EPA Grant LI-96144501
Quality Assurance Project Plan for Project Code 2013-022
Long Island Sound Study (LISS) Marsh Migration Modeling

Version 2

7/26/2013

Prepared for:
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Warren Pinnacle Consulting, Inc. (WPC) and sub-contractor GroundPoint Technologies, LLC (GP) prepared this Quality Assurance Project Plan (QAPP) under Contract LI-96144501, as a project-specific task. The Work Assignment (WA) involves data gathering, model application, delivery of model results, and a report summarizing model results.

This QAPP ensures the quality for model application and secondary data usage to complete the WA tasks and addresses documentation of model performance, and data accuracy issues that might arise in the use of secondary data.

This QAPP is based on the following EPA guidance documents: *Guidance for Quality Assurance Project Plans* (EPA QA/G-5, 2002), *Guidance for Quality Assurance Project Plans for Modeling* (EPA QA/G-5M, 2002), and *QAPP Requirements for Secondary Data Research Projects* (1999). The outline of this QAPP follows the project plan elements recommended by these guidance documents.

The WPC Quality Assurance Office is responsible for maintaining and distributing the official approved plan.

A. Project Management

A1. Title and Approval Sheet

Nora J. Conlon 8/29/2013
U.S. EPA Quality Assurance Coordinator, Nora Conlon — Date

Leah O'Neill 8/29/2013
U.S. EPA Region 1 Project Officer, Leah O'Neill — Date

Erin Jacobs 8/29/13
NEIWPCC Project Manager, Erin Jacobs — Date

Michael Jennings 8/29/13
NEIWPCC Quality Assurance Officer, Michael Jennings — Date

8-29-2013
Warren Pinnacle Consulting, Inc. (WPC) Program Manager, Mr. Jonathan Clough — Date

8-29-2013
WPC Quality Assurance (QA) Officer, Dr. Amy Polaczyk — Date

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A3. Distribution List

A copy of this QAPP has been distributed to the following individuals:

Nora Conlon	U.S. EPA Quality Assurance Officer
Leah O'Neill	U.S. EPA Region 1 Project Officer
Mark Tedesco	U.S. EPA, Director of the Long Island Sound Study Office
Erin L. Jacobs	Project Manager, NEIWPCC
Michael Jennings	Quality Assurance Officer, NEIWPCC
Victoria O'Neill	Environmental Analyst, NEIWPCC/NYSDEC
Jonathan S. Clough	President, Warren Pinnacle Consulting, Inc.
Amy Polaczyk	Research Associate, Warren Pinnacle Consulting, Inc.
Marco Propato	Research Associate, Warren Pinnacle Consulting, Inc.
Benjamin Houston	Groundpoint Technologies, LLC
Karen Kwasnowski,	Groundpoint Technologies, LLC

A4. Project Organization

The key WPC and sub-contractor personnel are presented in the organizational chart below (Figure 1).

