TOWN OF Kiawah Island

ENVIRONMENTAL COMMITTEE MEETING

Virtual Meeting via Zoom
July 14, 2021; 2:00 PM

AGENDA

I. **Call to Order:**

II. **Approval of Minutes:**
- **A.** Minutes of the May 2021 Environmental Committee Meeting

III. **Old Business**
- ***A.*** Kiawah Landscaping Workgroup (Grow Native)
- ***B.*** Shorebird Stewardship Program
- ***C.*** Flood Mitigation and Sea Level Rise
- ***D.*** Grow Native/Parkway Landscaping
- ***E.*** Rodenticides/Wildlife
- ***F.*** Deer Management
- ***G.*** Kiawah Conservancy Projects
- ***H.*** Green Initiative Working Group

IV. **New Business**
- ***A.*** Conservancy Project Funding for FY 21-22 (Integrated Watershed Study)

V. **Reports:**
- **A.** Town of Kiawah Island
- **B.** Kiawah Island Community Association Land & Lakes Management
- **C.** Kiawah Island Golf Resort
- **D.** Kiawah Island Architectural Review Board
- **E.** Kiawah Conservancy
- **F.** Turtle Patrol

VI. **Citizen Comments:**

VII. **Chairman's Comments:**

VIII. **Committee Member Comments:**

IX. **Adjournment:**

FOIA: Notice of this meeting has been published and posted in accordance with the Freedom of Information Act and the requirements of the Town of Kiawah Island.

ENVIRONMENTAL COMMITTEE MEETING

Virtual Meeting via Zoom
May 12, 2021; 2:00 PM

AGENDA

I. Call to Order: ***Mr. Jordan called the meeting to order at 2:00 pm.***

Present:	Jim Jordan, Chairman
	Jim Chitwood
	Lynn Sager
	Jane Ellis
	David Pumphrey
	Pam Wilson
KINHC:	Lee Bundrick
KICA:	Lucas Hernandez
KICA:	Matt Hill
ARB:	Sara Senst
KIGR:	Liz King
TOKI:	Aaron Given
Absent:	Jim Sullivan
	Scott Nelson
	John Leffler
	Jack Kotz
Also Attending:	Dr. Scott Parker, *Council Liaison*

II. Approval of Minutes:

A. Minutes of the March 10th, 2021 Environmental Committee Meeting

Mr. Pumphrey made a motion to approve the minutes of the March 10th, 2021 Environmental Committee meeting. The motion was seconded by Mr. Chitwood and was unanimously approved.

III. Old Business

A. Kiawah Landscaping Workgroup (Grow Native)

No Update

B. Shorebird Stewardship Program

Program Underway

C. Flood Mitigation and Sea Level Rise

Adaptive Management Plan Update – Mr. Hernandez stated that he had completed the draft of the presentation for Town Council and the KICA (Kiawah Island Community Association) Board. The presentation incorporates the information from the interviews used to establish thresholds, indicators, triggers, and a high-level monitoring program. The draft has been sent out to Mr. Jordan and others for review, and after feedback/comments are received, the final draft will be completed.

Mr. Hernandez responded to Dr. Parker's question on his presentation date by stating the anticipated presentation to the KICA Board in June or July, with the presentation to Town Council pending.

D. Grow Native/Parkway Landscaping

- The Parkway Landscaping Project is completed with all plants and mulch installed and the irrigation system working properly.
- Sod repair between the roundabout and the Resort sign will be taking place this week.
- Guard rail painting 90% complete

E. Rodenticides/Wildlife

- Tested 15 additional animals since the last meeting
  - Eight raccoons – 6/8 showed exposure (75%)
  - Seven opossums – 6/7 showed exposure (86%)

- SCDNR sampling – Did not occur

- Clemson Research Project – Funding of $500,000 has been secured for at least a minimum proposal with work continuing to secure the additional funding for the complete project. A graduate student has been selected. Work on the four-year study is scheduled to begin this month, wrapping up in Augusta of 2025.

F. Deer Management

No Update

G. Kiawah Conservancy Projects

Groundwater Project –Previously installed 21 wells on the island in the first phase of the project. Monitoring equipment was installed in the wells to begin a long-term effort to monitor changes to the depth and salinity of groundwater on Kiawah. The second phase of the project focused on better understanding contributions to salinity, the relationship between groundwater and pond levels, and the continuation of previous monitoring efforts. Three additional wells were installed to monitor the levels of freshwater wetlands and ponds. Surveying equipment will be used to provide accurate data on the relationship between pond levels and groundwater table depth. There are efforts currently being undertaken to create seasonal groundwater maps from the data collected. Nitrate, Chloride, and pH were collected from various wells on the island to conduct analyses. Preliminary data were shown at the meeting, with one well showing heightened salinity levels because of its proximity to tidal salt marsh.

Marsh Vulnerability Project – The first phase of the project focused on capturing historical conditions within the marsh by mapping vegetated shoreline changes over a period of over 40 years (1977-2019). These were illustrated by maps produced by the College of Charleston showing accretion and erosion within the marsh. Technical analysis of marsh shoreline changes will be conducted by a graduate student, Kaylee Smith, using the Digital Shoreline Analysis System (DSAS) developed by USGS. The current phase of the project focused on capturing current conditions with the marsh. Mapping products have been produced to show wave action from vessel traffic, marsh bank conditions (e.g., bank width, escarpment, slope), and land cover. These were collected based on recommendations from the SC Department of Natural Resources for siting living shorelines to restore/fortify marsh habitat. An additional mapping product was produced to capture the unvegetated-vegetated ratio (UVVR) of marsh habitat, which USGS developed as an indicator for

marsh vulnerability.

IV. New Business

A. Discussion of Funding for FY 21-22 Environmental Projects

Mr. Jordan stated the Conservancy had submitted four project proposals totaling $65,000.00 for funding in the Town's FY 2021-2022 budget. The Conservancy line-item has a total funding amount of $50,000.00. The members will need to identify which area of research or study the Committee is most interested in to help the Conservancy develop a final proposal to submit for Town Council formal approval.

