

**Modification 001  
To  
Task Agreement P13AC00891  
Against  
Cooperative Agreement  
P09AC00212  
between  
The United States Department of the Interior  
National Park Service  
and  
University of Rhode Island**

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Project Title: Hurricane Sandy Field Technician Support for Elevation Mapping of NPS Salt Marshes and other sites for Sea Level Rise Planning and Post- and Future Storm Evaluation

CFDA: 15.945, Cooperative Research and Training Programs – Resources of the National Park System (CESU)

This Task Agreement Modification is entered into by and between the University of Rhode Island and the United States Department of the Interior, National Park Service, hereinafter called “NPS.”

GENERAL: The purpose of this modification is to:

- a) To modify Article VI to add FY14 funds in accordance with the budget proposal in Attachment A of this Modification.
- b) To add deliverables including data and reports in accordance with Attachment A of this Modification and Article IX of this agreement.
- c) To add Attachment A of this Modification under Article XIII titled: Field Technician Support for Elevation Mapping of NPS Salt Marshes and other sites for Sea Level Rise Planning and Post- and Future Storm Evaluation

**ARTICLE VI – AWARD AND PAYMENT**

- A. The NPS has approved this project and the following documents have been submitted by the University of Rhode Island prior to award:
  - 1. SF-424, Request for Federal Financial Assistance
  - 2. SF-424A, Budget Information, Non-construction Programs
  - 3. SF-424B, Assurances, Non-construction Programs

Budget Information from the SF-424A is summarized later in this Article.

- B. **Financial Assistance:** NPS will provide funding to the University of Rhode Island in an amount not to exceed \$768,864 in fiscal year 2014 for the work described in Article IX and in accordance with the approved budget. Any award beyond the current fiscal year is subject to availability of funds.

**Appropriation Data:** The chargeable appropriation for this Task Agreement is \$768,864 ----

WBS: PX.P0201795A.00.1, Project Definition: PX.P0201795A

FA: PAN00AN61.XZ0000, Fund: 13XP010261, CC: PPNEFIIS00

- C. The University of Rhode Island shall request payment in accordance with the following:

1. **Method of Payment.** Payment will be made by advance and/or reimbursement through the Department of Treasury's ASAP system.
2. **Requesting Advances.** Requests for advances must be made submitted via the ASAP system. Requests may be submitted as frequently as required to meet the needs of the Cooperator/Recipient to disburse funds for the Federal share of project costs. If feasible, each request should be timed so that payment is received on the same day that the funds are dispersed for direct project costs and/or the proportionate share of any allowable indirect costs. If same-day transfers are not feasible, advance payments must be as close to actual disbursements as administratively feasible.
3. **Requesting Reimbursement.** Requests for reimbursements must be submitted via the ASAP system. Requests for reimbursement should coincide with normal billing patterns. Each request must be limited to the amount of disbursements made for the Federal share of direct project costs and the proportionate share of allowable indirect costs incurred during that billing period.
4. **Adjusting payment requests for available cash.** Funds that are available from repayments to, and interest earned on, a revolving fund, program income, rebates, refunds, contract settlements, audit recoveries, credits, discounts, and interest earned on any of those funds must be disbursed before requesting additional cash payments.
5. **Bank Accounts.** All payments are made through electronic funds transfer to the bank account identified in the U.S Treasury ASAP system by the Cooperator/Recipient.
6. **Supporting Documents and Agency Approval of Payments.** Additional supporting documentation and prior Agency (NPS) approval of payments may be required when/if a Cooperator/Recipient is determined to be "high risk" or has performance issues. If prior Agency payment approval is in effect for an award, the ASAP system will notify the Cooperator/Recipient when they submit a request for payment. The Recipient must then notify the NPS Awarding Officer identified on the Assistance Agreement that a payment request has been submitted. The NPS Awarding Officer may request additional information from the recipient to support the payment request prior to approving the release of funds, as deemed necessary. The Cooperator/Recipient is required to comply with these requests. Supporting

documents may include invoices, copies of contracts, vendor quotes, and other expenditure explanations that justify the reimbursement requests.