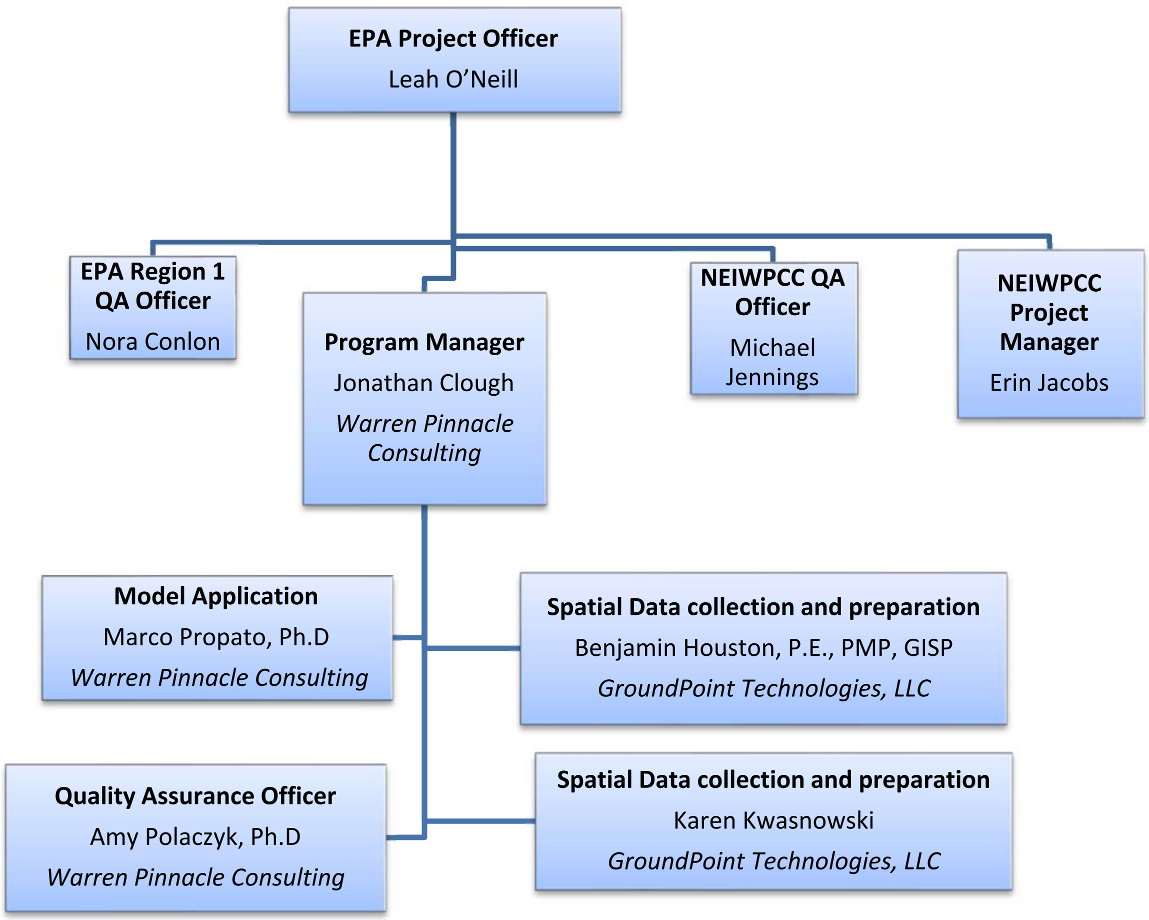

Figure 1. WA Personnel Organizational Diagram

The key personnel responsibilities are presented in Table 1.

Table 1. Key Personnel Responsibilities

Title	Name	Responsibility	Contact Information
EPA R1 QA Officer	Nora Conlon	Reviews and approves the QAPP.	conlon.nora@epa.gov (617) 918-8335
EPA Project Officer	Leah O'Neill	Provides LISS program and grant oversight. Reviews and approves the QAPP.	oneill.leah@epa.gov (617) 918-1633
NEIWPCC QA Officer	Mike Jennings	Reviews and approves the QAPP.	mjennings@neiwpcc.org (978) 349-2508
NEIWPCC Project Manager	Erin Jacobs	Provides oversight for contractual agreement between NEIWPCC and WPC. Reviews and approves QAPP and project deliverables. Coordinates with WPC and LISS partners, and others to ensure technical quality and contract adherence.	ejacobs@neiwpcc.org (978) 349-2521
Program Manager	Jonathan Clough	Directs all program activities and provides oversight of the Work Assignment. Writes and/or reviews final report.	jclough@warrenpinnacle.com (802) 496-3476
QA Officer	Amy Polaczyk	*Responsible for Maintaining the Official Approved QAPP* Assists with and writes the QAPP. Reviews model application procedures and reports and ensures that all elements of the project follow QA procedures in the QAPP.	apolaczyk@warrenpinnacle.com (802) 496-5144
Model Application Manager	Marco Propato	Prepares parameter inputs, applies model and interprets results. Writes final report.	mpropato@warrenpinnacle.com (802) 496-5581
Sub-contractor	Ben Houston	Assist with QAPP development. Performs and supervises all sub-contracting activities including preparation of spatial data.	bhouston@groundpointllc.com (845) 679-9223
Sub-	Karen	Assist with preparation of spatial data.	kkwasnowski@groundpointllc.com (315) 833-9389

contractor	Kwasnowski		

A5. Problem Definition/Background

Tidal marshes are among the most susceptible ecosystems to climate change, especially under accelerated sea-level rise (SLR). Rising sea levels may result in tidal marsh submergence and habitat migration as salt marshes transgress landward and replace tidal freshwater and irregularly flooded marshes. In order to identify the most appropriate adaptation strategies for areas near these marshes regarding land use and management, information on how these marshes may respond to SLR is needed.