Mr. Bundrick reviewed the proposals:

UNDERSTORY VEGETATION MONITORING ($10,000)

Objectives:

- Obtain equipment for monitoring vegetation density, forest structure, and productivity
- Analyze landscape vegetation density along parkway viewsheds

Funds for this project would be used to procure equipment to begin monitoring of understory vegetation on Kiawah Island. By obtaining these ground-based LiDAR systems, there is enhanced ability to conduct high-resolution analyses on the understory vegetation and marsh edges. Funds would be used to procure mountable LiDAR (e.g., LS CX32 3D surround LiDAR device) and ancillary equipment to begin analyzing vegetation in the maritime forest and along residential corridors on Kiawah Island.

MINK MONITORING ($15,000)

Objectives:

- Monitor the movement and distribution of minks around the marshes
- Monitor population size and reproductive success
- Determine priority areas within the marsh to inform on management efforts for protecting wildlife populations

This research project would also assist with future planned efforts to research the environmental effects of rodenticides on local wildlife populations. Seeing as how Minks have a similar diet to those of bobcats, they will provide another source for understanding the spread of SGA's on Kiawah.

CLIMATIC MONITORING FOR WATER BUDGETS ($10,000)

Objectives:

- Monitor and analyze climate data
- Create a water budget using climate data
- Observe seasonal weather patterns
- Identify management priorities for the conservation of freshwater resources.

With funding from the Town, equipment will be purchased to establish an additional weather station to collect and monitor climatic data. An Onset brand HOBO RX3000 can be outfitted with wind, solar radiation, temperature, and relative humidity measurements to gather information to calculate PET with both the Hamon PET model and the Hargreaves-Saman model. The calculated costs for obtaining this equipment are around $3,500, not accounting for cellular data and installation costs.

WATER QUALITY MONITORING ($30,000)

Objectives:

- Obtain equipment with the capacity to continuously monitor water quality in various aquatic ecosystems on Kiawah Island

- Identify appropriate, site-specific green-infrastructure practices based on site conditions to bolster resilience
- Initiate efforts to begin monitoring sediment transport and deposition through in-situ Measurements

The use of Town funds under this proposal item will be used to purchase amultiparameter water quality sonde. The sonde will be similar to the ones used in practice by federal agencies, with a preference towards YSI EXO series multiparameter sondes. Sondes such as these can be easily deployed into any coastal aquatic environment and moved to different locationsbased on current needs. The purchase of several sondes with similar parameters is recommended so researchers can compare conditions between upstream and downstream areas.

Additional equipment to monitor sedimentation within aquatic environments will also be purchased based on the availability of funds following the purchase of the water quality sonde(s). This includes sampling containers and equipment to gather data on suspended sediments, sedimentplates and flat surface traps to be installed in the marsh platform, and various other methods based.

Committee members engaged in an in-depth review and discussion of each proposal questioning Mr. Bundrick and offering their opinions, comments, and additional feedback. After the discussion, members recommended funding the:

1. Water Quality Monitoring ($30,000)
2. Climatic Monitoring For Water Budgets ($10,000)
3. Understory Vegetation Monitoring ($10,000)

Mr. Jordan suggested that one or two projects be selected and develop a detailed plan on the information to be obtained, how it will be collected, and a more detailed budget for each project proposal. He proposed the Water Quality Monitoring as the priority, working the Climatic Monitoring for Water Budgets proposal into that project, followed by the Understory Vegetation Monitoring and the Mink Monitoring. The committee members agreed with Mr. Jordan's suggestions and the timeline for Committee approval and recommendation to Town Council.

Dr. Parker stated that Mayor Labriola asked him to lead an ad hoc workgroup to look at various initiatives to reduce the communities carbon footprint. He indicated that the workgroup would consist of two representatives from the Town, KICA, the Resort, the Club, and the Conservancy would be charged with developing a template or roadmap with specific timelines to reach particular goals and encourage the use of alternate fuel sources.

V. Reports:

A. Town of Kiawah Island

- 2021 Bobcat GPS Study
  - 1 out of 6 (17%) bobcats have died
    - Bobcat 200 – 1/27 – 2-year-old Male, Willet Island, 19lbs 15oz.
    - Bobcat 250 – 1/28 – Juvenile Male, Preserve, 16lbs 8oz. New cat.
    - Bobcat 767 – 1/28 – Adult Female, Indigo Park, 13lbs 5oz. New cat. **Hit by car 4/4/21 and sent in for testing. No results at this time.**
    - Bobcat 300 – 1/29 – Adult Female, Flyway Drive, 13lbs 12oz. New cat.
    - Bobcat 450 – 10/18/20 – Adult Female, Captain Sams, 13lbs 3 oz.
    - Bobcat 550 – 1/29 – Adult Female, Little Bear Island, 15lbs, 10oz. 2020 recapture.
  - Two dens found
    - Bobcat 550 – 4/12/2021 - Two 8-10 days old male kittens. Den along Ocean

Course Drive.
- Bobcat 300 – 5/11/2021 – Three 4-day old kittens (2 males, one female). Den in secondarydunes along Flyway Drive.

- Breeding Bird Point Counts
  - Start May 24th. Nine days to complete. 238 points.

- Breeding Bird Survey
  - Early June. One day. 50 points.

B. Kiawah Island Community Association Land & Lakes Management

Mr. Hill gave an update on the previous discussion of the collection of baseline data on alligators. He reported that with the weather warming and an increase in alligator calls, two alligators were caught, one male and one female. The female that had not been caught before was tagged with #26 yellow visual tag, blue for males, and a pit tag to provide the option to scan and identify the alligator if the visual tag is lost. He also reported on alligator blue #015, which was recaptured for the third time, reviewing the data collected since 2015.

Mr. Hill stated that several areas were sprayed this past fall, targeting highly invasive tallow trees and phragmites. He reported the treatment was very effective, and the areas would continue to be monitored through the growing season.

Mr. Hill reported the planting of several different aquatic native species in ponds deemed suitable to support them. He noted that the plantings would all benefit wildlife by providing seed and/or vegetation to eat. Winter pruning of the pond edges allows for easier maintenance, including wildflowers and the spraying to control non-native plants allowing native species to fill in. He also reported the ponds had been stocked with carp and tilapia for nuisance aquatics control.

Mr. Hill stated that mole traps and their use on the island were recently brought to the KICA Board. He asked for the Committee's collective opinion on the proposed use of mole traps and if they should be banned from use on the island. He noted the alternative to control moles would be by chemical means.