- D. Nothing contained in this Agreement will be construed as binding the NPS to expend in any one fiscal year any sum in excess of the appropriation made by Congress or administratively allocated for purposes of this Agreement in that fiscal year.

## **ARTICLE IX – REPORTS AND/OR DELIVERABLES:**

### **E. Specific Deliverables**

A list of project deliverables and due dates for this Modification include (specific due dates will be dictated by the date of signature of this agreement and will be mutually agreed upon by both parties and documented in a work plan following signing of this agreement):

1. Written report on standard operating procedures and guidelines for on-the-ground high resolution elevation data collection in salt marshes (Summer 2014)
2. Assimilation and accumulation of training materials provided during total station and GPS training made available on the Regional Technical Support Center website for use by all NPS staff (Summer 2014)
3. Tidal datum calculations and report for each salt marsh site at Assateague Island NS, Gateway NRA, and Fire Island NS, based on closest and most accurate tide gauge data. (Spring 2016)
4. Geodatabase of elevation points for salt marsh sites at Assateague Island NS, Gateway NRA, and Fire Island NS, including vegetation data and heights relative to NAVD88 (As completed, finalized Spring 2016).
5. Draft Report and data products (Spring 2016)
6. Final Report and data products revised following peer review (Two years from the date of signature of this agreement)

## **ARTICLE XIII – ATTACHMENTS**

The following documents are attached and made part of this Task Agreement:

- A. The University of Rhode Island study proposal and budget, titled “Hurricane Sandy Field Technician Support for Elevation Mapping of NPS Salt Marshes and other sites for Sea Level Rise Planning and Post- and Future Storm Evaluation”
- B. Statement of work for which the National Park Service agrees to perform.

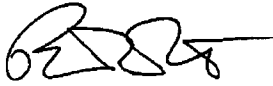
August

All other terms and conditions remain unchanged.

**ARTICLE XIV – SIGNATURES**

IN WITNESS WHEREOF, the parties hereto have executed this Cooperative Agreement on the date(s) set forth below:

**FOR THE UNIVERSITY OF RHODE ISLAND:**



6/26/2014

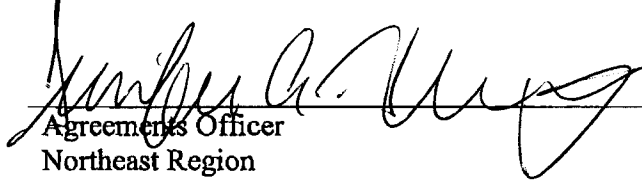
Date

Brian A. Nath, J.D.

Assistant Vice President

Intellectual Property (Legal)

**FOR THE NATIONAL PARK SERVICE**

  
Agreements Officer  
Northeast Region

07/07/2014

Date

**ATTACHMENT A: University of Rhode Island Study Proposal***OK August*

**PROPOSAL TITLE:** Hurricane Sandy Field Technician Support for Elevation Mapping of NPS Salt Marshes and other sites for Sea Level Rise Planning and Post- and Future Storm Evaluation

This proposal is a modification to Task Agreement P13ACAC00891 of Cooperative Agreement P09AC00212 Elevation Mapping of Critical Park Areas for Planning and Post- and Future Storm Evaluation and Modeling