Changes in tidal marsh area and habitat type in response to sea-level rise will be modeled using the Sea Level Affecting Marshes Model (SLAMM 6). SLAMM accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea-level rise (Park et al. 1989) and has been applied to numerous sites along the U.S. coast (Craft et al. 2009; Galbraith et al. 2002; Glick et al. 2013, 2007; National Wildlife Federation and Florida Wildlife Federation 2006; Park et al. 1993; Titus et al. 1991) SLAMM is a relatively simple, non-hydrodynamic model that relies on land elevation and tidal range to predict the future of wetland habitats given projected future SLR. It accounts for six primary processes that affect wetland fate in response rising to sea level: inundation, erosion, soil saturation, overwash, accretion, and salinity. Moreover, SLAMM has the capability to model feedbacks between marsh accretion rates and the rate of sea-level rise, considering elevation and distance-to-channel effects on rates of marsh accretion. The model is capable of including spatial maps of subsidence as well as including the potential effects of storm-generated overwash that may occur on barrier islands. A detailed description of model processes, underlying assumptions, and equations can be found in the SLAMM 6.0 *Technical Documentation* (available at the following URL: http://warrenpinnacle.com/prof/SLAMM).

The Sea Level Affecting Marshes Model (SLAMM) is currently being applied to the coast of Long Island and New York City to inform policymakers of the potential responses of coastal wetlands to SLR. The LISS Marsh Migration Modeling effort compliments that project by providing projections for coastal Westchester and Fairfield Counties on the north shore of Long Island Sound.

A6. Project/Task Description and Schedule

The main goal of this project is to provide both numerical and map-based projections of the potential effects of sea-level rise on the wetland communities of Westchester County, NY and Fairfield County, CT. Results will help identify the most appropriate adaptation strategies for specific areas regarding land acquisition, restoration, reduced infrastructure development, and other management actions. GIS map layers will be provided and will adhere to the requirements set by the EPA’s National Geospatial Data Policy (NGDP).

In fulfillment of the project goals, the following tasks will be performed:

Task 1. Project Management

Mr. Jonathan Clough shall be the Project Director for the project and shall be responsible for ensuring that the overall project goals are met and appropriate resources are allocated to tasks such as data gathering, testing, technology transfer, and reporting, control over the project budget and adherence to the project schedule, scheduling and conducting periodic review meetings with the NEIWPCC Project Manager, and providing all project reporting to NEIWPCC.

Task 2. Quality Assurance Project Plan (QAPP)

Task Deliverables:

- The contractor shall produce a QAPP, represented by this document. A second draft will be supplied to respond to any and all client and EPA comments.

Task 3. Collection of Input Parameter Data

Precise and recently derived input parameters will be collected for all Study Areas. Data to be collected include tide ranges, vertical marsh accretion rates, shoreline erosion rates, and historic SLR rates.

Task Deliverables:

- List of data and sources used for each of the Study Areas.

Task 4. Collection and Preparation of Spatial Input Data

Precise and recently derived spatial data covering the Study Areas shall be collected for

- Current Wetlands Maps, primarily derived from USFWS NWI data
- LiDAR derived elevations, multiple sources
- Slopes, derived from LiDAR elevations
- Dikes and impoundments, if relevant, derived from USFWS NWI data, Army Corps of Engineers database, and local sources
- Impervious surfaces within the study area, primarily from the USGS NLCD data
- Elevation datum corrections, taken from the NOAA VDATUM product

Once the spatial layers are assembled and updated, all the datasets collected shall be converted to a common raster format using ArcGIS software from ESRI with a 5 m cell-size for Westchester County, NY and a 10 m cell-size for Fairfield County, CT.

Task Deliverables:

- List of datasets and sources compiled and used for the creation of each data layer for each Study Area.

Task 5. SLAMM Modeling

The SLAMM model will be populated and parameterized with the data collected in Tasks 3 and 4. The model will be calibrated by testing the consistency between the conceptual model and available wetland, elevation, and tidal data. Following calibration, simulations will be run for scenarios under minimum and maximum SLR projections, with and without a rapid ice-melt scenario, as directed by NEIWPCC/LISS, with predicted outputs for the years 2025, 2055, 2085 and 2100 (i.e., 16 predicted output scenarios). Specific SLR values shall be determined upon consultation with NEIWPCC/LISS prior to running the model simulations.

A series of semi-automated data processing steps will be used to efficiently consolidate and visualize the data output by SLAMM, developing other required tools as needed. These include numerical processing of the projections using spreadsheets that calculate the overall percentage of wetland lost/gain under each scenario for the entire time period of simulation and the total area covered by each wetland category at each time step for each scenario. In addition, maps shall be produced to visually analyze projected coverage for each time step and scenario.

