Exhibit A - Statement of Work

This Research Statement of Work is made and entered into effective the 1st day of January, 2018 by Eversource Energy Service Company, for itself and as agent for its affiliates, having principal offices at 107 Selden Street, Berlin, CT 06037 ("Company") and UNIVERSITY OF CONNECTICUT ("University") pursuant to the terms of the SECOND AMENDED AND RESTATED SPONSOR RESEARCH AND SERVICES AGREEMENT between Company and University dated May 1st, 2015 (the "Sponsor Research Agreement").

Both Parties agree to participate in Research to be conducted in accordance with the terms and conditions of the Sponsor Research Agreement and this Research Statement of Work, provided however, that in the event of a conflict between the terms and conditions of the Sponsor Research Agreement and this Research Statement of Work, the terms of the Sponsor Research Agreement shall be controlling.

1. **Title of Research/Project:** *Evaluation of Substations Vulnerability of Flooding in Current and Climate Change Scenarios*
2. **Research/Project Description:**
   - **A. Problem Statement**
   - **B. Proposal Objectives**
   - **C. Methodology**
   - **D. Data requirements**
   - **E. Project Deliverables**
   - **E. Project Timetable and Milestones – 1/1/18 – 12/31/19**

University of Connecticut

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Date: Dec. 8, 2017

The Connecticut Light and Power Company doing business as Eversource Energy

By: [signature]

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Date: 12/18/17

By Sponsored Program Services [signature]

Printed Name: Laura Kozma

Title: Director Date: 12/18/17

Research/Project Description: Evaluation of Substations Vulnerability of Flooding in Current and Climate Change Scenarios

Project Lead(s): Xinyi Shen (PI), Efthymios Nikolopoulos (co-PI) and Emmanouil Anagnostou (co-PI)

A. Problem Statement

The 2011 and 2012 tropical storms (Irene and Sandy) in the Northeast were unprecedented in their severity and closeness in timing. During the peak, more than 880,000 customers in Connecticut alone from storm Irene experienced extended power outages that render citizens vulnerable to economic, food, health, and environmental insecurities. These storms and damages are not just historical events of the past. A recent (2011) report by the Council on Environmental Quality Interagency Climate Change Adaptation Task Force forecasts a 67% increase in the number of extreme storms over the Northeast attributable to climate change in this century. Webster et al. (2005) study showed increase in the occurrence of Category 3 or 4 hurricanes in the Northeast, and this is alarming considering the high potential for tree-related and flooding-related damages due to critical infrastructure and population in dense vegetation and floodplain (both inland and coastal) areas.

Eversource Energy has substations located within river and coastal floodplain areas that are vulnerable to thunderstorms. 12 of these substations and associated resilience needs have been identified by Tom Layton and are described below:

Table 1 Locations of the substations

Code	Name	Location
11R	Cos Cob	Cos Cob, CT 06807
1G	South End	1 South St Norwalk, CT 06854
	Norwalk Harbor	Norwalk, CT
9S	Norwalk	9 Norwalk Ave, Westport, CT 06880
29J	Burrville	Torrington, CT 06790
11W	Freight St.	11 Freight St. Waterbury, CT 06702
27F	Westport	349 MAIN ST, WESTPORT, CT 06880
31	Meadow	31 Meadow St Branford, CT 06405
11J	Branford	249 E Main St, Branford, CT 06405
90	Guilford	90 Meadow St Guilford, CT 06437
21U	Stonington	27 CUTLER ST, STONINGTON, CT 06355
180	East River	180 Boston Post Rd., Madison CT

