

**Task Agreement P14AC00230
Against
Cooperative Agreement
P09AC00212 (formerly H4503090700)
between
The United States Department of the Interior
National Park Service
and
University of Rhode Island**

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Project Title: **Post-Hurricane Sandy Salt Marsh Change Detection and Development of Salt Marsh Change Detection Protocol for the Northeast Coastal Parks**

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

This Task Agreement 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.”

ARTICLE I – BACKGROUND AND OBJECTIVES

Cooperative Agreement Number P09AC00212 (formerly H4503090700) dated June 19, 2009, was entered into by and between the Department of the Interior, NPS, Northeast Region, and the University of Rhode Island. The purpose of this cooperative agreement is to support coastal national parks in the Northeast Region of the National Park Service, and Servicewide, by providing research, technical assistance, and education through the cooperative relationship with partners of the North Atlantic Coast Cooperative Ecosystem Studies Unit (CESU), including the University of Rhode Island. Unless otherwise specified herein, the terms and conditions as stated in the Cooperative Agreement will apply to this Task Agreement.

Salt marsh communities are sensitive to disturbance and perturbations from natural causes such as storms and geomorphic processes, as well as human induced impacts associated with nutrient loading, watershed development, tidal restrictions, and ditching. The vegetation communities and spatial patterns in the coastal parks are highly dynamic resulting from interactions with driving forces such as sand deposition, storm-driven over wash, salt spray, surface water, as well as human disturbances. Climate change, as another major factor, brings extreme disruptive forces such as temperatures, precipitation, storm surge, drought, erosion to the ecosystems. Nor’easters are already occurring more frequently than in the 1970s and possible increases in the intensity of hurricanes are real concerns. In the near future, East Coast storms are predicted to occur more frequently during late winter and to bring more rain in shorter periods of time and for longer durations. With higher sea-levels, storm surge will penetrate further on shore. These storm events will accelerate erosion on low-lying coastlines, and islands will also experience more wash over and breaching events.

Hurricane Sandy and its impacts intensify the concern of climate change effects on the ecosystems of the coastal national parks in the Northeastern United States.

Hurricane Sandy had huge impacts on the coastal NPS sites in the Northeastern United States. Post-Sandy rapid response aerial imagery, collected and published by the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS) and National Geodetic Survey (NGS), revealed the significant impacts of this storm on parks. These images illustrated that the salt marsh in these parks was significantly affected. Fire Island National Seashore (FIIS) alone lost almost an entire section of the eastern end of the park and other areas were severely damaged. The NPS identified that the loss of salt marsh habitats in coastal parks, in particular for those affected by Hurricane Sandy, warrants the development of a cost-effective, high spatial resolution, satellite remote sensing-based salt marsh change detection protocol. This protocol would provide direction for parks on how to conduct change analyses for their salt marsh habitats, using satellite imagery. The focus of this project is to develop this monitoring protocol as well as pilot the protocol by conducting long term salt marsh change analysis for Gateway National Recreation Area (GATE), FIIS and Assateague Island National Seashore (ASIS), three parks severely affected by Hurricane Sandy.

ARTICLE II – AUTHORITIES

Authorities for this task agreement under Cooperative Agreement are:

- Pursuant to 16 U.S.C. Section 1g, the National Park Service may in fiscal year 1997 and thereafter enter into cooperative agreement that involve the transfer of National Park Service appropriated funds to State, local and tribal governments, other public entities, educational institutions, and private nonprofit organizations for the public purpose of carrying out National Park Service programs pursuant to 31 U.S.C. 6305 to carry out public purposes of National Park Service programs.
- Pursuant to 16 U.S.C. Section 1a-2(j), also known as "The Omnibus Parks and Public Lands Management Act of 1996", the National Park Service may enter into cooperative agreements with public or private educational institutions, States, and their political subdivisions, for the purpose of developing adequate, coordinated, cooperative research and training programs concerning the resources of the National Park System, and, pursuant to any such agreements, to accept from and make available to the cooperator such technical and support staff, financial assistance for mutually agreed upon research projects, supplies and equipment, facilities, and administrative services relating to cooperative research units as the Secretary deems appropriate; except that this paragraph shall not waive any requirements for research projects that are subject to the Federal procurement regulations.
- 16 U.S.C. Section 5933, Cooperative Study Units, authorizes and directs the Secretary to enter into cooperative agreements with colleges and universities, including but not limited to land grants schools, in partnership with other federal and state agencies, to establish cooperative study units to conduct multi-disciplinary research and develop integrated information products on the resources of the national park system, or the large region of which parks are a part.