Task Deliverables:

- 16 GIS output maps for each of the Study Areas, corresponding to each model simulation
- Tables summarizing predicted numerical results of land cover and predicted changes of each wetland category.
- Draft report with discussion of results of data analysis

Task 6. Uncertainty Analysis

A stochastic uncertainty analysis, producing hundreds of model outputs, will be completed. The individual model realizations will be complied into probability distributions of possible wetland coverage. Uncertainty simulations with predicted outputs will be run for the years 2025, 2055, 2085 and 2100. Maps showing the likelihood of land-cover change and the predicted vulnerability of each model cell will be produced. Confidence intervals shall be derived for all model acreage predictions.

Task Deliverables:

- Time-varying graphs of the wetland cover predictions and confidence intervals.
- Tables summarizing the most significant statistical indicators for predicted wetland cover distributions, and histograms depicting these distributions.
- 8 GIS maps for each of the Study Areas, showing the likelihood of land-cover change and predicted vulnerability (two map types for 2025, 2055, 2085 and 2100). Written discussion of results of uncertainty analysis.

Task 7. Reporting, Technology Transfer, and Dissemination

Once Task 5 is completed project results and deliverables will be presented in a Draft Report. This report shall describe the project thoroughly and contain a complete discussion of the results from this Statement of Work, including all test results excluded those from uncertainty analysis, data analysis, limitations of the study, research/data gaps, and policy implications (if applicable), as well as appropriate drawings, graphs, tables of data, and references. The Report shall include all details of model setup and parameter selection.

A Final Report is to be delivered at the end of the study. The Final Report shall address feedbacks and comments from project stakeholders on the Draft Report. It shall also include results and discussion of the uncertainty analysis as well as a description of the uncertainty model setup and uncertainty distributions selection.

Task Deliverables:

- Final Report
- All data acquired during the performance of the project work, including all deliverables from previous Tasks.
- Numerical model output and maps for each scenario and time-step shall be broken down by desired output areas.
- Uncertainty analysis results shall be presented both graphically and numerically.
- All input and output GIS layers (wetland and elevation layers) shall be organized and archived along with thorough metadata
- All GIS results from uncertainty analyses shall be delivered such that additional site-specific processing or mapping can take place if desired.

The schedule for completion of these tasks is shown in Table 2.

Table 2. Work Plan Schedule (Start date May 21, 2013)

Task	Deliverable	Expected delivery date	Notes
2	QAPP Draft	June 28, 2013	This document
2	QAPP Final	Two weeks following receipt of EPA/NEIWPCC Comments	Schedule depends on time of receipt of EPA comments/requirements.
4	Spatial Data Layers – Westchester County, NY	August 23, 2013	Creation of up-to-date spatial data layers: wetland, elevation, slope, dikes and impoundments, impervious and elevation datum correction
4	Spatial Data Layers – Fairfield County, CT	September 20, 2013	Creation of up-to-date spatial data layers: wetland, elevation, slope, dikes and impoundments, impervious and elevation datum correction
3,5,7	Base model development and simulation – Westchester County, NY	October 25, 2013	5 m x 5 m cells, Draft report with full description of methods and results
3,5,7	Base model development and simulation – Fairfield County, NY	December 20, 2013	10 m x 10 m cells, Draft report with full description of methods and results
5-7	Final model results with uncertainty analysis – Westchester County, NY	January 31, 2014	Final report including results of uncertainty analysis assessing the combined effects of accretion, erosion, tide, elevation and SLR uncertainty
5-7	Final model results with uncertainty analysis – Fairfield County, CT	March 31, 2014	Final report including results of uncertainty analysis assessing the combined effects of accretion, erosion, tide, elevation and SLR uncertainty
	Project End Date	May 31, 2014	

A7. Quality Objectives and Criteria

It is the intent of this project to use the best available data. Data discovery and evaluation are an implied part of the scope. Quality objectives for input data are as follows:

- Elevation data file – Each location within the study area will be populated with the best available elevation data to support a bare-earth digital elevation model (DEM) as required as a SLAMM input.
    - The most recently collected LIDAR data that has already been converted to a bare-earth DEM will generally be selected, assuming the bare-earth DEM has passed quality assurance. If the Root Mean Square Error (RMSE) of LiDAR data exceeds 18 cm then the data set may be replaced by older data, if more accurate. Our initial examination of the study area suggests that the vast majority of the study area is covered by LiDAR derived DEMs.
    - If LiDAR data that have not been converted to a quality-assured bare earth DEM are available, a bare earth DEM can be derived under this contract, but extensive QA/QC of this data set is outside of the scope of work. However, such a data set may still be preferable to use of older contour-derived data. The contractor will compare the two data sets and make a recommendation to be approved by NEIWPCC/LISS prior to using a bare-earth DEM that was derived from raw data as part of this project.
    - If LiDAR data is placed over older quality data and does not line up seamlessly, the hybrid elevation data set will likely still be used. When possible, staff of Warren Pinnacle Consulting will spatially interpolate between data sets to reduce or smooth spatial-data mismatches. Any such interpolation will be thoroughly documented as well as any model-result artifacts that may form due to a combination of multiple elevation data sets.
    - The RMSE of the elevation data used will form the basis for the elevation-data-uncertainty analysis to follow and quantitative estimates of model uncertainty driven by elevation will be produced. The means of evaluating elevation data uncertainty will be the application of a spatially autocorrelated error field to the existing digital elevation map in the manner of Heuvelink (1998). This approach uses the normal distribution as specified by the RMSE for the dataset and applies it randomly over the entire study area, but with spatial autocorrelation included. Since elevation error is generally spatially autocorrelated (Hunter and Goodchild 1997), this method provides a means to calculate a number of equally-likely elevation maps given error statistics about the data set. A stochastic analysis may then be run (running the model with each of these elevation maps) to assess the overall effects of elevation uncertainty. Heuvelink's method has been widely recommended as an approach for assessing the effects of elevation data uncertainty (Darnell et al. 2008; Hunter and Goodchild 1997).
    - Project reports will be transparent about the elevation data set chosen at each location and the quality of this data set and the subsequent uncertainty will be characterized both qualitatively and also quantitatively through the application of the stochastic uncertainty analysis discussed above.

- Wetland categories layer – The newest wetland data layer available in Cowardin Units or with a compatible crosswalk to SLAMM land-cover layers will be selected. Preference will be given to "ground-truthed" data layers. Examination of wetland layers against current satellite imagery and or recent digital aerial photography will occur to ensure they are representative of current conditions. Any discrepancies will be either manually fixed or remedied by choice of a different wetlands layer, and these changes will be discussed in the model report. At a minimum, these data will be derived from the National Wetland Inventory spatial data.
- Dike file – where relevant, dike layers will be derived from National Wetland Inventory data layer with confirmation of dike locations via US Army Corps of Engineers databases, visualization of LiDAR data, and other local sources. If model results suggest immediate inundation of dry lands or fresh marshes, local sources will be consulted to determine if an existing dike or seawall is preventing such inundation. If so, the dike layer will be amended with this information. Sources of all dike data will be transparent within results reporting.
- Percent impervious file – these data are derived from the most recent National Landcover Dataset
- VDATUM elevation correction file – these data are derived using the most recent version of NOAA's VDATUM software. Accuracy of VDATUM spatial model results will be spot checked using tidal Datums data sheets available from NOAA.
- Tide ranges, frequency-of-inundation analysis, and historic SLR rates - NOAA datums and verified data will be the primary source and shall be supplemented with other tide gauge data when available.
- Erosion, accretion, and beach sedimentation rates –preference will be given to peer-reviewed, long-term data (>10 years) collected through most current technology (RSET, etc.).

Quality objectives for output data:

All model forecast results shall be investigated prior to the data analysis step. GIS data layers will be rendered and examined to ensure they are artifact free. Visible model artifacts will be corrected if possible. If it is not possible to correct these artifacts (if they originate from the source data) these artifacts will be identified and explained
Any results that fall outside of typical model results encountered from previous runs of the model will be examined and the reason for these differences will be identified. These outlying model results will either be remedied or fully documented as to why they represent the most likely outcome given the SLR being simulated. This documentation will take place as part of the discussion section of the final project report in the form of maps, graphs, and discussion.

A8. Special Training Requirements/Certification

All key personnel have extensive training and experience in their respective roles and responsibilities described in Table 1.

A9. Documentation and Records

All project personnel (WPC and non-WPC) will have access to the most current approved version of the QA Project Plan through a file transfer protocol (FTP) site maintained by WPC. The WPC QA officer will be responsible for ensuring each successive version of the QAPP is dated and superseded versions filed in a directory marked as such. All personnel will be notified by email by the QA Officer when changes are made to the QAPP.

Quarterly progress reports will be delivered to the NEIWPCC Project Manager. These reports shall briefly describe the work performed during the reporting period, including a description of any difficulties encountered during the reporting period and a statement of the cost of the work during the reporting periods. Progress reports shall be in a letter format and shall include the following subjects in the order indicated, with appropriate explanation and discussion.