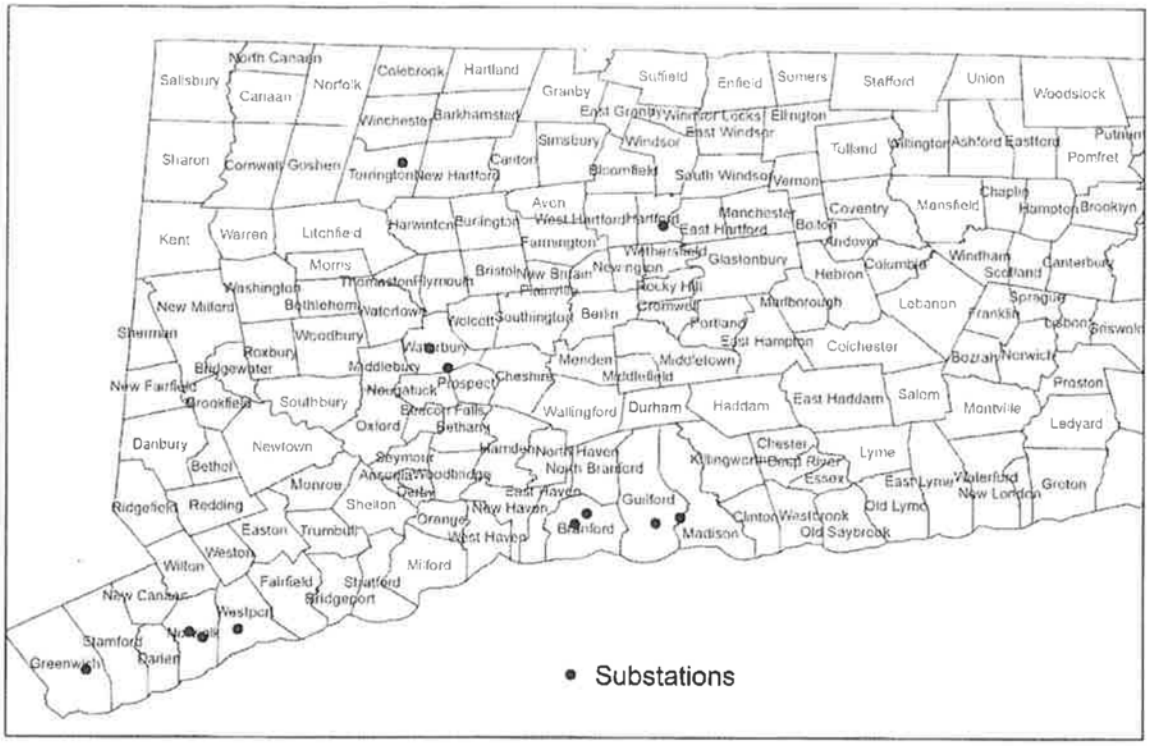

Figure 1. Vulnerable substations under investigation.

- Early warning; Eversource would like to have a hydrological forecasting system in place to predict potential flooding damages to critical substations triggered by thunderstorms.

Assessing the flood vulnerability of substations is a complex but important topic for research due to 1) accuracy improvement of ungagged watersheds and 2) real-time forecasting of thunderstorm caused inundation.

This project will extend the ability of our current distributed hydrologic model (named CREST v3.0) to include capabilities of short-term forecast and flood inundation mapping and will be applied operationally for the substation locations listed in Table 1.

B. Proposal Objectives

The primary scope of the proposed project is to develop a real-time early warning system by integrating existing meteorological, hydrological and hydraulic models to estimate potential damage and risk under design flood (specified frequency) and storm scenario based at Eversource substations over Connecticut and Massachusetts. Stepwise objectives are given below:

(1) Estimate 100-500 year flood frequencies of the entire network in Connecticut, Housatonic and Thames Rivers based on the existing hydrological framework we developed in the 2016-2017 project. These rivers covers Connecticut and Massachusetts substations.

(2) Develop a daily flood forecasting system tailored to the Eversource substation locations by
    a. Forcing the hydrological modeling framework to run with hourly precipitation fields from the NWS radar precipitation dataset to produce accurate basin initial conditions;
    b. Run the hydrological modeling framework for up to three days ahead using the real-time high-resolution weather forecasts available from the Outage Prediction Model (OPM) operational framework;
    c. Issue early warnings of flood occurrence indicating when and where the forecast flow exceeds a given flood return period (typically this will be 50 years).
(3) Overlay the surge & sea level tides from our existing OPM system to the inland flow output by the herein developed hydrologic model.
(4) Provide early warning of potential overtopping of critical infrastructure and inundation of critical substation levels if flood events are identified by the real-time forecast system in step (2).

The project tasks proposed to address the scope of work and associated project deliverables along with dates are discussed next.

C. Methodology – Project tasks

The scope of work will be accomplished by performing the following five major tasks:

- The first task will focus on the deriving optimized semi-distributed routing parameters used by CREST for the entire river network of Connecticut River or another basin (in future projects) that is gauged by multiple hydrological stations.
- The second task is to build the real-time flood forecasting system, by integrating WRF model outputs with CREST, for storm-triggered flood events.
- The third task is to assess the flood-inundation risk at the critical substations of Eversource (see Table 1) combining flood inundations from WRF-CREST output (inland/river flows) and storm-surge forecasts from our existing OPM system.

The system will continue to expand to include additional Eversource utilities in MA and NH, provided additional funds become available from these service territories.

The proposed project tasks are described below:

Task 1: Construct a cascading calibration system to calibrate the hydrological model in the entire network rather than at a downstream outlet.

The river basins under investigation will be cascaded to multiple levels using the river network information. To simulate the flow rate at a downstream gauge, all its tributaries gauged by upstream hydrological stations are assumed known and directly used as input. The calibration process is from upstream to downstream. All sub-basins of the same level are calibrated simultaneously in UCONN HPC.

Task 2: Predicting flood peaks in future extreme storm scenarios

Calibrated CREST v3.0 flow will run operationally at daily intervals. National Land Data Assimilation System (NLDAS2) reanalysis meteorological variables with its precipitation replaced by the Stage IV data are used to force the CREST v3.0 simulation until the present time. State variables will be saved. Then WRF-ARW 3.7 forecast data will continue to force CREST to generate flow-rate forecast for the next 5 days. On the next day, CREST will resume the simulation from the saved point (the first day).