ARTICLE III – STATEMENT OF WORK

- A. The University of Rhode Island agrees to implement the attached study proposal/work plan (ATTACHMENT A).
- B. The NPS agrees to the tasks presented in ATTACHMENT B.

ARTICLE IV – TERM OF AGREEMENT

This Agreement will become effective upon signature by the NPS Agreements Officer and extend through December 30, 2016.

ARTICLE V – KEY OFFICIALS

The personnel specified below are considered to be essential to ensure maximum coordination and communication between the parties and the work being performed hereunder. Either party, on notice to the other party, may designate another person or persons to act in his/her place for point of contact positions that do not require specific designation.

The NPS Agreements Technical Representative (ATR) will be designated in writing by the Agreements Officer. Authorities and limitations of authority will be explained in the designation letter.

The Cooperator/Recipient may change its Key Officials by notifying the NPS Agreements Officer in writing. The Cooperator/Recipient will address any communication regarding this Agreement to the NPS ATR.

1. For the National Park Service:

Signatory Agreements Officer

NER Agreements Officer
National Park Service
US Custom House
200 Chestnut Street-3rd Floor
Philadelphia, PA 19106
Telephone: 215-597-6476

Agreements Technical Representative

Mary K. Foley- Agreements Technical Representative (ATR)
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Project Technical Contacts

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2. For the University of Rhode Island:

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Principal Investigator

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(401) 874-4345; (401) 874-4561(f); yqwang@uri.edu

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 \$200,000 in fiscal year 2014 for the work described in Article III 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
\$100,000 ---- WBS: PX.P0195540A.00.1 FA: PLCLISD5S.CN0000 CC: PPNEASIS00
\$100,000---- WBS: PX.P0201092A.00.1 FA: PLCLISD5S.CN0000 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 VII – PRIOR APPROVAL

Provisions as set forth in the Cooperative Agreement shall apply to this Task Agreement.

ARTICLE VIII – LIABILITY

Provisions as set forth in the Cooperative Agreement shall apply to this Task Agreement.

ARTICLE IX – REPORTS AND/OR DELIVERABLES:

- A. **Where to Submit** – In accordance with 43 CFR Part 12, the Cooperator/Recipient will submit reports to the NPS Agreements Officer at the address specified in Article V. The Cooperator/Recipient will also submit a copy of each report to the ATR at the address specified in Article V.
- B. **What and When to Submit** – The Cooperator/Recipient will submit to the NPS the following reports at the specified times:
1. Federal Financial Report (FFR), SF425, submitted quarterly, no more than 30 days after the end of the reporting period. The following reporting period end dates will be used for quarterly reports: 3/31, 6/30, 9/30 or 12/31. Upon completion of the project a final FFR will be submitted no more than 90 days after the final project end date.
 2. FFR reports will be submitted for this agreement for any period of time within the quarterly report period.
 3. Performance Reports - In accordance with 2 CFR 215.51 or OMB Circular A-102, **Cooperator/Recipient** will provide quarterly performance reports describing the accomplishments of the Cooperator/Recipient, the expenses and income of the Cooperator/Recipient, and each entity to which the Cooperator/Recipient made any grant during the fiscal year. Quarterly reports shall be due 30 days after the end of the reporting period. Annual reports shall be due 90 days after the grant year. The final performance report is due 90 days after the end of the award.

- C. **Recordkeeping** – The Cooperator/Recipient will keep records concerning this Agreement in accordance with the requirements of the General Provisions, CFR and applicable Office of Management and Budget Circulars.
- D. The Secretary of the Interior and the Comptroller General of the United States, or their duly authorized representatives, will have access, for the purpose of financial or programmatic review and examination, to any books, documents, papers, and records that are pertinent to the Agreement at all reasonable times during the period of retention in accordance with 2 CFR 215.53 or OMB Circular A102.

E. Project-based Deliverables

Year 1 (based on funding obligation date-01-2015)

- 04/2014-05/2014: Accomplish the initial data assemblage and acquisition for GATE, FIIS and ASIS sites. Conduct data verification, initial image classification and improvement for GATE.
- 05/2014-09/2014: Accomplish the initial site assessment; accomplish 2012 and 2013 QuickBird-2 and WV2 image classification for GATE.
- 10/2014-12/2014: Deliver an initial report of prototype protocol for salt marsh mapping at the GATE, including the GIS data, metadata, accuracy assessment results

Year 2 (01/2015-12/2015)

- 01/2015-03/2015: Change analysis and report for GATE sites.
- 04/2015-05/2015: Accomplish the site assessment for FIIS and ASIS sites
- 06/2015-12/2015: Implement the protocol to FIIS and ASIS by image processing and classification of the 2013 QuickBird-2 and WV2 images. Accomplish the initial accuracy assessment for FIIS and ASIS sites.