**PRINCIPAL INVESTIGATORS:** Peter August, Charles LaBash, Michael Bradley, Scott Rasmussen, and Andrew Neil

**BACKGROUND:** There is strong consensus in the scientific literature which predicts 1 to 1.9 m of sea level rise by the end of the century (Church et al., 2013; Vermeer and Rahmstord, 2009) with extreme projections of several meters of sea level rise in the same time frame (Overpeck et al., 2006). This may be exacerbated in the North Atlantic, where changes in circulation could be producing a higher rate of relative sea level rise (Sallenger et al., 2012). Low lying areas in National Parks such as salt marshes are especially vulnerable to inundation from sea level rise (Holgate and Woodworth, 2004; Kemp et al., 2011, Murdukhayeva et al., 2013) and changing intensity of storms (IPCC, 2013). Marshes have different vegetation zones based on elevation (i.e., tidal inundation). The elevation of these vegetation zones sometimes differs by only a few centimeters (Takekawa et al., 2013). Additionally, salt marshes can vary sometimes in their ability to accrete in rising sea levels (Mancera et al., 2005; Cahoon et al., 2006). LiDAR data in salt marshes, while ubiquitous, are not accurate enough for evaluation of salt marsh elevation capital and vulnerability to sea level rise or storms (Morris et al., 2002; Gesch, 2009; Hladik and Alber, 2011; Schmik, Hadley, and Wijekoon, 2011). As a result, tying LiDAR-derived elevation of salt marshes into the NSRS - National Spatial Reference System (and thus the tidal datum computed by the National Water Level Observation Network) is problematic. The characterization of salt marsh vegetation communities with respect to tidal range is a basic input parameter for salt marsh models of vulnerability (Takekawa et al., 2013). Sediment Elevation Tables (SETs) accurately measure and detect relative elevation change in a 2 m circle (Cahoon et al., 2002). However, these trends may not be applicable over the areal extent of the marsh. Other techniques such as a total station surveying or kinematic GPS not only provide more accurate measurements of elevation than LiDAR, but also provide the ability to consistently measure the marsh surface as opposed to the LiDAR laser pulse which typically only characterizes the variable elevation of the top of marsh vegetation and not enough of the salt marsh peat surface or platform.

The NE Coastal and Barrier Network's Inventory and Monitoring Program (I&M) collects nekton and vegetation data on several salt marshes in coastal parks of the NE Region of the NPS (Figure 1). SETs have also been implemented along with tide gauges and water level loggers in National Park marshes to document accretion rates coupled with water level heights. Combining these different studies into a comprehensive model such as *The Wetland Accretion Rate Model for Ecosystem Resilience* (WARMER) (Takekawa et al., 2013) will project future salt marsh elevations.

Models such as WARMER combine the physical process of marsh elevation change with its relationship to organic matter accumulation to predict a non-linear trend of marsh surface elevation relative to SLR scenarios.

**PROJECT GOAL AND MEASURABLE OBJECTIVES:** The goal of this project is to develop and implement field procedures for precise mapping of the elevation of salt marsh habitats at Fire Island National Seashore (FIS), Gateway National Recreational Area (GATE), and Assateague Island National Seashore (ASIS). These data will support the implementation of the WARMER model. We will prioritize our study sites by working at the marshes where the I&M program collects SET, vegetation, and nekton data. At these marshes, we will collect comprehensive elevation data from the low marsh to the high marsh. These intensive on-the-ground kinematic GPS or total station surveys (along with water level data) will be used to tie the salt marshes to the NSRS and to calculate tidal datums specific to each salt marsh site. To help meet these goals, the NE Region of the NPS (along with the University of Rhode Island) has established a 'backbone' survey network of geodetic control for each of the parks. Backbone sites can be used to support GPS base stations for survey-quality elevation mapping around the backbone site. The working radius of each backbone monument is 5 km. This survey control network allows data gathering within 2 cm horizontal and vertical error, and is readily accessible online ([www.edc.uri.edu/monumentation](http://www.edc.uri.edu/monumentation)). However, it is assumed that some salt marsh sites will require additional survey control to support the field data collection for both kinematic GPS and total station devices. In these instances, the control will be installed by utilizing resources from our work on the project *"Elevation Mapping of Critical Park Areas for Planning and Post- and Future Storm Evaluation and Modeling."*

To meet our goal, we will accomplish the following objectives:

1. Develop procedures and guidelines (SOP) for salt marsh elevation data collection in the field using total station and survey kinematic GPS surveys coupled with vegetation classification.
2. Collect kinematic GPS and total station elevation data for salt marshes. These data will be suitable for interpolating elevation surfaces when desired. The elevation data will also serve as an input parameter for vulnerability modeling.
3. Organize training for NPS staff on geospatial data collection protocols (kinematic GPS and total station).
4. Combine with existing water level data from SETs and local tide gauges with additional gauge deployments as needed.