Committee members' discussion included that using chemicals was not the desired option, the need to control moles in a residential setting, the reasoning behind the proposed banning of mole traps, and the reasoning behind the proposed banning of mole traps. Members agreed if there is a mole issue using traps rather than chemical control.

C. Kiawah Island Golf Resort

Ms. King reported that Dr. Whit Gibbons be on Kiawah. Dr. Gibbons, a hermetologist who worked at UGA and Savannah River Ecology Lab, did the original reptile and amphibian study on Kiawah. He also began a research project on terrapins in the salt marsh on Kiawah in the 1980s, known as the longest continuous terrapin study in the world. In the continuation of his study, a transmitter will be placed on fifteen gravid female terrapins to determine where the population is nesting and what impact sea-level rise may have on the nesting sites.

Ms. King reported that on a recent bird trip, a banded red knot was found on the front beach, and the report showed that it was originally banned in Chile.

D. Kiawah Island Architectural Review Board

No Report

E. Kiawah Conservancy

Mr. Bundrick reported that during the PGA on May 26th, the Conservancy would be having a garden party. He reviewed the speakers that will be conducting a series of talks on the importance of native vegetation and vegetation on Kiawah and a plant sale in the garden.

F. Turtle Patrol

Ms. Sager reported the Turtle Patrol season is underway. The truck started running the beach on May 1st, and two nests have been found, the first two days ago and the second today. She noted more of a return to normalcy from DNR this year, allowing the ability to take volunteers and four people in the truck. She also reported approximately 320 people volunteering this year, a number of which had been on the waiting list since before last year.

VI. Citizen Comments:
None

VII. Chairman's Comments:
None

VIII. Committee Member Comments:
None

IX. Adjournment:

Ms. Sager motioned to adjourn the meeting at 3:12 pm. The motion was seconded by Ms. Ellis and carried unanimously.

Submitted by,

_____
Petra S. Reynolds, Town Clerk

Approved by,

_____
Jim Jordan, Chairman

_____
Date

Integrated Watershed Study

Project Proposal to the Town of Kiawah Island

FY 2021-2022

Revised July 1, 2021

INTEGRATED WATERSHED STUDY ($50,000)

Tidal marshlands and adjacent estuarine areas are some of the most biologically productive habitats in the world, providing many ecosystem services to both human and wildlife communities (Millennium Ecosystem Assessment, 2005; Constanza et al., 2014; Sandifer et al., 2015). These services include nutrient cycling, carbon sequestration, property protection from storm surge, and erosion control, among others, which have been valued at up to $78,510 per acre per year (USD $ 2007) (Costanza et al., 2014). This suggests the tidal salt marshes around Kiawah Island, roughly 3,500 acres, produce up to $274.8 million in ecosystem services for wildlife and property owners each year. Sea-level rise, climate change, and anthropogenic impacts significantly impact tidal marshes, with current projections suggesting 46-78% will lost by the year 2100 without significant mitigation efforts (Spencer et al., 2016). Understanding the impacts to these habitats and monitoring areas to inform management practices will help to protect our wetlands to allow them to continue providing services for human and wildlife communities.

Tidal salt marsh habitats are very dynamic in nature and influenced by local mesotidal changes, groundwater discharge, severe weather, and runoff generated from upland areas. There is a constant flux of saline water, suspended sediments, contaminants, and organic matter among others, which creates a very complex, dynamic aquatic environment. Making further contributions to this on Kiawah Island is the introduction of brackish water at the terminus of each pond outfall. Rainfall events introduce freshwater in upland areas and percolate into the shallow subsurface aquifer, referred to as 'groundwater' (Callahan et al., 2012). This recharges the groundwater and increases the elevation of the groundwater table. This freshwater reserve is gradually reduced overtime via plant uptake, evaporation, discharge into ponds, and discharge into the tidal marsh. Groundwater discharge through the marsh platform in coastal environments typically occurs during low tide events (Barlow, 2003). This produces a mechanism where freshwater is gradually introduced into the marsh to flush nutrients and salts within the soil, as well as allow groundwater levels to reach a stable equilibrium with adjacent tide levels.

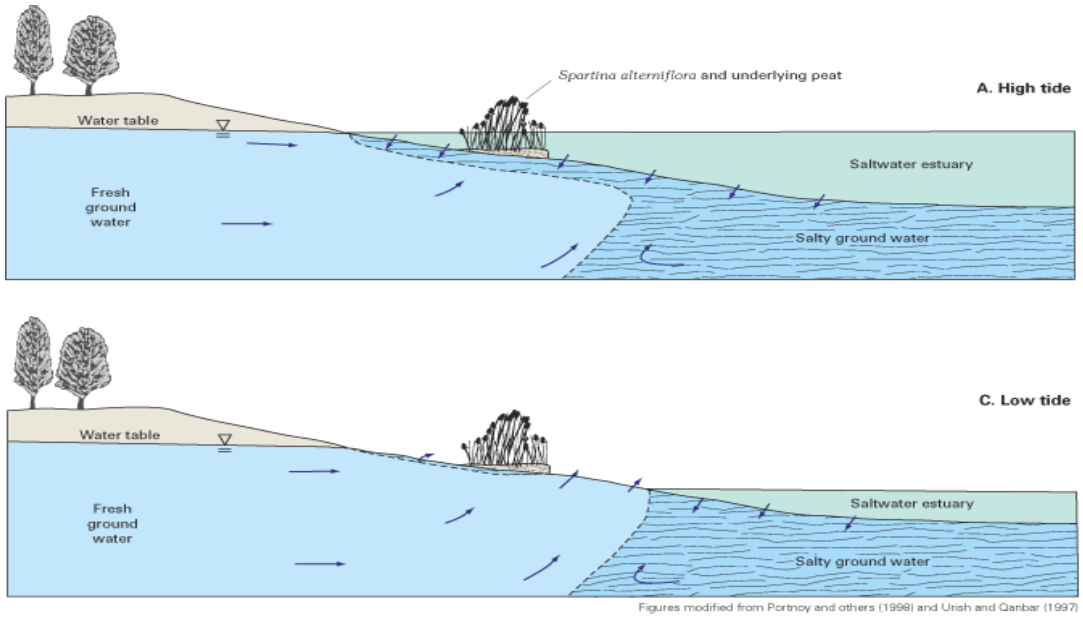

Figure 62 from USGS Circular 1262 describing energy and water flow between groundwater and saltwater estuarine areas (Barlow, 2003)

Residential development inhibits the replenishment of groundwater due to the change in landcover, mostly from the introduction of impervious surfaces (e.g., driveways, boardwalks, roofs). These surfaces cover or alter exposed soils, which would naturally facilitate the percolation of accumulated rainfall into the ground. Landscape changes, such as removing trees and installing turfgrass, reduce the ability for stormwater to infiltrate soils within the suburbanized forest. For instance, live oaks can intercept up to 30% of the rainfall intercepted by their canopy before it reaches the soil (Kim Morganello, personal communication, 2021). Turfgrass also impedes the infiltration of water due to their dense root structure, causing it to shed water similarly to impervious surfaces.