Year 3 (01/2016-12/2016)

- 01/2016-06/2016: Finalize image classification and salt marsh mapping for FIIS and ASIS. Finalize the accuracy assessment. Finalize salt marsh change analysis for GATE (Jamaica Bay), FIIS and ASIS for change analysis.
- 07/2016-10/2016: Complete the project report and generate publications.

ARTICLE X – PROPERTY UTILIZATION

Provisions as set forth in the Cooperative Agreement shall apply to this Task Agreement.

ARTICLE XI – MODIFICATION AND TERMINATION

Provisions as set forth in the Cooperative Agreement shall apply to this Task Agreement.

ARTICLE XII – GENERAL AND SPECIAL PROVISIONS

1. Provisions as set forth in the Cooperative Agreement shall apply to this Task Agreement.

2. **Certifications** – The following certification is required in accordance with the provisions of this Agreement: Certification in Regards to Lobbying, on individual awards made under this Agreement that are \$100,000 or over.

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 “Post-Hurricane Sandy Salt Marsh Change Detection and Development of Salt Marsh Change Detection Protocol for the Northeast Coastal Parks”
- B. Statement of work for which the National Park Service agrees to perform.

ARTICLE XIV – SIGNATURES

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

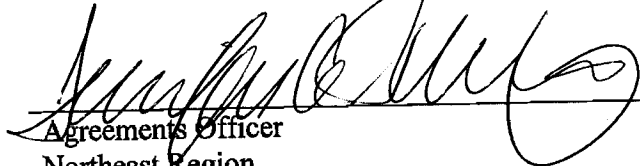
FOR THE UNIVERSITY OF RHODE ISLAND:



James K. Petell, Assoc VP

4/30/14
Date

FOR THE NATIONAL PARK SERVICE



Agreements Officer
Northeast Region

05/02/2014
Date

ATTACHMENT A: University of Rhode Island Study Proposal

A Proposal to the National Park Service

**Post-Hurricane Sandy Salt Marsh Change Detection and Development of Salt
Marsh Change Detection Protocol for the Northeast Coastal Parks**

Submitted by:

Dr. Yeqiao Wang (Principal Investigator)
Professor, Department of Natural Resources Science
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Requested Budget: \$200,000

BACKGROUND AND PROJECT STATEMENT

In October 2012, Hurricane Sandy imposed huge impacts to the coastal parks in the Northeast United States. Post-Sandy rapid response aerial imagery¹, collected and published by the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS) and National Geodetic Survey (NGS), revealed the significant impacts of this superstorm. The images illustrated that the salt marshes in these parks were significantly affected. Fire Island National Seashore (FIIS) alone lost almost an entire section of the eastern end of the park and other areas were severely damaged. The National Park Service (NPS) identified that the loss of salt marsh habitats in coastal parks, in particular for those affected by 2012 Hurricane Sandy, warrants change analysis and development of a cost-effective, high spatial resolution satellite remote sensing-based salt marsh change detection protocol. The focus of this project is long term salt marsh change analysis and monitoring at GATE, FIIS, and ASIS.

Salt marsh communities are sensitive to disturbance and perturbations from natural causes such as storms and geomorphic processes, as well as human induced impacts associated with nutrient loading, watershed development, tidal restrictions, and ditching. The vegetation communities and spatial patterns in the coastal parks are highly dynamic because of interactions with forces such as sand deposition, storm-driven over wash, salt spray, and surface water, as well as human disturbances. Climate change, another major factor, brings extremely disruptive forces such as changes in temperatures and precipitation, storm surge, drought, and erosion to the ecosystems. Nor'easters are already occurring more frequently than in the 1970s and possible increases in the intensity of hurricanes are among real concerns. In the near future, east coast storms are predicted to occur more frequently during late winter and to bring more rain in shorter periods of time and for longer durations. With higher sea-levels, storm surge will penetrate further on shore. These storm events will accelerate erosion on low-lying coastlines and islands will also experience more wash over and breaching events. The most recent 2012 superstorm Hurricane Sandy and the impacts intensify the concern of climate change effects on the ecosystems of the coastal national parks in the Northeast US.