#### **PROJECT ACTIVITIES:**

**Objective 1 – SOP development for field data collection of data DEM and elevation data collection**

## **guidelines and standard operating procedure (SOP)**

### **Task 1 – Grid spacing analysis**

The spacing between elevation measurements is an important parameter to establish. Fine spacing (short distance between points) will allow dense spatial coverage of a marsh but will require an inordinate amount of time to collect (Table 1).

| Point Spacing | # Pts/10 Ha Marsh | Data Collection Time/Point (Min) | Time to Survey 10 ha Marsh (Hrs) |
|---------------|-------------------|----------------------------------|----------------------------------|
| 20 m          | 250               | 10                               | 41.7                             |
| 10 m          | 1,000             | 8                                | 133.3                            |
| 5 m           | 4,000             | 6                                | 400.0                            |
| 2 m           | 25,000            | 5                                | 2,083.3                          |

**Table 1.** Estimates of time to collection elevation data from a 10 hectare salt marsh using different point spacing distances.

Some of the modeling applications and statistical analyses will require independence of elevation samples. Close points will be spatially autocorrelated, thus not independent measures of marsh elevation. Using bare earth LiDAR data as a surrogate for marsh elevation data, we will assess patterns of spatial autocorrelation by evaluating semivariograms created from the LiDAR data (Isaaks and Srivasta, 1989; Oliver and Webster, 2014). If we are striving for independence, the lag distance of the semivariogram's sill will provide us a point spacing interval where measures are independent of each other.

### **Task 2 – Site selection**

We will choose three marshes to do our analysis. The marshes will be selected based on the homogeneity of marsh geomorphology (e.g., no tidal creeks or upland islands) and elevation surface. However, all sites will include low marsh, high marsh, and salt meadow habitats so that the full range of vegetation communities and elevations are included.

### **Task 3 – Accuracy assessment**

The total station-derived elevation data (mm accuracy) will allow us to develop a detailed assessment of error in bare-earth elevation measurements obtained using LiDAR data. It will be

interesting to perform this error assessment using marsh vegetation as a statistical covariate.

## Objective 2 – Collect kinematic GPS and total station data for salt marshes in FIIS, GATE, and ASIS

### Task 1 – Site selection

Marshes with ongoing SET data and vegetation data collection efforts will have top priority for surveying (Table 1). Other potential survey sites include: I&M Program fish and vegetation sites (without SETs) and restoration sites at ASIS and GATE.