Task 3: Estimating the risk of failure (ROF) of critical substations of Ever Source Energy Co.

Inland flood and storm-surge caused inundation will be simulated using the U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) version 5. This newest version of HEC-RAS is capable of simulating steady and unsteady flow conditions in 1D and 2D. Making use of the improved unsteady flow component, our goal is to capitalize on the newest high resolution (<0.5 meter resolution) DEM (recently acquired by the State of Connecticut) to simulate flood propagation scenarios of the inland flood and derived in Task 1 and storm-surge forecast automatically downloaded from Connecticut Institute for Resilience & Climate Adaptation (CIRCA). Inland flow and surge will be used as upstream and downstream boundary conditions respectively.

D. Data Requirement

The main data requirements are location and infrastructural parameters at the substations and either cross-sectional river profiles. For the implementation of the hydraulic model, geometric data is required. Accurate description of the channel and floodplain geometry is needed at a number of cross sections. All these data will be acquired by the investigators of this project.

E. Project Deliverables and Timeline

Date	Activity Reports	Model Releases	Related Tasks
1/2018	Kickoff the project		
07/2018	- Report on the cascading calibration scheme of CREST	CREST v3.0 with cascading calibration module is released	1
10/2018	- Report on the evaluation of the flood forecast by the integrated WRF-CREST system	Release of the operational system of WRF-CREST; implementation of the model on UConn's High Performance Computer	2

Date	Activity Reports	Model Releases	Related Tasks
1/2019	- Report on river profiling and operational status of the WRF-CREST system		2
4/2019	- Report on inundation forecast result of substations		3
7/2019	- Report on inundation mapping of all substations based on integration of surge and inland flooding	Release of the inundation forecast system; implementation on UConn's HPC	3
12/2019	- Report on publications related to the project	Project related publications and performance evaluation report; Proposal for potential expansion to the MA and NH substations.	1-3

F. Acceptance Criteria:

The acceptance will be based on rigorous error metrics over 4 inland and 8 coastal substations. The primary metric is the difference of inundation area predicted by the model and Synthetic Aperture radar observed ones. The secondary error metric is the Nash-Sutcliffe efficiency of forecast flow time-series simulation. The quality and number of peer reviewed publications will also be used as an evaluation of this project.

G. Project significance:

Knowing the peak flow caused by storm event, inundated area and the damage it can cause to hydraulic structures to expect allows the public and government agencies to accurately assess the potential loss and appropriately determine the resilience of these structures and the necessity of upgrading them. Inundation has direct and indirect consequences for businesses, government and social services; and the failures and hydrological disasters need reliable and quantitative estimates. The State of Connecticut will be better prepared for natural hazards by using the integrated system that are under development in this project; namely, daily WRF-CREST driven HEC-RAS inundation mapping tools.

Some direct and indirect benefits from this project are listed below:

- The daily flood-inundation warning of the 12 aforementioned substations can be will be issued for Cat 2 and 3 scenarios.
- Potential inundation area is mapped so that

- Flood impact population can be estimated.
- Flood impact estates, utilities and assets can be estimated.

- Damage loss and casualties can be reduced by:
  - upgrade the capacity of existing hydraulic infrastructure if necessary
  - Early warning of the potential damage

H. Project Team:

The UConn team to be engaged in this project is listed below:

Xinyi Shen, Assistant Research Professor of Civil and Environmental Engineering, University of Connecticut, four months support to direct the Eversource Energy Center, project as PI, coordinate efforts on deploying the distributed hydrological model CREST v3.0 and the computation of flood extremities.

Efthymios Nikolopoulos, Assistant Professor of Civil and Environmental Engineering, University of Connecticut, five months support to lead the integration of dam ROF and inundation mapping modules using HEC-RAS.

Emmanouil Anagnostou, Professor, will advise on the model integration process.

PhD student, who will work on the model development and implementation.

Partial HPC system administration support from the Center

I. Budget

The total cost for this project is $245,000 and will be used to partially support the salaries of Drs. Shen and Nikolopoulos and a PhD student.

The dates listed in the table below refer to the start date of the corresponding task

Date (month/year)	**Task/ Description**	**Payment ($)**
01/2018	Collect USGS flow data and aggregate them to hourly	
02/2018	Develop the cascading calibration module for the CREST-SVAS model	40,000
03/2018	Extract flood events at each USGS station	11,000
07/2018	Calibrate the three basins in a cascading manner only during event periods at hourly scale	40,000
10/2018	Develop the regional flood frequency adjusting method	35,000
02/2019	Integrate daily WRF and CREST system	25,000

03/2019	Generate the flood map of the three river basin	20,000
07/2019	Setup regions/infrastructures of interest and integrate the real-time system to the hydraulic model	35,000
08/2019	Simulate ROF and inundation of regions/infrastructures of interest during extreme and forecast floods	20,000
12/2019	Project related publication submission	19,000
Grand Total		**$245,000**