assessment can be used to prioritize assets to study in further detail or to prioritize interventions.

festivals, celebrations, and remembrances; and impacts on other public goods the community has sought to achieve (especially those addressing quality housing for low income residents, accessibility for the disabled, the safety and fullness of opportunity for children to learn about the town's coastal heritage and environment, and the engagement of all residents in the town's civic life and the benefits of living in the community). This of necessity includes how sea level rise might impact the delivery of social support services.

iii. Economic consequences of flooding to assess may include: damage to property; loss of tax revenue; reduced tourism and recreation; changes to the coastal/maritime sector; and infrastructure costs due to damage, failure, and/or shortened lifespans.

c. Sea level rise projections for three different risk tolerance levels/exceedance probabilities for varying scenarios (*i.e*., include near-term inundation analysis for 2030 as well as analysis for 2050 and 2100 scenarios, making sure to account for storm surge on top of sea level rise for any projects/assets vulnerable to surge). Include maps and data. Also identify the selected greenhouse gas emissions scenario(s) to be used (*e.g.*, declining, stabilized, or growing).
   i. 2030
      1. SLR
      2. SLR plus storm surge
   ii. 2050
      1. SLR
      2. SLR plus storm surge
   iii. 2100
      1. SLR
      2. SLR plus storm surge

d. Projected flood impacts on the town, including the physical, social, and economic vulnerability[2] of the town pursuant to the 2030, 2050, and 2100 planning scenarios. Note interrelationships and cross-cutting impacts (*e.g.*, a building may not flood, but its road access might). Identify projected flood impacts shared with other jurisdictions. Also, consider conducting criticality assessments for infrastructure or services. ***[Community input and education; can be tied into visioning/vision statement development (2b) and solution/strategy development (4a) and prioritization (4b). May also use community input to narrow down which projected physical, social, and economic impacts to investigate in more detail.]***

[2] Vulnerability is a more nuanced way to describe the potential consequences of flooding. For the purposes of understanding how sea level rise may impact a town, vulnerability is defined here as "a combination of the exposure, sensitivity, and adaptive capacity of the [town's] assets, populations, and neighborhoods" (Plastrik, P., Simmons, J., & Cleveland, J. (2017) Essential Capacities for Urban Climate Adaptation: A Framework for Cities. Innovation Network for Communities. http://lifeaftercarbon.net/wp-content/uploads/2017/05/City-Adaptation-Essential-Capacities-March2017.pdf).

i. See 3.b. above for descriptions and examples of the categories for which to assess the town's vulnerability to SLR.

4. Solutions and Strategies

a. Identify and describe projects, programs, and strategies, as appropriate, to reduce flood risks, including those that may need to be undertaken by private property owners and developers. Work with neighboring jurisdictions, as appropriate, on solutions for shared problem areas, or on solutions that may have a wider impact. Include information on solutions' or strategies' expected life spans and performance given SLR scenarios, whether they will address short-, medium-, or long-term issues, if they are "scalable" to accommodate upgrades in future, and if the solution or strategy yields benefits on an individual or parcel scale, or on a neighborhood or wider scale. ***[Community input]***

i. Nature-based and natural ("passive") project examples
   1. Open space protection
   2. Living shorelines
   3. Planning for and enabling marsh migration
   4. Creating wetlands and allowing space for the migration of existing wetlands
   5. Flood spillover and retention areas, floodable parks
   6. Restoration of ecosystems to improve their flood mitigating functions
   7. Creating landforms that can both protect from flooding and provide a recreational amenity.

ii. Structural/engineering project examples
   1. Drain modifications
   2. Pump modifications
   3. Grading modifications
   4. Bulkhead, jetty, berm, and shoreline (hard and soft) modifications
   5. Road and bridge modifications
   6. Water storage and absorption capacity modification
      a. Green infrastructure (*e.g.*, measures that use plant/soil systems, permeable surfaces, stormwater harvest and reuse and landscaping to store, infiltrate, or evapotranspirate stormwater to include standard stormwater best management practices).
      b. Gray infrastructure (*e.g.*, measures that use conventional stormwater infrastructure like wet wells, underground culverts to move stormwater away from the built environment, stormwater retention ponds and floodwater diversion channels).
   7. Elevate structures and/or floodproof structures