Productivity of salt marshes is a primary indicator of ecosystem health (Leibowitz and Brown, 1990). Nationwide, emergent salt marshes declined by an estimated 14,450 acres in ten years from 1986 to 1997 (Dahl, 2000). In November 2000, the New York Department of Environmental Conservation released a study that shows a sustained trend of significant salt marsh loss in Jamaica Bay over the past 100 years. Interpretation of historical aerial photographs shows that 51% of salt marshes in the Bay had been lost between 1924 and 1999. A study shows that although the salt marshes in GATE have been protected since 1972, 38% of salt marshes in Jamaica Bay have still been lost since 1974 (Hartig, et al, 2002). Historically, Jamaica Bay was characterized by extensive marsh islands and fringing marsh. However, over 60% (by area) of the bay's emergent vegetated marsh islands have converted to intertidal and subtidal mudflats, and more than 90% of the fringing marsh has been lost, mainly due to development. The salt marsh decrease in Jamaica Bay has caught the attention of the public (Stewart 2001). GATE and numerous partners are engaged in several initiatives that will contribute to restoration of the bay. The park is working with leading science experts to better understand the ecosystem and the causes of marsh loss and habitat

¹ <http://ngs.woc.noaa.gov/storms/sandy/>

deterioration within the bay. Having a consistent methodology for mapping salt marsh is a key to understanding change over time. This information is used to monitor the long term response of the restoration sites and target future sites and as a base map of the dynamic marsh system in numerous other projects such as the General Management Plan. Such a protocol can also be applied to other coastal parks, such as the FIIS and ASIS among others.

Extensive studies have been conducted for monitoring and quantifying salt marsh related habitats and conditions at GATE and other NPS coastal parks (Boumans et al. 2002; Roman et al. 2002; Edinger et al. 2008; Wang and Christiano 2006; Patenaude and Pooler 2011; Nicosia 2013; Wang and Traber 2013). The salt marsh change in Jamaica Bay indicates the same trend of salt marsh change elsewhere in the Northeastern United States. After Hurricane Sandy, the City of New York has made salt marsh mapping and restoration a high priority as it helps lessen the impact of storm events. Therefore, using Jamaica Bay as a prototype site to develop a protocol using high spatial resolution satellite remote sensing imagery data for monitoring future extents and change of salt marshes in the coastal parks of the Northeast US is essential and important for long term monitoring.

In 2003, the NPS supported the University of Rhode Island, a CESU (*Cooperative Ecosystem Studies Units*) partner, in developing a protocol for change detection of salt marsh habitats for GATE using high spatial resolution remote sensing data. The protocol has since become a standard operating procedure (SOP) to map emergent vegetative habitat for the salt marsh of Jamaica Bay. The resulting SOP relies upon 4-band multispectral QuickBird-2 satellite imagery data and a trained classification system and has been successfully used to map and evaluate salt marsh loss in Jamaica Bay in 2003, 2008, and 2012. The change analysis will be repeated in 2013. This computer guided mapping protocol has provided a cost effective approach to conducting salt marsh habitat change analysis and tracking impacts of landscape altering events and management actions such as salt marsh conservation and restoration. The SOP provides managers with greater detail of the salt marsh islands than the park's vegetation study provided by the Inventory and Monitoring protocol. The current protocol identifies four salt marsh categories, including *Spartina* > 50%, *Spartina* 10-50 %, *Mudflat*, and *Water*. These classes allow the park to track changes in marsh condition (*i.e.* ponding, expansion of tidal creeks and pools, change in vegetation density) as well as marsh gains and losses site (island) by site (island) (Wang and Christiano, 2006; Wang et al., 2010).

The current SOP uses imagery collected from the QuickBird-2 satellite sensor system, which provides data in blue, green, red and near infrared spectral bands at 2.5 meter spatial resolution and, in addition, 0.6 meter spatial resolution imagery data for the panchromatic band. The near infrared band is a key information source to the classification as it is specifically designed to capture vegetation reflectance which allows for more detailed mapping of the marshes.

While the QuickBird-2 data-based SOP provides a repeatable methodology, there are some limitations. The first is that the imagery lacks capacity to penetrate water, and therefore the mudflat category was very subjective to tidal influence. This can be controlled to some extent with imagery collected at or about low tide. The availability of imagery, however, is limited to the orbit pattern of the satellite and imagery at dead low tide may not be possible. Since salt marsh loss is observed as the conversion of vegetated to non-vegetated intertidal habitat, accurately quantifying the mudflat category is important. The new *Coastal Blue* spectral band carried by the World View II (WV2)

sensor system was designed to penetrate waters in coastal environments. By evaluating the capacity of this new spectral band we expect to increase mapping accuracy at the intertidal vegetated and mudflat boundary area.

The second problem is that the fringe marshes were not part of the original SOP development. The spatial resolution of QuickBird-2 multispectral imagery (2.5 m) might not be adequate for accurate mapping of these narrow features. The finer spatial resolution data available with WV2 will increase the number of pixels in the fringe marsh areas and create a better signature for category identification.