This creates conditions that increase the volume of excess stormwater runoff that flows into Kiawah Island's interconnected stormwater pond system. For the most part, each parcel on the island is graded in order to allow the conveyance of stormwater into low-lying areas and roadways during a rainfall event. The water then flows to the lowest points in the roads and directed into the pond network. The volumetric flow of stormwater in this process is influenced by the permeability of land cover, ground saturation, and any obstruction in drainage. If stormwater runoff is conveyed into the drainage network too quickly due to too much impervious cover, there is less of a chance for replenishing groundwater reserves and a higher risk of overtaxing our stormwater infrastructure in major rainfall events (i.e., 50-year rainfall). Alternatively, if the same system's conveyance were slowed without any intervention to promote infiltration, you could see localized flooding. At the terminus of the pond systems, excess stormwater flows into tidal saltmarshes via the outfalls during low tide events, similar to the mechanisms behind groundwater discharge.

Along with the changes in the quantity of water being increased during rainfall events, water quality within the ponds is impacted as well. As stormwater enters the ponds, dissolved oxygen levels are lowered, temperatures are drastically inverted, organic matter and other particulates are introduced, and pollutants (e.g., pesticides, fertilizers, heavy metals, polycyclic aromatic hydrocarbons) are also introduced into the system. As mentioned previously by KICA, the ponds on Kiawah Island often experience fish kills as a direct result of temperature extremes and changes. As temperatures reach extremes in the summer, dissolved oxygen becomes less soluble. Lowered dissolved oxygen levels in the aquatic environment significantly impairs fisheries survival and causes fisheries evacuations in open waters (Bailey & Secor, 2016). This is further impacted by salinity which decreases the capacity for water to hold onto dissolved oxygen. Some fish species are also intolerant to drastic changes in temperatures, often caused by rainfall events or changes in air temperature. This is often a major result of localized fish kills on Kiawah Island.

In addition to these factors, other pressing environmental perturbations drive pond health. Pollutants which accumulate in the tissues of aquatic wildlife often bioaccumulate in the tissues of organisms. This further produces negative downstream effects on local wildlife as these pollutants concentrate in higher trophic levels, with a recent example being the effects on the local bobcat population caused by the use of second-generation anticoagulants for rodent control. Excess nutrients in the water column also produces eutrophic conditions which cause the abrupt growth of algae in the water. These are often in the form of harmful algal blooms, where algae produce strong neurotoxins which are dangerous to humans, pets, and wildlife. Furthermore, dead algae decompose in the ponds causing a sharp decrease in dissolved oxygen levels.

While data are available on the aquatic conditions within Kiawah Island's pond network, little to no information has been collected in the tidal salt marsh where the system's waters are discharged. Stormwater discharge from the pond system potentially has a large deleterious effect on aquatic life

in the nearby estuarine area caused by declines in water quality. With simple changes to water quality conditions (e.g., dissolved oxygen, temperature), impacting fisheries in ponds upstream, there is more than likely going to be observable impacts in estuarine waters downstream. It is likely dissolved oxygen is significantly lowered and contaminants are increasingly more detrimental to fisheries and wildlife in estuarine waters due to the chemical composition of seawater. The discharge can also produce significant impacts to oyster reefs which protect marsh shorelines from erosion and improve water quality.

To better understand how discharge affects local fisheries and wildlife, efforts to continuously monitor conditions within the island's tidal creeks and estuarine waters needs to be initiated. These efforts also need to include comparing water quality data between stormwater ponds and tidal creeks to investigate the holistic effect of biological and chemical conditions caused by stormwater. The Kiawah Island Community Association currently collects data on conditions within ponds through weekly in-house monitoring and contracted sampling from the S.C. Department of Natural Resources who generate monthly and annual reports. This comprehensive data collection includes information on pond levels, temperature, salinity, pH, turbidity, dissolved oxygen, and various species of bacteria and harmful algae. Monitoring estuarine and tidal creek areas with similar equipment and techniques will facilitate avenues for comparing data collected within the stormwater pond system.

Studying aquatic environments also involves developing a comprehensive understanding of the hydrological cycle. Previous monitoring efforts provide key components to improve understanding of water resources within our coastal environment: frequent pond level monitoring, groundwater monitoring (Callahan et al., 2012; Kassabian et al., 2015), the Kiawah River Bridge tidal gauge, Ocean Park tide gauge, and the various weather station locations. Expansion of monitoring efforts helps to capture conditions within specific regions with different stormwater runoff regimes. In particular, weather conditions (e.g., wind, rainfall, temperature) vary throughout Kiawah Island, resulting in microclimates and differing conditions within individual watersheds at any given point in time. For instance, one region of the island may receive a burst of rainfall while another will receive little to no rainfall in the same day. The distribution of rainfall accumulation on the island can help identify areas where stormwater recharges groundwater and freshwater wetland levels most efficiently. Placing additional weather stations will capture meteorological conditions to provide more precise data for each watershed region.

Furthermore, efforts to integrate the various environmental monitoring efforts through the development of a water budget will provide a comprehensive assessment of conditions within each watershed region. A well-developed understanding of water resources provides the means for evaluating availability and sustainability of natural water supplies and provides a foundation for effectively managing and planning for water resources (Healy et al., 2007; Kassabian et al., 2015). This would also integrate data related to landscape irrigation on the island, which accounted for 587 million gallons of water introduced to the hydrological system in 2017 (TOKI Sea Level Rise Subcommittee, 2018, p. 73). Water budgets are especially important in this regard, as water resources govern ecosystem functions that provide benefits to both humans and wildlife. As a result of integrating water resource data and expanding efforts to study inputs to the hydrologic system, land managers on Kiawah Island can further develop an ecosystem-based management approach to improve the resilience of the local hydrological system and protect estuarine habitats.