1. Title of project.
2. Agreement number.
3. Period of report.
4. Progress of project.
5. Planned progress in the future.
6. Identification of problems.
7. Planned solutions.
8. Ability to meet schedule, reasons for slippage in schedule.
9. Schedule—percentage completed and project percentage of completion of performance by months—could be a bar chart or milestone chart.
10. Analysis of actual cost incurred in relation to budget

In addition to progress reports, several deliverables will provide LISS with an opportunity either to approve products and decisions or to request changes:

- Quality assurance project plan (QAPP);
- List of input data and sources used for each of the Study Areas (parameter and spatial data), including derived input data;
- GIS output data maps;
- Tables summarizing predicted numerical results;
- Uncertainty analysis results: Time-varying graphs, tables summarizing statistical indicators, and maps;
- Draft model application report;
- Final model application report;
- Manuscripts for publication in open literature.

Model inputs will be organized through databases of parameters, GIS-based parameter projects, and log files that describe parameter sources and selection rationale.

Automated daily backups are made of all project-related files and off-site backups are made periodically. Records will be kept on CD or other durable medium for at least three years from the close of the project. In addition, model inputs and outputs will be archived in .zip directories at both the draft and final model implementation phases. These directories will be placed on an FTP site maintained by WPC as well on local WPC backup for a minimum of 7 years.

Both draft and final model application reports will include the following elements, except where specified:

1. Project Objectives, including project scope and technical objectives
2. Details regarding the SLAMM conceptual model, system boundaries, key processes data sources and gaps, and important model assumptions will be discussed.
3. Discussion of the technical approach
4. Data and rationale used for parameter estimation
5. Uncertainty and error analysis (final application report only)
6. Model results, including summaries of all input parameters and numerical and map-based presentations of model results in both model application reports and uncertainty bounds in the final report.
7. Basic discussion of results
8. Recommendations' for additional analysis, if applicable.

The response of NEIWPCC/LISS staff to these products will provide additional external quality control.

B. Data Acquisition

This section will discuss secondary data and quality control with respect to the data requirements; the acceptance criteria for data; and the importance of data tracking and archiving. It is important to note that this project does not propose any primary data acquisition, data development, sampling, or measurement. All the project inputs will be derived from secondary (existing) data.

B1. Data Requirements

Detailed descriptions of the input data required are listed in both the SLAMM technical documentation (http://warrenpinnacle.com/prof/SLAMM6/SLAMM6_Technical_Documentation.pdf) and the SLAMM user's manual (http://warrenpinnacle.com/prof/SLAMM6/SLAMM_6_Users_Manual.pdf). The level of precision, accuracy, completeness, representativeness, and comparability (for definitions see Section F, Appendix) achievable for the model inputs is dictated by the available data.

There is no specific set of thresholds for data acceptability. The SLAMM model has been under development since the mid-1980s and is therefore capable of running in data rich or data poor environments. However, with the uncertainty-analysis procedure we will quantify the effects of data precision on model predictions and output-data uncertainty. Furthermore, initial examination finds the proposed study area to have high-quality data for the most important data sources for the model (land elevations, wetlands maps, and tide range information.)

B2. Types, Sources, and Quality of Input Data

SLAMM accepts several types of input data, which may come from a variety of sources, often requiring unit conversions, and with differing quality assurance, even in the same study.

At a minimum the project will use the most current public-domain datasets as described in A.7. above, augmented or replaced with data that may be discovered by the project team or made available to the project by Stakeholders or other related/interested parties that is determined to be of higher quality or otherwise enhances the project. The rationale for using the listed data sources is that the data are of known consistency and origin, and in many cases have a proven utility for SLAMM modeling on previous projects. The rationale for augmenting with additional data is that such data may be more recent, more descriptive, of higher spatial resolution, and/or may reflect more local knowledge of environmental conditions that are not reflected in the more "standardized" public domain data. Ultimately, this project can be run and the model can be developed from datasets identified through the public domain as discussed above, but our team remains interested in augmenting this dataset with higher-quality data whenever possible.

Input data can be divided into parameter and spatial categories:

Parameter Input Data:

- Local NOAA gauges are the primary source of data regarding tide ranges, frequency-of-inundation analyses, and historic SLR rates. These shall be supplemented with other tide gauge data where available. In order to keep track of the potential applicability of the tide data available through NOAA, the analysis period /period of record will be recorded for each tidal measurement used. Frequency of inundation analyses will be carried out using at least 5 years of the most recent high/low water level data available.
- Erosion, accretion, and beach sedimentation rates will be determined through a literature search and a search of data-sources from local agencies and researchers.
- Nearly all parameters may be represented by distributions when the model is run in uncertainty mode. Distributions may be based on multiple values to be found in parameter sources.