The third problem that QuickBird-2 is coming to the end of its projected life cycle in 2014 and data from the satellite will no longer be available. Digital Globe has launched the WV2 satellite with a sensor that replaces QuickBird-2. WV2 has upgraded the sensor capabilities and added spectral bands. The improved WV2 and the next generation WV3 sensors will improve our current mapping capacity in the following import areas.

To date other technologies such as Lidar have not been applied to low-clarity water bodies to map the mudflat areas. It should also be noted that Lidar as well as any other low flying aircraft imagery missions are extremely difficult to use in Jamaica Bay, due to its proximity to JFK International Airport. This has prevented the Lidar coastal protocols from being implemented in the Jamaica Bay Unit of GATE. What little Lidar information has been collected by the City of New York has proven ineffective in mapping due to the limits of vertical scale accuracy ($\pm 15\text{cm}$ at best) and the inability to penetrate the water. Satellite imagery has proven to be the cost effective method to collect imagery in the Bay.

In 2003, the NPS supported a University of Rhode Island to conduct terrestrial and submerged aquatic vegetation mapping for FIIS. The project employed QuickBird-2 satellite imagery data to map the terrestrial vegetation. The project referenced the same classification system employed by the USGS/NPS Vegetation Mapping Program (Klopfer *et al.*, 2002). The classification used five broadly defined vegetation groups: salt marshes, dune grasslands, dune shrublands, interdunal swales, and forests/shrublands. These types were further classified into 27 different associations representative of a typical middle and upper Atlantic barrier island system. The generated FIIS vegetation map from image classification of the 2003 QuickBird-2 satellite data provided the base line information for change analysis. The project also identified several potential points for improvement. One of the suggestions was that since the barrier island is constantly changing, updates to the map product should be completed on a regular basis as to ensure changes are rapidly assessed. In addition, the study suggested the need to explore new data sources and approaches that could be more efficiently used to update vegetation map, including exploration of using new type of improved satellite data (Wang *et al.*, 2007; Wang and Traber, 2013).

With the above research and data background, this project will conduct a technical crosswalk to assure continuity in long-term trend analysis from QuickBird-2 to WV2 satellite sensors and conduct accuracy assessment and peer-review so that the final product protocol can be widely applied to coastal marshes of the NPS interests. Using GATE as the protocol development site, this project will generate a 2013 and a future 2016 salt marsh map, respectively. With the derived data, we will conduct change analysis of salt marsh for time periods between 2003-2008, 2008-2013 and

2013-2016 for the Jamaica Bay unit of GATE. This new protocol will be expanded to FIIS and ASIS and implemented for salt marsh change analysis, in particular the changes caused by Hurricane Sandy. Graduate students will assist in completing the work and be given the opportunity to work collaboratively with the National Park Service. Publications and graduate level work will be presented at the parks and professional conferences.

OBJECTIVES

1. Use the new World View II sensor system data to close existing data gaps for improved salt marsh habitat mapping and change analysis.
2. Use existing 2012 QuickBird-2 and World View II data sets to develop reliable and repeatable protocol that crosswalk between the QuickBird-2 and WV2 image classifications.
3. Develop the base map of the salt marsh for fall 2013 and 2016 and conduct assessment to evaluate 2003-2008, 2008-2012, 2012-2013, and 2013-2016 marsh habitat change for GATE. The 2012-2013 change analysis reflects the impacts from Hurricane Sandy.
4. Develop similar data products for the FIIS and ASIS using QuickBird-2 data.
5. Test and implement the new protocol for change analysis of salt marsh and immediately adjacent areas for FIIS and ASIS and provide an assessment of Hurricane Sandy impacts on those coastal parks.

APPROACH AND METHODS

Image and GIS Data Acquisition

We will begin the project using GATE and the prototype site for protocol development. We will compile existing information, such as historical aerial photographs, available high spatial resolution satellite imagery data, and previous project results from interpretation of salt marsh areas and the generated map data. Predominately these data will come from previous efforts conducted by the GATE, FIIS and ASIS. In preparation for this project the region and the park have invested time and money in collecting the necessary imagery. For example, in 2012 GATE obtained both Quickbird-2 and WV2 imagery data during the fall collection time window (Table 1). For the purpose of this project, additional new QuickBird-2 and WV2 imagery data for FIIS and ASIS will be purchased for protocol verification and post-Sandy change analysis (Table 1)

Table 1. Available and planned acquisition of high spatial resolution satellite imagery data for GATE, FIIS and ASIS