Water Quality Monitoring. Multiparameter water quality sondes are used by SCDHEC, USGS, USEPA, and NOAA's National Estuarine Research Reserves System [NERRS] to monitor water quality and influence management decisions. These are typically equipped with several sensors to capture data on various conditions within the marsh. NOAA-NERRS uses multiparameter sondes with sensors to monitor temperature, depth, conductivity, pH, turbidity, dissolved oxygen, chlorophyll, and nutrients (NOAA). Information related to these measurements can be found in Appendix A. These sondes are deployed directly into aquatic areas to collect data continuously.

The use of Town funds under this proposal item will be used to purchase a pair of multiparameter water quality sondes and the necessary components. The procured sondes will be the YSI EXO series multiparameter sondes used in practice by federal agencies and local universities. Sondes such as these can be easily deployed into any coastal aquatic environment and moved to different locations based on current needs. YSI Exo 3 sondes come with 4 sensor ports to measure these parameters. Recommended parameters to include in the available ports include conductivity + temperature, dissolved oxygen, depth, and turbidity. Additional sensors can be purchased to supplement collect data collection, including on fluorescent dissolved organic matter (fDOM) and total algae, among others, depending on future needs (optional equipment and materials included herein for future reference).

These sondes would allow for additional monitoring of aquatic conditions in pond and estuarine environments. The sondes can be moved further upstream into various stormwater ponds or further downstream into the marsh based on future needs. Monitoring data collected by KICA and the Conservancy will be shared to study aquatic conditions and their responses to focusing events (e.g., rainfall, saltwater inundation, tides). KICA has historically gathered data within the interconnected stormwater pond system for the past 30 years. The study herein would be focused on analyzing water quality in estuarine areas directly downstream from the system at pond outfalls where monitoring has not yet occurred.

Previous discussions have indicated two areas where the volumetric majority of water is evacuated from the system: the Canvasback Pond outfall and Beachwalker Drive outfall. These two areas will be initial focus of the monitoring efforts through the proposed project. Sondes will be deployed near pond outflows into the marsh and provide information on areas where the greatest complexity of water conditions occurs due to salinity changes, tidal regimes, and flow of nutrients. Watershed maps showing the land mass where runoff originates will be created to provide a geographical unit for further analysis with water budgets (see subsequent section).

Weather Monitoring. Gaining a better understanding of rainfall accumulation by installing monitoring stations in different sites provides additional information on the various microclimates on our island. Currently, two weather stations with data accessibility are on the island: Town-supported station located on the Timbers and KICA's newly installed station adjacent to Kestrel Court. Both weather stations are Davis Vantage Pro 2 models, which collects temperature, accumulated rainfall, wind speed and direction, barometric pressure, ultraviolet radiation, solar radiation, and relative humidity. Both of these stations provide data on local meteorological conditions for the western region of Kiawah Island. However, conditions can differ in areas further east on the island.

With funding from the Town, two (2x) Davis Vantage Pro 2s and ancillary equipment for logging data will be purchased to establish two additional weather stations. These will be near Canvasback

Pond and the center of the island where we currently do not have equipment to collect and monitor climatic data. With the supporting equipment, data will be automatically sent to Weatherlink, an online repository for weather data, via nearby WiFi connections. Potential sites include the fire station along Governors Drive, Turtle Point Clubhouse, Cinder Creek Pavilion, and-or nearby residential areas. Information gathered from the weather station can be used to generate localized information specific for different regions on Kiawah Island. This ultimately provides more precise data on meteorological conditions to create regionalized water budgets for managing water resources.

Preliminary Water Budgets. Efforts within this project also include the development of water budgets for major drainage watersheds on Kiawah Island. Watersheds would be based on local monitoring efforts (i.e., weather stations, groundwater wells, stormwater drainage), as validated by KICA staff. A water budget allows a community to assess and manage the physical conditions of water stored in a regional hydrological system, which is balanced by the water introduced into and released from the system. Generally, this would provide information to help predict flooding conditions within specific watersheds, identify areas where soil infiltration rates are impaired, and help manage stormwater pond levels. Water budgets also provide guidance on mitigating changes to groundwater elevation and saltwater intrusion, both of which can severely impact the health of maritime forest vegetation and cause it to convert into wetlands (Kirwan & Gedan, 2019). They also provide a means for prioritizing areas to promote the use of nature-based solutions to enhance the infiltration of stormwater into the subsurface aquifer.

The inclusion of groundwater, rainfall, standing water (i.e., tide levels, pond levels) and evapotranspiration data (Pyzoha et al., 2008) can be used to calculate a water budget in a coastal environment. There are several methods for determining the potential evapotranspiration [PET] for developing water budgets in shallow aquifers in the lower coastal plain, as discussed by Kassabian et al. (2015). One method is the Hamon PET model, which uses daytime length (Ld, measured in x/12 hours), saturated vapor density (RHOSAT; measured inches), and a calibration coefficient (KPEC, = 1.2) to calculate PET in mm/day:

$$PET\ (mm/day) = 0.1651 \cdot\ Ld \cdot RHOSAT \cdot\ KPEC$$

Another method is the Modified Hargreaves - Samani model (Dai et al., 2013; Kassabian et al., 2015) which calculates PET using daily mean air temperature (T; measured in Celsius), extraterrestrial solar radiation (Ra; measured in MJ m^{-2} day^{-1}), and daily difference in max/min temperature (TD):

$$PET = 0.408 \cdot 0.0021 \cdot Ra \cdot TD\ 0.50 \cdot (T + 17.8)$$

Data from the installed weather stations mentioned previously will be used to calculate these measurements. Coupled with the collection of rainfall and groundwater data, monitoring the evapotranspiration will provide sufficient information to create a water budget for a given ecosystem. The following calculation is used to create a water budget where ΔS is the change in storage, P is precipitation, and ΔG is change in groundwater levels. Groundwater is also normalized with specific yield (Sy) calculated using precipitation (P) divided by changing groundwater table following a rain event (ΔWT) (Kassabian et al., 2015):

$$\Delta S = P - PET + \Delta G$$
$$\Delta G = \bar{x}Sy \quad where \quad Sy = P / \Delta WT$$

Because land cover and runoff conditions vary across Kiawah Island, localized water budgets would provide more accurate information. Watershed data generated by KICA staff will be used to define management areas to calculate localized water budgets. This would include analyzing land cover (e.g., impervious versus pervious surfaces) and specific yield of soil types within the defined watershed areas. Priority will be placed on defining land areas that feed stormwater runoff into the major stormwater pond outfalls at Canvasback Pond and Beachwalker Drive where water quality monitoring equipment will be deployed. Additional analysis will occur on the remaining watersheds, with future potential monitoring efforts providing more site-specific data.