iii. Management (*e.g*. planning/policy/regulatory/design) strategy examples

1. Assess and recommend modifications to existing, or develop new:
    a. Zoning laws
    b. Building codes
    c. Permits
    d. Ordinances
    e. Land use policies (*e.g.*, critical area program) and broad landscape design measures
    f. Architectural guidance for new buildings (*e.g.*, floodable structures)
    g. Infrastructure design guidelines (that incorporate projected SLR and precipitation changes)
    h. Regulations to coordinate the use and development of shorelines structures and piers

iv. Managed retreat and relocation strategy examples
    1. Develop strategies for withdrawal of residential and commercial buildings from highly vulnerable areas and identify approaches to relocation and acquisition that may be become necessary. Strategies should take into consideration the scale of the strategy/approach (*e.g*. parcel or neighborhood scale) and whether the affected properties or assets are privately or publicly owned/maintained.
        a. Identify thresholds or tipping points for when a structure/road/etc . . . should be relocated or decommissioned.
        b. Retreat (i.e., remove structures and create open space)
        c. Relocate
            i. Develop ideas for relocating but retaining residents/businesses, community character, revenue, etc . . .

v. Community capacity-building programs
    1. Education and outreach on measures residents and other target audiences can take to reduce their flood risks. ***[Community education and engagement]***

b. Recommend project, program, or strategy priority and timing. Consider scalability of the project, program, or strategy and the impact of sea level rise projections. ***[Community input]***

5. Budget and Funding Scenarios

To the extent that implementation of the plan may require the expenditure of public funds at the municipal, county and state levels:

a. Identify and describe project, program, and strategy budget scenarios
    i. Low cost, low impact
    ii. Medium cost, medium impact

iii. High-cost, high-impact

b. Identify and describe project, program, and potential strategy financing scenarios
   i. Town and county general funds
   ii. Grants
   iii. Utility/authority/dedicated revenue stream
   iv. Loans and bonds
   v. Public-private partnership
   vi. Blended funding
c. Recommend project, program, or strategy budget and financing scenarios and incorporate into Capital Improvement Plan, as appropriate. ***[Community input]***
d. Identify funding role for county, especially where vital public interests are shared.
e. Identify and/or recommend grant and other funding programs that the state can, or of necessity, is most apt to provide.

6. Conclusion

a. Findings
b. Summary of recommendations
c. Issues requiring further analysis in coordination with other agencies, units of government, citizen and neighborhood groups, or non-profit organizations or that would benefit from further and/or ongoing collaboration with them. Also, identify changes that may be needed in local and state regulations, if any, to facilitate implementation of the measures.
d. Issues being deferred to a future update or different process.
e. Plan implementation and maintenance process.
   i. Formal adoption by town.
   ii. Establish a timeline for implementing and updating the plan (*i.e.*, link to Maryland's 5-year SLR projection updates), as well as for integrating strategies into other relevant planning documents.
   iii. Establish a process to track and evaluate outputs and results and provide updates to all interested parties (e.g., regularly make this information available to the public via the town's website, annual report, etc. .). ***[Community education and engagement]***

Appendices Examples

- Data and methods
- Maps and graphs

This framework was prepared by the University of Maryland Environmental Finance Center using Federal funds under award number NA18NOS4190145 from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

APPENDIX B – Sample Maps

0 50 100 200

1 INCH = 100 FEET

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CITY OF CRISFIELD
SURVEY MAP

SHEET 9 OF 15

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MATCHLINE SEE SHEET 11

MATCHLINE SEE SHEET 6

MATCHLINE SEE SHEET 13

MATCHLINE SEE SHEET 8

MATCHLINE SEE SHEET 7

MATCHLINE SEE SHEET 10

N 3RD ST

N 1ST ST

N 1ST ST

LOCUST ST

CRISFIELD HWY

COLUMBIA AVE

WYNNFALL AVE

HUDSON ST

MYRTLE ST

W MAIN ST

W CHESAPEAKE AVE

POTOMAC ST

N: 169,800
E: 1643,200

N: 169,800
E: 1645,000

N: 169,800
E: 1645,000

MARYLAND GRID SYSTEM (NAD'83/'91)

0 50 100 200
1 INCH = 100 FEET

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SHEET 9 OF 15

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