Year	Imagery	Note	Site
2003	QuickBird-2	Already acquired and processed	GATE, FIIS
2008	QuickBird-2	Already acquired and processed	GATE
2012	QuickBird-2 and WV2	Already acquired	GATE
2013	QuickBird-2 and WV2	Data acquisition between September and November 2013	GATE, FIIS, ASIS
2016	WV-III	Planned for WV3 data	GATE

		acquisition	
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Field Reference Database (FRDB)

With referencing the existing field reference data, further ground referencing at the GATE, FIIS and ASIS will be conducted to obtain an assessment of Hurricane Sandy impacts among other changes. The NPS professionals will provide guidance for the ground referencing. Trimble GPS system will be employed to document sampling locations throughout the salt marsh. The tentative sampling strategy is to designate several transects. At each sampling point, a GPS location will be recorded and a georeferenced digital photograph will be taken in the direction of each of four compass directions (North, South, East, West). GPS coordinates will be recorded for several prominent ground control points throughout the sampling sites. On return from the field, the GPS data and georeferenced photographs will be compiled to create a Field Reference Database (FRDB). The FRDB will be used during imagery classification process and will be a valuable record for future monitoring efforts as the benchmark reference record.

Initial Image Processing

To reduce the spectral effects of the water surface on terrestrial vegetation, we will define the area of interest (AOI) by clipping out from the georegistered and georeferenced QuickBird-2 and WV2 images the open bay water. This process will mask out the pixels that cover open bay water areas. We will create the AOIs for salt marsh mapping by manual delineations closely along the shoreline combined with unsupervised classification to separate land and water areas.

Image Classification

The current SOP relies upon using unsupervised classification to separate the pixels in distinct spectral classes; the new protocol will take this process one step further. We will employ a stratified digital image classification technique (Wang et al., 2007) to extract salt marsh types from the Quickbird-2 and WV2 imagery data. This protocol requires the support from existing salt marsh mapping data in GIS format. The existing salt marsh data defined approximate boundaries of salt marsh from previous delineations on aerial photos and image classification process. We will reference the existing salt marsh maps as the Phase I maps of corresponding years. The procedures will be as follows.

The existing USGS/NPS Vegetation Mapping Program vegetation maps for the GAE, FIIS and ASIS are considered as the Phase I map and the reference information for change analysis. First we will rasterize the vector format Phase I map data if the data were not in raster format. Since both GATE and FIIS had rasterized Phase I data adopted from previous mapping project, this will be applicable to the ASIS. The resampled pixel size will match with the spatial resolution of the QuickBird-2 and/or new WV2 imagery data. Upon finishing, the pixels of rasterized Phase I vegetation map will match with quickBird-2 or WV2 imagery pixels in corresponding locations. We then will use the salt marsh types in the rasterized Phase I map data as the control mask to extract pixels from WV2 images that fell into the corresponding areas. Those pixels would most likely belong to the type of masking salt marsh category. This will be done using the mask function of the ERDAS Imagine software system. We will repeat this procedure to extract pixels that correspond to each salt marsh type and other land cover category defined by the Phase I map. This masking process separated the QuickBird-2 and/or WV2 imagery data into subset images for further image classifications.

We will employ unsupervised classifications on those masked subset images. After labeling the clusters resulting from unsupervised classification, the dominant category should be the salt marsh or related category type defined as the masking type from the Phase I map data. Pixels that had distinct spectral differences than the masked type will be labeled as other different corresponding types. We will repeat this procedure until all the masked subset images are classified and labeled. Upon finishing, we will conduct visual comparison and examination for the agreements between Phase I map and the new image classification result. We will then mosaic all classified subset images to create the final updated salt marsh map. Salt marsh data derived from QuickBird-2 and WV2 imagery classification and mapping in previous projects are considered as part of the Phase I data as well for change comparison and analysis.

By stratified and unsupervised classifications, we will label the changed pixels as new categories, while unchanged pixels kept the same category as the Phase I map. The advantages of this procedure include that it values the previous vegetation mapping efforts, keep the classification scheme consistent, meet the goal of updating vegetation map, and is valid for change analysis and monitoring. Because digital image classifications are pixel based, more detailed spectral features within each Phase I data are extracted. The Phase I maps will play an important role as the control data layer. Combination of the Phase I and new WV2 satellite remote sensing data will help achieve more comprehensive information on salt marsh communities. Comparison of the two datasets allowed us to identify the locations and communities that are changed since the last mapping time period. This is a practical protocol for future mapping replications.