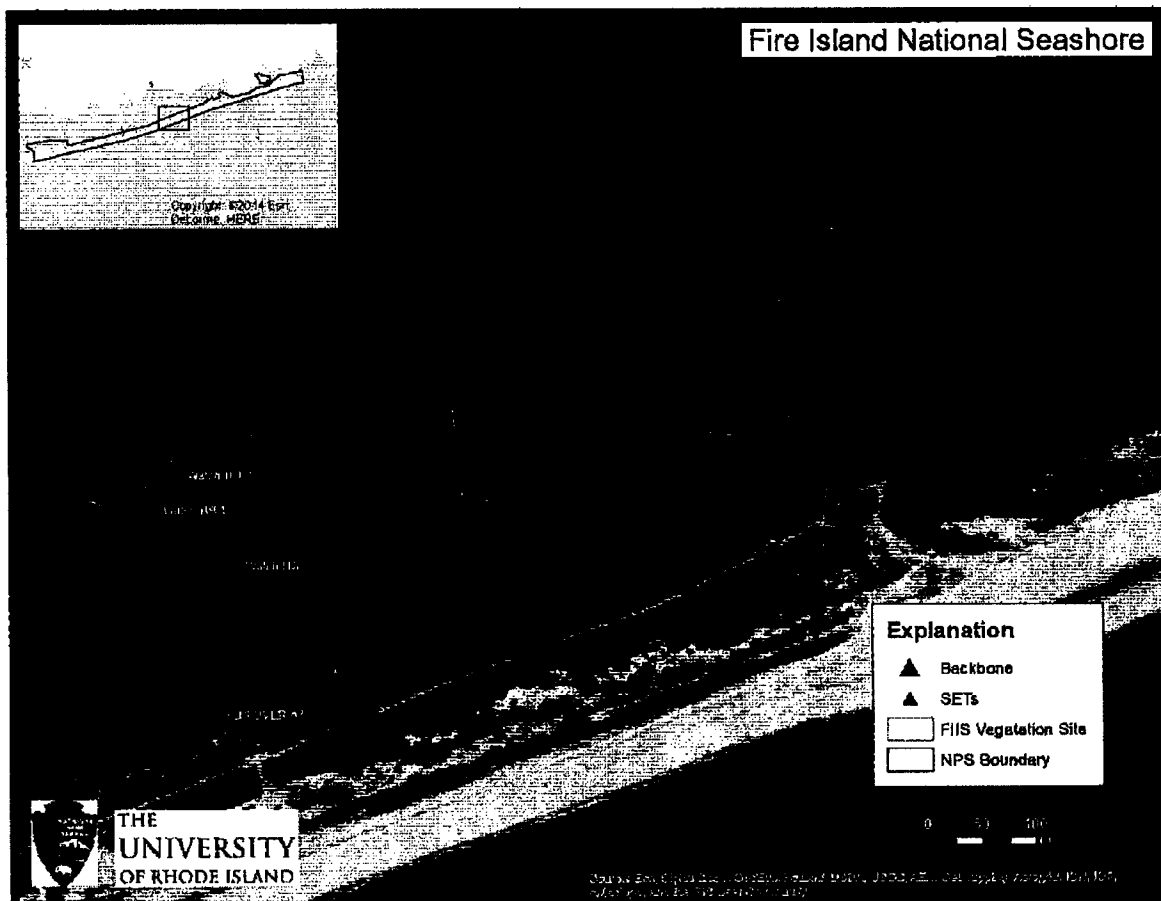


**Figure 1.** Current vegetation site in FIIS for potential kinematic GPS and total station data collection. The site has SETs with water level data and a benchmark for elevation control. The vegetation site includes high and low marsh.

### Task 2 – Field data collection

Kinematic GPS or total station elevation data will be collected at a grid spacing determined by

Objective 1 and input from NPS personnel. GPS data will be collected at existing or temporary benchmarks established at each field site as necessary. Table 2 depicts estimated time of field work based on two field technicians, 20m grid spacing, and in current vegetation sites. The density of data points could change based on outcome of Objective 1 and as study sites are refined. Timing of field work will be during the Spring and Fall seasons with vegetation plots conducted in the summer of the same season.

**Table 2.** Time estimates to survey target marsh systems

| Unit                   | Marsh ID (EDC ID) | Area (ha)    | Points 20 m | Weeks of Field Work |
|------------------------|-------------------|--------------|-------------|---------------------|
| FIIS                   | FIIS 1            | 7.6          | 277         |                     |
|                        | FIIS 2            | 6.7          | 237         |                     |
|                        | FIIS 3            | 5.7          | 213         |                     |
|                        | FIIS 4            | 5.3          | 201         |                     |
|                        | FIIS 5            | 5.3          | 242         |                     |
|                        | FIIS 6            | 5.5          | 253         |                     |
|                        | <b>Total: 6</b>   | <b>36.1</b>  | <b>1423</b> | <b>5</b>            |
| GATE                   | SAHO 1            | 7.0          | 267         |                     |
|                        | SAHO 2            | 15.1         | 809         |                     |
|                        | SAHO 3            | 6.6          | 311         |                     |
|                        | <b>Total : 3</b>  | <b>28.7</b>  | <b>1387</b> | <b>3</b>            |
| ASIS                   | ASIS 1            | 5.1          | 192         |                     |
|                        | ASIS 2            | 7.5          | 281         |                     |
|                        | ASIS 3            | 6.7          | 262         |                     |
|                        | ASIS 4            | 8.3          | 304         |                     |
|                        | ASIS 5            | 8.0          | 319         |                     |
|                        | ASIS 6            | 5.1          | 198         |                     |
|                        | ASIS 7            | 7.4          | 286         |                     |
|                        | ASIS 8            | 6.6          | 251         |                     |
|                        | ASIS 9            | 5.4          | 211         |                     |
|                        | <b>Total: 9</b>   | <b>60.1</b>  | <b>2304</b> | <b>8</b>            |
| <b>Grand total: 18</b> |                   | <b>124.9</b> | <b>5114</b> | <b>16</b>           |