Data selection shall be quality controlled via the Contractor's internal peer-review and contact with local experts. The Contractor shall use peer-reviewed data exclusively and data from federal databases unless given direction from NEIWPCC Project Manager to use an alternative. All input data shall be subject to quality assurance as defined in this QAPP.

Spatial Input Data:

As discussed in A.7, the spatial data requirements to support this project include:

- Wetland,
- Elevation,
- Slope,
- Dikes and impoundments, and
- Impervious (developed) regions.

In general, data that is more recent is preferred; however, data consistency across the study area and the richness of content may occasionally have higher priority than temporal accuracy. For example, wetlands data with rich attribution may be preferred over very accurate high resolution wetlands data with only rudimentary attribution.

The project is divided into two geographic areas based on the political boundaries of Westchester County NY and Fairfield County, CT. Because it is anticipated that the elevation data sources for each area will differ, and due to budget limitations, the target precision elevation data in the two areas will differ. All spatial data will be clipped to the project boundaries from existing sources and then be converted to gridded raster data with a 5 m resolution for Westchester County, NY and a 10 m resolution for Fairfield County, CT. The different cell resolutions within the study area are primarily due to budget constraints but technical issues also play a role. The horizontal resolution of the available LiDAR elevation datasets are 1 m for Westchester (NY), but 20 feet (6.1 m) for Fairfield (CT). Therefore a 5 m resolution for CT is less applicable. More importantly, this choice was required to stay within the available project budget, while simultaneously maintaining a NY study area that is as compatible as possible with the project funded by NYSERDA.

B3. Acceptance Criteria for Data

The identified sources and peer-reviewed scientific literature will be reviewed based on their relevance to the task. Selected sources will include well established organizations, academic institutions, or government agencies in the field of water resources management.

As datasets are compiled and post-processed, an independent technical review of each dataset shall be performed to ensure that there are no visible errors in the input data.

Each input data source, including any additional or supplemental data discovered during the course of the project, will be evaluated by at least two different members of the project team to determine the appropriateness for use of the data, including an evaluation of the spatial and temporal resolution, completeness of the data (i.e., gaps in coverage or level of content detail).

All geospatial input datasets shall be reviewed in accordance with the following QC checklist:

- Metadata availability and completeness
- Unit Consistency
- Spatial Reference System
- Spatial coverage/extent (i.e., data gaps)
- Grid size and tiling consistency
- NODATA values in Rasters
- Attribute consistency

All final geospatial input datasets will be derived from existing sources. In some cases inputs may represent a combination or hybrid of existing data. As such both the final input and the final output GIS data will adhere to the requirements set by the EPA's National Geospatial Data Policy (NGDP). Specifically, each digital data layer will be accompanied by supporting documentation that includes data source information (i.e., scale and accuracy, map projection, coordinate system, etc.), and specific information about the data layer itself (i.e., method used, geographic extent of data layer, file format, date of creation, staff contact, description and definition of data fields and their contents, related files, if any, and description of data quality and quality assurance methods used). The EPA Metadata Editor (EME) will be used as the tool for streamlining production of required metadata.

DISCLAIMER

In accordance with the QAPP REQUIREMENTS FOR SECONDARY DATA RESEARCH PROJECTS, a disclaimer similar to the following should be used for all derived input and model output data:

> *"These data are derived from source data of varying quality to include accuracy, precision, and completeness. As such no warrantee or representation is made as to the applicability or suitability of this data for any implied or specified use other than that for which it was originally intended. "*

B4. Model Calibration

Initially, SLAMM simulates a "time zero" step, in which the consistency of model assumptions for wetland elevations is validated with respect to available wetland coverage information, elevation data, and tidal frames. This step allows for site-specific calibration/validation of the SLAMM conceptual model.

Due to simplifications within the SLAMM conceptual model, DEM and wetland layer uncertainty, or other local factors, some cells may fall below their lowest allowable elevation category and would be immediately converted by the model to a different land cover category (e.g. an area categorized in the wetland layer as swamp where water has a tidal regime according to its elevation and tidal information will be converted to a tidal marsh). These cells represent outliers on the distribution of elevations for a given land-cover type.

Model calibration will be completed for each of the project sites (Westchester, NY and Fairfield, CT Counties). A threshold tolerance of up to 5% change will be allowed for in major land cover categories (those comprising over five percent of initial land cover). When initial calibration results are inconsistent with available wetland coverage, the model is adjusted as follows. First, wetland coverages are amended where satellite imagery shows that inundation has already occurred, or where site-specific knowledge confirms that wetland coverage should be indeed amended. Second, the tidal range domain in the affected area can be adjusted to better reflect the local conditions. The layer designating which areas are protected by dikes may also be replaced if more high-quality local data is available.