Accuracy Assessment

Accuracy assessment is a general term for comparing the classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process. The assumed-true data for this project is derived from ground truth data. The FRDB data will provide the most accurate ground truth data possible matching with satellite imagery acquisition time. Also historical and current aerial photography data, post-Sandy Rapid Response Imagery data collected and published in November 11, 2012 by the DOC, NOAA, NOS and NGS will be used as a reference data for visual analysis of damage in the area illustrated the significant impacts of Hurricane Sandy. Using the reference pixels an Accuracy Assessment Cell Array (error table) is created to compare the classified image with reference data. It's a simple calculation of number of correct values divided by the total number of reference pixels to determine the overall accuracy. In addition to the overall accuracy, the error table shows the accuracy on a class by class basis. This will be especially useful in determining the effectiveness of the coastal blue band in mapping the mudflat category.

Evaluation of the Spectral Capacity

In creating the new salt marsh map, the project will evaluate the effectiveness of each of the new bands, the near infrared band and the coastal blue band. The new near infrared band of the WV2 is designed to overlap the old near infrared band but is less affected by atmospheric influence. It was designed to support vegetation analysis and biomass studies. Testing the effectiveness of the new near infrared band is fairly straightforward because each pixel in the dataset will contain both the old and the new near infrared data. With good field data collected at the time that the imagery was

collected, we just need to run the stratified imagery classification, first with the old band and then with the new band and then evaluate the resulting dataset with the accuracy assessment. The resulting accuracy assessment will evaluate how effective the new band is in vegetation mapping.

Testing the coastal blue band will be more of a challenge, because the visibility of the mudflat category is tidal dependent. We need to document the edges of the mudflat area for multiple marshes. We are in the unique position where we have multiple years of both QuickBird-2 and WV2 data for 2012 & 2013. With four sets of data all collected during the fall collection time window, plus high resolution aerial photography provided by the City of New York and field reference data, we will have a number of datasets collected at different tidal stages. Using the multiple dataset we will be able to determine the edges of the mudflat areas for several marshes. This will provide the training signature for the computer and a way of testing the mapping accuracy. We will map the marshes using the original SOP method and using new coastal band, using error table we can evaluate how effective the coastal blue band is in mapping mudflat.

MEASURABLE RESULTS

The measurable results include:

1. Developed protocol for long term monitoring of salt marshes change analysis.
2. Salt marsh maps for Jamaica Bay marsh islands and fringing marsh for 2012, 2013 and 2016 derived from classification of the QuickBird-2 and WV2 imageries.
3. Salt marsh maps for FIIS and ASIS derived from imagery classification of 2013 QuickBird-2 and WV2 data
4. Implement the protocol for post-Hurricane Sandy change analysis of salt marsh and immediately adjacent areas for GATE (Jamaica Bay), FIIS and ASIS. The protocol could also be tested in Cape Cod National Seashore (CACO) for salt marsh mapping and change analysis.

TIMELINE (tentative depending on the funding availability and scope of work)

Year 1

- 04/2014-05/2014: Accomplish the initial data assemblage and acquisition for GATE, FIIS and ASIS sites. Conduct data verification, initial image classification and improvement for GATE.
- 05/2014-09/2014: Accomplish the initial site assessment; accomplish 2012 and 2013 QuickBird-2 and WV2 image classification for GATE.
- 10/2014-12/2014: Deliver an initial report of prototype protocol for salt marsh mapping at the GATE, including the GIS data, metadata, accuracy assessment results

Year 2 (01/2015-12/2015)

- 01/2015-03/2015: Change analysis and report for GATE sites.
- 04/2015-05/2015: Accomplish the site assessment for FIIS and ASIS sites
- 06/2015-12/2015: Implement the protocol to FIIS and ASIS by image processing and classification of the 2013 QuickBird-2 and WV2 images. Accomplish the initial accuracy assessment for FIIS and ASIS sites.

Year 3 (01/2016-12/2016)

- 01/2016-06/2016: Finalize image classification and salt marsh mapping for FIIS and ASIS. Finalize the accuracy assessment. Finalize salt marsh change analysis for GATE (Jamaica Bay), FIIS and ASIS for change analysis.

- 07/2016-10/2016: Complete the project report and generate publications.

Accompanying the Final project documents, all project data files, including metadata, will be submitted to the NPS.