### Task 3 – Data processing and analysis

All coordinate data will be standardized to UTM Zone 18 NAD83 (2011) and NAVD88 (Geoid12A).

### **Objective 3 – Training**

URI will organize and host training for NPS staff of new total station and survey grade GPS equipment with a qualified vendor.

### **Objective 4 – Organize and evaluate water level data for salt marsh**

A basic element necessary for maximizing park preparedness is an accurate measure of present sea level with respect to the fixed vertical orthometric datum (e.g., NAVD88) that is used as the reference for vertical elevation data on land. Due to spatial variability in the oceanic tidal response and in non-tidal currents, the vertical height of a particular tidal datum (e.g., Mean Sea Level (MSL) or Mean High Water (MHW)) relative to an orthometric datum is generally not spatially uniform. To address this, NOAA has installed a series of temporary tide gauges at FIIS, GATE, and ASIS. In addition, the NPS and other research partners have deployed other water level loggers at shorter time intervals and coarser measurement accuracies.

**DELIVERABLES and SCHEDULE:** Our six main deliverables include:

1. Written report on SOP guidelines for elevation data collection in salt marshes (Summer '14)
2. Assimilation and accumulation of training materials provided during total station and GPS training (Summer '14)
3. Field work on salt marshes to begin (Fall '14)
4. Tidal datum calculations and report for each salt marsh site based on closest and most accurate tide gauge data. (Spring '16)
5. Geodatabase of elevation points for salt marsh sites including vegetation data and heights relative to NAVD88 (As completed, finalized Spring '16).
6. Report on Findings (Spring '16)

# **BUDGET AND BUDGET EXPLANATION**

| <b>Start Date: upon execution of agreement<br/>Duration: 2 years</b>                                                                | <b>Man<br/>Months</b> | <b>Total<br/>Request</b> |
|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------|
| <b>A. Personnel</b>                                                                                                                 |                       |                          |
| Michael Bradley, Research Associate IV                                                                                              | 7.7                   | 43,380                   |
| Scott Rasmussen, Research Associate II                                                                                              | 24.0                  | 96,113                   |
| Andrew Neil, Research Associate II                                                                                                  | 24.0                  | 96,113                   |
| Graduate Student Lvl I Summer Stipend                                                                                               | 8.4                   | 30,476                   |
| Graduate Student MESM Lvl I Academic Year                                                                                           | 9.5                   | 67,242                   |
| <b>TOTAL PERSONNEL COSTS</b>                                                                                                        |                       | <b>333,324</b>           |
| <b>B. Fringe</b>                                                                                                                    |                       |                          |
| Fringe for Bradley Res Assoc IV@ 57%                                                                                                |                       | 24,748                   |
| Fringe for Rasmussen Res Assoc II@ 70%                                                                                              |                       | 67,394                   |
| Fringe for Neil Res Assoc II@ 40%                                                                                                   |                       | 38,849                   |
| FICA for Graduate Student Summer Stipend                                                                                            |                       | 2,331                    |
| <b>TOTAL FRINGE BENEFITS</b>                                                                                                        |                       | <b>133,322</b>           |
| <b>C. Equipment</b>                                                                                                                 |                       |                          |
| Sea-Bird SBE 26plus wave & tide recorder                                                                                            |                       | 15,000                   |
| <b>TOTAL EQUIPMENT</b>                                                                                                              |                       | <b>15,000</b>            |
| <b>D. Travel</b>                                                                                                                    |                       |                          |
| Vehicle rental/mileage RI-GATE/FIIS/ASIS (10 trips/park)                                                                            |                       | 48,480                   |
| Travel per diem for Park visits (10 trips, 2 people, 3-14 days/trip)                                                                |                       | 17,407                   |
| GIS Conference Training (NEARC Northeast US, Esri UC California)                                                                    |                       | 6,313                    |
| <b>TOTAL TRAVEL</b>                                                                                                                 |                       | <b>72,200</b>            |
| <b>E. Supplies</b>                                                                                                                  |                       | 25,891                   |
| <b>TOTAL SUPPLIES</b>                                                                                                               |                       | <b>25,891</b>            |
| <b>F. OTHER COSTS</b>                                                                                                               |                       |                          |
| EDC Computing Charges (includes GIS software, computing workstations, data backup services, security infrastructure, GPS equipment) |                       | 76,849                   |
| <b>TOTAL OTHER COSTS</b>                                                                                                            |                       | <b>76,849</b>            |
| <b>TOTAL DIRECT COSTS</b>                                                                                                           |                       | <b>656,586</b>           |
| <b>TOTAL MODIFIED DIRECT COSTS</b>                                                                                                  |                       | <b>641,586</b>           |
| <b>FACILITIES AND ADMINISTRATIVE COSTS 17.5% MTDC</b>                                                                               |                       | <b>112,278</b>           |
| <b>TOTAL REQUESTED FROM AGENCY</b>                                                                                                  |                       | <b>\$ 768,864</b>        |