Future predictions of wetland changes will be compared to SLAMM time-zero results so that model results are showing the effect of a sea-level rise signal, and are not reflective of model and data uncertainty.

Uncertainty will not be assessed during model calibration; instead a stochastic uncertainty analysis will be carried out on model projections to provide uncertainty bounds on model results.

B5. System Documentation and Archiving

Through the use of text-based log files, the draft report, and the final report, the following information will be documented, as applicable:

- underlying model assumptions
- parameter values and sources
- boundary conditions used in the model
- limiting conditions on model applications, including details on where the model is or is not suited
- actual input data (type and format) used
- overview of the immediate (non-manipulated or -post processed) results of the model runs
- output of model runs and interpretation
- documentation of significant changes to the model (not likely relevant)

Model inputs will be organized through: databases of parameters, GIS-based parameter projects as well as log files and reports describe parameter sources and selection rationale.

Model inputs and outputs will be archived in .zip directories at both the draft and final model implementation phases. These directories will be placed on an FTP site maintained by WPC as well on local WPC backup for a minimum of 7 years.

C. Model Application

C1. Assessment and Response Actions

A QC checklist shall be completed by the QA Officer and shall include the steps described in Appendix B. An electronic Quality Control Log will be generated for each project site and stored in a directory with the SLAMM project file. The QC Log will document the findings of each of the steps described in Appendix B with actions need and taken to rectify any issues discovered. The log files will be archived with the SLAMM projects and available upon request.

Any questionable results shall be identified and investigated prior to the data analysis step. Observations noted in this step will be shared with key project personnel. A summary of this assessment will be included in the modeling report. GIS data layers will be rendered and examined to ensure they are artifact free.

Both maps and numeric data will be used to assess the "time zero" step for model calibration as described in section B4.

NEIWPCC may implement, at their discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with the NEIWPCC Quality Management Plan.

D. Data Validation and Usability

D1. Data Review, Verification, and Usability

Model results will be examined for consistency and accepted based on the criteria outlined in Section A7 of this QAPP. Any questionable results shall be identified and investigated prior to the data analysis step. GIS data layers will be rendered and examined to ensure they are artifact free.

Uncertainty in model results will be assessed through the application of the SLAMM uncertainty module. Maps and tables of output data, along with the confidence statistics for model results provided by the uncertainty-analysis module will determine the data usability for LISS.

D2. Reconciliation with User Requirements

Quality objectives are addressed in this QAPP for both data acquisition (Section B) and modeling development and application (Section C). Acceptance criteria for data and model calibration were selected to ensure achievement of the quality objectives. If there are irreconcilable discrepancies from the quality criteria, the ability of the model to achieve quality objectives and provide accurate output might be compromised. Under such circumstances, the consultant will confer with EPA to determine if the quality discrepancies could still allow user requirements to be met. If not, then a plan to address the issue will be developed to ensure model quality and user satisfaction.

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F. Appendices

Appendix A – Definition of Terms

Because it is not always clear how QAPP terms are defined, the following is taken from a memo by Solomon et al. (2001) on the terms and definitions from the EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5 EPA/600/R-98/018:

> Accuracy — The measure of the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; the EPA recommends using the terms “precision” and “bias”, rather than “accuracy,” to convey the information usually associated with accuracy.
>
> Bias — The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample’s true value).
>
> Precision — A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions expressed generally in terms of the standard deviation.
>
> Representativeness — Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition. Representativeness is a qualitative term that should be evaluated to determine whether in-situ and other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied.
>
> Comparability — Comparability is the qualitative term that expresses the confidence that two data sets can contribute to a common analysis and interpolation. Comparability must be carefully evaluated to establish whether two data sets can be considered equivalent in regard to the measurement of a specific variable or groups of variables.

Appendix B—Quality Assurance Checklist

QA/QC Checklist:

- examination of derived wetland layers as compared to satellite photography
- examination of all derived parameters and spatial averaging techniques
- examination of "time-zero" model results (model calibration/validation)
- analysis of wetland elevation ranges against conceptual model
- quality assurance of output to ensure model results are reasonable and logical given the interplay between accretion rates and rates of sea-level rise
- examination of maps for any artifacts from the model or input data
- review of maps and tables of output data from the uncertainty analysis.