RESEARCH FACILITIES

This project will be accomplished through a partnership with the Laboratory for Terrestrial Remote Sensing (LTRS) at the University of Rhode Island (URI). The LTRS possesses all computing power necessary to fulfill the project requirements in remote sensing data processing and GIS analysis. As part of the project costs associated with this agreement, the ERDAS Imagine software annual fee of \$4500 would be cost shared with other lab project. The LTRS is within the same research complex of the URI's Environmental Data Center, which is the Field Technical Support Center for the New England Cluster of the National Park Service. The LTRS, under the direction of Professor Y.Q. Wang, has a long and productive history with the NPS, specifically on projects focusing on park vegetation mapping and change detection (Wang and Christiano, 2006; Wang et al., 2009; Kennedy et al. 2009; Wang et al., 2010; Wang and Traber 2013). The original QuickBird-2 SOP was developed under Dr. Wang's direction as was the mapping of the terrestrial and submerged aquatic vegetation for FIIS (Wang et al., 2007). In addition, GATE GIS Specialist Mark Christiano will be on the project team as a NPS Technical Expert. Mr. Christiano has 9 years of GIS and remote sensing experience and developed the original GATE SOP at URI with Professor Wang. Mr. Christiano has been responsible for implementing the SOP at GATE and can provide valuable insight in the development of a protocol.

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BUDGET

PROJECT NAME	Year 1	Year 2	Year 3	Total
PERSONNEL	-	-	-	-
GRA - Academic Year - LEVEL I	\$16,952	\$17,630	\$18,848	\$53,430
GRA - Summer - LEVEL I	\$11,535	\$12,000	\$12,828	\$36,363
TOTAL PERSONNEL COSTS	\$28,487	\$29,630	\$31,676	\$89,793
FRINGE	-	-	-	-
GRA - AY - Fringe Benefits (see Grad Rate Sheet)	\$2,341	\$2,558	\$2,871	\$7,770
GRA - Summer FICA (see Grad Rate Sheet)	\$882	\$918	\$981	\$2,781
				-
TOTAL FRINGE BENEFITS	\$3,223	\$3,476	\$3,852	\$10,551
EQUIPMENT	-	-	-	-
TOTAL EQUIPMENT	-	-	-	-
TRAVEL				-
Domestic	\$3,000	\$3,000	\$3,000	\$9,000
Foreign				-
TOTAL TRAVEL	\$3,000	\$3,000	\$3,000	\$9,000
SUPPLIES				-
Consumables: data storage				-
TOTAL SUPPLIES	-	-	-	-
OTHER COSTS				-
Satellite imagery data acquisition	\$16,600	-	-	\$16,600
ERDAS Imagine Software cost share of total costs (\$4500/year)	\$1,000	\$1,000	\$1,000	\$3,000
Mapping supplies for data imagining including printing maps	\$1,050	\$1,075	\$1,051	\$3,176
In-State Tuition	\$13,264	\$14,856	\$16,639	\$44,759
TOTAL OTHER COSTS	\$31,914	\$16,931	\$18,690	\$67,535
TOTAL DIRECT COSTS	\$66,624	\$53,037	\$57,218	\$176,879
TOTAL MODIFIED DIRECT COSTS	\$53,360	\$38,181	\$40,579	\$132,120
FACILITIES AND ADMINISTRATIVE COSTS 17.5% MTDC	\$9,338	\$6,682	\$7,101	\$23,121
TOTAL REQUESTED FROM AGENCY	\$75,962	\$59,719	\$64,319	\$200,000

BUDGET JUSTIFICATION

Personnel: Dr. Wang is not requesting any portion of his salary as part of this project. One graduate student will assist Dr. Wang (PI) on the project for routine remote sensing data processing, interpretation, classification, and change analysis. The assistantship includes graduate stipends and fringe benefits for the three project years. The summer stipend is calculated at the corresponding rate for 35 hour/week for 14 weeks.

Travel: The travel fund will support the project team members in fieldwork and to attend appropriately related professional conferences to present this project.

Imagery: Satellite imagery acquisition is for purchasing the QuickBird-2 and WorldView2 satellite data for the FIIS and ASIS sites with quotations from the data acquisition company (DigitalGlobe, Inc.).

Overhead: URI Facilities and Administrations Cost is 17.5%, a special rate negotiated between the URI and the NPS, through the CESU Agreement.

ATTACHMENT B

The National Park Service agrees to:

- Assign the Northeast Coastal and Barrier Network (NCBN) Program Manager as the Science Technical Advisor on this project. The Project Manager and the NCBN Data Manager will actively collaborate with the University of Rhode Island investigator, research associates, and graduate students on the project priorities, design, data management, data interpretation, and production of final deliverables as needed.
- Provide the cooperators with all relevant GIS and LiDAR data sets that may be important to the study, as well as any park-based data needed to complete the project.
- Provide guidance and expertise on NPS data management procedures and protocols, and work closely with the RTRS lab to meet NPS data and web standards.
- NCBN staff will meet regularly with the URI staff to provide assistance and expertise with all components of this project.
- Review and provide feedback on draft documents, data, material and reports prior to URI's final submission.