## Budget Notes

Project period is 2 years from date of execution

Personnel consist of salaries and benefits for Michael Bradley, Scott Rasmussen, Andrew Neil, summer MESM Graduate Students (2 in YR2), and academic year MESM Graduate Students (2 in YR1; 2 in YR2) to assist in this project.

Equipment consists of a Sea-Bird SBE 26plus wave & tide recorder to obtain refined local tidal reference estimates at key salt marsh sites.

Travel consists of URI travel to the three parks and includes vehicle rental/mileage, per diem, and lodging costs. We anticipate ten trips to each park over the course of the project with each trip spanning 3-14 days. Per diem rates from federal guidelines and auto mileage computed at \$0.55/mile. Also included is travel to the ArcGIS user conferences for the northeast US (NEARC) and national/international (San Diego, CA) communities to present the results of our work and to gain advanced training in elevation mapping and modeling.

Supplies for survey instrumentation, GPS accessories, tidal measurement accessories, tablet computers, notebook computers, desktop computers to carry out the objectives of the project; survey monument hardware, tools, and accessories to install survey markers; items to conduct GPS and survey training for park staff.

EDC computing costs are based on 2 FTE seats. EDC costs include GIS software, access to desktop computers, disk storage space, data backups, network security, and use of EDC printers and plotters.

Indirect Costs are computed at the CESU rate of 17.5%

## LITERATURE CITED:

- Cahoon, D.R., Lynch, J.C., Hensel, P., Boumans, R., Perez, B.C., Segura, B. & Day Jr, J.W. 2002, "High-Precision Measurements of Wetland Sediment Elevation: I. Recent Improvements to the Sedimentation-Erosion Table: RESEARCH METHODS PAPERS", *Journal of Sedimentary Research*, vol. 72, no. 5, pp. 730-733.
- Cahoon DR, Hensel PF, Spencer T, Reed DJ, McKee KL, Saintilan N. 2006. Coastal wetland vulnerability to relative sea-level rise: wetland elevation trends and process controls. Chapter 12. In Verhoeven J., Whigham D., Bobbink R., and Beltman B. Wetlands as a Natural Resource, Volume 1: Wetlands and Natural Resource Management. Springer Ecological Studies series.
- Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan, 2013: Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
- Gesch, D. B. (2009). Analysis of Lidar elevation data for improved identification and delineation of lands vulnerable to sea-level rise. *Journal of Coastal Research*, 53, 49–58.