Reasoning

- Tidal estuaries and marshes are the most biologically productive habitats in the world and provide many benefits to humans and wildlife.
- Water resources in coastal habitats are very dynamic and can be impacted by various contributing factors to water quality.
- Rainfall accumulation and stormwater runoff significantly influence quality of water resources on Kiawah Island.
- Water budgets can be developed to help plan land management practices to conserve natural groundwater resources.
- Understanding the impact of water quality and quantity on the entire hydrological system helps to prioritize management efforts and restoration practices to benefit the community.

Objectives

- Obtain equipment and capacity to continuously monitor water quality in estuarine waters around Kiawah Island.
- Expand monitoring of climatic conditions into other regions of Kiawah Island.
- Analyze and integrate climate data into comprehensive, integrated assessments.
- Create localized water budgets for Kiawah Island using a watershed approach.

Requirements and approximate costs associated or needed to accomplish this project

- Use of tidal salt marsh areas, aquatic environments, and adjacent properties for the deployment and anchoring of equipment.
- Coordination and collaboration with KICA, TOKI, and other on-island partners.
- Use of buildings to attach weather monitoring stations, with prior approval from property owner(s)
- Use of data from the Town's weather station, KICA's weather station, and the Kiawah River Bridge Tide Station.
- Conservancy staff time and effort for deploying equipment, data collection, and equipment maintenance.
- Use of open-source statistics software (R Statistical Package) for analyzing data.
- Total funds necessary for carrying out the project (**$50,000**)
    - Purchase of water quality monitoring equipment (**$33,000**).

    - *Two multiparameter water quality sonde(s) with recommended sensors and equipment (Total: Initial sonde w/ sensors - $17,862; Second sonde w/ sensors $13,267).*
    - *Housing and anchoring within aquatic environments ($1,871).*

      Note: Optional sensory and deployment equipment to incorporate with EXO Sonde at future dates shown in optional equipment below
  - Purchase of Davis Vantage Pro 2 weather stations, WeatherLink, and related equipment (**$3,000 total**, $1,500 each).
  - Additional organizational capacity for data collection and analysis: either 1) staffing of graduate assistant or intern with the Conservancy, or 2) contract efforts with external parties (e.g., SCDNR) for analyzing water samples (**$14,000**)

Outcomes

- Better understand water resources on Kiawah Island through integrative analysis.
- Initiate water quality monitoring within Kiawah Island's tidal salt marshes.
- Develop a water budget for planning preservation and restoration efforts, low-impact development practices, and green-infrastructure projects.
- Enhance monitoring of localized rainfall accumulation on Kiawah Island.
- Assist the Town in pursuing goals listed in the amended comprehensive plan by providing information about protecting natural resources and promoting community resilience:
  - Land Use goal 5b - Consideration of development strategies based on objective data to better respond to impacts due to flooding and sea level rise.
  - Natural Resources goal 2b - Going forward with recommendations from scientists at the College of Charleston to incorporate a better understanding of impacts to marsh.
  - Natural Resources goal 6a - Understanding the health of tidal salt marshes and influencing land use based on efforts through a federally funded resilience project (NFWF ECRF 2019).
- Improve the community's FEMA CRS rating by measuring environmental data and highlighting the need for green-infrastructure practices to promote onsite infiltration and treatment of stormwater runoff (several FEMA CRS Manual references below)
  - 330 Outreach – Provide additional content for messaging related to flooding and flood mitigation, as well as prioritize communication efforts.
  - 510 Floodplain Management Planning - Additional projects and measures that will reduce the adverse impact of the hazard on the community and help meet other community needs.
  - 530 Flood Protection - Utilization of small/minor structural flood control projects for protecting buildings.

General Line Items	Cost
(2x) EXO Sondes for Water Quality Monitoring	$33,000
(2x) Davis Vantage Pro2 for Climatic Monitoring	$3,000
Graduate Assistant or Intern	$14,000
Total	$50,000

Required Equipment	Price
EXO3 Sonde, 10m Depth, 5 Sensor Ports, Central Wiper Compatible	$5,599.00
EXO Wiped Conductivity/Temperature Sensor	$1,700.00
EXO Optical DO Sensor, Ti	$1,999.00
EXO Central Wiper, EXO2, Ti	$1,225.00
EXO 10-m Field Cable	$645.00
C-Spray (1 bottle) 100-mL Unique nanopolymer coating that inhibits biofouling attachment	$40.00
EXO Handheld Display, 2.0 Handheld interface for EXO Sondes with standard features to include GPS, Temperature Compensated Barometer, Color LED Screen, Built-in Help Menus, Rechargeable Li-Ion Battery, USB On-The-Go Data Backup, Wet-Mate Connector, and IP-67 Rating	$2,765.00
EXO Signal Output Adapter - USB Allows for USB connection to computers	$405.00
3169 Conductivity Calibrator, 50,000-umhos/cm (8 ea, pint)	$133.00
EXO Turbidity Sensor, Ti Reads from 0-4000 FNU (Formazin Nephelometric Units)	$1,845.00
6073G Turbidity Std. 100 NTU (6026), 126 NTU (6136), 1 Gallon	$352.00
3824 pH Buffer, Assorted Case	$85.00
EXO2 Anti Fouling Guard	$899.00
EXO2 Probe and Sonde Anti-Fouling Sleeves (10 Disposable)	$85.00
Anti-Fouling Tape - Used to wrap all standard YSI probes - Customer re-apply as needed	$85.00
Initial Sonde Equipment Total	$17,862.00
Additional Sonde w/ Sensors	$13,267.00
Total w/o tax	**$31,129.00**