- Hladik, C., and Alber, M., 2012. Accuracy assessment and correction of a LIDAR-derived salt marsh digital elevation model. *Remote Sensing of the Environment*, v 121, p. 224-235.
- Holgate, S. J., and Woodworth, P. L., 2004. Evidence for enhanced coastal sea level rise during the 1990s: *Geophysical Research Letters*, v. 31, p. L07305.
- IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Isaaks, E. H., & Srivastava, R. M., 1989. *Applied Geostatistics*. London: Oxford University.
- Kemp, A. C., Horton, B. P., Donnelly, J. P., Mann, M. E., Vermeer, M., and Rahmstorf, S., 2011. Climate related sea-level variations over the past two millennia: *Proceedings of the National Academy of Science of the United States of America*: v. 108, p. 11017–11022.
- Mancera, J. E., Meche, G. C., Cardona-Olarte, P. P., Castaneda-Moya, E., Chiasson, R. L., Geddes, N. A., Schile, L. M., Wang, H. G., Guntenspergen, G. R., and Grace, J. B., 2005. Fine-scale spatial variation in plant species richness and its relationship to environmental conditions in coastal marshlands: *Plant Ecology*, v. 178, p. 39–50.
- Morris, J. T., Sundareshwar, P. V., Niench, C. T., Kjerfve, B., & Cahoon, D. R. (2002). Responses of coastal wetlands to rising sea level. *Ecology*, 83, 2869–2877.
- Murdukhayeva, A.; August, P.; Bradley, M.; LaBash, C., and Shaw, N., 2013. Assessment of inundation risk from sea level rise and storm surge in northeastern coastal national parks. *Journal of Coastal Research*, 29(6A), 1–16. Coconut Creek (Florida), ISSN 0749-0208.
- Oliver, M.A. and Webster, R. 2014. A tutorial guide to geostatistics: Computing and modeling variograms and kriging. *Catena* 113: 56-69.
- Overpeck, J.T., Otto-Bliesner, B.L., Miller, G.H., Muhs, D.R., Alley, R.B., and Kiehl, J.T., 2006. Paleoclimatic evidence for future ice-sheet instability and rapid sea level rise: *Science*, v. 311, p. 1747-1750.
- Sallenger, A.H., Doran, K.S., and Howd, P.A., 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America: *Nature Clim. Change*, v. advance online publication.
- Schmid, K.A., Hadley, B.C. & Wijekoon, N. 2011, "Vertical Accuracy and Use of Topographic LIDAR Data in Coastal Marshes", *Journal of Coastal Research*, vol. 27, no. 6, pp. 116-132.
- Takekawa, J.Y., Thorne, K.M., Buffington, K.J., Spragens, K.A., Swanson, K.M., Drexler J.Z., Schoellhamer, D.H., Overton, C.T., Casazza M.L. 2013. Final report for sea-level rise Response modeling for San Francisco Bay estuary tidal marshes. U.S. Geological Survey Open File Report 2012-1081, 161 p.
- Vermeer, M., and Rahmstorf, S., 2009, Global sea level linked to global temperature: *Proceedings of the National Academy of Sciences of the United States of America*, v. 106, p. 21527-21532.

## **ATTACHMENT B**

The National Park Service agrees to:

- Assign a Northeast Coastal and Barrier Network (NCBN) Program Manager as the Science Technical Advisor on this project. The Program Manager and the NCBN Data Manager will actively collaborate with the University of Rhode Island investigator, research associates, graduate students and undergraduate interns on the project design, data collection, and data interpretation, and production of final deliverables including data formats.
- Provide the cooperators with all relevant GIS data sets and elevation monitoring data that may be important to the study.
- Provide logistical support during visits to the parks for data collection, including access and potential assistance with field surveys by both Park and NCBN staff.
- Provide temporary park housing at Fire Island National Seashore, Gateway NRA and Assateague Island NS, as available, for the University of Rhode Island researchers as needed.
- The NCBN Sediment Elevation Monitoring Program Lead will provide guidance and expertise on RTK and leveling equipment and will provide expertise and assistance on field visit to the parks.