Optional Equipment Considerations	List Price
EXO Total Algae - PE Sensor, Ti - Optimized for saltwater use - Phycoerythrin - Includes chlorophyll and blue green algae sensors in a single sensor	$3,500.00
EXO fDOM Sensor, Ti - AKA CDOM or UV Fluorometer - Tested and used by North Inlet - Winyah Bay NERRS	$2,660.00
EXO GO wireless bluetooth communication device - Features GPS, Barometer, Rechargeable Li-Ion Battery, Wet- Mate Connector, and IP-67 rating	$995.00
EXO ISE06 pH/ORP Sensor Assembly, Unguarded, Ti	$699.00
Zobell Solution, ORP Calibrator 250 mL	$53.00
DB600 buoy with Ai1 system Includes: -Verizon 4G modem, solar charger, solar panels and lithium-ion battery, and navigation beacon	$9,999.00
2 Way Cellular Communications, 12 Months, NEW	$530.00
Software, LoggerNet Data Logger Software	$860.00
HydroSphere Cloud based data hosting and visualization platform. Includes: Alarms, data exports, public website, scalable user roles, and more. Monthly service fee for new accounts.	$9.99 / month ($119.88 / year)
Total (Comprehensive)	$14,921.00
Subsequent Costs	$650 / year

Weather Station	
Equipment	**Cost per unit**
Davis Instruments Vantage Pro2 (model 6163) - Wireless Weather Station - Sensors: ultraviolet, solar radiation, rainfall, wind speed + direction, humidity - 24-hour Fan Aspirated Radiation Shield - Further documentation and specifications: https://www.davisinstruments.com/products/wireless-vantage-pro2-plus-with-24-hr-fan-aspirated-radiation-shield - Can withstand winds up to 200mph and salt corrosion	$1074.00
Davis 7717 Mounting Pole Kit - For mounting on structures and surfaces	$52.00
Davis 6100 WeatherLink Data Collection Hub - For cloud-based datalogging of weather data	$195.00
Approximated total per unit w/o tax	$1321.00
Cost of two units (proposed) w/o tax	**$2642.00**

Resources

Bailey, H., & Secor, D. H. (2016). Coastal evacuations by fish during extreme weather events. Scientific reports, 6(1), 1-9. Retrieved from: https://www.nature.com/articles/srep30280

Barlow, P. M. (2003). Ground water in freshwater-saltwater environments of the Atlantic coast (Vol. 1262). Geological Survey (USGS). Retrieved from: https://pubs.usgs.gov/circ/2003/circ1262/#figurecaption56179976

Callahan, T. J., Vulava, V. M., Passarello, M. C., & Garrett, C. G. (2012). Estimating groundwater recharge in lowland watersheds. Hydrological Processes, 26(19), 2845-2855. Retrieved from: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hyp.8356?casa_token=GyTcQPeutnMAAAAA:W-TfmpopTqYTRAMtkzYPPu4Fh-h5dJkUd9L3AnENZMXEq4s8O0cY7p0pfnM5-zwsXy66wSlaEaY3rw8

Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services. Global environmental change, 26, 152-158. Retrieved from: https://wwfit.awsassets.panda.org/downloads/changes_in_global_value_of_ecosystem_services.pdf

Healy, R.W., Winter, T.C., LaBaugh, J.W., and Franke, O.L. (2007). Water budgets: Foundations for effective water-resources and environmental management: U.S. Geological Survey Circular 1308, 90 p Retrieved from: https://water.usgs.gov/watercensus/AdHocComm/Background/WaterBudgets-FoundationsforEffectiveWater-ResourcesandEnvironmentalManagement.pdf

Higgins, Patrick (2014). Southeastern Estuarine Research Society Meeting fDOM Sensor Research. Web. Retrieved from: https://www.ysi.com/ysi-blog/water-blogged-blog/2014/07/ southeastern-estuarine-research-society-meeting-fdom-sensor-research

Kassabian, R. L., Callahan, T. J., & Upchurch, S. (2015). Water Budget of a Shallow Aquifer in the Lower Coastal Plain: ACE Basin, SC. *Journal of South Carolina Water Resources*, *2*(1), 3. Retrieved from: https://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1012&context=jscwr

Kirwan, M. L., & Gedan, K. B. (2019). Sea-level driven land conversion and the formation of ghost forests. Nature Climate Change, 9(6), 450-457. Retrieved from: https://par.nsf.gov/servlets/purl/10109781

Lin, W. C., Brondum, K., Monroe, C. W., & Burns, M. A. (2017). Multifunctional Water Sensors for pH, ORP, and Conductivity Using Only Microfabricated Platinum Electrodes. Sensors (Basel, Switzerland), 17(7), 1655. https://doi.org/10.3390/s17071655

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being. World Health Organization. Retrieved at: https://www.millenniumassessment.org/documents/document.357.aspx.pdf

NOAA (n.d). Monitoring Estuaries: Estuaries Tutorial. National Ocean Service website. Retrieved from: https://oceanservice.noaa.gov/education/tutorial_estuaries/est10_monitor.html

Nolte, S., Koppenaal, E. C., Esselink, P., Dijkema, K. S., Schuerch, M., De Groot, A. V., Bakker, J. P., & Temmerman, S. (2013). Measuring sedimentation in tidal marshes: a review on methods and their applicability in biogeomorphological studies. *Journal of Coastal Conservation*, *17*(3), 301-325. Retrieved from: https://www.jstor.org/stable/42657025?seq=1#metadata_info_tab_contents

Pyzoha, J. E., Callahan, T. J., Sun, G., Trettin, C. C., & Miwa, M. (2008). A conceptual hydrologic model for a forested Carolina bay depressional wetland on the Coastal Plain of South Carolina, USA. Hydrological Processes: An International Journal, 22(14), 2689-2698. Retrieved from: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hyp.6866?casa_token=h9gPKzFn_XkAAAAA:if7DAV1dhHKLwBabiypVzMuomPuSokOU2_JR66JunC83dz3fOj7MRtIwX6QFGnxOToQcdtqeuesvBqo

Sandifer, P. A., Sutton-Grier, A. E., & Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Ecosystem services, 12, 1-15. Retrieved at: https://core.ac.uk/download/pdf/82072537.pdf

SCDNR (2019). Summary of Living Shoreline Research to Inform Regulatory Decision-Making in South Carolina. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 110. 49 p. Retrieved from: www.nerrssciencecollaborative.org/media/files/SCDNRLivingShorelinesSummaryDocument_20190731.pdf

Sea Level Rise Subcommittee (2018). Flood Mitigation and Sea Level Rise Adaptation for Kiawah Island, SC. Town of Kiawah Island, SC. Retrieved from: https://www.kiawahisland.org/wp-content/uploads/2018/08/FINAL-Flood-Sea-Level-Rise-Report-clickable-links-1-1.pdf

Smith, Stephanie (2016). Harmful Algal Bloom Water Quality: Everything You Need To Know. Webpage. Retrieved from: https://www.ysi.com/ysi-blog/water-blogged-blog/2016/09/harmful-algal-blooms-everything-you-need-to-know

Spencer, T., Schuerch, M., Nicholls, R. J., Hinkel, J., Lincke, D., Vafeidis, A. T., ... & Brown, S. (2016). Global coastal wetland change under sea-level rise and related stresses: The DIVA Wetland Change Model. Global and Planetary Change, 139, 15-30. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0921818115301879?casa_token=oShwKdQOTkgAAAAA:qxEbD5v-7kPIomOHqQVle2qxDuTRu9B-2oXZfyNVkCujSwzmVVMKtbuRtoOsyQvxtIJdjrxGJA

Szögi, A. A., Hunt, P. G., Sadler, E. J., & Evans, D. E. (2004). Characterization of oxidation-reduction processes in constructed wetlands for swine wastewater treatment. Applied Engineering in Agriculture, 20(2), 189. Retrieved from: https://www.ars.usda.gov/ARSUserFiles/60820000/Manuscripts/2004/Man675.pdf

U.S. Environmental Protection Agency (USEPA)(no date). National Recommended Water Quality Criteria - Aquatic Life Criteria Table. Webpage. Retrieved from: https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

U.S. Geological Survey (n.d.). Oxidation/Reduction (Redox). Water Resources website. Retrieved from: https://www.usgs.gov/mission-areas/water-resources/science/oxidationreduction-redox?qt-science_center_objects=0#qt-science_center_objects

Appendix - Additional Information on Water Quality Parameters

Temperature and dissolved oxygen [DO] are important factors for monitoring water quality, as they determine the health and abundance of fisheries. As dissolved oxygen is reduced, fish leave these areas and it can sometimes result in massive die offs (Bailey and Secor, 2016). Temperature also impacts DO, where a rise in temperature leads to lower DO levels. Stormwater runoff has very low DO levels and reduces DO levels when introduced into open water areas. DO can be increased by two natural processes: diffusion with the atmosphere and aquatic plants (NOAA). Coupling these parameters with climatic data, such as rainfall, provides further insight into how these areas are impacted by changing conditions over seasons.

Depth measurements are essential for determining site specific tidal fluctuations. As tides rise and flood the marsh platform, the tide levels will vary with location and distance from the Atlantic Ocean. Understanding these site-specific conditions helps to understand elevation related characteristics, which can lead to an appropriate approach to restoration efforts. Furthermore, federally funded restoration projects, such as restoration projects funded through the National Fish and Wildlife Foundation [NFWF], often require the use of depth monitoring equipment.

Conductivity provides information on the salinity content within the estuarine environment. Following rainfall events, stormwater runoff lowers salinity levels. Some organisms cannot tolerate low salinity conditions so their survival is affected. Oyster reefs for example are not typically found in low saline marsh environments with a salinity <15ppt and are not recommended for recruitment activities in these areas (SCDNR, 2019). This information is especially valuable for determining the placement of habitat restoration projects involving oysters so they can be appropriately sited to optimize recruitment and establishment.

pH + Oxidation Reduction Potential [ORP] are often included together on a single sensor and provide information on the chemical properties of aquatic environments. pH provides insight into the biological activities occurring within the marsh, including plant production and algal growth. As plants and algae remove CO_2 from the water and introduce DO, the pH rises and the water becomes more basic. This can lead to an increase in algal blooms, which significantly increase the pH of water to 10-11 (Smith, 2016). Since aquatic life typically tolerates a pH between 5.5 and 9.0 (USEPA), this results in massive die-offs of aquatic organisms. Furthermore, the breakdown of dead algae by bacteria and the nighttime respiration processes of algae are both oxygen consumptive and can severely deplete DO levels, resulting in massive die-offs of aquatic organisms.

ORP/redox is also important for understanding impacts related to contaminants. ORP levels can help determine whether water contains elevated levels of contaminants, including heavy metals, nitrates, and manmade contaminants, among others (USGS). Understanding ORP and the resulting redox reactions will provide information about how the ecosystem breaks down products from animals, vegetation, and chemical contaminants. It is often used in wastewater treatment analyses, where abnormal values of pH + ORP can indicate contaminated, unsafe water supplies (Lin et al., 2017).

Turbidity will provide information on sediment transport through the aquatic system and be included as a component of a sediment budget for Kiawah Island. Sediment budgets are important for understanding erosion and accretion processes, which can lead to developing the best approaches for marsh protection and restoration practices (Ganju, 2019). In particular, turbidity

measurements can provide information on suspended sediments within the water column. This can be coupled with additional measurements to create a sediment budget.

Fluorescent Dissolved Organic Matter (fDOM) Dissolved organic carbon (DOC) from organic matter is a key indicator into predicting the health and future conditions within an estuary ecosystem. **"**DOC acts as a food supplement which supports the growth of microorganisms and also plays an important role in the global carbon cycle" (Higgins, 2014). fDOM sensors measure the fluorescence of dissolved organic matter in the water column to provide a better understanding of DOC. This specific sensor was tested through a study by the North Inlet - Winyah Bay NERRS and determined it can be used in brackish and estuarine environments (see https://www.ysi.com/File% 20Library/Documents/News%20Briefs/NB16-USC-fDOM-Assessment.pdf)

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Jim Jordan, Chairman

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Date